Volume III. Desmids, Part A

Freshwater Algae in Northwest Washington



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Special thanks go to my friend and colleague Alfred van Geest, who contributed extensively to the taxonomic identifications and descriptions used in this volume. Alfred is recognized internationally for his outstanding work on desmid taxonomy, which includes numerous publications, as well as the creation and maintenance of the Digital Image Collection of Desmids (http://www.digicodes.info). Without his ongoing encouragement and technical guidance, this volume would never have been written.

I also want to thank my daughter Elizabeth, who patiently helped me write a computer program that made the cell measurement calculations easier and more accurate, and my husband Geoffrey, who has written numerous custom software programs that made this book possible, and is always willing to scrape a rock or wade out to get one more sample that is just beyond my reach!

Finally, I must acknowledge T. J. the office cat, who assisted with all levels of writing for this guide.

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Chapter 1

Introduction

The idea for this guide began in 2006 when the Institute for Watershed Studies (www.wwu.edu/iws) expanded its Northwest Lakes project to collect samples from more than 70 lakes. Plankton samples collected from these lakes provided many of the algae depicted in earlier versions of this guide. The first version of this guide was finished in 2009 and used as a reference for *Freshwater Algal Bioindicators* (ESCI 428, Western Washington University). After much additional sampling and taxonomic effort, the guide expanded to the point where it was not feasible to print as a single volume. As a result, the current version has been separated into multiple volumes as described in Table 1.1.

All identifications represent my best effort to provide accurate classifications using major keys (Brook and Williamson, 2010; Coesel and Meesters, 2007, 2013; Croasdale and Appollonia, 1965; Croasdale, et al., 1983; Dillard, 1900, 1991a, 1991b; John and Williamson, 2009; John, et al., 2011; Prescott, et al., 1975, 1977, 1981, 1982; Růžička 1977, 1981; Wehr, et al., 2015); and other sources listed in the references (page 1295). Uncertain identifications were flagged using "cf." prior to the species or variety name. Unknown taxa[1] that could be separated using morphological features were given a unique code (e.g., *Carteria* sp. 1). The terms "sp." and "spp."were used to indicate when one, or more one species were present, respectively. For a more detailed discussion of algal nomenclature rules and practices, see Section 1.1).

[1]The word "taxa" (singular "taxon") is used to distinguish unique groups of organisms.

Unless otherwise noted, all images in this manual were photographed by Dr. Robin Matthews using a Nikon Eclipse 80i with phase contrast and Nomarski (DIC) objectives equipped with a QImaging, AmScope MU1403, or Nikon DS-Fi2 digital camera; the SEM images were created using a Vega Tescan 5136MM scanning electron microscope.

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1.1 Algal Nomenclature

Historically, most species identifications have been based on morphological characteristics, with each species being described by a set of visible characteristics called a "diagnosis." Ideally, the diagnosis for each species would be uniquely different compared to all other species. While this is often possible, in some cases two species are so similar that it is almost impossible to assign a specimen to one or the other species. A further complication is that two species can differ significantly from each other but be connected by transitional forms that are difficult to assign to either species. The term "species complex" is often used to define a large group of species that are so similar in appearance that the boundaries between them are unclear. If species within a complex can be distinguished using non-morphological features (e.g., chemical or molecular analysis) the term "cryptic species" may be used. Occasionally the term "pseudo-cryptic species" is used when species can be distinguished morphologically, but only when examined very carefully.

Even when dealing with species that seem to have a unique diagnosis, it may be difficult to see the diagnostic features, or the descriptions may be unclear or arbitrary. For example, cells in one species may be described as subcircular compared to a similar species where the cells are described as pyramidal. If you are working with small cells (e.g., small species of *Cosmarium* or *Euastrum*), most morphological characteristics are difficult to see, so the taxonomic choices can be difficult. Also, cells within a single species can have different shapes during various stages of development or when exposed to different environmental conditions. As a result, cells from the same species may be subcircular or pyramidal depending on when and where the samples were collected. Adding to this complexity is that the diagnostic features of new species may have been established using a single cell

viewed from one side. The use of Scanning Electronic Microscopy (SEM) often provides additional morphological details compared to light microscopy, but may complicate identifications because it reveals features that were not described in the original species diagnosis.

Taxonomists often use "cf." (Latin: "conferre" or "conformis" means to confer or compare) to indicate uncertainty. For example, a specimen that resembles *Cosmarium phaseolus* but doesn't display all of the diagnosis characteristics could be listed as *Cosmarium* cf. *phaseolus*.[2] Taxonomists may also use "aff." (Latin: "affinis" means related) to indicate uncertainty in a species identification, but this abbreviation is used less frequently. Some taxonomists (e.g., Lucas, 1986) argue that uncertainty indicators like "cf." and "aff." should not be placed between the genus and species names, so the above example would be listed as *Cosmarium* cf. *Cosmarium phaseolus*. Most taxonomists use the shorter version (*Cosmarium* cf. *phaseolus*), which is the format that will be will use in this guide.

Within a given species there can be morphological variations that, while consistent within a population, are not sufficient to be used to describe a new species. To solve this problem taxonomist have invented infraspecific taxa. The International Code of Nomenclature for Algae, Fungi and Plants (www.iapt-taxon.org/nomen/main.php) recognizes the following taxonomic ranks below species: subspecies, variety, subvariety, form, and subform. Subspecies are often used in zoology when the variation can be attributed to differences in geographic distribution. Although it is possible to demonstrate some geographical differences for desmids, it is more the exception than the rule, so the subspecific rank is not used. Subvariety and subforms are also rarely uses in algal nomenclature, so only variety and form are discussed here in detail.

Variety or "var." (Latin: "varietas"; plural: "varietates") is the most commonly used subspecific rank in algal nomenclature. The name itself indicates its meaning - this rank is used for subgroups where the differences are not sufficient to be described as a separate species. Forms or "f." (Latin: "forma"; plural: "formae") represent a lower rank than variety, and can be used if the difference in characteristics is even smaller than with the use of a variety. Forms are also used if there is some reason to suspect that the difference are solely the result of environmental influences. To make things more complicated the abbreviations "var." and "f." are also used to indicate that a specimen is considered to belong to a certain species but does not

[2]Genus and species names are normally italicized and genus is capitalized; cf. is not italicized or capitalized.

completely agree with the diagnose. In that case the Latin name is followed by the variety or form abbreviation (e.g. *Cosmarium quadratum* f. or *Cosmarium quadratum* var.).

In advanced taxonomic guides, when there are varieties included under a species, the authors will list a "nominate" variety (variety name = species name) with the other varieties. This is for clarity because otherwise the species description would need to encompass all morphological features found in the lower ranks. For example, the description for *Micrasterias americana* would need to include features for both *Micrasterias americana* var. *americana* and *Micrasterias americana* var. *lewisiana*. For simplicity, in this guide you may assume that a species description is automatically for the nominate variety unless otherwise indicated.

The decisions about how much morphological variation can be included within the description for a single species, and whether to create varieties and forms from smaller differences, will be influenced by the judgment of the taxonomist. Some taxonomists accept a larger amount of variation at the species level and limit the use of lower ranks like variety and form; others prefer to subdivide species into varieties and forms to account for subtle but consistent differences. These two types of taxonomists ("lumpers" and "splitters") don't necessarily disagree about the morphological differences, but they disagree on how the variability should be described. Not surprisingly, many nomenclature revisions are the result of elevating a variety to species status, or vice versa.

There is a large similarity between the desmid flora of North America and Europe. Most species listed for North America and Europe were originally described using specimens from Europe. But there are regional differences between North America and Europe, so it is possible that specimens from North America are somewhat different from European specimens and should be described as separate varieties or species. It is important to keep this in mind when classifying North American specimens on basis of European taxonomic literature.

Algal nomenclature has been changing rapidly over the past few decades, largely due to the use of genetic analysis to separate algal species (see Brodie and Lewis, 2007, for a good discussion of recent changes in algal systematics). It has become increasingly difficult to keep up with changes in algal scientific names. To the extent possible, the nomenclature in this guide follows AlgaeBase (https://www.algaebase.org, Guiry and Guiry, 2023) because it provides a summary of taxonomic synonyms and citations to source literature containing the diagnostic features for each taxon.

Some genetic revisions have resulted in the separation of taxa that are very similar in appearance, but significantly different genetically. When this type of revision affected a small number of species, the revised species were kept in the same section with other morphologically similar species and the revision was indicated in the taxa list. If the revision was at the genus level, and affected a small number of taxa, the new genus name was added to the chapter heading. For example, *Netrium interruptum* (Brébisson ex Ralfs) Lütkemüller is currently named *Planotaenium interruptum* (Brébisson ex Ralfs) Fetlovany and Palamar-Mordvintseva. To accommodate this type of revision, all species of *Planotaenium* and *Netrium* were placed in a chapter named **Netrium and Planotaenium**. This approach didn't work for complex examples like *Xanthidium tumidum* (Ralfs) Šťastný, Škaloud & Neustupa, which is listed as *Staurastrum tumidum* Brébisson ex Ralfs or *Staurodesmus tumidum* (Brébisson ex Ralfs) Teiling in most taxonomic sources. For this type of revision, the full description for *Xanthidium tumidum* was included in the **Xanthidium** chapter, with cross-listings in the **Staurastrum** and **Staurodesmus** chapters. In all cases, remember that scientific names are a moving target, so check recent authoritative sources if you need to cite the correct name.

1.2 Collecting and Identifying Algae Samples

Guidelines for collecting algae: Collect your sample using a plankton net, by scraping visible algae from rocks or wet surfaces, or by collecting a small sample of shoreline vegetation. Put the sample into a clean, wide-mouth jar or bottle along with a small amount of clear water from the site. Leave 1–2 inches of air space and put it in a cool location away from direct sunlight. If the sample must be held for more than one day, you can preserve the algae using Lugol's iodine solution or formalin, but this may make the algae more difficult to identify.

- Algae that sit in a sealed jar may form oxygen bubbles in the chloroplast, especially if the jar sits in direct sunlight. This damages the chloroplast, and makes the specimen hard to identify.
- If the sample is sealed too long or gets too hot (sits in a hot car or in direct sunlight), the algae die and start to decompose. Not only does this smells really bad, the algae are nearly impossible to identify. If you can't examine your sample within an hour, loosen or remove the lid to allow fresh air to reach the water surface.

- Similarly, algae that sit too long (i.e., more than 10–15 minutes) on a hot microscope slide will be hard to identify. The cells may start shedding flagella (not a problem with desmids) or excreting mucilage (definitely a problem with desmids), and will eventually be deformed or crushed by the cover slip as the slide dries.

Guidelines for identifying algae: Start your identification by reviewing Table 1.1 to make sure you are using the correct volume in this series. Algae described in this volume will usually stain dark brown or purple in Lugol's iodine solution and most live cells will be bright green. Desmids will not be motile by means of flagella, but they may twitch, rotate, and glide by secreting mucilage.

The preliminary key on page 21 separates desmids based on whether the cells are usually solitary or form filaments. The preliminary key will direct you to advanced genus keys that help identify species and varieties. Algae are diverse! You will almost certainly encounter specimens that do not match the figures or are not described in the text. Try to find several examples of the cell or filament.

Here are a few guidelines for identifying algae using the keys in this volume:

- The keys in this guide are not dichotomous.[3] Instead, you are offered several choices among matching numbers or letters.
- The keys in this volume are designed to identify freshwater algae collected in northwest Washington. For a broader coverage, refer to the taxonomic sources listed in the references (page 1295).
- The advanced keys may require cell measurements to separate species and varieties. Unless otherwise indicated, these measurements represent **total** length and width, including spines, teeth, or other projections.
- Many types of algae form resting cells or other specialized cells that look different than the vegetative cells. Where possible, figures were included that show specialized cells that help distinguish different taxa.
- Try to work with *healthy*, live specimens. Preserved samples are fine for someone familiar with algae, but they are difficult to work with if you are a beginner.

[3] Dichotomous keys are based on paired choices.

- If possible, take photographs of your specimens. If you do not have access to a good camera on your microscope, carefully drawn illustrations can be a good alternative.
- Keep detailed records of your observations, including the sampling location, date, and magnifications for any drawings or photographs.
- Take advantage of online image libraries like these:
  - Digicodes (http://www.digicodes.info)
  - AlgaeBase (https://www.algaebase.org)
  - Desmids of the Outer Hebrides (https://www.outerhebridesalgae.uk/desmids.php)
  - Desmids of Drenthe (www.desmids.science4all.nl/?Desmid_pictures)
  - PhycoKey (http://www.cfb.unh.edu/phycokey/phycokey.htm)

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  ⇒**Warning: not all online images are correctly identified!**

1.3 Recognizing the Algal Divisions

This guide is designed to be used by students and citizen scientists who are beginning their exploration of algal taxonomy. The taxonomic identifications are based on simple morphological features rather than genetic relationships. Photographs and cell dimensions are included for all taxa. Keeping with the goal of introducing new students to algal taxonomy, the descriptions avoid the use of specialized taxonomic terms (jargon) except when necessary for clarity. This guide emphasizes algae collected from northwest Washington lakes and ponds, so it contains fewer taxa than guides that cover all types of freshwater algae in broad geographic regions.

The first step in this book requires separating algae into major divisions.[4] Even this broad separation can be difficult. Table 1.1 provides a summary of major distinguishing features for the divisions and indicates which volume describes each type of algae. If you are having difficulty separating by division, try using several keys or looking at photographs that show the different examples.

Each chapter includes species keys and cell measurements for taxa collected from northwest Washington. Section 1.4.2, beginning on page 37, provides a list of taxa included in this book with links to the species keys. When possible, cell measurements were collected using at least 10 specimens from different sites collected on different dates; taxa represented by fewer than 5 specimens are identified in the cell measurement tables.

Motility as a key feature in algal taxonomy: Motility is very common in freshwater algae. Some algae are motile by means of flagella and may have a red eyespot that detects light. The presence of these features usually indicates potential motility, even if the cells in your sample are stationary. But flagella and eyespots are not necessary for motility. Many types of desmids move by means of gliding, rotating, or twitching.

Although motility can be a distinctive taxonomic feature, the lack of motility is not as helpful. Motile algae often respond to stress by shedding flagella and becoming nonmotile. Conversely, algae that glide across surfaces may need to settle on the slide before they start moving, and algae that spiral or twitch may become increasingly active as the slide warms and dries under the hot microscope light. And, just to keep things interesting, there are a few common nonmotile algae that have residual eyespots or nonfunctional structures that resemble flagella.

[4] Botanical taxonomists often use "division" rather than phylum to describe the taxonomic level between kingdom and class.

Table 1.1: Summary of the Major Algal Divisions

Volume I	**Cyanobacteria** (blue-green algae): cells lack organelles like chloroplasts; no flagella (may move by gliding); starch absent.
Volume II*	**Chlorophyta** (green algae): chloroplasts often bright green; motile cells have two or four flagella; starch present.[†] **Rhodophyta** (red algae): chloroplasts red or blue-green; nonmotile; starch present.[†]
Volume III	**Charophyta - Desmids:** nonmotile; chloroplasts often bright green; most form mirror image semi-cells; starch present;[†] separated into Part A. Desmids, excluding *Actinotaenium* & *Cosmarium* and Part B. Desmids, *Actinotaenium* & *Cosmarium*
Volume IV**	**Chrysophyceae** (golden algae) and **Xanthophyceae** (yellow-green algae): chloroplasts golden-brown or yellow-green; motile cells with two unequal flagella; starch absent. **Haptophyta:** solitary cells; chloroplasts golden-brown; all cells motile with what looks like three flagella (two flagella + one haptomere); starch absent.
Volume V**	**Cryptophyta:** solitary cells; chloroplasts greenish, golden-brown, or brown; all cells motile with two nearly equal flagella; oral groove; starch present.[†] **Dinophyta:** solitary cells; chloroplasts golden-brown or brown; usually motile with visible trailing flagellum; second flagellum encircles cell; cell wall often plate-like; starch present.[†] **Euglenophyta:** solitary cells; chloroplast usually bright green; single visible flagellum; starch absent.

*Volume II includes non-desmid **Charophyta**; **Volumes currently in preparation.
[†]Cells with starch will stain dark purple/brown in Lugol's iodine solution.

1.4 Introduction to Desmids

Desmids are a subgroup of algae that share many features with green algae (**Chlorophyta**).[5] Desmids are typically placed in division **Charophyta** or **Streptophyta**[6] because they do not produce flagellated cells during sexual or asexual reproduction. In addition to desmids, the division **Charophyta** includes several very common types of filamentous green algae, including *Mougeotia*, *Spirogyra*, and *Zygnema*. Like the **Chlorophyta**, desmids are eukaryotes, which means the cells contain organelles like chloroplasts and a nucleus. The chloroplast contains chlorophyll, the green pigment that is used to capture light energy for photosynthesis. Desmids are also similar to **Chlorophyta** in that the cells create starch inside the chloroplast (Lee, 2008) using special structures called pyrenoids (Figure 1.1). The starch causes the cell to stain dark purple or brown in Lugol's iodine solution. The cell wall typically contains cellulose, similar to terrestrial plants. In addition to chlorophyll, the cells may contain accessory pigments for capturing light energy at different wavelengths, but the accessory pigments usually don't obscure the characteristic green color of this division. Desmid asexual reproduction occurs by simple cell division, whereby each half of the desmid cell (semi-cells) forms a new half (Figure 1.2). Sexual reproduction involved conjugation between two cells or filaments, resulting in one or more thick-walled resting cells (zygotes) that can overwinter or tolerate unfavorable environmental conditions (Figures 1.3–1.4).

Desmids are subdivided into the saccoderm desmids (order **Zygnematales**; family **Mesotaeniaceae**) and placoderm desmids (order **Desmidiales**). The saccoderm desmids have simple, unconstricted cells that lack median suture lines and do not have mucilage pores in the cell walls (Figure 1.5). Despite the absence of mucilage pores, saccoderm desmids usually excrete mucilage through the cell wall. The pores in placoderm desmid cells are rarely visible using conventional light microscopy, so the presence/absence of mucilage pores isn't the best visual tool for separating the two types of desmids. The saccoderm desmids in northwest Washington samples include *Cylindrocystis* (Section 5, page 289), *Mesotaenium* (Section 12, page 501), *Netrium* (Section 14, page 607), *Roya* (Section 18, page 699), *Spirotaenia*, and *Tortitaenia* (Section 20, page 717).[7]

[5] See **Freshwater Algae in Northwest Washington, Volume II. Chlorophyta and Rhodophyta**.

[6] **Streptophyta** is usually listed as an Infrakingdom that includes the division **Charophyta** (AlgaeBase, https://www.algaebase.org, Guiry and Guiry, 2023.

[7] *Spirotaenia* may not be a true desmid but it was included because of its similarity to *Tortitaenia*.

The placoderm desmid cells are divided into two mirror image semi-cells, usually connected by an "isthmus" (Figure 1.6), with the opening between the semi-cells called the "sinus." A few genera do not have a distinct isthmus separating the semi-cells, but will still have a suture separating the semi-cells (Figure 1.7). Placoderm desmid cells range from very simple and smooth-walled (e.g., *Cosmocladium*; Section 4, page 279) to extraordinarily ornate (e.g., *Micrasterias*; Section 13, page 511). The cell walls contain pores and excrete mucilage that is clearly visible under phase contrast, DIC, or SEM (Figure 1.8). Placoderm desmids divide at the isthmus (or suture), with each semi-cell forming a new half, so recently divided cells may be asymmetric (Figure 1.9). Placoderm desmids are extraordinarily common and diverse in boggy northwest Washington lakes and ponds, and it is not unusual to find >30–40 different species in a single small lake.

Desmids are most diverse in lakes that have low concentrations of dissolved calcium and magnesium, low salinity levels, and high concentrations of dissolved organic carbon (Wetzel, 2001). Lakes with granitic or igneous watersheds or acid bogs often have a high desmid diversity. These conditions are common in high elevation lakes in the Pacific Northwest.

Desmid taxonomy can be quite difficult, particularly because many different desmid species may be collected from a single lake. Desmids often have ornate, three-dimensional shapes, with elaborate wall ornamentation, spines, and projections. Capturing the exact cell shape for taxonomic purposes is challenging. To add to the difficulty, the taxonomy is not standardized. For example, some early taxonomic experts (e.g., Prescott) did not recognize *Staurodesmus* as a distinct genus, and placed all *Staurodesmus* species into *Arthrodesmus* or *Staurastrum*. John, et al. (2006) assigns nearly all *Arthrodesmus* species to the genus *Staurodesmus*. To minimize confusion, nomenclature will be based on AlgaeBase (www.algaebase.org, Guiry and Guiry, 2023) because it is a good, comprehensive source for freshwater and marine algal taxonomy, and has an excellent search function that includes commonly used synonyms.

As a reminder, most of the desmids described in this guide were collected from freshwater sites in northwest Washington, and the keys are greatly simplified compared to keys that cover larger geographical regions. If you are using this guide to identify species from other locations, be aware that there are thousands of desmid species that were not present in the samples used for this guide, so your desmid specimen might not be depicted in this guide.

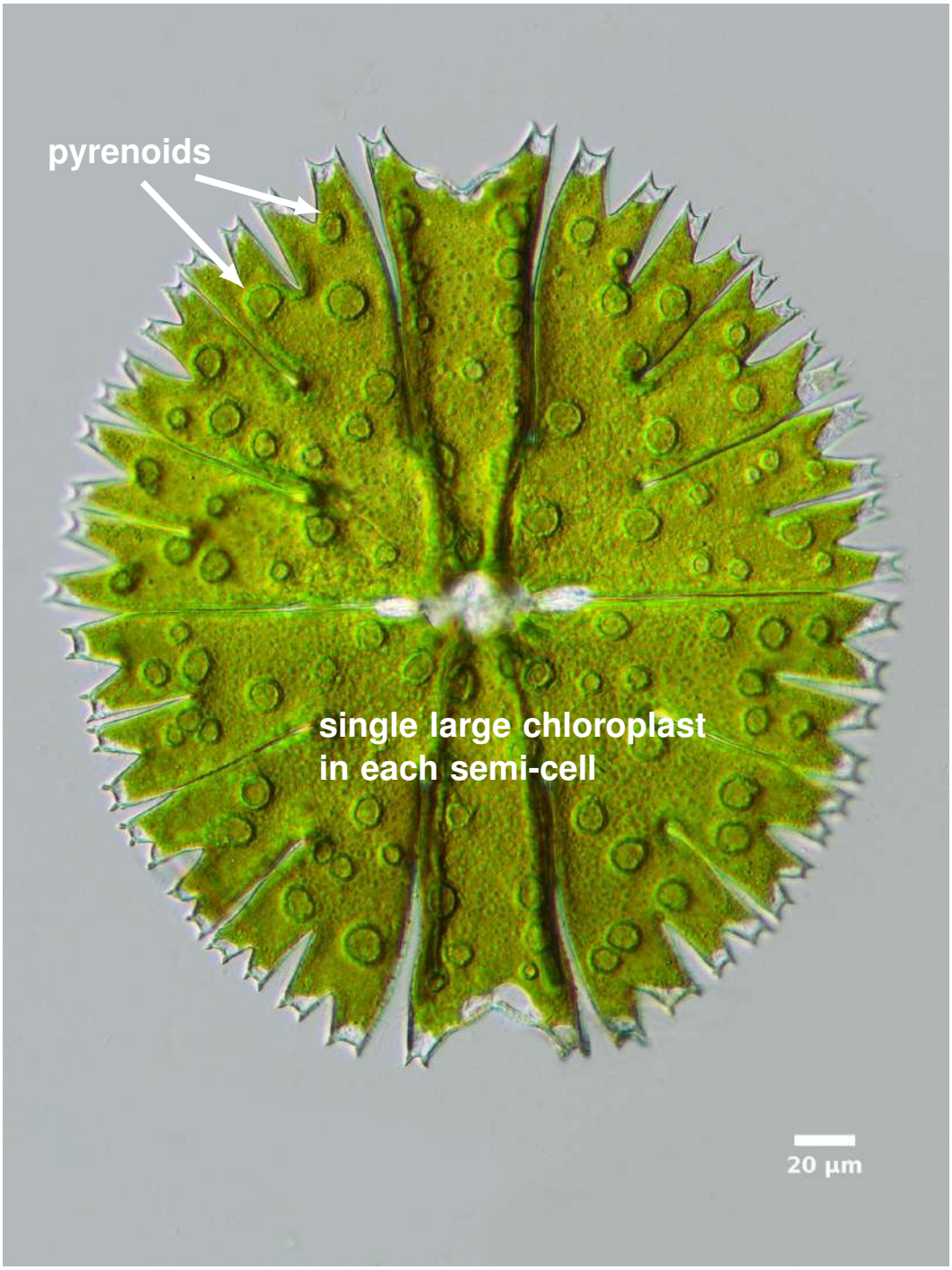


Figure 1.1: Typical desmid chloroplasts and pyrenoids (*Micrasterias*).

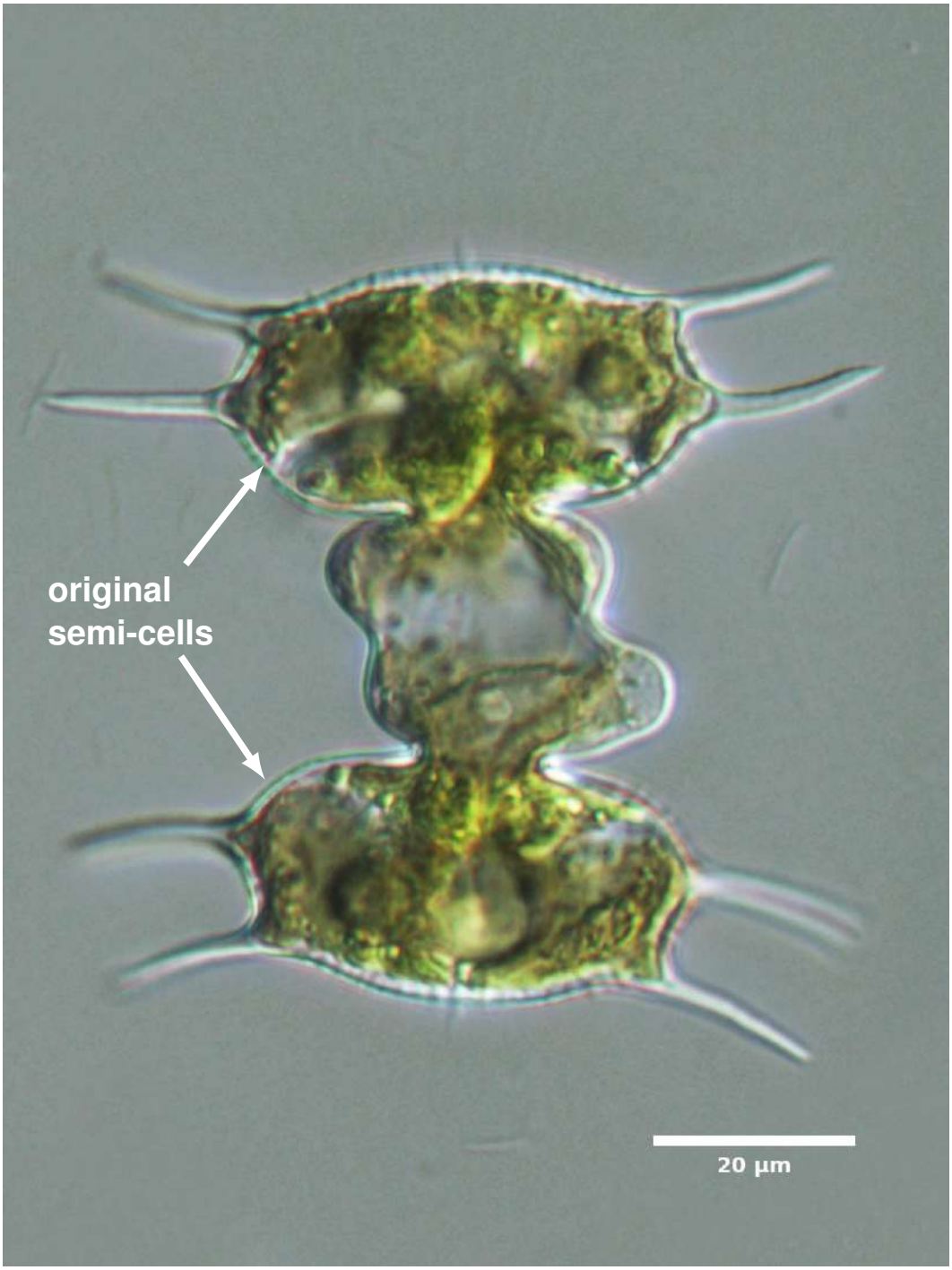


Figure 1.2: Example of desmid cell division (*Xanthidium*).

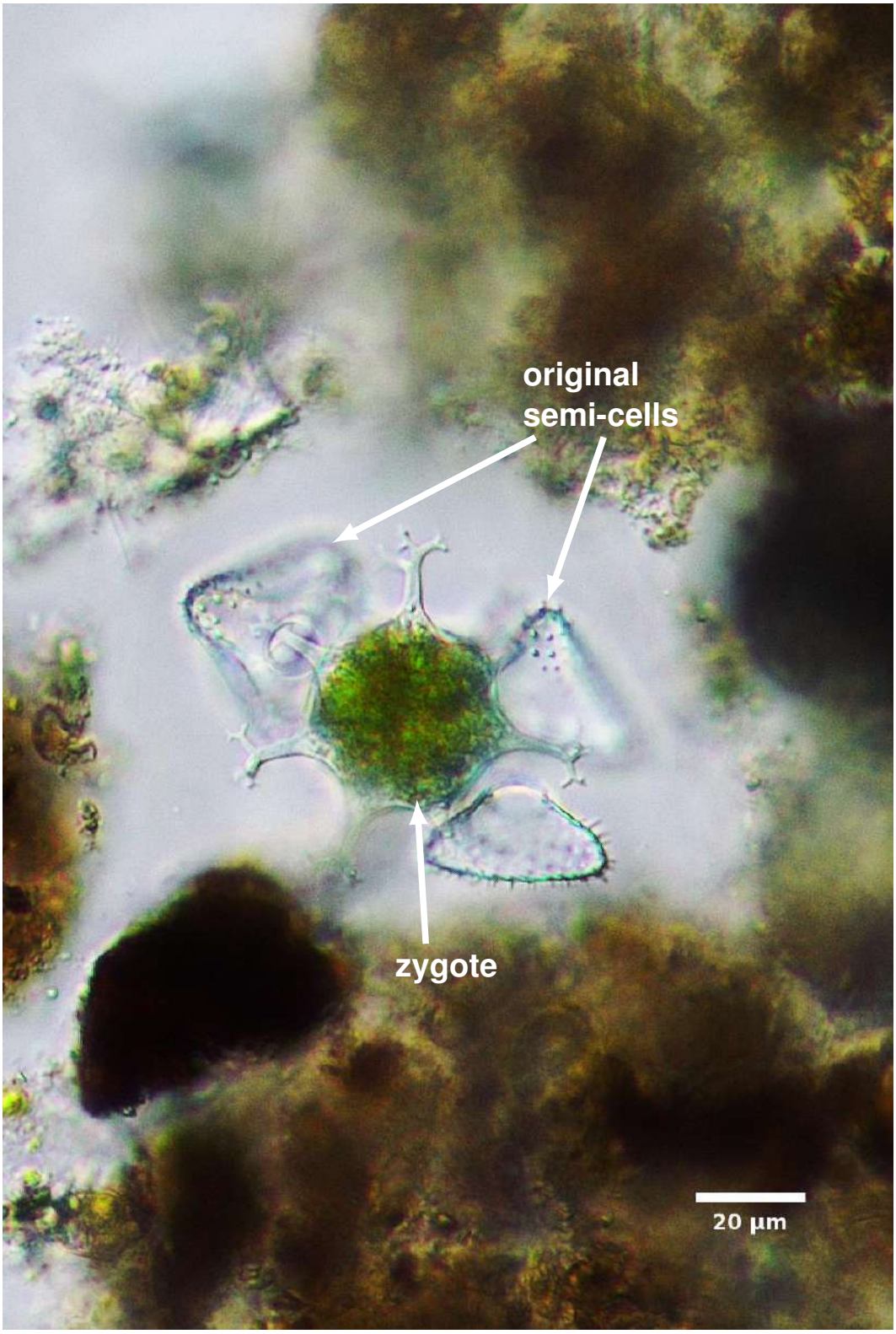


Figure 1.3: Example of desmid conjugation resulting in zygote formation (*Staurastrum*).

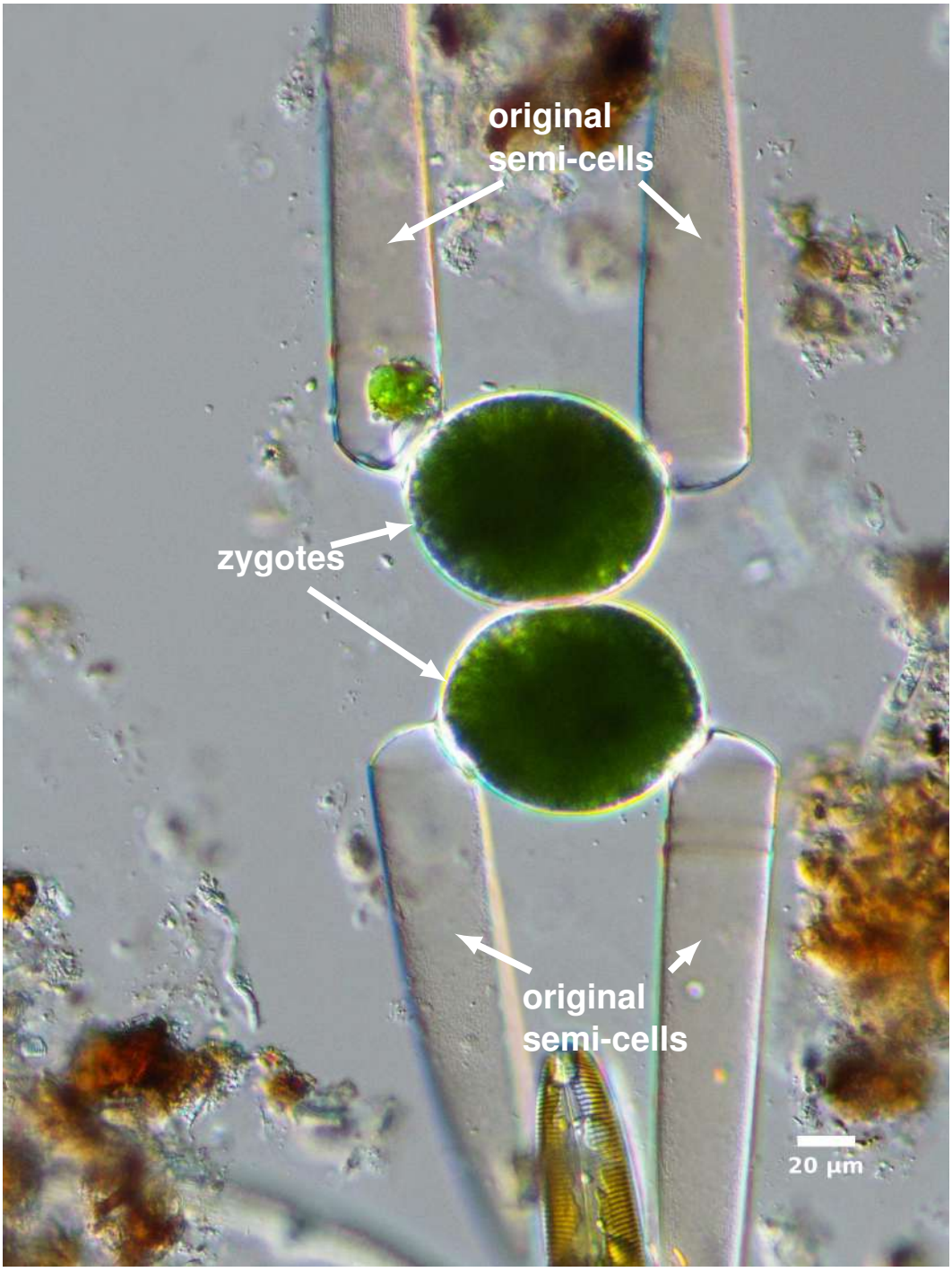


Figure 1.4: Example of desmid conjugation resulting in twin zygotes (*Closterium*).

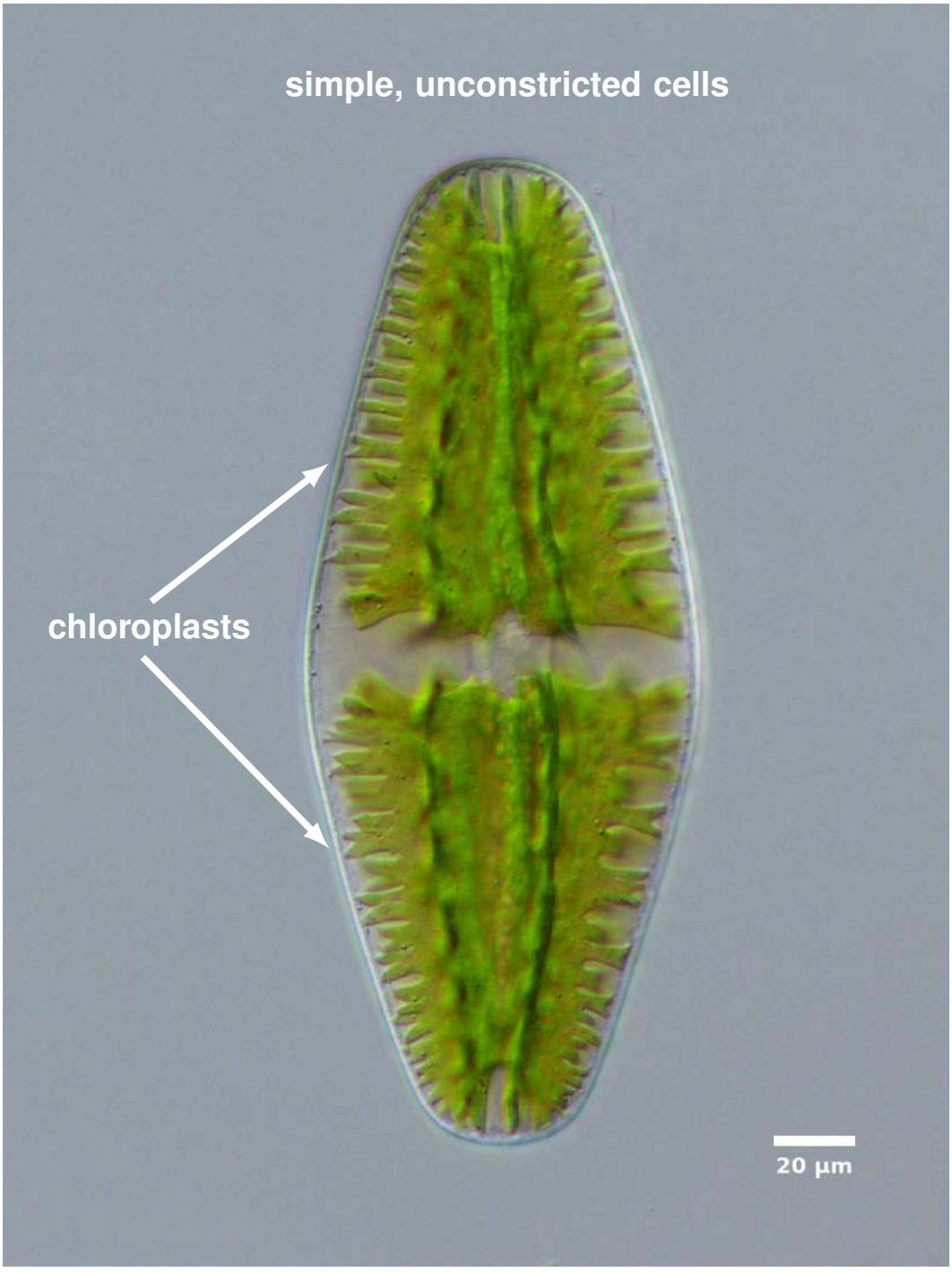


Figure 1.5: Typical saccoderm desmid (*Netrium*).

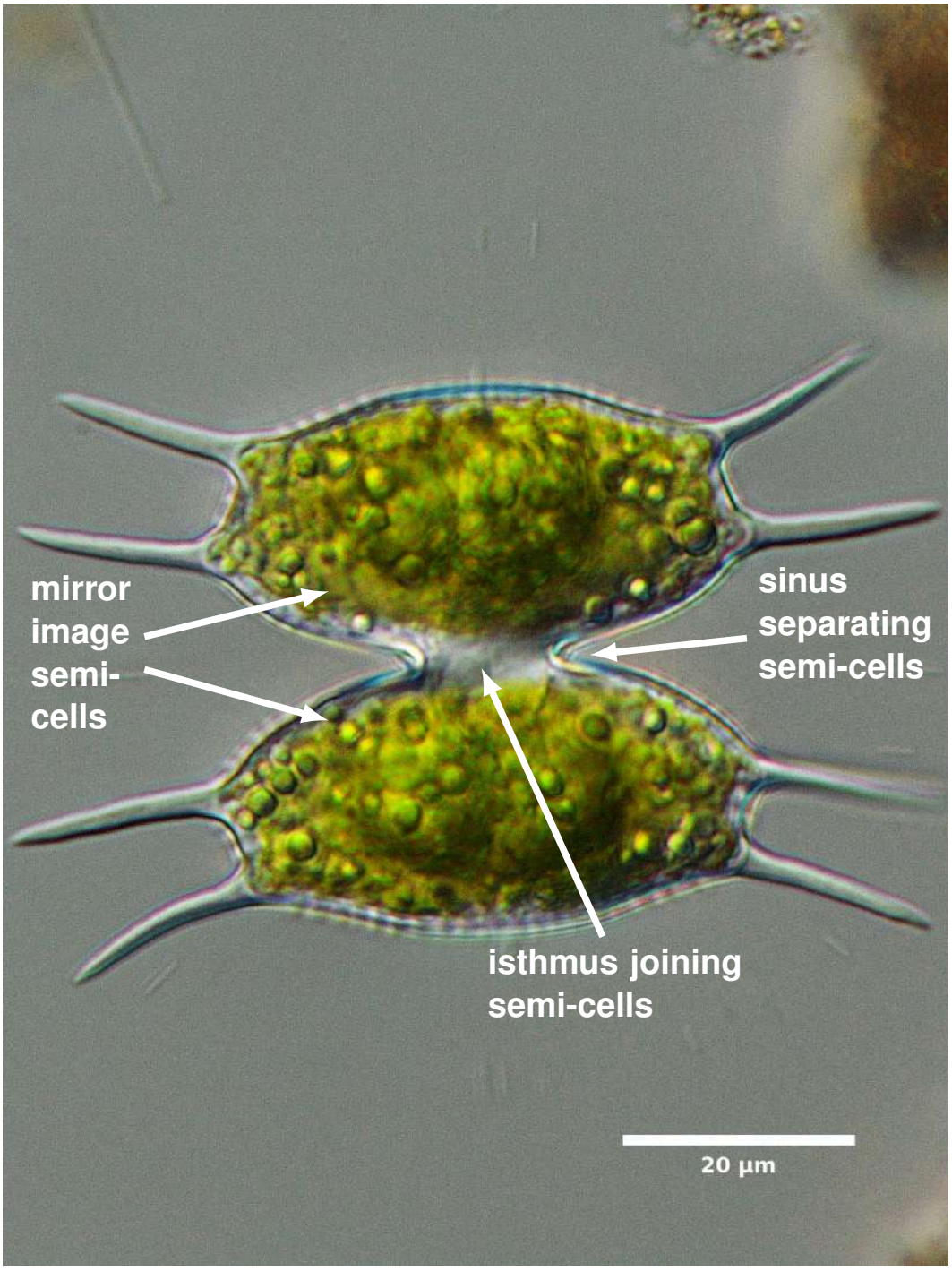


Figure 1.6: Typical placoderm desmid with distinct isthmus (*Xanthidium*).



Figure 1.7: Typical placoderm desmid without a distinct isthmus (*Closterium*).

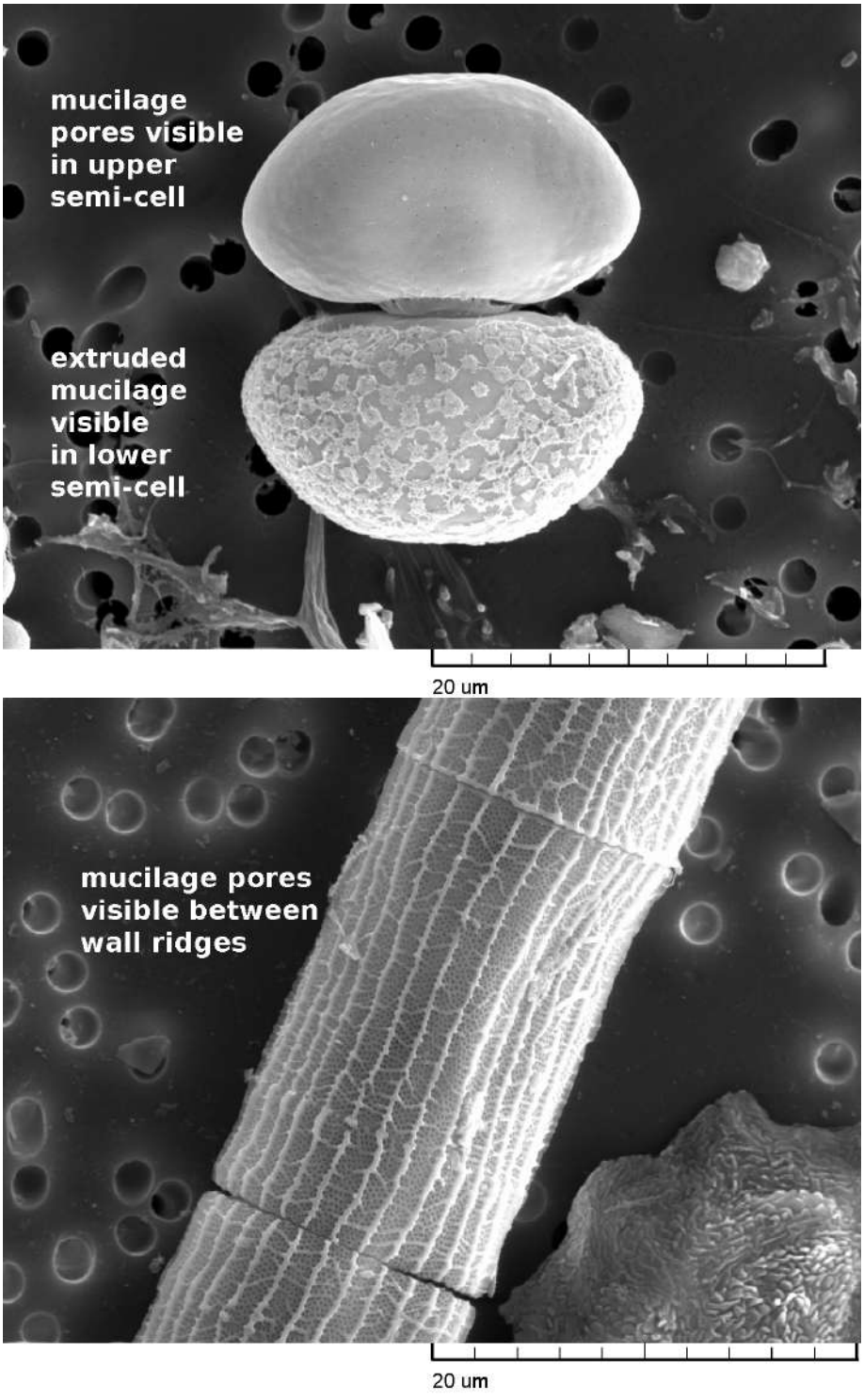


Figure 1.8: SEM images showing placoderm desmid mucilage pores in *Cosmarium* (upper image) and *Penium* (lower image).



Figure 1.9: Asymmetry of *Micrasterias* semi-cells following division.

Table 1.2: Preliminary Key to Desmid Genera

Cells form clumps or filaments; rarely solitary		
A	Cells connected by long, mucilaginous threads to form open, branching colonies	*Cosmocladium* (page 279)
B	Cells form groups enclosed in thick mucilage; individual cells unconstricted (saccoderm desmid)	*Mesotaenium* (page 501)
C	Cells joined end-to-end to form filaments	Go to page 22
Cells usually solitary; often large and showy		
D	Cells angular (often triangular) in cross-section	Go to page 23
E	Cells circular or slightly compressed (oval) in cross-section; elliptical, cylindrical, or fusiform in outline (L/W>2)	Go to page 23
F	Cells moderately or strongly compressed (elliptical) in cross-section	Go to page 25
G	Cells circular or oval in cross-section; spherical, broadly oval, or broadly rectangular in outline (L/W≤2); cell wall smooth, granular, or with small teeth but lacking long spines; very common and diverse group	*Actinotaenium* & *Cosmarium* see Part B of this volume

continued on next page

Table 1.2: Key to Desmid Genera, continued

C	Cells joined end-to-end to form filaments	
	C.1 Cells with shallow sinus or unconstricted; L≤W	
	C.1d Cells cylindrical; circular or oval in cross-section;	*Hyalotheca* (page 485)
	C.1e Cells angular, with angular projections or wall extensions	*Desmidium* (page 303)
	C.2 Cells with shallow sinus or unconstricted; L>W	
	C.2a Cells barrel-shaped, distinctly expanded at center	*Bambusina* (page 47)
	C.2b Cells approximately cylindrical but slightly expanded at center	*Groenbladia* (page 473)
	C.2c Cells cylindrical, very long (L≫W), with no apparent sinus; solitary or in short filaments	*Genicularia* and *Gonatozygon* (page 449)
	C.3 Cells with moderately deep or deeply constricted sinus	
	C.3a Semi-cells oval or broadly elliptical; cells joined by flat, smooth apical surface; cell walls smooth	*Spondylosium* (page 735)
	C.3b Semi-cells kidney-shaped; cells joined by short, widely spaced rod-like extensions; cell walls smooth	*Onychonema* (page 625)

continued on next page

Table 1.2: Key to Desmid Genera, continued

	C.3c Semi-cells elliptical, with deeply constricted sinus; cells joined by short, closely spaced, twisted, rod-like extensions; cell walls smooth or faintly granular	*Sphaerozosma* (page 707)
	C.3b Semi-cells oval or elliptical, with moderately deep, widely open sinus; cells joined by inconspicuous apical granules (difficult to see); cell walls coarsely granulated	*Teilingia* (page 1207)
D	Solitary cells; angular (often triangular) in cross-section	
	D.1 Cells triangular in cross-section (or multiples of 3x); cell wall usually smooth; may have teeth or spines at the angles	*Staurodesmus* (page 1107)
	D.2 Cells triangular in cross-section (or multiples of 3x); cell wall usually granular, warty, or spiny; with teeth or spines at the angles; angles may be extended to form long arms	*Staurastrum* (page 755)
	D.3 Cells very broadly triangular in cross-section (nearly circular); cell wall smooth except for blunt teeth at the cell angles	*Xanthidium tumidum* (page 1292)
E	Solitary cells; circular or slightly compressed oval in cross-section; elliptical, cylindrical, or fusiform in outline (L/W>2)	
	E.1 Cells with no visible sinus	

continued on next page

Table 1.2: Key to Desmid Genera, continued

	E.1a Cells oval or broadly elliptical (L/W$\leq$5); chloroplast with very finely dissected edge (saccoderm desmid)	*Cylindrocystis* or *Netrium* (pages 289 or 607)
	E.1b Cells fusiform (L/W$\leq$10); chloroplasts form spiralling longitudinal bands (not true desmid but resembles saccoderm desmid)	*Spirotaenia* or *Tortitaenia* (page 717)
	E.1c Cells oval, broadly elliptical, or fusiform (L/W$\leq$10); chloroplast with longitudinal ridges and ragged, notched, or serrated edge (saccoderm desmid);	*Netrium* and *Planotaenium* (page 607)
	E.1d Cells cylindrical (L/W$>$10) and straight; single, undivided chloroplast (saccoderm desmid)	*Roya* (page 699)
	E.1e Cells cylindrical (L/W$>$10) and straight; chloroplasts divided at center of cell	*Gonatozygon* (page 449)
	E.1f Cells fusiform and slightly to strongly curved; chloroplasts divided at center of cell; apex with terminal vacuole containing moving crystals	*Closterium* (page 55)
E.2	Cells with shallow but distinct sinus	
	E.2a Cells fusiform; apex rounded, with deep, central incision	*Tetmemorus* (page 1221)
	E.2b Cells cylindrical or fusiform; apex with no central incision; walls often with horizontal bands	*Penium* (page 631)

continued on next page

Table 1.2: Key to Desmid Genera, continued

	E.2c Cells cylindrical; cell wall smooth or slightly pitted, usually with several (or many) undulation above the sinus; apex with terminal vacuole containing moving crystals	*Pleurotaenium* (page 661)
	E.2c Cell cylindrical, with a single undulation above the sinus; apex smooth and rounded, lacking terminal vacuole containing crystals	*Haplotaenium* (page 479)
	E.4c Cell cylindrical; cell wall with regularly spaced sharp teeth; apex with 2 or more sharp teeth	*Triploceras* (page 1239)
F	Solitary cells; cells moderately or strongly compressed (elliptical) in cross-section	
	F.1 Cells rectangular in outline; strongly or moderately flattened in cross-section; semi-cells with 2 or more long, sharp spines	*Xanthidium* (in part) (page 1245)
	F.2 Cells strongly or moderately flattened in cross-section; walls smooth, granular or covered with short spines, but lacking long spines	
	F.2a Cells spherical or broadly oval in outline; strongly flattened; semi-cells divided into 3-5 lobes; large, showy cells	*Micrasterias* (page 511)
	F.2b Cells oval, rectangular, or trapezoidal in outline; strongly or moderately flattened; apex (polar lobe) narrowed, and usually with a median notch	*Euastrum* (page 323)

continued on next page

Table 1.2: Key to Desmid Genera, continued

F.3	Cells oval in cross-section; not strongly flattened (also see F, page 23)	
	F.3a Cells typically in groups surrounded by thick mucilage; cells small, oval, with no visible sinus	*Mesotaenium* (page 501)
	F.3b Semi-cells with 2 or more long, sharp spines; cell wall smooth	*Xanthidium* (in part) (page 1245)
	F.3c Cells variable in shape; walls smooth, granular, warty, or with short teeth or spines, but lacking long, sharp spines; diverse group!	*Actinotaenium* or *Cosmarium* (see Part B of this volume)

1.4.1 Desmid Collecting Sites

Table 1.3 lists GPS locations for the sites where desmids were collected and used to create figures in this volume. This table does not represent all locations where desmids were found in northwest Washington; that is a much longer list. All locations are approximate because samples were collected from multiple locations at each site. Most samples were collected using a 20 μm plankton net cast from the shore or a public boat dock. Samples from large lakes (e.g., Lake Whatcom, Lake Samish) occasionally included mid-basin plankton tows and Schindler trap samples from 5 meter depths. The samples were placed in 250-mL sample bottles until they they could examined in the laboratory. When possible, small pieces of submerged aquatic vegetation, woody debris, and stones with visible algal growth on the surface were included in the sample to increase the habitat variety. Samples from rocky areas (e.g., waterfall spray zones) were scraped using a rubber spatula and placed in 250-mL sample bottles with a small amount of water. The samples were kept cool and out of direct sunlight until they could be examined in the laboratory.

Water quality data are available for some of the desmid sampling sites from the Institute for Watershed Studies, Western Washington University, Bellingham, Washington (USA). Table 1.3 includes median pH, conductivity, and alkalinity for sites sampled by the Institute; additional nutrient, chlorophyll, and organic carbon data can be found on the Institute for Watershed Studies website (https://diatom.cenv.wwu.edu/?page=lakeslist).

Table 1.3: Latitude and longitude for desmid collecting sites listed in this volume. The "code" entry was used to sort the file into groups from similar locations. Median values were entered for pH, conductivity, and alkalinity if more than one sample was analyzed.

Code	Description	Lat.	Long.	pH	Cond (μS)	Alk (mg/L)
	Whatcom County Sites					
AND	Lower Anderson Lake, Mt. Baker area, Whatcom County	48.6592	-121.5888	–	–	–
ANDinlet	Lower Anderson Lake at inlet stream, Mt. Baker area, Whatcom County	48.6592	-121.5888	–	–	–
ANDtrail	Seeps and standing water on trail to Lake Anderson, Mt. Baker area, Whatcom County	48.6592	-121.5888	–	–	–
ANDU	Upper Anderson Lake, Mt. Baker area, Whatcom County	48.6592	-121.5884	–	–	–
ANDUtrib	Tributary between sections of Upper Anderson Lake, Mt. Baker area, Whatcom County	48.6592	-121.5884	–	–	–
ANN	Lake Ann, Mt. Baker area, Whatcom county	48.8260	-121.6443	–	–	–
ANNpond	Small ponds on trail to Lake Ann, Mt. Baker area, Whatcom County	48.8506	-121.6869	–	–	–
ANNtrail	Seeps on trail to Lake Ann, Mt. Baker area, Whatcom County	48.8506	-121.6869	–	–	–
APR	Small pond near Artist Point Ridge trail, Mt. Baker area, Whatcom County	48.8469	-121.6924	–	–	–
BAGL	Lower Bagley Lake, Mt. Baker area, Whatcom County	48.8598	-121.6849	7.1	14	5.6
BAGU	Upper Bagley Lake, Mt. Baker area, Whatcom County	48.8541	-121.6918	7.1	14	5.7

continued on next page

Table 1.3: Desmid collecting sites, continued

Code	Description	Lat.	Long.	pH	Cond (μS)	Alk (mg/L)
BAK	Baker Lake, Mt. Baker area, Whatcom/Skagit Counties	48.6574	-121.6868	7	34	6.2
BEApond	Beaver Pond Lake, Whatcom County	48.7327	-122.3756	6.3	49	15.5
BUG	Bug Lake, Whatcom County	48.7767	-122.4724	–	–	–
CAI	Cain Lake, Whatcom County	48.6495	-122.3293	7.7	57	16.7
CAY	Canyon Lake, Whatcom County	48.8321	-122.0688	7.1	23	9.6
CAYmisc	Small pond near Canyon Lake, Whatcom County	48.8321	-122.0688	–	–	–
CKNcreek	Side channel on Chuckanut Creek, Whatcom County	48.7019	-122.4808	–	–	–
DFNpond	Pond near Damfino Lake, Mt. Baker area, Whatcom County	48.9550	-121.7941	–	–	–
DIA	Diablo Lake, Ross Lake National Recreation Area, Whatcom County	48.7117	-121.1124	–	–	–
FAIR	Small pond near Fairhaven College, Whatcom County	48.7256	-122.4860	–	–	–
FAIRpark	Small ponds in Fairhaven Park, Whatcom County	48.7139	-122.4974	–	–	–
FAZ	Lake Fazon, Whatcom County	48.8653	-122.3684	7.5	295	48.6
FRAG	Fragrance Lake, Whatcom County	48.6588	-122.4712	–	–	–
FRS	Fraser St culvert, Bellingham, Whatcom County	48.7518	-122.4453	–	–	–
GEN	Lake Geneva, Whatcom County	48.7365	-122.3816	6.7	42	15.8
HIG	Highwood Lake, Mt. Baker area, Whatcom County	48.8646	-121.6752	6.8	20	3.5

continued on next page

Table 1.3: Desmid collecting sites, continued

Code	Description	Lat.	Long.	pH	Cond (μS)	Alk (mg/L)
HMP	Heather Meadows Pond, Mt. Baker area, Whatcom County	48.8540	-121.6842	6.5	5	1.2
HOAG	Hoag Pond, Whatcom County	48.7081	-122.4824	7	164	69
KWAN	Kwan Lake, Whatcom County	48.9423	-122.7802	8.4	1414	181.7
LAU	Small pond near Laurel Washington, Whatcom County	48.8559	-122.4887	–	–	–
LOU	Lake Louise, Whatcom County	48.7089	-122.3278	7.5	65	21.2
LW	Lake Whatcom, Whatcom County	48.7584	-122.4079	–	–	–
MIR	Mirror Lake, Whatcom County	48.6633	-122.2200	7.3	49	17.4
MISC	Small residential pond, Whatcom County	NA	NA	–	–	–
NKR	Side channel on Nooksack River, Whatcom County	48.8846	-122.3373	–	–	–
PAD	Lake Padden, Whatcom County	48.7038	-122.4546	8.1	99	27.5
PIC	Picture Lake, Mt. Baker area, Whatcom County	48.8654	-121.6771	6.8	16	3.6
PINE	Pine Lake, Whatcom County	48.6754	-122.4446	7.1	42	9.8
REE	Reed Lake, Whatcom County	48.6635	-122.3258	7.1	58	18.9
ROS	Ross Lake, Ross Lake National Recreation Area, Whatcom County	48.7370	-121.0447	–	–	–
RRG	Snow melt ponds on Railroad Grade trail, Mt. Baker area, Whatcom County	48.7071	-121.8126	–	–	–
SAM	Lake Samish, Whatcom County	48.6708	-122.4118	7.5	67	18.3

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Table 1.3: Desmid collecting sites, continued

Code	Description	Lat.	Long.	pH	Cond (μS)	Alk (mg/L)
SCswt	Western Washington University storm water treatment pond, Whatcom County	48.7259	-122.4884	–	–	–
SIL	Silver Lake, Whatcom County	48.9792	-122.0703	8	141	53.3
SKYDIV	Small ponds along Skyline Divide trail, Mt. Baker area, Whatcom County	48.8814	-121.8645	–	–	–
SQA	Squalicum Lake, Whatcom County	48.7980	-122.3507	7.1	71	26.7
SQI	Squires Lake, Whatcom County	48.6457	-122.3536	7	44	16.2
SRZ	Sunrise Lake, Mt. Baker area, Whatcom County	48.8626	-121.6803	7.1	33	8.6
SUN	Sunset Lake, Whatcom County	48.7766	-122.4597	8.3	151	60.2
SWTcedarhills	Cedar Hills storm water treatment pond, Whatcom County	48.7398	-122.4153	–	–	–
TBIRD	Thunderbird Lake, Whatcom County,	48.9392	-122.7848	8.3	1136	144.1
TER	Lake Terrell, Whatcom County	48.8637	-122.6874	7.8	91	32.6
TERM	Terminal Lake, Mt. Baker area, Whatcom County	48.853	-121.6885	6.5	6	2.1
TWINL	Lower Twin Lake, Mt. Baker area, Whatcom County	48.9522	-121.6371	7.9	55	24.5
WC	Side channel on Whatcom Creek, Whatcom County	NA	NA	–	–	–
WCCpond	Small pond near Whatcom Community College, Whatcom County	48.7955	-122.4938	–	–	–
WIS	Wiser Lake, Whatcom County	48.9038	-122.4821	8.6	364	67.6

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Table 1.3: Desmid collecting sites, continued

Code	Description	Lat.	Long.	pH	Cond (μS)	Alk (mg/L)
	Snohomish County Sites					
ASHL	Lower Ashland Lake, Mountain Loop Highway, Snohomish County	48.0278	-121.7265	–	–	–
ASHU	Upper Ashland Lake, Mountain Loop Highway, Snohomish County	48.0315	-121.7199	–	–	–
BDM	Boardman Lake, Mountain Loop Highway, Snohomish County	48.0265	-121.6909	NA	NA	2.5
BEAR	Bear Lake, Mountain Loop Highway, Snohomish County	48.1642	-121.4486	6.3	6	1.4
BEPL	Beaver Lake, Mountain Loop Highway, Snohomish County	48.1639	-121.7127	–	–	–
BLACK	Blackman Lake, Snohomish County (new IWS site, 2022)	47.9325	-122.094	NA	NA	27.9
BVF	Bridal Veil Falls outlet on trail to Lake Serene, Snohomish County	47.7819	-121.5703	–	–	–
COAL	Coal Lake, Mountain Loop Highway, Snohomish County	48.1124	-121.5167	7.8	53	25.4
EVAN	Lake Evan, Mountain Loop Highway, Snohomish County	48.0312	-121.6878	6.5	10	2
GOAT	Goat Lake, Mountain Loop Highway, Snohomish County	48.0182	-121.3509	–	–	–
GOLD	Gold Basin Mill Pond, Mountain Loop Highway, Snohomish County	48.0773	-121.7384	6.2	19	7.6
HEAT	Heather Lake, Mountain Loop Highway, Snohomish County	48.0683	-121.7819	–	–	–
ICEpond	Small pond on trail to Big Four Ice Caves, Mountain Loop Highway, Snohomish County	48.0678	-121.5163	–	–	15.7

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Table 1.3: Desmid collecting sites, continued

Code	Description	Lat.	Long.	pH	Cond (μS)	Alk (mg/L)
ISL	Island Lake, Mountain Loop Highway, Snohomish County	48.0174	-121.7016	–	–	–
KET	Lake Ketchum, Snohomish County	48.2824	-122.3454	8.7	163	41.9
KI	Lake Ki, Snohomish County	48.1525	-122.2646	7.7	45	10.1
LWD	Small pond near Lynnwood, Snohomish County	47.8279	-122.3054	–	–	–
MON	Monte Cristo Lake, Mountain Loop Highway, Snohomish County	48.0536	-121.4301	6.9	39	15.2
MYR	Myrtle Lake, Mountain Loop Highway, Snohomish County	48.0537	-121.4262	7	27	11.6
SDY	Sunday Lake, Snohomish County	48.2292	-122.2572	7	83	24.2
STEVENS	Lake Stevens, Snohomish County	48.0062	-122.0868	–	–	32.5
STORM	Storm Lake, Snohomish County	47.9398	-121.9721	–	–	8.3
TWTW	Lake Twenty-two, Mountain Loop Highway, Snohomish County	48.0646	-121.7638	–	–	–
VCP	Small residential pond on Valley Circle Drive, Snohomish County	47.8388	-122.1984	–	–	–
	Skagit County Sites					
BEA	Beaver Lake, Skagit County	48.4460	-122.2210	7.3	102	46
BIG	Big Lake, Skagit County	48.3801	-122.2339	7.6	86	32.8
CAFENewMex	Small residential pond, Skagit County	48.4231	-122.3542	–	–	–
CAM	Lake Campbell, Skagit County	48.4426	-122.6142	8.3	258	83.3
CAV	Lake Cavanaugh, Skagit County	48.3117	-121.9888	7.3	29	9.4

continued on next page

Table 1.3: Desmid collecting sites, continued

Code	Description	Lat.	Long.	pH	Cond (μS)	Alk (mg/L)
CLE	Clear Lake, Skagit County	48.4647	-122.2258	7.3	86	32.2
DOCK	Small pond on trail to Dock Butte, Mt. Baker area, Skagit County	48.6542	-121.7843	–	–	–
DOCKblue	Blue Lake, on trail to Dock Butte, Mt. Baker area, Skagit County	48.6469	-121.7928	–	–	–
ERI	Lake Erie, Skagit County	48.4535	-122.6404	8.1	250	72.6
EVT	Lake Everett, Skagit County	48.5426	-121.7251	7.9	137	65.1
GRA	Grandy Lake, Skagit County	48.5662	-121.8002	7.8	136	66.5
HEA	Heart Lake, Skagit County	48.4761	-122.6306	8.6	218	67
JUD	Judy Reservoir, Skagit County	48.4749	-122.1825	–	–	–
LILY	Lily Lake, Skagit County	48.6256	-122.4048	–	–	–
LIZARD	Lizard Lake, Skagit County	48.6321	-122.4068	–	–	–
SHA	Lake Shannon, Skagit County	48.5565	-121.7282	7.4	47	14.9
SHADE	Small pond on trail to Lily Lake near Oyster Dome, Skagit County	48.6256	-122.4047	–	–	–
SIX	Lake Sixteen, Skagit County	48.3446	-122.2896	7.7	86	31.8
SUM	Summer Lake, Skagit County	48.3334	-122.1682	6.5	33	10.8
VOG	Vogler Lake, Skagit County	48.5708	-121.7735	6.6	14	3.3
	Skamania County Sites					
CHAIN	Chain Lake, Gifford Pinchot National Forest, Skamania County	46.2938	-121.5962	6.5	8	2.5
CHAINsmall	Side channel of Chain Lake, Gifford Pinchot National Forest, Skamania County	46.2938	-121.5962	–	–	3.2

continued on next page

Table 1.3: Desmid collecting sites, continued

Code	Description	Lat.	Long.	pH	Cond (μS)	Alk (mg/L)
HPbog	Small floating bog near Baby Shoe Pass on road to Takhlakh Lake, Gifford Pinchot National Forest, Skamania County	46.2782	-121.5965	6.1	21	8.2
OLA	Lake Olallie, Gifford Pinchot National Forest, Skamania County	46.2891	-121.6164	7.1	17	7
TAKH	Takhlakh Lake, Gifford Pinchot National Forest, Skamania County	46.2782	-121.5965	7.1	10	4.1
	Okanogan County Sites (Eastern Washington)					
CAMwin	Lake Campbell (eastern Washington), Okanogan County	48.4405	-120.0665	–	–	–
CUT	Cutthroat Lake, North Cascades Highway (Hwy 20)	48.5411	-120.6801	–	–	–
TWINbig	Big Twin Lake (eastern Washington), Okanogan County	48.4481	-120.1926	–	–	–
TWINsmall	Little Twin Lake (eastern Washington), Okanogan County	48.4490	-120.1911	–	–	–
	Morris Valley Road Sites (BC, Canada)					
Fbog	Small floating bog along Morris Valley Road near Harrison, BC.	49.3773	-121.8398	–	–	–
HTbog	Small boggy pond along Morris Valley Road near Harrison BC	49.3371	-121.8378	–	–	–
WOOD	Wood Lake, Morris Valley Road near Harrison, BC	49.4580	-121.8560	–	–	–
	Other Sampling Locations					
BEARalw	Bear Lake, Alpine Lakes Wilderness, King County	47.5736	-121.3947	–	–	–

continued on next page

Table 1.3: Desmid collecting sites, continued

Code	Description	Lat.	Long.	pH	Cond (μS)	Alk (mg/L)
KIT	Kitsap Lake, Kitsap County	47.5730	-122.7047	–	–	–
LON	Lone Lake, Island County	48.0211	-122.4623	9.1	169	61.3
MilitaryRd	Small pond along Military Road south of Tacoma, Pierce County	47.1348	-122.2562	–	–	–
ML	Moses Lake (eastern Washington), Grant County	47.1092	-119.2887	–	–	–
RAINcliff	Spray zone from waterfall near Rainy Pass, North Cascades Highway (Hwy 20)	48.5180	-120.7340	–	–	–

1.4.2 Species List of Desmids in Volume III. Part A

Bambusina

Bambusina borreri (Ralfs) Cleve

Closterium ..... Key to Closterium species

Closterium abruptum West
Closterium acerosum Ehrenberg ex Ralfs
Closterium acerosum var. *elongatum* Brébisson
Closterium aciculare T. West
Closterium acutum Brébisson
Closterium acutum var. *variable* (Lemmermann) Willi Krieger
Closterium angustatum Kützing ex Ralfs
Closterium archerianum Cleve ex P. Lundell
Closterium baillyanum (Brébisson ex Ralfs) Brébisson
Closterium baillyanum var. *alpinum* (Viret) Gröblad
Closterium braunii Reinsch
Closterium closterioides (Ralfs) A. Louis & Peeters
Closterium closterioides var. *intermedium* (J. Roy & Bisset) Růžička
Closterium cf. *cornu* Ehrenberg ex Ralfs
Closterium costatum Corda ex Ralfs
Closterium cynthia De Notaris
Closterium dianae Ehrenberg ex Ralfs
Closterium dianae cf. var. *minus* Hieronymus
Closterium didymotocum Corda ex Ralfs
Closterium directum W. Archer
Closterium ehrenbergii Meneghini ex Ralfs
Closterium gracile Brébisson ex Ralfs
Closterium gracile f. *elongatum* (West & G. S. West) Kossinskaja
Closterium cf. *idiosporum* West & G. S. West
Closterium incurvum Brébisson
Closterium incurvum var. *latius* (Irénée-Marie) Irénée-Marie
Closterium cf. *jenneri* var. *robustum* G. S. West
Closterium juncidum Ralfs
Closterium kuetzingii Brébisson

Closterium leibleinii Kützing ex Ralfs
Closterium limneticum Lemmermann
Closterium limneticum var. *fallax* Růžička
Closterium lineatum Ehrenberg ex Ralfs
Closterium littorale F. Gay
Closterium lunula Ehrenberg & Hemprich ex Ralfs
Closterium moniliferum Ehrenberg ex Ralfs
Closterium navicula (Brébisson) Lütkemüller
Closterium nematodes Joshua
Closterium parvulum Nägeli
Closterium praelongum Brébisson
Closterium pritchardianum W. Archer
Closterium pronum Brébisson
Closterium pseudolunula Borge
Closterium pusillum Hantzsch
Closterium ralfsii var. *hybridum* Rabenhorst
Closterium cf. *rectimarginatum* A. M. Scott & Prescott
Closterium rostratum Ehrenberg ex Ralfs
Closterium setaceum Ehrenberg ex Ralfs
Closterium striolatum Ehrenberg ex Ralfs
Closterium venus Kützing ex Ralfs

Cosmocladium ..... Key to Cosmocladium species
Cosmocladium constrictum (W. Archer) W. Archer ex Joshua
Cosmocladium saxonicum De Bary

Cylindrocystis ..... Key to Cylindrocystis species
Cylindrocystis brebissonii (Ralfs) De Bary
Cylindrocystis brebissonii var. *turgida* Schmidle
Cylindrocystis crassa De Bary
Cylindrocystis cushleckae A. J. Brook

Desmidium ..... Key to Desmidium species
Desmidium aptogonum Brébisson ex Kützing
Desmidium baileyi (Ralfs) Nordstedt
Desmidium coarctatum Nordstedt
Desmidium grevilli (Kützing ex Ralfs) De Bary
Desmidium swartzii C. Agardh ex Ralfs

Euastrum . . . . . Key to Euastrum species

Euastrum ansatum Ehrenberg ex Ralfs
Euastrum ansatum f. *angustum* Prescott
Euastrum bidentatum Nägeli
Euastrum bidentatum var. *oculatum* (Istvanfy) Willi Krieger
Euastrum binale var. *gutwinskii* (Schmidle) Homfeld
Euastrum binale var. *papilliferum* Gutwinskii
Euastrum coeselii Kouwets
Euastrum crassum Ralfs
Euastrum denticulatum F. Gay
Euastrum didelta Ralfs
Euastrum dubium var. *ornatum* Woloszynska
Euastrum elegans Ralfs
Euastrum fissum West & G. S. West
Euastrum gayanum De Toni
Euastrum gemmatum var. *taftii* Prescott
Euastrum humerosum Ralfs
Euastrum humerosum var. *affine* (Ralfs) Raciborski
Euastrum insulare (Wittrock) J. Roy
Euastrum cf. *lacustre* (Messikommer) Coesel
Euastrum latipes var. *evolutum* (Grönblad) C. E. Taft
Euastrum luetkemuelleri var. *carniolicum* (Lütkemüller) Willi Krieger
Euastrum montanum West & G. S. West
Euastrum neosinuosum O. V. Anissimona & Guiry
Euastrum obesum Joshua
Euastrum oculatum Børgensen
Euastrum oblongum Greville ex Ralfs
Euastrum pectinatum Brébisson ex Ralfs
Euastrum pinnatum Ralfs
Euastrum pulchellum Brébisson
Euastrum subalpinum var. *crassum* Messikommer
Euastrum sublobatum Brébisson ex Ralfs
Euastrum turneri West
Euastrum verrucosum Ehrenberg ex Ralfs

Genicularia

Genicularia cf. *elegans* (West & G. S. West) Molinari & Guiry

Gonatozygon . . . . . Key to Gonatozygon species
Gonatozygon aculeatum W. N. Hastings
Gonatozygon brebissonii De Bary
Gonatozygon brebissonii var. *minutum* (West) West & G. S. West
Gonatozygon kinahanii (W. Archer) Rabenhorst
Gonatozygon monotaenium De Bary

Groenbladia
Groenbladia neglecta (Raciborski) Teiling

Haplotaenium
Haplotaenium rectum (Delponte) Bando

Hyalotheca . . . . . Key to Hyalotheca species
Hyalotheca dissiliens Brébisson ex Ralfs
Hyalotheca dissiliens cf. var. *tatrica* Raciborski
Hyalotheca mucosa Ralfs

Mesotaenium *Mesotaenium macrococcum* (Kützing ex Kützing) J. Roy & Bisset
Mesotaenium macrococcum cf. var. *minus* (De Bary) Compère

Micrasterias . . . . . Key to Micrasterias species
Micrasterias americana Ehrenberg ex Ralfs
Micrasterias americana var. *lewisiana* West
Micrasterias apiculata Meneghini ex Ralfs
Micrasterias brachyptera Lundell
Micrasterias compereana Neustupa, Šťastný & Škaloud
Micrasterias conferta Lundell
Micrasterias denticulata Brébisson ex Ralfs
Micrasterias depauperata var. *wollei* J. A. Cushman
Micrasterias furcata C. Agardh ex Ralfs
Micrasterias laticeps Nordstedt
Micrasterias mahabuleshwarensis J. Hobson
Micrasterias muricata Bailey ex Ralfs
Micrasterias nordstedtiana Wolle
Micrasterias papillifera Brébisson ex Ralfs
Micrasterias pinnatifida Ralfs
Micrasterias radiosa var. *elegantior* (G. S. West) Croasdale
Micrasterias rotata Ralfs
Micrasterias thomasiana W. Archer

Micrasterias thomasiana var. *notata* (Nordstedt) Grönblad
Micrasterias truncata Brébisson ex Ralfs
Micrasterias truncata var. *semiradiata* Wolle
Micrasterias verrucosa Bisset

Netrium *Netrium digitus* (Brébisson ex Ralfs) Itzigsohn & Rothe

Onychonema
Onychonema filiforme (Ralfs) J. Roy & Bisset

Penium . . . . . Key to Penium species
Penium cylindrus Brébisson ex Ralfs
Penium exiguum West
Penium margaritaceum Brébisson
Penium margaritaceum var. *papilliferum* Whelden
Penium polymorphum (Perty) Perty
Penium spinulosum (Wolle) Gerrath
Penium spirostriolatum J. Barker

Planotaenium . . . . . Key to Planotaenium species
Planotaenium interruptum (Brébisson ex Ralfs) Petlovany & Palamar-Mordvintseva
Planotaenium ohtanii Gontcharov & Melkonian

Pleurotaenium . . . . . Key to Pleurotaenium species
Pleurotaenium archeri Delponte
Pleurotaenium coronatum (Brébisson) Rabenhorst
Pleurotaenium ehrenbergii (Ralfs) De Bary
Pleurotaenium nodosum (Bailey ex Ralfs) Lundell
Pleurotaenium nodulosum (Brébisson ex Ralfs) Rabenhorst
Pleurotaenium trabecula Nägeli

Roya . . . . . Key to Roya species
Roya anglica G. S. West
Roya cambrica West & G. S. West

Sphaerozosma . . . . . Key to Sphaerozosma species
Sphaerozosma vertebratum Brébisson ex Ralfs
Sphaerozosma vertebratum var. *latius* West & G. S. West

Spirotaenia . . . . . Key to Spirotaenia species
Spirotaenia condensata Brébisson
Spirotaenia cf. *diplohelica* Coesel
Spirotaenia erythrocephala Itzigsohn

Spondylosium . . . . . Key to Spondylosium species
Spondylosium cf. *javanicum* (Gutwinski) Gröblad
Spondylosium moniliforme Lundell
Spondylosium planum (Wolle) West & G. S. West
Spondylosium pulchrum (Bailey) W. Archer

Staurastrum . . . . . Key to Staurastrum species
Staurastrum acarides Nordstedt
Staurastrum alternans Brébisson
Staurastrum anatinum Cooke & Wills
Staurastrum anatinum var. *longibrachiatum* West & G. S. West
Staurastrum arctiscon (Ehrenberg ex Ralfs) P. Lundell
Staurastrum arctiscon f. *glabrum* West & G. S. West
Staurastrum arctiscon var. *truncatum* Irénée-Marie
Staurastrum arcuatum Nordstedt
Staurastrum asteroideum West & G. S. West
Staurastrum aversum P. Lundell
Staurastrum avicula Brébisson
Staurastrum avicula var. *lunatum* (Ralfs) Coesel & Meesters
Staurastrum avicula cf. var. *subarcuatum* (Wolle) West & G. S. West
Staurastrum bicorne Hauptfleisch
Staurastrum bieneanum Rabenhorst
Staurastrum boreale West & G. S. West
Staurastrum borgeanum Schmidle
Staurastrum brachiatum Ralfs ex Ralfs
Staurastrum brasiliense Nordstedt
Staurastrum brebissonii W. Archer
Staurastrum brevispina Brébisson
Staurastrum chaetoceras (Schröder) G. M. Smith
Staurastrum cingulum (West & G. S. West) G. M. Smith
Staurastrum cingulum cf. var. *obesum* G. M. Smith
Staurastrum clevei (Wittrock) J. Roy
Staurastrum crassangulatum Coesel
Staurastrum crenulatum (Nägeli) Delponte

Staurastrum cyrtocerum var. *inflexum* (Brébisson) Coesel & Meesters
Staurastrum dilatatum Ehrenberg ex Ralfs
Staurastrum cf. *dybowskii* Wołoszyńska
Staurastrum forficulatum P. Lundell
Staurastrum furcigerum (Brébisson) W. Archer
Staurastrum gemelliparum Nordstedt
Staurastrum geminatum Nordstedt
Staurastrum gracile Ralfs ex Ralfs
Staurastrum grande Bulnheim
Staurastrum grande var. *rotundatum* West & G. S. West
Staurastrum haaboeliense Wille
Staurastrum hexacerum Wittrock
Staurastrum hirsutum var. *pseudarnellii* Coesel & Meesters
Staurastrum hystrix Ralfs
Staurastrum inconspicuum Nordstedt
Staurastrum insigne P. Lundell
Staurastrum johnsonii West & G. S. West
Staurastrum kurilense Okada
Staurastrum laeve Ralfs
Staurastrum lanceolatum var. *compressum* West & G. S. West
Staurastrum lapponicum (Schmidle) Grönblae
Staurastrum lenzenwegeri Coesel & Meesters
Staurastrum longipes (Nordstedt) Teiling
Staurastrum longispinum (Baily) W. Archer
Staurastrum manfeldtii Delponte
Staurastrum margaritaceum Meneghini ex Ralfs
Staurastrum margaritaceum var. *alpinum* Schmidle
Staurastrum meriani Reinsch
Staurastrum micron West & G. S. West
Staurastrum minnesotense Wolle
Staurastrum monticulosum Brébisson
Staurastrum muticum Brébisson ex Ralfs
Staurastrum natator West
Staurastrum novae-terrae W. R. Taylor
Staurastrum ophiura P. Lundell
Staurastrum orbiculare Meneghini ex Ralfs
Staurastrum orbiculare var. *protractum* Playfair
Staurastrum cf. *pachyrhynchum* Nordstedt

Staurastrum paradoxum Meyen ex Ralfs
Staurastrum pingue Teiling
Staurastrum pingue var. *planctonicum* (Teiling) Coesel & Meesters
Staurastrum polytrichum (Perty) Rabenhorst
Staurastrum pseudotetracerum (Nordstedt) West & G. S. West
Staurastrum punctulatum Brébisson
Staurastrum ralfsii (West & G. S. West) Coesel & Meesters
Staurastrum ralfsii var. *depressum* (J. Roy & Bisset) Coesel & Meesters
Staurastrum reductum (Messikommer) Coesel
Staurastrum setigerum Cleve
Staurastrum setigerum cf. var. *occidentale* West & G. S. West
Staurastrum simonyi Heimerl
Staurastrum smithii Teiling
Staurastrum spongiosum Brébisson ex Ralfs
Staurastrum striatum (West & G. S. West) Růžička
Staurastrum striolatum (Nägeli) W. Archer
Staurastrum subcomptum Van Western & Coesel
Staurastrum subcruciatum Cooke & Wills
Staurastrum subnudibrachiatum var. *incisum* G. M. Smith
Staurastrum teliferum var. *gladiosum* [W. B. Turner] Coesel & Meesters
Staurastrum tetracerum Ralfs ex Ralfs
Staurastrum tetracerum var. *trigonum* P. Lundell
Staurastrum tohopekaligense Wolle
Staurastrum trapezioides Coesel & Meester
Staurastrum trifidum var. *inflexum* West & G. S. West
Staurastrum vestitum Ralfs

Staurodesmus . . . . . Key to Staurodesmus species
Staurodesmus bulnheimii (Raciborski) Round & A. J. Brook
Staurodesmus connatus (P. Lundell) Thomasson
Staurodesmus convergens (Ehrenberg ex Ralfs) S. Lillieroth
Staurodesmus cf. *cuspidatus* (Brébisson) Teiling
Staurodesmus cuspidicurvatus Coesel & Meesters
Staurodesmus dejectus (Brébisson) Teiling
Staurodesmus dejectus var. *apiculatus* (Brébisson) Croasdale
Staurodesmus dickiei Hinode
Staurodesmus dickiei var. *circularis* (W. B. Turner) Croasdale
Staurodesmus extensus (O. F. Andersson) Teiling

Staurodesmus extensus var. *isthmosus* (Heimerl) Coesel
Staurodesmus extensus var. *Josh's* (Gutwinski) Teiling
Staurodesmus extensus cf. var. *rectus* (B. Eichler & Raciborski) Coesel & Meesters
Staurodesmus glaber (Ralfs) Teiling
Staurodesmus glaber var. *hirundinella* (Messikommer) Teiling
Staurodesmus incus (Hassal ex Ralfs) Teiling
Staurodesmus megacanthus (P. Lundell) Thunmark
Staurodesmus octocornis Ehrenberg ex Ralfs] Šťastný, Škaloud & Neustupa
Staurodesmus omearae (W. Archer) Teiling
Staurodesmus patens (Nordstedt) Croasdale
Staurodesmus phimus (W. B. Turner) Thomasson
Staurodesmus semilunaris (Schmidle) Coesel & Meesters
Staurodesmus subquadratus (West & G. S. West) Coesel & Meesters
Staurodesmus triangularis (Lagerheim) Teiling
Staurodesmus triangularis var. *brevispina* (V. Allorge & P. Allorge) Coesel & Meesters

Teilingia ..... Key to Teilingia species
Teilingia excavata (Ralfs ex Ralfs) Bourrelly
Teilingia granulata (J. Roy & Bisset) Bourrelly

Tetmemorus ..... Key to Tetmemorus species
Tetmemorus brebissonii Ralfs
Tetmemorus brebissonii var. *minor* De Bary
Tetmemorus granulatus Brébisson ex Ralfs
Tetmemorus laevis Ralfs ex Ralfs

Tortitaenia ..... Key to Tortitaenia species
Tortitaenia alpina (Schmidle) A. J. Brook
Tortitaenia obscura (Ralfs) A. J. Brook

Triploceras
Triploceras gracile Bailey

Xanthidium ..... Key to Xanthidium species
Xanthidium antilopaeum Kützing
Xanthidium antilopaeum var. *depauperatum* West & G. S. West
Xanthidium antilopaeum f. *javanicum* (Nordstedt) Coesel
Xanthidium antilopaeum var. *minneapoliense* Wolle

Xanthidium antilopaeum var.*planum* Roll
Xanthidium antilopaeum f. *polymazum* (Nordstedt) Petlovany)
Xanthidium antilopaeum cf. var. *subeurycerum* Scott & Gröblad
Xanthidium armatum var. *fissum* Nordstedt
Xanthidium bifidum (Brébisson) Deflandre
Xanthidium scrobiculatum (Scott & Grönblad) Šťastný, Škaloud & Neustupa
Xanthidium subhastiferum West
Xanthidium tumidum (Ralfs) Šťastný, Škaloud & Neustupa

Chapter 2

Bambusina Kützing ex Kützing

Northwest Washington taxa
Bambusina borreri (Ralfs) Cleve

Table 2.1: *Bambusina* Cell Measurements

		Cell Width	Cell Length	Isthmus Width	L/W Ratio
Bambusina borreri	min	16.7 μm	20.2 μm	15.1 μm	0.9
	med	21.1 μm	28.6 μm	18.5 μm	1.4
	max	26.5 μm	35.4 μm	24.2 μm	1.7

Description
Bambusina borreri filaments are long, relatively straight, and usually surrounded by a faint mucilage layer (Figures 2.1–2.5). The individual cells are barrel-shaped, with an expanded central region and a very shallow, v-shaped sinus. Each semi-cell contains a single chloroplast that is star-shaped (stellate) in end view and contains a single pyrenoid. The cell wall usually looks smooth, but has very fine longitudinal striations on opposite ends of the cell and is dotted with horizontal rows of mucilage pores. The rows of extruded mucilage can give the cell a granular appearance. These features are visible using SEM or through careful examination of empty cells

(Figures 2.3–2.4). This species is morphologically variable, especially in terms of the cell length and the degree to which the central region is expanded on either side of the sinus. Older taxonomic publications may list this species as *Bambusina brebissonii* Kützing (e.g., Croasdale, et al., 1983), but that name is now considered to be a synonym for *Bambusina borreri*.

Bambusina borreri is common in many types of nutrient poor, acidic habitats and was one of the most common desmids collected in peat bogs in mountain regions of the Czech Republic (Štěpánková, et al., 2008). In northwest Washington it is common in peaty ponds, lakes, and boggy areas, especially in association with shoreline vegetation.



Figure 2.1: *Bambusina borreri* (DIC), Summer Lake, Skagit County.



Figure 2.2: *Bambusina borreri* (DIC), Myrtle Lake, Mountain Loop Highway, Snohomish County.

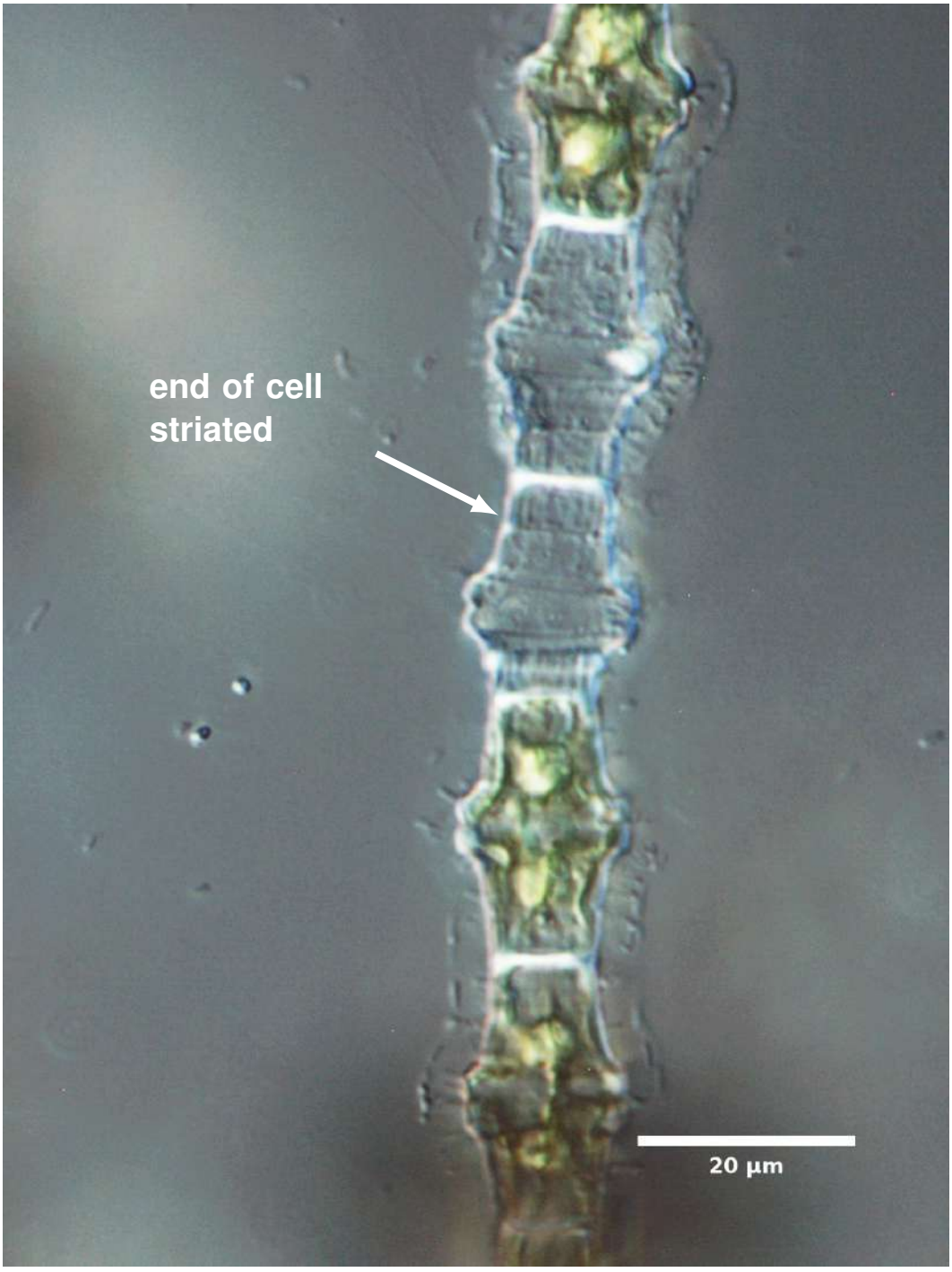


Figure 2.3: *Bambusina borreri* (DIC), Bear Lake, Mountain Loop Highway, Snohomish County.

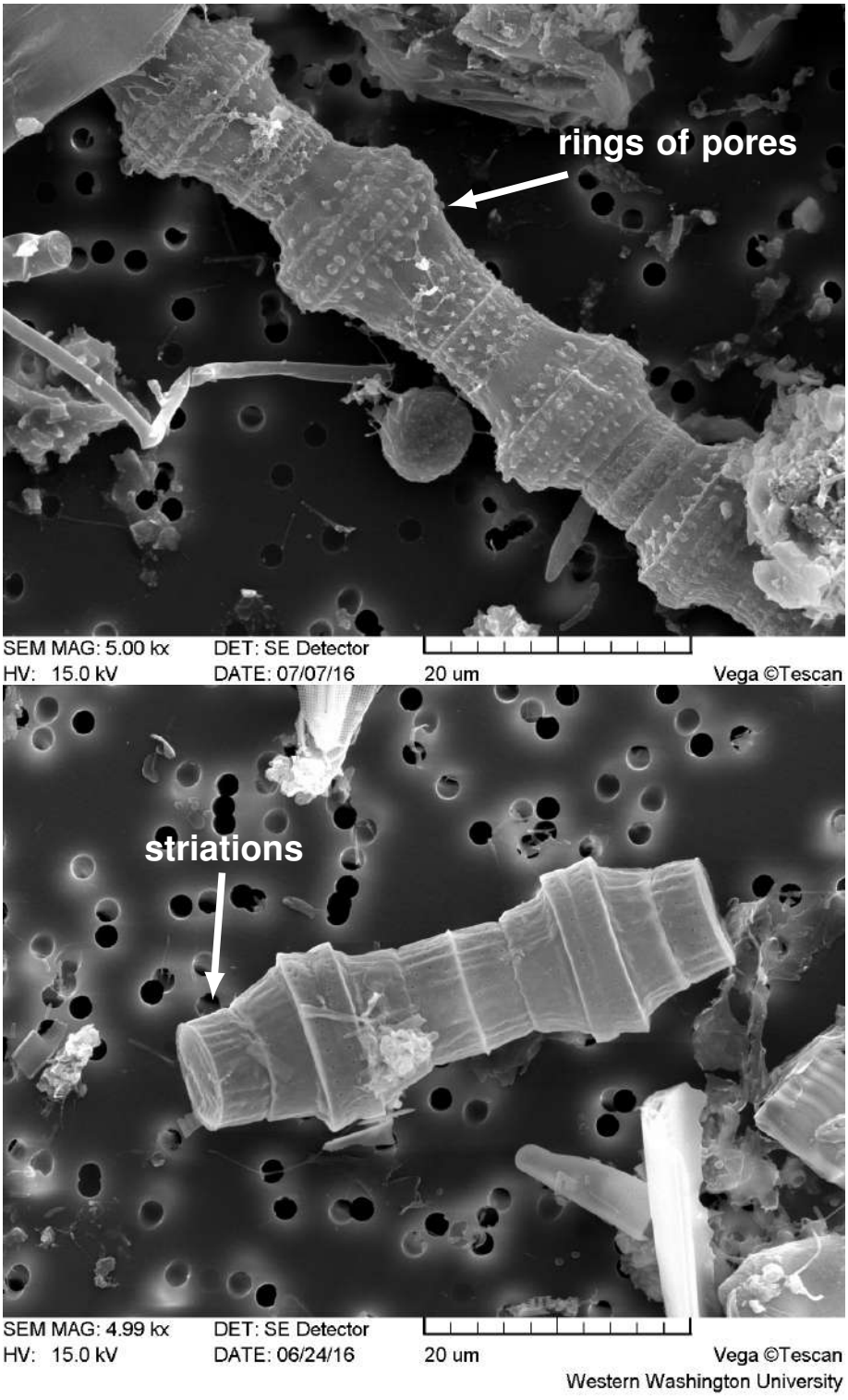


Figure 2.4: *Bambusina borreri* (SEM/SEM), Lake Evan, Mountain Loop Highway, Snohomish County (upper image); Boardman Lake, Mountain Loop Highway, Snohomish County (lower image).



Figure 2.5: Atypical *Bambusina borreri* cells with unusually shallow sinus (DIC), Summer Lake, Skagit County.

Chapter 3

Closterium Nitzsch ex Ralfs

Northwest Washington taxa
Closterium abruptum West
Closterium acerosum Ehrenberg ex Ralfs
Closterium acerosum var. *elongatum* Brébisson
Closterium aciculare T. West
Closterium acutum Brébisson
Closterium acutum var. *variable* (Lemmermann) Willi Krieger
Closterium angustatum Kützing ex Ralfs
Closterium archerianum Cleve ex P. Lundell
Closterium baillyanum (Brébisson ex Ralfs) Brébisson
Closterium baillyanum var. *alpinum* (Viret) Gröblad
Closterium braunii Reinsch
Closterium closterioides (Ralfs) A. Louis & Peeters
Closterium closterioides var. *intermedium* (J. Roy & Bisset) Růžička
Closterium cf. *cornu* Ehrenberg ex Ralfs
Closterium costatum Corda ex Ralfs
Closterium cynthia De Notaris
Closterium dianae Ehrenberg ex Ralfs
Closterium dianae cf. var. *minus* Hieronymus
Closterium didymotocum Corda ex Ralfs
Closterium directum W. Archer
Closterium ehrenbergii Meneghini ex Ralfs
Closterium gracile Brébisson ex Ralfs
Closterium gracile f. *elongatum* (West & G. S. West) Kossinskaja

Closterium cf. *idiosporum* West & G. S. West
Closterium incurvum Brébisson
Closterium incurvum var. *latius* (Irénée-Marie) Irénée-Marie
Closterium cf. *jenneri* var. *robustum* G. S. West
Closterium juncidum Ralfs
Closterium kuetzingii Brébisson
Closterium leibleinii Kützing ex Ralfs
Closterium limneticum Lemmermann
Closterium limneticum var. *fallax* Růžička
Closterium lineatum Ehrenberg ex Ralfs
Closterium littorale F. Gay
Closterium lunula Ehrenberg & Hemprich ex Ralfs
Closterium moniliferum Ehrenberg ex Ralfs
Closterium navicula (Brébisson) Lütkemüller
Closterium nematodes Joshua
Closterium parvulum Nägeli
Closterium praelongum Brébisson
Closterium pritchardianum W. Archer
Closterium pronum Brébisson
Closterium pseudolunula Borge
Closterium pusillum Hantzsch
Closterium ralfsii var. *hybridum* Rabenhorst
Closterium cf. *rectimarginatum* A. M. Scott & Prescott
Closterium rostratum Ehrenberg ex Ralfs
Closterium setaceum Ehrenberg ex Ralfs
Closterium striolatum Ehrenberg ex Ralfs
Closterium venus Kützing ex Ralfs

Table 3.1: Key to *Closterium* Species.

I. Cell bow-shaped with fusiform (lens-shaped) center and long, beak-like apical extensions; apical pores present; cell wall finely striated (Figure 3.1)	Go to I (below)
II. Cell fusiform (lens-shaped) but without beak-like apical extensions; apical pores present or absent (Figure 3.1)	Go to II (page 58)
III. Cell crescent-shaped with tapered apex; curved along both lateral margins (may be asymmetric); apical pores present or absent; girdle bands mostly absent (Figure 3.1)	Go to III (page 60)
IV. Cell cylindrical with sides parallel at least in central portion of cell; apical pores present or absent (Figure 3.1)	Go to IV (page 64)
I. Cell bow-shaped with fusiform (lens-shaped) center and long, beak-like apical extensions; apical pores present; cell wall finely striated	
A Center of cell evenly inflated (symmetric); extensions long and delicate	
A.1 Cell center narrow (W$<$15 μm); chloroplast shorter than extensions	*Closterium setaceum* (Figures 3.174–3.177)
A.2 Cell center slightly wider (W$>$15 μm); chloroplast same length as extensions	*Closterium kuetzingii* (Figures 3.97–3.101)
B Center of cell asymmetric with curved dorsal margin; extensions relatively short and robust	*Closterium rostratum* (Figures 3.169–3.173)

continued on next page

Table 3.1: Key to *Closterium* Species, continued

II. Cell fusiform (lens-shaped) but without beak-like apical extensions; apical pores present or absent	
A Cell straight with no perceptible curvature; cell wall smooth; apical pores absent	
A.1 Cell narrowly fusiform (L/W>10)	*Closterium* cf. *cornu* (Figures 3.48–3.50)
A.2 Cell broadly fusiform (L/W<10)	
A.2a Cell small (L<75 μm); chloroplast intact along lateral margin	*Closterium navicula* (Figures 3.128–3.131)
A.2b Cell larger (L>100 μm); chloroplast notched along lateral margin	*Closterium closterioides* (Figures 3.42–3.47)
B Cell very slightly curved (10–40°); cell wall smooth; apical pores present or absent[8]	
B.1 Apical pores present; cell narrowly fusiform or slightly crescent-shaped; chloroplast ends well below apex	*Closterium* cf. *idiosporum* (Figures 3.82–3.84)
B.2 Apical pores absent	
B.2a Cell large (L>200 μm); angular and broadly fusiform (L/W<10); chloroplast extends nearly to apex	*Closterium* cf. *rectimarginatum* (Figures 3.165–3.168)
B.2b Cell large (L>200 μm); narrowly fusiform, cylindrical at center (L/W>20); chloroplast ends well below apex	*Closterium pronum* (Figures 3.150–3.152)

continued on next page

[8]Some taxa in this key are separated based on cell curvature (see Figure 3.6). This feature is quite variable so measure more than one cell and try alternate key options if you are having difficulty.

Table 3.1: Key to *Closterium* Species, continued

	B.2c Cell smaller (L<200 μm); narrowly fusiform, tapered (L/W>20); chloroplast ends well below apex	*Closterium acutum* (Figures 3.19–3.21)
C	Cell slightly to moderately curved (30–90°); cell wall smooth or finely striated; apical pores present or absent	
	C.1 Apical pore present; cell large, narrowly fusiform or crescent-shaped (L>400 μm), dorsal margin evenly curved; ventral margin inflated at center; cell wall finely striated	*Closterium ralfsii* var. *hybridum* (Figures 3.160–3.164)
	C.2 Apical pore absent	
	C.2a Cell large, broadly fusiform or crescent-shaped (L>300 μm); dorsal margin evenly curved; ventral margin straight or slightly inflated; cell wall very finely striated (appears smooth)	*Closterium lunula* (Figures 3.119–3.123)
	C2.b Cell small (L<50 μm); broadly cylindrical or fusiform (L/W <10); curvature often irregular	*Closterium pusillum* (Figures 3.156–3.159)

continued on next page

Table 3.1: Key to *Closterium* Species, continued

III. Cell crescent-shaped with tapered apex; curved along both lateral margins (may be asymmetric); apical pores present or absent; girdle bands mostly absent	
A Apical pores absent	
A.1 Cell wall coarsely striated; striations visible under low magnification	
A.1a Cell nearly straight at center then slightly to moderately curved to apex (30–90°); girdle bands present; vacuole with many small crystals	*Closterium costatum* (Figures 3.51–3.55)
A.1b Cell moderately to strongly curved (>100°), with similar curvature on both margins; girdle bands absent; vacuole with single large crystal	*Closterium archerianum* (Figures 3.30–3.31)
A.2 Cell wall finely striated; striations visible on empty cell at high magnification; vacuole with single large crystal	
A.2a Cell moderately to strongly curved on both margins (>100°); apex with thickened subapical ring	*Closterium nematodes* (Figures 3.132–3.135)
A.2b Cell moderately to strongly curved on dorsal margin (>100°); ventral margin curved or straight near center; apex without thickened ring	*Closterium cynthia* (Figures 3.56–3.59)
A.3 Cell wall finely striated; striations visible on empty cell at high magnification; vacuole with many crystals	

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Table 3.1: Key to *Closterium* Species, continued

	A.3a Cell large and robust (usually L>300 μm, L/W<10); dorsal margin slightly curved (30–90°); ventral margin nearly straight; apex narrowly truncated, appearing reflexed; pyrenoids axial	*Closterium pseudolunula* (Figures 3.153–3.155) compare to *Closterium acerosum* (Figures 3.10–3.15)
	A.3b Cell large (usually L>300 μm); dorsal margin slightly curved (30–90°); ventral margin nearly straight or inflated; apex broadly truncated, not appearing reflexed; pyrenoids scattered	*Closterium lunula* (Figures 3.119–3.123)
	A.3c Cell slightly smaller (usually L<300 μm); broadly crescent-shaped (L/W<10); dorsal margin moderately or strongly curved (usually >100°); ventral margin inflated; pyrenoids axial	*Closterium moniliferum* (Figures 3.124–3.127)
A.4	Cell walls smooth	
	A.4a Cell large, robust; (L>400 μm; L/W<10); dorsal margin moderately to strongly curved (>100°); ventral margin inflated; chloroplast extends nearly to apex; vacuole with many tiny crystals	*Closterium ehrenbergii* (Figures 3.74–3.77)
	A.4b Cell very narrowly crescent-shaped or sigmoid (L>150 μm; L/W>25); strongly curved or sigmoid (>130°); chloroplast ends well short of apex; vacuole with several crystals	*Closterium acutum* var. *variable* (Figures 3.22–3.25)

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Table 3.1: Key to *Closterium* Species, continued

	A.4c Cell medium sized (L=100–300 μm); dorsal margin slightly to moderately curved (30–90°) ventral margin nearly straight or inflated; chloroplast ends well below apex; vacuole with single crystal	*Closterium littorale* (Figures 3.116–3.118)
	A.4d Cell medium sized (L=100–300 μm); dorsal margin moderately to strongly curved (>100°); ventral margin curved or straight near center; chloroplast extends nearly to apex; vacuole with single crystal	*Closterium cynthia* (Figures 3.56–3.59)
	A.4e Cell small, robust (L<75 μm; L/W<10); strongly curved on both margins (>130°); chloroplast extends nearly to apex; vacuole with single crystal	*Closterium* cf. *jenneri* var. *robustum* (Figures 3.91–3.92)
B	Apical pores present	
	B.1 Cell wall finely striated; cell large (L>400 μm), dorsal margin slightly to moderately curved (30–90°); ventral margin inflated at center; chloroplast extends nearly to apex	*Closterium ralfsii* var. *hybridum* (Figures 3.160–3.164)
	B.2 Cell wall smooth; cell moderately large (L=150–250 μm); slightly to moderately curved (30–90°) but with straight center; chloroplast ends well below apex	*Closterium dianae* (Figures 3.60–3.66
	B.3 Cell wall smooth; cell small to moderately large (L=50–250 μm); strongly curved (>120°); difficult group with overlapping morphological features	

continued on next page

Table 3.1: Key to *Closterium* Species, continued

B.3a Cell small (L<100 μm); very strongly curved or hemispherical (>150°); chloroplast extended nearly to apex; vacuole with one large crystal	*Closterium incurvum* (Figures 3.85–3.90)
B.3b Cell slightly larger (L=100-130 μm); moderately to strongly curved, but not hemispherical (100–170°); chloroplast ends well below apex; vacuole with several scattered crystals	*Closterium venus* (Figures 3.182–3.184)
B.3c Cell relatively large (L=110–200 μm); strongly curved with inflated ventral margin (140–170°); chloroplast ends well below apex; apex bluntly rounded; vacuole poorly defined, with many scattered crystals	*Closterium leibleinii* (Figures 3.102–3.104)
B.3d Cell relatively large (L=150–225 μm); strongly and evenly curved (140–170°), without inflated ventral margin; chloroplast ends well below apex; apex somewhat acute, with thickened wall; vacuole poorly defined, with several scattered crystals	*Closterium parvulum* (Figures 3.136–3.143)

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Table 3.1: Key to *Closterium* Species, continued

IV. Cell cylindrical with sides parallel at least in central portion of cell; apical pores present or absent	
A Cell wall coarsely striated; striations visible under low magnification	
A.1 Girdle bands and apical pores present	
A.1a Cell narrowly cylindrical in center; gently tapered near apex; apex broadly truncated and inflated (capitate)	*Closterium angustatum* (Figures 3.26–3.29)
A.1b Cell crescent-shaped or cylindrical in center, then tapered to apex; apex narrowly truncated	*Closterium striolatum* (Figures 3.178–3.181)
A.2 Girdle bands and apical pores absent	
A.2a Cell broadly cylindrical or crescent-shaped; striations formed by double rows of punctae	*Closterium braunii* (Figures 3.38–3.41)
A.2b Cell broadly cylindrical or crescent-shaped; striations formed by single vertical rows of punctae	*Closterium pritchardianum* (Figures 3.148–3.149)
B Cell wall finely striated; striations visible on empty cell at high magnification	
B.1 Girdle bands and apical pores absent; cells large (L>300 μm); dorsal margin slightly curved (30–90°); ventral margin nearly straight; apex narrow, truncated, appearing reflexed;	*Closterium acerosum* (Figures 3.10–3.15)

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Table 3.1: Key to *Closterium* Species, continued

B.2 Girdle bands and apical pores present	
B.2a Cell narrowly cylindrical with straight, parallel sides for most of length (L/W >20); apex tapered and slightly curved; cell wall faintly striated	*Closterium juncidum* (Figures 3.93–3.96)
B.2b Cell broadly cylindrical or crescent-shaped (L/W<15); and only slightly tapered at apex; network of fine punctae visible between striations	*Closterium didymotocum* (Figures 3.67–3.70)
B.3 Girdle bands present; apical pores absent	
B.3a Cell long and narrowly cylindrical or crescent-shaped (L>250 μm; L/W>15); apex truncated and recurved	*Closterium praelongum* (Figures 3.144–3.147)
B.3b Cell long and narrowly cylindrical or crescent-shaped (L>250 μm; L/W<15); apex truncated but not recurved	*Closterium lineatum* (Figures 3.112–3.115)
B.4 Girdle bands absent; apical pores present	
B.4a Cell narrowly cylindrical in center, then tapered to apex; cell relatively small (L<200 μm)	*Closterium abruptum* (Figures 3.7–3.9)
B.4b Cell narrowly cylindrical to apex; apex slightly inflated; cell larger (L>200 μm)	*Closterium directum* (Figures 3.71–3.73)

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Table 3.1: Key to *Closterium* Species, continued

C	Cell walls smooth	
	C.1 Apical pores present; girdle bands absent; cells long and narrowly cylindrical; untapered and straight until near apex	
	C.1a Chloroplast covers only about half of cell length; cells very long and narrow (L>400 μm; L/W>70)	*Closterium aciculare* (Figures 3.16–3.18)
	C.1b Chloroplast extends nearly to apex; cell length and L/W ratio varies (L=100–400 μm; L/W=25–110)	*Closterium gracile* (Figures 3.78–3.81)
	C.2 Apical pores present; girdle bands absent; cells broadly cylindrical or crescent-shaped (L/W<20)	*Closterium baillyanum* Figures 3.32–3.37
	C.3 Cell lacking both apical pores and girdle bands	
	C.3a Cell long and narrowly cylindrical (LW>20 μm; L>150 μm); chloroplast extends nearly to apex; vacuole with single crystal	*Closterium limneticum* (Figures 3.105–3.111)
	C.3b Cell long and narrowly cylindrical (LW>20 μm; L>100 μm); chloroplast ends well below apex; vacuole with several crystals	*Closterium acutum* (Figures 3.19–3.21)
	C.3c Cell short and broadly cylindrical to broadly fusiform (L<50 μm; L/W <10)	*Closterium pusillum* (Figures 3.156–3.159)

Table 3.2: *Closterium* Cell Measurements.

		Cell Width	Cell Length	Curve	L/W Ratio
Closterium abruptum†	min	12.8 μm	195.2 μm	39°	11.0
	med	13.2 μm	212.8 μm	45°	16.6
	max	17.7 μm	241.6 μm	51°	17.9
Closterium acerosum	min	37.9 μm	344.4 μm	31°	8.0
	med	43.9 μm	487.0 μm	45°	11.4
	max	58.2 μm	759.8 μm	61°	17.8
Closterium acerosum	min	61.8 μm	1143.8 μm	31°	16.6
var. *elongatum*†	med	65.3 μm	1375.8 μm	36°	21.1
	max	68.8 μm	1429.0 μm	41°	23.1
Closterium aciculare	min	5.5 μm	444.6 μm	8°	74.0
	med	6.5 μm	566.3 μm	10°	82.1
	max	8.4 μm	621.4 μm	11°	94.5
Closterium acutum	min	3.0 μm	101.4 μm	6°	24.2
	med	4.6 μm	158.4 μm	13°	32.7
	max	7.7 μm	206.2 μm	22°	40.8
Closterium acutum var. *variable*	min	6.0 μm	154.6 μm	132°	25.8
	med	6.5 μm	291.2 μm	166°	43.4
	max	7.8 μm	368.8 μm	179°	53.5
Closterium acutum var. A	min	4.3 μm	96.6 μm	130°	17.1
	med	5.3 μm	111.4 μm	149°	23.2
	max	6.5 μm	126.6 μm	170°	25.5
Closterium angustatum	min	15.1 μm	251.5 μm	27°	14.5
	med	21.6 μm	456.1 μm	42°	21.1
	max	28.4 μm	682.0 μm	50°	31.7

†*summary statistics based on <5 cells*

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Table 3.2: *Closterium* Cell Measurements, continued

		Cell Width	Cell Length	Curve	L/W Ratio
Closterium archerianum†	min	–	–	–	–
	med	22.5 μm	285.4 μm	143°	12.7
	max	–	–	–	–
Closterium baillyanum	min	43.7 μm	322.3 μm	29°	7.0
	med	46.9 μm	463.1 μm	46°	9.8
	max	52.3 μm	680.1 μm	64°	15.6
Closterium baillyanum var. *alpinum*†	min	29.5 μm	440.6 μm	44°	14.9
	med	30.2 μm	488.3 μm	46°	16.2
	max	31.4 μm	613.2 μm	49°	19.5
Closterium braunii	min	45.4 μm	720.8 μm	27°	14.0
	med	49.8 μm	920.2 μm	39°	17.4
	max	68.2 μm	1326.2 μm	51°	25.3
Closterium closterioides	min	29.9 μm	176.0μm	–	5.1
	med	38.9 μm	225.3 μm	0	5.7
	max	68.6 μm	390.0 μm	–	6.8
Closterium closterioides	min	15.9 μm	94.2 μm	–	4.0
var. *intermedium*	med	24.6 μm	118.2 μm	0	4.9
	max	30.0 μm	165.0 μm	–	6.2
Closterium cf. *cornu*	min	7.5 μm	90.9 μm	–	11.9
	med	7.8 μm	105.1 μm	0	13.0
	max	9.8 μm	151.2 μm	–	15.4
Closterium costatum	min	20.6 μm	205.0 μm	45°	7.1
	med	45.6 μm	364.9 μm	77°	8.1
	max	49.0 μm	504.4 μm	90°	12.9

†*summary statistics based on <5 cells*

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Table 3.2: *Closterium* Cell Measurements, continued

		Cell Width	Cell Length	Curve	L/W Ratio
Closterium cynthia	min	9.8 μm	93.4 μm	138°	7.2
	med	12.8 μm	104.8 μm	142°	8.4
	max	13.8 μm	115.5 μm	162°	10.6
Closterium dianae	min	14.5 μm	160.8 μm	92°	10.1
	med	16.2 μm	199.5 μm	106°	11.1
	max	18.0 μm	247.2 μm	126°	14.7
Closterium cf. *dianae*[†]	min	13.3 μm	187.7 μm	65°	11.7
	med	16.6 μm	227.8 μm	72°	13.8
	max	22.3 μm	270.7 μm	102°	14.6
Closterium dianae cf. var. *minus*	min	10.9 μm	132.8 μm	90°	11.9
	med	11.4 μm	158.6 μm	116°	13.1
	max	16.4 μm	208.0 μm	147°	14.6
Closterium didymotocum	min	48.0 μm	422.7 μm	44°	7.9
	med	50.3 μm	516.3 μm	46°	10.1
	max	54.5 μm	591.2 μm	50°	11.8
Closterium directum	min	12.5 μm	225.2 μm	25°	12.1
	med	16.5 μm	292.6 μm	42°	18.9
	max	21.3 μm	407.4 μm	54°	26.5
Closterium ehrenbergii	min	75.9 μm	442.8 μm	86°	4.7
	med	95.7 μm	533.2 μm	111°	5.5
	max	148.8 μm	702.4 μm	145°	6.9
Closterium gracile	min	4.9 μm	168.8 μm	14°	27.4
	med	5.9 μm	212.4 μm	21°	32.5
	max	8.6 μm	272.0 μm	26°	40.8

[†]*summary statistics based on <5 cells*

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Table 3.2: *Closterium* Cell Measurements, continued

		Cell Width	Cell Length	Curve	L/W Ratio
Closterium gracile f. *elongatum*	min	3.6 μm	199.8 μm	13°	44.4
	med	4.1 μm	340.8 μm	18°	86.0
	max	4.6 μm	426.4 μm	34°	107.1
Closterium cf. *idiosporum*	min	6.9 μm	190.7 μm	17°	19.1
	med	7.8 μm	221.2 μm	23.5°	26.6
	max	11.3 μm	244.6 μm	33°	33.0
Closterium incurvum	min	8.8 μm	66.1 μm	141°	7.1
	med	10.5 μm	87.4 μm	174°	8.3
	max	11.6 μm	100.4 μm	178°	9.0
Closterium incurvum var. *latius*	min	15.3 μm	84.2 μm	161°	5.5
	med	15.8 μm	93.3 μm	171°	5.9
	max	16.2 μm	96.3 μm	180°	6.0
Closterium cf. *jenneri*	min	11.3 μm	55.6 μm	138°	4.9
var. *robustum*†	med	11.3 μm	58.8 μm	138°	5.2
	max	11.3 μm	62.0 μm	139°	5.5
Closterium juncidum	min	6.0 μm	145.9 μm	33°	18.9
	med	8.0 μm	243.5 μm	36°	27.4
	max	15.0 μm	405.3 μm	40°	31.6
Closterium kuetzingii	min	16.0 μm	257.8 μm	16°	15.1
	med	20.1 μm	405.1 μm	29°	18.8
	max	31.6 μm	587.6 μm	47°	34.2
Closterium leibleinii	min	17.2 μm	118.9 μm	145°	5.8
	med	19.7 μm	147.7 μm	158°	7.7
	max	24.7 μm	189.8 μm	171°	8.6

†*summary statistics based on <5 cells*

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Table 3.2: *Closterium* Cell Measurements, continued

		Cell Width	Cell Length	Curve	L/W Ratio
Closterium limneticum	min	4.4 μm	253.7 μm	6°	34.5
	med	6.9 μm	400.2 μm	11°	60.3
	max	8.4 μm	493.2 μm	23°	91.0
Closterium limneticum var. *fallax*	min	8.4 μm	155.8 μm	22°	18.4
	med	12.6 μm	284.4 μm	35°	20.9
	max	15.6 μm	299.6 μm	42°	24.0
Closterium lineatum	min	11.3 μm	320.1 μm	19°	28.3
	med	16.5 μm	600.2 μm	22°	36.3
	max	22.3 μm	897.6 μm	35°	40.3
Closterium littorale	min	15.5 μm	121.0 μm	49°	7.8
	med	16.2 μm	144.6 μm	68°	8.9
	max	18.6 μm	174.2 μm	79°	9.8
Closterium lunula	min	53.3 μm	325.5 μm	31°	4.4
	med	87.0 μm	628.5 μm	52°	7.1
	max	99.5 μm	1074.0 μm	66°	10.8
Closterium moniliferum	min	28.4 μm	185.2 μm	91°	5.3
	med	39.8 μm	263.8 μm	116°	6.5
	max	49.8 μm	328.0 μm	156°	8.0
Closterium navicula	min	11.7 μm	32.4 μm	–	2.7
	med	15.2 μm	50.7 μm	0	3.4
	max	17.5 μm	73.4 μm	–	4.5
Closterium nematodes	min	18.1 μm	259.3 μm	112°	9.4
	med	26.7 μm	287.5 μm	125°	11.1
	max	27.6 μm	304.0 μm	133°	15.1

[†]*summary statistics based on <5 cells*

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Table 3.2: *Closterium* Cell Measurements, continued

		Cell Width	Cell Length	Curve	L/W Ratio
Closterium parvulum	min	15.8 μm	149.0 μm	106°	8.1
	med	17.3 μm	165.3 μm	135°	9.6
	max	21.1 μm	211.2 μm	151°	10.1
Closterium cf. *parvulum* var. A	min	33.6 μm	244.0 μm	139°	6.9
	med	37.1 μm	307.6 μm	146°	8.1
	max	38.9 μm	319.8 μm	158°	8.6
Closterium cf. *parvulum* var. B	min	17.7 μm	117.1 μm	155°	6.5
	med	18.7 μm	135.7 μm	166°	7.2
	max	20.4 μm	147.5 μm	174°	7.5
Closterium praelongum	min	13.2 μm	274.8 μm	24°	17.1
	med	20.8 μm	582.0 μm	31°	23.6
	max	36.6 μm	756.2 μm	35°	39.1
Closterium pritchardianum†	min	27.6 μm	520.0 μm	49°	13.0
	med	33.8 μm	529.6 μm	50°	16.3
	max	40.0 μm	539.2 μm	52°	19.5
Closterium pronum	min	5.9 μm	211.4 μm	12°	30.8
	med	8.0 μm	399.5 μm	12°	48.5
	max	10.7 μm	451.7 μm	16°	55.8
Closterium pseudolunula	min	43.2 μm	282.0 μm	45°	5.7
	med	49.2 μm	313.2 μm	54°	6.4
	max	55.1 μm	398.9 μm	83°	9.2
Closterium pusillum	min	8.2 μm	30.8 μm	57°	3.6
	med	8.9 μm	35.4 μm	83°	4.0
	max	9.9 μm	52.7 μm	94°	6.4

†*summary statistics based on <5 cells*

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Table 3.2: *Closterium* Cell Measurements, continued

		Cell Width	Cell Length	Curve	L/W Ratio
Closterium ralfsii var. *hybridum*	min	35.7 μm	415.0 μm	36°	11.2
	med	58.0 μm	731.8 μm	46°	12.6
	max	62.1 μm	914.4 μm	61°	16.0
Closterium cf. *rectimarginatum*	min	20.5 μm	149.2 μm	27°	7.3
	med	21.6 μm	187.9 μm	34°	8.9
	max	23.8 μm	225.6 μm	42°	10.3
Closterium rostratum	min	21.1 μm	189.8 μm	35°	7.5
	med	25.0 μm	298.9 μm	52°	12.1
	max	29.1 μm	500.2 μm	66°	18.3
Closterium setaceum	min	9.7 μm	259.4 μm	10°	24.2
	med	10.5 μm	323.0 μm	20°	31.2
	max	12.0 μm	424.8 μm	29°	36.6
Closterium striolatum	min	17.5 μm	221.0 μm	30°	8.8
	med	25.3 μm	316.9 μm	58°	11.9
	max	41.1 μm	532.2 μm	77°	16.9
Closterium venus	min	8.6 μm	103.6 μm	104°	8.6
	med	11.7 μm	112.8 μm	152°	9.8
	max	12.2 μm	128.4 μm	172°	12.5

[†]*summary statistics based on <5 cells*

Description

Closterium cells are mostly elongated and cylindrical, crescent-shaped, or fusiform, and circular in cross-section (Figure 3.1). The cells are usually curved and tapered toward the apex, which contains a terminal vacuole with one or more inorganic crystals of barium or strontium sulfate (Figures 3.2–3.5). The purpose of these crystals in not known. *Closterium* can be mistaken for a saccoderm desmid because the cells lack a median constriction (isthmus), but *Closterium* is a placoderm desmid because each cell is divided into mirror image semi-cells separated by a thin suture, and the semi-cells contain separate chloroplasts.

Closterium species identification can be challenging because many *Closterium* species are polymorphic or incompletely described in the taxonomic literature and different species may look very similar under low magnification. Before attempting to identify species of *Closterium*, it is essential that you examine more than one specimen, preferable from more than one site or collected on different dates. You may also need to collect length, width, and curvature data in order to make the correct identification.

Species identification is based primarily on cell shape, degree of curvature, chloroplast structure, number and placement of pyrenoids, number of inorganic crystals in the terminal vacuole, and cell wall properties. During cell division, some species develop one or more ring-like sutures at the point of semi-cell division. Cells may also develop girdle bands, which are wide, straight extensions of the mid-portion of the cell wall, or pseudo-girdle bands, which are extensions from the sutures, but look similar to true girdle bands (Figures 3.3–3.4). The cell wall may be smooth or striated with fine longitudinal ridges or coarse costae (Figure 3.5). Cell curvature, another important feature, can be estimated using two measurements as indicated in Figure 3.6. The curvature measurement usually represents the dorsal (outer) margin, which is often more strongly curved than the ventral (inner) margin. Straight or nearly straight cells may have only 10–20° of dorsal curvature while strongly curved cells may be nearly hemispherical (180°).

Closterium abruptum cells are long, cylindrical, and slightly curved (Figures 3.7–3.9). The cell margins are nearly straight in the mid-region, but become tapered near the apex. The apex is truncated or slightly rounded and lacks a pore. The terminal vacuoles are small, each containing a single large crystal. The cell wall is colorless to yellowish brown, usually has girdle bands and sutures, and appears to be smooth but should be very faintly striated. Each chloroplast contains an axial row of 4–6 pyrenoids and extends nearly to the apex of the semi-cell.

Closterium abruptum is usually found is slightly acidic, nutrient-poor sites. This species resembles *Closterium angustatum* (Figure 3.26) and *Closterium directum* (Figure 3.71), both of which are usually larger and less tapered near the apex.

Closterium acerosum cells are fusiform, nearly straight on the ventral margin, and slightly curved along the dorsal margin (Figures 3.10–3.15). The apex is abruptly narrowed, truncated or slightly rounded, and lacks an apical pore. It may appear reflexed due to the dissimilar curvatures of the dorsal and ventral margins. The terminal vacuoles are spherical and contain about 2–10 small crystals. The cell wall is colorless or yellowish brown, lacks true girdle bands (false girdle bands are occasionally present), and appears smooth but is usually very faintly striated. Each chloroplast contains an axial row of 5-30 pyrenoids and extends nearly to the apex of the semi-cell. ***Closterium acerosum* var. *elongatum*** is distinguished by its longer, more distinctly curved cells (Figures 3.13–3.15). According to Prescott et al. (1975), this variety may be invalid as it overlaps with morphological features found in the nominate variety.[9]

Closterium acerosum is widely distributed and can be found in eutrophic and polluted habitats as well as acidic or boggy ponds. *Closterium acerosum* resembles *Closterium braunii* (Figure 3.38) and *Closterium pritchardianum* (Figure 3.148, which can be distinguished by having rows of punctae rather than striations on the cell wall. Very careful examination is needed to distinguish *Closterium acerosum* from these other two species. Habitat is occasionally helpful because *Closterium acerosum* is more likely to be present in eutrophic and polluted habitats, but *Closterium acerosum* can also be collected in acidic or boggy ponds.

Closterium aciculare cells are cylindrical, exceptionally long, and narrow (Figures 3.16–3.18). The cells are nearly straight in the mid-region, then taper gradually to the gently curved apex. The apex is rounded, with a tiny apical pore and a long, indistinct vacuolated region containing a few small crystals. The cell wall is smooth, colorless, and lacks girdle bands. Each chloroplast is usually a simple, flat ribbon with approximately 5–20 axial pyrenoids, and occupies only about half the length of the semi-cell.

Closterium aciculare is typically planktonic and is common in eutrophic lakes and ponds. *Closterium aciculare* resembles *Closterium gracile* f. *elongatum* (Figure 3.80), which has sides that are parallel nearly to the apex; and *Closterium acutum* (Figure 3.19), which is usually much shorter than the other two taxa.

[9] *Closterium acerosum* var. *acerosum*

Closterium acutum cells are narrowly fusiform, tapering gradually from the center of the cell to the apex (Figures 3.19–3.25). The cells may be nearly straight or slightly curved, with the exception of *Closterium acutum* var. *variable* (see below), which has strongly curved crescent-shaped or sigmoid cells. The apex is narrowly truncated; lacks an apical pore; and contains a long, poorly defined terminal vacuole. The vacuoles contain one or more crystals; when multiple crystals are present, they may form bead-like chains. The cell wall is smooth and colorless and lacks girdle bands. Each chloroplast is a simple, flat ribbon, with 2–4 axial pyrenoids, and ends well below the apex. Most of the northwest Washington specimens were nearly linear with a length/width ratio $\geq$33 (Figures 3.19–3.21), which is an intermediate shape between the nominate variety[10] and a narrow variety, *Closterium acutum* var. *linea* (Perty) West & G. S. West. The major diagnostic feature used to separate the two forms is the length/width ratio, which is 20–33 for *Closterium acutum* var. *acutum* vs. 34–56 for *Closterium acutum* var. *linea* (Prescott, et al., 1975). Coesel and Meesters (2007) and Brook and Williamson (2010) question whether separating var. *linear* is valid, given that both forms are often present in the same sample.

Closterium acutum is common in eutrophic lakes and may form blooms. It resembles *Closterium aciculare* (Figure 3.16), *Closterium gracile* f. *elongatum* (Figure 3.80), and *Closterium pronum* (Figure 3.150), all of which are usually much longer than *Closterium acutum*.

Closterium acutum* var. *variable is characterized by strongly curved or twisted (sigmoid) cells, often with dissimilar curvature on opposite semi-cells (Figures 3.22–3.24). *Closterium acutum* var. *variable* was not especially common in the northwest Washington samples, but was found in similar eutrophic habitats as the nominate variety. ***Closterium acutum* var. A** specimens were collected from two artificial, alkaline, freshwater lakes located adjacent to an estuary (Figure 3.25). The cells may be morphological variations of *Closterium acutum* var. *variable*, but were shorter than other specimens of *Closterium acutum* var. *variable* and were collected in a very different habitat.

Closterium angustatum cells are long, cylindrical, and slightly curved (Figures 3.26–3.29). The cell sides are parallel through the mid-region, then gently tapered near the apex. The apex is truncated, thickened, slightly swollen (capitate) or recurved, and should have a distinct apical pore. The terminal vacuoles are spherical and contain one or more large, stacked crystal. The cell wall is yellowish brown and

[10] *Closterium acutum* var. *acutum*

has coarse striations (costae) with tiny pores visible between the striations; girdle bands are often present. Each chloroplast extends nearly to the apex and has 4–10 (or more) axial pyrenoids.

This species is usually found is slightly acidic, nutrient-poor sites. *Closterium angustatum* resembles *Closterium abruptum* (Figure 3.7), which is smaller and more evenly tapered; and *Closterium directum* (Figure 3.71), which is finely striated and lacks the expanded (capitate) apex.

Closterium archerianum cells are crescent-shaped, relatively narrow, strongly curved, and gradually tapered to the acutely rounded apex (Figures 3.30–3.31). The apex lacks an apical pore. The terminal vacuole is small and spherical, with a single large crystal or group of fused crystals. The walls are yellowish brown and distinctly striated. According to Prescott et al. (1975), the cell wall often has girdle bands, but this feature was not present in the northwest Washington specimen. Each chloroplast extends nearly to the apex and contains 5–8 axial pyrenoids.

Coesel and Meesters (2010) state that *Closterium archerianum* is associated with oligo-mesotrophic water, which is consistent with the site where the single specimen was collected (Storm Lake, Snohomish County, WA).

Closterium baillyanum cells are cylindrical and very slightly curved, usually with a nearly straight ventral margin and a more strongly curved dorsal margin (Figures 3.32–3.37). The apex is broadly truncate, slightly reflexed, with an apical pore. The terminal vacuoles contain many small crystals. The cell wall is colorless to dark brown, with a dark brown apex; lacks girdle bands; and appears smooth, but high magnification may show fine punctae. Each chloroplast extends nearly to the apex and contains 5–8 axial pyrenoids. ***Closterium baillyanum* var. *alpinum*** is distinguished by its narrower cells (Figures 3.36–3.37), but note that Brook and Williamson (2010) question whether the variety is valid, give the considerable morphological variation for the species.

Closterium baillyanum is found in slightly acidic meso-oligotrophic lakes and ponds. This species resembles *Closterium didymotocum* (Figure 3.67), which has distinctly striated walls with girdle bands.

Closterium braunii cells are long, cylindrical, and very slightly curved, with nearly parallel sides up to the abruptly tapered apex (Figures 3.38–3.41). The apex is abruptly narrowed, truncated, and lacks an apical pore. It may appear reflexed due to the dissimilar curvatures of the dorsal and ventral margins. The terminal vacuoles are spherical and contain many small crystals. The cell wall is brownish,

lacks girdle bands, and appears coarsely striated; however, the striations are actually double rows of closely spaced punctae. Each chloroplast extends nearly to the apex and has 14–16 (or more) axial pyrenoids.

Closterium braunii is found in boggy, slightly acidic lakes and ponds. This species resembles *Closterium acerosum* (Figure 3.10), which lacks the distinctive double rows of punctae; and *Closterium pritchardianum* (Figure 3.148), which is striated with single (not double) rows of closely spaced punctae. Very careful examination is needed to distinguish *Closterium acerosum* from the other two species. Habitat is occasionally helpful because *Closterium acerosum* is more likely to be present in eutrophic and polluted habitats, but *Closterium acerosum* can also be collected in acidic or boggy ponds.

Closterium closterioides cells are straight and broadly fusiform, with rounded or truncated apices (Figures 3.42–3.47). The apex contains a well-defined spherical vacuole with numerous crystals. Although the apex wall is thickened, there does not appear to be an apical pore. The cell wall is smooth, colorless or brownish, and lacks girdle bands. Each chloroplast contains 3–6 axial pyrenoids and has distinctive lateral notches about half way between the apex and isthmus. ***Closterium closterioides* var. *intermedium*** was present in several mountain lake samples (Figures 3.45–3.47). This variety is quite difficult to distinguish from the nominate variety,[11] especially because it may be collected in the same sample (Figure 3.45). The primary distinguishing features for *Closterium closterioides* var. *intermedium* include slightly shorter cell lengths, lower L/W ratios, and fewer pyrenoids (2–3) compared to the nominate variety.

Closterium closterioides is usually found in slightly acidic water; all of the northwest Washington specimens were collected in oligo-mesotrophic or mesotrophic mountain lakes and ponds. The large size and notched chloroplasts make *Closterium closterioides* fairly distinctive, but small specimens of *Closterium closterioides* var. *intermedium* resemble *Closterium navicula* (Figure 3.128), which can be distinguished by its unnotched chloroplast.

Closterium cornu cells are narrowly fusiform, straight or slightly curved, with bluntly truncated apices that lack an apical pore (Figures 3.48–3.50). The terminal vacuoles are small and spherical, with single crystals. The cell wall is smooth, colorless, and lacks girdle bands. Each chloroplast extends nearly to the apex and contains 2–4 axial pyrenoids.

[11] *Closterium closterioides* var. *closterioides*

Closterium cornu is associated with slightly acidic, boggy lakes and ponds. This identification is uncertain because *Closterium cornu* is usually described as having a slightly curved dorsal margin, but all of the northwest Washington specimens have equally straight margins. This species resembles *Closterium acutum* (Figure 3.19), which is narrower; *Closterium pronum* (Figure 3.150), which is longer; and *Closterium idiosporum* (Figure 3.82), which has an apical pore.

Closterium costatum cells are large, robust, and broadly crescent-shaped (Figures 3.51–3.55). The mid-region along the ventral margin is often nearly straight or very slightly inflated while the dorsal margin is evenly curved. The apex is bluntly truncated and often slightly thickened (capitate), but with no apical pore. The terminal vacuoles are spherical and contain many tiny crystals (Figures 3.52–3.53) or a single large crystal (Figure 3.55). The cell wall is yellowish brown or reddish brown, with a darker brown apex, lacks girdle bands, and is coarsely striated with thick "costae." Each chloroplast extends nearly to the apex and contains many scattered pyrenoids.

Closterium costatum is usually associated with boggy, slightly acidic lakes and ponds. The coarse wall striations make this species is fairly distinctive, but it can be confused with *Closterium didymotocum* (Figure 3.67) and *Closterium striolatum* (Figure 3.178), both of which have girdle bands.

Closterium cynthia cells are crescent-shaped and moderately to strongly curved (Figures 3.56–3.59). The mid-section of the cell may be nearly straight or continuously curved; the sides may be nearly parallel until near the apex, or gently tapered across the length of the cell. The apex is broadly rounded and lacks a terminal pore. The terminal vacuole is spherical and contains a single large crystal. Each chloroplast extends nearly to the apex and contains 2–5 axial pyrenoids. The cell wall is highly variable, appearing colorless, yellowish, or brownish; smooth or very faintly striated; and with or without girdle bands and sutures. Smooth walled cells were separated by many taxonomists into a different species, *Closterium jenneri* Ralfs, which is otherwise morphologically identical to *Closterium cynthia*; both species are typically found in slightly acidic lakes and ponds. Růžička (1977) suggested that *Closterium jenneri* could be an immature form of *Closterium cynthia* (see discussion by Coesel and Meesters, 2007). In this guide, the striated specimens were merged with *Closterium cynthia* except for *Closterium jenneri* var. *robustum*, which is sufficiently different that it deserves separate treatment (see species discussion below). All of the northwest Washington specimens appeared to lack girdle bands and have smooth or very faintly striated

walls. In addition to the possibly synoymy with *Closterium jenneri*, *Closterium cynthia* resembles *Closterium incurvum* (Figure 3.85), which is more strongly curved and usually smaller.

Closterium dianae cells are narrowly crescent-shaped and moderately or strongly curved (Figures 3.60–3.62). This species is highly polymorphic, but the northwest Washington specimens have straight, parallel sides through the mid-portion of the cell, becoming moderately curved and tapered approaching the apex. The apex is acutely rounded or obliquely tapered, with a thickened wall below the apex, and a small pore on the dorsal margin just below the apex. The terminal vacuole is relatively large and contains 2–10 (or more) small crystals dispersed throughout the vacuole. The cell wall is colorless or brownish, smooth, and lacks girdle bands. Each chloroplast ends slightly below the apex and contains 4–8 axial pyrenoids.

The specimens in Figures 3.63–3.64 may be ***Closterium dianae* cf. var. *minus***, which is characterized by small, strongly curved cells (cell length $\leq$150 μm; cell width $\leq$15 μm). The specimens in Figures 3.65–3.66 are also tentatively identified as *Closterium dianae*; this variety (or morphological form) is characterized by cells that are inflated at the center.

Closterium dianae can be found in slightly acidic, boggy ponds (Brook and Williamson, 2010), but the northwest Washington specimens were in small, mesotrophic lakes and ponds. *Closterium dianae* can resemble several other species of *Closterium*. The northwest Washington specimens are similar to *Closterium calosporum* Wittrock (no image available), which has a distinctive zygote that is needed for species identification; and *Closterium parvulum* (Figure 3.136), which is usually more strongly curved. Some of the specimens resemble *Closterium dianae* var. *pseudodianae* (J. Roy) Willi Krieger (see description by Růžička, 1977), but confirmation of this variety is not feasible.

Closterium didymotocum cells are cylindrical, nearly straight along the ventral margin, slightly curved along the dorsal margin, and only slightly tapered at the apex (Figures 3.67–3.70). The apex is broadly truncate, slightly thickened, and appears to have an apical pore. The terminal vacuole is spherical and contains many tiny crystals. The cell wall is yellowish-brown, becoming dark brown at the apex, and is faintly but distinctly striated, with a network of fine punctae between the striations. Both girdle bands and sutures were observed in most specimens. Each chloroplast extends nearly to the apex and contains many scattered pyrenoids.

Brook and Williamson (2010) state that the wall striations in *Closterium didymotocum* stop short of the apex, but Figure 3.69 shows that the striations in the northwest Washington specimens extend to the apex. In addition, Brook and Williamson suggest there may have been many incorrect identifications of *Closterium didymotocum* and the similar species, *Closterium baillyanum* (Figure 3.32). *Closterium baillyanum* is a common desmid in northwest Washington lakes, and can be distinguished by its lack of true girdle bands and smooth or very faintly striated walls. The northwest Washington specimens have very obvious girdle bands, so they were not assigned to *Closterium baillyanum*. All of the *Closterium didymotocum* specimens were collected from a single floating bog in British Columbia and may represent a new species or variety.

Closterium directum cells are narrowly cylindrical and straight or slightly curved (Figures 3.71–3.73). The sides are parallel along most of the cell, becoming only slightly tapered near the apex so that the apex is nearly as wide as the rest of the cell. The apex is broadly truncated, slightly reflexed, and lacks an apical pore. The terminal vacuole is small, spherical, and contains one large, compound crystal. The cell wall is colorless or yellowish, with true girdle bands, and is finely striated. Each chloroplast contains 6–20 axial pyrenoids and extends nearly to the apex.

Closterium directum is usually found in boggy, slightly acidic lakes and ponds. *Closterium directum* resembles *Closterium abruptum* (Figure 3.7), which is smaller and more evenly tapered; and *Closterium angustatum* (Figure 3.26), which has a coarsely striated wall and expanded (capitate) apex.

Closterium ehrenbergii cells are large and crescent-shaped, with a strongly curved dorsal margin and a moderately curved ventral margin that is inflated at the center of the cell (Figures 3.74–3.77). The sides are gradually tapered to the acutely rounded apex; the apex does not have an apical pore. The terminal vacuoles are large and spherical, containing many small crystals. The cell wall is colorless or brownish, lacks girdle bands, and usually appears smooth, but actually is finely striated; these striations are hard to see unless highly magnified. Each chloroplast extends nearly to the apex and contains many small, scattered pyrenoids.

Brook and Williamson (2010) suggest that *Closterium ehrenbergii* may be a "catch-all" species comprised of more than one undescribed species. Not surprisingly, it is found in a very wide range of habitats, and is especially common in nutrient enriched ponds and ditches, sometimes forming blooms. *Closterium ehrenbergii* is relatively easy to identify based in its large, crescent-shaped cells and numerous scattered pyrenoids, even if the form encompasses more than one species.

Closterium gracile cells are narrowly cylindrical, with parallel sides for most of the length of the cell (Figures 3.78–3.81). The cells are usually straight except near the apex, where they are gently curved and slightly tapered. The apex is truncated with a tiny pore. The terminal vacuoles are poorly defined and contain one or more crystals distributed throughout the vacuole. The cell wall is smooth, colorless or pale yellow, and lacks girdle bands but may have numerous sutures. Each chloroplast is a simple ribbon that extends nearly to the apex and has 4–7 (or more) axial pyrenoids.

Most of the *Closterium gracile* specimens were exceptionally long and narrow, fitting descriptions for ***Closterium gracile* f. *elongatum*** (Figures 3.80–3.81). Brook and Williamson (2010) argue against separating this as a variety because the nominate variety[12] has been shown to include specimens covering a gradient encompassing both long and short morphological forms. In addition, AlgaeBase lists *Closterium gracile* f. *elongatum* as a synonym for *Closterium gracile* (Guiry & Guiry, 2023). However, the long and short northwest Washington specimens were collected from different locations, so *Closterium gracile* f. *elongatum* was separated from *Closterium gracile* in Table 3.2.

Closterium gracile is generally found in slightly acidic lakes and ponds; the elongated form was particularly abundant in Summer Lake, a floating sphagnum bog in Skagit County, WA. Short *Closterium gracile* cells (Figure 3.78) resemble *Closterium limneticum* (Figure 3.105) and *Closterium acutum* (Figure 3.19), both of which are more uniformly tapered. *Closterium gracile* f. *elongatum* (Figure 3.80) resembles *Closterium aciculare* (Figure 3.16), which has long, uniformly tapered cells and chloroplasts that do not extend to the apex.

Closterium idiosporum cells are narrowly fusiform or very slightly crescent-shaped, nearly straight (sometimes asymmetrically curved), tapering gradually from the center of the cell to the apex (Figures 3.82–3.84). The apex is truncate, with a tiny apical pore. The terminal vacuoles are long and poorly defined, with several small crystals that may be irregularly distributed or form short chains. The cell wall is colorless, smooth, and lacks girdle bands. Each chloroplast stops well below the apex and contains 3–4 axial pyrenoids.

Closterium idiosporum is described as being found in slightly acidic lakes and ponds (Brook and Williamson, 2010), which is consistent with the sites where the northwest Washington specimens were collected. Without the presence of zygotes,

[12] *Closterium gracile* var. *gracile*

however, species confirmation is difficult. *Closterium idiosporum* resembles *Closterium acutum* (Figure 3.19), which is smaller, and *Closterium gracile* (Figure 3.78), which has parallel sides and a small terminal vacuole.

Closterium incurvum cells are relatively small, crescent-shaped (Figures 3.85–3.90). The cells are very strongly curved ($\geq$170°), with an evenly curved ventral margin that lacks any median inflation. The apex is acute, with a small pore just below the apex on the dorsal side. The terminal vacuole is well-defined and contains one or more large crystals. The cell wall is colorless, smooth, and lacks girdle bands. The chloroplast extends nearly to the apex and has 1–3 large, axial pyrenoids. ***Closterium incurvum* var. *latius*** was present at several locations (Figures 3.89–3.90). This variety has slightly wider cells, which gives it a more robust appearance.

Closterium incurvum has a wide habitat tolerance, and many of the northwest Washington specimens were collected in mesotrophic or eutrophic sites. *Closterium incurvum* cells are very similar to *Closterium parvulum* (Figure 3.136), and *Closterium venus* (Figure 3.182). Both species are characterized by strongly curved, crescent-shaped cells with nearly the same size ranges for length and width. Both species can be present at the same site (Figure 3.88; Sovran, et al., 2013), so habitat does not help with separation. Despite the morphological similarity of the vegetative cells, the separation between *Closterium venus* and *Closterium incurvum* is supported by differences in their zygotes (Cook, 1963). The best visual features for separating these two species is the dorsal curvature, which is nearly hemispherical for *Closterium incurvum* vs. crescent-shaped for *Closterium venus*; and the chloroplast length, which extends nearly to the apex in *Closterium incurvum* cells, but ends well below the apex in *Closterium venus* cells.

Closterium jenneri* var. *robustum cells are small, crescent-shaped, and moderately curved (Figures 3.91–3.92). The apex is broadly rounded and lacks an apical pore. The terminal vacuole is spherical and contains a single large crystal. The cell wall is colorless or brownish, usually appears to be smooth, and lacks girdle bands. Each chloroplast extends nearly to the apex and contains 2–3 axial pyrenoids.

Closterium jenneri is a confusing species and all of the nominate variety[13] specimens were merged with *Closterium cynthia* (see discussion above). The specimens in Figures 3.91–3.92 are sufficiently distinctive that they were not merged with *Closterium cynthia*, and are instead presented as one of the described

[13] *Closterium jenneri* var. *jenneri*

varieties of *Closterium jenneri* (Prescott, et al., 1975). Only two specimens were collected, both from a small, high elevation snow-melt pond in the Mt. Baker Recreational Area. Additional specimens are needed to confirm the identification.

Closterium juncidum cells are narrowly cylindrical, slightly curved, tapered near the apex, with parallel sides in the mid-region (Figures 3.93–3.96). The apex is truncated, often oblique, and contains an apical pore. The terminal vacuole is small and spherical, with one large, compound crystal or several smaller crystals. The cell wall is colorless, yellow, or brown, and has true girdle bands, but this feature may be absent in young cells. The wall is striated, but this feature is also variable, so the cells may appear smooth. Each chloroplast extends nearly to the apex and contains 4–9 (or more) axial pyrenoids.

Closterium juncidum is generally found in slightly acidic, oligotrophic lakes and ponds. *Closterium juncidum* cells resemble *Closterium gracile* (Figure 3.78), which can be distinguished by its smooth, unstriated cell wall and *Closterium lineatum* (Figure 3.112), which is much larger and is more likely to be collected in mesotrophic waters.

Closterium kuetzingii cells are bow-shaped and nearly straight, with an inflated center, and long, narrow, beak-like extensions (Figures 3.97–3.101). The extensions are straight almost to the apex, then gently curved, giving the cell a symmetric appearance with equal dorsal and ventral curvature. Each extension is approximately as long as the combined length of both chloroplasts. The apex is usually slightly expanded and contains a small apical pore. The vacuoles are located at the upper end of each chloroplast near the base of the narrow extensions (subapical), and contain several small crystals. The cell wall is colorless, yellowish or brownish, lacks girdle bands, and is faintly striated; the striations are very fine, so the cell wall usually appears smooth. The chloroplasts are confined to the central fusiform portion of the cell and each contains 4–7 axial pyrenoids.

Closterium kuetzingii has a wide habitat tolerance, and some of the northwest Washington specimens were collected in mesotrophic sites while others were found in slightly acidic boggy ponds and lakes. *Closterium kuetzingii* can be difficult to distinguish from *Closterium setaceum* (Figure 3.174), especially because both species may be present in the same sample. The best separation feature is the greater length of the extensions in *Closterium setaceum*, which gives that species a more delicate appearance (see Figure 3.101).

Closterium leibleinii cells are strongly curved, crescent-shaped, and slightly inflated at the center (Figures 3.102–3.104). The apex is bluntly pointed, with a very small subapical pore located on the dorsal margin. The terminal vacuole is fairly large and contains many small crystals. The cell wall is smooth, colorless or very pale brown, and lacks girdle bands. Each chloroplast ends well below of the apex and contains 2–6 axial pyrenoids.

Closterium leibleinii is usually found in mesotrophic or eutrophic sites; many of northwest Washington specimens were collected in small residential ponds. This species closely resembled *Closterium moniliferum* (Figure 3.124), which can also be found in eutrophic sites, but is larger and lacks the subapical pore.

Closterium limneticum cells are narrowly cylindrical, with straight, parallel sides in the mid-section, then tapered and gently curved in the upper portion of the cell (Figures 3.105–3.111). The apex is narrowly rounded and lacks an apical pore. The terminal vacuole is spherical or slightly elongated, usually containing only one crystal. The cell wall is colorless, smooth, and lacks girdle bands. The chloroplasts extend nearly to the apex and contains 3–5 (or more) axial pyrenoids. In addition to the nominate variety,[14] the northwest Washington samples contained ***Closterium limneticum*** var. ***fallax*** (Figures 3.109–3.111), which is a shorter and wider (fusiform) variation compared to the nominate. The northwest Washington specimens for both varieties had lengths and widths that were outside the ranges listed by Prescott et al. (1975); however, this species exhibits considerable morphological variability with respect to length.

Closterium limneticum closely resembles *Closterium gracile* (Figure 3.78), which has a tiny apical pore. One of the best features for separating these two species is habitat: *Closterium gracile* is usually collected in benthic samples and along shorelines in slightly acidic oligotrophic waters; *Closterium limneticum* is usually collected in plankton samples from eutrophic lakes (Brooke and Williamson, 2010).

Closterium lineatum cells are narrowly cylindrical, with straight, parallel sides throughout most of the cell length, then tapered and slightly curved near the apex (Figures 3.112–3.115). The apex is narrow and truncated, with a distinct apical pore. The terminal vacuole is small and spherical, with many crystals. The cell wall is finely striated, lacks girdle bands, and is colorless in young cells but usually yellowish or brownish in older cells. Each chloroplast extends nearly to the apex and contains 9–11 (or more) axial pyrenoids.

[14] *Closterium limneticum* var. *limneticum*

Closterium lineatum is generally found in mesotrophic lakes and ponds. *Closterium lineatum* is very similar in size and shape to *Closterium praelongum* (Figure 3.144), which can be distinguished by its recurved apex. *Closterium lineatum* also resembles *Closterium gracile* (Figure 3.78), which can be distinguished by its smooth, unstriated cell wall and *Closterium juncidum* (Figure 3.112), which is much smaller and is more likely to be collected in boggy, slightly acidic sites.

Closterium littorale cells are crescent-shaped and slightly curved, with a nearly straight or slightly inflated ventral margin and evenly curved dorsal margin (Figures 3.116–3.118). The apex is narrowly rounded, with a thickened wall and no apical pore. The terminal vacuole located below the thickened apex, at the top of the chloroplast. The vacuole usually contains a single large crystal. The cell wall is smooth, colorless, and lacks girdle bands. Each chloroplast extends nearly to the apex and contains 3–10 axial pyrenoids.

Closterium littorale has a wide habitat tolerance and can be found in boggy acidic sites, eutrophic lakes and ponds, and associated with submerged vegetation in streams and rivers (Brook and Williamson, 2010). All of the northwest Washington specimens were collected along the shoreline of creeks and rivers or in small ponds.

Closterium lunula cells are large and broadly fusiform or crescent-shaped, with a nearly straight or slightly inflated ventral margin and slightly curved dorsal margin (Figures 3.119–3.123). The apex is bluntly truncated and may appear recurved due to the uneven dorsal/ventral curvature. The terminal vacuole is spherical or oval (sometimes described as conical), lacks an apical pore, and contains many small crystals that may form stacked groups. The cell wall is colorless or brownish, lacks girdle bands, and may appear smooth, but is actually very finely striated. Each chloroplast extends nearly to the apex and contains many small, scattered pyrenoids.

Closterium lunula is usually found along the shoreline of slightly acidic, boggy lakes and ponds. The northwest Washington specimens were collected from a very broad range of habitats, including low elevation mesotrophic lakes, oligotrophic mountain ponds, and floating sphagnum bogs. The large size and numerous scattered pyrenoids makes this species distinctive and easy to identify.

Closterium moniliferum cells are large and crescent-shaped, with a slightly inflated ventral margin and evenly curved dorsal margin (Figures 3.124–3.127). The apex is bluntly pointed, lacks an apical pore, and contains a well-defined spherical vacuole with many small crystals. The cell wall is colorless or brownish, lacks girdle bands, and usually appears smooth but is very finely striated. Each chloroplast

extends nearly to the apex and contains 2–10 (or more) axial pyrenoids. Figure 3.127 shows cells with axial pyrenoids near the apex and scattered pyrenoids near the center of the cell. Cells with this pyrenoid arrangement are often listed as *Closterium moniliferum* var. *submoniliferum* (Woronchin) Krieger; however, Brook and Williamson (2010) state that this feature can be induced in the nominate variety[15] when the cells are grown in high light intensities.

Brook and Williamson (2010) describe *Closterium moniliferum* as a "complex of biological species" that may include more than one morphologically similar species. Not surprisingly, *Closterium moniliferum* it is found in a very wide range of habitats. *Closterium moniliferum* resembles *Closterium ehrenbergii* (Figure 3.74), which is larger and unstriated; and *Closterium leibleinii*, which is smaller, unstriated, and has a tiny subapical pore (Figure 3.102).

Closterium navicula cells are straight and broadly fusiform with truncate apices (Figures 3.128–3.131). The apex is broadly rounded, lacks an apical pore, and contains a spherical vacuole with one or more crystals. The cell wall is colorless, smooth, and lack girdle bands. Each chloroplast extends nearly to the apex and usually contains a single axial pyrenoid (dividing cells may have two pyrenoids).

Nearly all of the northwest Washington *Closterium navicula* specimens were collected in slightly acidic boggy lakes and ponds. Although the cells are typically small, *Closterium navicula* exhibits considerable variation in cell lengths (Figure 3.131). Larger cells may resemble *Closterium closterioides* var. *intermedium* (Figure 3.45), which can be distinguished by its notched chloroplast and (usually) larger size.

Closterium nematodes cells are narrowly crescent-shaped and strongly curved (Figures 3.132–3.135). The apex is narrowly rounded and lacks an apical pore but has a distinctive, thickened, subapical ring. The terminal vacuole is positioned near the top of the chloroplast, below the thickened subapical ring, and contains a single large crystal. The cell wall is brownish and striated, lacks girdle bands, but has prominent sutures between the semi-cells. Each chloroplast extends nearly to the apex and contains 5–8 (or more) axial pyrenoids.

Closterium nematodes is associated with slightly acidic, boggy lakes and ponds. This species resembles *Closterium striolatum* and several other strongly curved species, but none will have the thickened subapical ring.

[15] *Closterium moniliferum* var. *moniliferum*

The ***Closterium parvulum group*** is a poorly defined species complex that needs taxonomic resolution because the cell morphology overlaps with *Closterium dianae* (Figure 3.60), *Closterium incurvum* (Figure 3.85), *Closterium leibleinii* (Figure 3.102), *Closterium parvulum* (Figure 3.136), and *Closterium venus* (Figure 3.182). All members of this group have strongly and evenly curved, crescent-shaped cells with an acutely rounded apex. The cells should have an indistinct pore located just below the apex (subapical) on the dorsal margin, but this feature is not always visible. In addition to the group characteristics described above, the species ***Closterium parvulum*** is characterized by a thickened apex wall and large, poorly defined terminal vacuole that occupies the space between the top of the chloroplast and the apex (Figures 3.136–3.143). The vacuole contains 2–8 (or more) crystals that are distributed throughout the large vacuole. The cell wall is colorless or yellowish brown, unstriated, and lacks girdle bands. Each chloroplast contains 2–6 (or more) axial pyrenoids and extends nearly to the apex, ending just below the large terminal vacuoles

Figures 3.139–3.143 appear to represent three different varieties, forms, or species within the *Closterium parvulum* species complex, all with features that differ from the *Closterium parvulum* specimens depicted in Figures 3.136–3.138. The specimens in Figures 3.139–3.141 (*Closterium parvulum* group var. A) have nearly all of the features for this group, including the thickened apex wall and small subapical pore on the dorsal margin, but are much larger than any of the varieties listed by Prescott et al. (1975). The specimens in Figures 3.142–3.143 (*Closterium* cf. *parvulum* var. B) have a single large crystal in the terminal vacuole and are strongly curved, resembling *Closterium incurvum* (Figure 3.85), except in size.

Closterium praelongum cells are narrowly cylindrical, with nearly parallel sides and almost no curvature until near the apex, where the cell becomes tapered and gently curved (Figures 3.144–3.147). The apex is truncated and somewhat narrowed, with the ventral margin narrowing abruptly and the dorsal margin turning slightly outward (recurved). The apex may have an apical pore, but this feature is not always visible. The spherical terminal vacuole contains one or more crystals that may form stacked groups. The cell wall is colorless or brownish, finely striated, and lacks true girdle bands but may have asymmetric false girdle bands. Each chloroplast extends nearly to the apex and contains 7-25 axial pyrenoids.

Closterium praelongum can be found in a wide range of habitats, including eutrophic waters. Most of the northwest Washington specimens were collected from residential ponds and ditches, but a few samples were collected along shorelines in

slightly acidic, mesotrophic lakes. *Closterium praelongum* is very similar in size and shape to *Closterium lineatum* (Figure 3.112), which lacks the recurved apex. *Closterium lineatum* also resembles *Closterium gracile* (Figure 3.78), which can be distinguished by its smooth, unstriated cell wall and *Closterium juncidum* (Figure 3.112), which is much smaller and is more likely to be collected in boggy, slightly acidic sites.

Closterium pritchardianum cells are narrowly cylindrical, with nearly parallel sides in the mid-region (Figures 3.148–3.149). The dorsal margin is slightly but evenly curved; the ventral margin is usually less curved, and may be straight in the mid-region of the cell. The apex is lacks a pore and is truncated, often appearing to be recurved because it is abruptly narrowed on the dorsal side. The terminal vacuole is spherical and contains many small crystals. The cell wall is colorless, yellowish, or light brown; lacks girdle bands; and is striated with single vertical rows of punctae. Each chloroplast extends nearly to the apex and contains five or more axial pyrenoids.

Closterium pritchardianum is found in boggy, slightly acidic lakes and ponds. This species resembles *Closterium acerosum* (Figure 3.10), which lacks the distinctive double rows of punctae; and *Closterium braunii* (Figure 3.38), which is striated with double rows of closely spaced punctae. Very careful examination is needed to distinguish *Closterium pritchardianum* from the other two species. Habitat is occasionally helpful because *Closterium acerosum* is more likely to be present in eutrophic and polluted habitats, but *Closterium acerosum* can also be collected in acidic or boggy ponds.

Closterium pronum cells are narrowly fusiform and straight or nearly straight, often with some curvature near the apex (Figures 3.150–3.152). The sides are tapered across most of the length of the cell except for near the center, which has parallel sides. The terminal vacuole is long and poorly defined, lacks an apical pore, and contains one or more small crystals that often form small bead-like chains. The cell wall is colorless, smooth, and lacks girdle bands. Each chloroplast has 5–12 axial pyrenoids and stops well below the apex.

Closterium pronum is usually found in slightly acidic, boggy lakes and ponds. It resembles *Closterium aciculare* (Figure 3.16), which is much longer, has an apical pore (hard to see), and parallel sides along most of the length of the cell; and *Closterium acutum* (Figure 3.19), which is usually shorter, with a chloroplast that extends nearly to the apex of the cell.

Closterium pseudolunula cells are large and broadly fusiform or crescent-shaped, with a nearly straight or slightly inflated ventral margin and slightly curved dorsal margin (Figures 3.153–3.155). The apex is bluntly truncated and may appear recurved due to the uneven dorsal/ventral curvature. The terminal vacuole is spherical, lacks an apical pore, and contains many small crystals. The cell wall is colorless or brownish, lacks girdle bands, and may appear smooth, but is actually very finely striated. Each chloroplast extends nearly to the apex and contains 4–10 large axial pyrenoids. *Closterium pseudolunula* closely resembles *Closterium lunula* (Figure 3.119), but *Closterium lunula* has many small scattered pyrenoids (not axial) and is usually larger. *Closterium pseudolunula* also resembles *Closterium acerosum* (Figure 3.10), which is narrower relative to length (L/W usually $>$10). *Closterium pseudolunula* was collected in a very broad range of habitats, including low elevation mesotrophic lakes, oligotrophic mountain ponds, and floating sphagnum bogs.

Closterium pusillum cells are very small, irregularly cylindrical, with a straight or nearly straight ventral margin and very slightly curved dorsal margin (Figures 3.156–3.159). The apex is broadly rounded and nearly as wide as the rest of the cell; apical pores are absent. The terminal vacuole usually contains one large crystal but occasionally has several smaller fused crystals. The cell wall is colorless, smooth, and lacks girdle bands. Each chloroplast contains 1–2 axial pyrenoids and extends to the base of a large, spherical terminal vacuole. *Closterium pusillum* is morphologically variable, and because of its small size, it is easy to overlook in a sample. The northwest Washington specimens were collected along the shoreline in slightly acidic, oligo-mesotrophic lakes.

Closterium ralfsii cells are large and crescent-shaped or fusiform, with a slightly to moderately curved dorsal margin and inflated ventral margin (Figures 3.160–3.164). The apex is truncated at an angle and contains a large apical pore. The spherical terminal vacuoles contain one or more crystals; when many crystals are present they may form fused groups. The cell wall is yellowish to dark reddish brown, lacks girdle bands, and is finely striated, with tiny punctae between the striations. The striations stop short of the apex, but the punctae continue to the apex, making this feature difficult to see, especially in darkly colored cells. Each chloroplast extends nearly to the apex and contains 4–10 (or more) axial pyrenoids. All of the northwest Washington specimens appear to be ***Closterium ralfsii* var. *hybridum***, which is narrower, with a less pronounced ventral inflation, and with finer striations compared to the nominate variety.[16]

[16] *Closterium ralfsii* var. *ralfsii*

Closterium ralfsii var. *hybridum* is found in slightly acidic, boggy lakes and ponds. This species can be difficult to separate from some varieties of *Closterium striolatum* (Figure 3.178), which are usually smaller, lack the ventral inflation, have girdle bands, and usually have a single large apical crystal.

Closterium* cf. *rectimarginatum cells are fusiform and nearly straight except near the apex, which is slightly curved along the dorsal margin (Figures 3.165–3.168). The apex in the northwest Washington specimens is truncated or broadly rounded,[17] lacks an apical pore, and has an oval or spherical vacuole with several large crystals. The cell wall is colorless, smooth, and lacks girdle bands. Each chloroplast extends almost to the apex and contains 2–8 axial pyrenoids. *Closterium rectimarginatum* appears to be a rare desmid because it is not described in most desmid keys, so the species identification is uncertain. The northwest Washington specimens were collected from several slightly acidic, mesotrophic ponds and lakes.

Closterium rostratum cells are bow-shaped, with a broadly inflated center, and short, curved, beak-like extensions (Figures 3.169–3.173). The dorsal margin is usually more strongly curved than the ventral margin, which can be nearly straight in the central portion of the cell. The apex is slightly inflated and contains a small apical pore. The vacuoles are located at the upper end of each chloroplast near the base of the beak-like extensions (subapical), and contain several small crystals. The cell wall ranges from colorless to yellowish brown, lacks girdle bands, and is faintly striated. The chloroplasts are confined to the central fusiform portion of the cell, and each contains 3–8 axial pyrenoids.

Closterium rostratum is usually found in slightly acidic, mesotrophic lakes and ponds, but the northwest Washington specimens were collected in a wide variety of habitats, including moderately eutrophic residential ponds. *Closterium rostratum* cells exhibit considerable morphological variability, even in samples collected at the same location (Figure 3.173). *Closterium rostratum* resembles *Closterium kuetzingii* (Figure 3.97) and *Closterium setaceum* (Figure 3.174), both of which are much more delicate in structure have have long, mostly straight extensions. The *Closterium rostratum* extensions form a continuous curve with the fusiform portion of the cell along the dorsal margin of the cell.

Closterium setaceum cells are bow-shaped and nearly straight, with a narrowly inflated center, and long, narrow, beak-like extensions (Figures 3.174–3.177). The extensions are straight almost to the apex, then gently curved, giving the cell a

[17] Scott and Prescott (1961) describe the *Closterium rectimarginatum* apex as narrowly rounded.

symmetric appearance with equal dorsal and ventral curvature. Each extension is longer than the combined length of both chloroplasts. The apex is usually slightly expanded and contains a small apical pore. The vacuoles are located at the upper end of each chloroplast near the base of the narrow extensions (subapical), and contain several small crystals. The cell wall is colorless or pale yellow, lacks girdle bands, and is faintly striated; the striations are very fine, so the cell wall usually appears smooth. The chloroplasts are confined to the central fusiform portion of the cell and each contains 2–3 axial pyrenoids.

Closterium setaceum is usually found in slightly acidic, oligo-mesotrophic or mesotrophic lakes and ponds. *Closterium setaceum* can be difficult to distinguish from *Closterium kuetzingii* (Figure 3.97), especially because both species may be present in the same sample. The best separation feature is the greater length of the extensions in *Closterium setaceum*, which gives the species a more delicate appearance (see Figure 3.101).

Closterium striolatum cells are approximately cylindrical, with a nearly straight center and slightly curved upper region (Figures 3.178–3.181). The center of the cell may have parallel sides or may be slightly inflated above the isthmus; the upper portion of the cell is gently curved and tapered to the apex. The apex is broadly truncated (sometimes rounded or inflated), with an apical pore. The terminal vacuole is spherical and contains one or more aggregated crystals. The cell wall is brown or rusty colored, distinctly striated, with girdle bands, and sutures. Each chloroplast extends nearly to the apex and contains 4–10 (or more) axial pyrenoids.

Closterium striolatum is common in boggy, slightly acidic lakes and ponds, but can also be found in other habitats, including eutrophic residential sites. The species is polymorphic, but the heavily striated, brownish cell wall is fairly distinctive. *Closterium striolatum* resembles *Closterium costatum* (Figure 3.51), which has much wider cells; *Closterium nematodes* (Figure 3.132), which has a thickened subapical ring; and *Closterium ralfsii* (Figure 3.160), which has an inflated ventral margin, lacks girdle bands, and has many small crystals in the terminal vacuole.

Closterium venus cells are relatively small, crescent-shaped, and strongly curved ($\sim$150–160°; Figures 3.182–3.184). The ventral margin is evenly curved, with no median inflation. The apex is acute, with a small pore just below the apex on the dorsal side. The terminal vacuole is well-defined and contains one or more large crystals. The cell wall is colorless or yellowish brown, smooth, and lacks girdle bands. The chloroplasts usually only fills about half of the cell, ending well below the apex; each chloroplast contains 1–3 large, axial pyrenoids.

Closterium venus cells are very similar to *Closterium incurvum* (Figure 3.85). Both species are characterized by strongly curved, crescent-shaped cells with nearly the same size ranges for length and width. Both species can be present at the same site (Figure 3.88; Sovran, et al., 2013), so habitat does not help with separation. Despite the morphological similarity of the vegetative cells, the separation between *Closterium venus* and *Closterium incurvum* is supported by differences in their zygotes (Cook, 1963). The best visual features for separating these two species is the dorsal curvature, which is nearly hemispherical for *Closterium incurvum* vs. crescent-shaped for *Closterium venus*; and the chloroplast length, which extends nearly to the apex in *Closterium incurvum* cells, but ends well below the apex in *Closterium venus* cells.

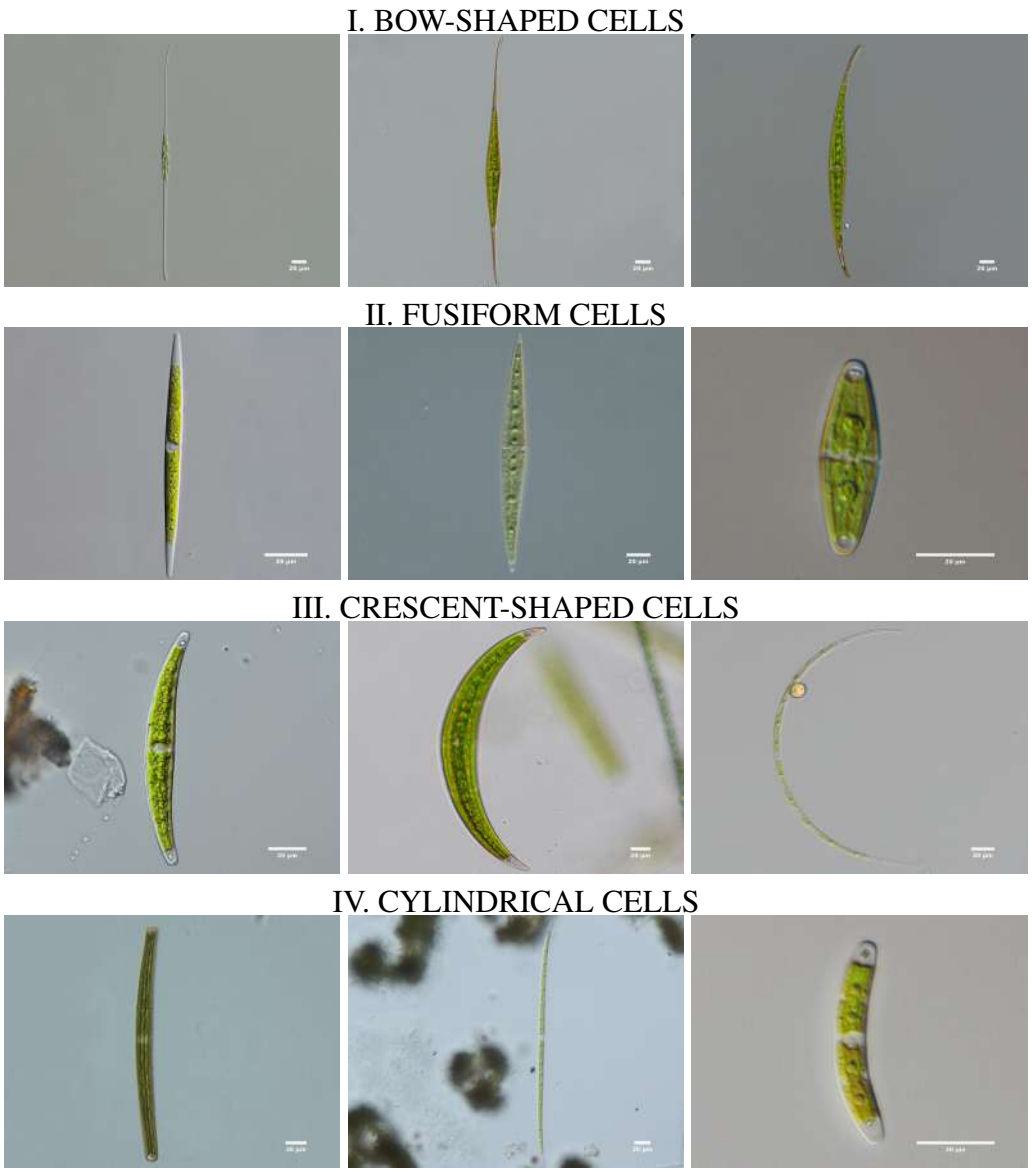


Figure 3.1: Examples of *Closterium* cell shapes. First row: bow-shaped cells with fusiform center and beak-like apical extensions (from left to right, *Closterium setaceum*, *Closterium kuetzingii*, *Closterium rostratum*). Second row: fusiform cells that are expanded at the center and evenly tapered to the apex (from left to right, *Closterium* cf. *cornu*, *Closterium* cf. *rectimarginatum*, *Closterium navicula*). Third row: crescent-shaped cells that are curved on one or both margins, usually with greater curvature on dorsal margin, and tapered near the apex (from left to right, *Closterium littorale*, *Closterium* cf. *parvulum*, *Closterium acutum* var. *variable*). Fourth row: cylindrical cells with parallel sides near center; cells are often curved and may be tapered near apex (from left to right, *Closterium directum*, *Closterium limneticum*, *Closterium pusillum*).

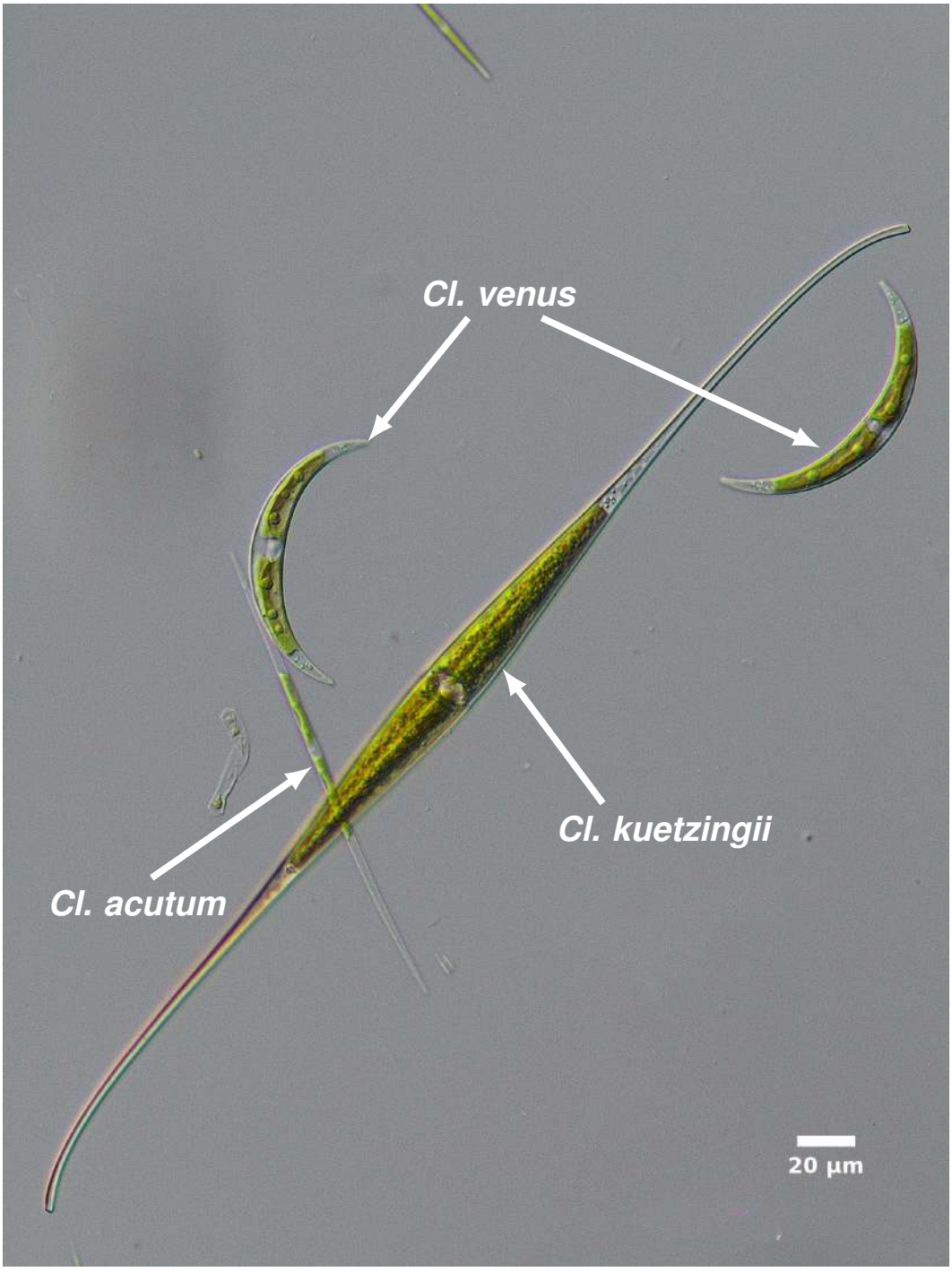


Figure 3.2: Size and curvature variations between three species of *Closterium*.

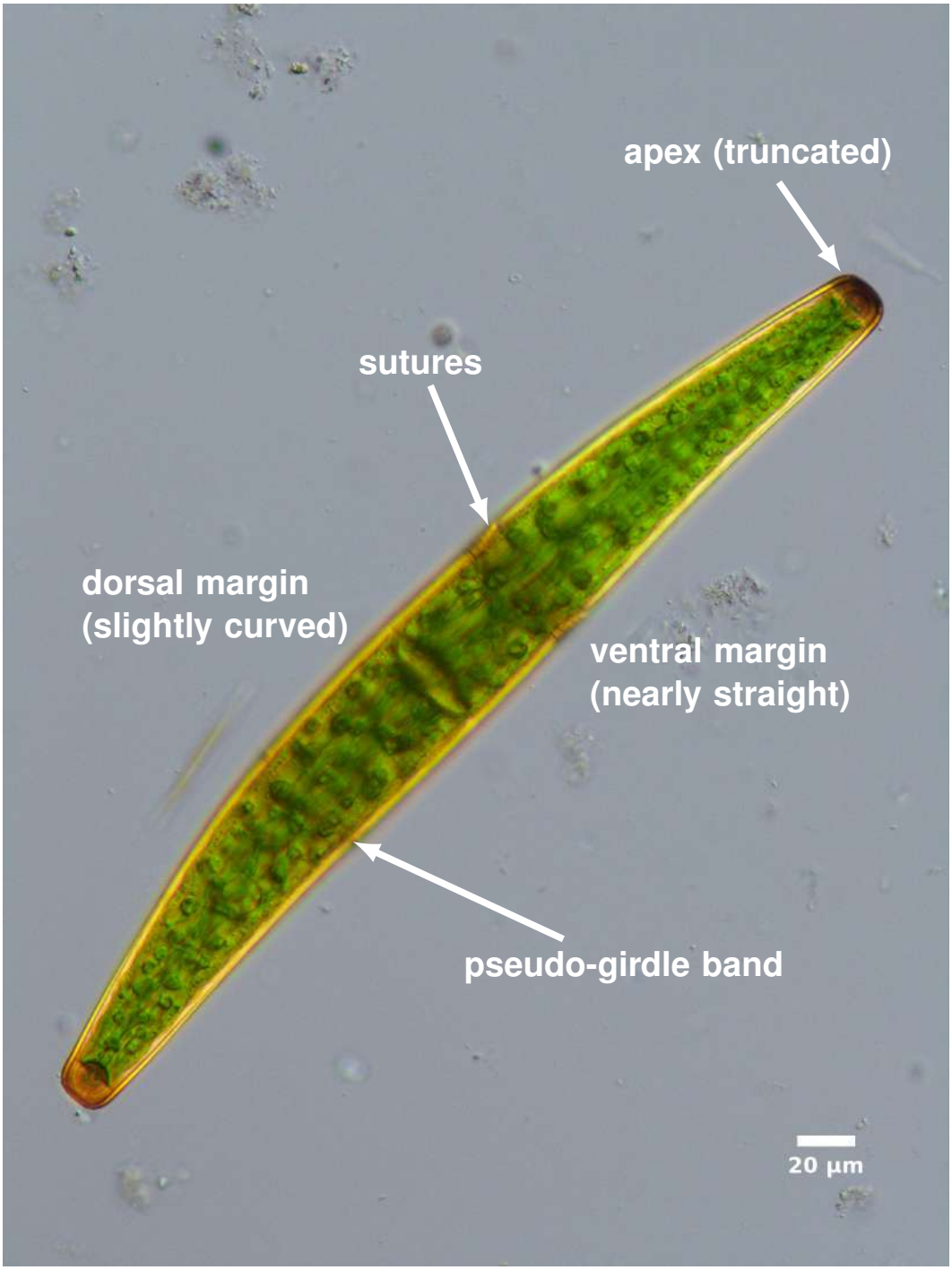


Figure 3.3: *Closterium* basic morphological features (*Closterium baillyanum*).

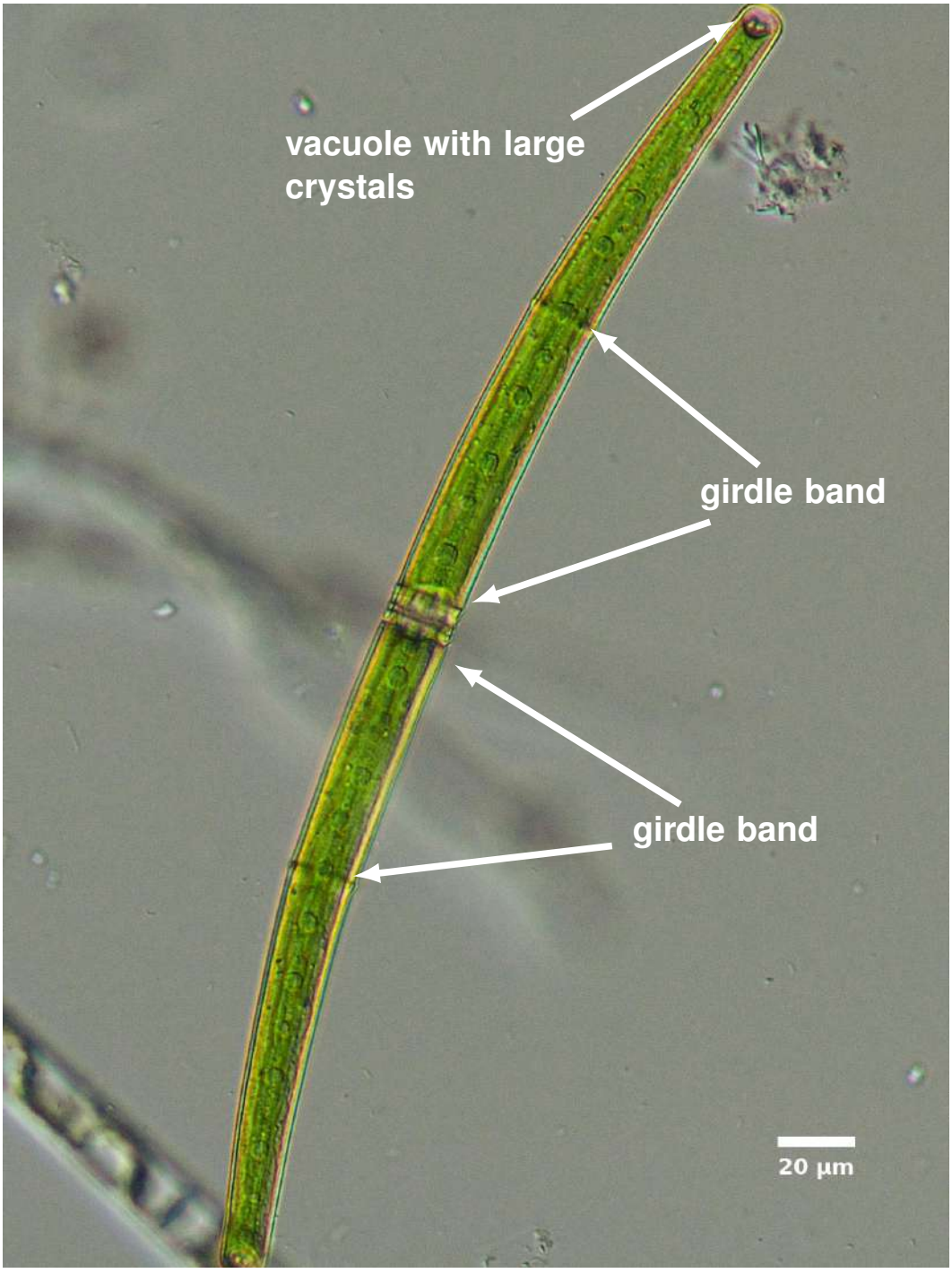


Figure 3.4: Example of *Closterium* girdle bands and terminal vacuole (*Closterium directum*).

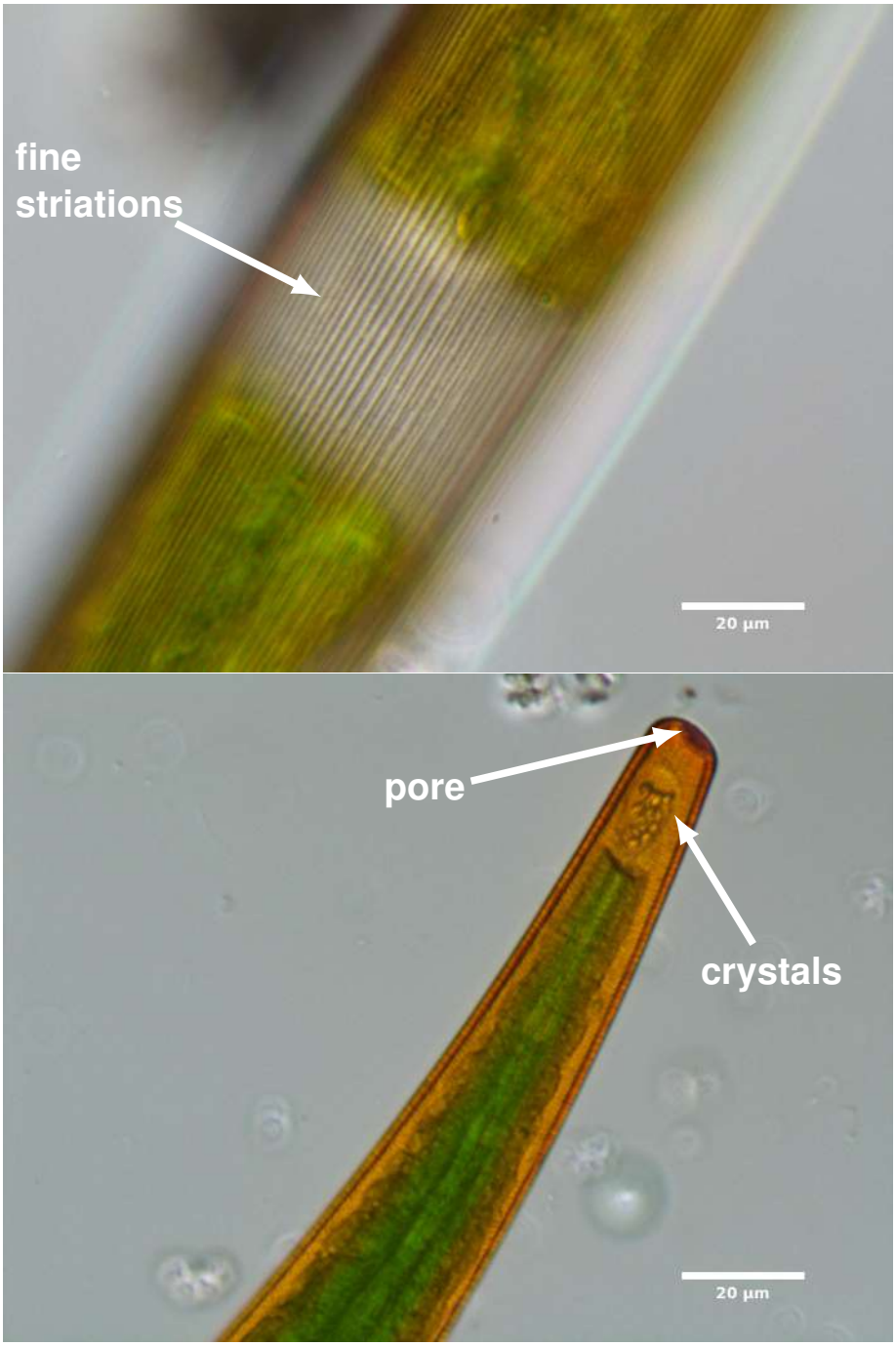
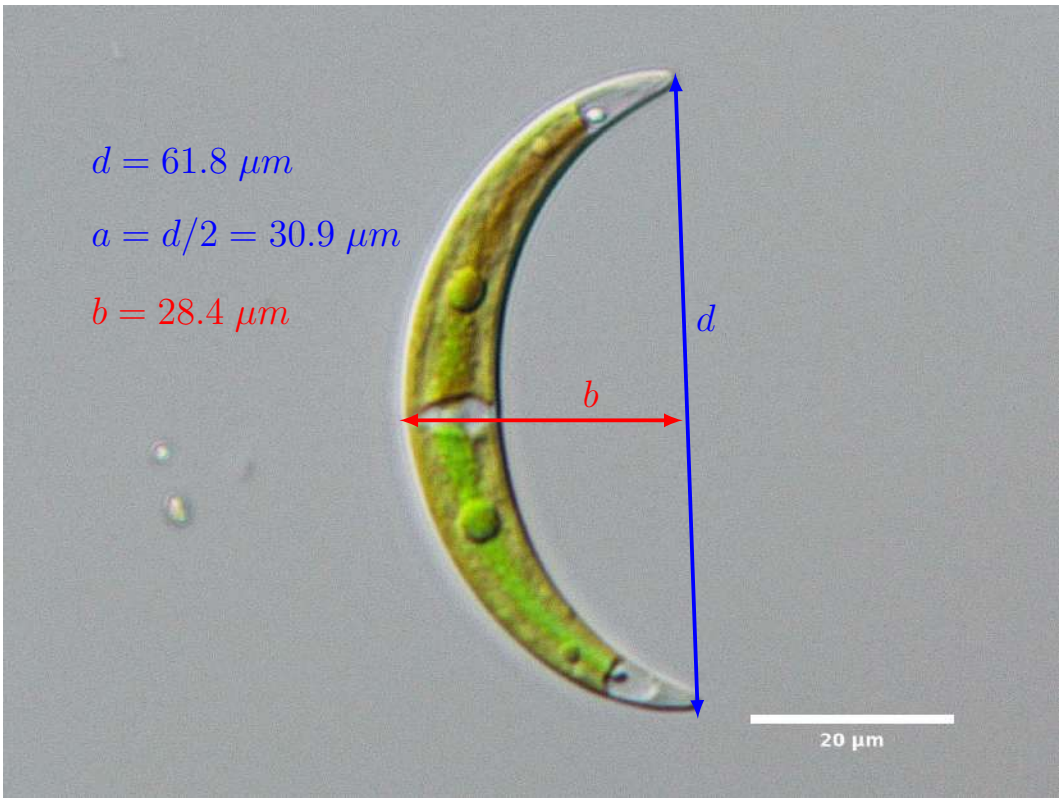


Figure 3.5: Example of *Closterium* wall striations, apical crystals, and apical pore (*Closterium ralfsii*).



$$\text{curvature} \quad = \quad 2\sin^{-1}\left(\frac{2ab}{a^2+b^2}\right) \times \frac{180}{\pi}$$

$$\text{curvature} \quad = \quad 2\sin^{-1}\left(\frac{2 \times 30.9 \times 28.4}{30.9^2+28.4^2}\right) \times \frac{180}{\pi} = 170^\circ \text{ (strongly curved)}$$

Figure 3.6: Example of cell curvature measurements.

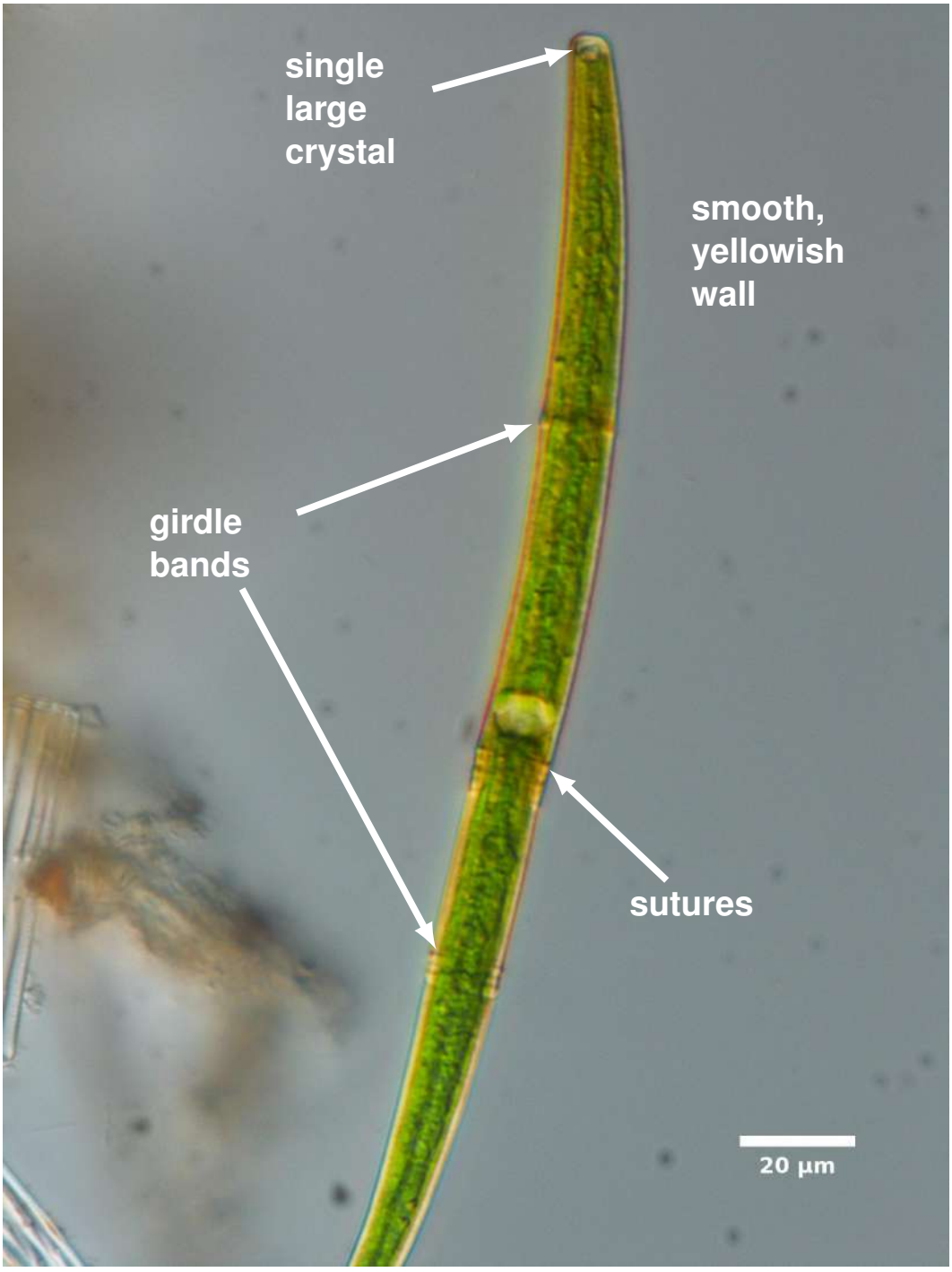


Figure 3.7: *Closterium abruptum* (DIC), small pond on trail to Big Four Ice Caves, Mountain Loop Highway, Snohomish County.

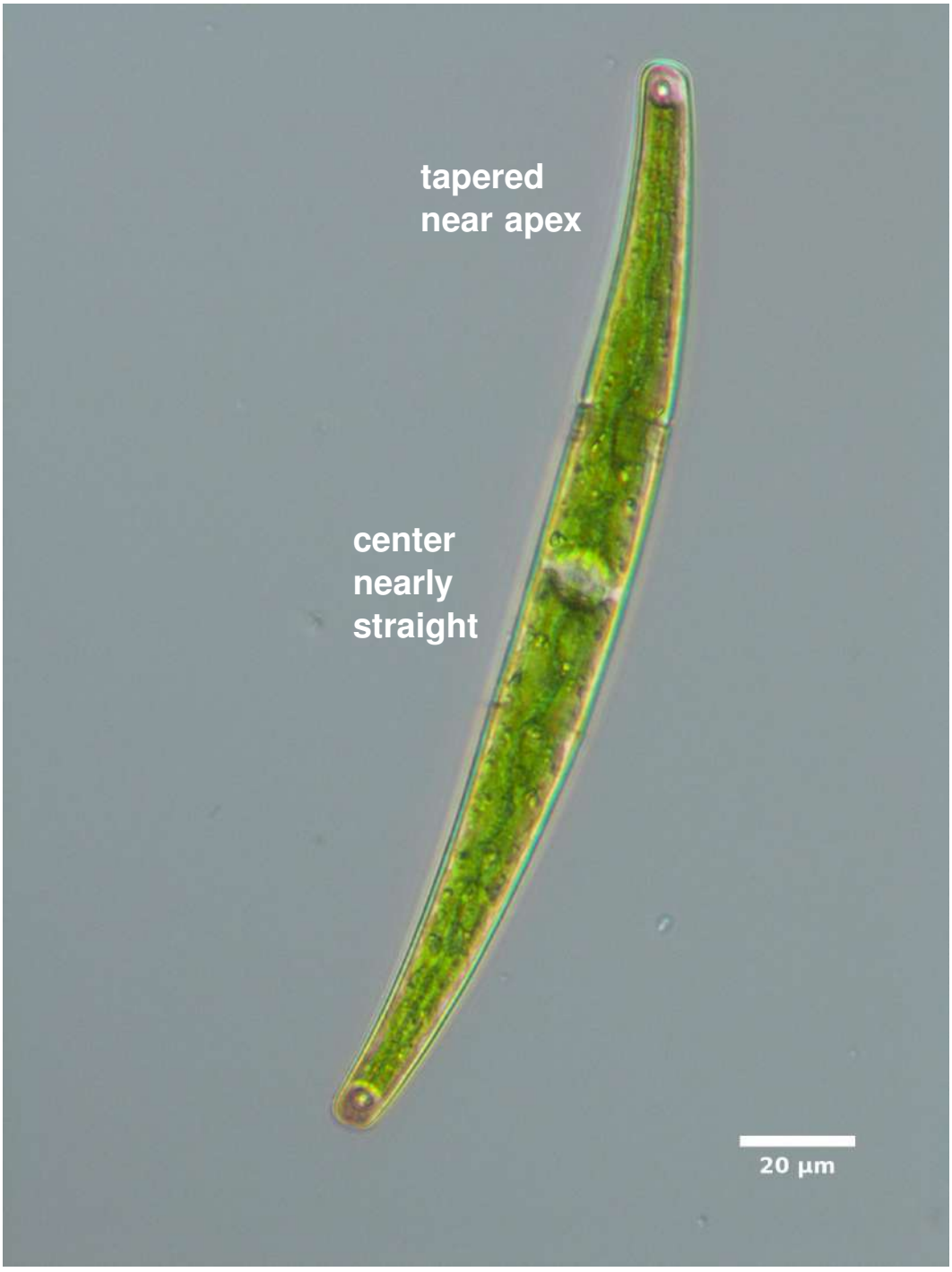


Figure 3.8: *Closterium abruptum* (DIC), Lower Ashland Lake, Mountain Loop Highway, Snohomish County.



Figure 3.9: *Closterium abruptum* (DIC), Myrtle Lake, Mountain Loop Highway, Snohomish County.

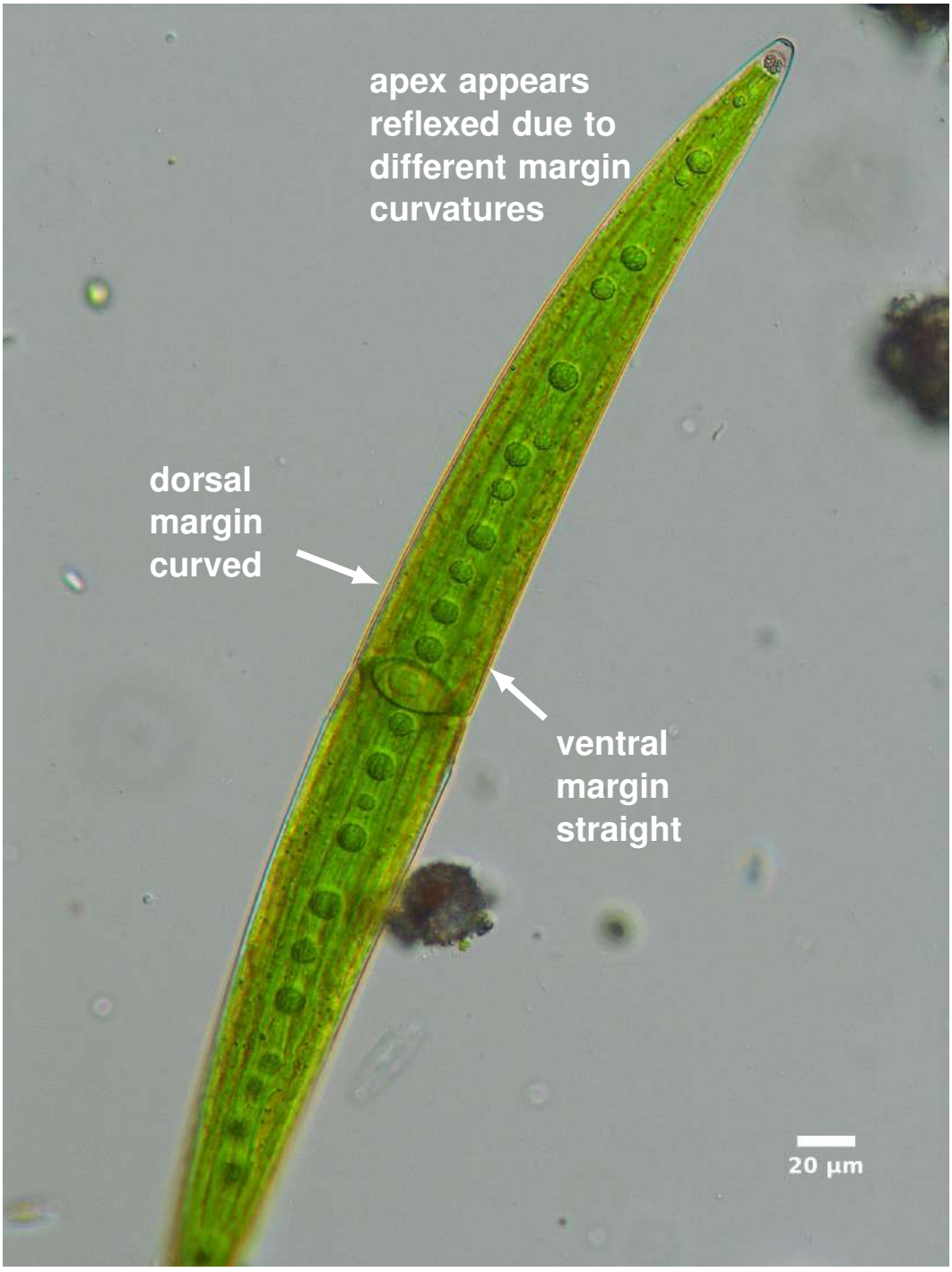


Figure 3.10: *Closterium acerosum* (DIC), small residential pond, Whatcom County.

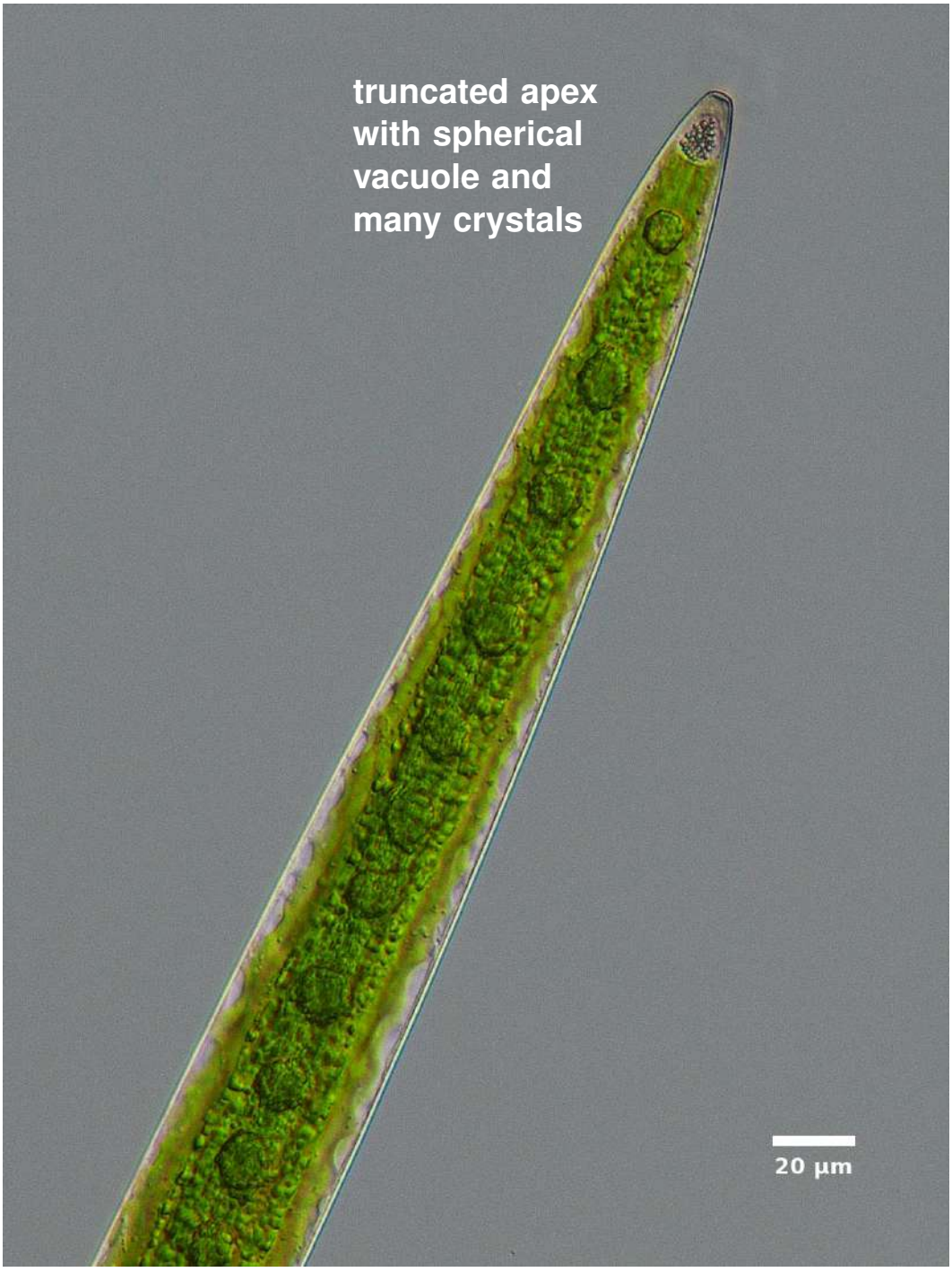


Figure 3.11: *Closterium acerosum* (DIC), Western Washington University storm water treatment pond, Whatcom County.

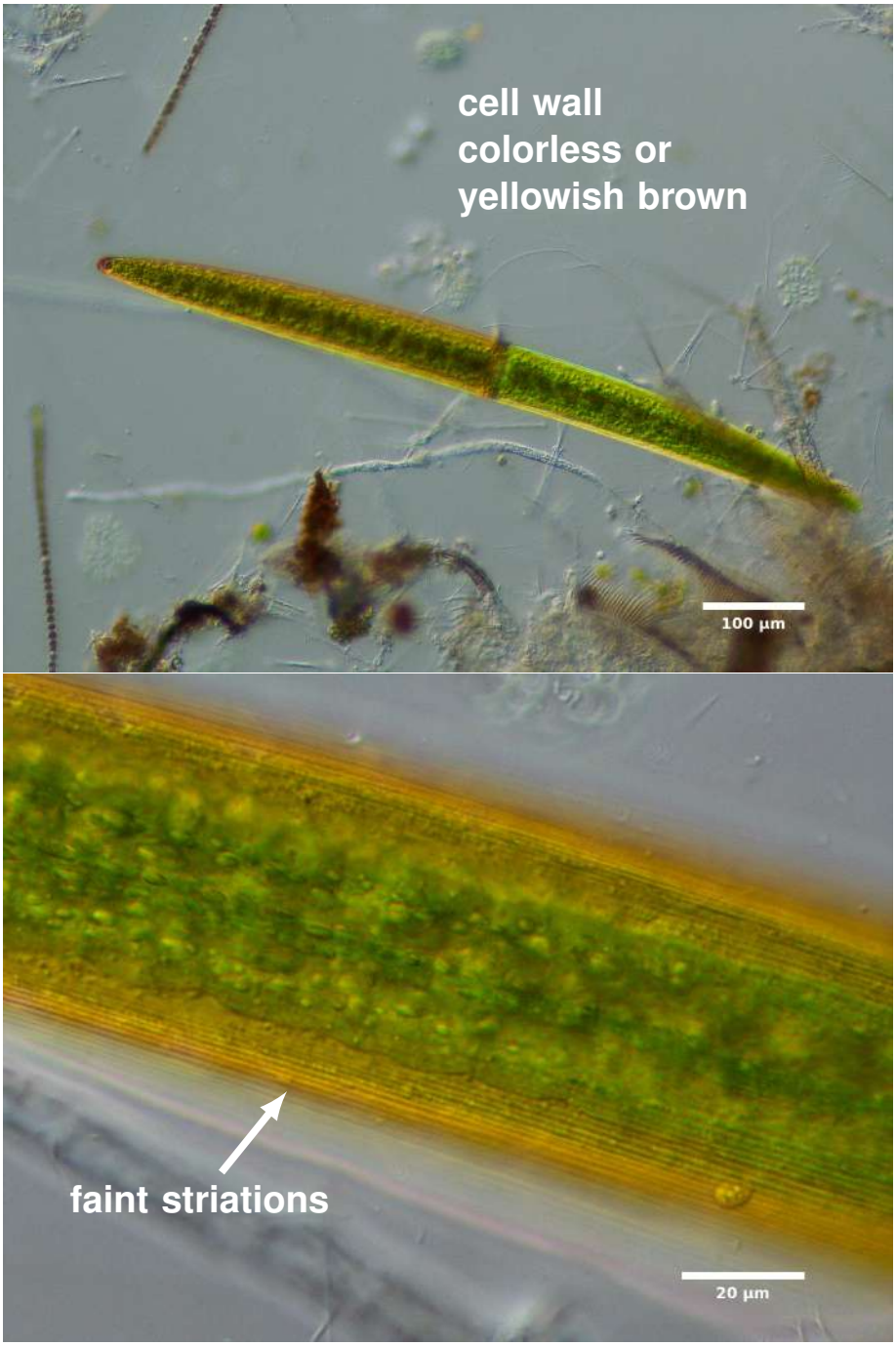


Figure 3.12: *Closterium acerosum* (DIC/DIC), Clear Lake, Skagit County (upper/lower images).



Figure 3.13: *Closterium acerosum* var. *elongatum* apex (bright field), Beaver Lake, Skagit County.



Figure 3.14: *Closterium acerosum* var. *elongatum* (DIC), Beaver Lake, Skagit County.



Figure 3.15: *Closterium acerosum* var. *elongatum* apex (DIC), Beaver Lake, Skagit County.

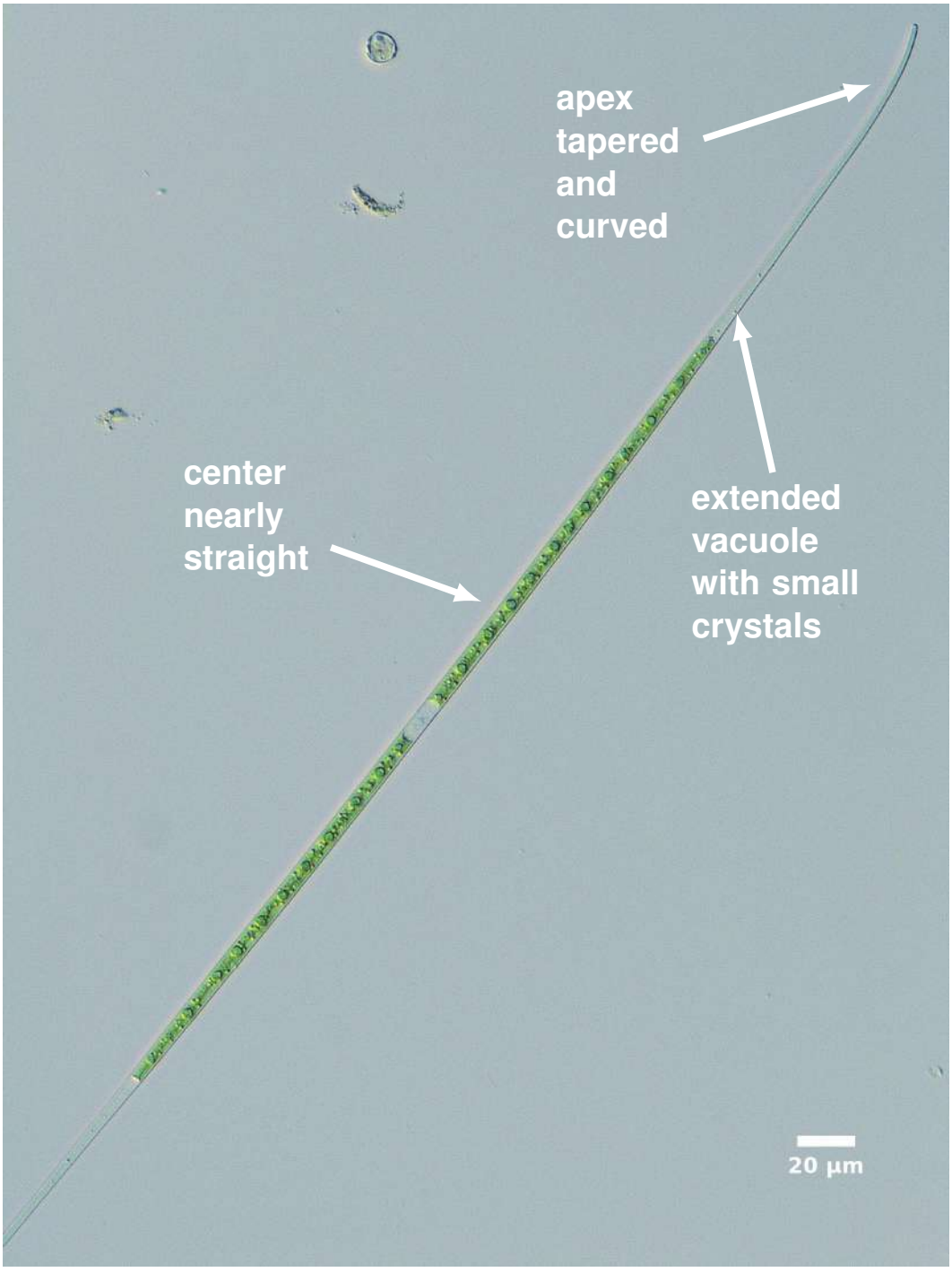


Figure 3.16: *Closterium aciculare* (DIC), Lake Terrell, Whatcom County.



Figure 3.17: *Closterium aciculare* (DIC), Lake Terrell, Whatcom County.

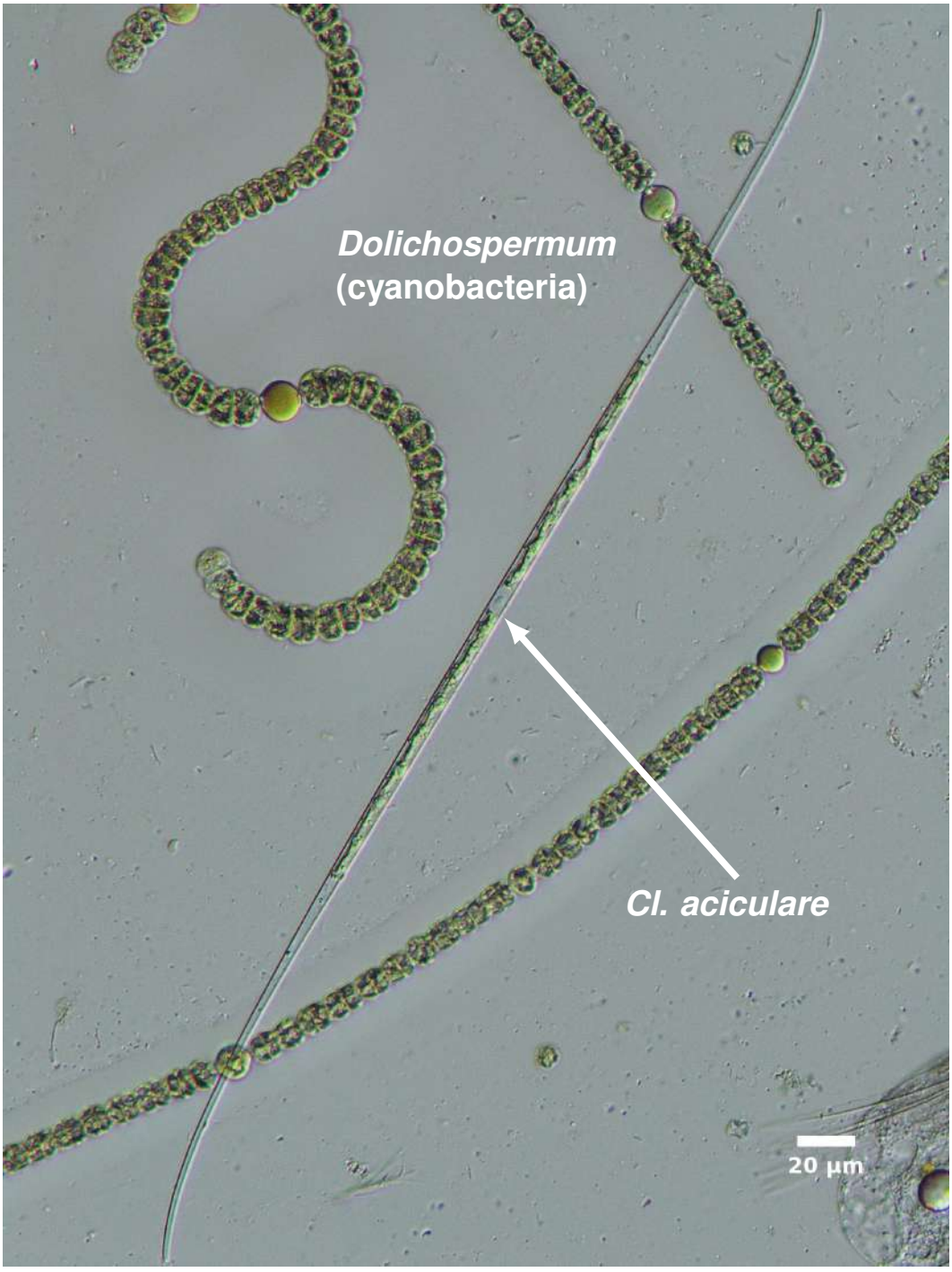


Figure 3.18: *Closterium aciculare* in cyanobacteria bloom (DIC), Heart Lake, Skagit County.

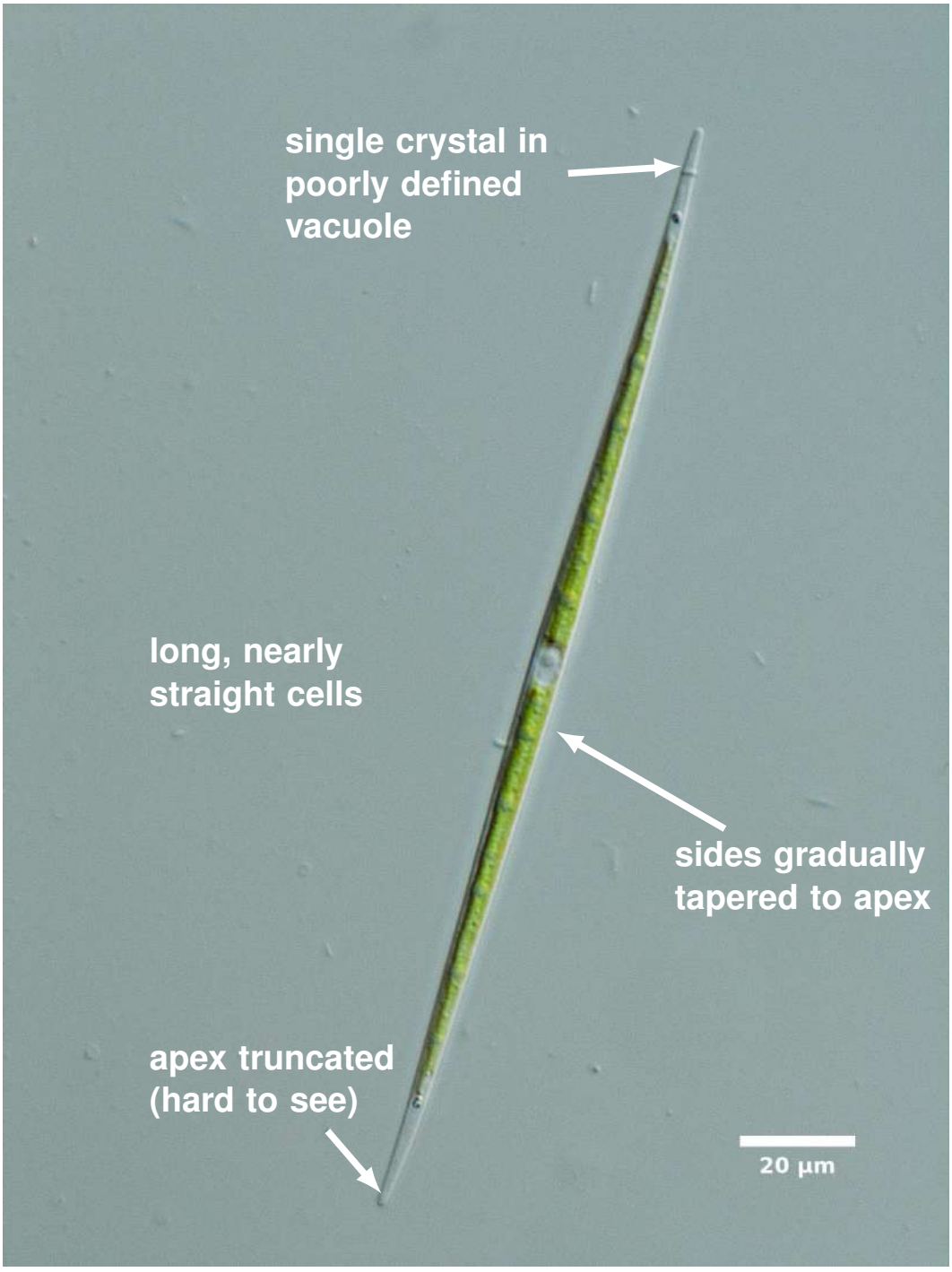


Figure 3.19: *Closterium acutum* (DIC), Reed Lake, Whatcom County.



Figure 3.20: *Closterium acutum* (DIC), small pond on trail to Dock Butte, Mt. Baker area, Skagit County.

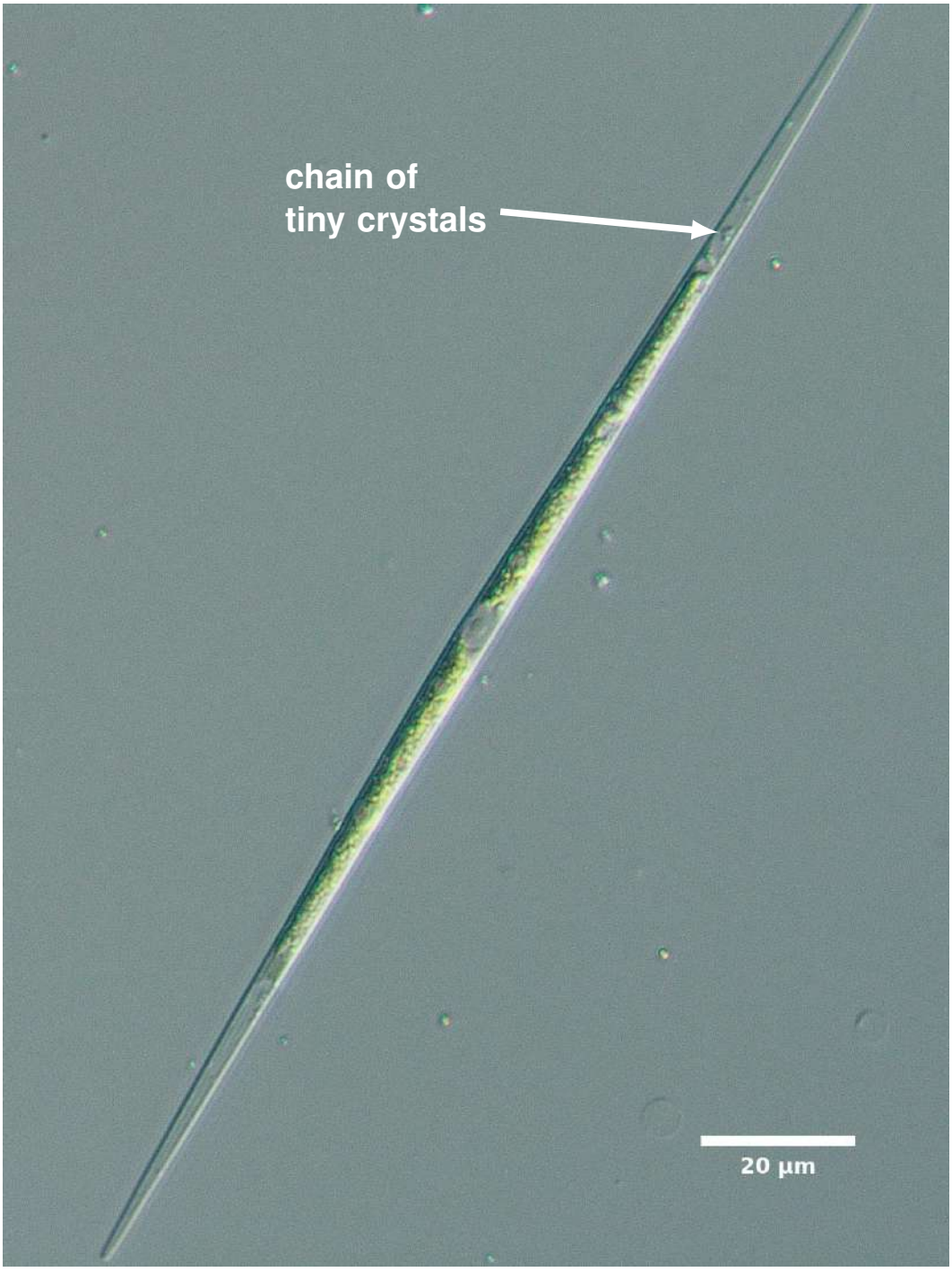


Figure 3.21: *Closterium acutum* (DIC), Lake Terrell, Whatcom County.



Figure 3.22: *Closterium acutum* var. *variable* (DIC), Moses Lake (eastern Washington), Grant County.



Figure 3.23: *Closterium acutum* var. *variable* (DIC), Heart Lake, Skagit County.



Figure 3.24: *Closterium acutum* var. *variable* (DIC), Heart Lake, Skagit County.



Figure 3.25: *Closterium acutum* var. A (DIC/DIC), Kwan Lake, Whatcom County (upper image); Thunderbird Lake, Whatcom County (lower image). Despite variation in curvature, these cells may be the same variety.

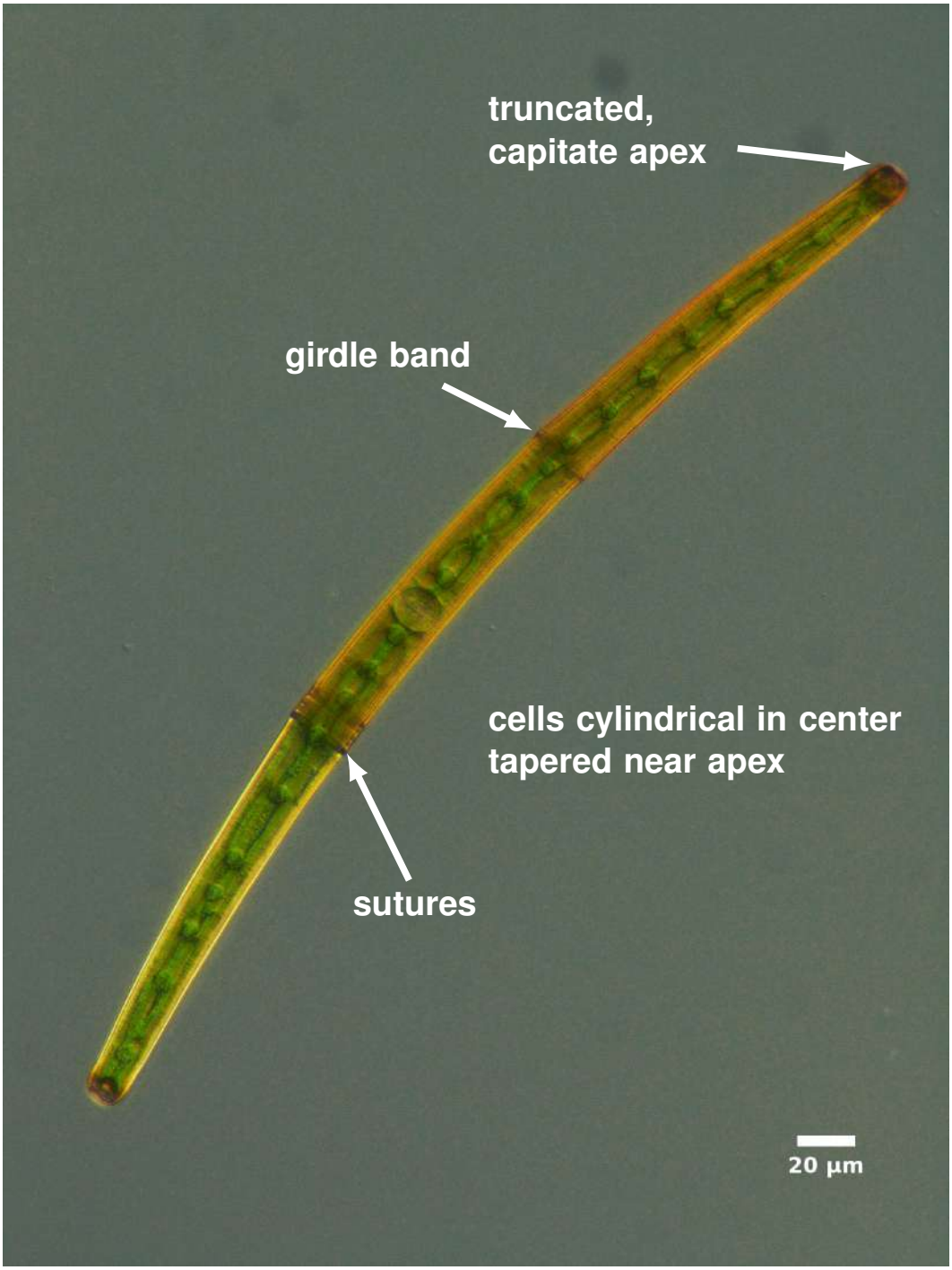


Figure 3.26: *Closterium angustatum* (DIC), Highwood Lake, Mt. Baker area, Whatcom County.

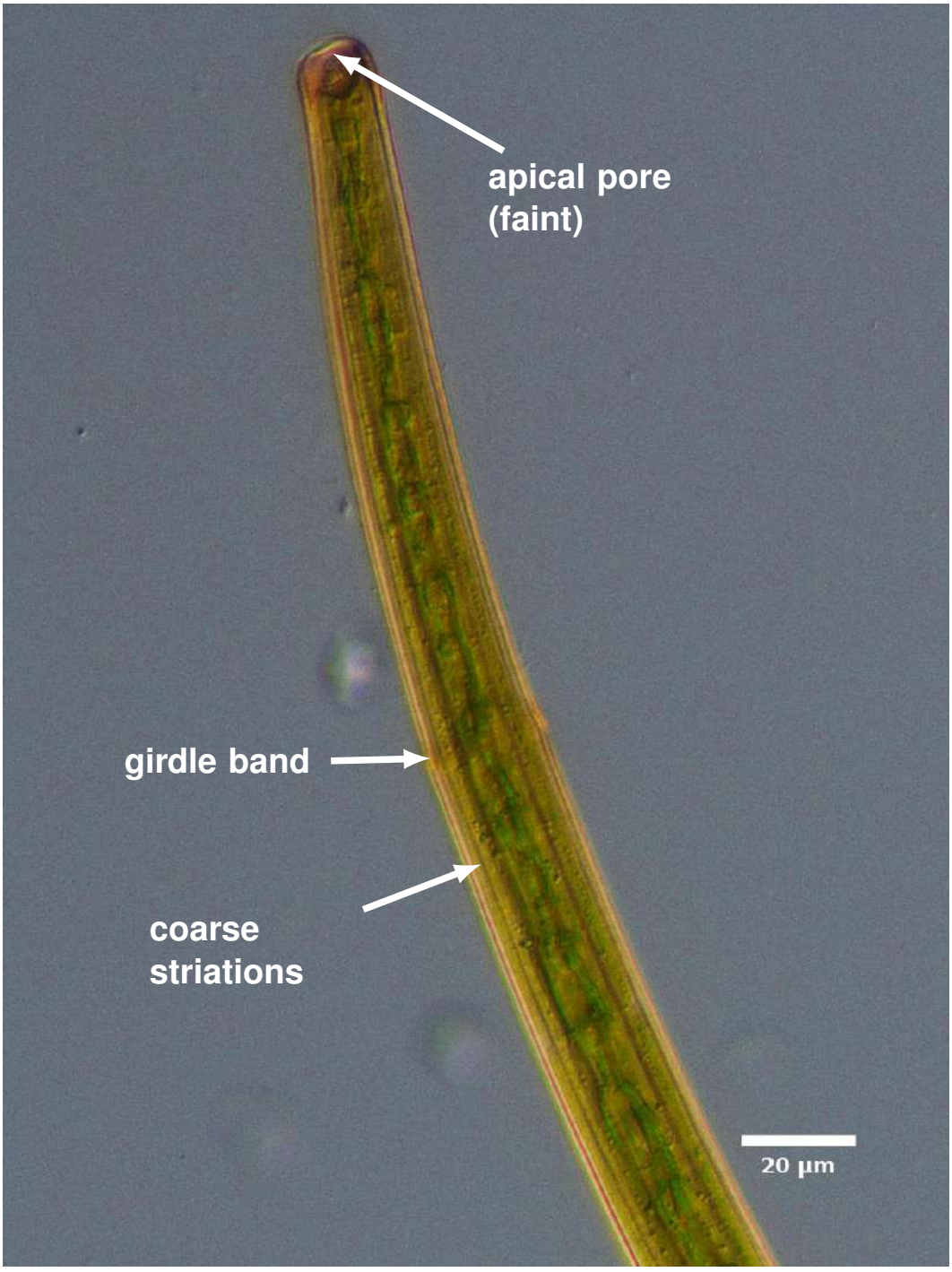


Figure 3.27: *Closterium angustatum* (DIC), Myrtle Lake, Mountain Loop Highway, Snohomish County.

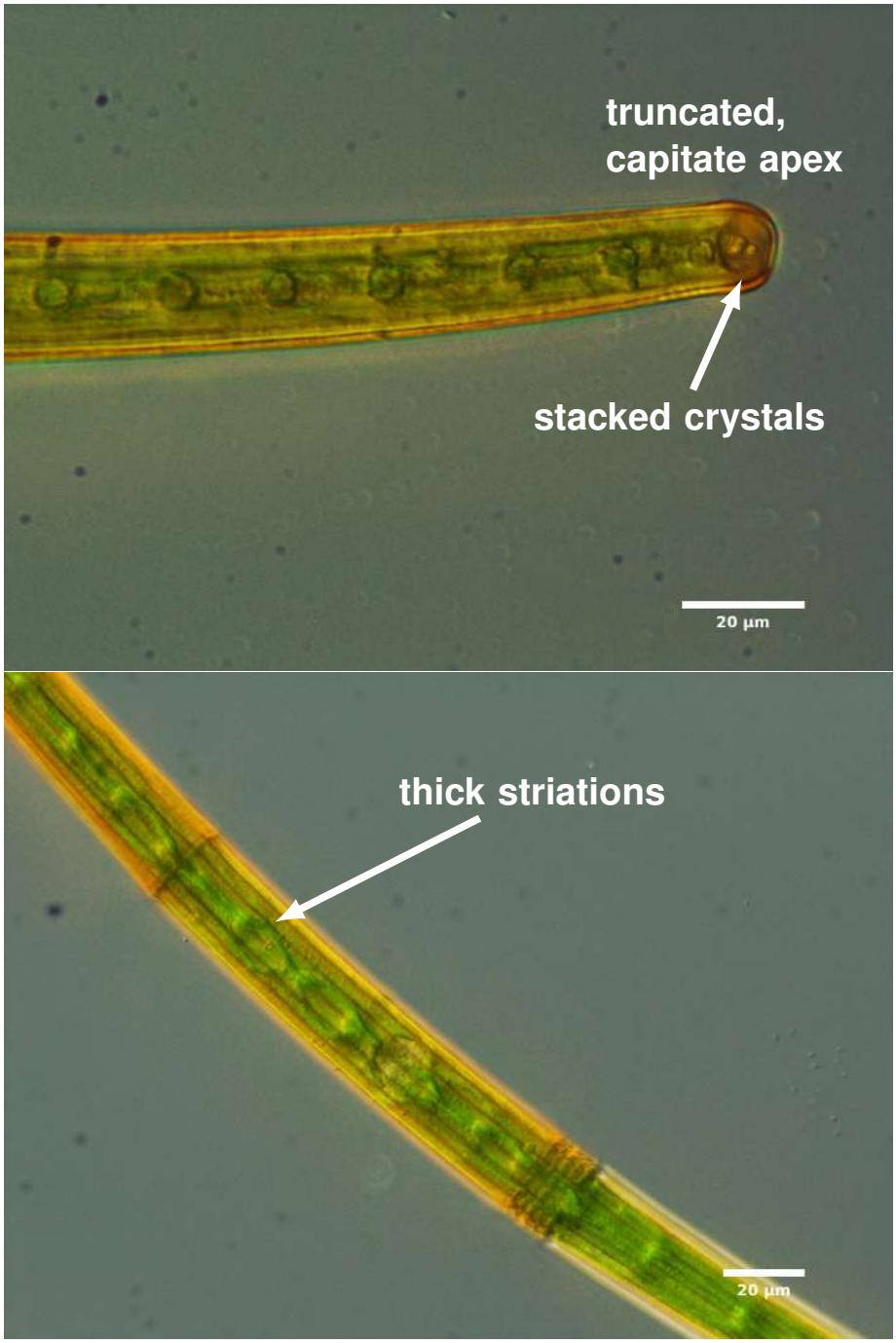


Figure 3.28: *Closterium angustatum* (DIC/DIC), Highwood Lake, Mt. Baker area, Whatcom County (upper/lower images).



Figure 3.29: *Closterium angustatum* (DIC), Myrtle Lake, Mountain Loop Highway, Snohomish County.



Figure 3.30: *Closterium archerianum* (DIC), Storm Lake, Snohomish County.



Figure 3.31: *Closterium archerianum* (DIC), Storm Lake, Snohomish County.



Figure 3.32: *Closterium baillyanum* (DIC), Mirror Lake, Whatcom County.



Figure 3.33: *Closterium baillyanum* (DIC), Lower Ashland Lake, Mountain Loop Highway, Snohomish County.



Figure 3.34: *Closterium baillyanum* (DIC), Summer Lake, Skagit County.



Figure 3.35: *Closterium baillyanum* (DIC), Mirror Lake, Whatcom County.



Figure 3.36: *Closterium baillyanum* var. *alpinum* (DIC), small floating bog along Morris Valley Road near Harrison, BC.

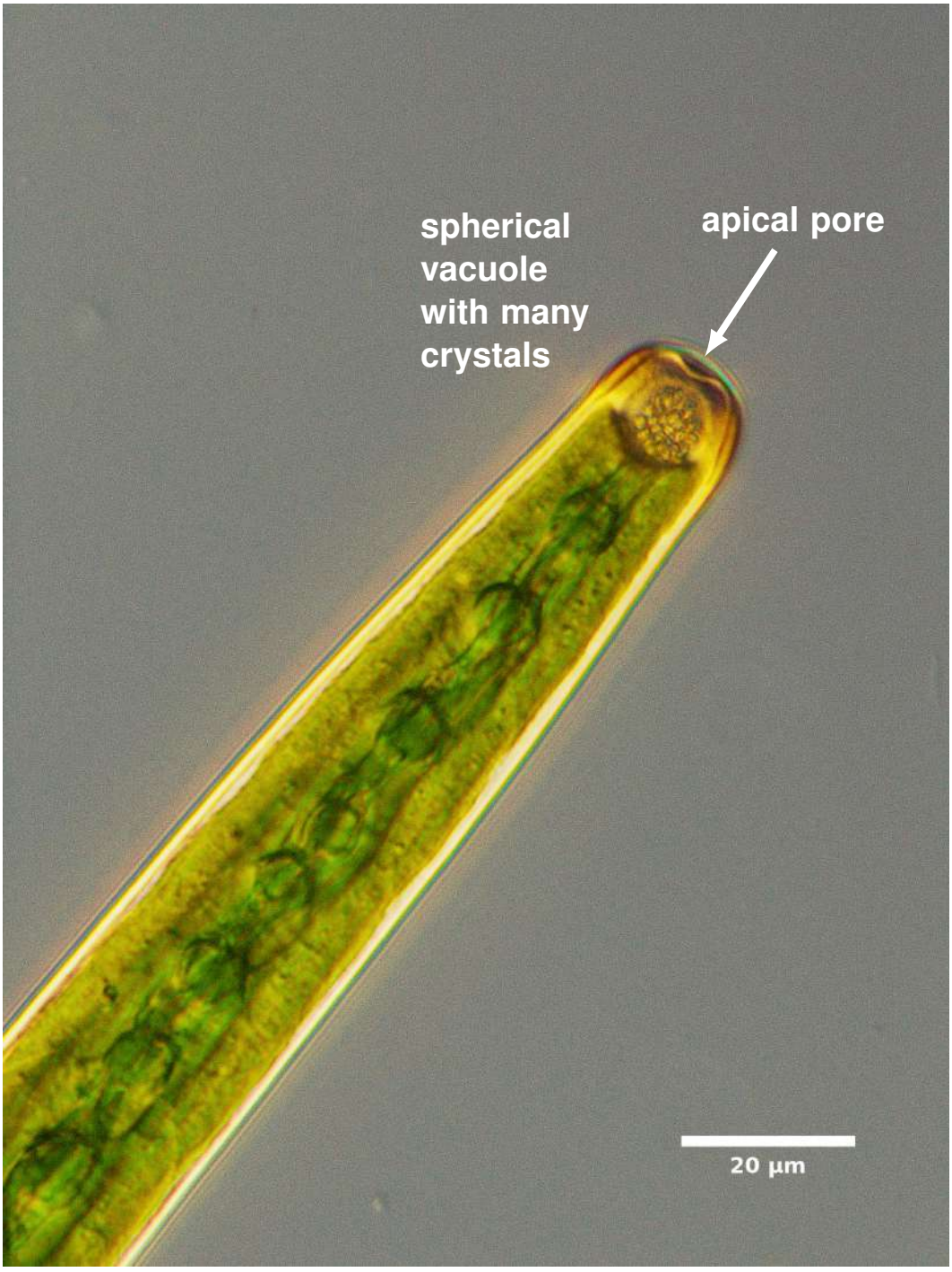


Figure 3.37: *Closterium baillyanum* var. *alpinum* (DIC), small floating bog along Morris Valley Road near Harrison, BC.



Figure 3.38: *Closterium braunii* (DIC), Myrtle Lake, Mountain Loop Highway, Snohomish County.



Figure 3.39: *Closterium braunii* (DIC), Summer Lake, Skagit County.

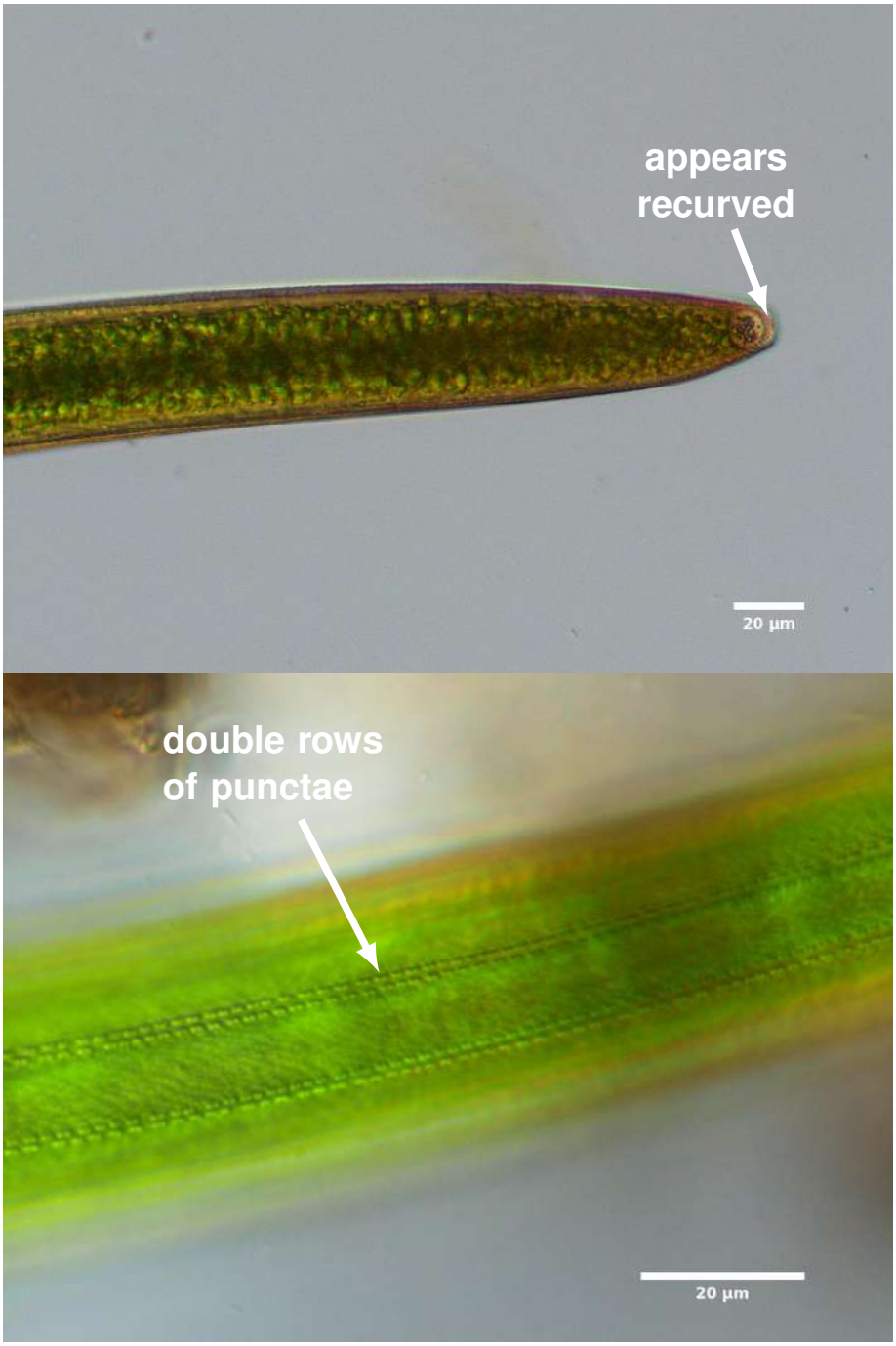


Figure 3.40: *Closterium braunii* (DIC/DIC), Myrtle Lake, Mountain Loop Highway, Snohomish County (upper/lower images).

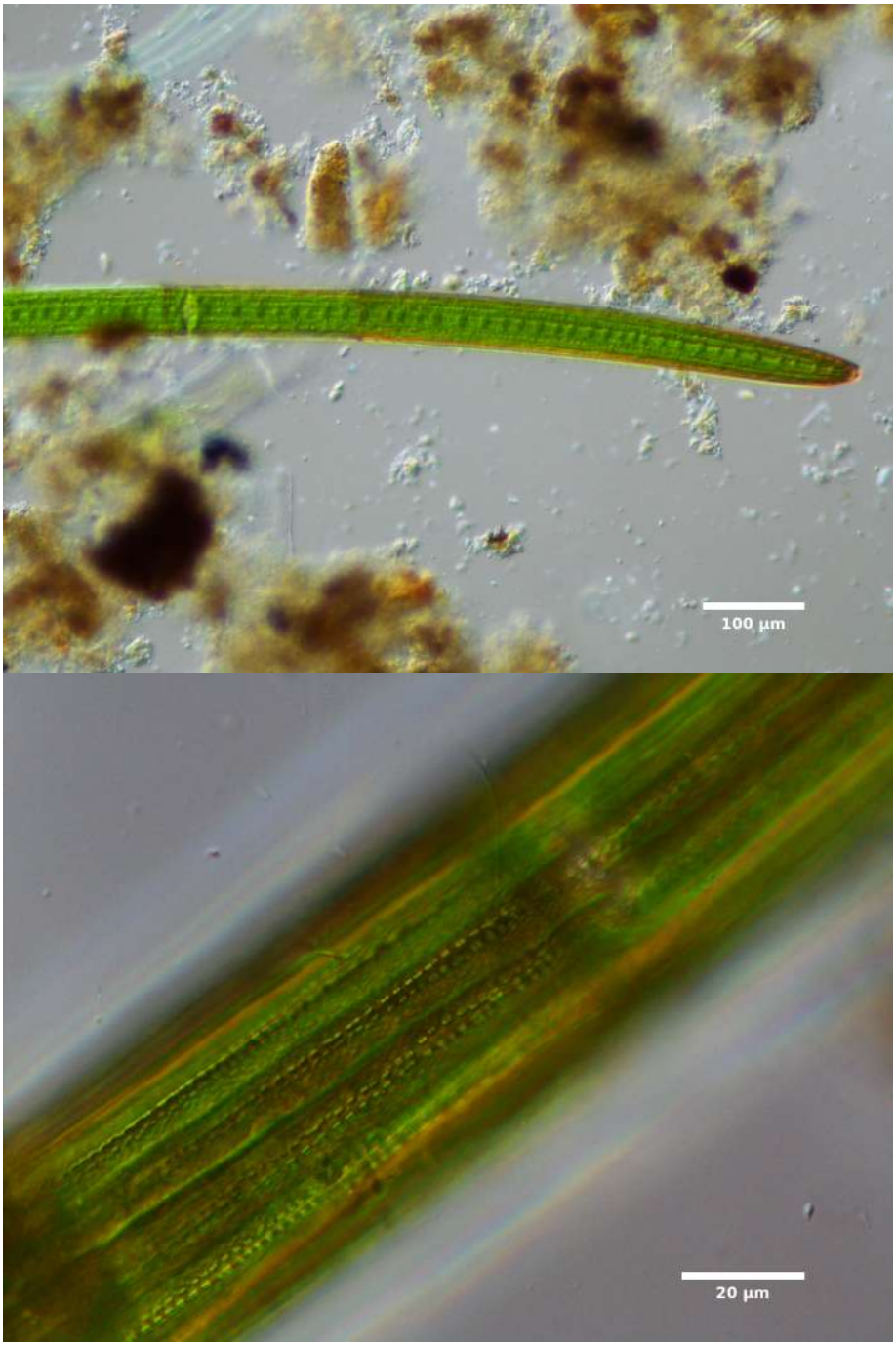


Figure 3.41: *Closterium braunii* (DIC/DIC), Beaver Pond Lake, Whatcom County (upper/lower images).

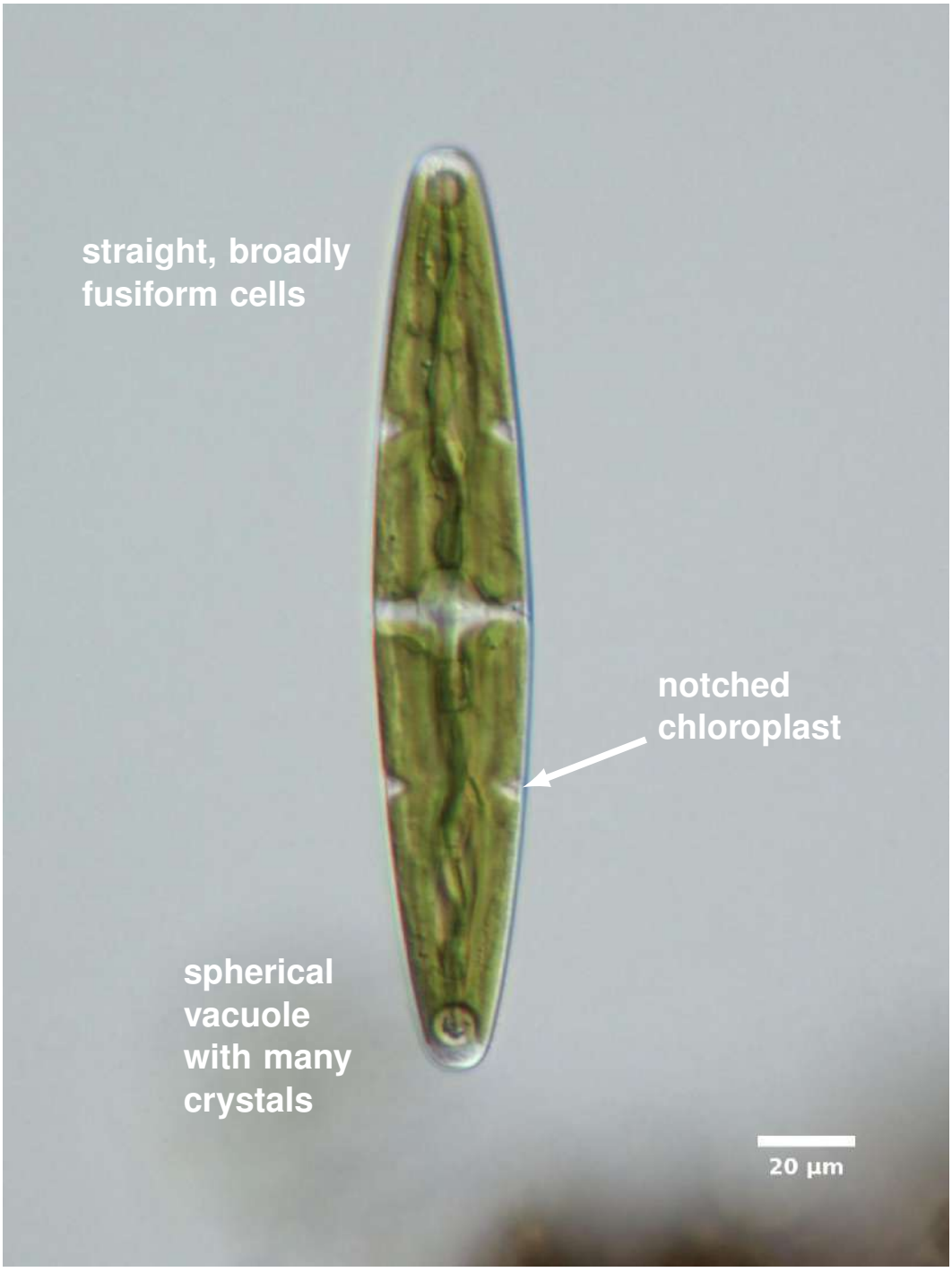


Figure 3.42: *Closterium closterioides* (DIC), Lake Evan, Mountain Loop Highway, Snohomish County.



Figure 3.43: *Closterium closterioides* (DIC), Lower Ashland Lake, Mountain Loop Highway, Snohomish County.



Figure 3.44: *Closterium closterioides* (DIC), Pine Lake, Whatcom County.

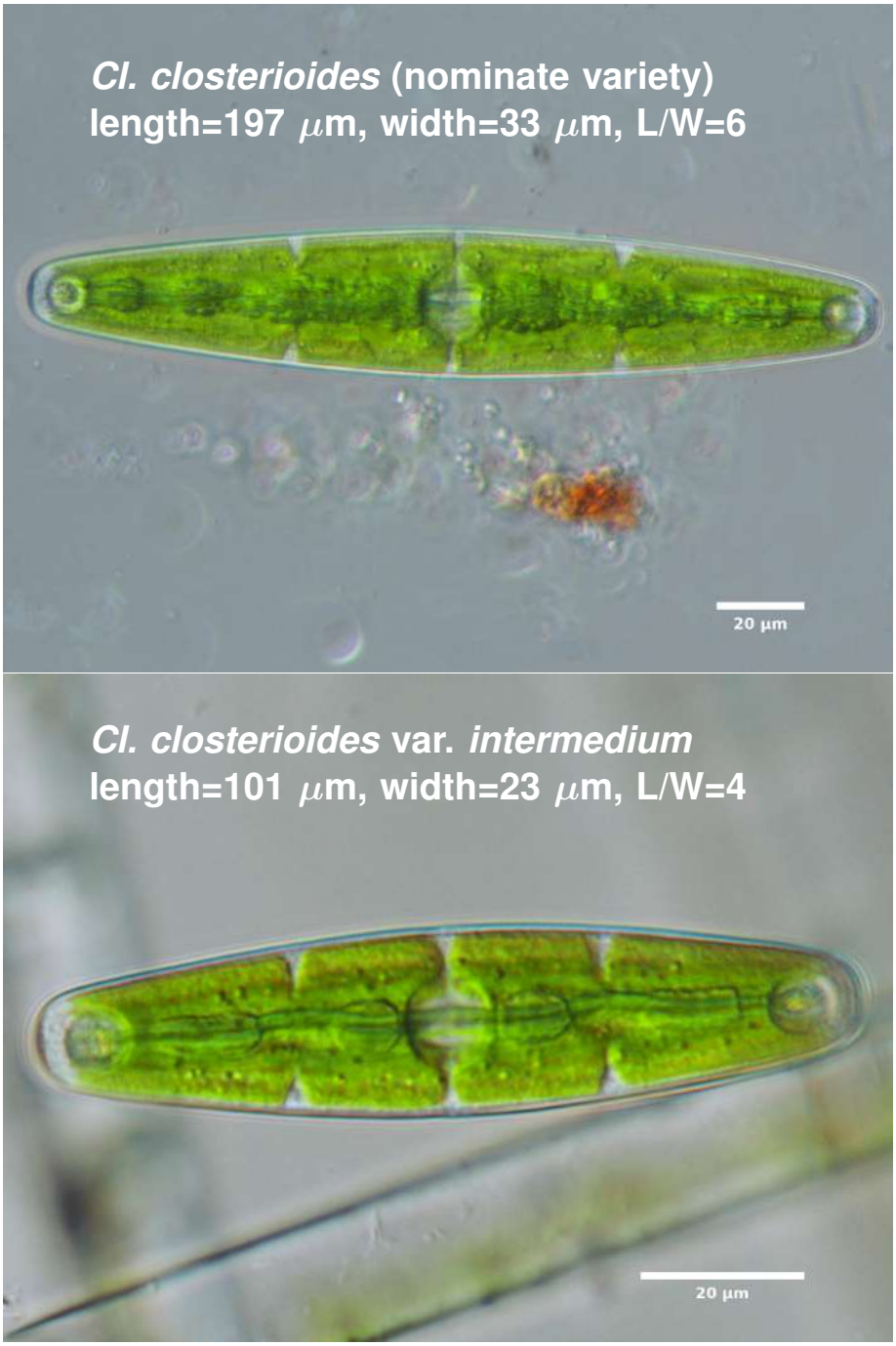


Figure 3.45: *Closterium closterioides* and *Closterium closterioides* var. *intermedium* (DIC/DIC), samples collected on same date, Lower Ashland Lake, Mountain Loop Highway, Snohomish County (upper/lower images).

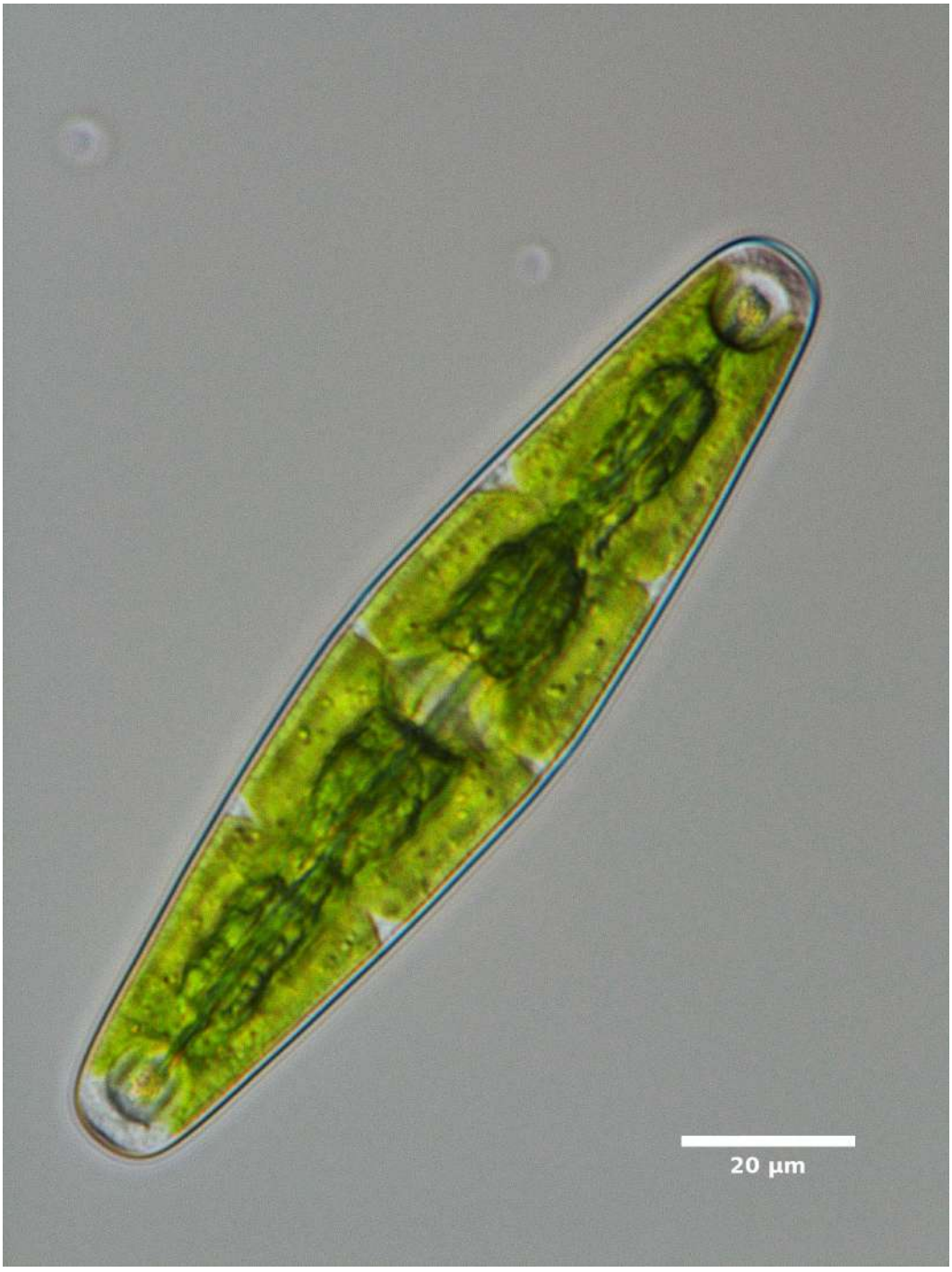


Figure 3.46: *Closterium closterioides* var. *intermedium* (DIC), Upper Anderson Lake, Mt. Baker area, Whatcom County.



Figure 3.47: *Closterium closterioides* var. *intermedium* (DIC), Chain Lake, Gifford Pinchot National Forest, Skamania County.

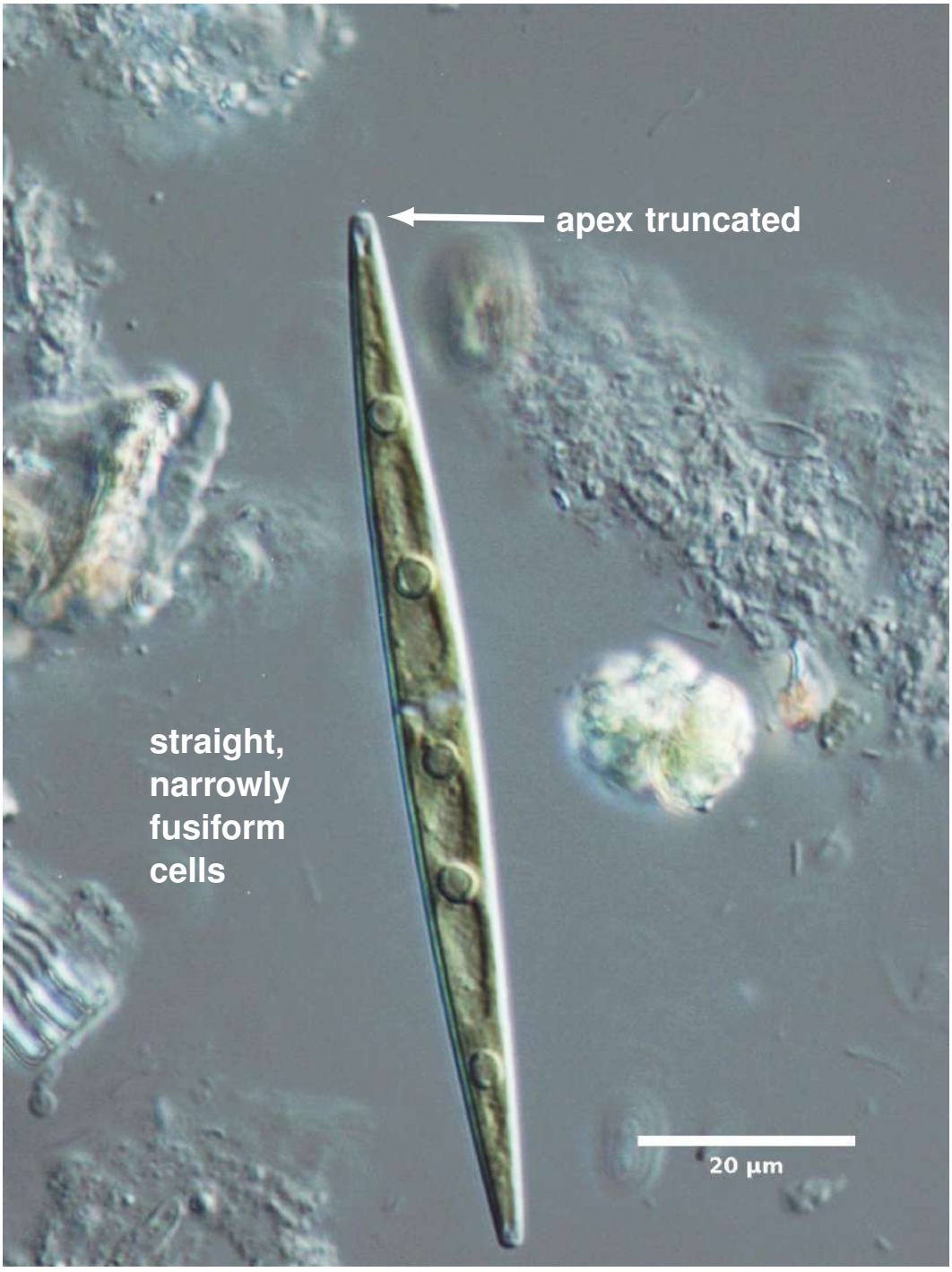


Figure 3.48: *Closterium* cf. *cornu* (DIC), Bear Lake, Mountain Loop Highway, Snohomish County.



Figure 3.49: *Closterium* cf. *cornu* (DIC), Heather Lake, Mountain Loop Highway, Snohomish County.

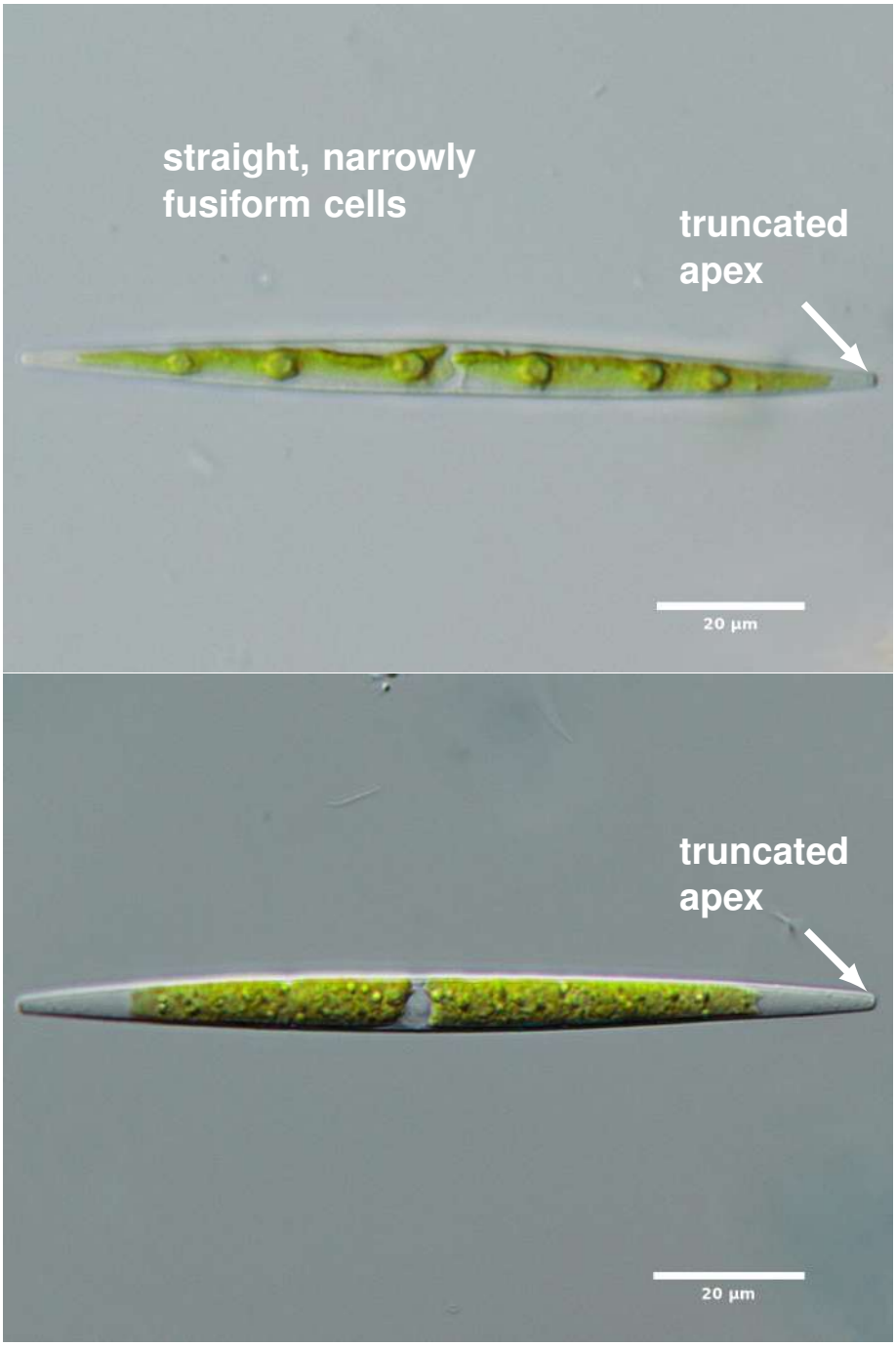


Figure 3.50: *Closterium* cf. *cornu* (DIC/DIC), Bear Lake, Mountain Loop Highway, Snohomish County (upper/lower images). Cell in lower image has damaged chloroplasts - chloroplast should extend nearly to apex.



Figure 3.51: *Closterium costatum* (DIC), Lake Evan, Mountain Loop Highway, Snohomish County.



Figure 3.52: *Closterium costatum* (DIC), Lake Evan, Mountain Loop Highway, Snohomish County.

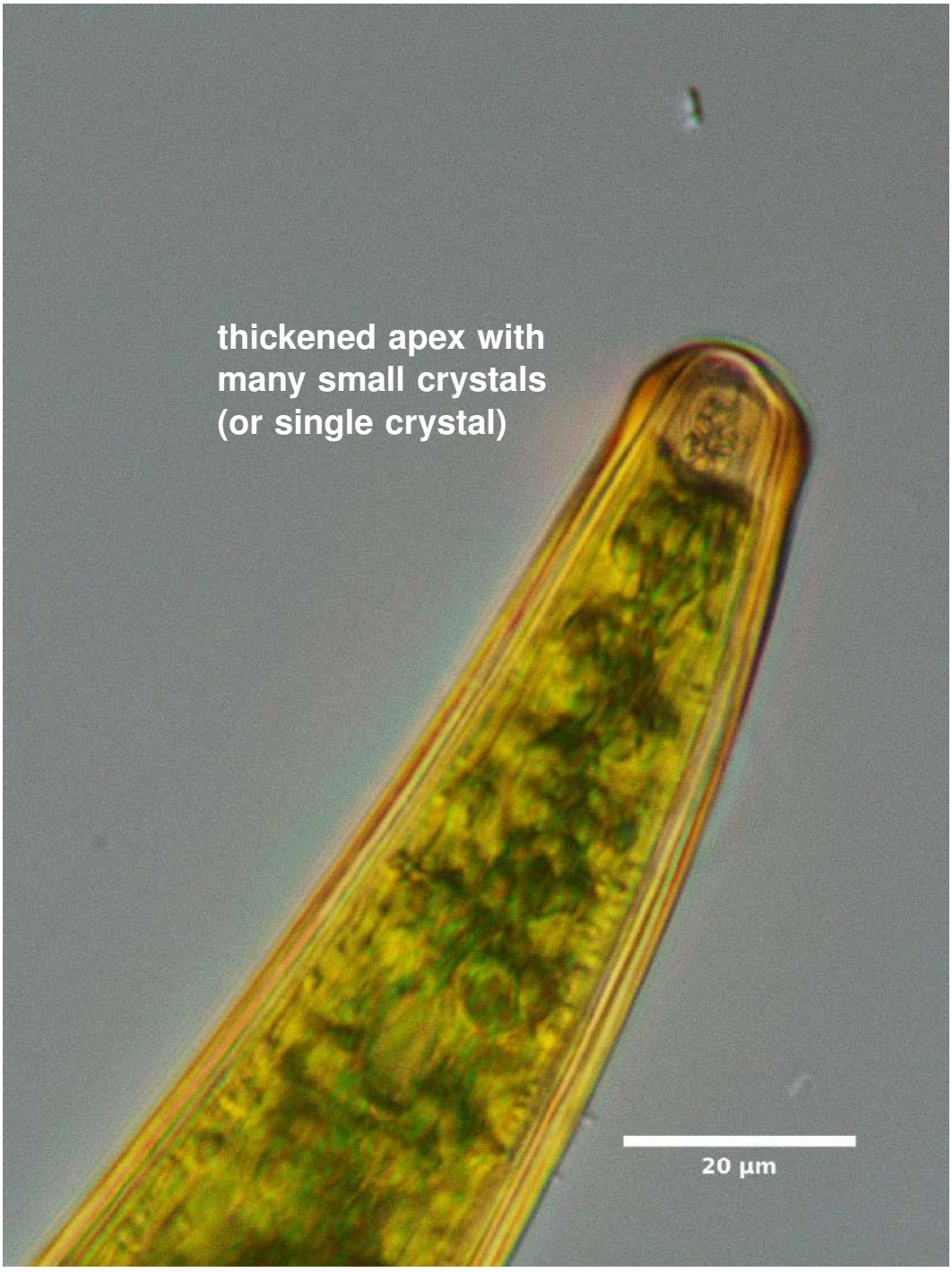


Figure 3.53: *Closterium costatum* (DIC), Bear Lake, Mountain Loop Highway, Snohomish County.



Figure 3.54: *Closterium costatum* wall striations (DIC/DIC), Lake Evan, Mountain Loop Highway, Snohomish County (upper/lower images).



Figure 3.55: *Closterium costatum* (DIC), Myrtle Lake, Mountain Loop Highway, Snohomish County.

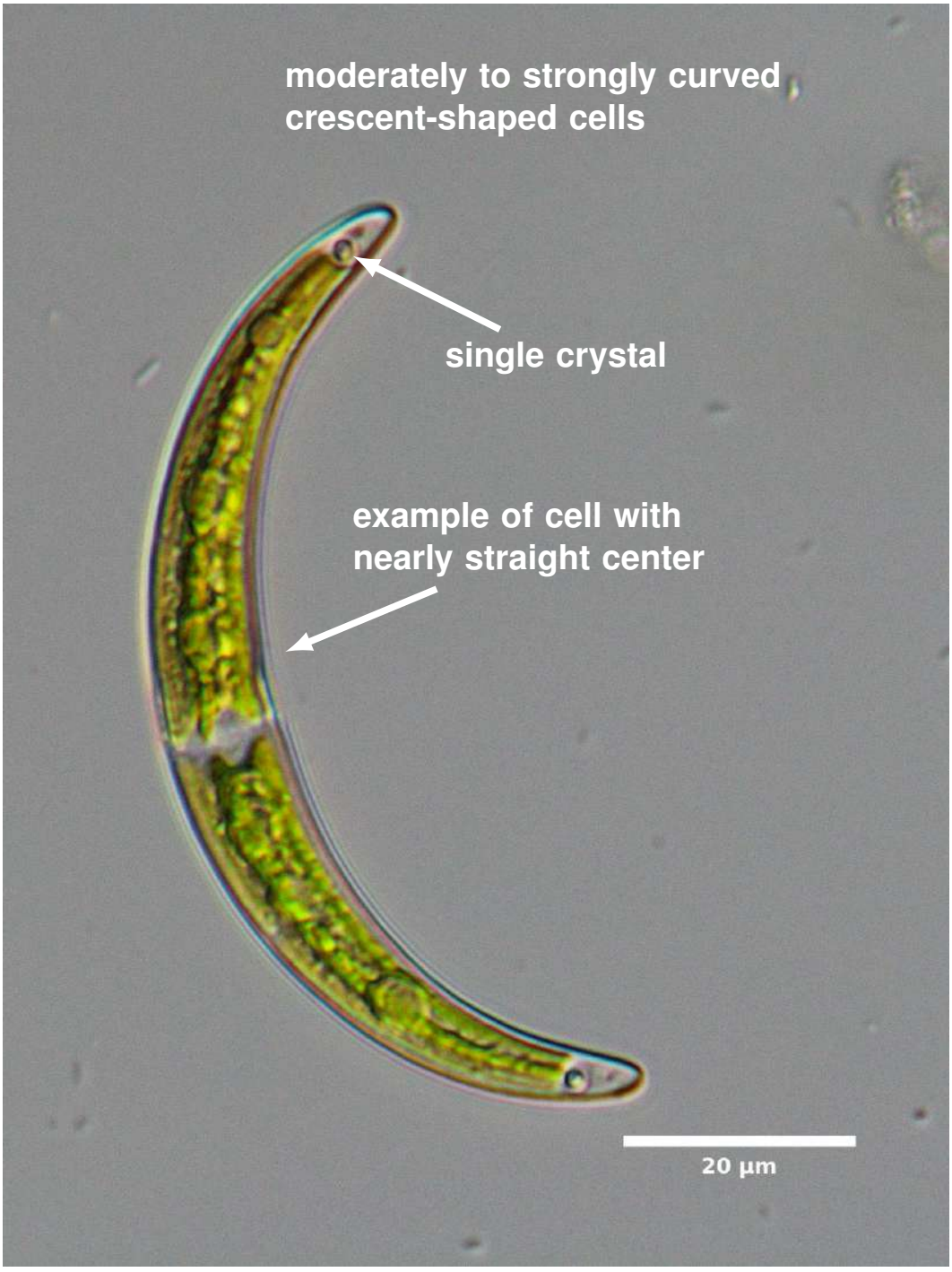


Figure 3.56: *Closterium cynthia* (DIC), Myrtle Lake, Mountain Loop Highway, Snohomish County.



Figure 3.57: *Closterium cynthia* (DIC), Myrtle Lake, Mountain Loop Highway, Snohomish County.

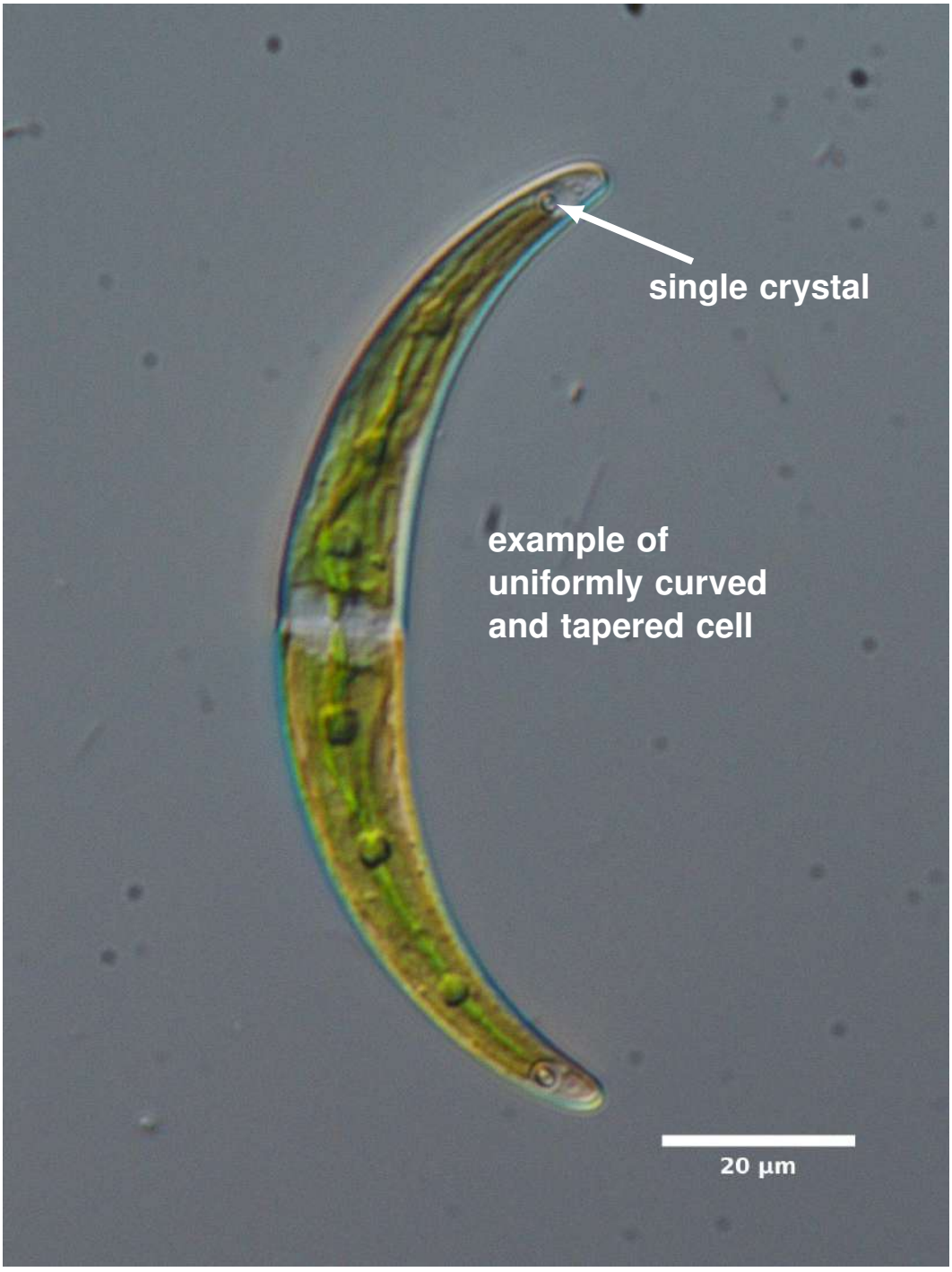


Figure 3.58: *Closterium cynthia* (DIC), Picture Lake, Mt. Baker area, Whatcom County.



Figure 3.59: *Closterium cynthia* (DIC), Lake Twenty-two, Mountain Loop Highway, Snohomish County.

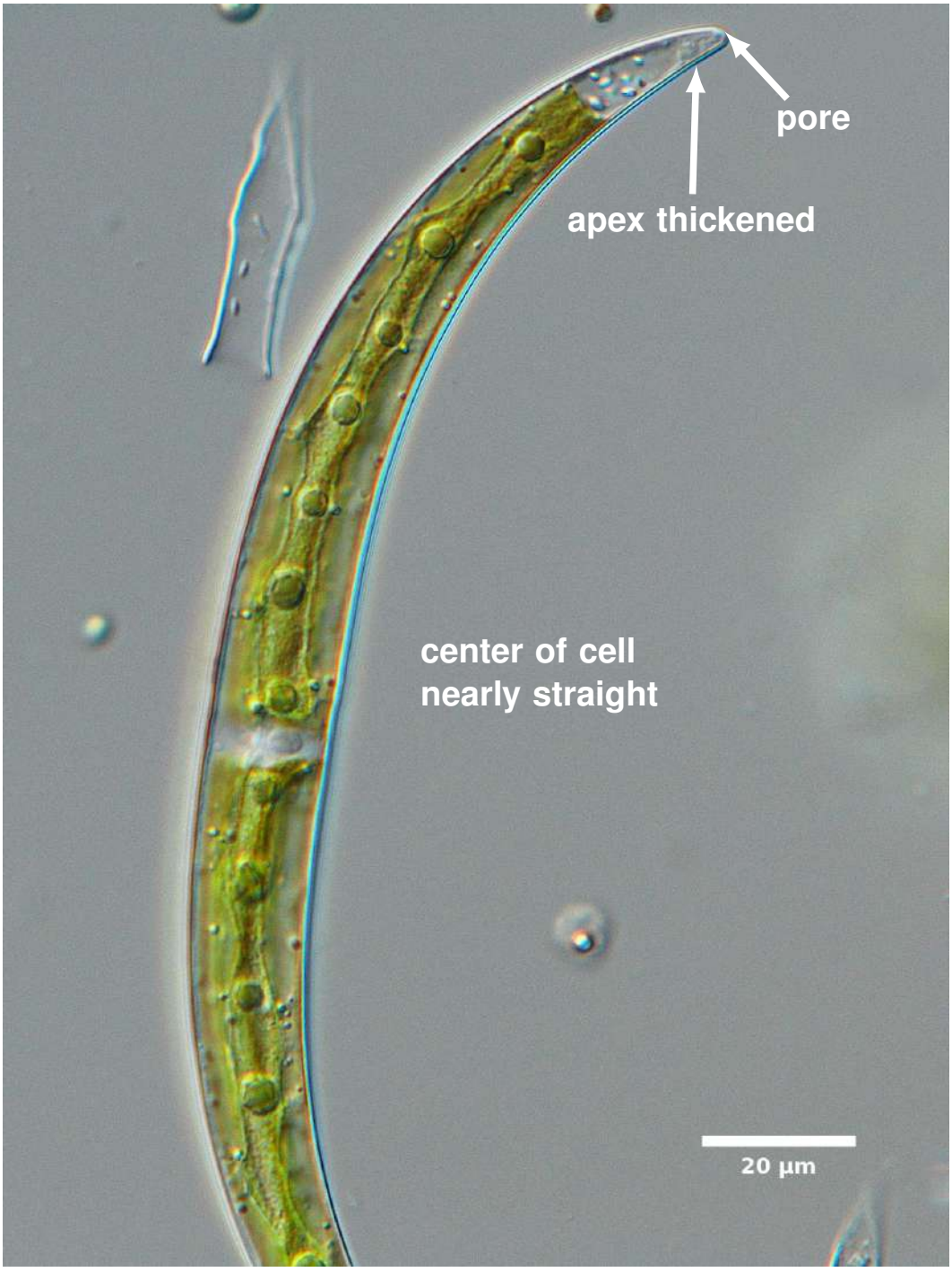


Figure 3.60: *Closterium dianae* (DIC), Big Twin Lake (eastern Washington), Okanogan County.



Figure 3.61: *Closterium dianae* (DIC), Big Twin Lake (eastern Washington), Okanogan County.



Figure 3.62: *Closterium dianae* (DIC), Lake Everett, Skagit County.



Figure 3.63: *Closterium dianae* cf. var. *minus* (DIC), small pond on trail to Big Four Ice Caves, Mountain Loop Highway, Snohomish County.



Figure 3.64: *Closterium dianae* cf. var. *minus* (DIC), Bear Lake, Mountain Loop Highway, Snohomish County.

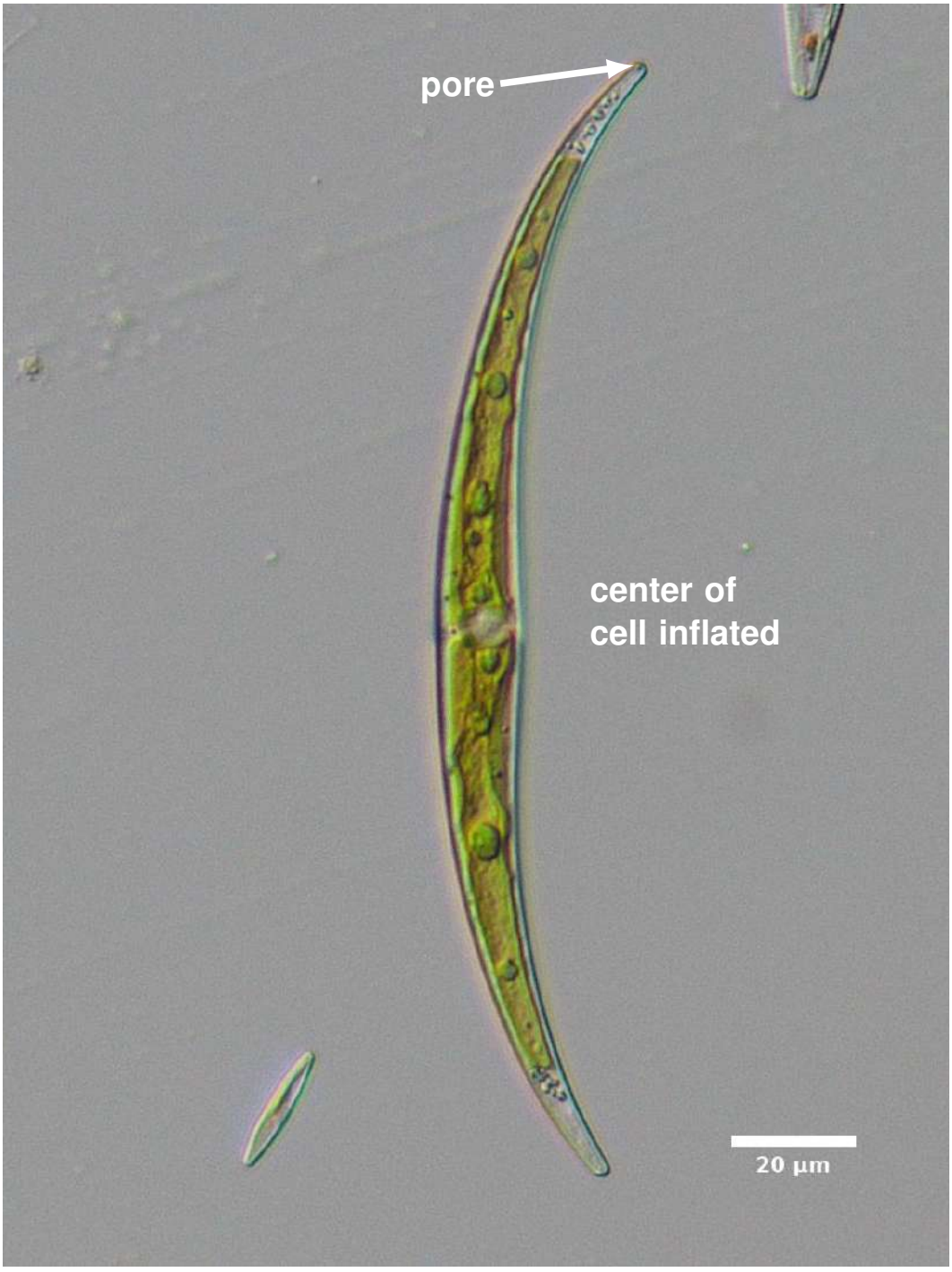


Figure 3.65: *Closterium* cf. *dianae* (DIC), Squalicum Lake, Whatcom County.



Figure 3.66: *Closterium* cf. *dianae* (DIC), Beaver Pond Lake, Whatcom County.



Figure 3.67: *Closterium didymotocum* (DIC), small floating bog along Morris Valley Road near Harrison, BC.

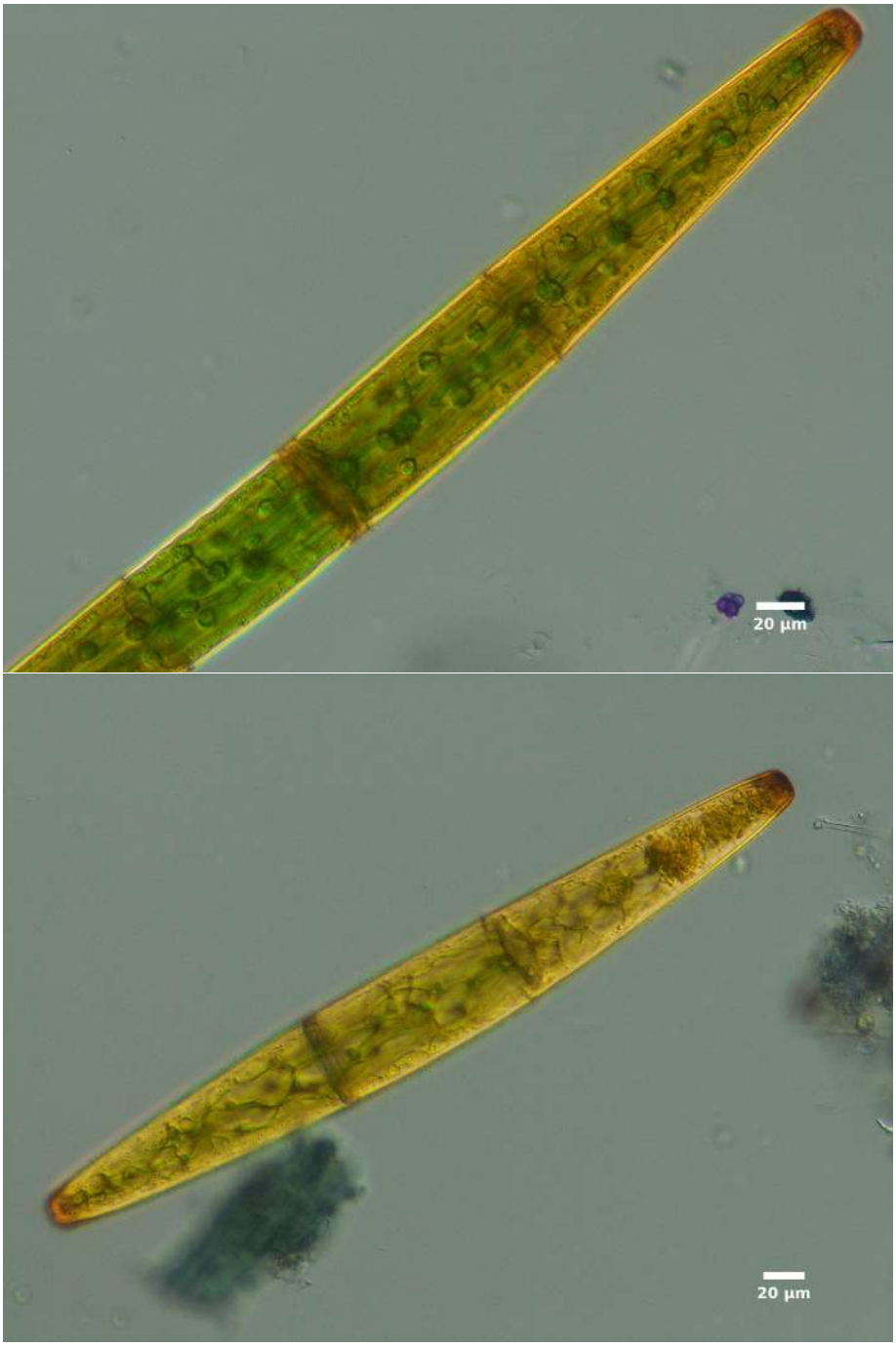


Figure 3.68: *Closterium didymotocum* girdle bands (DIC/DIC), small floating bog along Morris Valley Road near Harrison, BC (upper/lower images).

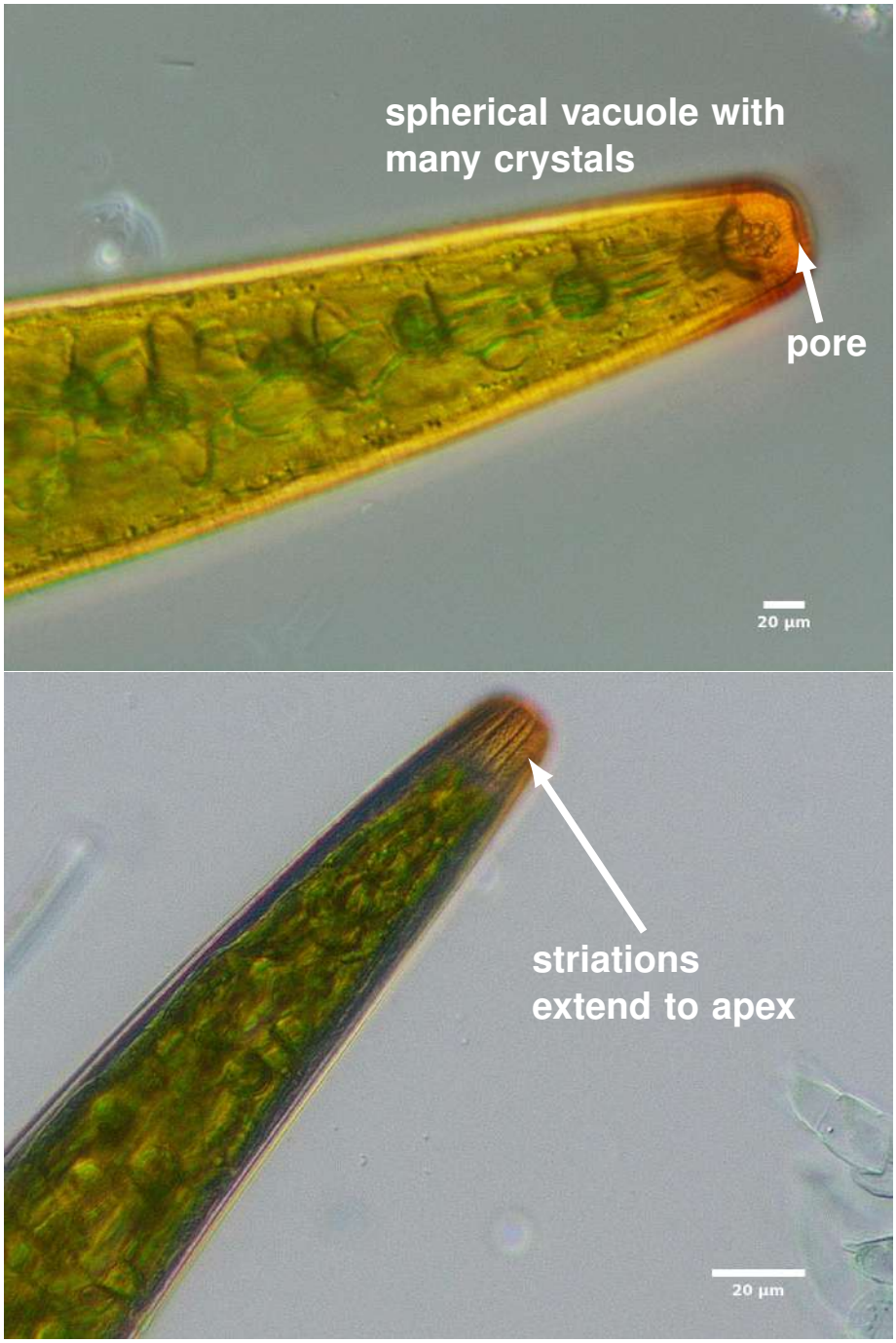


Figure 3.69: *Closterium didymotocum* (DIC/DIC), small floating bog along Morris Valley Road near Harrison, BC quality sampling site, Snohomish County (upper/lower images).

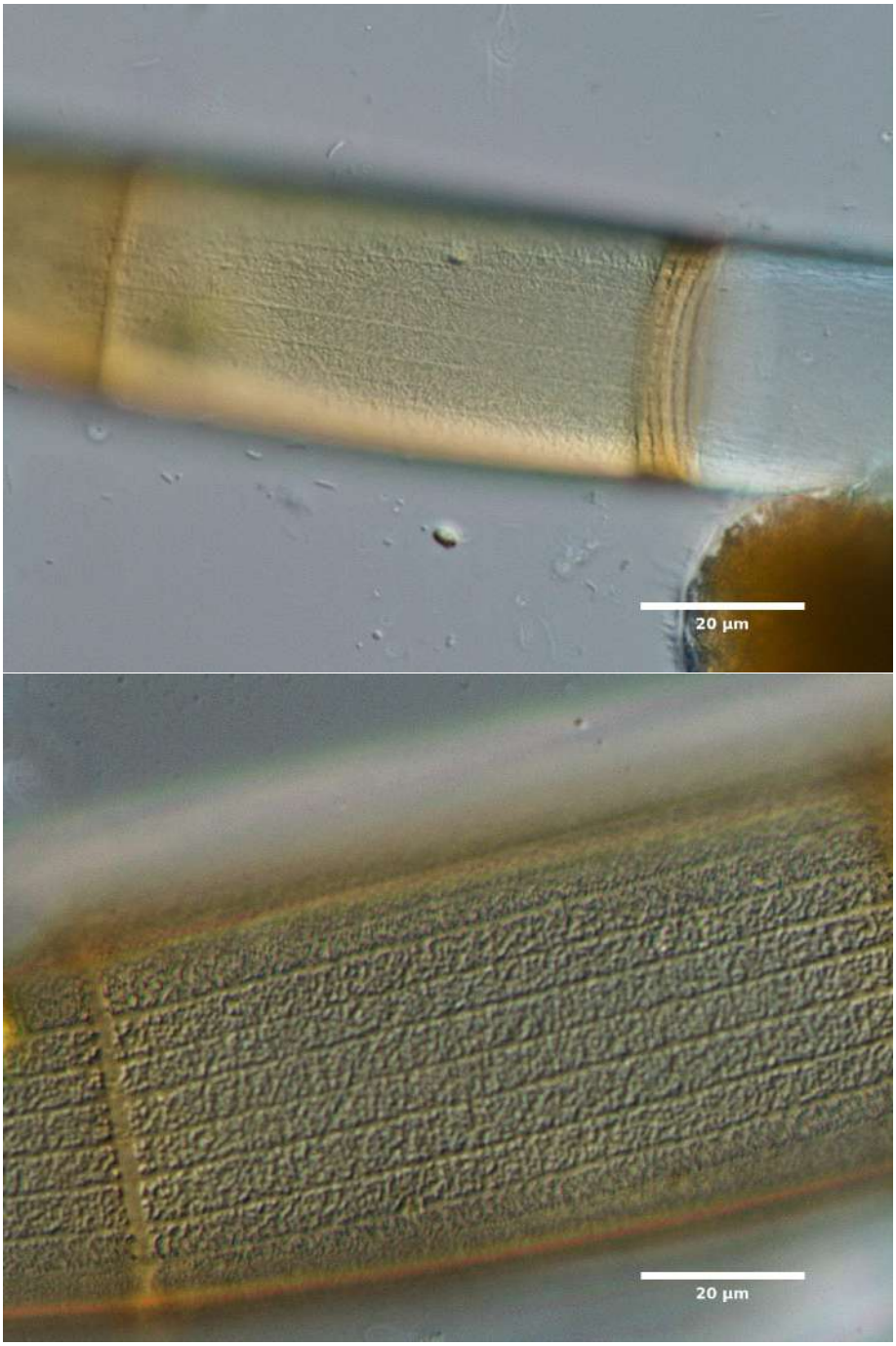


Figure 3.70: *Closterium didymotocum* wall striations and punctae (DIC/DIC), small floating bog along Morris Valley Road near Harrison, BC (upper/lower images).

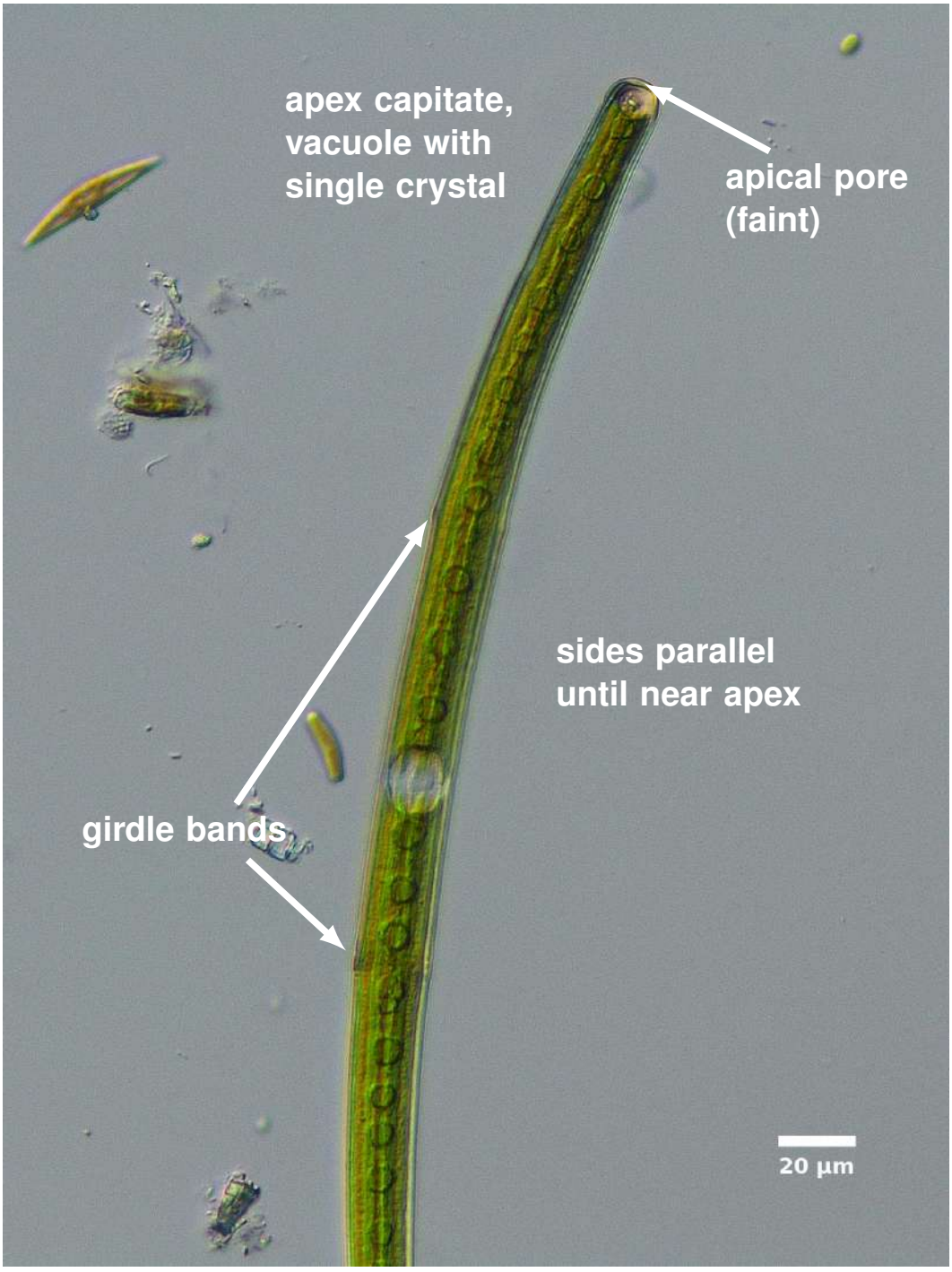


Figure 3.71: *Closterium directum* (DIC), Lake Evan, Mountain Loop Highway, Snohomish County.

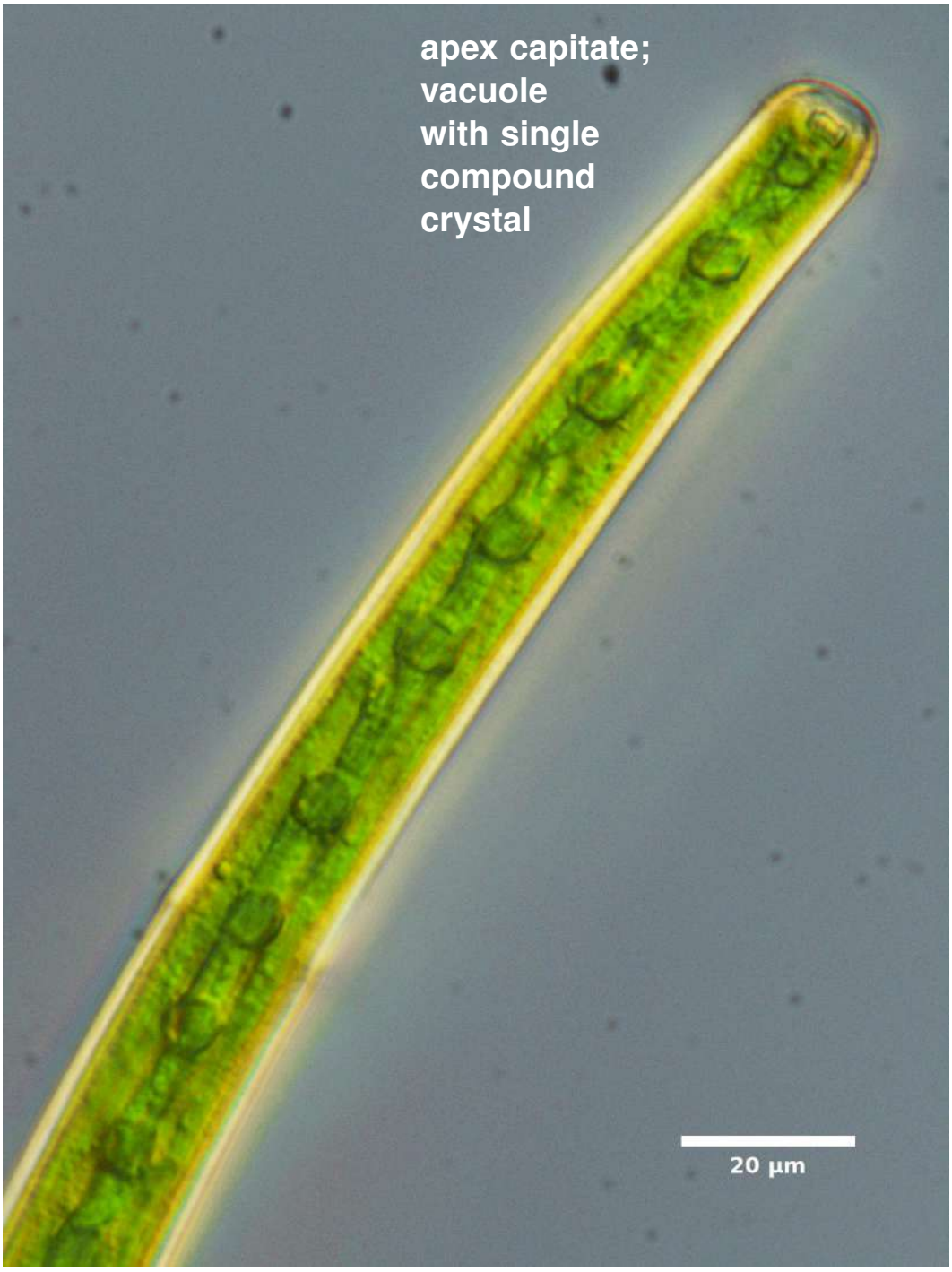


Figure 3.72: *Closterium directum* (DIC), Lake Evan, Mountain Loop Highway, Snohomish County.



Figure 3.73: *Closterium directum* girdle bands and wall striations (DIC/DIC), Boardman Lake, Mountain Loop Highway, Snohomish County (upper/lower images).



Figure 3.74: *Closterium ehrenbergii* (DIC), small residential pond, Whatcom County.

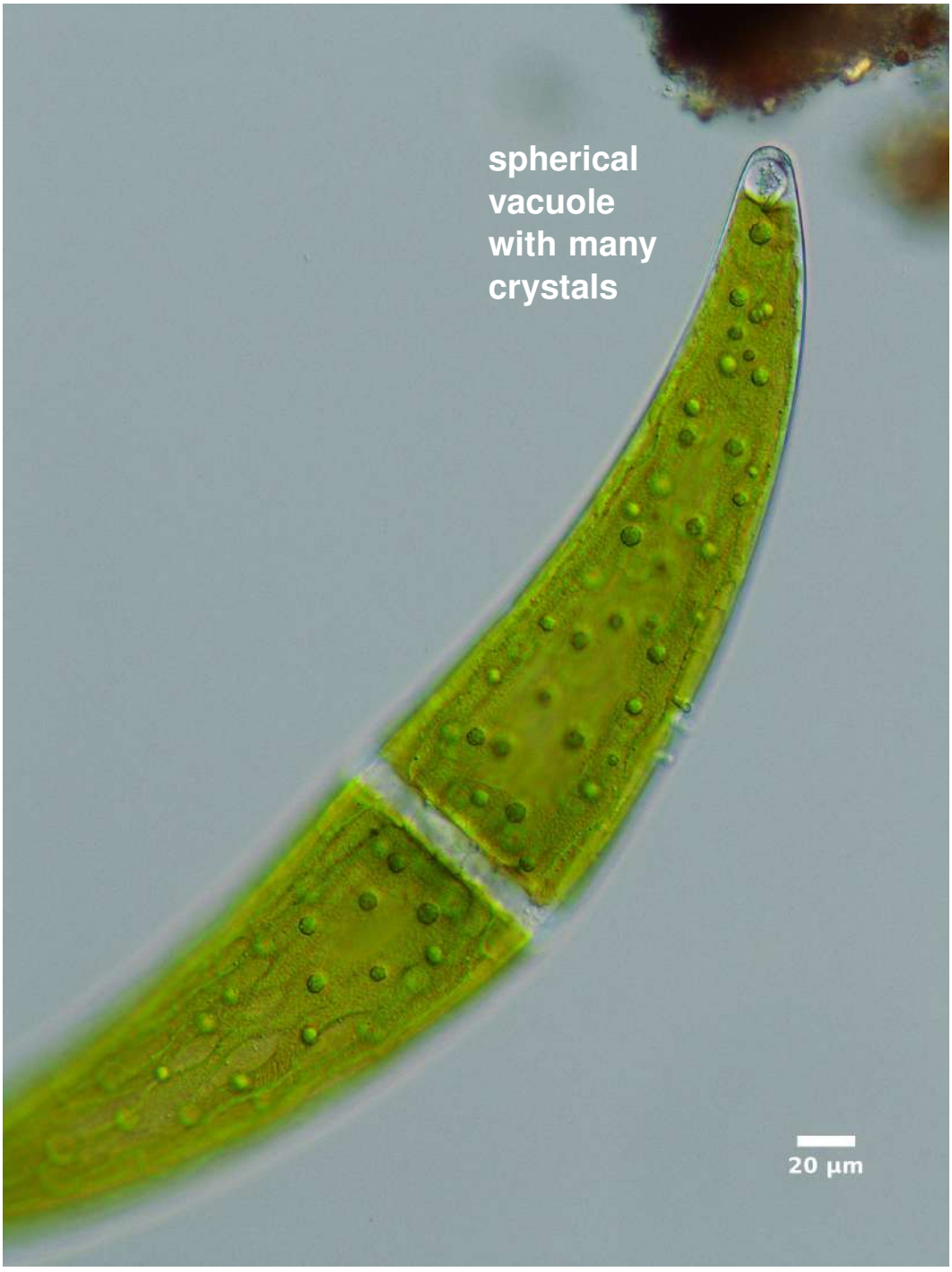


Figure 3.75: *Closterium ehrenbergii* (DIC), Cedar Hills stormwater treatment pond, Whatcom County.



Figure 3.76: *Closterium ehrenbergii* (DIC), Lake Campbell (eastern Washington), Okanogan County.



Figure 3.77: *Closterium ehrenbergii* conjugation and zygote formation (DIC), small residential pond, Whatcom County.

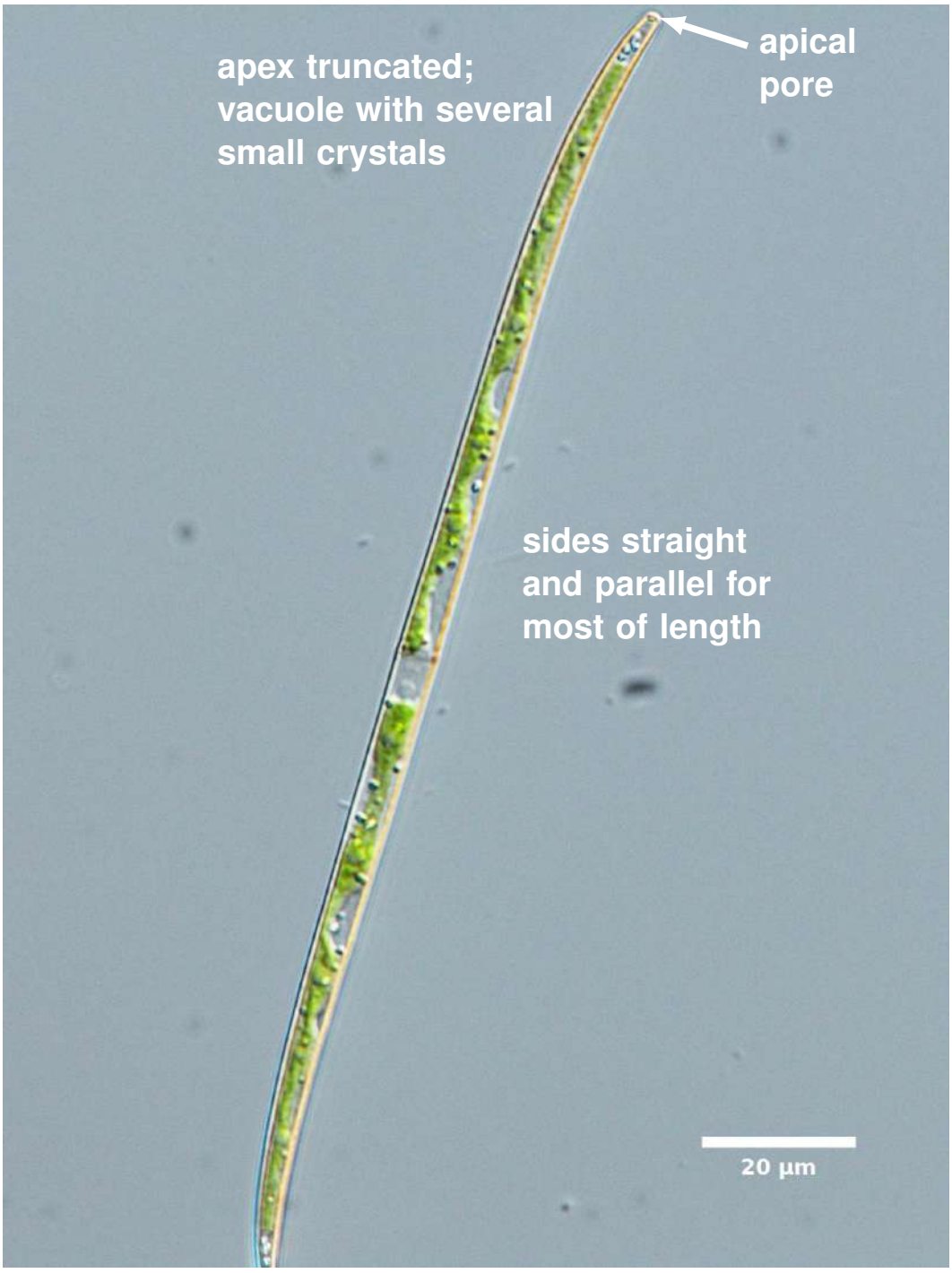


Figure 3.78: *Closterium gracile* (DIC), Lake Louise, Whatcom County.

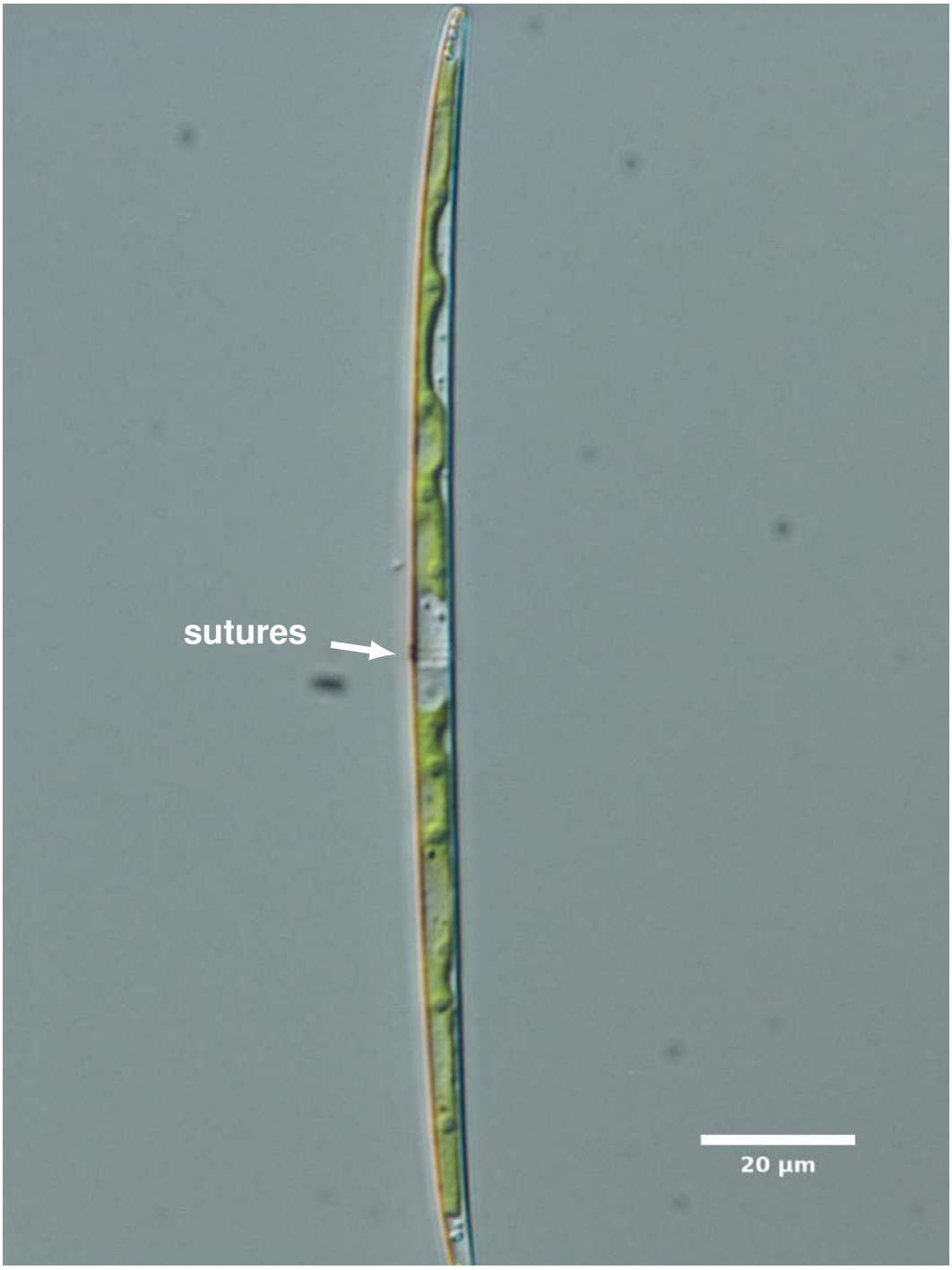


Figure 3.79: *Closterium gracile* (DIC), Lake Geneva, Whatcom County.



Figure 3.80: *Closterium gracile* f. *elongatum* (DIC), Summer Lake, Skagit County.



Figure 3.81: *Closterium gracile* f. *elongatum* (DIC), Summer Lake, Skagit County.

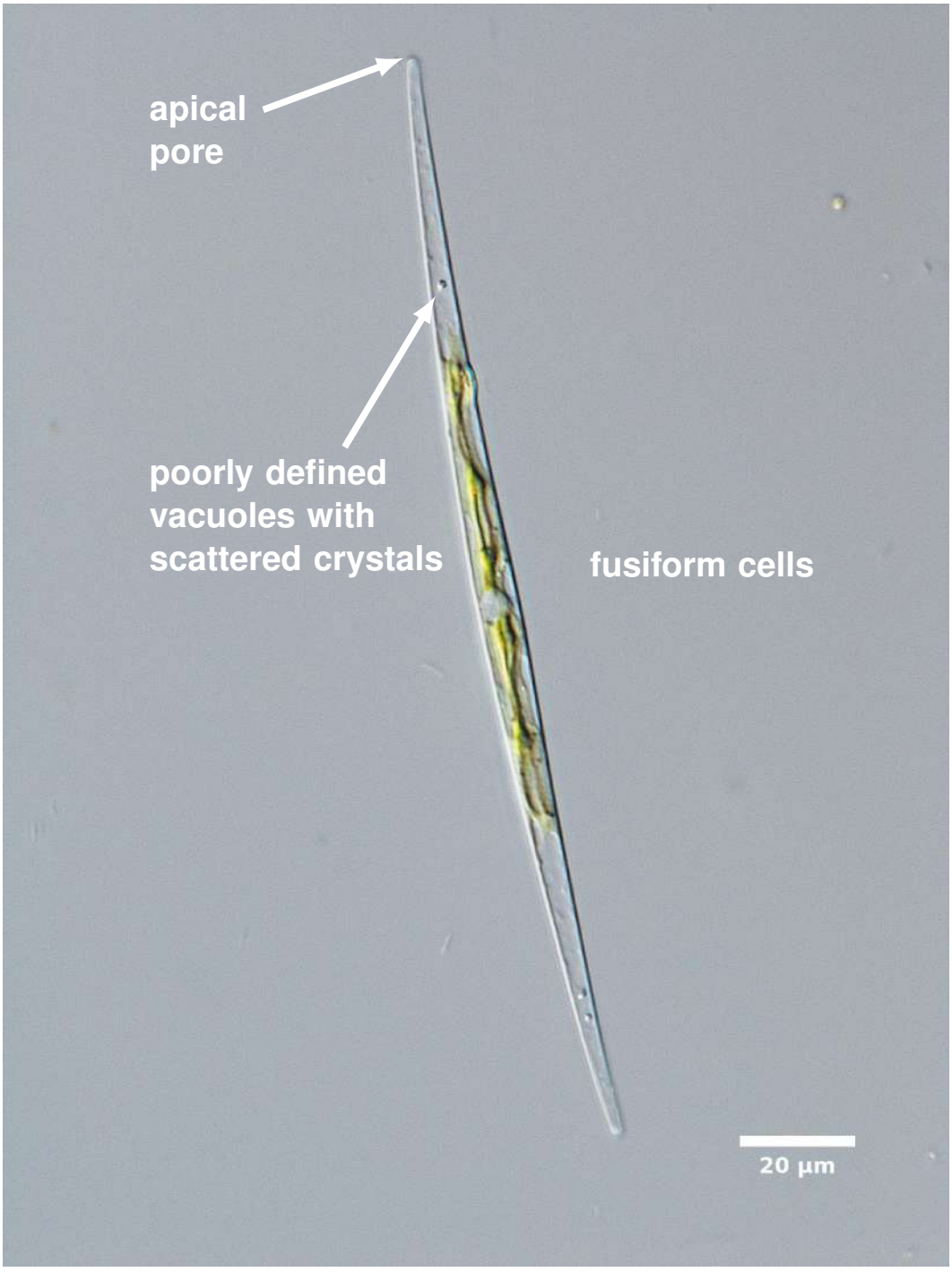


Figure 3.82: *Closterium* cf. *idiosporum* (DIC), Chain Lake, Gifford Pinchot National Forest, Skamania County.



Figure 3.83: *Closterium* cf. *idiosporum* (DIC), Summer Lake, Skagit County.

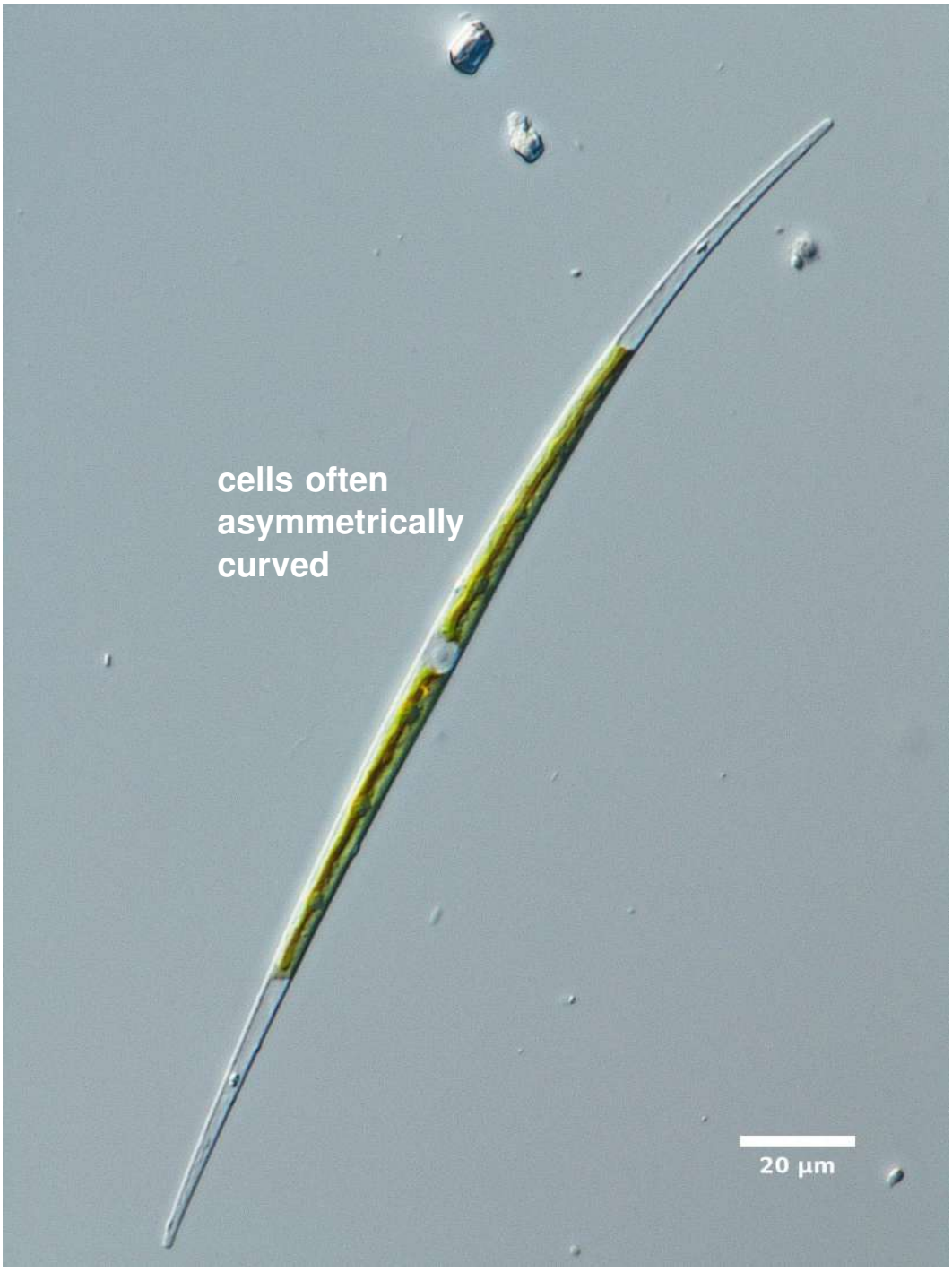


Figure 3.84: *Closterium* cf. *idiosporum* (DIC), Lake Geneva, Whatcom County.

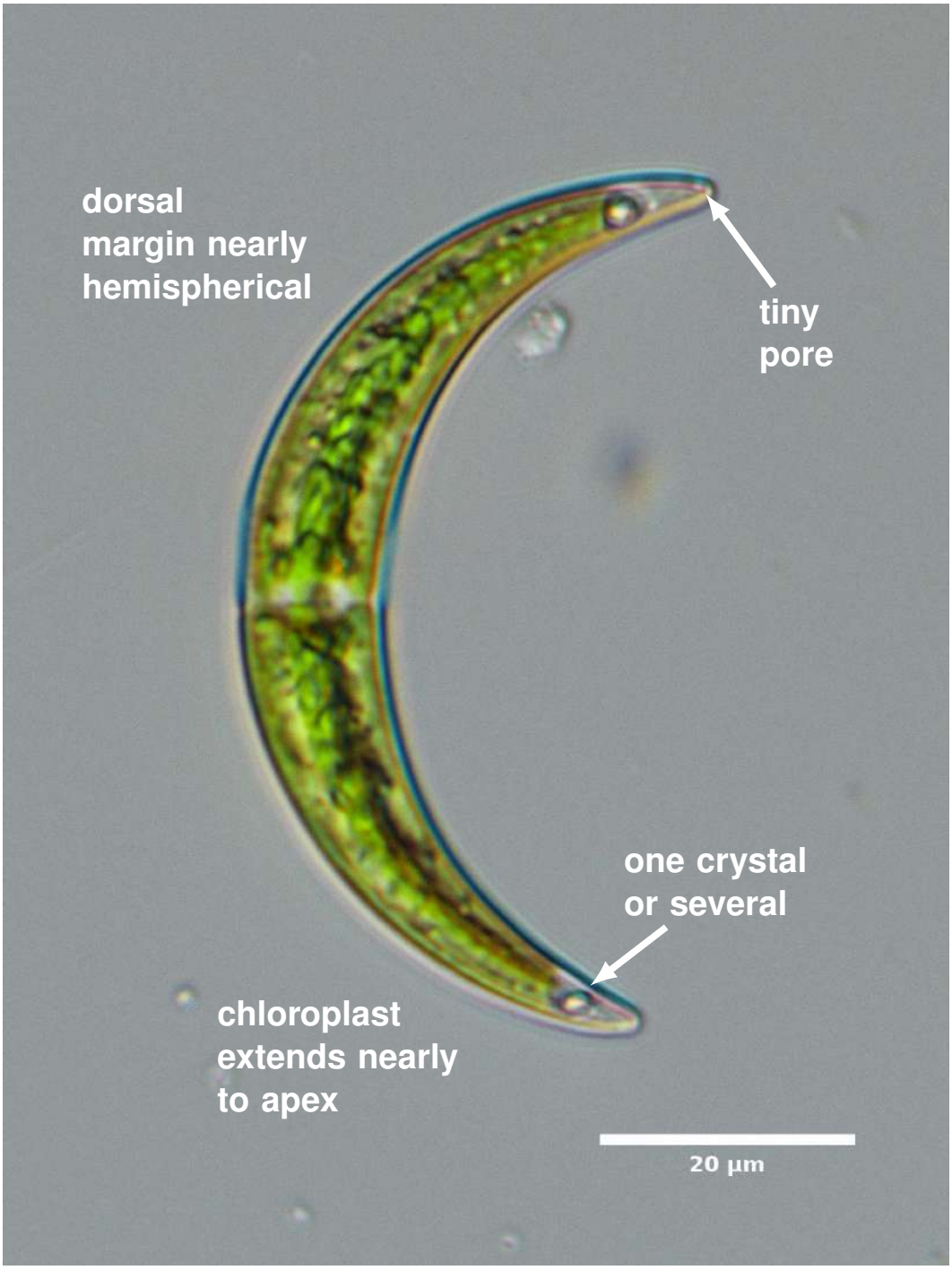


Figure 3.85: *Closterium incurvum* (DIC), small residential pond on Valley Circle Drive, Snohomish County.



Figure 3.86: *Closterium incurvum* (DIC), Beaver Lake, Skagit County.



Figure 3.87: *Closterium incurvum* (DIC), Myrtle Lake, Mountain Loop Highway, Snohomish County.



Figure 3.88: *Closterium incurvum* and *Closterium venus* (DIC/DIC), sample collected on same date, Hoag Pond, Whatcom County (upper/lower images).



Figure 3.89: *Closterium incurvum* var. *latius* (DIC), Cain Lake, Whatcom County.



Figure 3.90: *Closterium incurvum* var. *latius* (DIC/DIC), Grandy Lake, Skagit County (upper/lower images).

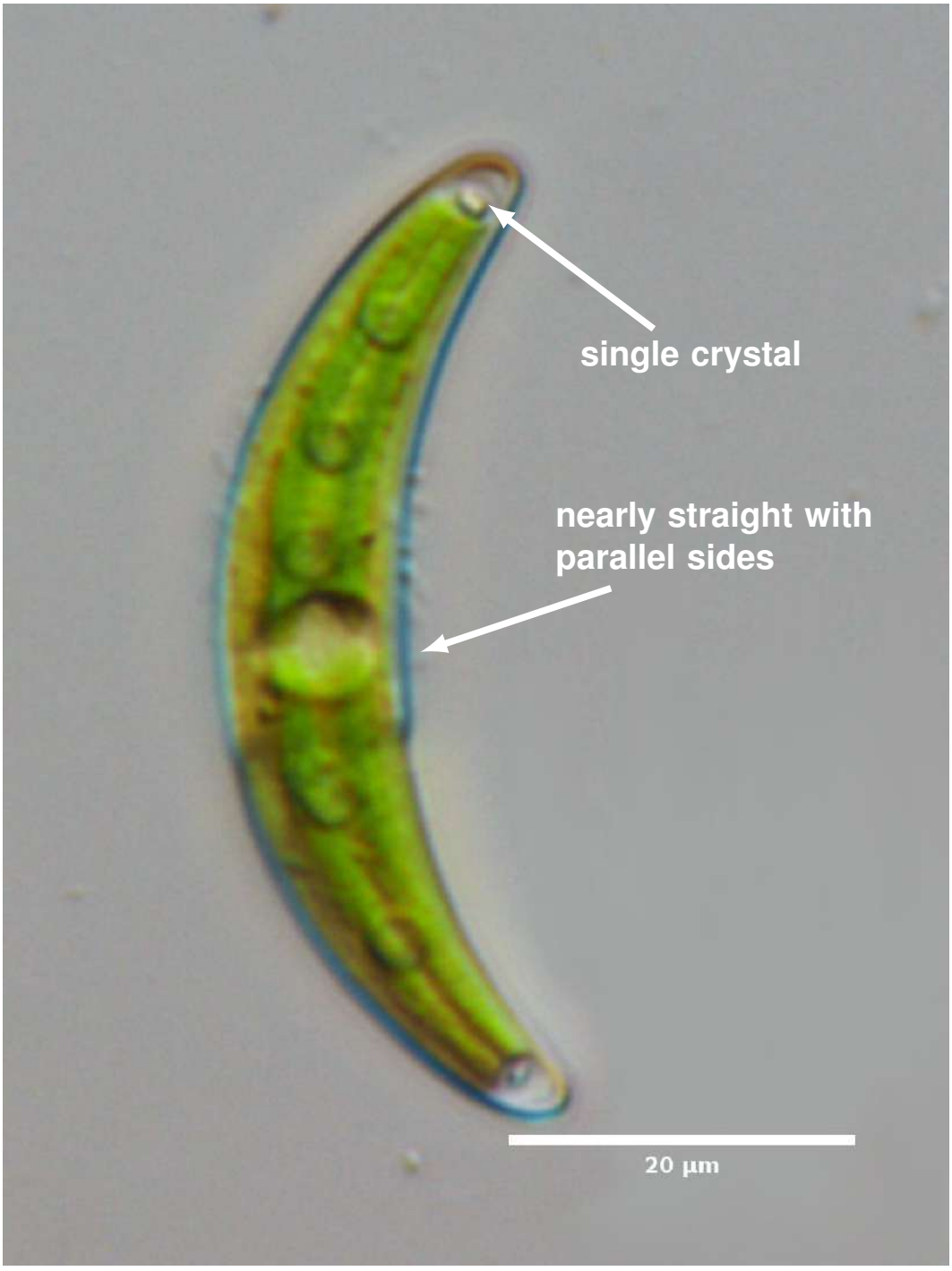


Figure 3.91: *Closterium* cf. *jenneri* var. *robustum* (DIC), small pond near Artist Point Ridge trail, Mt. Baker Recreational Area, Whatcom County.



Figure 3.92: *Closterium* cf. *jenneri* var. *robustum* (DIC), small pond near Artist Point Ridge trail, Mt. Baker area, Whatcom County.

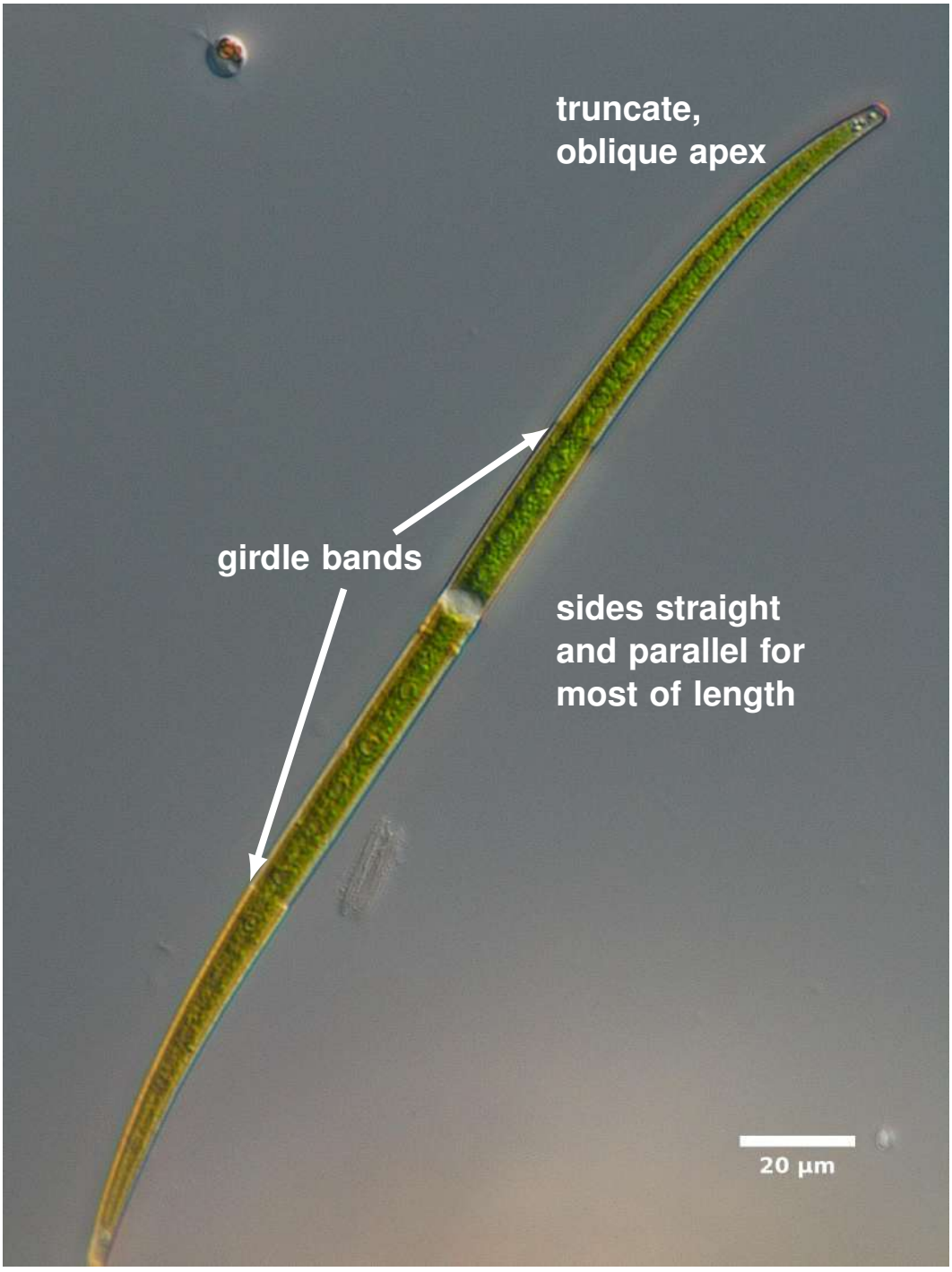


Figure 3.93: *Closterium juncidum* (DIC), Chain Lake, Gifford Pinchot National Forest, Skamania County.

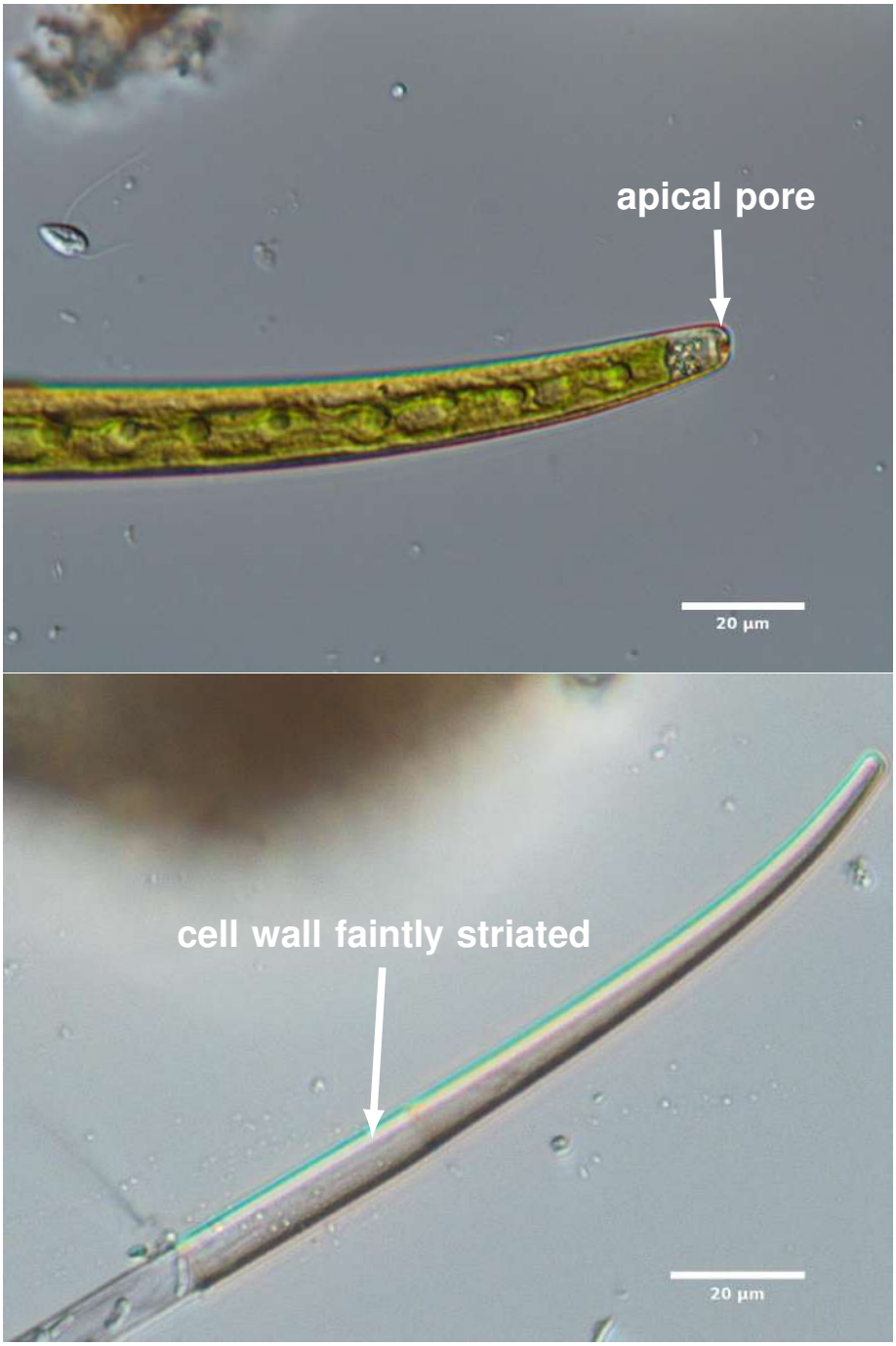


Figure 3.94: *Closterium juncidum* (DIC/DIC), Myrtle Lake, Mountain Loop Highway, Snohomish County (upper/lower images).



Figure 3.95: *Closterium juncidum* (DIC), Myrtle Lake, Mountain Loop Highway, Snohomish County.



Figure 3.96: *Closterium juncidum* (DIC), small floating bog along Morris Valley Road near Harrison, BC.

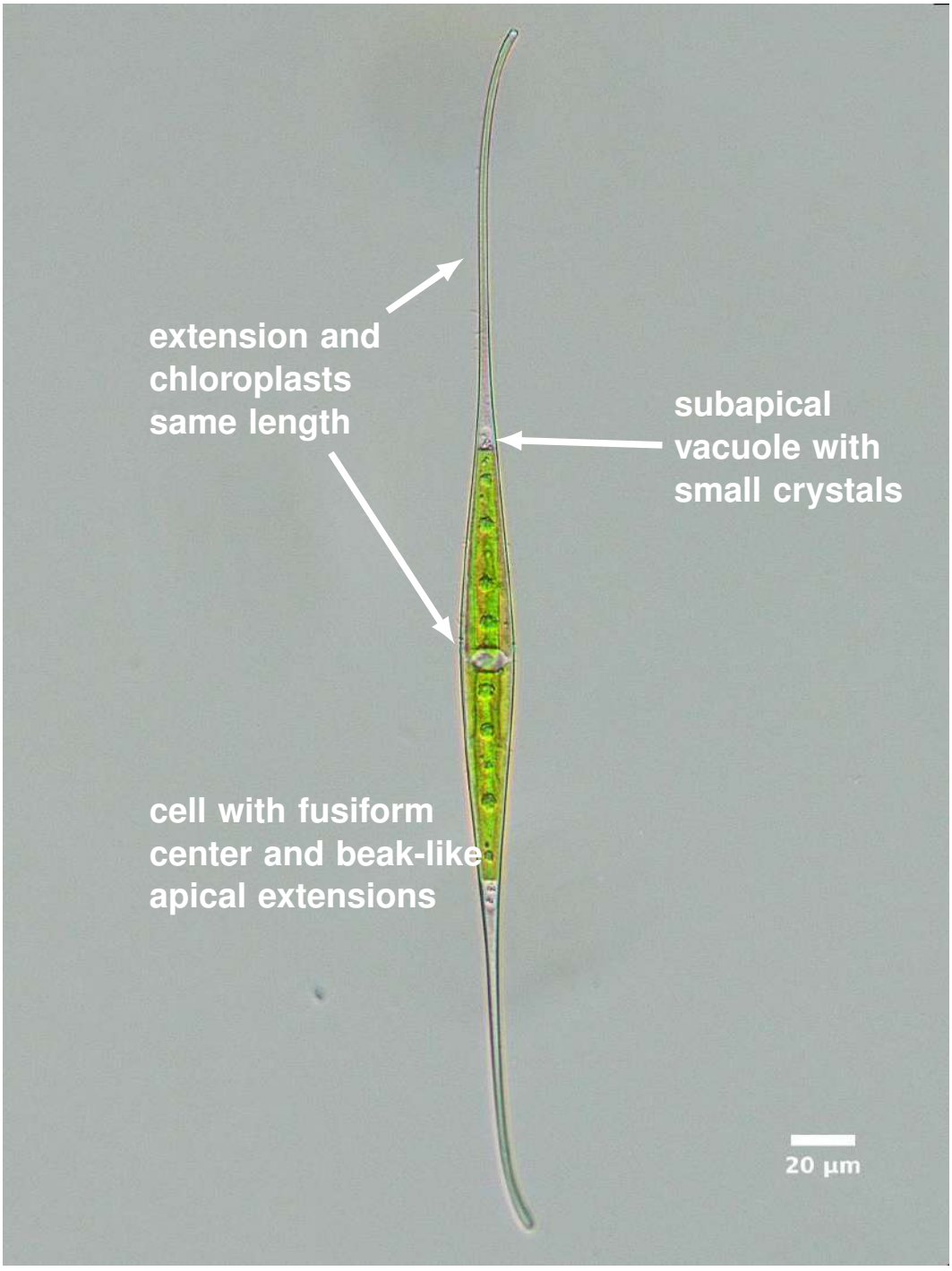


Figure 3.97: *Closterium kuetzingii* (DIC), Hoag Pond, Whatcom County.

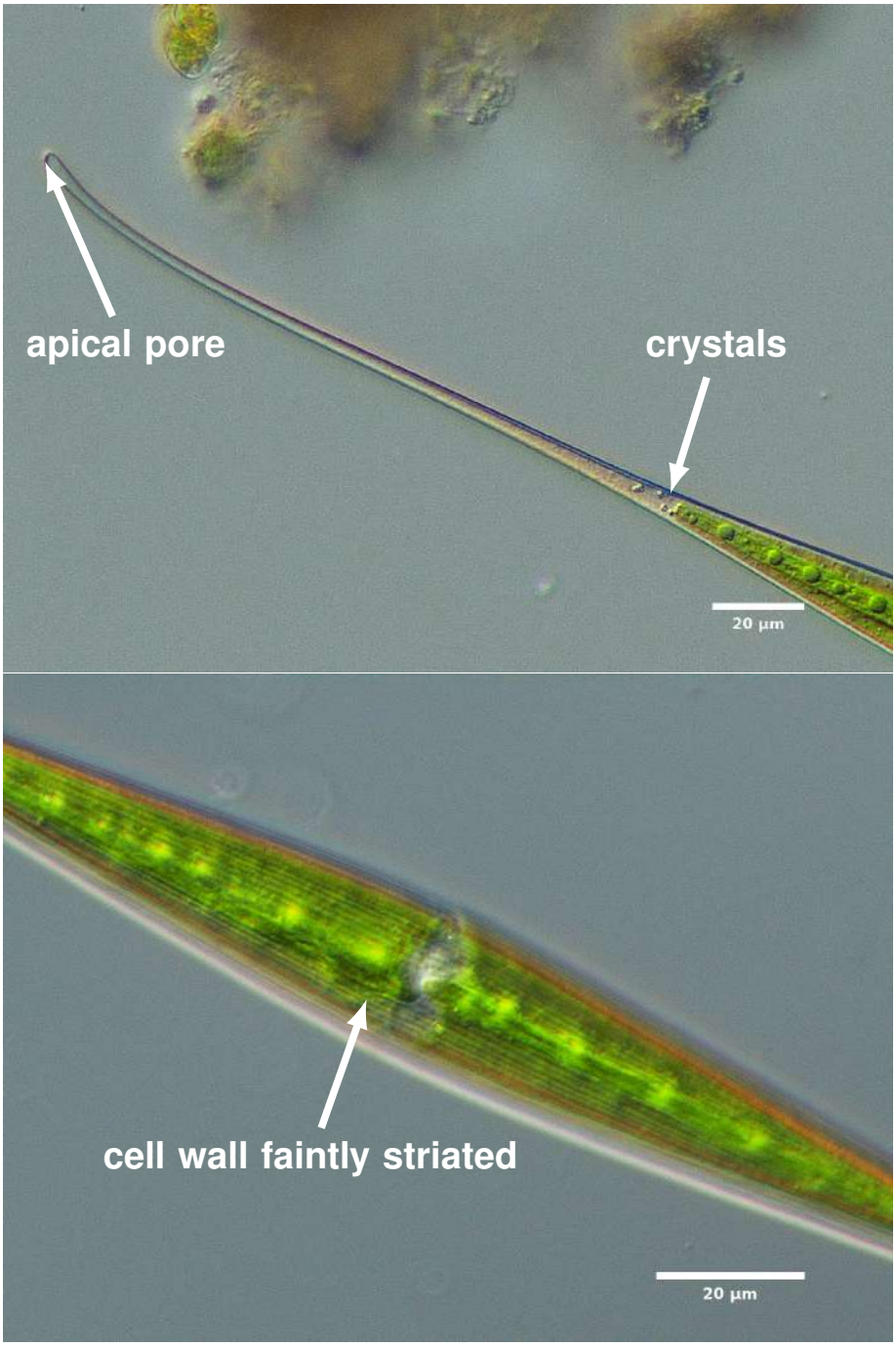


Figure 3.98: *Closterium kuetzingii* (DIC/DIC), Beaver Pond Lake, Whatcom County (upper/lower images).



Figure 3.99: *Closterium kuetzingii* (DIC), Myrtle Lake, Mountain Loop Highway, Snohomish County.



Figure 3.100: *Closterium kuetzingii* (DIC), Summer Lake, Skagit County.



Figure 3.101: *Closterium kuetzingii* and *Closterium setaceum* (DIC/DIC), sample collected on same date, Summer Lake, Skagit County (upper/lower images).



Figure 3.102: *Closterium leibleinii* (DIC), side channel on Nooksack River, Whatcom County.



Figure 3.103: *Closterium leibleinii* (DIC), side channel on Whatcom Creek, Whatcom County.



Figure 3.104: *Closterium leibleinii* (DIC), Hoag Pond, Whatcom County.



Figure 3.105: *Closterium limneticum* (DIC), Wiser Lake, Whatcom County.



Figure 3.106: *Closterium limneticum* (DIC), Wiser Lake, Whatcom County.



Figure 3.107: *Closterium limneticum* (DIC), Wiser Lake, Whatcom County.

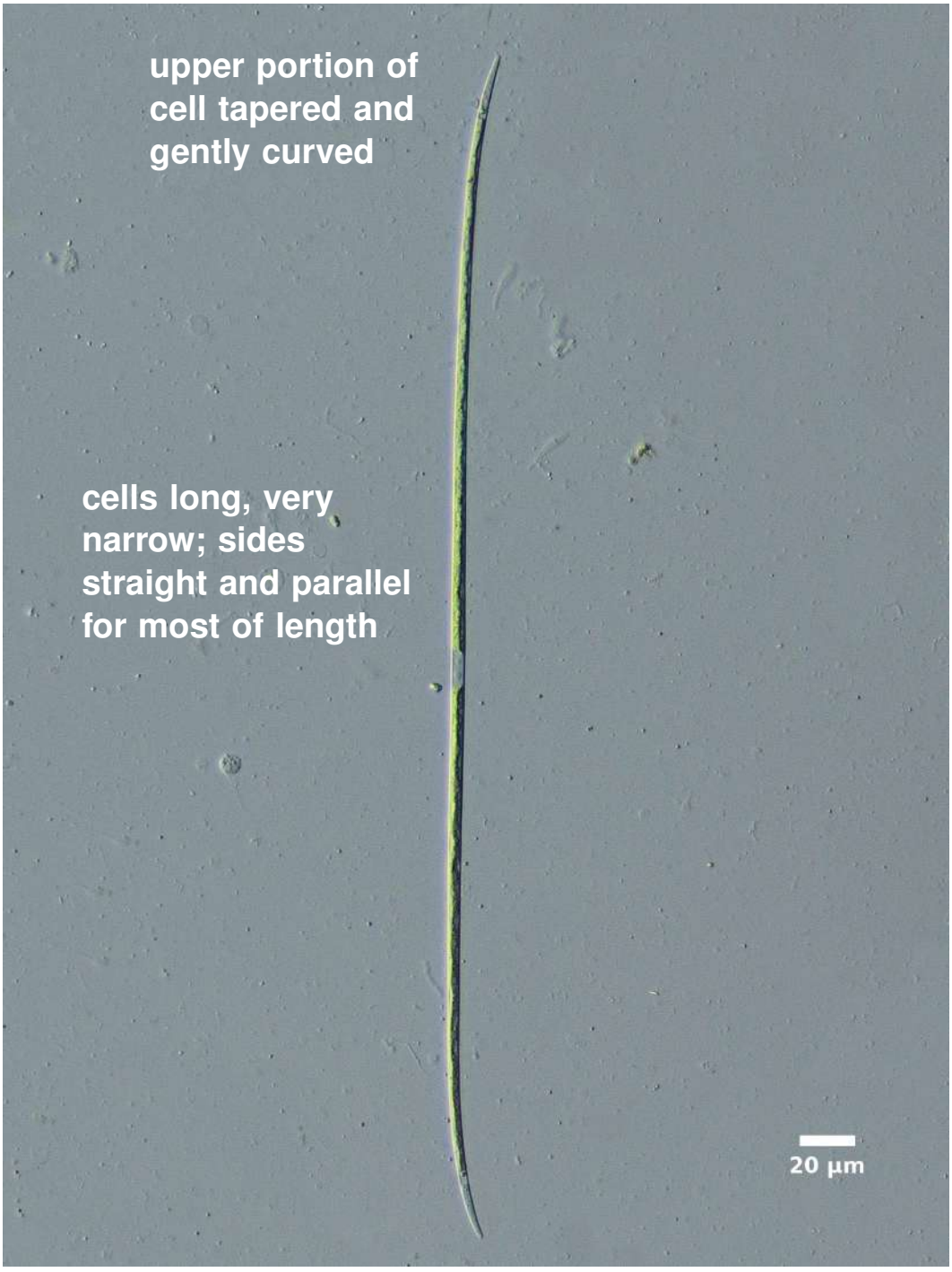


Figure 3.108: *Closterium limneticum* (DIC), Lake Terrell, Whatcom County.



Figure 3.109: *Closterium limneticum* var. *fallax* (DIC), Sunset Lake, Whatcom County.



Figure 3.110: *Closterium limneticum* var. *fallax* (DIC), Grandy Lake, Skagit County.



Figure 3.111: *Closterium limneticum* var. *fallax* (DIC), Fraser St. culvert, Bellingham, Whatcom County.



Figure 3.112: *Closterium lineatum* (DIC), Summer Lake, Skagit County.



Figure 3.113: *Closterium lineatum* (DIC/DIC), Summer Lake, Skagit County (upper/lower images).



Figure 3.114: *Closterium lineatum* (DIC), Beaver Pond Lake, Whatcom County.



Figure 3.115: *Closterium lineatum* (DIC), Beaver Pond Lake, Whatcom County.

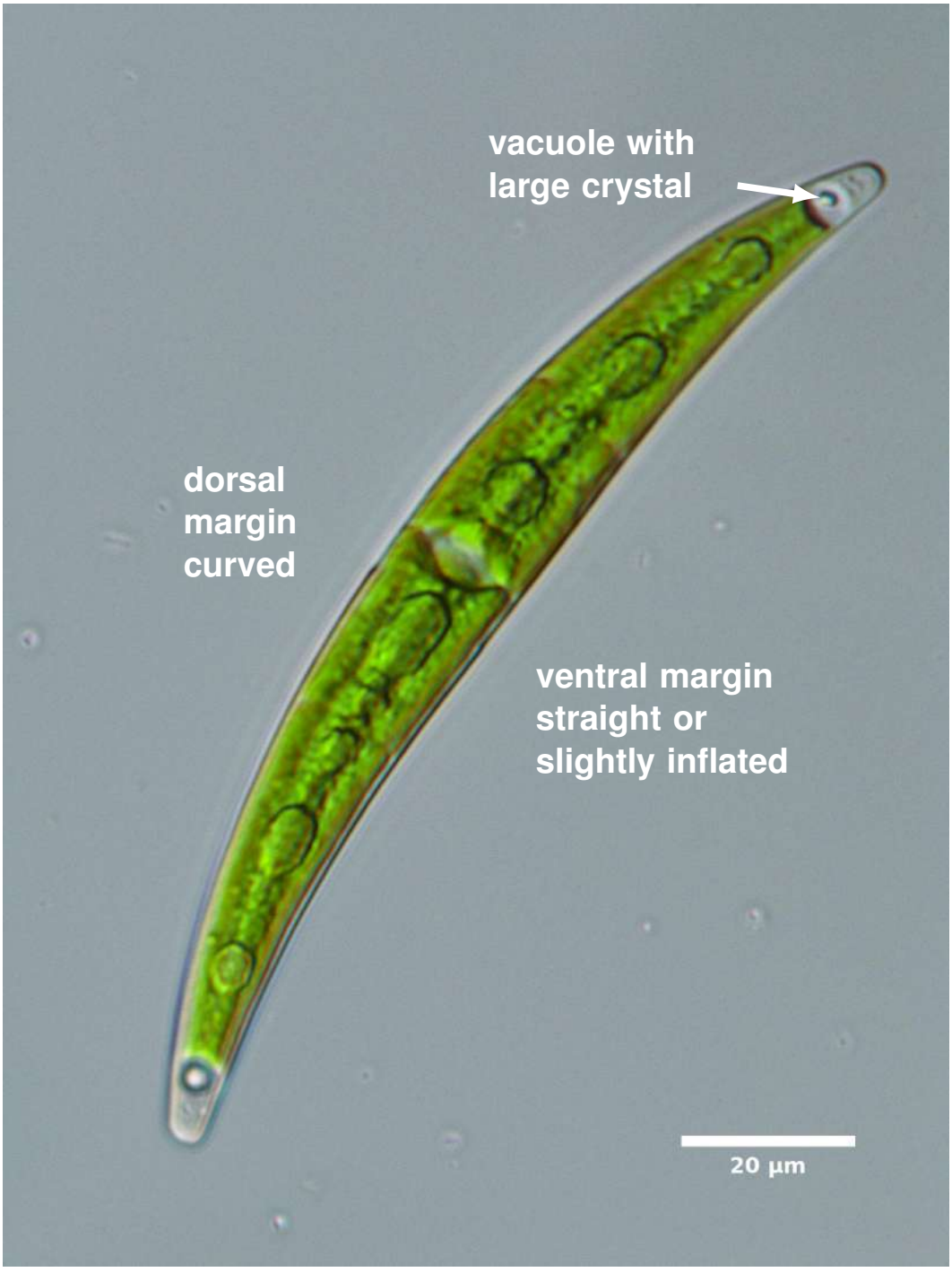


Figure 3.116: *Closterium littorale* (DIC), side channel on Chuckanut Creek, Whatcom County.



Figure 3.117: *Closterium littorale* (DIC), side channel on Nooksack River, Whatcom County.



Figure 3.118: *Closterium littorale* (DIC), small residential pond, Whatcom County.



Figure 3.119: *Closterium lunula* (DIC), Highwood Lake, Mt. Baker area, Whatcom County.

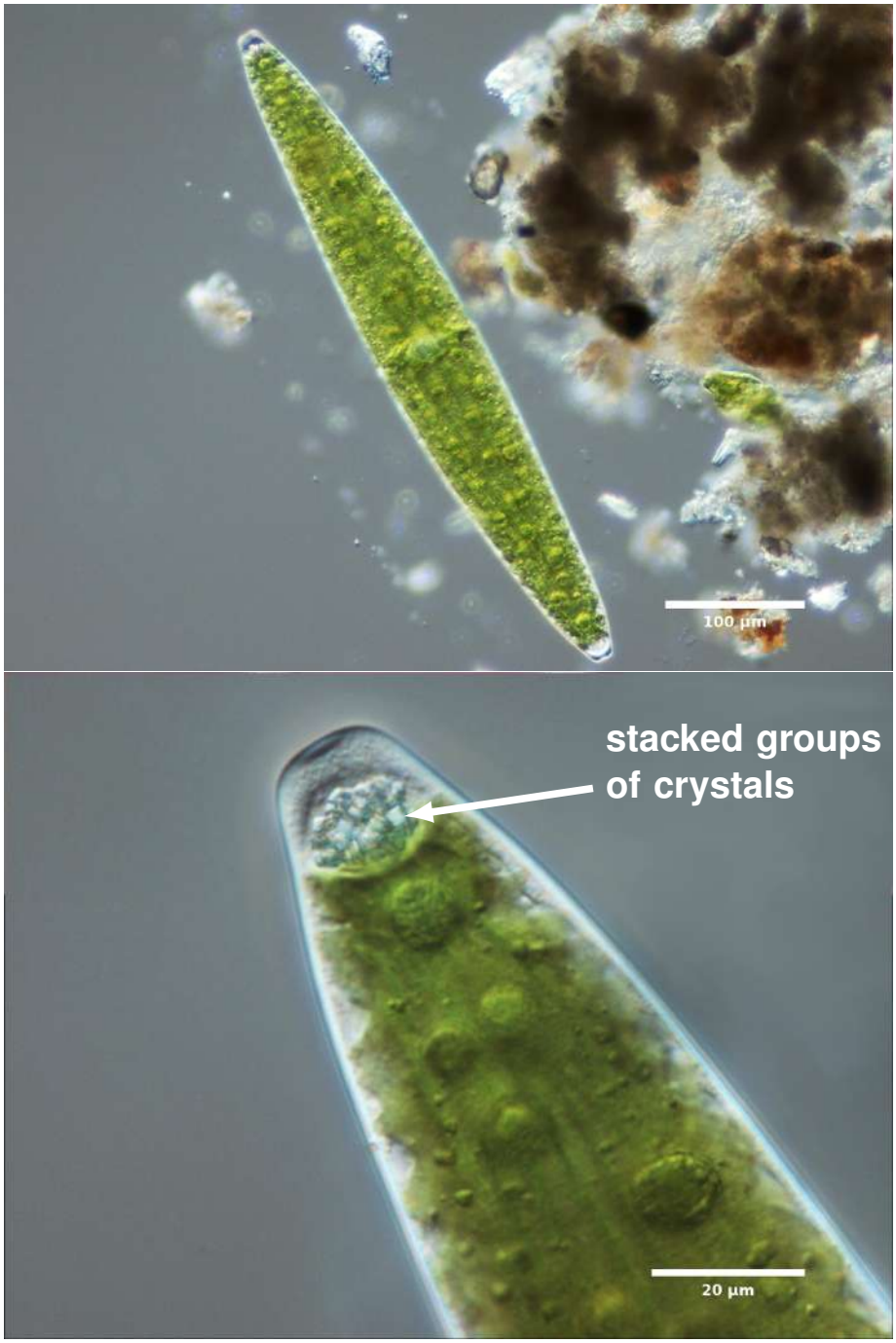


Figure 3.120: *Closterium lunula* (DIC/DIC), Highwood Lake, Mt. Baker area, Whatcom County (upper/lower images).



Figure 3.121: *Closterium lunula* (DIC/DIC), Mirror Lake, Whatcom County (upper/lower images).



Figure 3.122: *Closterium lunula* (DIC), small floating bog along Morris Valley Road near Harrison, BC.



Figure 3.123: *Closterium lunula* (DIC), Lower Ashland Lake, Mountain Loop Highway, Snohomish County.

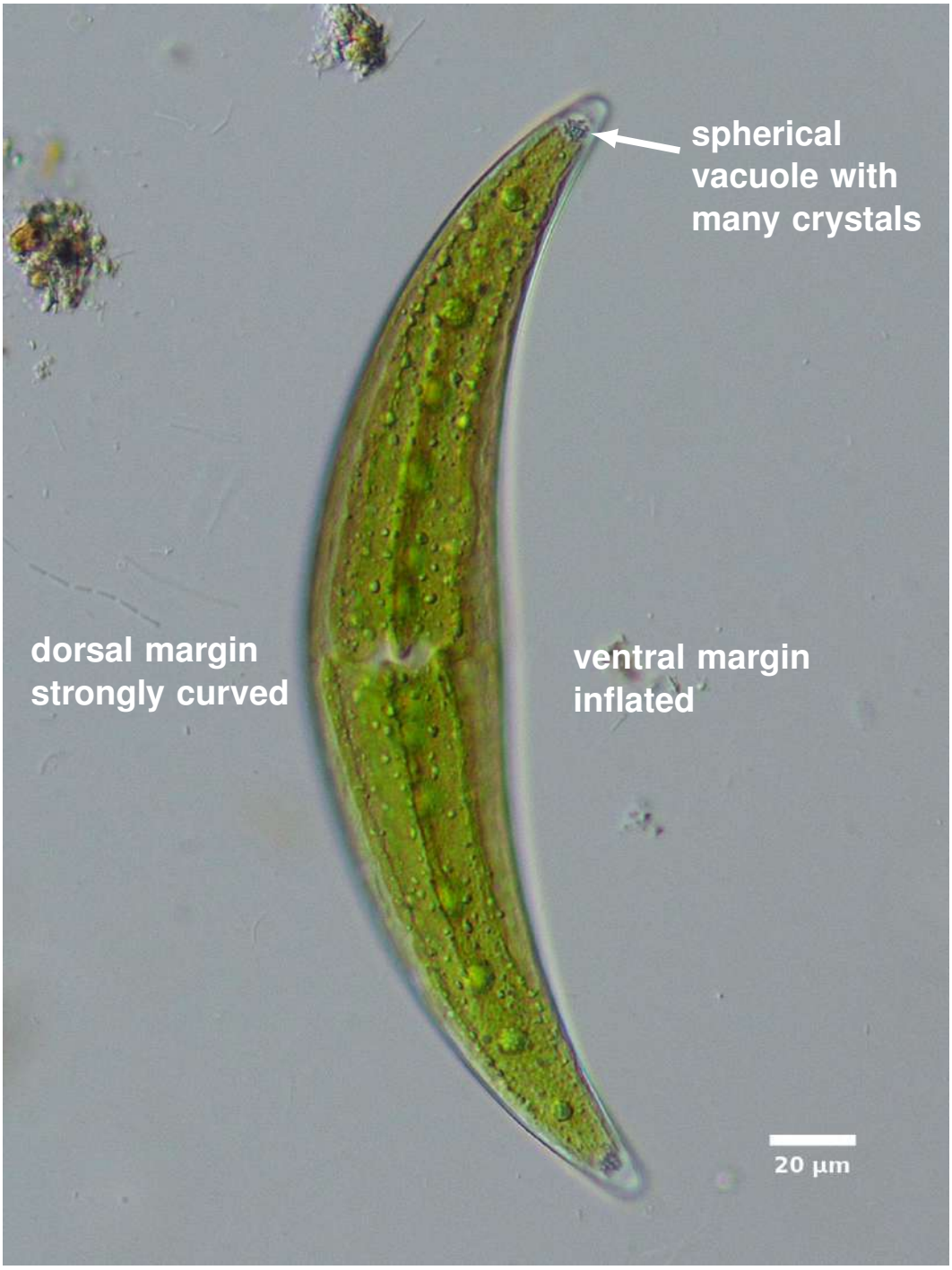


Figure 3.124: *Closterium moniliferum*), Myrtle Lake, Mountain Loop Highway, Snohomish County.



Figure 3.125: *Closterium moniliferum* (DIC/DIC), Lake Campbell (eastern Washington), Okanogan County (upper image); Squalicum Lake, Whatcom County (lower image).



Figure 3.126: *Closterium moniliferum*), Beaver Pond Lake, Whatcom County.

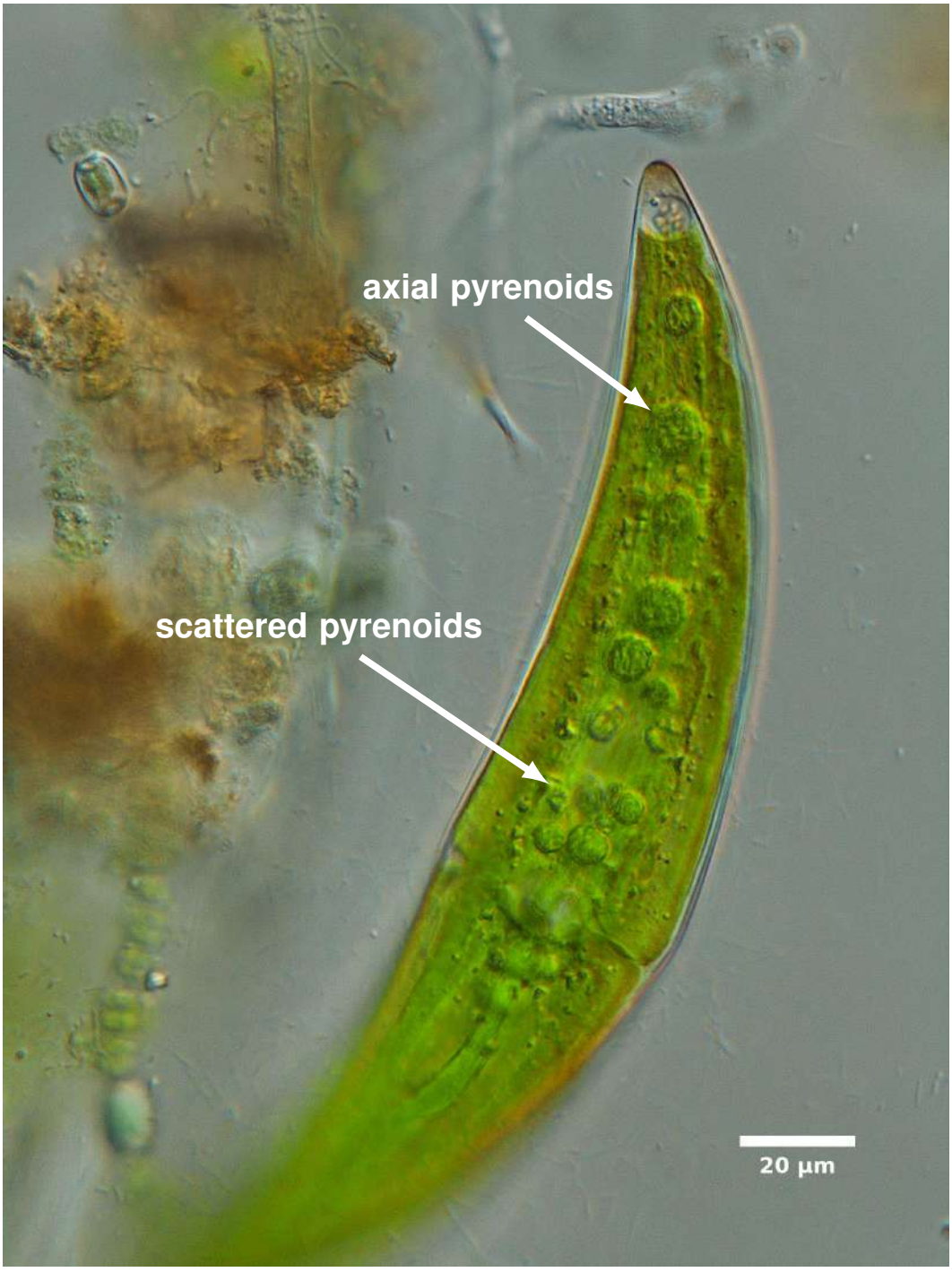


Figure 3.127: *Closterium moniliferum*) with axial and scattered pyrenoids, Lake Geneva, Whatcom County.

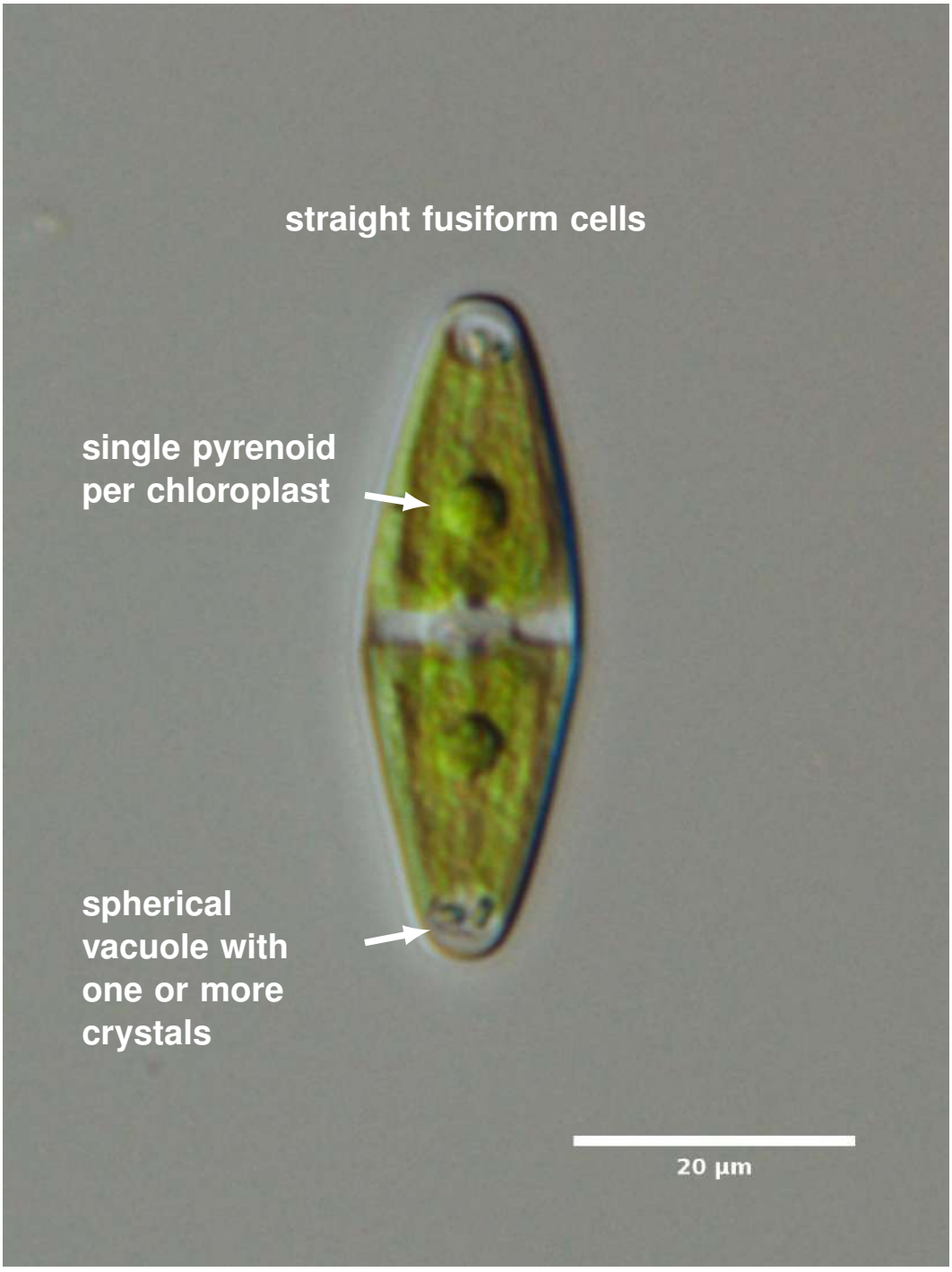


Figure 3.128: *Closterium navicula* (DIC), small pond near Artist Point Ridge trail, Mt. Baker Recreational Area, Whatcom County.



Figure 3.129: *Closterium navicula* (DIC), side channel on Nooksack River, Whatcom County.



Figure 3.130: *Closterium navicula* (DIC), small pond on trail to Big Four Ice Caves, Mountain Loop Highway, Snohomish County.



Figure 3.131: Size variations in *Closterium navicula* (DIC), Myrtle Lake, Mountain Loop Highway, Snohomish County (upper left image); small pond along Artist Point Ridge trail, Mt. Baker area, Whatcom County (upper right and lower left images); small pond on trail to Dock Butte, Mt. Baker area, Skagit County (lower right image).

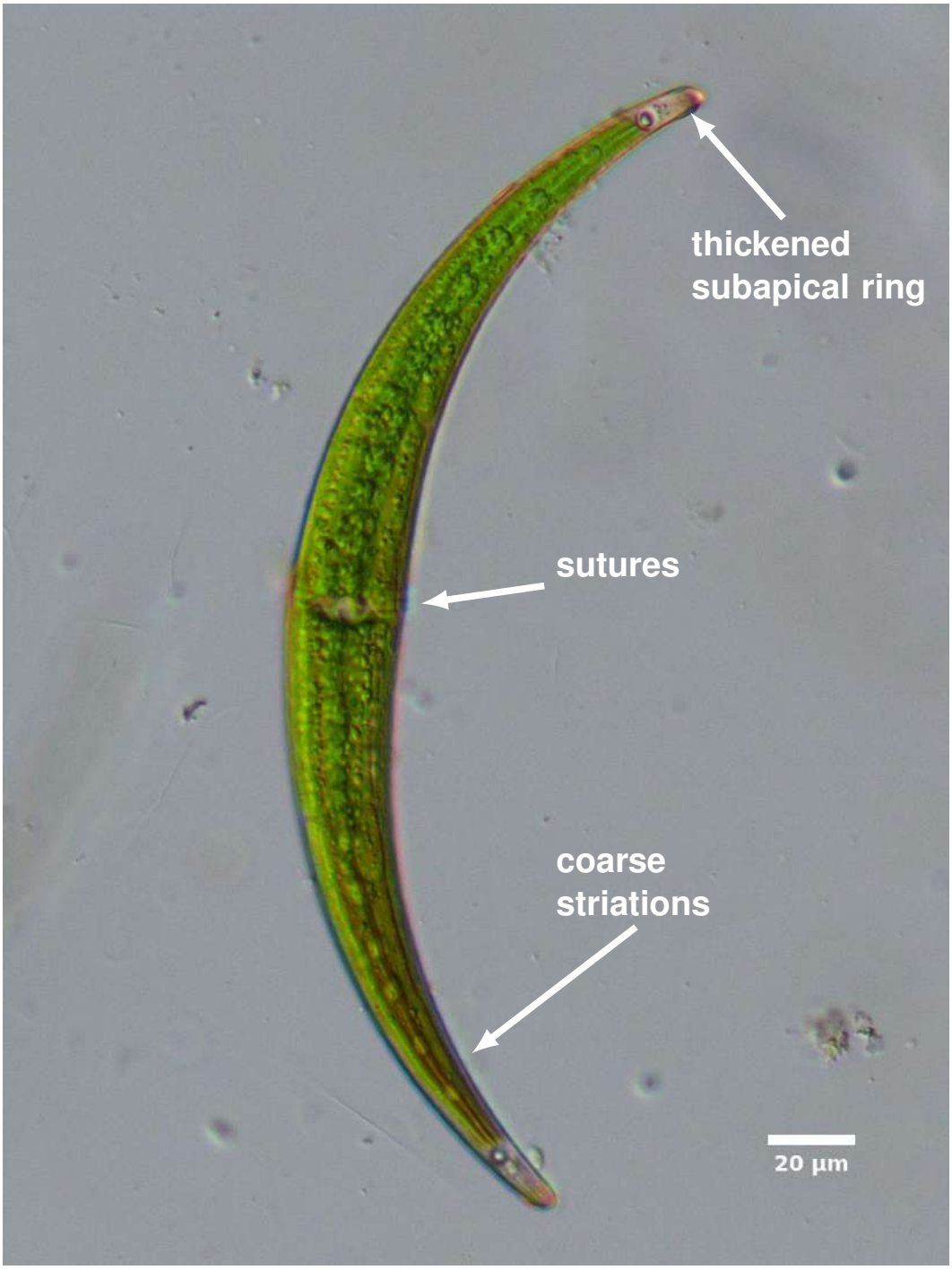


Figure 3.132: *Closterium nematodes* (DIC), Upper Ashland Lake, Mountain Loop Highway, Snohomish County.



Figure 3.133: *Closterium nematodes* (DIC), Upper Ashland Lake, Mountain Loop Highway, Snohomish County.



Figure 3.134: *Closterium nematodes* (DIC), Bear Lake, Mountain Loop Highway, Snohomish County.



Figure 3.135: *Closterium nematodes* (DIC), Lake Evan, Mountain Loop Highway, Snohomish County.

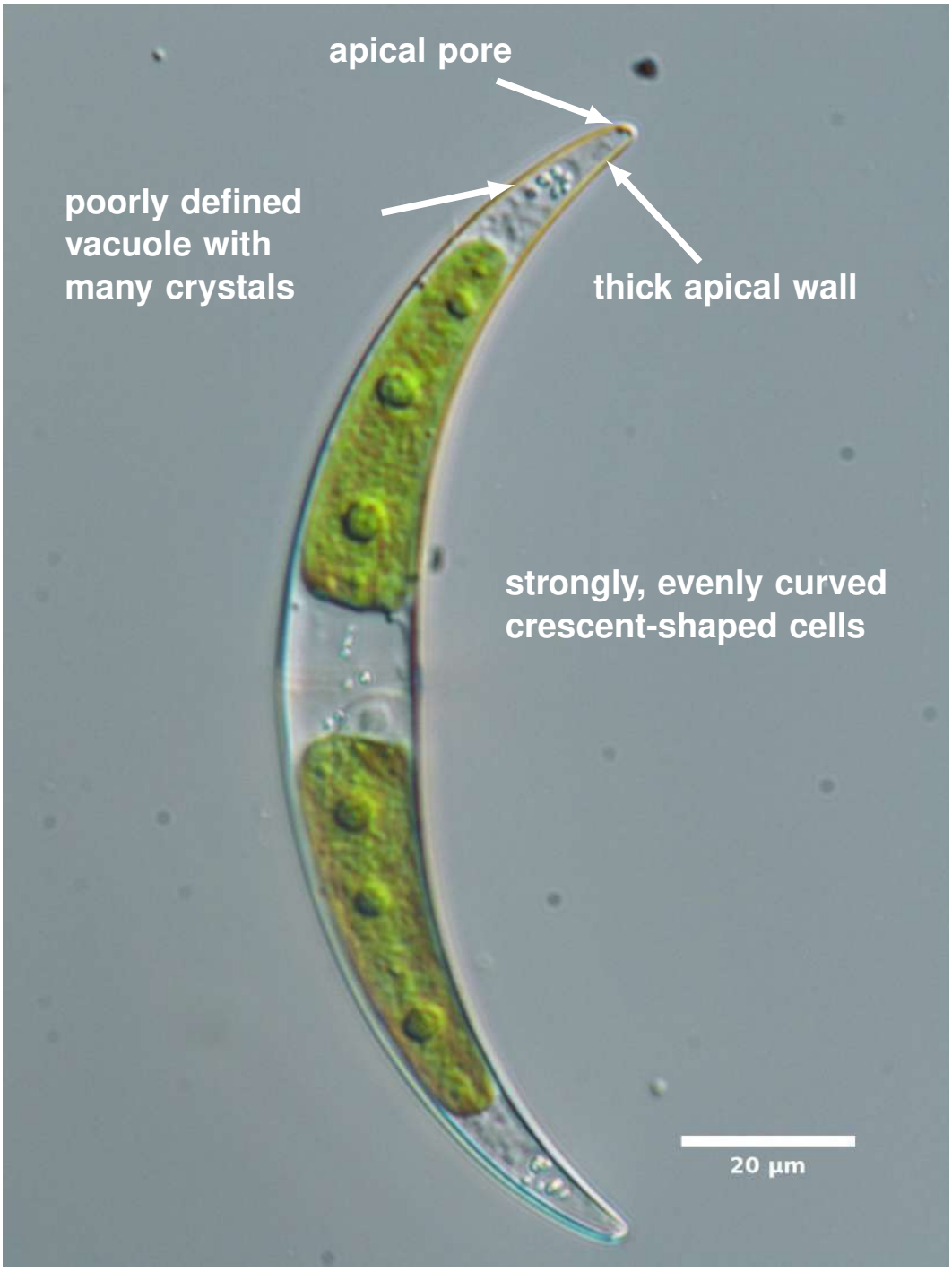


Figure 3.136: *Closterium parvulum* (DIC), Beaver Pond Lake, Whatcom County.



Figure 3.137: *Closterium parvulum* (DIC/DIC), Squalicum Lake, Whatcom County (upper/lower images).



Figure 3.138: *Closterium parvulum* (DIC), Pine Lake, Whatcom County.



Figure 3.139: *Closterium parvulum* group var. A (DIC), Myrtle Lake, Mountain Loop Highway, Snohomish County.



Figure 3.140: *Closterium parvulum* group var. A (DIC), Beaver Pond Lake, Whatcom County.



Figure 3.141: *Closterium parvulum* group var. A (DIC), Lake Evan, Mountain Loop Highway, Snohomish County.



Figure 3.142: *Closterium parvulum* group var. B (DIC), Myrtle Lake, Mountain Loop Highway, Snohomish County.



Figure 3.143: *Closterium parvulum* group var. B (DIC), Myrtle Lake, Mountain Loop Highway, Snohomish County.



Figure 3.144: *Closterium praelongum* (DIC), Lake Ketchum, Snohomish County.

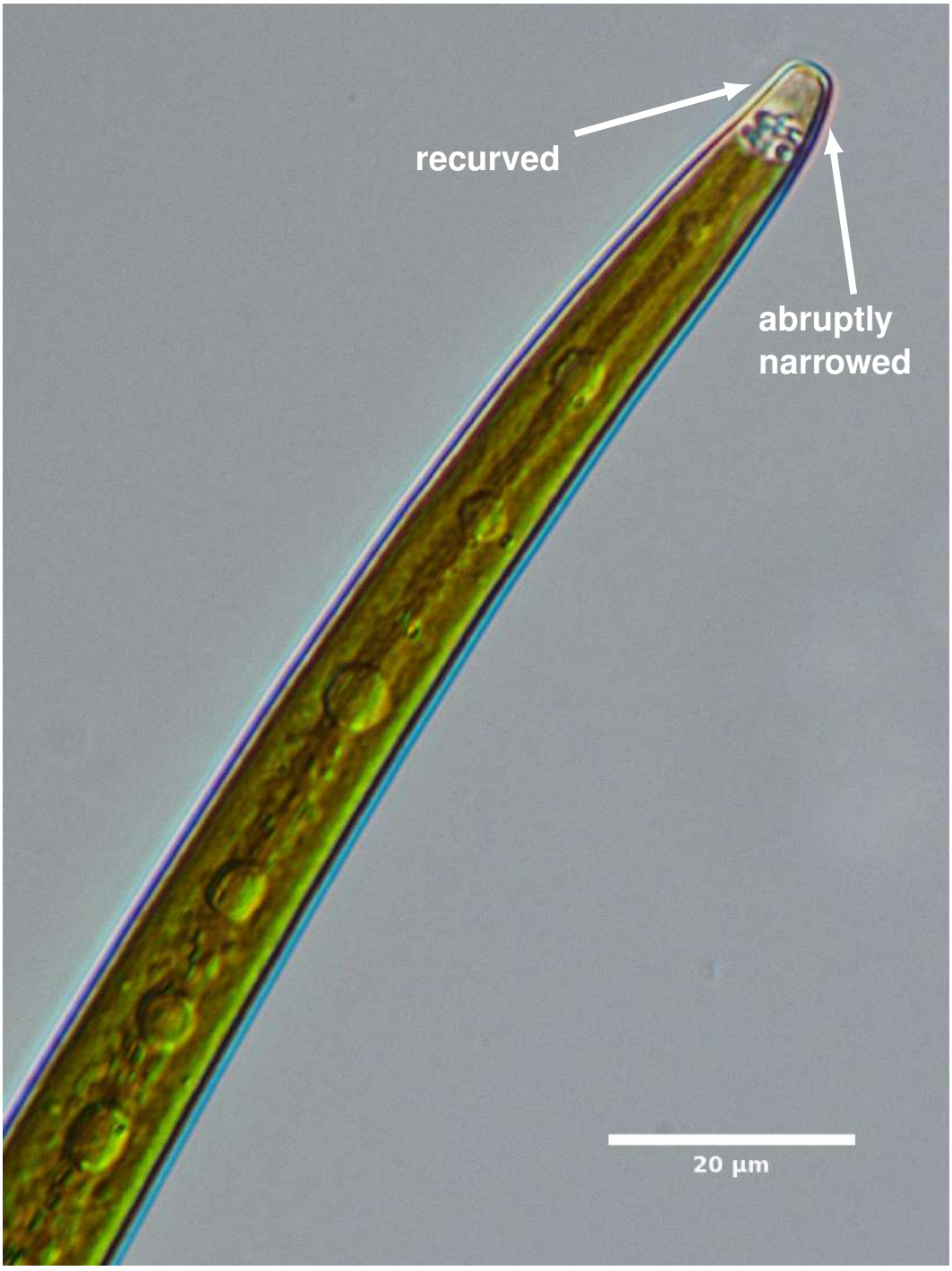


Figure 3.145: *Closterium praelongum* (DIC), Lake Ketchum, Snohomish County.



Figure 3.146: *Closterium praelongum* (DIC), Fraser St. culvert, Bellingham, Whatcom County.



Figure 3.147: *Closterium praelongum* (DIC/DIC), Fraser St. culvert, Bellingham, Whatcom County (upper/lower images).



Figure 3.148: *Closterium pritchardianum* (DIC), Vogler Lake, Skagit County.



Figure 3.149: *Closterium pritchardianum* (DIC/DIC), Vogler Lake, Skagit County (upper/lower images).



Figure 3.150: *Closterium pronum* (DIC), Lake Campbell (eastern Washington), Okanogan County.



Figure 3.151: *Closterium pronum* (DIC), Lake Terrell, Whatcom County.



Figure 3.152: *Closterium pronum* (DIC), small floating bog along Morris Valley Road near Harrison, BC.

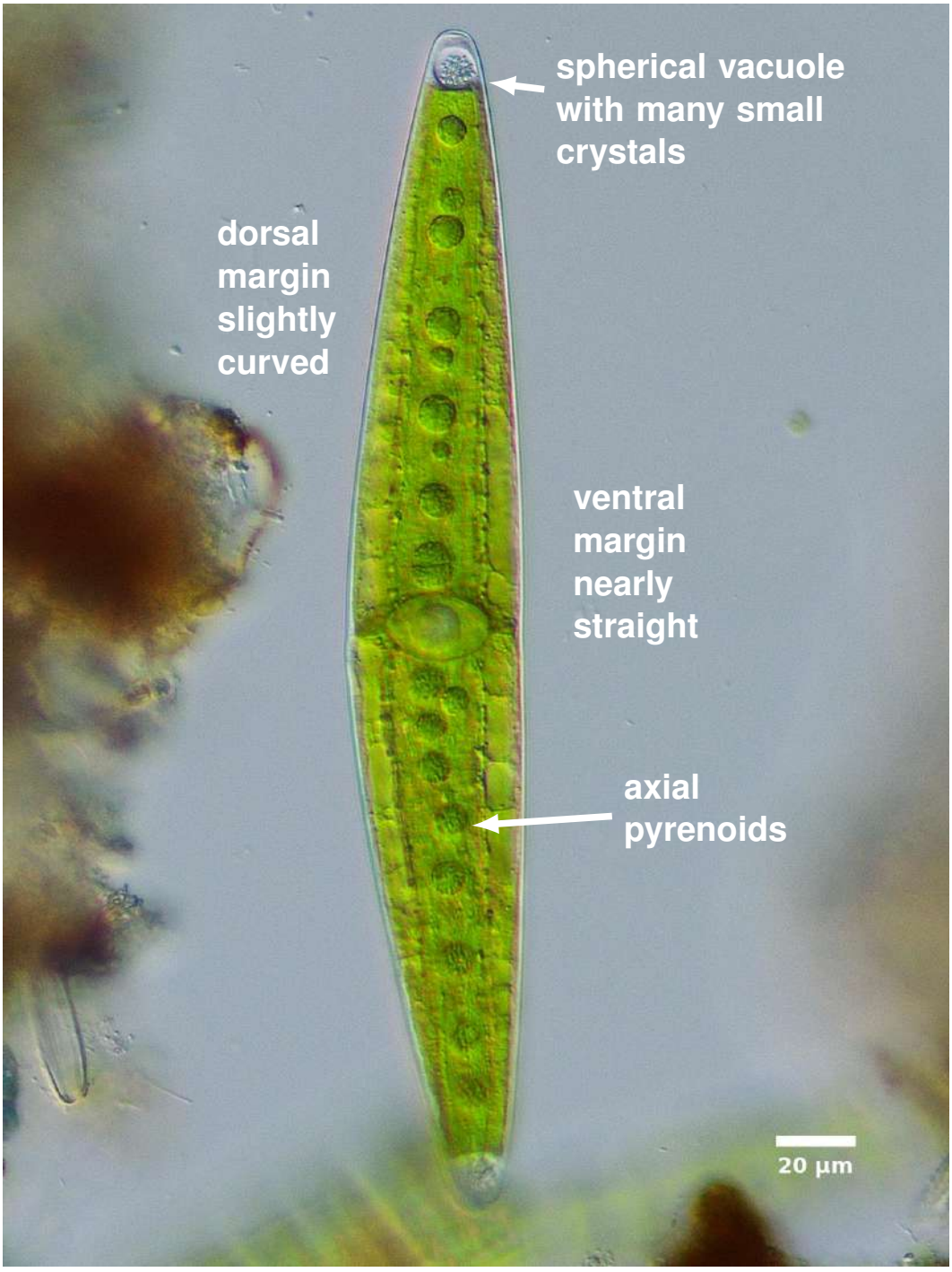


Figure 3.153: *Closterium pseudolunula* (DIC), small pond along Military Road south of Tacoma, Pierce County.



Figure 3.154: *Closterium pseudolunula* (DIC), Lake Sixteen, Skagit County.



Figure 3.155: *Closterium pseudolunula* (DIC), Lake Sixteen, Skagit County.

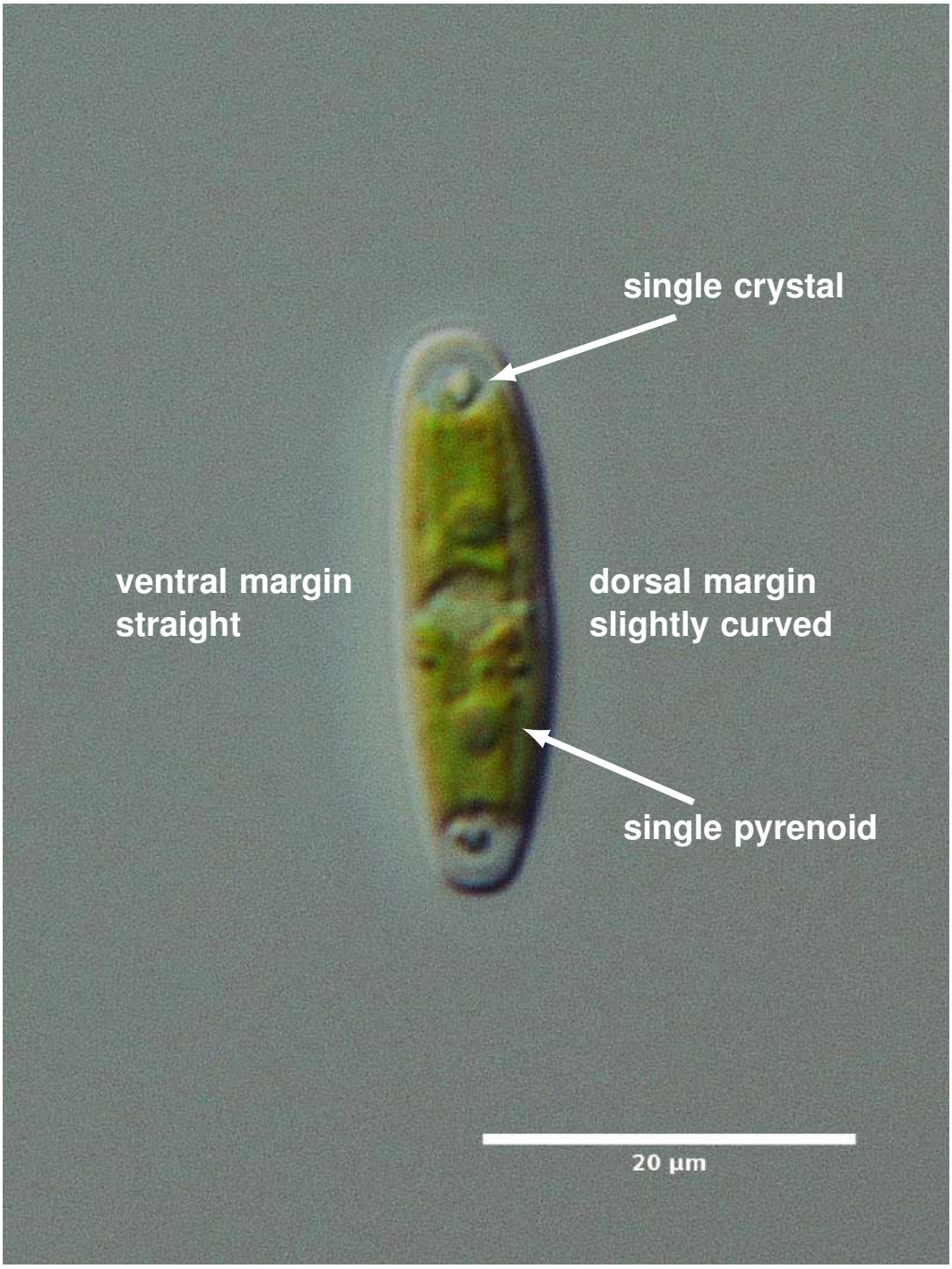


Figure 3.156: *Closterium pusillum* (DIC), Takhlakh Lake, Gifford Pinchot National Forest, Skamania County.



Figure 3.157: *Closterium pusillum* (bright field), Vogler Lake, Skagit County.



Figure 3.158: *Closterium pusillum* (DIC), Takhlakh Lake, Gifford Pinchot National Forest, Skamania County.



Figure 3.159: *Closterium pusillum* (DIC/DIC), Takhlakh Lake, Gifford Pinchot National Forest, Skamania County (upper/lower images).



Figure 3.160: *Closterium ralfsii* var. *hybridum* (DIC), Myrtle Lake, Mountain Loop Highway, Snohomish County.

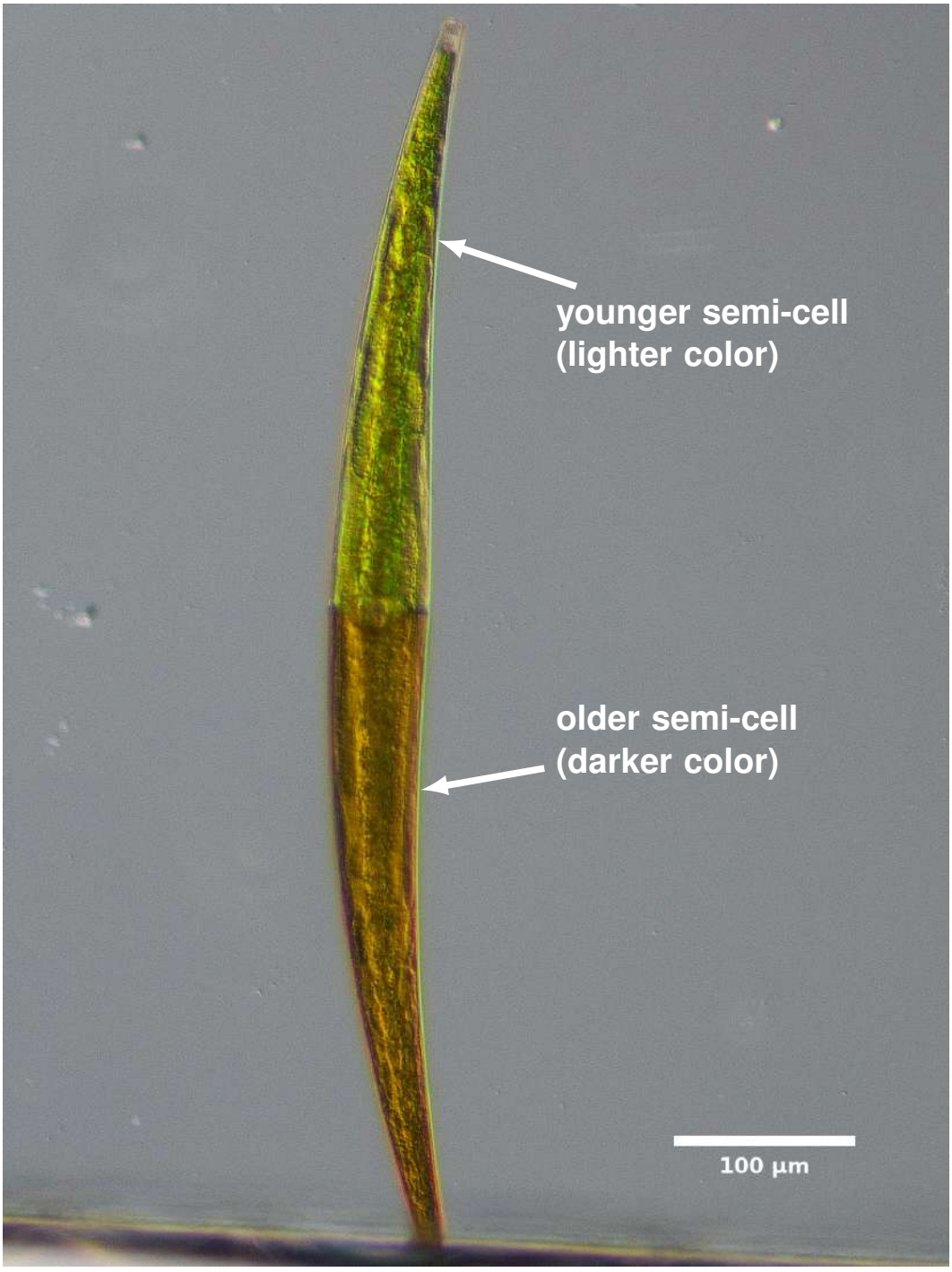


Figure 3.161: *Closterium ralfsii* var. *hybridum* (DIC), Mirror Lake, Whatcom County.



Figure 3.162: *Closterium ralfsii* var. *hybridum* (DIC/DIC), Summer Lake, Skagit County (upper/lower images).

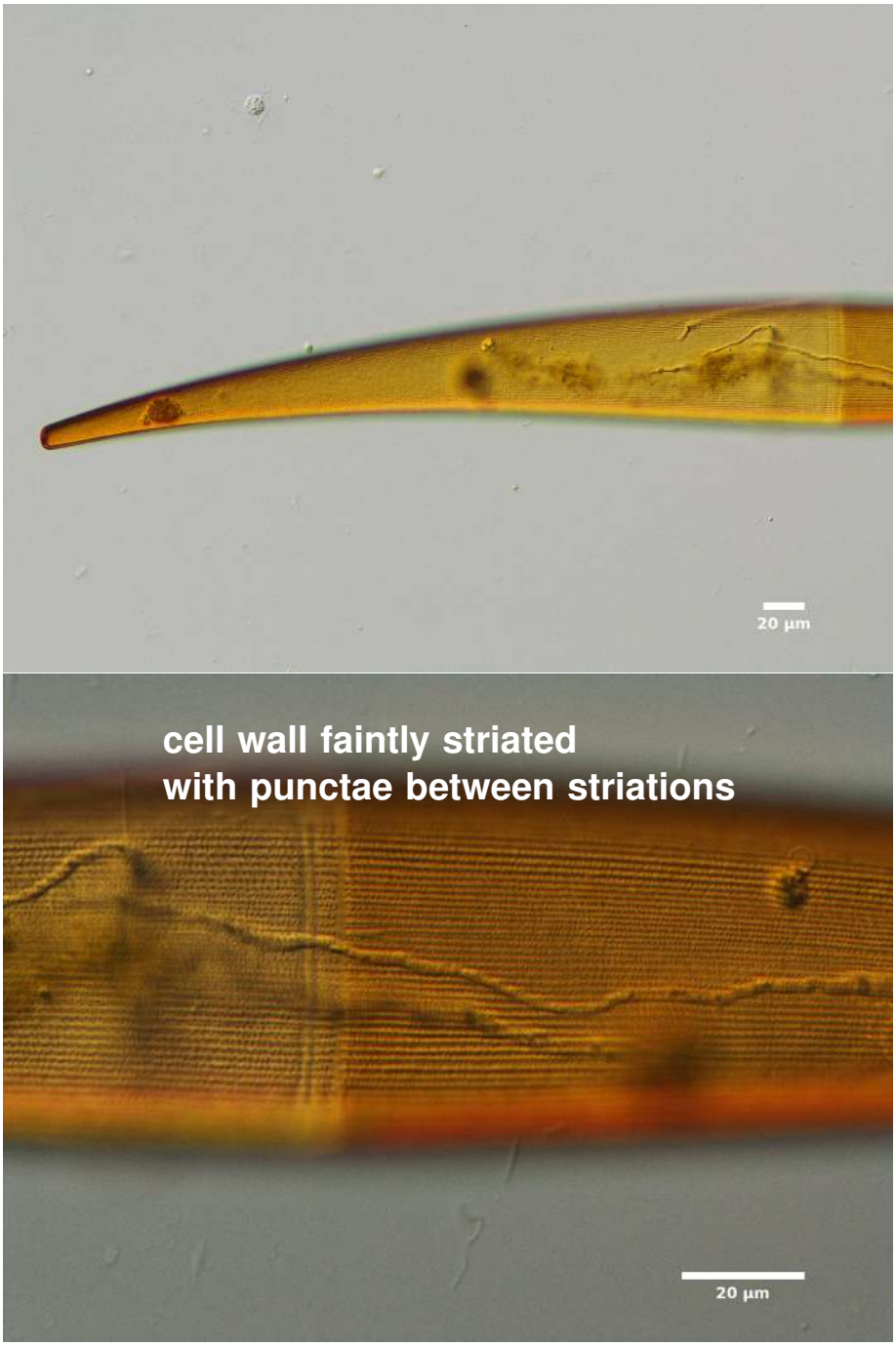


Figure 3.163: *Closterium ralfsii* var. *hybridum* (DIC/DIC), Summer Lake, Skagit County (upper/lower images).

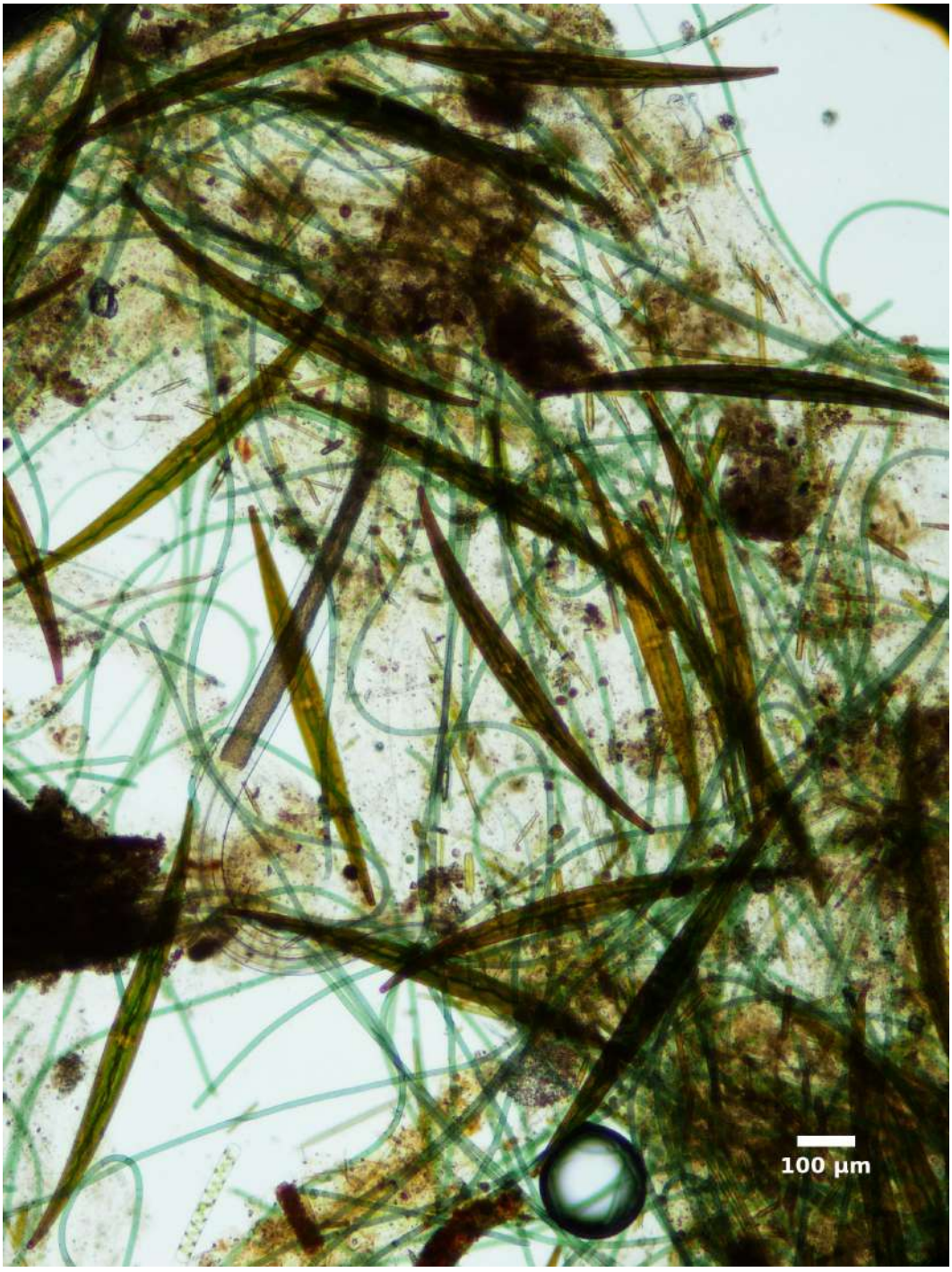


Figure 3.164: *Closterium ralfsii* var. *hybridum* bloom (bright field), Summer Lake, Skagit County.

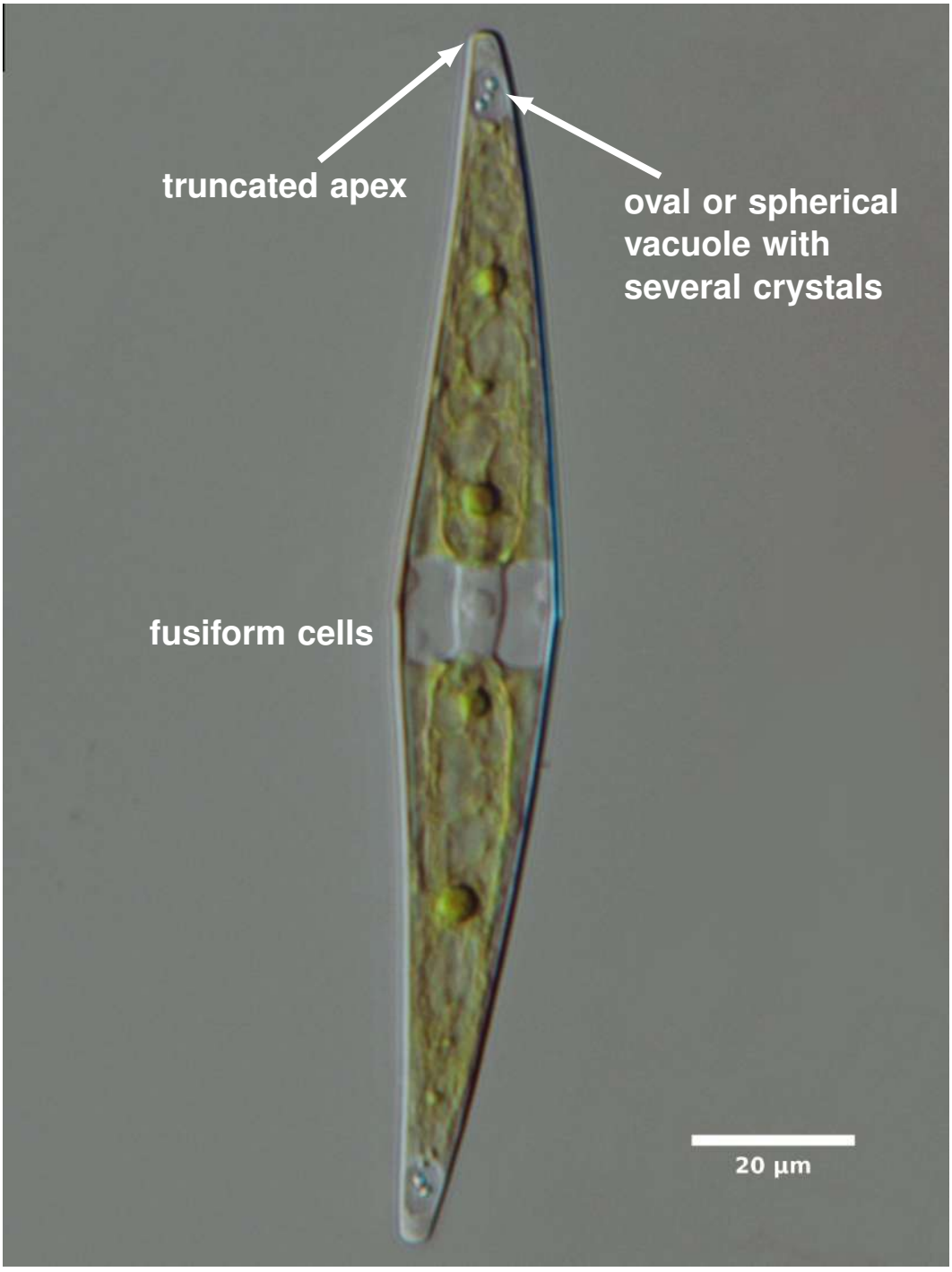


Figure 3.165: *Closterium* cf. *rectimarginatum* (DIC), Myrtle Lake, Mountain Loop Highway, Snohomish County.



Figure 3.166: *Closterium rectimarginatum* (DIC), Myrtle Lake, Mountain Loop Highway, Snohomish County.



Figure 3.167: *Closterium* cf. *rectimarginatum* (DIC), Lake Everett, Skagit County.



Figure 3.168: *Closterium* cf. *rectimarginatum* (bright field), Squalicum Lake, Whatcom County.

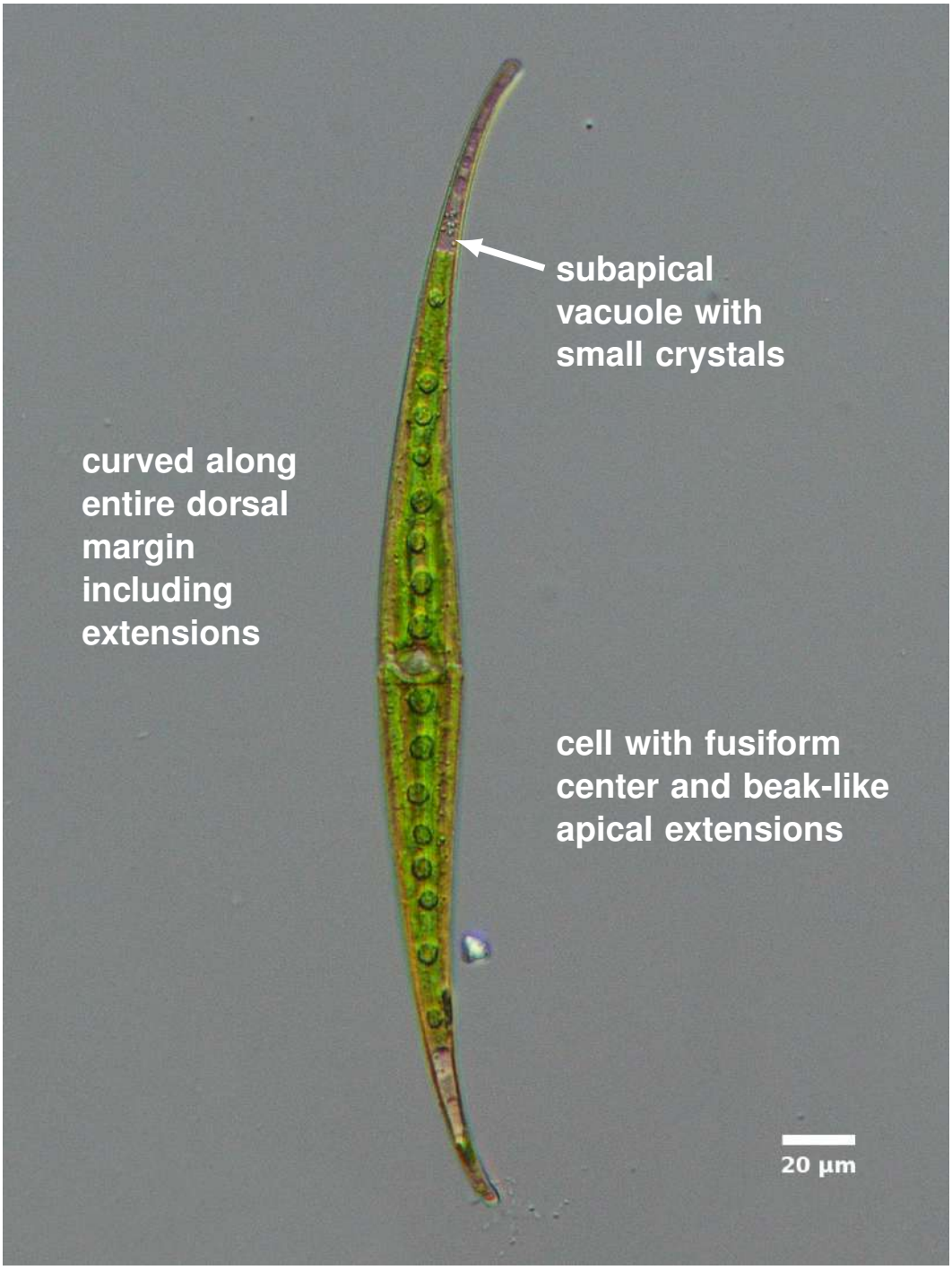


Figure 3.169: *Closterium rostratum* (DIC), Goat Lake, Mountain Loop Highway, Snohomish County.

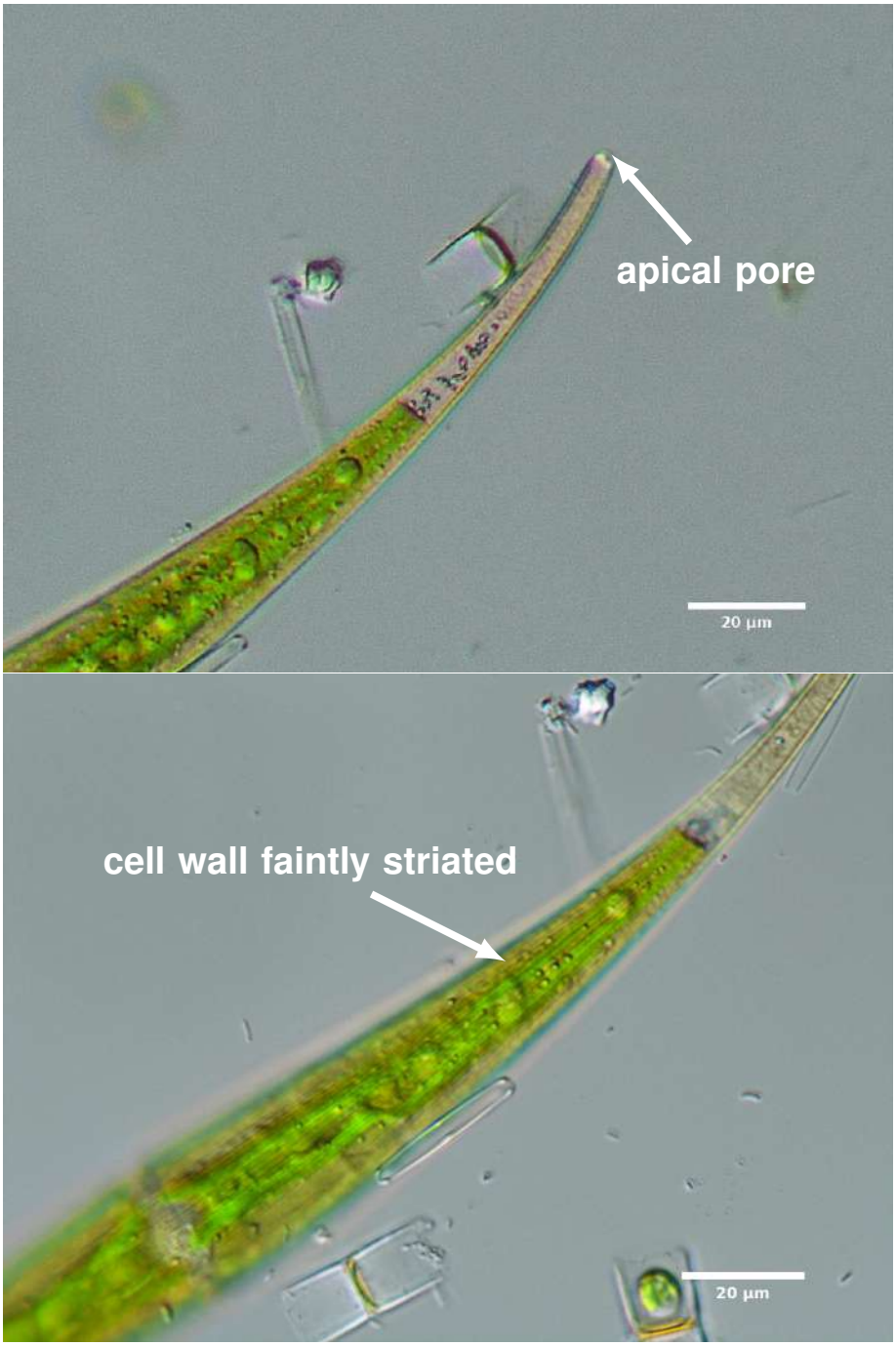


Figure 3.170: *Closterium rostratum* (DIC/DIC), side channel on Nooksack River, Whatcom County (upper/lower images).



Figure 3.171: *Closterium rostratum* (DIC), Beaver Lake, Skagit County.



Figure 3.172: *Closterium rostratum* (DIC), small residential pond, Whatcom County.



Figure 3.173: *Closterium rostratum* (DIC/DIC), cell variations in sample collected on same date, small pond along Military Road south of Tacoma, Pierce County (upper/lower images).

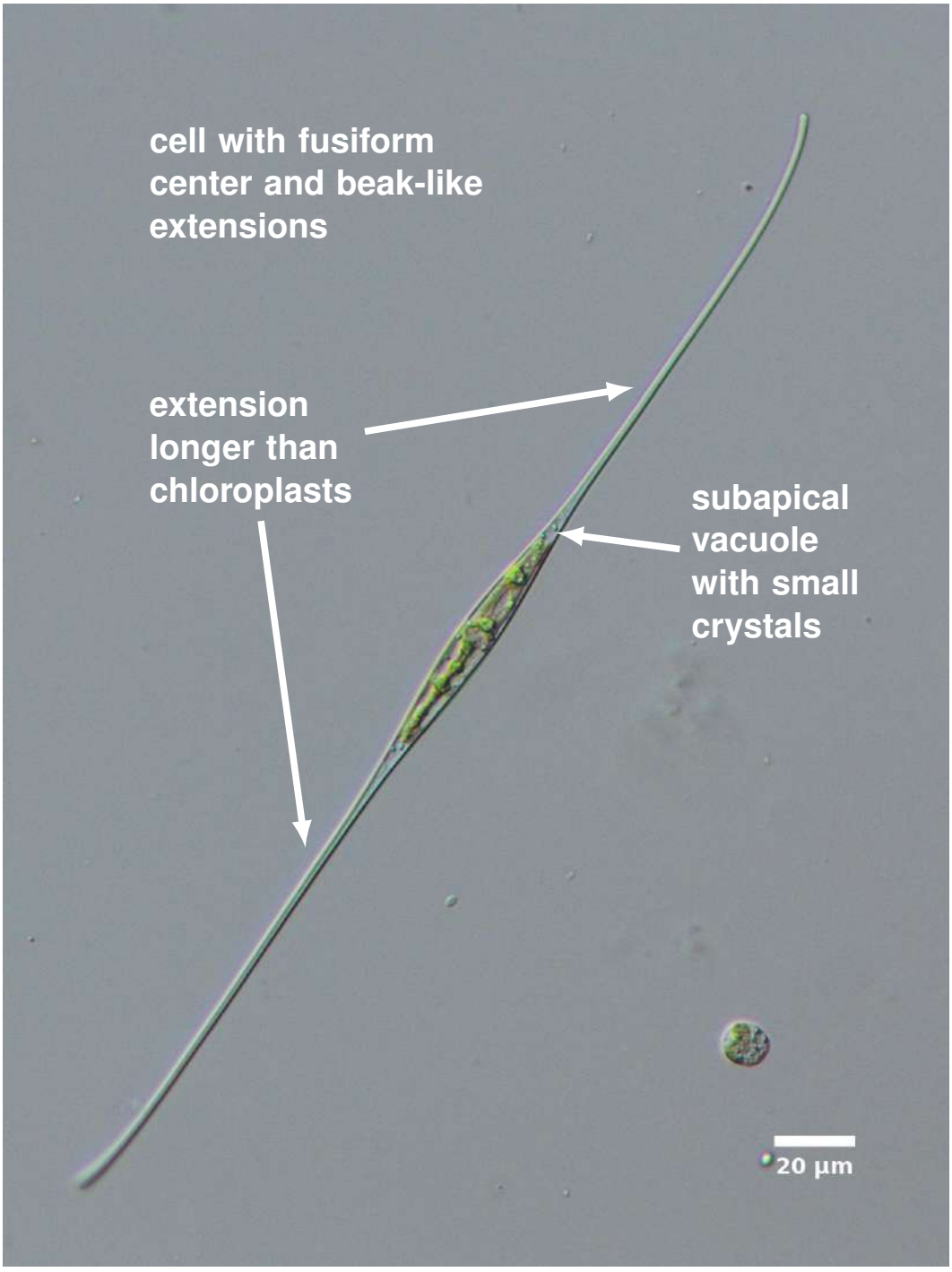


Figure 3.174: *Closterium setaceum* (DIC), Lake Evan, Mountain Loop Highway, Snohomish County.



Figure 3.175: *Closterium setaceum* (DIC/DIC), Summer Lake, Skagit County (upper/lower images).



Figure 3.176: *Closterium setaceum* (DIC), Myrtle Lake, Mountain Loop Highway, Snohomish County.



Figure 3.177: *Closterium setaceum* (DIC), Boardman Lake, Mountain Loop Highway, Snohomish County.

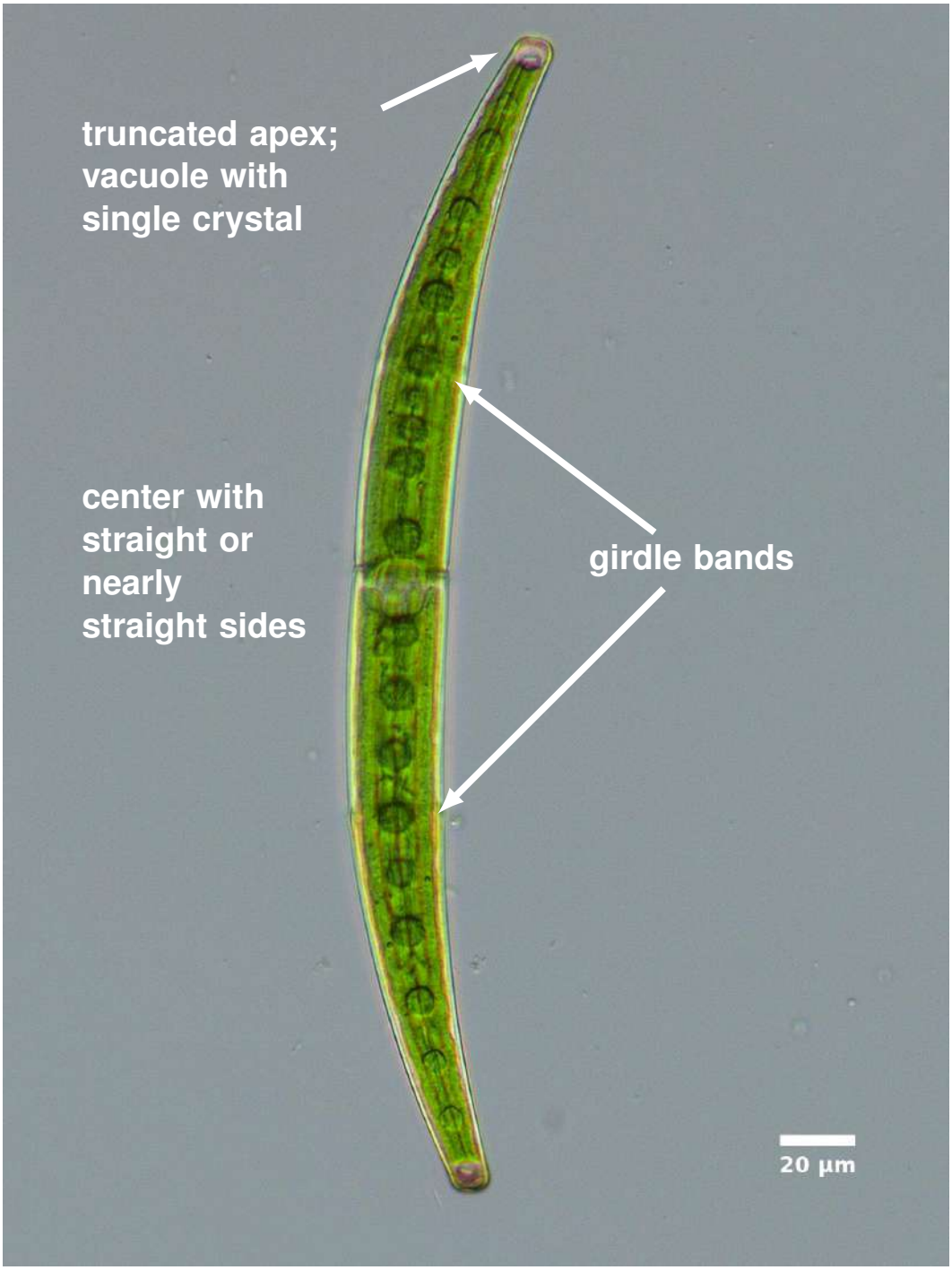


Figure 3.178: *Closterium striolatum* (DIC), Lake Evan, Mountain Loop Highway, Snohomish County.

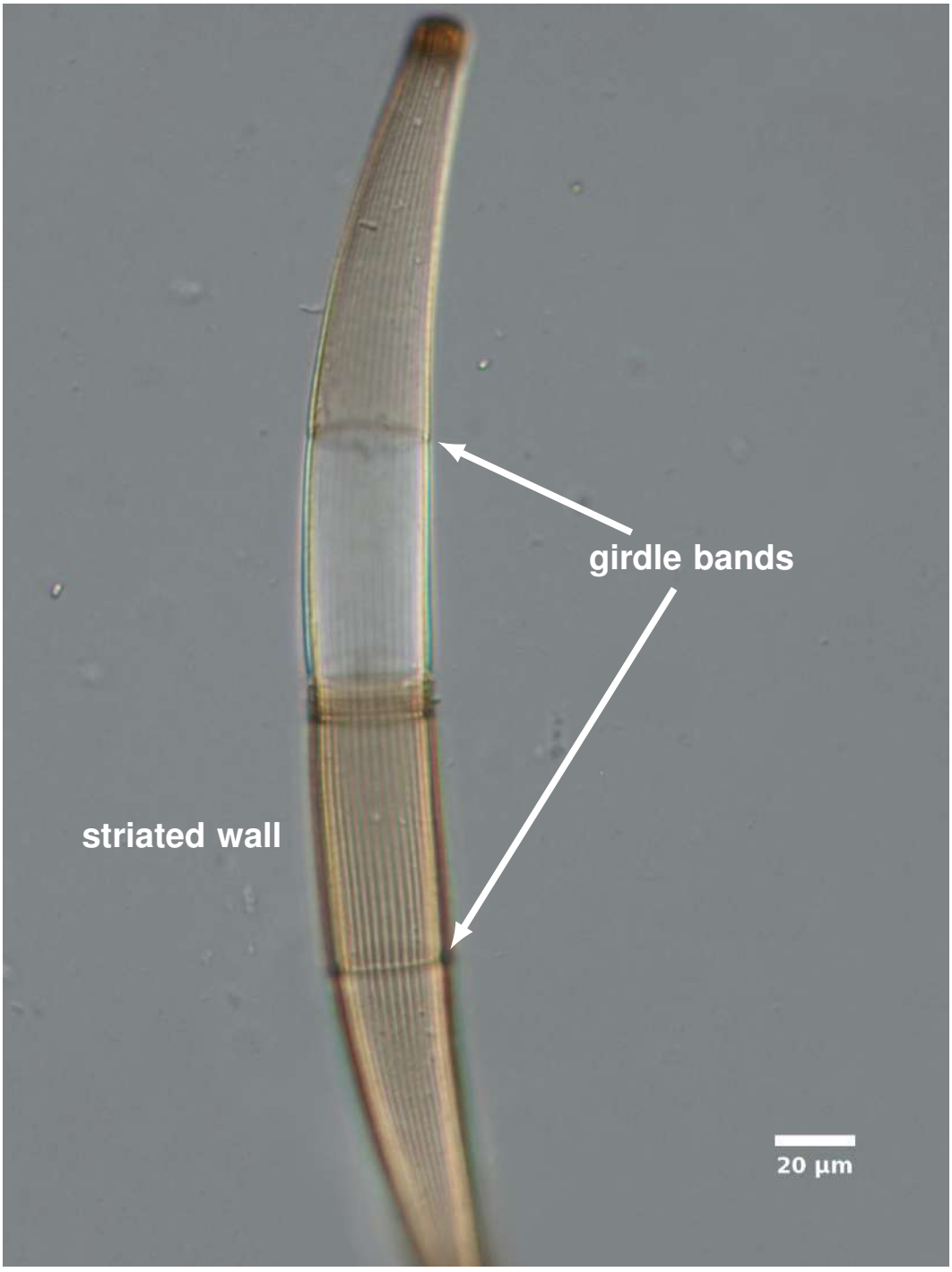


Figure 3.179: *Closterium striolatum* (DIC), Lake Evan, Mountain Loop Highway, Snohomish County.



Figure 3.180: *Closterium striolatum* (DIC/DIC), Mirror Lake, Whatcom County (upper/lower images).

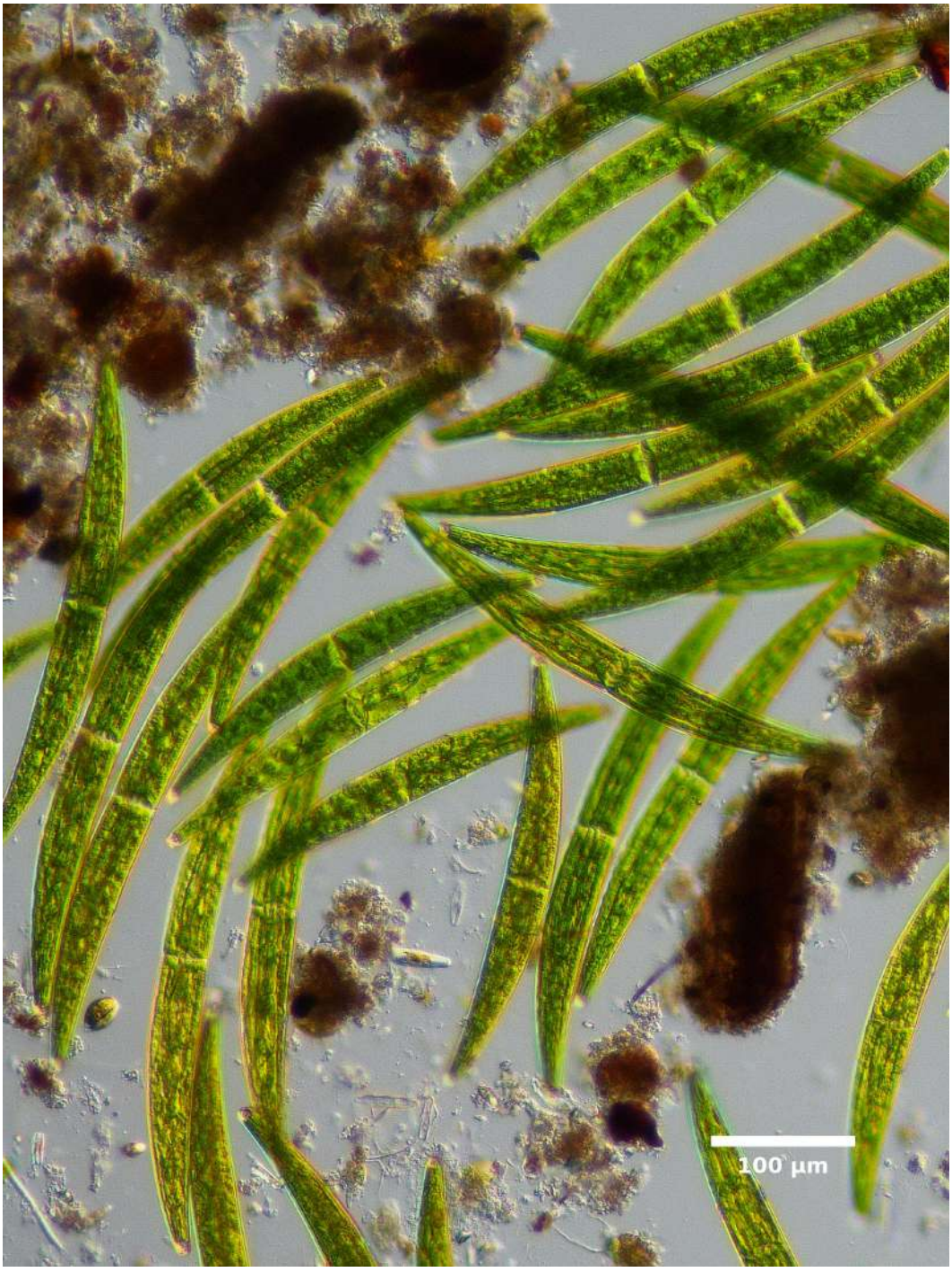


Figure 3.181: *Closterium striolatum* bloom (DIC), Western Washington University storm water treatment pond, Whatcom County.

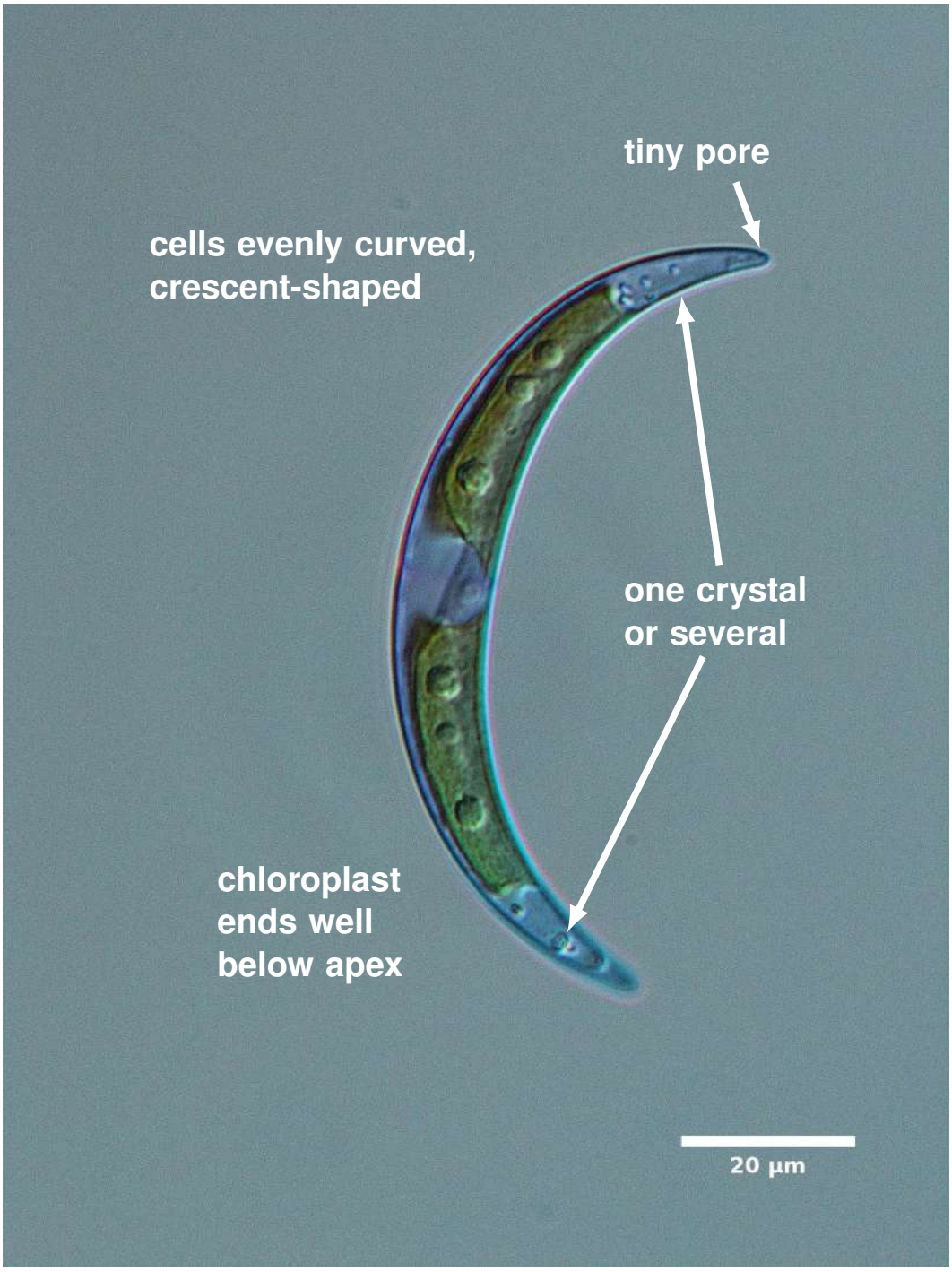


Figure 3.182: *Closterium venus* (DIC), stained with methylene blue, Hoag Pond, Whatcom County.



Figure 3.183: *Closterium venus* (DIC), Lake Everett, Skagit County.



Figure 3.184: *Closterium venus* (DIC), Beaver Lake, Skagit County.

Chapter 4

Cosmocladium Brébisson

Northwest Washington taxa
Cosmocladium constrictum (W. Archer) W. Archer ex Joshua
Cosmocladium saxonicum De Bary

Table 4.1: Key to *Cosmocladium* Species

A	Sinus very shallow; semi-cells oval or pyramidal	*Cosmocladium constrictum* (Figures 4.1–4.4)
B	Sinus moderately deep; semi-cells elliptical or kidney-shaped	*Cosmocladium saxonicum* (Figures 4.5–4.8)

Table 4.2: *Cosmocladium* Cell Measurements

		Cell Width	Cell Length	Isthmus Width	L/W Ratio
Cosmocladium constrictum	min	7.95 μm	11.8 μm	6.3 μm	1.3
	med	10.3 μm	16.6 μm	9.1 μm	1.6
	max	15.5 μm	22.2 μm	12.9 μm	1.7

continued on next page

Table 4.2: *Cosmocladium* Cell Measurements, continued

		Cell Width	Cell Length	Isthmus Width	L/W Ratio
Cosmocladium saxonicum	min	11.3 μm	15.0 μm	4.6 μm	1.1
	med	17.8 μm	22.4 μm	6.9 μm	1.3
	max	20.4 μm	28.0 μm	8.3 μm	1.5

Description

Cosmocladium semi-cells are oval, pyramidal, elliptical, or kidney-shaped with smooth walls and a shallow or deep, open sinus (Figures 4.1–4.8). Individual cells resemble small, smooth-walled *Actinotaenium* or *Cosmarium* cells[18], but the cells are connected by long, thin mucilage strands to form open, branching colonies. In addition to the connecting strands, the cells excrete radiating mucilage strands that resemble setae. Each semi-cell contains one axial chloroplast with a large pyrenoid.

Cosmocladium constrictum cells are peanut-shaped with an extremely shallow sinus separating oval or pyramidal semi-cells (Figures 4.1–4.4). The cells are connected by a thin mucilage strand (occasionally two strands). The specimens in Figures 4.3–4.4 are slightly smaller than expected for this species, but match other diagnostic features for *Cosmocladium constrictum*. Small specimens such as these were collected from several locations, on multiple dates, and were not interspersed with larger cells, so they may represent an undescribed variety.

Cosmocladium saxonicum is moderately common in boggy northwest Washington lakes and ponds. The cells have a deep, open sinus separating the elliptical or kidney-shaped semi-cells (Figures 4.5–4.8). The cells are loosely connected by two mucilage strands (occasionally single strands).

[18] See **Freshwater Algae in Northwest Washington, Volume III. Part B**



Figure 4.1: *Cosmocladium constrictum* (DIC), Squires Lake, Whatcom County.

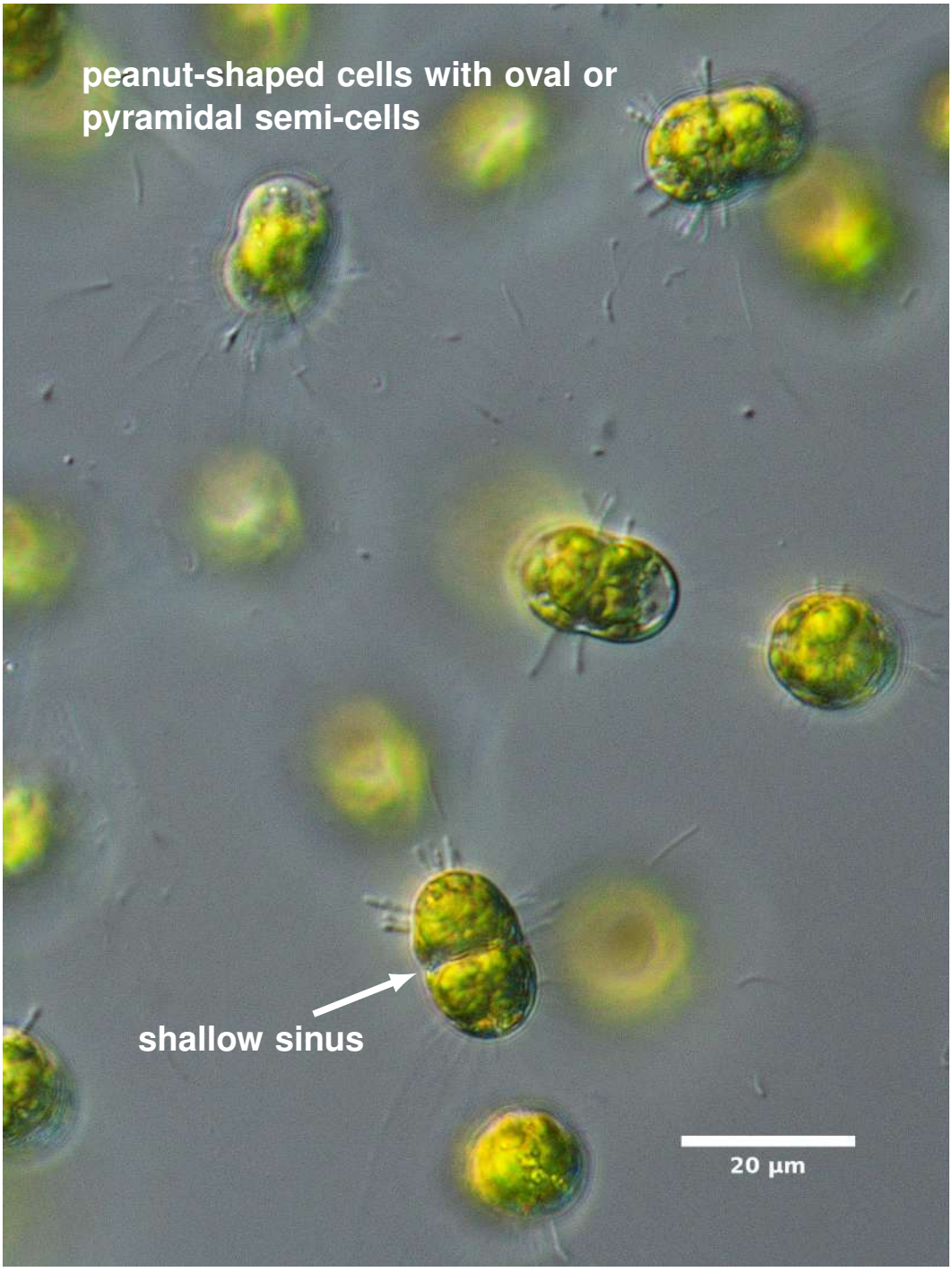


Figure 4.2: *Cosmocladium constrictum* (DIC), Squires Lake, Whatcom County.

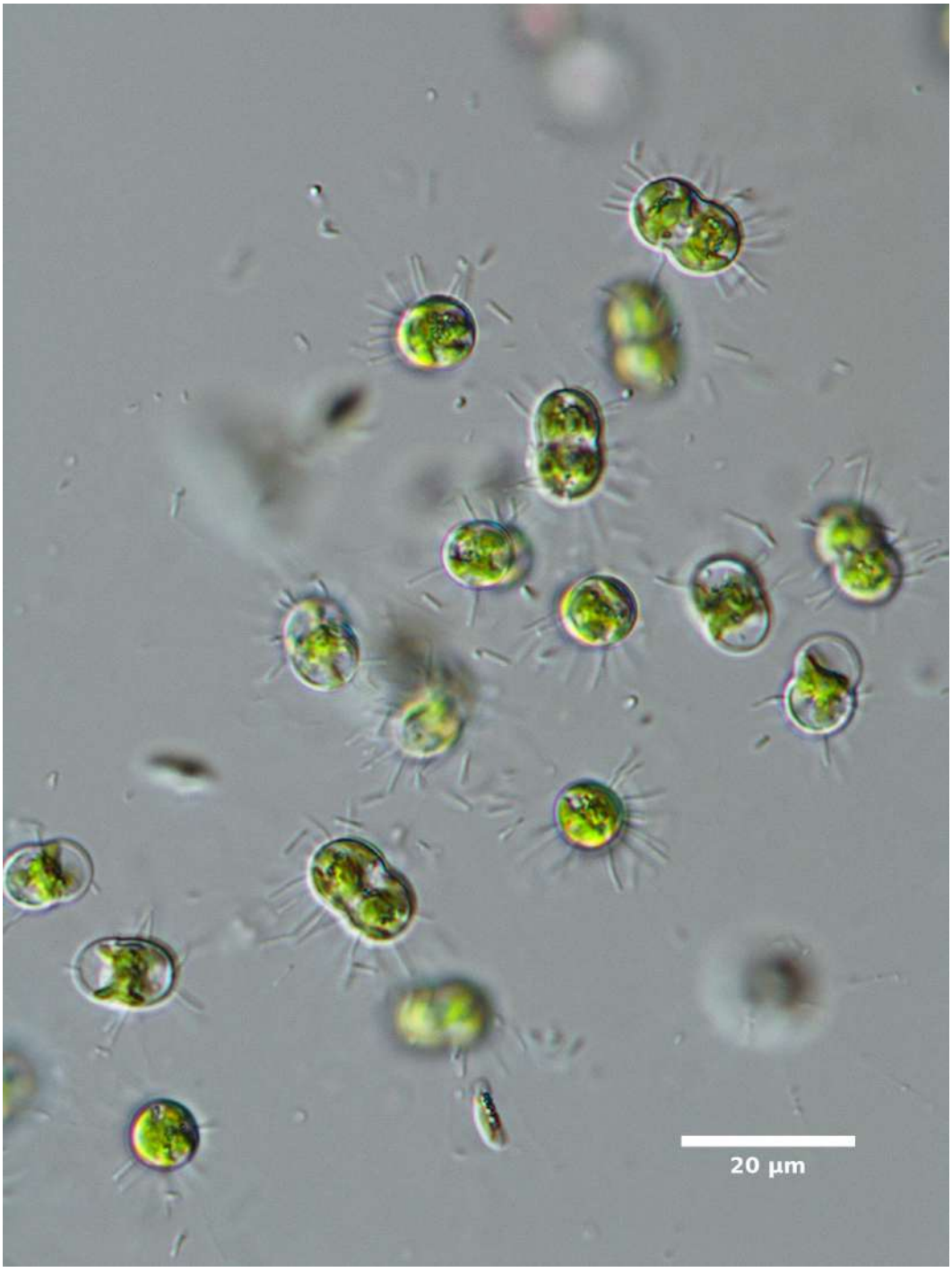


Figure 4.3: *Cosmocladium constrictum* (DIC), small pond on Valley Circle Drive, Snohomish County.

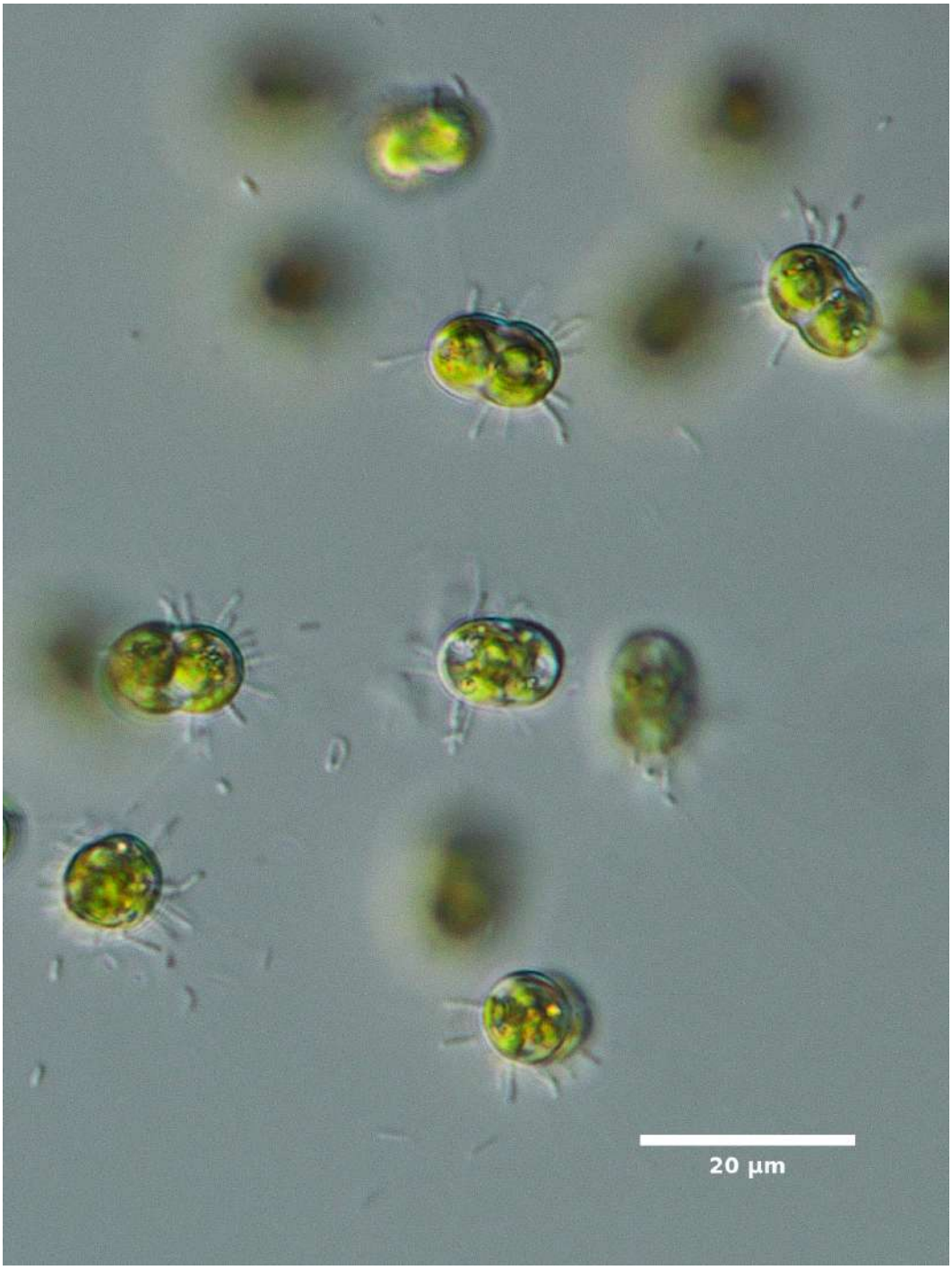


Figure 4.4: *Cosmocladium constrictum* (DIC), Silver Lake, Whatcom County.



Figure 4.5: *Cosmocladium saxonicum*, (DIC), Bear Lake, Mountain Loop Highway, Snohomish County.

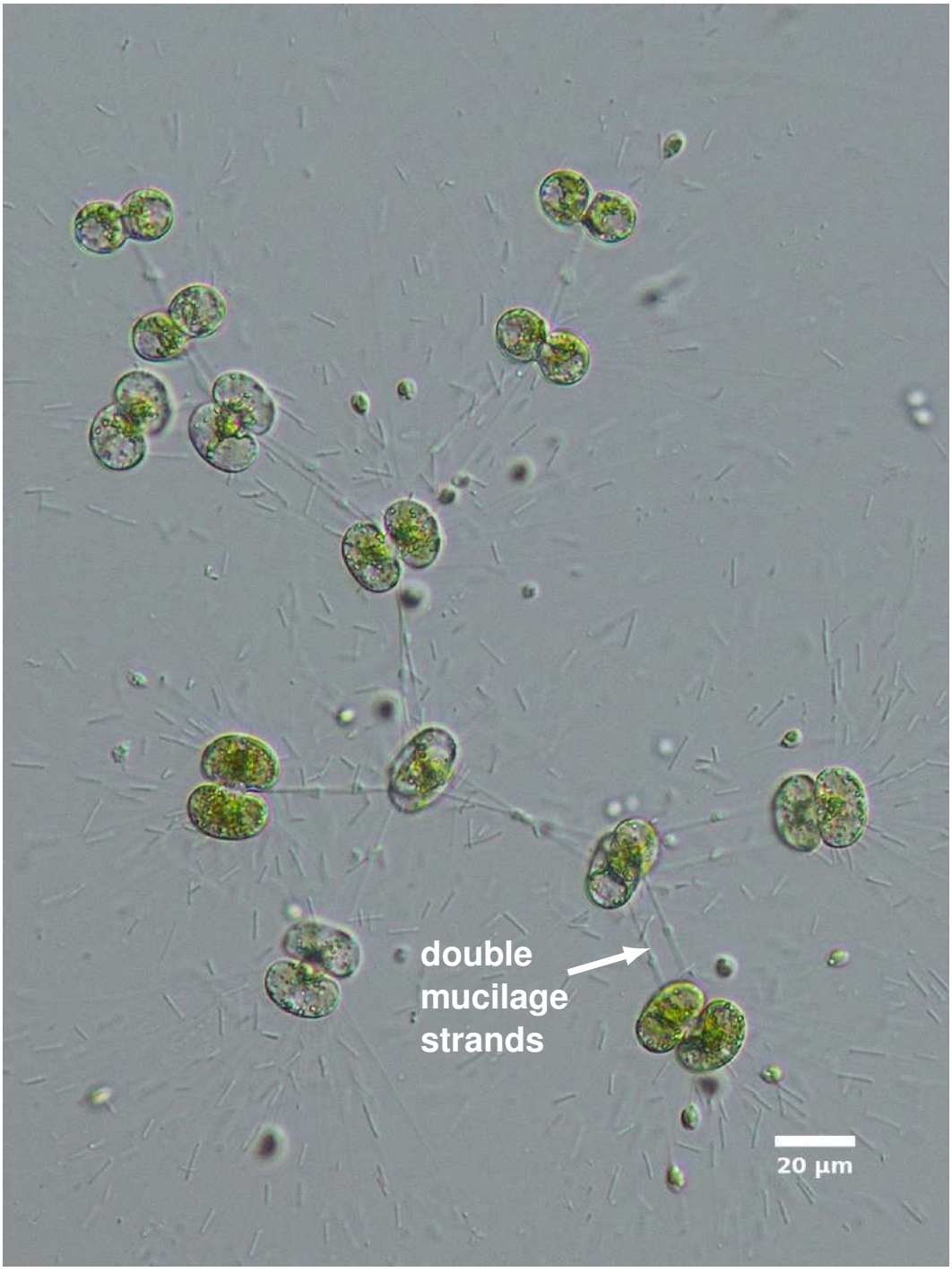


Figure 4.6: *Cosmocladium saxonicum*, (DIC), Bear Lake, Mountain Loop Highway, Snohomish County.

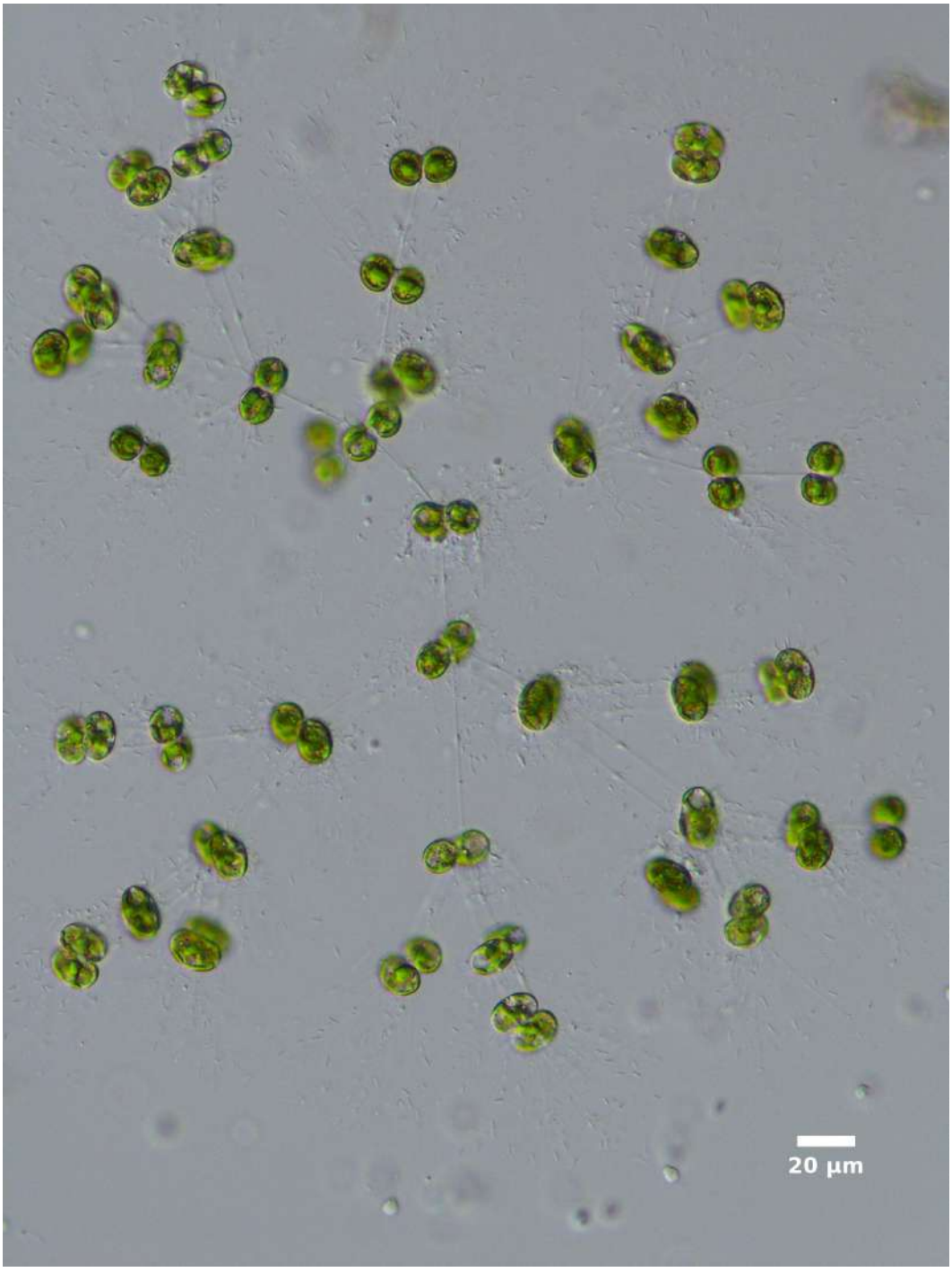


Figure 4.7: *Cosmocladium saxonicum*, (DIC), Summer Lake, Skagit County.

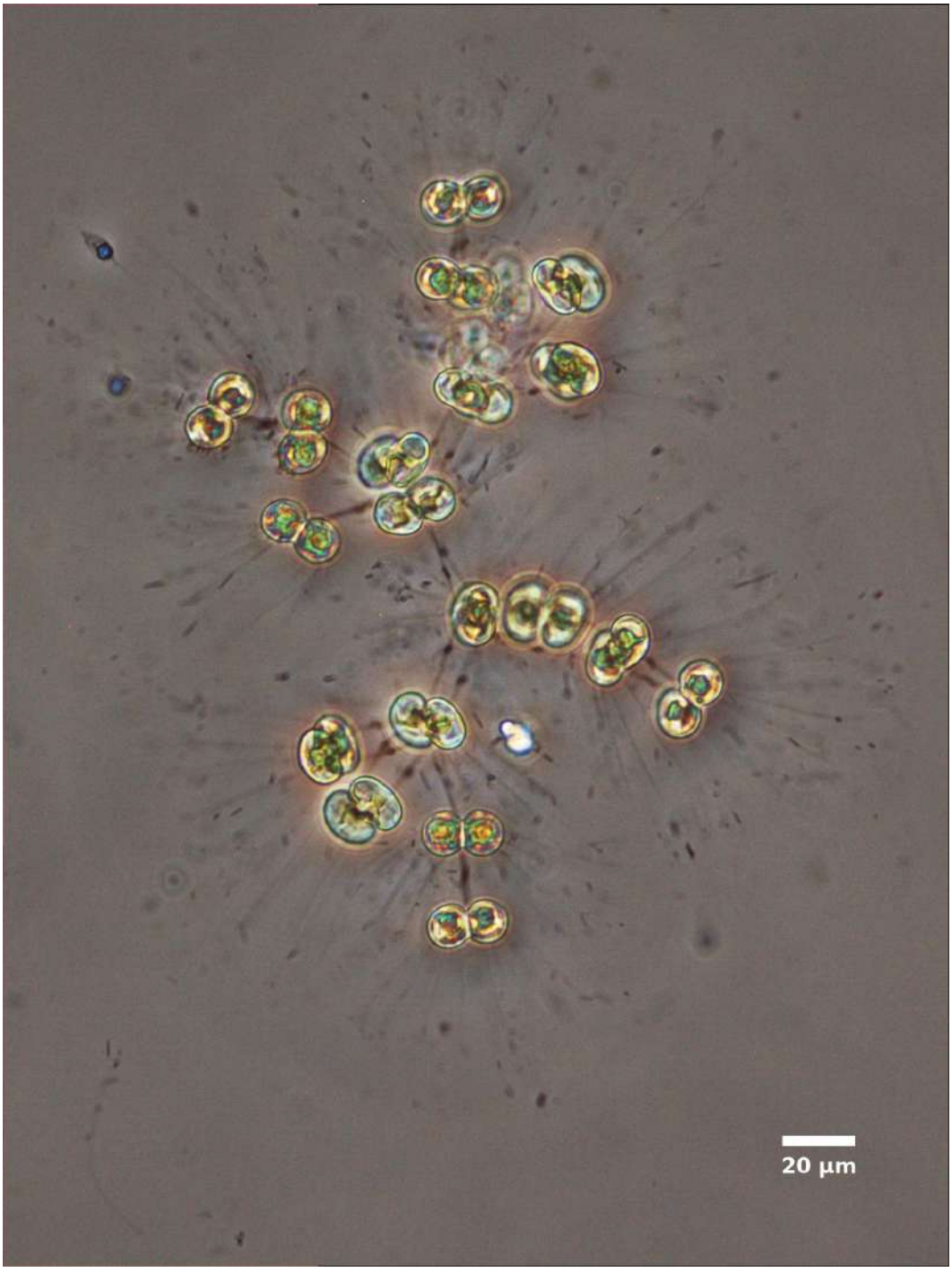


Figure 4.8: *Cosmocladium saxonicum*, (phase contrast), Lake Padden, Whatcom County.

Chapter 5

Cylindrocystis Meneghini ex De Bary

Northwest Washington taxa
Cylindrocystis brebissonii (Ralfs) De Bary
Cylindrocystis brebissonii var. *turgida* Schmidle
Cylindrocystis crassa De Bary
Cylindrocystis cushleckae A. J. Brook

Table 5.1: Key to *Cylindrocystis* Species

A	Cells oval (L/W $\leq$2)	*Cylindrocystis crassa* (Figures 5.8–5.9)
B	Cells elliptical (L/W usually >2)	
	B.1 Pyrenoids spherical; cells very small (W$\leq$10 μm; L<40 μm)	*Cylindrocystis cushleckae* (Figures 5.10–5.11)
	B.2 Pyrenoids in older cells elongated; cells slightly larger (W usually >15; L usually >40 μm)	

continued on next page

Table 5.1: Key to *Cylindrocystis* Species, continued

B.2a W<25 μm;	*Cylindrocystis brebissonii* (Figures 5.1–5.4)
B.2b W≥25 μm;	*Cylindrocystis brebissonii* var. *turgida* (Figures 5.5–5.7)

Table 5.2: *Cylindrocystis* Cell Measurements

		Cell Width	Cell Length	Isthmus Width	L/W Ratio
Cylindrocystis brebissonii	min	13.1 μm	32.2 μm	–	1.7
	med	17.6 μm	47.4 μm	–	2.8
	max	23.9 μm	67.5 μm	–	3.7
Cylindrocystis brebissonii var. *turgida*	min	24.2 μm	48.5 μm	–	2.0
	med	25.2 μm	58.4 μm	–	2.3
	max	26.7 μm	74.3 μm	–	2.9
Cylindrocystis crassa	min	21.4 μm	28.2 μm	–	1.3
	med	22.2 μm	35.6 μm	–	1.5
	max	25.2 μm	40.0 μm	–	1.7
Cylindrocystis cushleckae	min	8.3 μm	21.9 μm	–	2.5
	med	8.8 μm	28.6 μm	–	3.2
	max	9.2 μm	39.0 μm	–	4.3

Description

Cylindrocystis cells are small, oval or elliptical, and circular in cross-section, with a broadly rounded apex and no discernible sinus (saccoderm desmid; Figures 5.1–5.11). Most species contain two axial, star-shaped (stellate) chloroplasts, each with a single, large, pyrenoid. The pyrenoids may be circular in outline, but are usually

elongated. The chloroplasts are often notched or fringed along the margin and may have a few longitudinal ridges. *Cylindrocystis* can be difficult to distinguish from *Netrium*[19] (see Section 14, page 607), but most *Netrium* species will be larger (cell length >100 μm) and the chloroplast will have distinct ridges.

Cylindrocystis brebissonii cells are elliptical, with broadly rounded ends (Figures 5.1–5.4). Each cell contains two star-shaped chloroplasts with notched or irregular edges; each chloroplast contains a central pyrenoid that is usually elongated. The chloroplast features may be obscured by starch grains, and there are often spherical granules that accumulate adjacent to the chloroplast along the cell wall (Figure 5.2). This species has a wide range of cell lengths, but can be distinguished by its width and length/width ratios ($\sim$15–25 μm; L/W$\geq$1.7). Most other species of *Cylindrocystis* are narrower, except *Cylindrocystis crassa* (see below), and most species of *Netrium* are wider ($\geq$25 μm). ***Cylindrocystis brebissonii* var. *turgida*** is distinguished by its wider cells (W$\geq$25 μm) that are often slightly asymmetric (Figures 5.5–5.7).

Cylindrocystis brebissonii is common in many types of acidic habitats, including dripping rock walls and adjacent to waterfalls, and was the most common desmid found in mountainous regions of the Czech Republic (Štěpánková, et al., 2008). *Cylindrocystis brebissonii* is considered a "catch-all" species that probably includes several undescribed species (Coesel and Meesters, 2007).

Cylindrocystis crassa cells are oval, with thick walls and two dense, star-shaped chloroplasts, each of which contain a single, large, spherical (not elliptical) pyrenoid (Figures 5.8–5.9). *Cylindrocystis crassa* is difficult to distinguish from short specimens of *Cylindrocystis brebissonii*. According to John, et al. (2011), *Cylindrocystis crassa* is frequently collected in mossy, dripping rock walls.

Cylindrocystis cushleckae cells are elliptical and much narrower than the other species (width $\leq$10 μm; Figures 5.10–5.11). The cells usually have a single, ridged chloroplast that is partially divided by a central notch that contains the nucleus. Shortly before division the cell may contain two chloroplasts and up to six pyrenoids. Because the cells contain a single chloroplast, this species can be confused with *Mesotaenium* (Section 12, page 501), which forms gelatinous masses of cells with plate-like chloroplasts; and *Roya* (Section 18, page 699), which has longer cells with ribbon-like chloroplasts.

[19] According to Brook and Williamson (2010), there is no clear division between the small types of *Cylindrocystis* and *Netrium*



Figure 5.1: *Cylindrocystis brebissonii*, (DIC), snow melt pond on Railroad Grade trail, Mt. Baker area, Whatcom County.



Figure 5.2: *Cylindrocystis brebissonii*, (DIC), small pond along Military Road south of Tacoma, Pierce County.

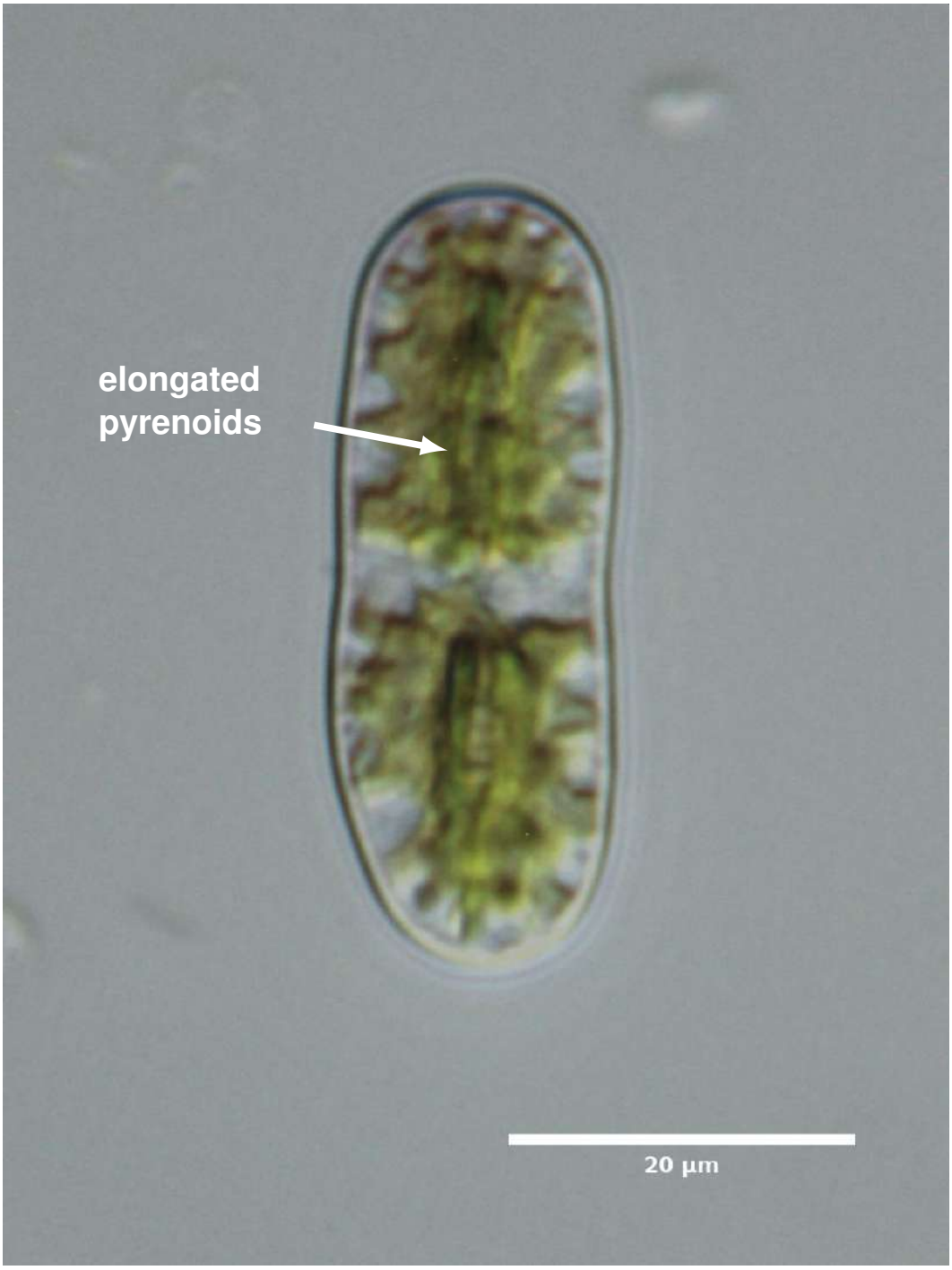


Figure 5.3: *Cylindrocystis brebissonii*, (DIC), Bridal Veil Falls outlet on trail to Lake Serene, Snohomish County.



Figure 5.4: *Cylindrocystis brebissonii*, (DIC), Boardman Lake, Mountain Loop Highway, Snohomish County.

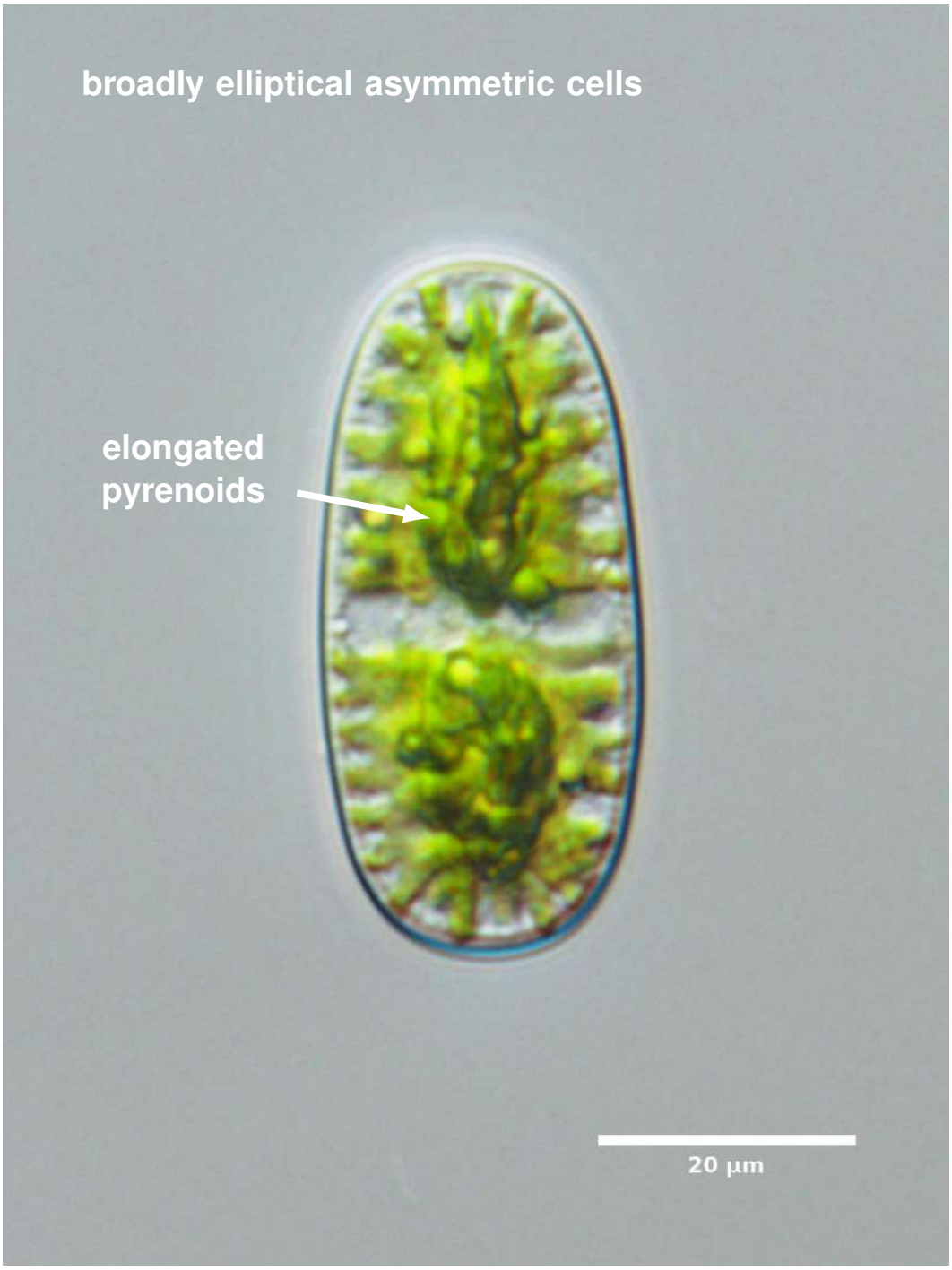


Figure 5.5: *Cylindrocystis brebissonii* var. *turgida*, (DIC), small ponds on trail to Lake Ann, Mt. Baker area, Whatcom County.



Figure 5.6: *Cylindrocystis brebissonii* var. *turgida*, (DIC), small pond on trail to Dock Butte, Mt. Baker area, Skagit County.



Figure 5.7: *Cylindrocystis brebissonii* var. *turgida*, (DIC), small ponds on trail to Lake Ann, Mt. Baker area, Whatcom County.



Figure 5.8: *Cylindrocystis crassa*, (DIC), Upper Bagley Lake, Mt. Baker area, Whatcom County.



Figure 5.9: *Cylindrocystis crassa*, (DIC), Diablo Lake, Ross Lake National Recreation Area, Whatcom County.



Figure 5.10: *Cylindrocystis cushleckae*, (DIC), Summer Lake, Skagit County.



Figure 5.11: *Cylindrocystis cushleckae*, (DIC), Summer Lake, Skagit County.

Chapter 6

Desmidium C. Agardh ex Ralfs

Northwest Washington taxa
Desmidium aptogonum Brébisson ex Kützing
Desmidium baileyi (Ralfs) Nordstedt
Desmidium coarctatum Nordstedt
Desmidium grevilli (Kützing ex Ralfs) De Bary
Desmidium swartzii C. Agardh ex Ralfs

Table 6.1: Key to *Desmidium* Species

A	Cells joined by ladder-like apical extensions resulting in visible spaces between adjacent cells	
	A.1 Cells rectangular with no obvious sinus	*Desmidium baileyi* (Figures 6.4–6.6)
	A.2 Cells with distinct sinus, wall inflated and rounded on either side of sinus	*Desmidium aptogonum* (Figures 6.1–6.3)
B	Cells joined end-to-end with no ladder-like apical extensions	

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Table 6.1: Key to *Desmidium* Species, continued

B.1	Cells spherical, oval, or broadly elliptical	
	B.1a Cells nearly spherical (L/W = 0.9–1.1); cells joined by short, narrow extensions	*Desmidium coarctatum* (Figures 6.7–6.9)
	B.1b Cells slightly compressed (L/W = 0.5–0.8); cells joined by short, broad extensions	*Desmidium grevilli* (Figures 6.10–6.13)
B.2	Cells angular and strongly compressed (L/W <0.5); triangular in cross-section	*Desmidium swartzii* (Figures 6.14–6.16)

Table 6.2: *Desmidium* Cell Measurements

		Cell Width	Cell Length	Isthmus Width	L/W Ratio
Desmidium aptogonum	min	28.1 μm	14.2 μm	23.5 μm	0.4
	med	30.9 μm	17.3 μm	25.6 μm	0.6
	max	35.0 μm	19.5 μm	27.6 μm	0.7
Desmidium bailey	min	21.3 μm	21.5 μm	NA	0.9
	med	22.3 μm	22.4 μm	NA	1.0
	max	26.3 μm	23.7 μm	NA	1.1
Desmidium coarctatum	min	35.3 μm	38.1 μm	30.8 μm	0.8
	med	44.4 μm	40.4 μm	37.5 μm	1.0
	max	47.9 μm	45.8 μm	42.1 μm	1.1
Desmidium grevilli	min	36.8 μm	22.9 μm	32.0 μm	0.5
	med	44.5 μm	26.7 μm	38.2 μm	0.6
	max	51.6 μm	29.3 μm	45.3 μm	0.8

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Table 6.2: *Desmidium* Cell Measurements, continued

		Cell Width	Cell Length	Isthmus Width	L/W Ratio
Desmidium swartzii	min	39.8 μm	15.4 μm	28.5 μm	0.4
	med	41.9 μm	16.6 μm	30.2 μm	0.4
	max	46.7 μm	18.2 μm	33.3 μm	0.4

Description

Desmidium filaments are comprised of short, angular cells with a shallow sinus (Figures 6.1–6.16). The filaments are usually long, twisted, and may be surrounded by a faint or distinct mucilage layer. Each semi-cell contains a single chloroplast that is star-shaped (stellate) in end view, and contains a single pyrenoid. In some species the cells are joined by ladder-like apical extensions.

Desmidium aptogonum cells are rectangular, slightly compressed, and inflated on either side of the shallow sinus (Figures 6.1–6.3). The cells are joined by ladder-like apical extensions that produce visible spaces between the cells. This species resembles *Desmidium swartzii* (Figure 6.14), which can be distinguished by its strongly compressed, angular cells that lack ladder-like apical extensions.

Desmidium baileyi cells are rectangular, nearly equal in length and width, with no discernible sinus (Figures 6.4–6.6). The cells are joined by ladder-like apical extensions that leave oval spaces between adjacent cells. Despite the rectangular outline, SEM reveals that the cells are actually triangular in cross-section (Figure 6.6). The only other *Desmidium* species from northwest Washington sites that has ladder-like apical extensions is *Desmidium aptogonum*, which has rounded inflations on either side of a distinct sinus (Figure 6.1).

Desmidium coarctatum cells are nearly spherical, with a very shallow, rounded sinus (Figures 6.7–6.9). The cells are joined by short, narrow, flat apical extensions. The apical extensions are not ladder-like and do not leave visible openings between the cells. This species resembles *Desmidium grevilli* (Figure 6.10), which is about the same size, but more strongly compressed, and has much shorter, wider apical extensions joining adjacent cells.

Desmidium grevilli cells are broadly oval, slightly compressed, with a very shallow, rounded sinus (Figures 6.10–6.13). The cells are joined by very short, broad, flat apical extensions. The apical extensions are not ladder-like and do not leave visible openings between the cells. This species resembles *Desmidium coarctatum*, but *Desmidium grevilli* cells are more strongly compressed, and have wider apical extensions.

Desmidium swartzii cells are very short and triangular in cross-section, and form long, strongly twisted filaments (Figures 6.14–6.16). The cells are inflated and angular on either side of the shallow, V-shaped sinus. Although there are ladder-like apical extensions joining the cells, the extensions are short and inconspicuous, so they lack a ladder-like appearance. *Desmidium swartzii* resembles *Desmidium aptogonum*, which can by distinguished by its smaller, more rounded cells that have ladder-like extensions that produce open spaces between adjacent cells.

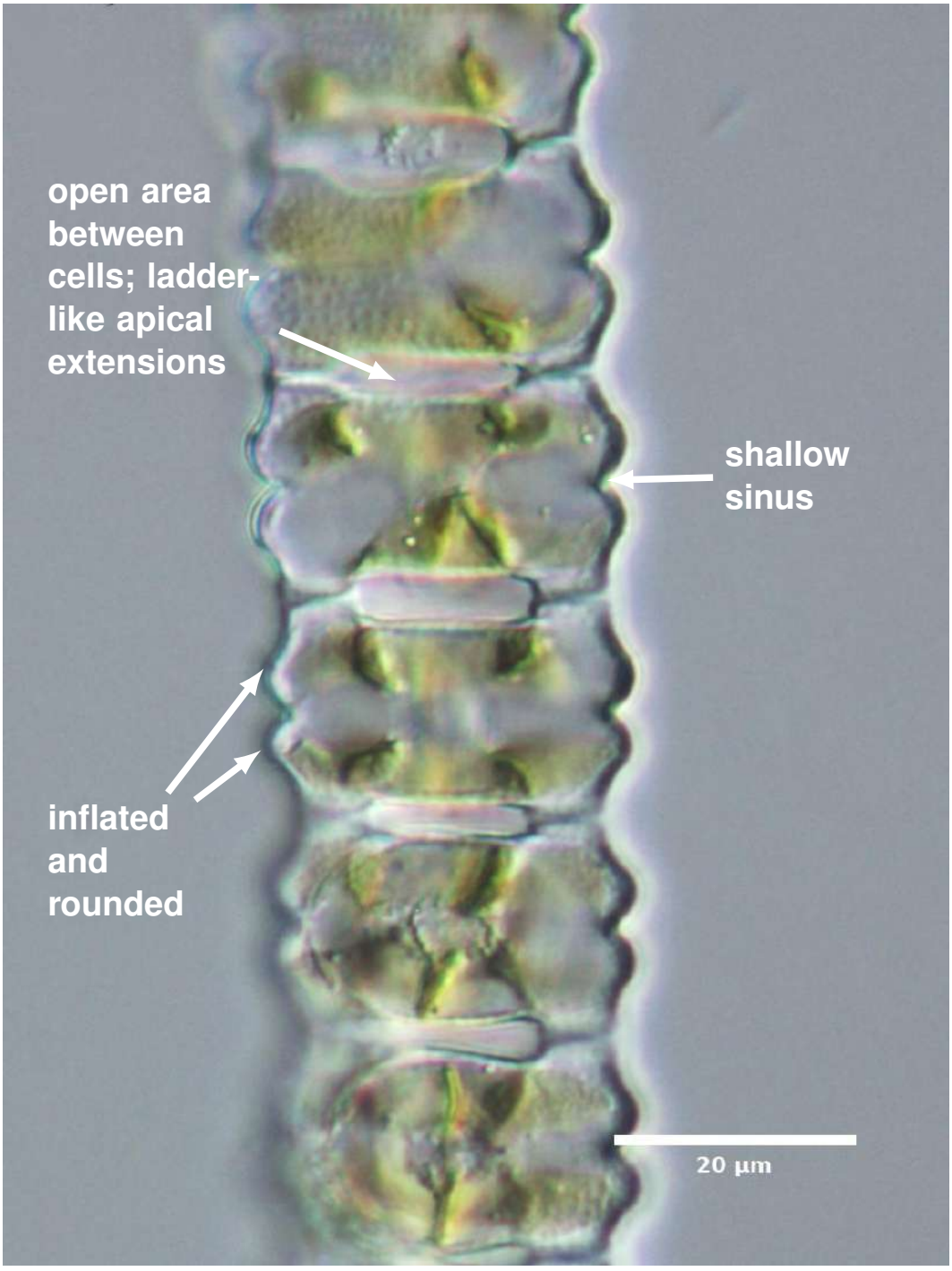


Figure 6.1: *Desmidium aptogonum* (DIC), Ross Lake, Ross Lake National Recreation Area, Whatcom/Skagit Counties.

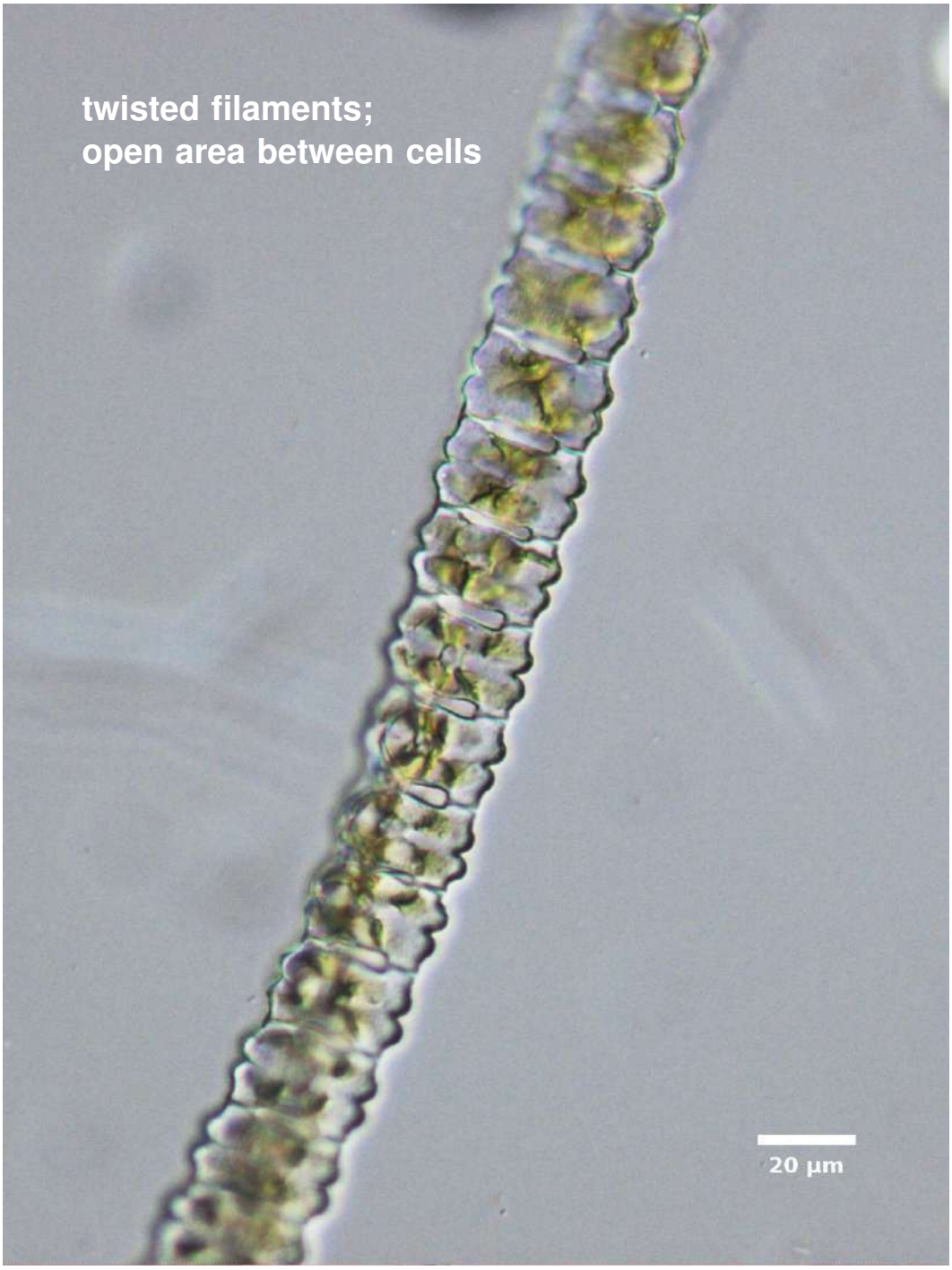


Figure 6.2: *Desmidium aptogonum* (DIC), Ross Lake, Ross Lake National Recreation Area, Whatcom/Skagit Counties.



Figure 6.3: *Desmidium aptogonum* (DIC), Summer Lake, Skagit County.

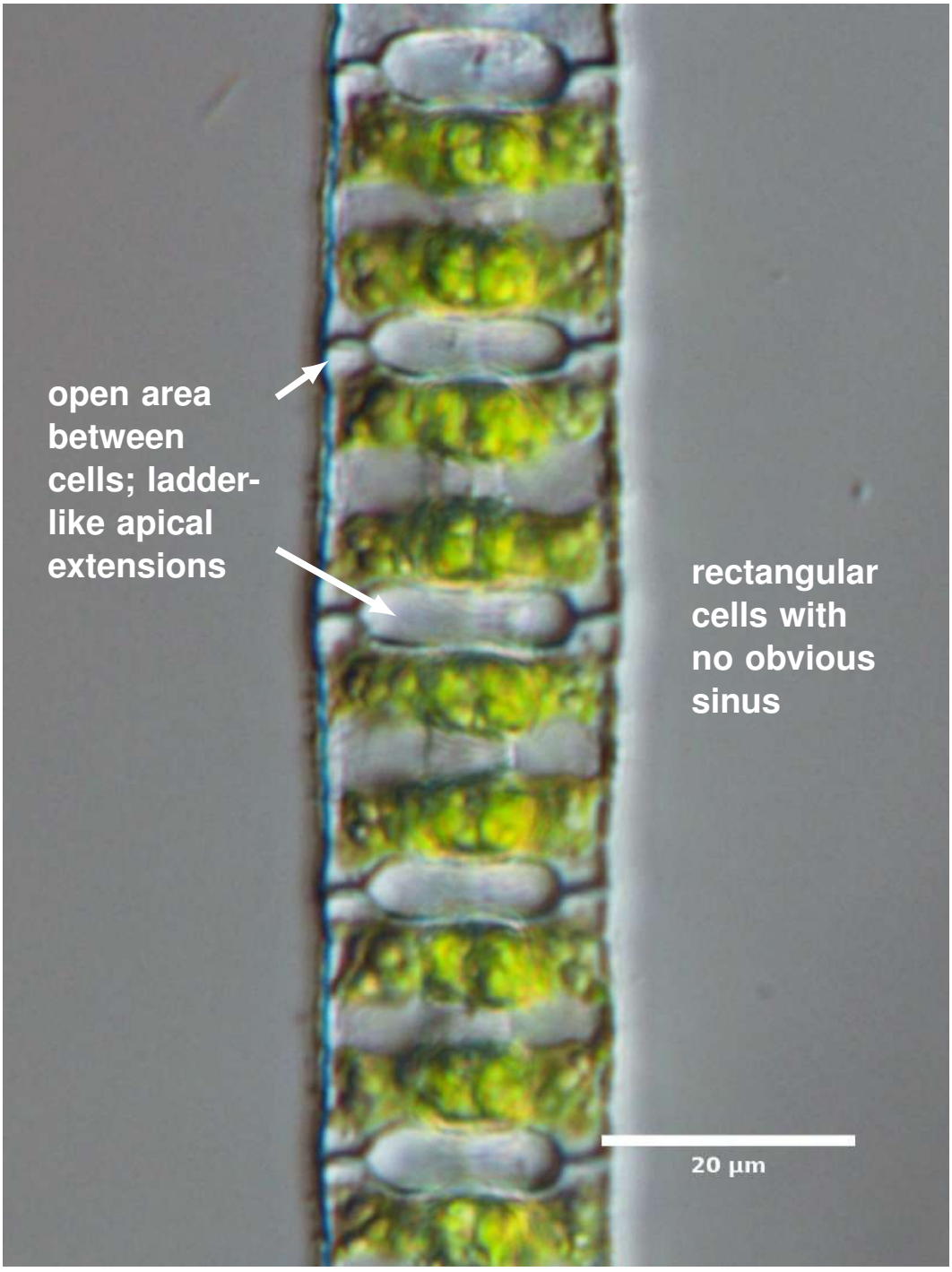


Figure 6.4: *Desmidium baileyi* (DIC), Summer Lake, Skagit County.



Figure 6.5: *Desmidium baileyi* (DIC), Cain Lake, Whatcom County.

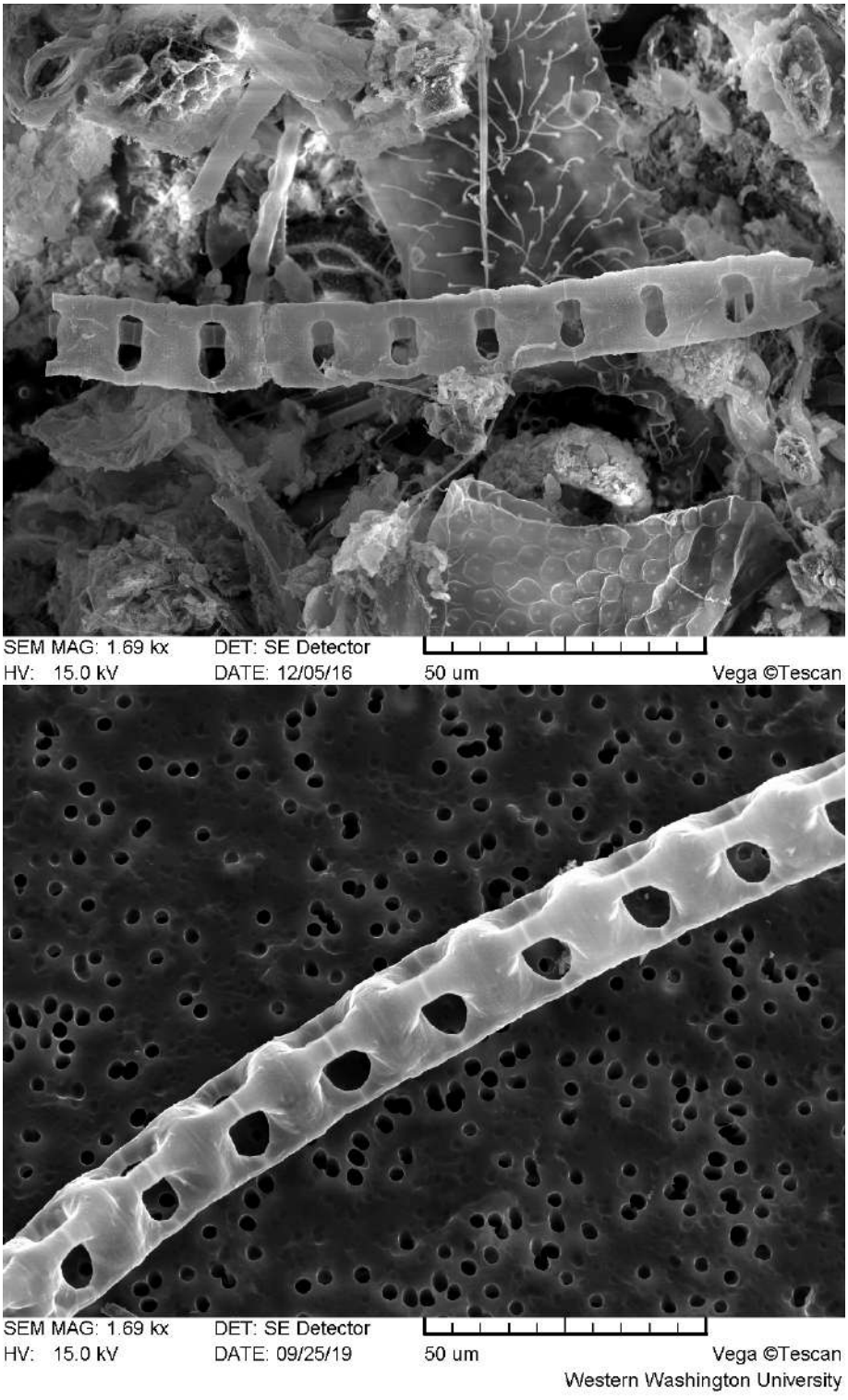


Figure 6.6: *Desmidium baileyi* (SEM/SEM), Vogler Lake, Skagit County (upper image); small boggy pond along Morris Valley Road near Harrison BC (lower image).

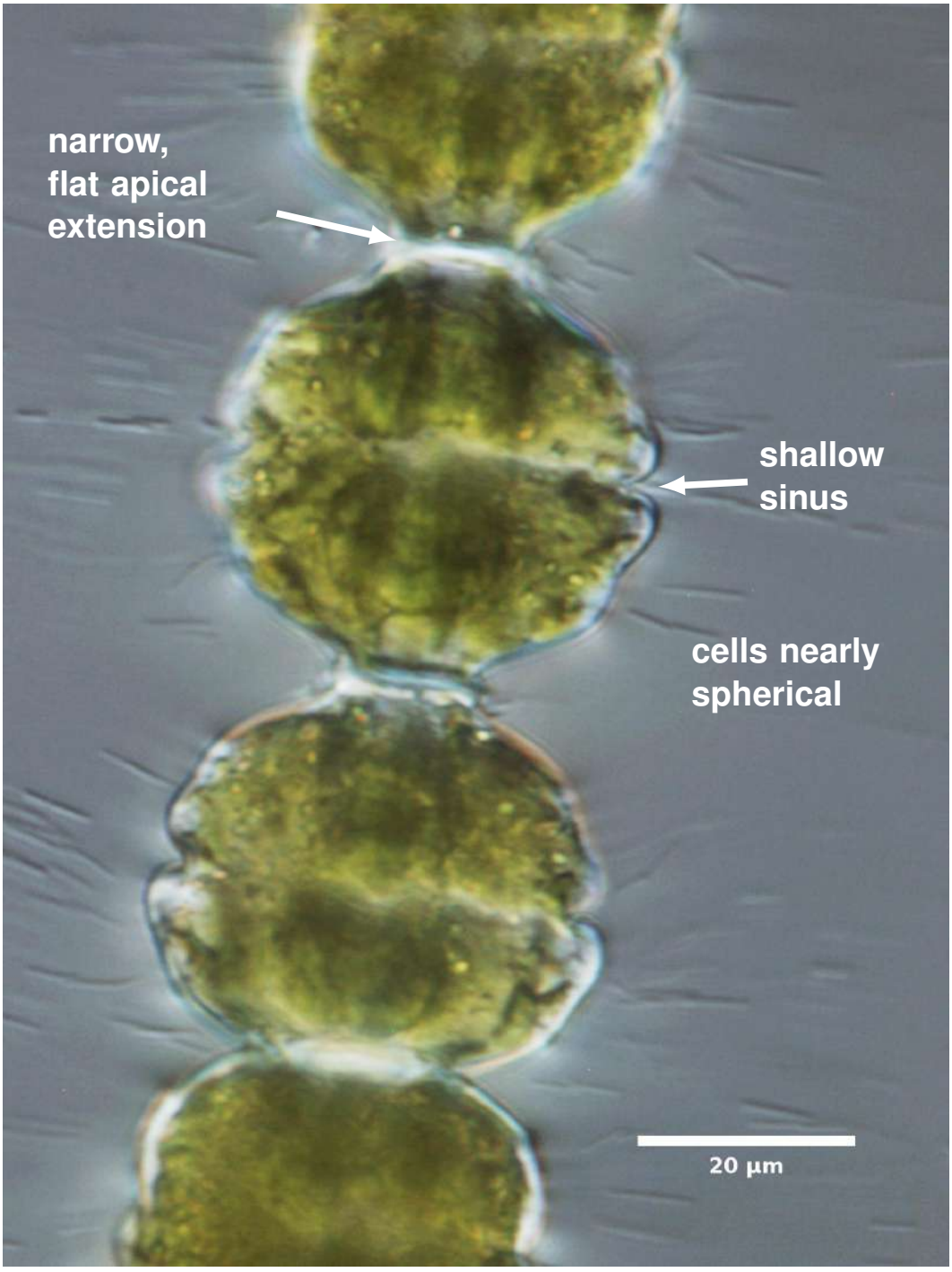


Figure 6.7: *Desmidium coarctatum* (DIC), Lily Lake, Skagit County.



Figure 6.8: *Desmidium coarctatum* (DIC), Lily Lake, Skagit County.

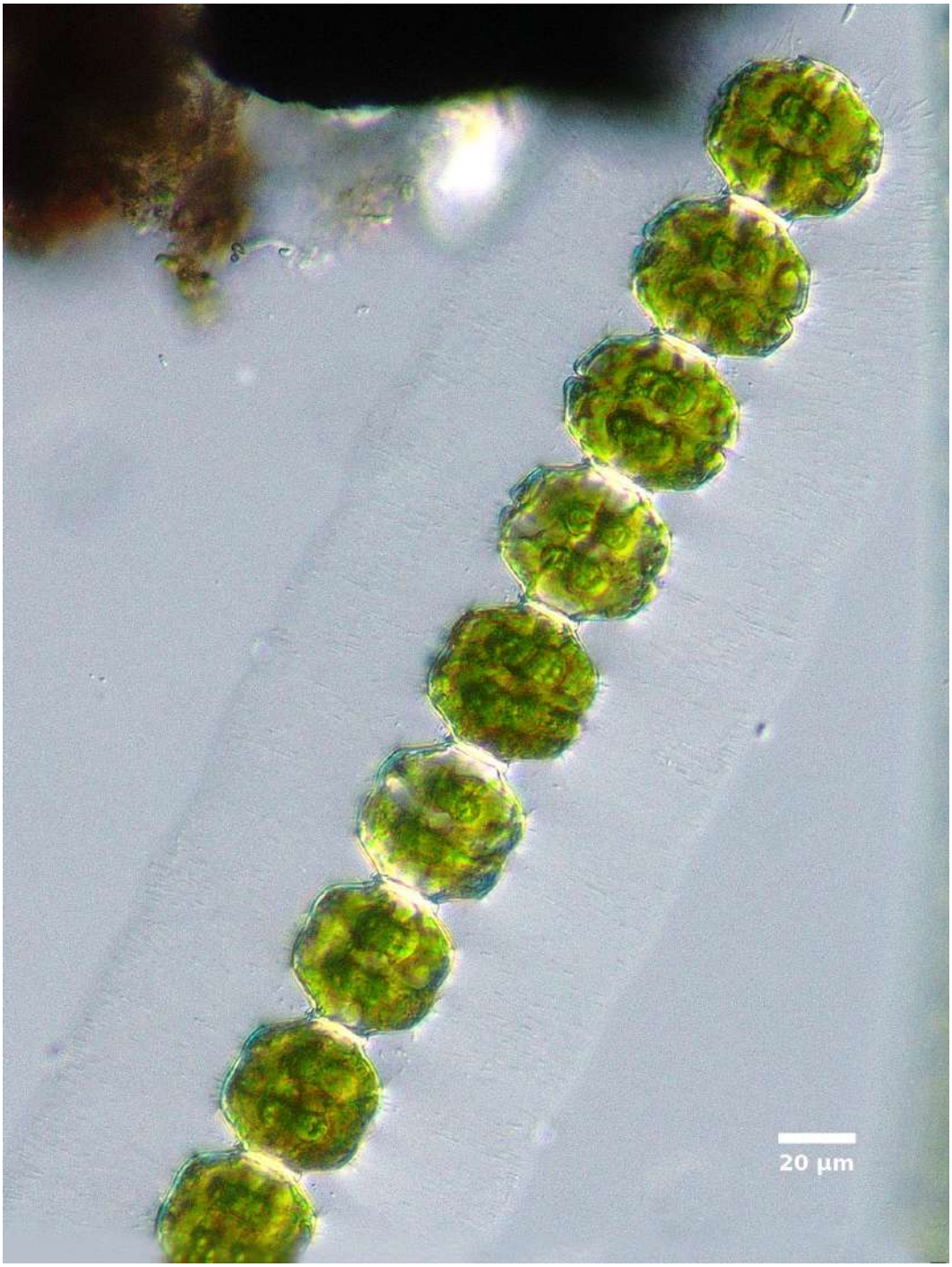


Figure 6.9: *Desmidium coarctatum* (DIC), Wood Lake, Morris Valley Rd near Harrison, BC.

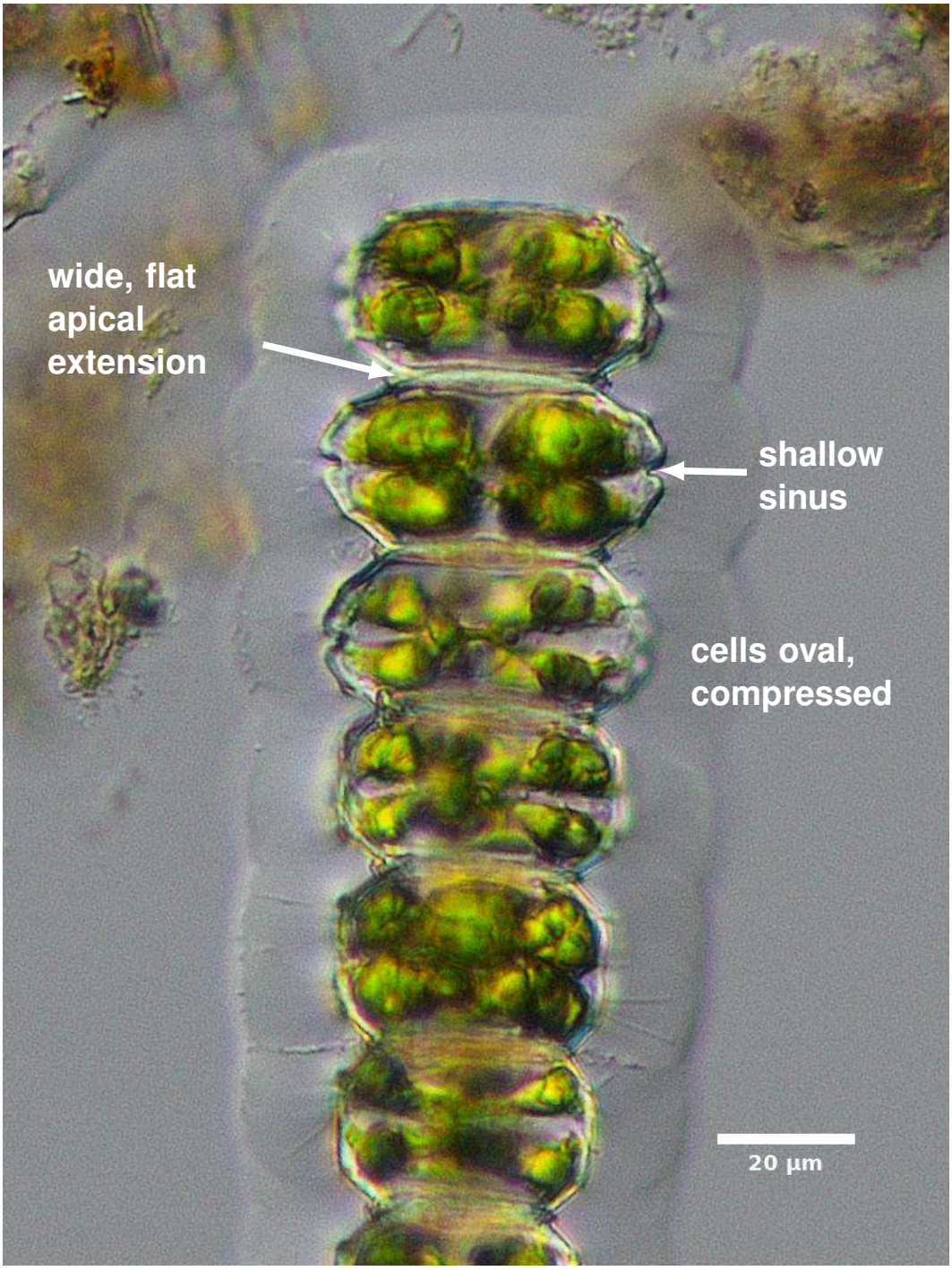


Figure 6.10: *Desmidium grevilli* (DIC), Summer Lake, Skagit County.

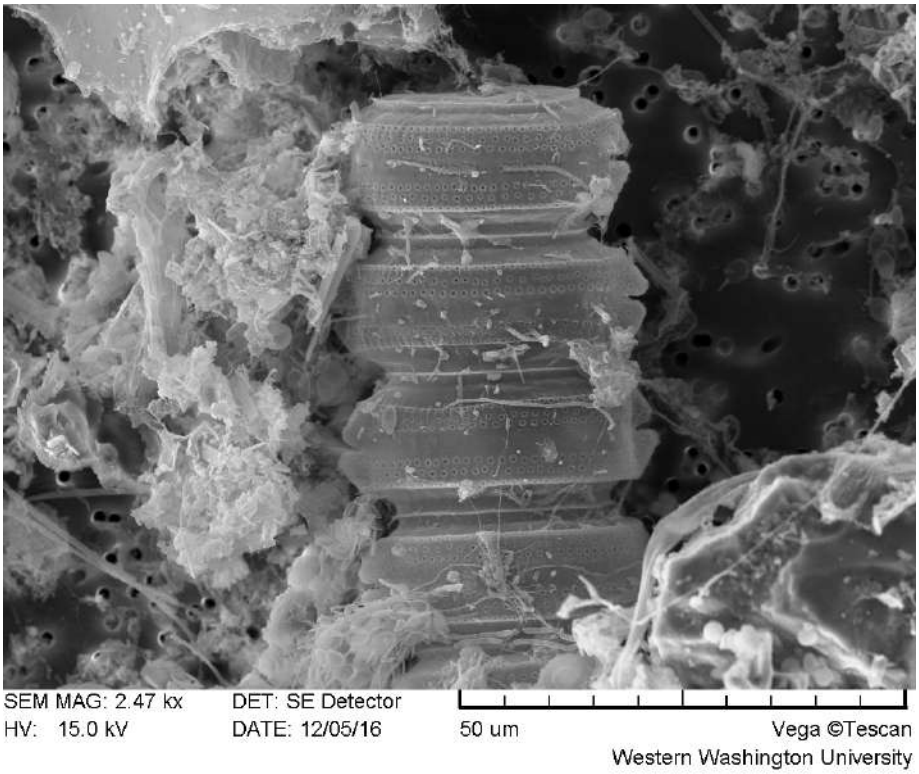




Figure 6.11: *Desmidium grevilli* (SEM/DIC), Vogler Lake, Skagit County (upper image); Summer Lake, Skagit County (lower image).

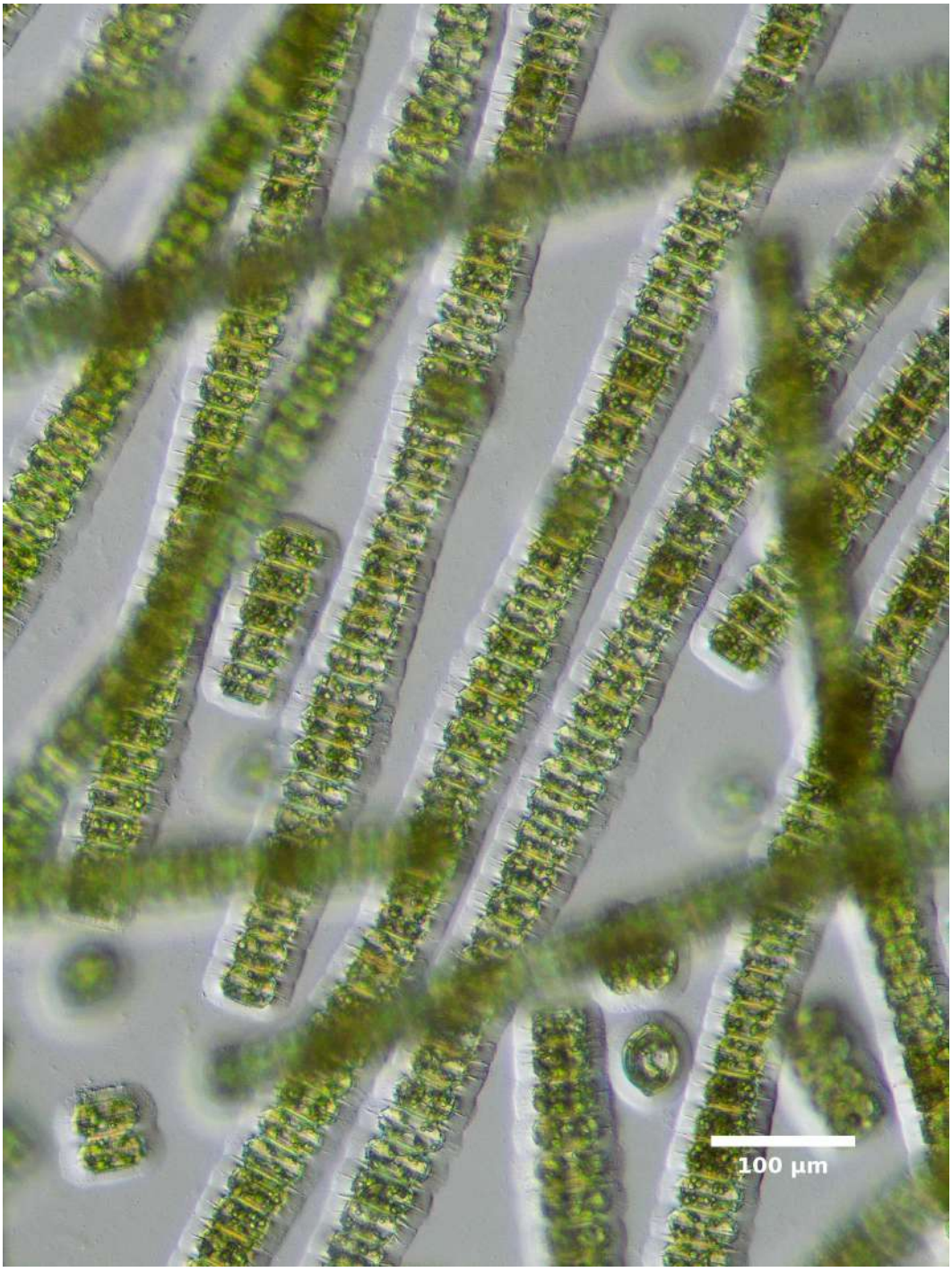


Figure 6.12: *Desmidium grevilli* bloom (DIC), Summer Lake, Skagit County.

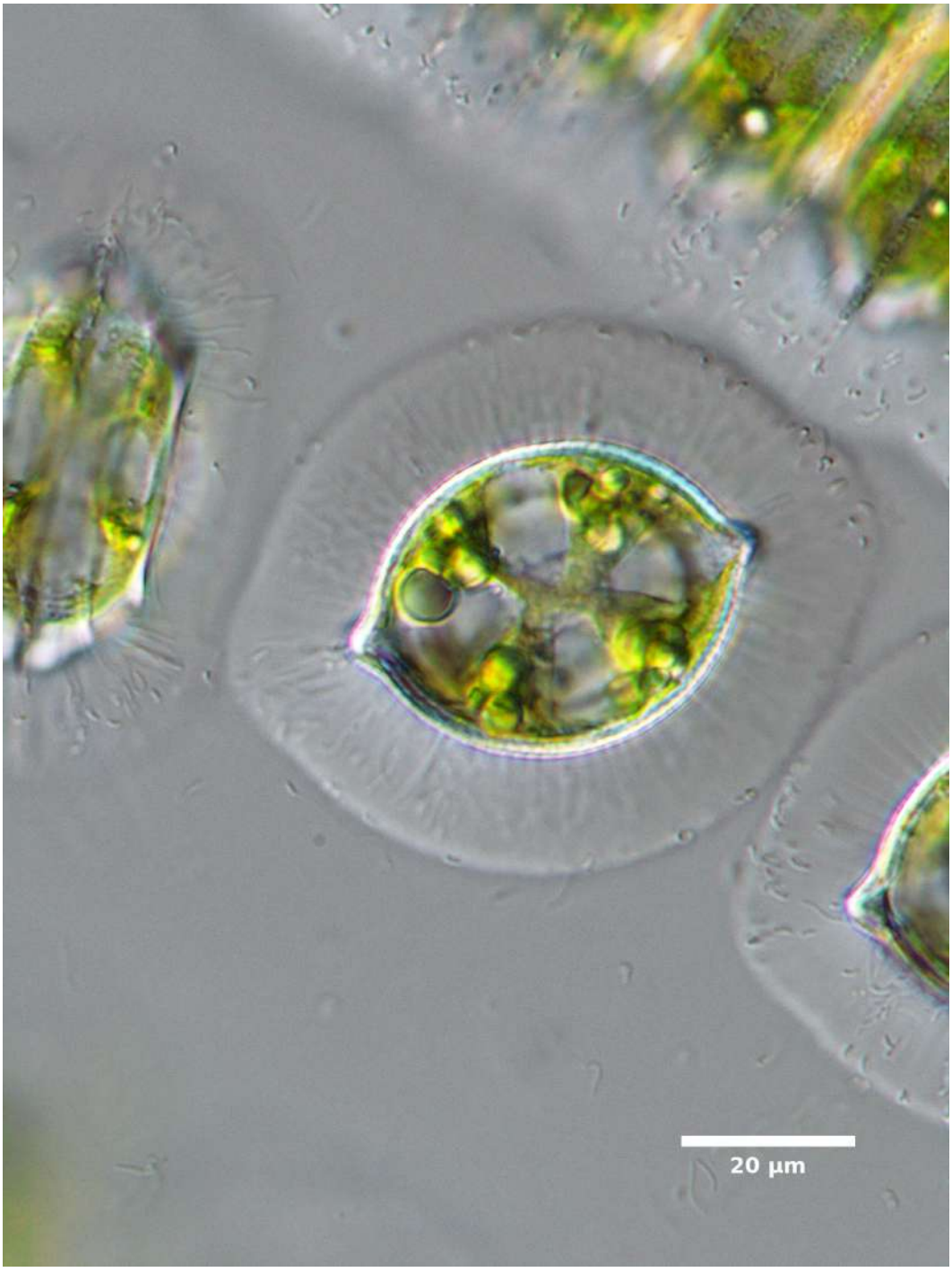


Figure 6.13: *Desmidium grevilli* end view of individual cell showing star-shaped (stellate) chloroplast (DIC), Summer Lake, Skagit County.

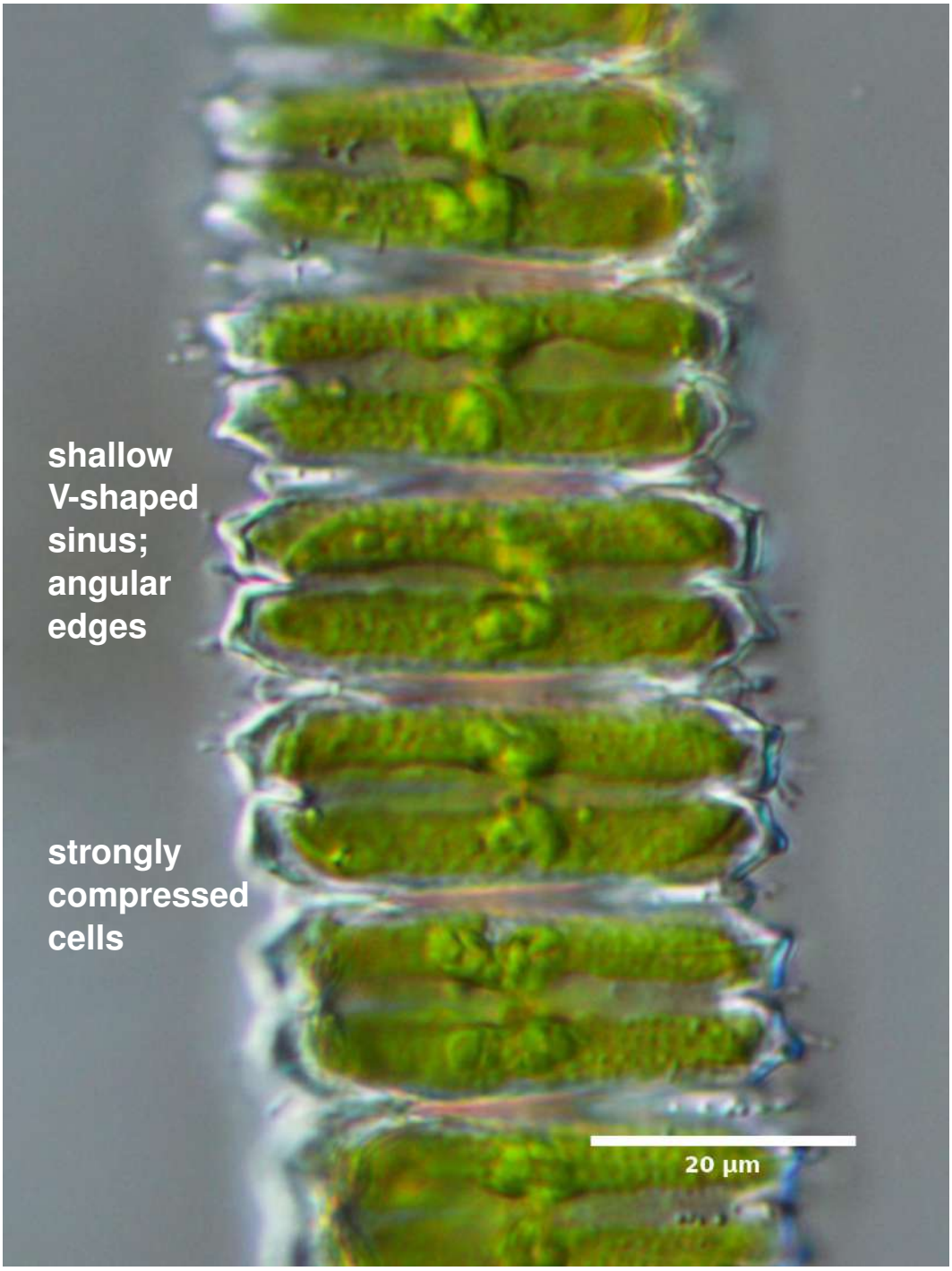


Figure 6.14: *Desmidium swartzii* (DIC), Summer Lake, Skagit County.

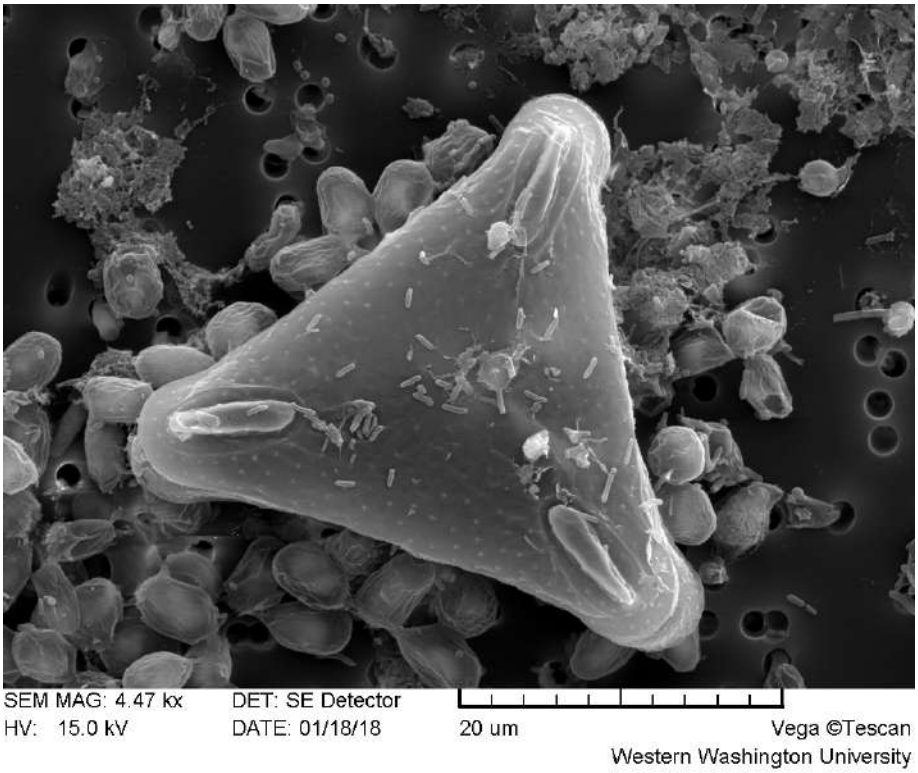




Figure 6.15: *Desmidium swartzii* end view of individual cells (SEM/DIC), Picture Lake, Mt. Baker area, Whatcom County (upper image); Summer Lake, Skagit County (lower image).

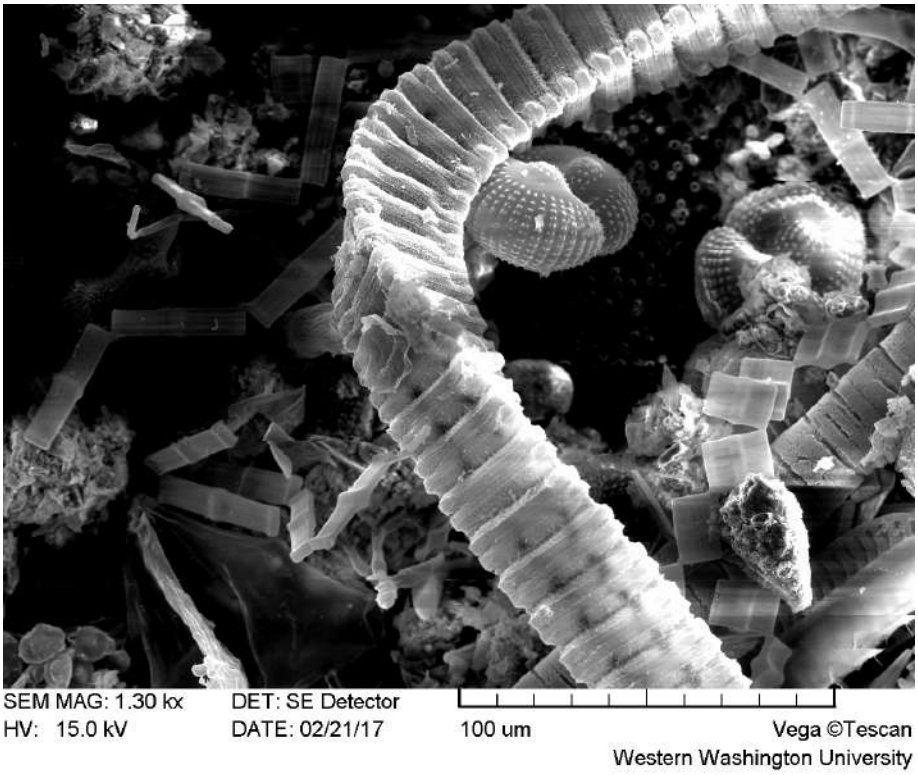




Figure 6.16: *Desmidium swartzii* filaments (SEM/DIC), Highwood Lake, Mt. Baker area, Whatcom County (upper image); Summer Lake, Skagit County.

Chapter 7

Euastrum Ehrenberg ex Ralfs

Northwest Washington taxa
Euastrum ansatum Ehrenberg ex Ralfs
Euastrum ansatum f. *angustum* Prescott
Euastrum bidentatum Nägeli
Euastrum bidentatum var. *oculatum* (Istvanfy) Willi Krieger
Euastrum binale var. *gutwinskii* (Schmidle) Homfeld
Euastrum binale var. *papilliferum* Gutwinskii
Euastrum coeselii Kouwets
Euastrum coeselii var. A
Euastrum crassum Ralfs
Euastrum denticulatum F. Gay
Euastrum didelta Ralfs
Euastrum dubium var. *ornatum* Woloszynska
Euastrum elegans Ralfs
Euastrum fissum West & G. S. West
Euastrum gayanum De Toni
Euastrum gemmatum var. *taftii* Prescott
Euastrum humerosum Ralfs
Euastrum humerosum var. *affine* (Ralfs) Raciborski
Euastrum insulare (Wittrock) J. Roy
Euastrum cf. *lacustre* (Messikommer) Coesel
Euastrum latipes var. *evolutum* (Grönblad) C. E. Taft
Euastrum luetkemuelleri var. *carniolicum* (Lütkemüller) Willi Krieger
Euastrum montanum West & G. S. West

Euastrum neosinuosum O. V. Anissimona & Guiry
Euastrum obesum Joshua
Euastrum oculatum Børgensen
Euastrum oblongum Greville ex Ralfs
Euastrum pectinatum Brébisson ex Ralfs
Euastrum pinnatum Ralfs
Euastrum pulchellum Brébisson
Euastrum subalpinum var. *crassum* Messikommer
Euastrum sublobatum Brébisson ex Ralfs
Euastrum turneri West
Euastrum verrucosum Ehrenberg ex Ralfs

Table 7.1: Key to *Euastrum* Species

Cells large (W>50 μm)	Go to A below
Cells medium sized (W=30–50 μm)	Go to B on page 326
Cells small (W<30 μm)	Go to C on page 327
A Cells large (W>50 μm)	
A.1 Cell wall covered with rough granules; semi-cells trapezoidal; apical lobe concave, with no median notch	*Euastrum verrucosum* (Figures 7.99–7.104)
A.2 Cell wall smooth; semi-cells rectangular, with wavy lateral edge; apical lobe short and broadly inflated (wedge-shaped), with deep, closed median notch	*Euastrum crassum* (Figures 7.24–7.27)

continued on next page

Table 7.1: Key to *Euastrum* Species, continued

A.3	Cell wall smooth; semi-cells with well-defined basal and lateral lobes	
	A.3a Semi-cells elliptical or rectangular; apical lobe wedge-shaped; basal and lateral lobes truncated along margin	*Euastrum oblongum* (Figures 7.75–7.77)
	A.3b Semi-cells rectangular; apical lobe inflated, flattened; lateral lobe triangular and horizontally directed; basal lobe rectangular, deeply indented	*Euastrum pinnatum* (Figures 7.85–7.87)
	A.3c Semi-cells triangular; apical lobe inflated, flattened; lateral lobe triangular and upwardly directed; basal lobe rectangular, distinctly indented	*Euastrum humerosum* var. *affine* (Figures 7.51–7.53)
A.4	Cell wall smooth; semi-cells triangular or flask-shaped; lateral lobe inconspicuous or absent	
	A.4a Semi-cells triangular; lateral lobe inconspicuous or absent; apical lobe long, narrow, with slightly inflated apex	*Euastrum didelta* (Figures 7.32–7.34)
	A.4b Semi-cells triangular with wavy lateral margin; lateral lobe small but distinct; basal lobe rectangular, slightly indented	*Euastrum humerosum* (Figures 7.48–7.50)
	A.4c Semi-cells flask-shaped (W>L); lateral lobe inconspicuous or absent; basal lobe bluntly acute and thickened at the sinus; apical lobe flattened with thickened angles	*Euastrum latipes* var. *evolutum* (Figures 7.58–7.60)

continued on next page

Table 7.1: Key to *Euastrum* Species, continued

B	Cells medium sized (W=30–50 μm)	
	B.1 Semi-cells trapezoidal or elliptical; apical lobe with blunt teeth on outer angles	
	B.1a apical lobe elevated and rounded (dome-like)	*Euastrum bidentatum* (Figures 7.9–7.13)
	B.1b apical lobe flattened or concave	*Euastrum oculatum* (Figures 7.78–7.81)
	B.2 Cells cruciform (cross-shaped); semi-cells rectangular; apical lobe flattened, with no median notch	
	B.2a Cell wall smooth; outer angles of apical and lateral and basal lobes thickened	*Euastrum pectinatum* (Figures 7.82–7.84)
	B.2b Cell covered with coarse granules; outer lobe angles not thickened	*Euastrum gemmatum* (Figures 7.44–7.47)
	B.3 Semi-cells triangular with smooth lateral margin; apical lobe with median notch	
	B.3a apical lobe long, narrow; lateral lobe absent or inconspicuous	*Euastrum ansatum* (Figures 7.3–7.8)
	B.3b apical lobe short, merging smoothly with lateral margin; lateral lobe absent	*Euastrum obesum* (Figures 7.72–7.74)
	B.3c apical lobe short; lateral margin wavy, with distinct lateral and basal lobes	*Euastrum neosinuosum* (Figures 7.68–7.71)

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Table 7.1: Key to *Euastrum* Species, continued

C	Cells small (W<30 μm) - difficult group	
	C.1 Semi-cells rectangular; apex broad and flat; median notch often indistinct	
	C.1a Teeth not visible on outer angle of apical lobe; median notch indistinct, v-shaped; basal lobe inflated above sinus (not wavy)	*Euastrum coeselii* (Figures 7.20–7.21)
	C.1b Teeth not visible on outer angle of apical lobe; median notch indistinct, v-shaped; lateral margin wavy (basal and lateral lobes evident)	*Euastrum montanum* (Figures 7.65–7.67)
	C.1c Short, blunt teeth on outer angle of apical lobe; apical lobe with shallow, flaring notch; cells tiny (W<15 μm)	*Euastrum gayanum* (Figures 7.42–7.43)
	C.1d Short, blunt teeth on outer angle of apical lobe; apical lobe with deep, open, v-shaped (or u-shaped) notch; cells slightly larger (W>15 μm)	*Euastrum gayanum* (Figures 7.42–7.43)
	C.2 Semi-cells trapezoidal; teeth not visible on outer angle of apical lobe; cell wall appears smooth	
	C.2a Apex very slightly concave (nearly flat); median notch indistinct; cells cruciform (cross-shaped) in outline	*Euastrum insulare* (Figures 7.54–7.56)

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Table 7.1: Key to *Euastrum* Species, continued

	C.2b Apex very slightly concave (nearly flat); median notch indistinct; cells rectangular in outline	*Euastrum luetkemuelleri* var. *carniolicum* (Figures 7.62–7.64)
	C.2c Apex strongly concave with flaring median notch; cells approximately oval in outline	*Euastrum sublobatum* (Figures 7.93–7.95)
C.3	Semi-cells trapezoidal; cell wall smooth; apical or subapical teeth outer angle of apical lobe; cell wall appears smooth	
	C.3a Cells oval or short elliptical; apex elevated; notch deep, mostly closed; blunt subapical teeth on lateral margin of apical lobe	*Euastrum elegans* (Figures 7.37–7.39)
	C.3b Cells elliptical; apex elevated; notch deep, open near apex and base; subapical teeth on lateral margin of apical lobe	*Euastrum fissum* (Figures 7.40–7.41)
	C.3c Cells elliptical; apex rounded but not elevated; notch shallow, V-shaped; blunt teeth on outer margin of apical lobe	*Euastrum* cf. *lacustre* (Figure 7.57)
C.4	Semi-cells trapezoidal; cell wall granular; apical teeth outer angle of apical lobe	
	C.4a Apical lobe concave; median notch shallow, flaring; difficult group to separate without SEM	*Euastrum binale* (Figures 7.16–7.19) and *Euastrum subalpinum* (Figure 7.92)

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Table 7.1: Key to *Euastrum* Species, continued

C.4b Apical lobe broadly rounded; median notch shallow, closed	*Euastrum dubium* (Figures 7.35–7.36)
C.4c Apical lobe flat or very slightly rounded; median notch open, u-shaped (or v-shaped); W≥20 and L≥30 μm; difficult to separate from C.4d without SEM	*Euastrum turneri* (Figures 7.96–7.98)
C.4d Apical lobe flat or very slightly rounded; median notch open, v-shaped; W<20 and L<30 μm; very difficult group to separate without SEM images	*Euastrum denticulatum* (Figures 7.28–7.31) and *Euastrum pulchellum* (Figures 7.88–7.91)

Table 7.2: *Euastrum* Cell Measurements

		Cell Width	Cell Length	Isthmus Width	Apex Width	L/W Ratio
Euastrum	min	30.9 μm	62.6 μm	10.9 μm	16.9 μm	1.8
ansatum	med	43.3 μm	84.2 μm	13.9 μm	21.2 μm	1.9
	max	48.6 μm	95.0 μm	17.3 μm	23.7 μm	2.2
Euastrum	min	41.1 μm	98.5 μm	15.3 μm	20.2 μm	2.3
ansatum	med	46.4 μm	108.5 μm	16.2 μm	23.8 μm	2.4
f. *angustum*	max	49.3 μm	119.1 μm	18.7 μm	25.4 μm	2.5
Euastrum	min	26.3 μm	39.6 μm	6.9 μm	14.9 μm	1.4
bidentatum	med	35.5 μm	50.8 μm	9.1 μm	23.9 μm	1.5
	max	43.8 μm	68.1 μm	11.6 μm	29.9 μm	1.6
Euastrum	min	15.4 μm	19.2 μm	4.4 μm	10.0 μm	1.2
binale	med	16.3 μm	22.7 μm	5.1 μm	11.3 μm	1.3
var. *gutwinskii*	max	21.0 μm	28.1 μm	6.2 μm	13.5 μm	1.5

†*summary statistics based on <5 cells*

continued on next page

Table 7.2: *Euastrum* Cell Measurements, continued

		Cell Width	Cell Length	Isthmus Width	Apex Width	L/W Ratio
Euastrum binale	min	11.8 μm	13.2 μm	3.4 μm	8.5 μm	1.1
var. *papilliferum*	med	14.8 μm	17.4 μm	4.9 μm	10.1 μm	1.2
	max	19.7 μm	22.4 μm	6.6 μm	14.0 μm	1.3
Euastrum	min	11.3 μm	13.9 μm	3.1 μm	9.9 μm	1.1
coeselii	med	13.2 μm	15.9 μm	3.7 μm	10.9 μm	1.2
	max	15.3 μm	17.5 μm	5.2 μm	11.9 μm	1.3
Euastrum	min	12.6 μm	14.7 μm	3.1 μm	10.4 μm	1.1
coeselii	med	13.2 μm	15.6 μm	3.3 μm	10.8 μm	1.2
var. A[†]	max	13.9 μm	15.9 μm	3.7 μm	11.1 μm	1.2
Euastrum	min	60.3 μm	134.5 μm	20.0 μm	40.8 μm	1.9
crassum	med	79.1 μm	161.2 μm	24.6 μm	50.1 μm	2.0
	max	92.2 μm	186.0 μm	28.5 μm	56.2 μm	2.2
Euastrum	min	15.3 μm	17.4 μm	3.5 μm	12.9 μm	1.1
denticulatum	med	17.9 μm	21.7 μm	4.8 μm	14.4 μm	1.2
	max	20.6 μm	25.7 μm	6.5 μm	14.4 μm	1.3
Euastrum	min	53.8 μm	99.6 μm	15.8 μm	25.5 μm	1.8
didelta	med	60.3 μm	125.3 μm	18.1 μm	27.5 μm	1.9
	max	72.2 μm	139.9 μm	21.4 μm	30.7 μm	2.2
Euastrum	min	19.3 μm	27.3 μm	5.6 μm	11.5 μm	1.4
dubium	med	20.0 μm	27.9 μm	5.8 μm	12.0 μm	1.4
var. *ornatum*[†]	max	20.6 μm	28.4 μm	5.9 μm	12.5 μm	1.4
Euastrum	min	21.1 μm	29.3 μm	4.0 μm	14.1 μm	1.3
elegans	med	22.6 μm	32.2 μm	5.6 μm	17.6 μm	1.4
	max	24.0 μm	35.8 μm	8.2 μm	19.5 μm	1.6

[†]*summary statistics based on <5 cells*

continued on next page

Table 7.2: *Euastrum* Cell Measurements, continued

		Cell Width	Cell Length	Isthmus Width	Apex Width	L/W Ratio
Euastrum	min	24.2 μm	45.2 μm	4.5 μm	19.0 μm	1.7
fissum	med	26.0 μm	45.8 μm	6.9 μm	20.8 μm	1.8
	max	27.9 μm	51.2 μm	8.3 μm	23.1 μm	1.9
Euastrum	min	11.4 μm	12.4 μm	3.8 μm	9.9 μm	1.1
gayanum[†]	med	11.6 μm	12.4 μm	4.0 μm	10.1 μm	1.1
	max	11.7 μm	12.4 μm	4.2 μm	10.3 μm	1.1
Euastrum	min	37.2 μm	51.3 μm	8.8 μm	17.5 μm	1.2
gemmatum	med	39.7 μm	53.8 μm	11.3 μm	20.8 μm	1.3
	max	45.4 μm	56.3 μm	12.3 μm	23.0 μm	1.4
Euastrum	min	47.1 μm	92.3 μm	16.6 μm	21.5 μm	1.7
humerosum	med	67.9 μm	129.7 μm	20.4 μm	29.9 μm	1.9
	max	78.3 μm	149.0 μm	23.5 μm	33.6 μm	2.1
Euastrum	min	59.6 μm	101.7 μm	17.5 μm	32.6 μm	1.7
humerosum	med	65.9 μm	109.1 μm	17.7 μm	32.9 μm	1.7
var. *affine*	max	67.4 μm	114.3 μm	19.2 μm	34.5 μm	1.7
Euastrum	min	13.3 μm	18.4 μm	3.5 μm	9.5 μm	1.3
insulare	med	15.5 μm	22.7 μm	4.3 μm	10.8 μm	1.4
	max	17.6 μm	24.6 μm	5.4 μm	12.7 μm	1.5
Euastrum	min	–	–	–	–	–
cf. *lacustre*[†]	med	24.3 μm	35.2 μm	9.0 μm	15.4 μm	1.4
	max	–	–	–	–	–
Euastrum	min	60.8 μm	108.6 μm	14.9 μm	25.3 μm	1.4
latipes	med	71.8 μm	112.8 μm	16.9 μm	30.6 μm	1.6
var. *evolutum*	max	85.4 μm	128.8 μm	21.0 μm	33.1 μm	1.8

[†]*summary statistics based on <5 cells*

continued on next page

Table 7.2: *Euastrum* Cell Measurements, continued

		Cell Width	Cell Length	Isthmus Width	Apex Width	L/W Ratio
Euastrum	min	14.7 μm	20.9 μm	5.2 μm	10.1 μm	1.4
luetkemuelleri	med	18.1 μm	27.7 μm	6.3 μm	12.4 μm	1.5
var. *carniolicum*	max	19.5 μm	29.3 μm	7.4 μm	13.5 μm	1.7
Euastrum	min	16.0 μm	20.4 μm	5.1 μm	11.8 μm	1.2
montanum	med	16.8 μm	23.0 μm	5.5 μm	12.0 μm	1.3
	max	18.9 μm	23.9 μm	6.8 μm	13.5 μm	1.5
Euastrum	min	38.1 μm	67.2 μm	10.6 μm	19.9 μm	1.6
neosinuosum	med	43.9 μm	71.4 μm	13.2 μm	21.2 μm	1.6
	max	45.6 μm	73.4 μm	14.7 μm	22.9 μm	1.8
Euastrum	min	35.9 μm	58.7 μm	9.8 μm	15.3 μm	1.6
obesum	med	47.4 μm	78.6 μm	12.8 μm	26.0 μm	1.7
	max	50.7 μm	87.7 μm	15.9 μm	28.2 μm	1.8
Euastrum	min	54.1 μm	106.8 μm	13.4 μm	33.5 μm	1.9
oblongum	med	69.1 μm	138.6 μm	22.0 μm	41.5 μm	2.0
	max	78.4 μm	160.9 μm	25.0 μm	46.7 μm	2.2
Euastrum	min	29.5 μm	46.8 μm	6.7 μm	21.8 μm	1.5
oculatum	med	31.1 μm	49.6 μm	7.8 μm	23.6 μm	1.6
	max	32.1 μm	51.6 μm	9.2 μm	24.6 μm	1.6
Euastrum	min	45.4 μm	69.5 μm	10.6 μm	25.8 μm	1.5
pectinatum	med	48.2 μm	73.9 μm	13.5 μm	26.4 μm	1.5
	max	52.2 μm	79.4 μm	15.8 μm	29.7 μm	1.6
Euastrum	min	54.4 μm	113.3 μm	18.2 μm	33.1 μm	1.8
pinnatum	med	69.2 μm	133.9 μm	20.1 μm	40.5 μm	1.9
	max	78.9 μm	148.0 μm	24.6 μm	44.8 μm	2.4

[†]*summary statistics based on <5 cells*

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Table 7.2: *Euastrum* Cell Measurements, continued

		Cell Width	Cell Length	Isthmus Width	Apex Width	L/W Ratio
Euastrum	min	18.3 μm	24.5 μm	4.2 μm	14.7 μm	1.2
pulchellum†	med	19.4 μm	24.6 μm	4.3 μm	15.3 μm	1.3
	max	20.2 μm	24.8 μm	4.3 μm	16.5 μm	1.3
Euastrum	min	–	–	–	–	–
cf. *subalpinum*	med	18.5 μm	23.5 μm	6.4 μm	12.7 μm	1.3
var. *crassum*†	max	–	–	–	–	–
Euastrum	min	19.6 μm	22.9 μm	5.2 μm	15.1 μm	1.2
sublobatum	med	20.6 μm	26.2 μm	6.6 μm	16.9 μm	1.2
	max	22.2 μm	28.5 μm	7.2 μm	17.9 μm	1.3
Euastrum	min	23.6 μm	30.2 μm	5.8 μm	19.2 μm	1.2
turneri	med	25.7 μm	33.2 μm	6.7 μm	20.3 μm	1.3
	max	27.1 μm	35.4 μm	7.6 μm	21.3 μm	1.4
Euastrum	min	56.4 μm	65.6 μm	14.8 μm	27.1 μm	1.1
verrucosum	med	84.9 μm	99.8 μm	22.6 μm	38.2 μm	1.2
	max	126.2 μm	130.4 μm	27.6 μm	44.0 μm	1.2

†*summary statistics based on <5 cells*

Description

Euastrum cells are typically oval, elliptical, or rectangular in outline, and most species have a distinctive median notch in the center of the apical lobe (Figures 7.1–7.2). A few species lack the notch, and instead have either a concave or flattened apical lobe. The semi-cells are separated by a deep sinus, and are divided either into three segments, consisting of apical and basal lobes; or five segments, consisting of apical, lateral, and basal lobes. This genus is extremely diverse, with many species and varieties. It is also well-known for morphological variability, making the taxonomy particularly difficult. The *Euastrum* key at the beginning of this section requires that you measure the size of your specimen, which is critical for separating *Euastrum* species with widths in the 10–30 μm range. In addition, due to the diversity of this genus, it is highly likely that you will encounter species or varieties of *Euastrum* that are not described in this guide.

Euastrum ansatum is a medium sized species characterized by simple, triangular semi-cells with a deep, closed sinus (Figures 7.3–7.8). The apical lobe has nearly parallel sides that expand slightly near the apex; the apex is flattened and contains a shallow, closed median notch. The lateral edges are evenly curved, or very slightly undulating, with no distinct separation into lateral and basal lobes. When examined using SEM, *Euastrum ansatum* cells have a single central mucilage pore, two shallow protrusions on either side of the pore, and three shallow protrusions in a line just above the isthmus (Figures 7.5–7.6). The cell wall may appear smooth, but SEM reveals that the wall is covered with shallow pits, with larger pits near the apex. This species resembles *Euastrum didelta* (Figure 7.32), which can be distinguished by its larger cells (W>50 μm). Figures 7.7–7.8 show a variety from northwest Washington lakes, *Euastrum ansatum* f. *angustum*,[20] that is characterized by longer cells, with sides that taper very gradually into the apical lobe.

Euastrum bidentatum semi-cells are trapezoidal or semi-elliptical in outline, with a deep, closed sinus and wavy lateral margins that form lateral and basal lobes (Figures 7.9–7.13). The apical lobe is rounded and slightly elevated (dome-like), with a deep, closed or narrowly open median notch. The outer angles of the apical lobe contain short, blunt teeth; the inner angles of the apical lobe are often thickened at the top of the median notch. Nearly all of the specimens collected from northwest Washington lakes fit the description for ***Euastrum bidentatum* var. *speciosum***. This variety is characterized by a narrowly open median notch in the apical lobe, double or crenulated margins on the lateral and basal lobes, and a rosette of central granules that are arranged in three vertical rows. The specimen in Figure 7.13 has two large pits just above the central rosette of granules, fitting the description for ***Euastrum bidentatum* var. *oculatum***.

Euastrum binale is a diverse species with many varieties, all of which are quite small and difficult to identify correctly. Most of the varieties have trapezoidal semi-cells with a deep, closed sinus; a short, broad apical lobe with a shallow, flaring, median notch; and a wavy lateral margin that is usually inflated above the sinus. One common variety found in northwest Washington lakes and ponds is ***Euastrum binale* var. *gutwinskii*** (Figures 7.16–7.17), which is characterized by trapezoidal semi-cells that have a relatively short apical lobe, slightly flared median notch, and short, blunt teeth on the outer apical angles. The lateral margin undulates, forming indistinct lateral and basal lobes; the basal lobe is slightly inflated above the sinus. The cell wall may appear smooth, but SEM shows a distinctive raised

[20] Forma, abbreviated "f" is used to indicate minor morphological variations that occur regularly, often within a geographical region.

central region surrounded by shallow pits, as well as a few rounded granules along the lateral margin (Figure 7.17). Another relatively common variety of *Euastrum binale* is ***Euastrum binale* var. *papilliferum***, which resembles *Euastrum binale* var. *gutwinskii*, but can be distinguished by its slightly smaller, shorter cells; deeper and more broadly flared apical lobe; and the coarser teeth, pits, and granules on the cell wall (Figures 7.18–7.19).

Euastrum coeselii cells are tiny, with rectangular semi-cells and a deep, closed sinus (Figures 7.20–7.21). The apical lobe is wide and flat, with a shallow, indistinct median notch. The lateral margin is slightly inflated above the sinus, and obliquely truncated at the sinus (Figure 7.21). The cell walls appear to lack ornamentation, but SEM reveals a few symmetric pits on the face of the cell. The specimens in Figures 7.22–7.23 may be a variety of *Euastrum coeselii* that is characterized by a slightly deeper, flaring median notch; however, other specimens collected in the same sample exhibited a range of apical lobe features, so these cells may simply illustrate morphological variability in this tiny species. *Euastrum coeselii* is moderately common in northwest Washington lakes and ponds, but it is often overlooked because of its small size and minimal ornamentation, and when found, is very difficult to distinguish from small species of *Cosmarium*.[21]

Euastrum crassum cells are large and smooth-walled, with a deep, closed or partly open sinus separating rectangular semi-cells (Figures 7.24–7.27). The apical lobe is short, inflated (wedge-shaped), and broadly rounded, with a deep, closed median notch. The lateral margin is slightly concave (wavy), forming shallow lateral and basal lobes. There are three large median protrusions above the sinus (Figure 7.26). *Euastrum crassum* closely resembles *Euastrum ventricosum* (no image available), which is smaller, with deeper lateral indentations that form broadly rounded lateral and basal lobes. *Euastrum crassum* semi-cells can exhibit significant variation in the degree of lateral indentation (Figure 7.27), so it is important to measure cell sizes when attempting to identify these two species.

Euastrum denticulatum cells are small, with rectangular or slightly trapezoidal semi-cells, and a deep, closed sinus (Figures 7.28–7.31). The apical lobe is flat, with a shallow, v-shaped median notch and blunt teeth on the outer angles. The cell wall and lateral margins are sparsely covered with large, scattered granules. There is also a cluster of approximately five large granules located centrally above the isthmus, usually consisting of two granules adjacent to the isthmus and three granules forming a triad above the lower granules (Figures 7.30–7.31). *Euastrum*

[21] See **Freshwater Algae in Northwest Washington, Volume III. Part B**

denticulatum resembles *Euastrum turneri* (Figures 7.31), which is larger, slightly longer relative to width, and usually has coarser and more numerous granules on the cell surface. Except for size, the morphological features are quite similar for both species, making them difficult to identify correction, even in SEM images (Figure 7.31). *Euastrum denticulatum* is also very difficult to separate from *Euastrum pulchellum*, which is about the sample size and superficially has many of the same morphological features. Comparing SEM images, however, shows that the surface ornamentation is quite different (Figure 7.91). *Euastrum pulchellum* has a smoother cell face, with only three central granules, and most of the granulation is located on the apical and lateral margins.

Euastrum didelta semi-cells are large and triangular, with gently sloping lateral margins that merge with the narrow apical lobe (Figures 7.32–7.34). The lateral lobe is absent or reduced to a small bump. The apical lobe has nearly parallel sides and an unexpanded or very slightly expanded, rounded apex containing a deep, closed median notch. The cells usually appear smooth, but empty cells show that the surface is covered with small, regularly spaced pits (Figure 7.34). In addition, there are three shallow protrusions just above the sinus and two additional protrusions on either side of a large central pit. *Euastrum didelta* is extremely polymorphic, making identification challenging.

Euastrum didelta can be difficult to distinguish from *Euastrum humerosum* (Figure 7.48) and *Euastrum latipes* var. *evolutum* (Figure 7.58). Fully developed cells can usually be separated based on lateral and basal lobe differences and surface features; unfortunately, it is common to find intermediate forms resembling all three species in the same sample. *Euastrum didelta* also resembles *Euastrum ansatum* (Figure 7.3), which is much smaller (*Euastrum didelta* cells are 60-75 μm wide; *E. ansatum* cells are $<$50 μm wide).

Euastrum dubium is characterized by small trapezoidal semi-cells with a relatively shallow, closed sinus (Figures 7.35–7.36). The apical lobe is short and broad, with a flat apex and v-shaped median notch. The lateral and basal lobes are separated by shallow indentations, forming a wavy lateral margin. This species resembles *Euastrum bidentatum* (Figure 7.9), but is much smaller and has fewer granules on the cell wall. The specimens in Figures 7.35–7.36 appear to be ***Euastrum dubium* var. *ornatum***, which is distinguished by a closed median notch and a circle of raised granules in the center of the semi-cell.

Euastrum elegans cells are small, oval or elliptical in outline, with trapezoidal semi-cells and a deep, closed sinus (Figures 7.37–7.39). The apical lobe is rounded, with a deep, closed or partly open median notch that extends up to half the length of the semi-cell. The outer angles of the apical lobe have blunt teeth located slightly below the apex. The lateral margin is gently curved and slightly inflated above the sinus but is not distinctly separated into lateral and basal lobes. The SEM images reveal that the lateral margin may also have short, blunt teeth or granules, while the center of the semi-cell contains a circle of large granules with oval ring-like pits on either side. The cell face is ornamented with additional scattered granules (Figures 7.38–7.39).

Euastrum fissum cells are small and broadly elliptical, with trapezoidal semi-cells and a wide, elevated apical lobe (Figures 7.40–7.41). The median notch extends to the base of the apical lobe and is slightly open at the base and near the apex. The lateral margin of the apical lobe may be smooth, but usually has paired subapical teeth located at the widest point along the apical lobe margin. Below the apical lobe the lateral margin slopes gradually to the sinus and has an undulating margin but is not separated into distinct lateral and basal lobes. This species resembles *Euastrum elegans*, which is much more common. Not surprisingly, *Euastrum fissum* is sometimes listed as *Euastrum elegans* var. *fissum* Borge.

Euastrum gayanum cells are very small, with rectangular semi-cells and a deep, closed sinus (Figures 7.42–7.43). The apical lobe is concave and nearly as wide as the rest of the cell, with a flaring median notch and small, blunt marginal teeth. The lateral margin is broadly rounded, with no distinct separation into lateral and basal lobes. The cell is so small that surface ornamentation is difficult to see without SEM, but there is a prominent central protrusion that should be visible, and the lateral margins may appear rough due to the presence of small granules. This tiny *Euastrum*, while easily overlooked, can be found in several lakes along the Mountain Loop Highway.

Euastrum gemmatum* var. *taftii semi-cells are shaped like an inverted T, forming distinctive cruciform (cross-shaped) cells (Figures 7.44–7.47). The lower portion of the apical lobe has nearly parallel sides that expand into a broadly rounded, concave apex with no distinguishable median notch. The lateral and basal lobes form a rectangular base adjacent to the sinus; the sinus is slightly open in this variety. The cell wall is ornamented with regular patterns of large granules, including three oval rings of granules above and below the sinus (Figures 7.45–7.47).

Euastrum humerosum cells are moderately large, with triangular semi-cells and a deep, closed sinus (Figures 7.48–7.50). The apical lobe is rounded and slightly inflated, with a deep, closed median notch. The basal lobe is rectangular, usually with an indented margin. The lateral lobe is small, but distinct, and usually upwardly directed. The cell face has a large central pore surrounded by three large protrusions; two additional protrusions are present above the sinus near the lateral margins (Figure 7.50). This species is very polymorphic and can be difficult to distinguish from *Euastrum didelta* (Figure 7.32) and *Euastrum latipes* var. *evolutum* (Figure 7.58). Fully developed cells can usually be separated based on lateral and basal lobe differences and surface features; unfortunately, it is common to find intermediate forms resembling all three species in the same sample.

Euastrum humerosum* var. *affine is characterized by its short, flat, inflated apical lobe containing a deep, closed median notch; narrow, upwardly directed lateral lobes; and rectangular, indented (wavy) basal lobes (Figures 7.51–7.53). The three central tubercles are very well developed and can be seen in both light microscope and SEM (Figure 7.52–7.53). This variety, while less common in northwest Washington lakes, is more easily identified than other varieties of *Euastrum humerosum* because of the distinctive lateral and basal lobe features. In some taxonomic keys this variety is listed as a separate species (*Euastrum affine* Ralfs) rather than a variety of *Euastrum humerosum*. *Euastrum humerosum* var. *affine* resembles *Euastrum pinnatum* (Figure 7.85), which can be distinguished by its larger, horizontally directed lateral lobes and more deeply indented basal lobes.

Euastrum insulare cells are small and cruciform (cross-shaped), with trapezoidal semi-cells, and a deep, closed sinus (Figures 7.54–7.56). The apical lobe is nearly flat, with parallel sides and a very shallow apical indentation. The lateral margin is very slightly indented but not distinctly separated into lateral and basal lobes. There are small tooth-like projections just above the sinus on the lateral margins that may extend to the point of touching the projection on the other semi-cell. The cell surface appears smooth, but SEM reveals a central pit, several elongated lateral grooves, and shallow scattered pores. The semi-cell should also have a small central protrusions above the central pit (Anissimova, 2021), but this feature was only seen in one of the SEM images (Figure 7.55). Anissimova (2021) described the cell ornamentation as being somewhat variable, which was true for the northwest Washington specimens.

Euastrum lacustre semi-cells are trapezoidal, with a deep, closed sinus (Figure 7.57). The broad, slightly concave apical lobe has a very shallow v-shaped median notch, and short, blunt teeth on the outer margin. The lateral and basal lobes are separated, forming a wavy margin. The cell wall is relatively smooth, with little surface ornamentation visible using DIC illumination. The species identification is uncertain because *Euastrum lacustre* closely resembles *Euastrum biscrobiculatum* (no image available), which is nearly identical in size and general appearance except for surface ornamentation that isn't visible in Figure 7.57. *Euastrum lacustre* also resembles *Euastrum insulare* (Figure 7.54), which is smaller and has less distinct separation of the lateral and basal lobes.

Euastrum latipes **var.** ***evolutum*** is characterized by large, flask-shaped semi-cells with a deep sinus that is closed near the center and open near the margin (Figures 7.58–7.60). The apical lobe is flattened or slightly concave, thickened on the outer angles, and has a deep, closed median notch. The lateral margin has a undulating margin; the lateral lobe is reduced to a small protrusion and the basal lobe is bluntly acute, with a thickened margin above the sinus. The cell face has a large central pore surrounded by three large protrusions; two additional protrusions are present above the sinus near the lateral margins The three tubercles surrounding the central pore are often visible without using SEM (Figure 7.60). Prescott et al. (1977) describe this taxon as having tooth-like projections on the outer edge of the lateral margin just above the sinus, but this feature was not evident in the northwest Washington images and was not included in the description by deMenezes, et al. (2013). This species is uncommon, and appears to be polymorphic because specimens collected on the same date from the same location exhibit traits ranging from "classic" *Euastrum latipes* var. *evolutum* to specimens that resemble *Euastrum humerosum* (Figure 7.61). Both taxa have similar tubercles on the face of the cell surrounding a large central pore, an undulating lateral margin, and lateral lobes represented by a small bump. But fully developed *Euastrum latipes* var. *evolutum* semi-cells can be distinguished by their unusually wide, flask-shaped semi-cells.

Euastrum luetkemuelleri **var.** ***carniolicum*** semi-cells are small and trapezoidal, with a deep, closed sinus. The apical lobe is broad, slightly concave, with a slightly flared apex, and an indistinct median notch (Figures 7.62–7.64). The base of the apical lobe is nearly as wide as the lateral margin. The margin of the lateral lobe is wavy, but there is no clear separation into lateral and basal lobes. The SEM images reveal a shallow, oval pit that is centrally located and slightly below the median notch (Figures 7.63–7.64). The SEM images also show two tiny pores located in the notch. This feature is not visible in Anissimova's SEM images for this species

(Anissimova, 2021), so it may represent a feature unique to northwest Washington specimens. *Euastrum luetkemuelleri* var. *carniolicum* resembles *Euastrum insulare* (Figure 7.54), but has slightly longer cells and a more obviously inflated apical lobe. This species is difficult to distinguish from small species of *Cosmarium*.[22]

Euastrum montanum cells are small, with short, rectangular semi-cells (W>L) and a deep, closed sinus (Figures 7.65–7.67). The apical lobe is almost as wide as the lateral margin and is flat with an indistinct, v-shaped median notch. The lateral margin is wavy, forming a separation between the lateral and basal lobes. The cell wall appears relatively smooth, but SEM reveals a small central protrusion and pitted surface (Figures 7.66–7.67). This species closely resembles *Cosmarium humile* and *Cosmarium regnellii* (described in Part B of this volume) but the *Cosmarium* species do not have the apical notch.

Euastrum neosinuosum cells are medium-sized, with triangular semi-cells and a deep, closed sinus (Figures 7.68–7.71).[23] The apical lobe is short and broad, with a rounded apex and deep, closed median notch. The base of the apical lobe should have a short neck with nearly parallel sides. The lateral and basal lobes are short and broadly rounded, resulting in a wavy or sinuous cell margin. The cells have a large central mucilage pore with two shallow protrusions on either side of the pore and three shallow protrusions in a line just above the isthmus (Figures 7.69–7.70). Each protrusion has a smaller mucilage pore, and there are additional large pores scattered across the face of the cell. This species is difficult to distinguish from *Euastrum aboense* Elfving (no image available), which has slightly smaller cells with a shorter, narrower apical lobe that merges smoothly with the lateral lobe. In the northwest Washington samples, apical lobe lengths were somewhat variable in specimens from the same sample, suggesting that the species separation might not be valid (Figure 7.71).

Euastrum obesum is characterized by medium sized, broadly triangular semi-cells, with a deep, closed sinus (Figures 7.72–7.74). *Euastrum obesum* cells have a very short apical lobe with a closed median notch. The apical lobe merges smoothly with the undivided lateral margin. This species resembles some of the varieties of *Euastrum ansatum*, especially since the SEM images reveal three shallow protrusions just above the sinus and two more in the center of the cell (Figures 7.73–7.74); similar protrusions are present on *Euastrum ansatum* cells (Figure 7.5).

[22] See **Freshwater Algae in Northwest Washington, Volume III. Part B.**

[23] *Euastrum neosinuosum* will be listed as *Euastrum sinuosum* Lenormand ex W. Archer in most taxonomic guides but the species was renamed by Anissimova and Guiry (2021) to avoid confusion with a different *Euastrum sinuosum* Kützing, which was renamed *Cosmarium crenatum* Ralfs.

But the SEM images also show that there is no central pore in the *Euastrum obesum* specimens, which would be present if the cells were a variety of *Euastrum ansatum*.

Euastrum oblongum cells are large, with elliptical or slightly rectangular semi-cells and a deep, closed sinus (Figures 7.75–7.77). The apical lobe is short and wedge-shaped, with a slightly rounded apex and a deep, closed median notch. The lateral and basal lobes are truncated, with flattened edges; the basal lobe is slightly indented along the margin. The SEM images reveal large protrusions: three along the sinus and two more on either side of the central pore (Figures 7.76–7.77).

Euastrum oculatum is characterized by trapezoidal semi-cells with a closed sinus (Figures 7.78–7.81). The apical lobe has parallel lateral margins and a flat or slightly concave apex containing a shallow, open, v-shaped notch that is thickened along the inner margins. There are stout, blunt, upwardly directed teeth on the outer angles of the apical lobe. The lateral margins are wavy, forming shallow lateral and basal lobes. The basal lobe has tooth-like projections just above the sinus near the lateral angles. Although the cells appear smooth in the DIC images, SEM shows a shallow protrusion just above the isthmus, with two deep mucilage pores located above the protrusion and a few additional granules on the angles of the lateral and apical lobes (Figure 7.81).

Euastrum pectinatum is a medium-sized desmid with cruciform (cross-shaped) cells, trapezoidal semi-cells, and a deep, partly closed sinus (Figures 7.82–7.84). The apical lobe is wedge-shaped, with a flat, slightly expanded apex that has no median notch. The cell wall appears smooth when examined using light microscopy, with slightly thickened marginal angles. While it may be difficult to recognized this unusual desmid is a member of the genus *Euastrum*, the species identification is straightforward due to the distinctive smooth wall, thickened angles, and absence of an apical notch.

Euastrum pinnatum is characterized by large, rectangular cells with deeply divided lateral and basal lobes, and a narrowly open sinus (Figures 7.85–7.87). The apical lobe is wedge-shaped, with a broad, flat apex and deep, closed median notch. The lateral lobe is triangular, bluntly acute, and nearly horizontal along the top edge; the basal lobe is rectangular and shallowly indented along the margin. The cell face has three large tubercles surrounding a central pore (Figures 7.86–7.87). This species resembles *Euastrum humerosum* var. *affine* (Figure 7.51), which also has three large tubercles surrounding a central pore, but has a narrower apical lobe, shorter L/W ratio, and upwardly directed lateral lobes; and *Euastrum oblongum* (Figures 7.75), which can be distinguished by its truncated lateral and basal lobes.

Euastrum pulchellum cells are small, with rectangular of oval semi-cells and a deep, closed sinus (Figures 7.88–7.91). The apical lobe is flat or very slightly rounded, with a deep, narrowly open median notch and blunt teeth on the outer angles. The basal lobe is inflated above the sinus and has short teeth just above the sinus near the lateral margins. The center of the cell face contains three large granules positioned just below two large pits. Two additional large pits are located above the granules near the base of the apical lobe. Additional granules are located along the inflated portion of the basal lobe and near the apex. *Euastrum pulchellum* resembles *Euastrum turneri* (Figure 7.96), which is larger, longer relative to width, and more coarsely granulated. *Euastrum pulchellum* is very difficult to distinguish from *Euastrum denticulatum*, which is about the same size and superficially has many of the same morphological features. Comparing SEM images, however, shows that the surface ornamentation is quite different (Figure 7.91). *Euastrum pulchellum* has a relatively smooth cell face, with only three central granules; most of the granulation is confined to the apical and lateral margins.

Euastrum subalpinum* var. *crassum is characterized by small, trapezoidal semi-cells with a deep, closed sinus (Figure 7.92). The apical lobe is broad, with a wide, v-shaped notch. The basal lobe is slightly inflated above the sinus and slightly indented along the lateral margin. Species identification of this uncommon desmid was based largely on comparisons to SEM images published by Anissimova (2021). The diagnostic features for the northwest Washington specimen shown in Figure 7.92 include a large central protrusion, minute teeth on the outer angles of the apical lobes, and groups of three smaller protrusions on each of the apical and basal lobes.

Euastrum sublobatum cells are small, smooth-walled, with trapezoidal or rectangular semi-cells and a deep, closed sinus (Figures 7.93–7.95). The apical lobe is nearly as wide as the lateral margin, with a flattened, slightly concave apex and no distinct median notch. The basal lobe is usually slightly indented along the lateral margin and incised at the sinus. Although the cell wall appears smooth when viewed using light microscopy, the SEM image reveals a pitted surface and a large, shallow central protrusion (Figures 7.94–7.95). The SEM images also reveal additional shallow subapical and lateral protrusions. This species is easily mistaken for a type of *Cosmarium*.[24]

[24] See **Freshwater Algae in Northwest Washington, Volume III. Part B.**

Euastrum turneri cells are small, with trapezoidal semi-cells and a deep, closed sinus (Figures 7.96–7.98 and Figure 7.31). The apical lobe is flat, with a shallow, u-shaped or v-shaped median notch[25], and blunt teeth on the outer angles and inner angles. The cell wall and lateral margins are covered with large, coarse granules. There is also a cluster of approximately five large granules located centrally above the isthmus, usually consisting of two granules adjacent to the isthmus and three granules forming a triad above the lower granules (Figure 7.98). *Euastrum turneri* resembles *Euastrum denticulatum* (Figures 7.31), which is smaller, slightly shorter relative to width, and usually has fewer and smaller granules on the cell surface. Except for size, the other separation features are quite variable for both species, making them difficult to identify correction, even in SEM images (Figure 7.31). *Euastrum turneri* also resembles *Euastrum pulchellum*, which is nearly the same size but has a much smoother appearance (Figure 7.88).

Euastrum verrucosum is characterized by large, trapezoidal semi-cells and a deep sinus that may be closed to the margin or narrowly open for about half its length (Figures 7.99–7.104). The apical lobe is short, broad, and rounded, with a concave apex but with no median notch. The lateral lobes are small, rounded, and often angled upward. The basal lobe is triangular and often slightly recurved just above the sinus. The entire cell surface is covered with large, rough granules, including three concentric rings of granules on the face of the cell just above the sinus (Figure 7.101). *Euastrum verrucosum* is morphologically diverse, with many of the forms listed as separate varieties. But it is common to find a gradient of these forms present in the same sample or in lakes that are in close proximity, so the northwest Washington specimens were only identified to the species level. Figure 7.104 shows the forms that are common in samples from lakes in the Mt. Baker area.

[25]Prescott, et al. (1977) describes *Euastrum turneri* as having a u-shaped median notch, but this feature does not seem to be consistent in specimens from northwest Washington lakes.

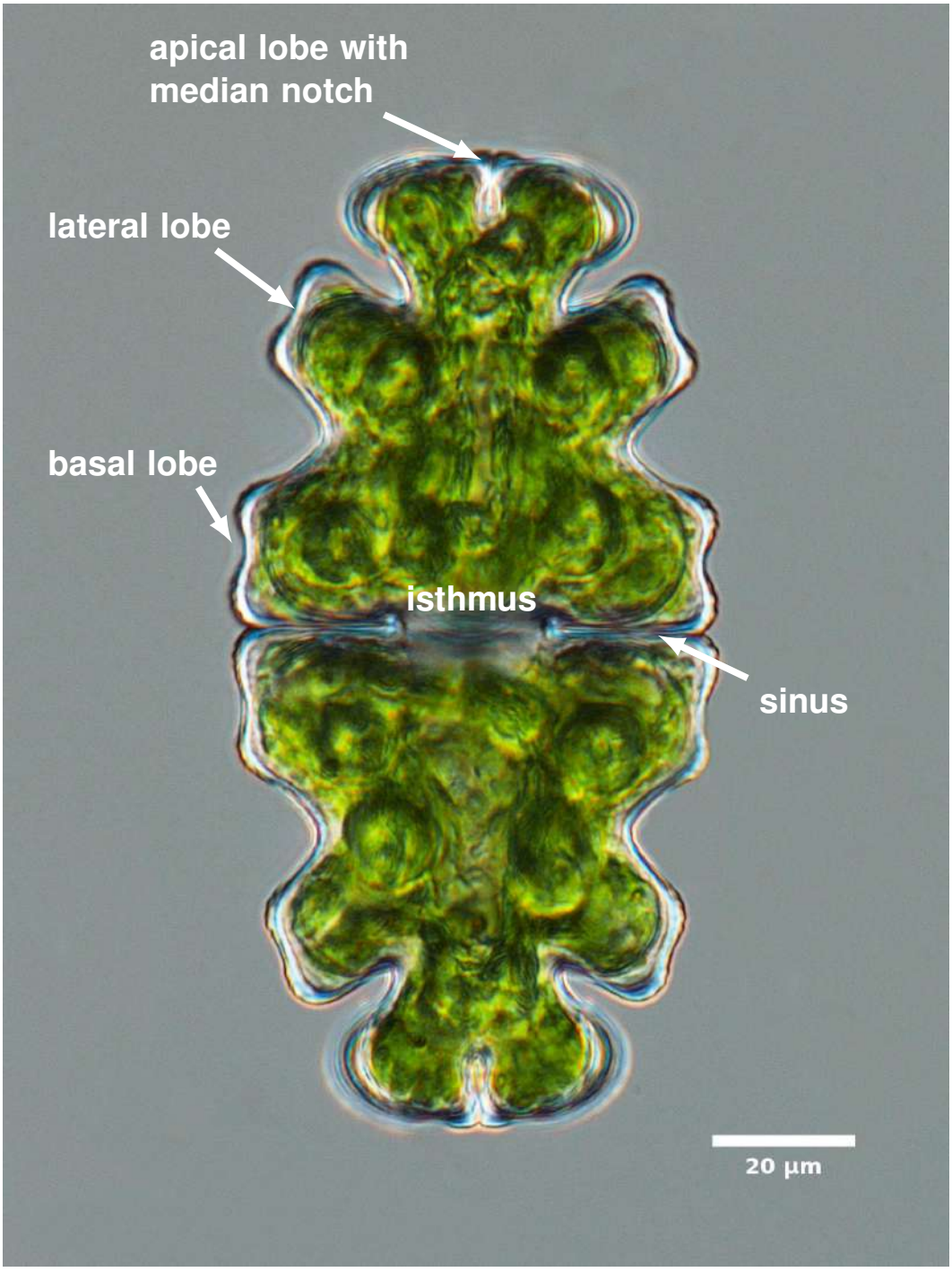


Figure 7.1: *Euastrum* basic morphological features for species with notched apical lobes (*Euastrum oblongum*).

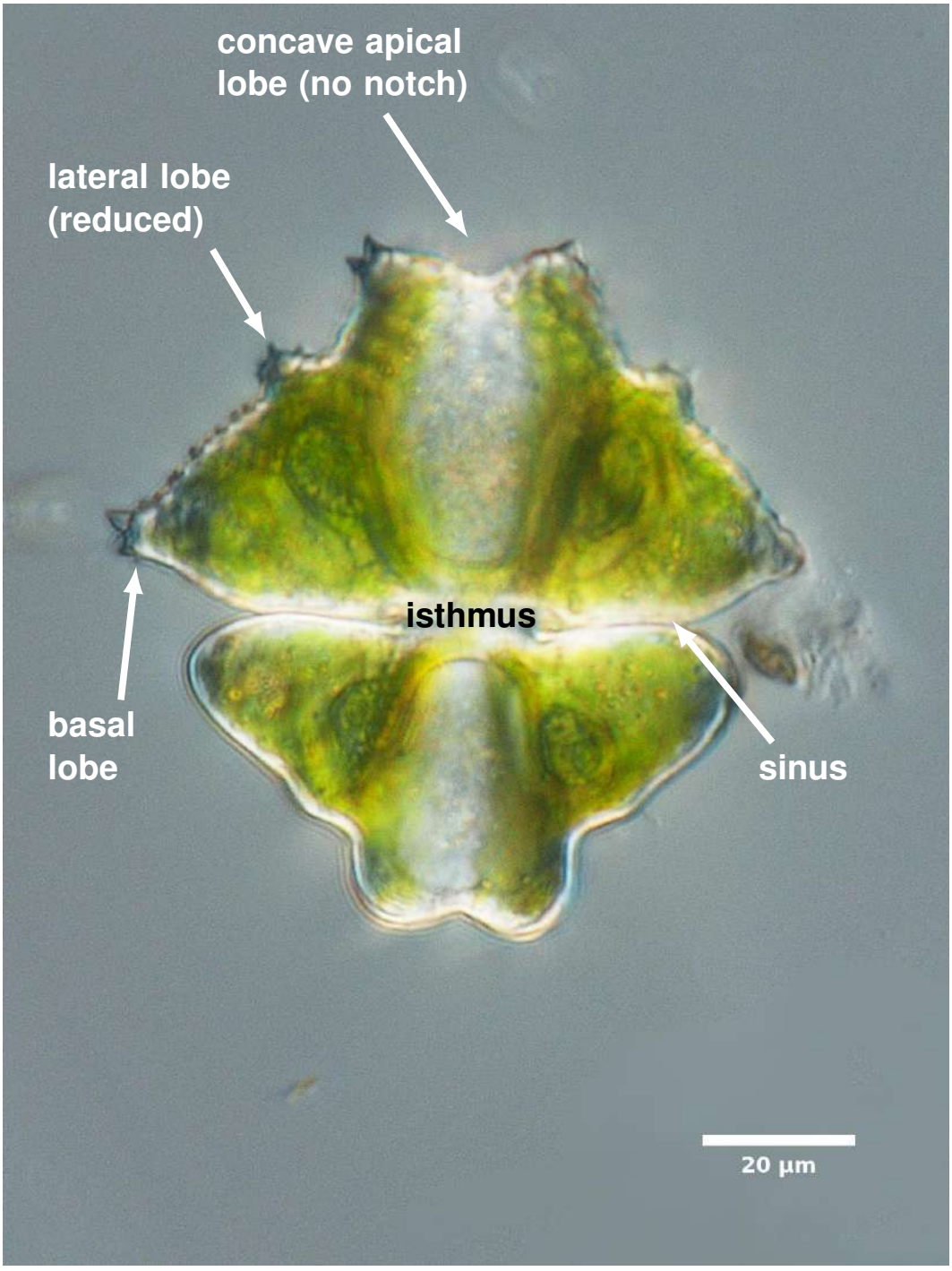


Figure 7.2: *Euastrum* basic morphological features for species with unnotched apical lobes (*Euastrum verrucosum*).

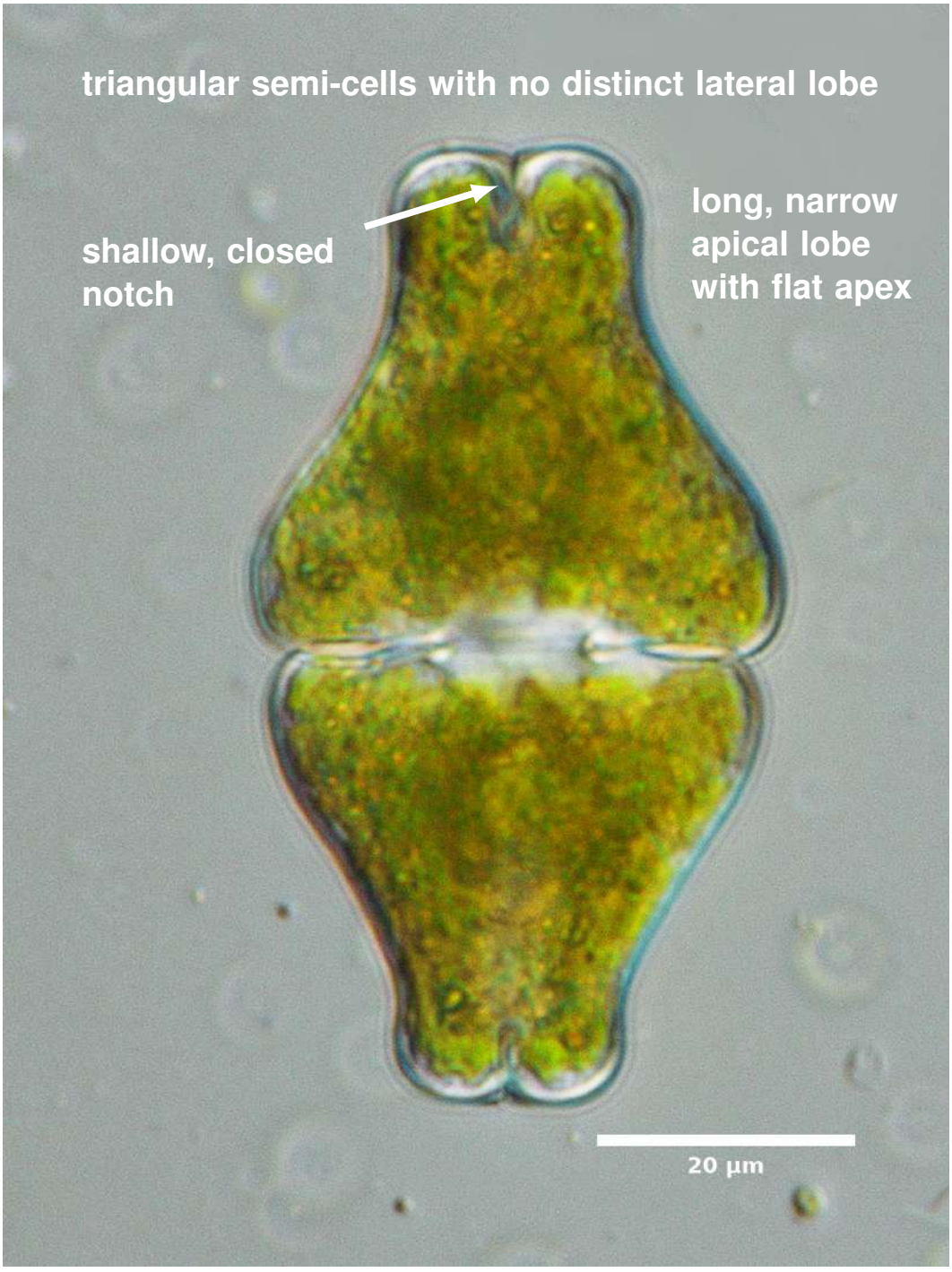


Figure 7.3: *Euastrum ansatum* (DIC), Heather Lake, Mountain Loop Highway, Snohomish County.



Figure 7.4: *Euastrum ansatum* (DIC), Lake Evan, Mountain Loop Highway, Snohomish County.

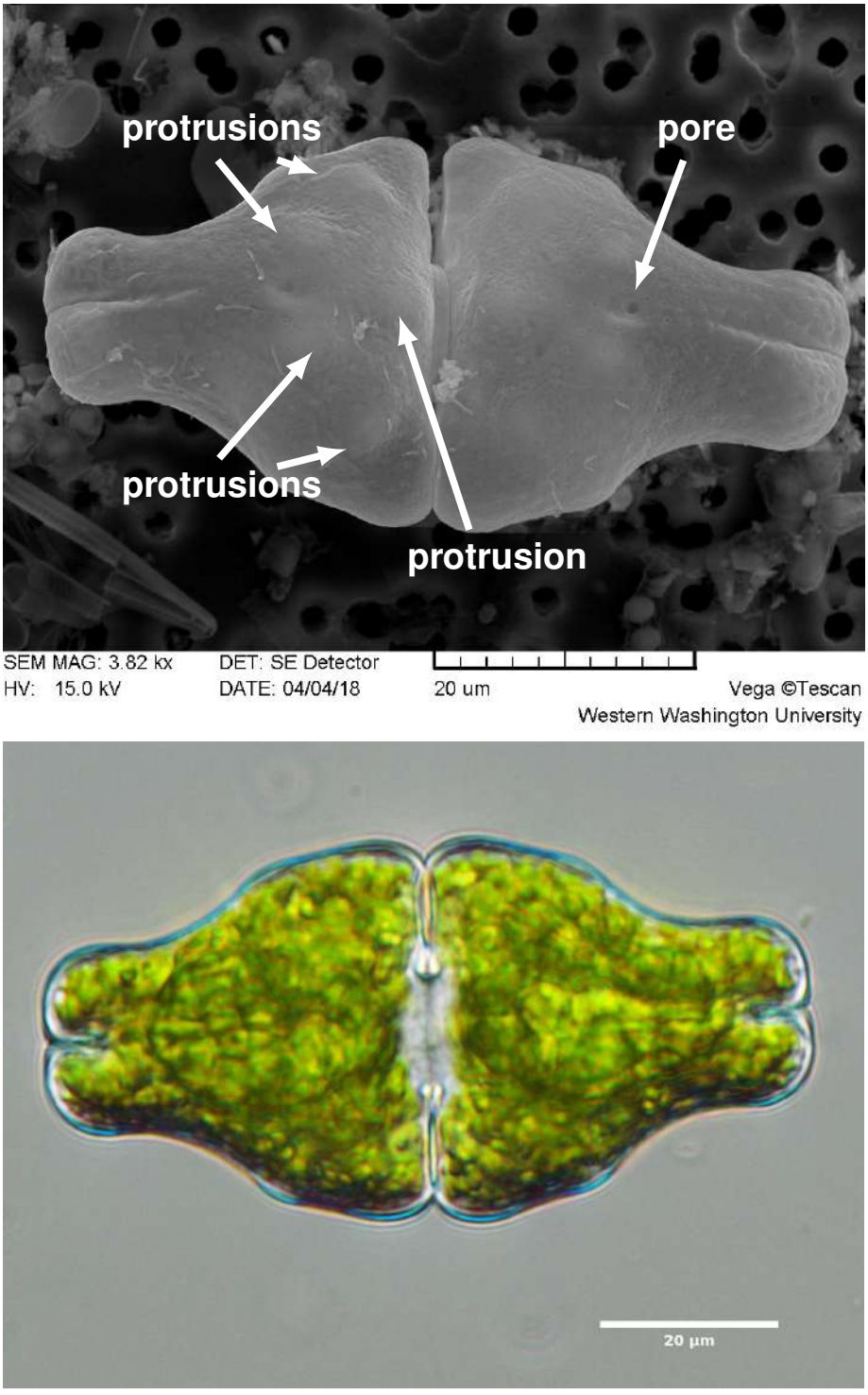
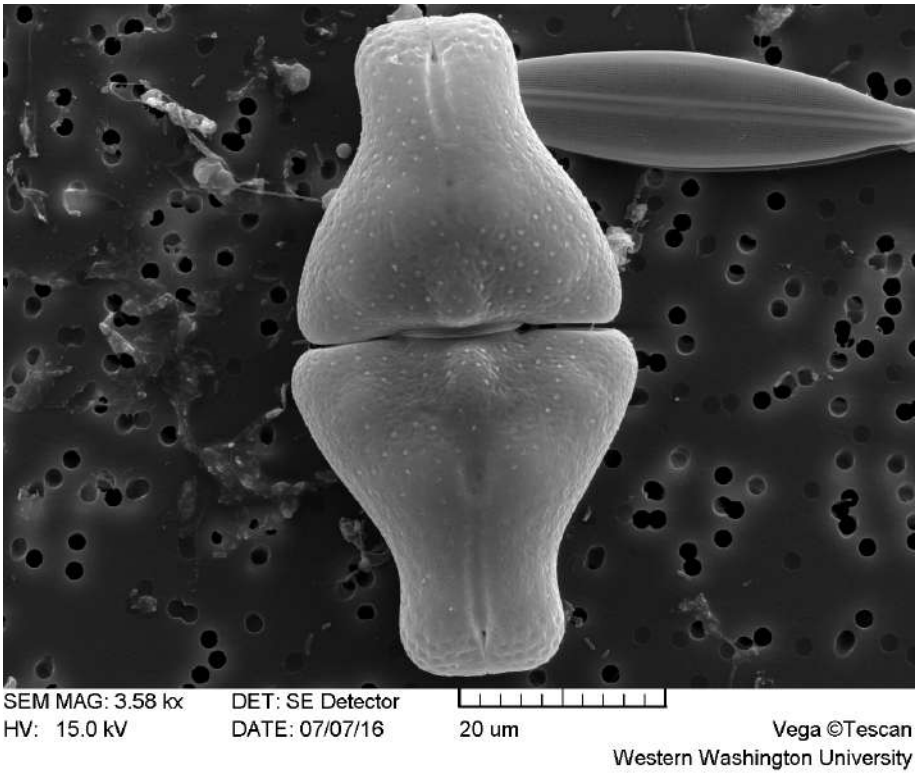


Figure 7.5: *Euastrum ansatum* (SEM/DIC), Highwood Lake, Mt. Baker area, Whatcom County (upper/lower images).



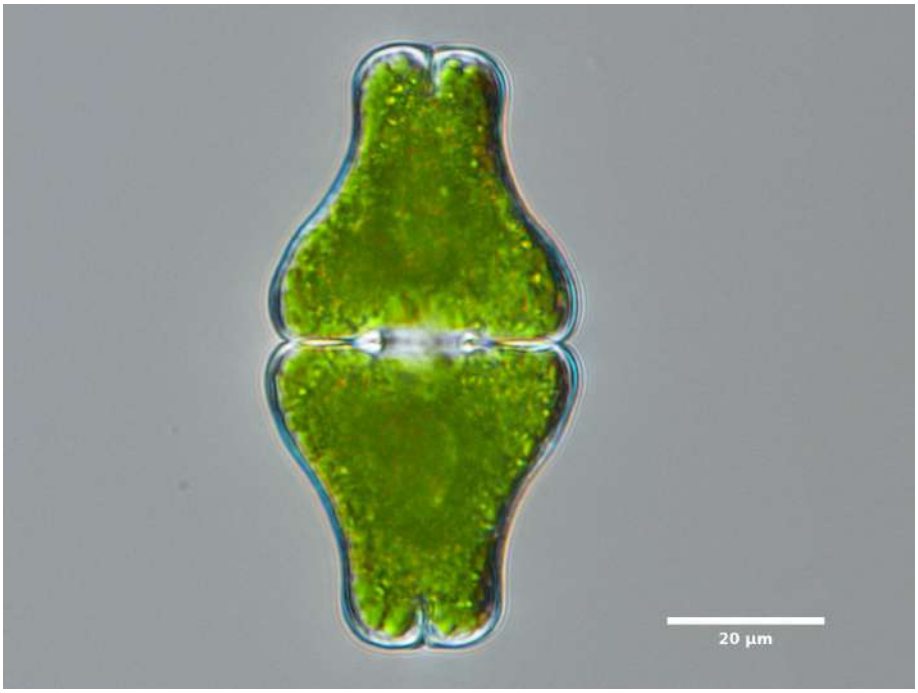


Figure 7.6: *Euastrum ansatum* (SEM/DIC), Bear Lake, Mountain Loop Highway, Snohomish County (upper image); Boardman Lake, Mountain Loop Highway, Snohomish County (lower image).

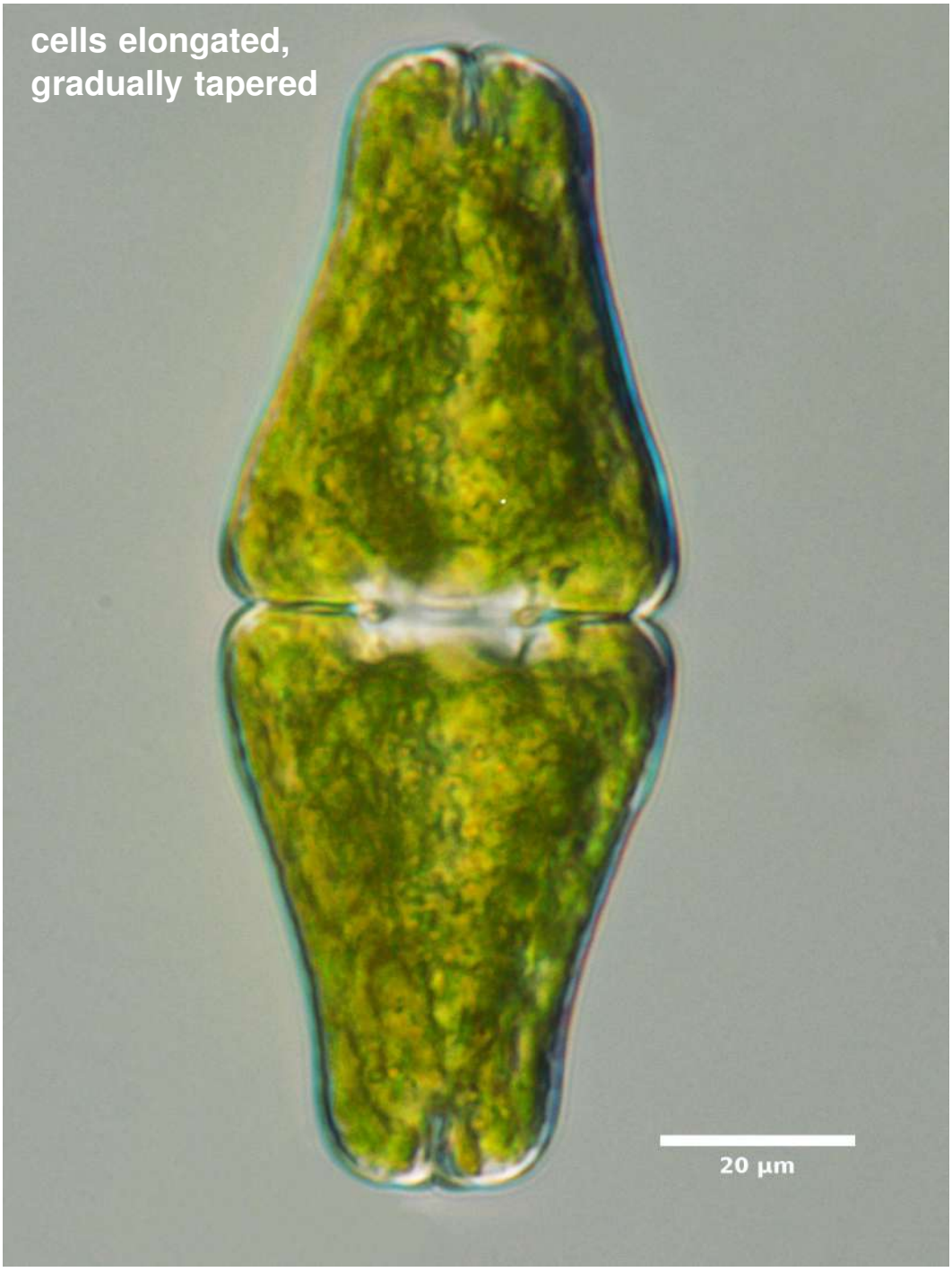


Figure 7.7: *Euastrum ansatum* f. *angustum* (DIC), Summer Lake, Skagit County.



Figure 7.8: *Euastrum ansatum* f. *angustum* (DIC), Myrtle Lake, Mountain Loop Highway, Snohomish County.

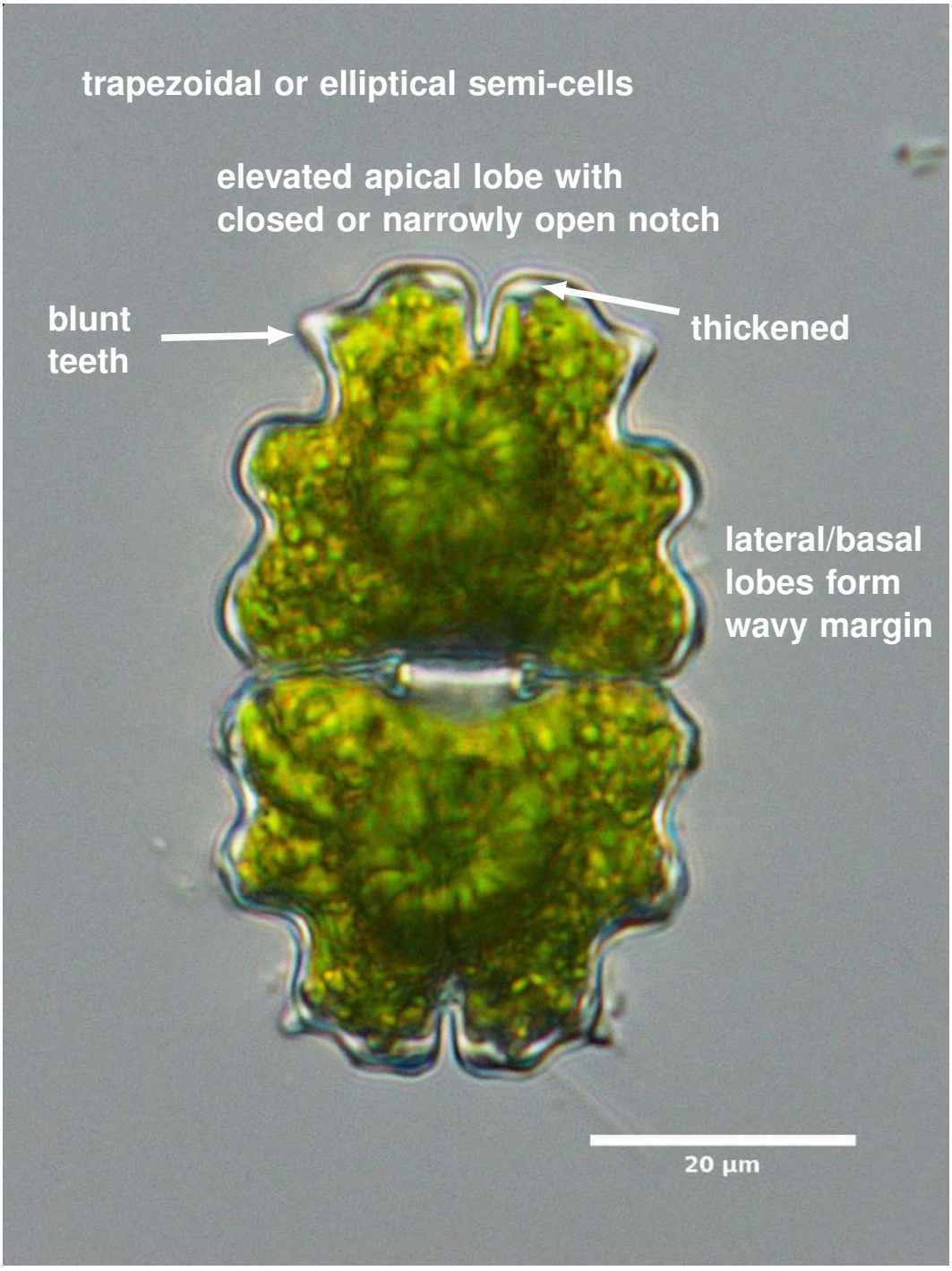


Figure 7.9: *Euastrum bidentatum* (DIC), Coal Lake, Mountain Loop Highway, Snohomish County.

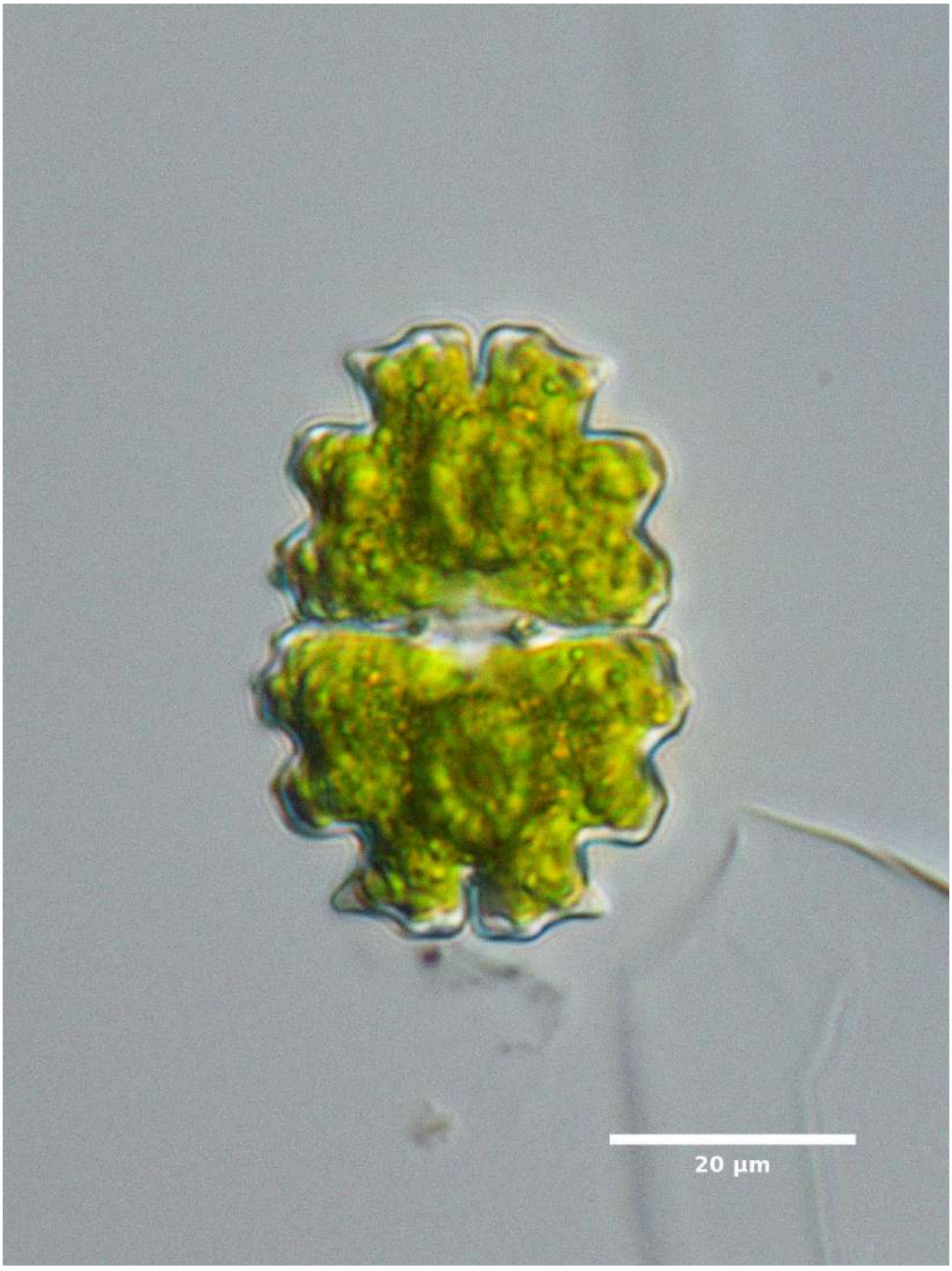
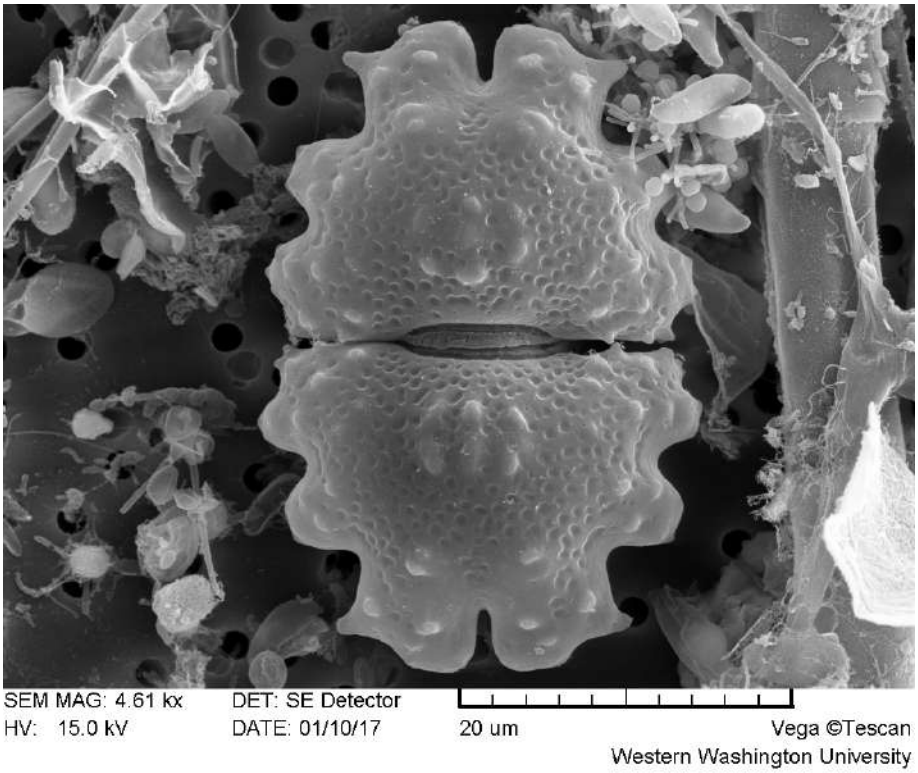


Figure 7.10: *Euastrum bidentatum* (DIC), Lake Twenty-two, Mountain Loop Highway, Snohomish County.



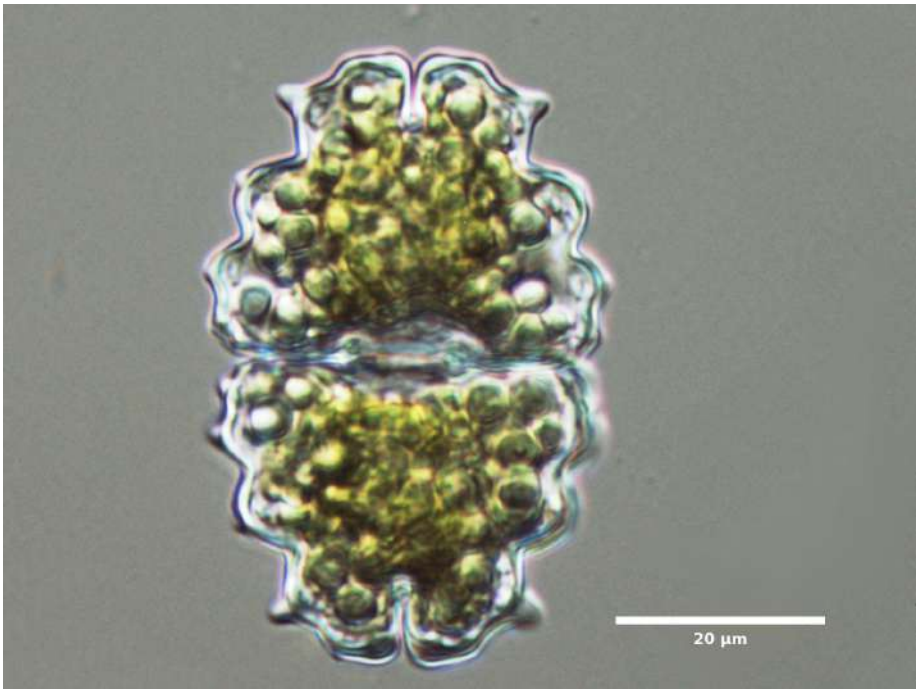


Figure 7.11: *Euastrum bidentatum* var. *speciosum* (SEM/DIC), Picture Lake, Mt. Baker area, Whatcom County (upper/lower images).

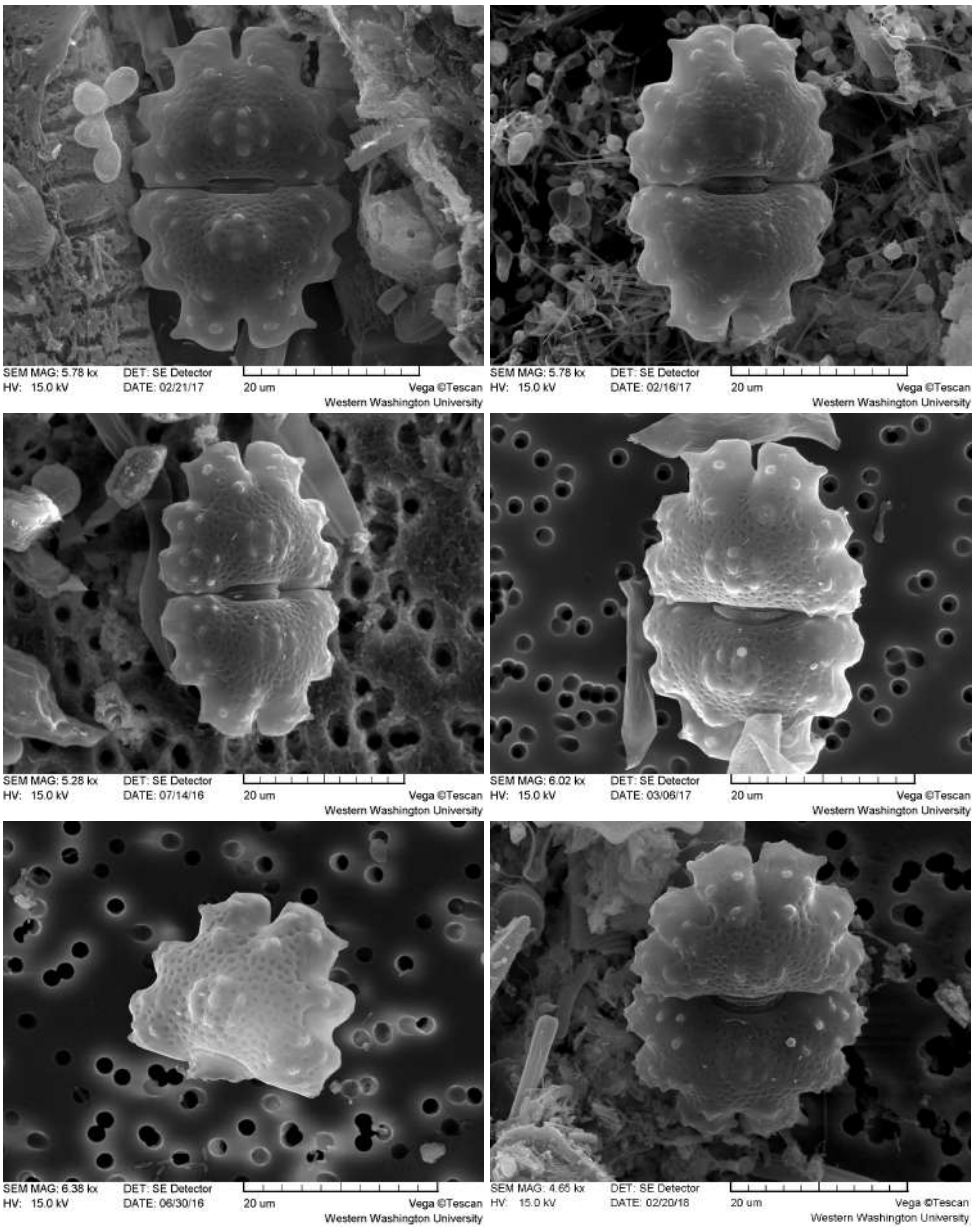


Figure 7.12: *Euastrum bidentatum* var. *speciosum* (SEM), multiple lakes in the Mt. Baker area (Whatcom County) and along the Mountain Loop Highway (Snohomish County).

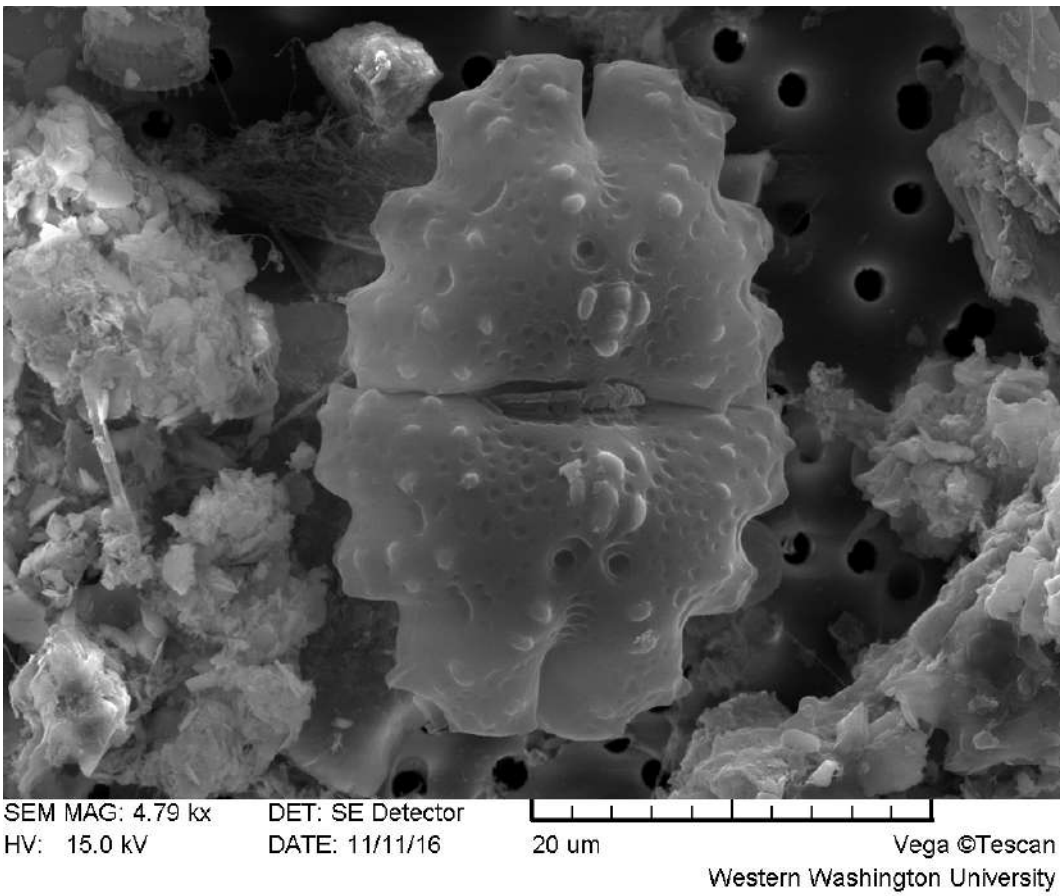


Figure 7.13: *Euastrum bidentatum* var. *oculatum* (SEM), Myrtle Lake, Mountain Loop Highway, Snohomish County.

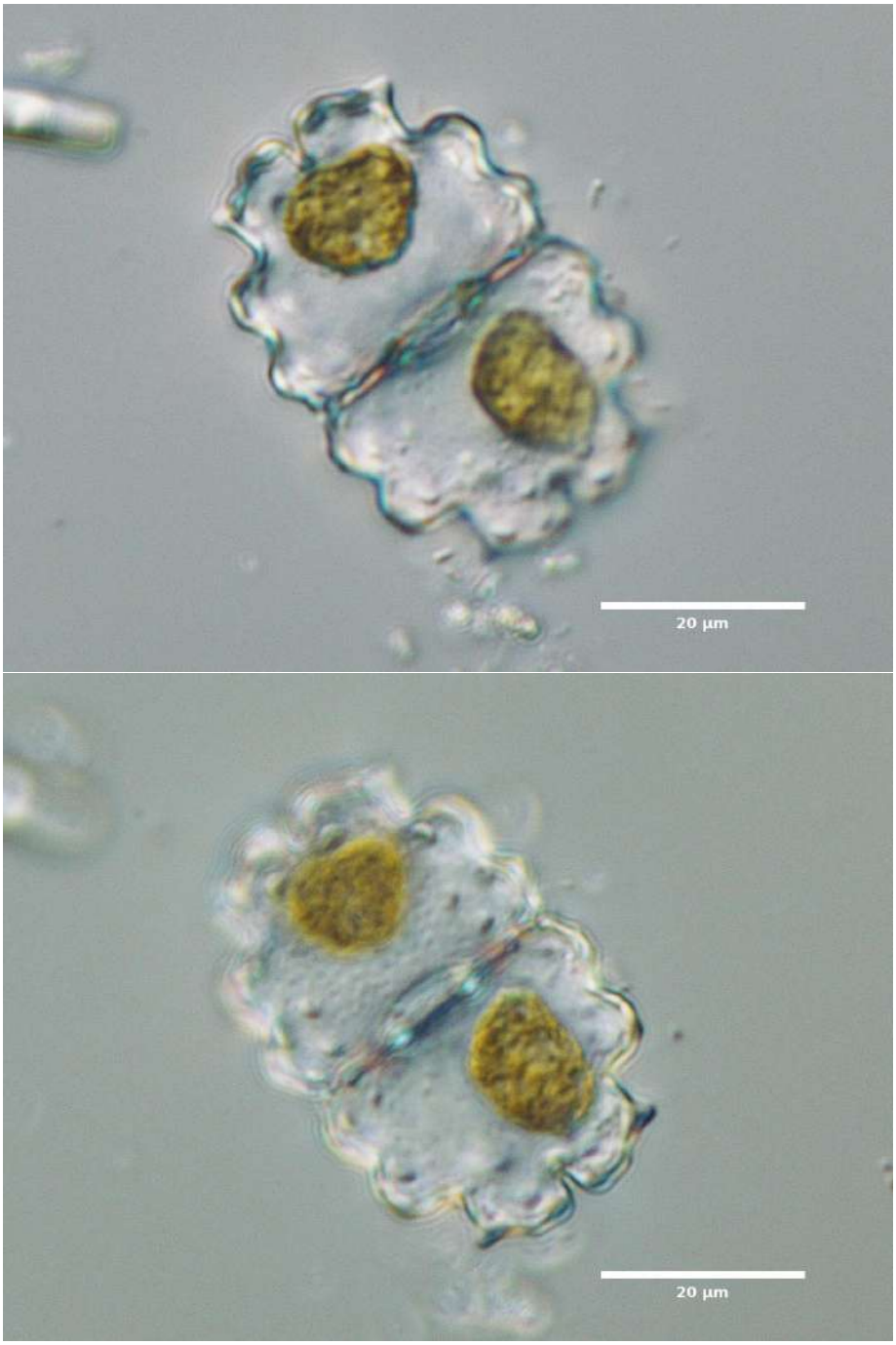


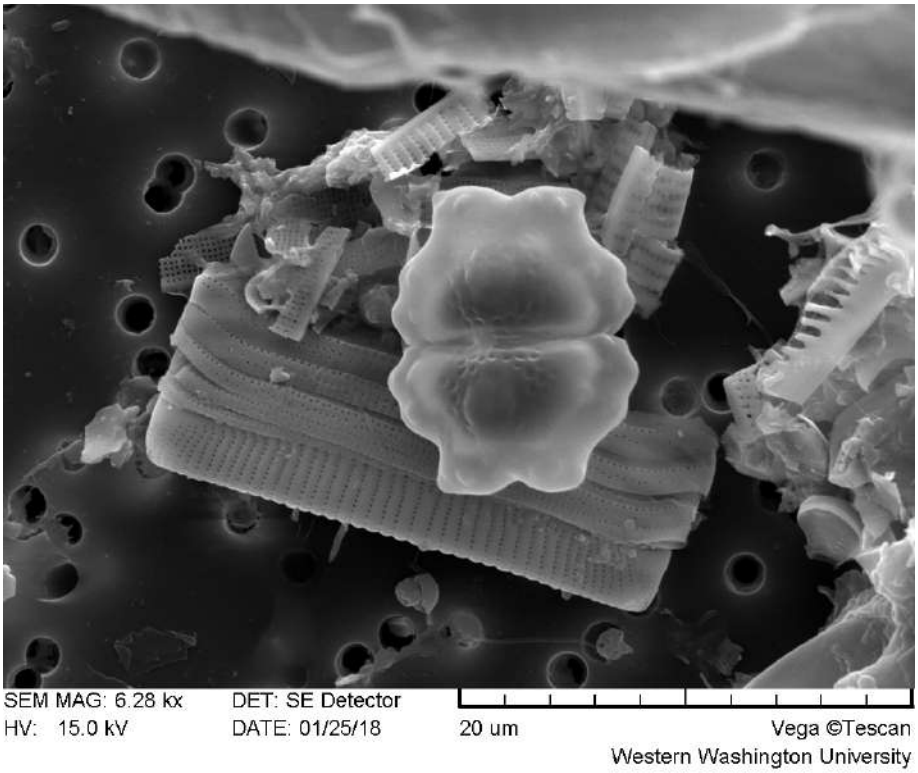
Figure 7.14: *Euastrum* cf. *bidentatum* (DIC/DIC), small pond on trail to Big Four Ice Caves, Mountain Loop Highway, Snohomish County (upper/lower images).



Figure 7.15: *Euastrum* cf. *bidentatum* var. A (DIC), small pond on trail to Big Four Ice Caves, Mountain Loop Highway, Snohomish County.



Figure 7.16: *Euastrum binale* var. *gutwinskii* (DIC), Summer Lake, Skagit County.



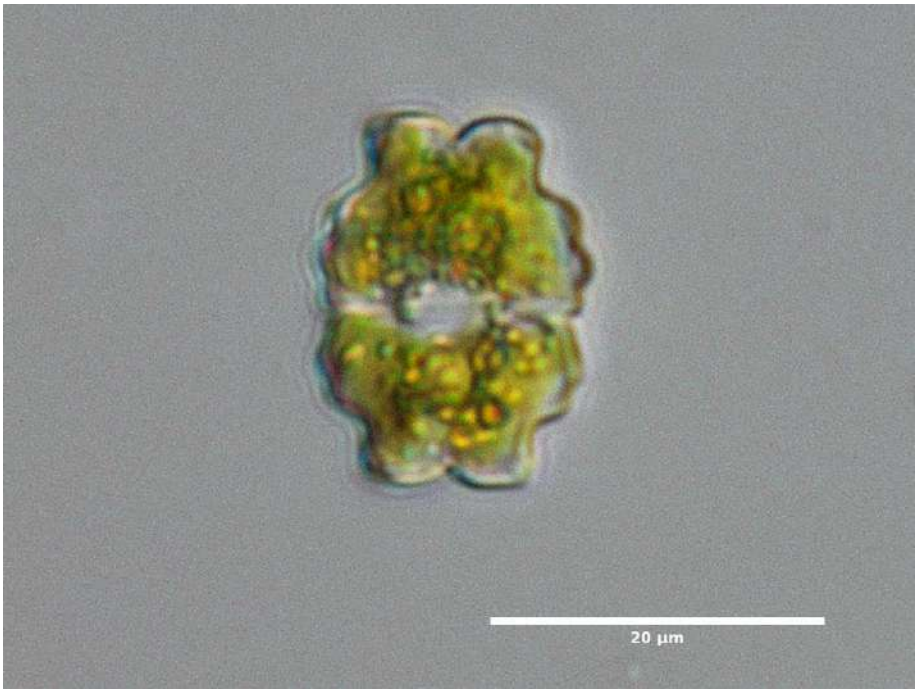


Figure 7.17: *Euastrum binale* var. *gutwinskii* (SEM/DIC), Heather Lake, Mountain Loop Highway, Snohomish County (upper/lower images).

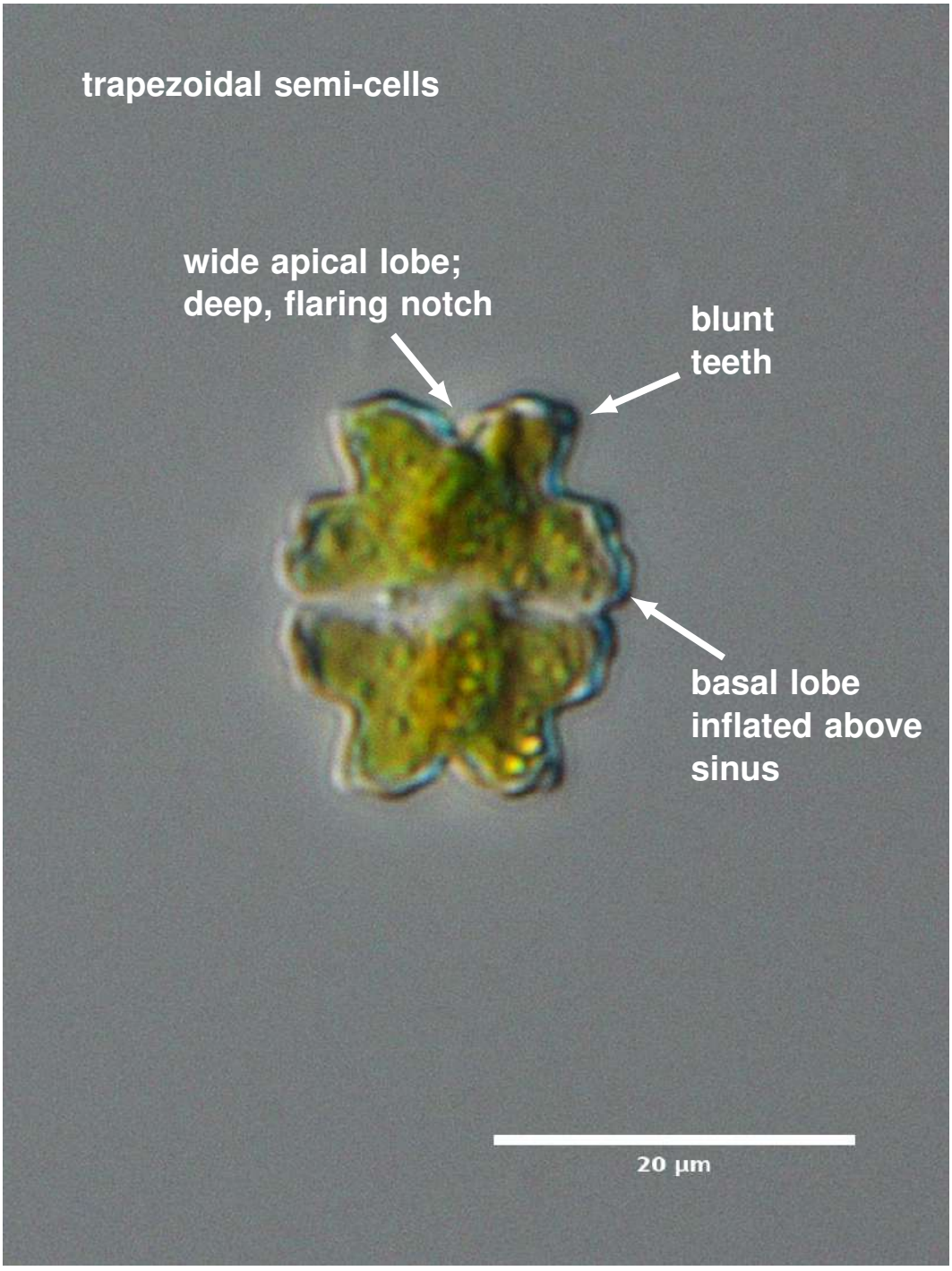


Figure 7.18: *Euastrum binale* var. *papilliferum* (DIC), Lake Ann, Mt. Baker area, Whatcom County.

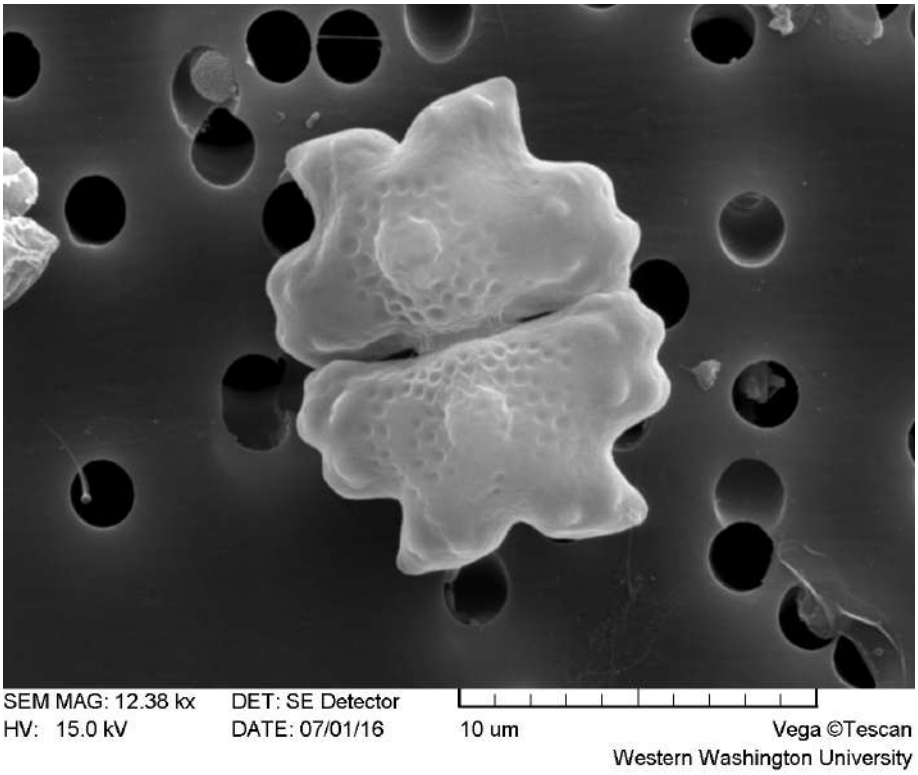




Figure 7.19: *Euastrum binale* var. *papilliferum* (SEM/DIC), Lake Twenty-two, Mountain Loop Highway, Snohomish County (upper/lower images).

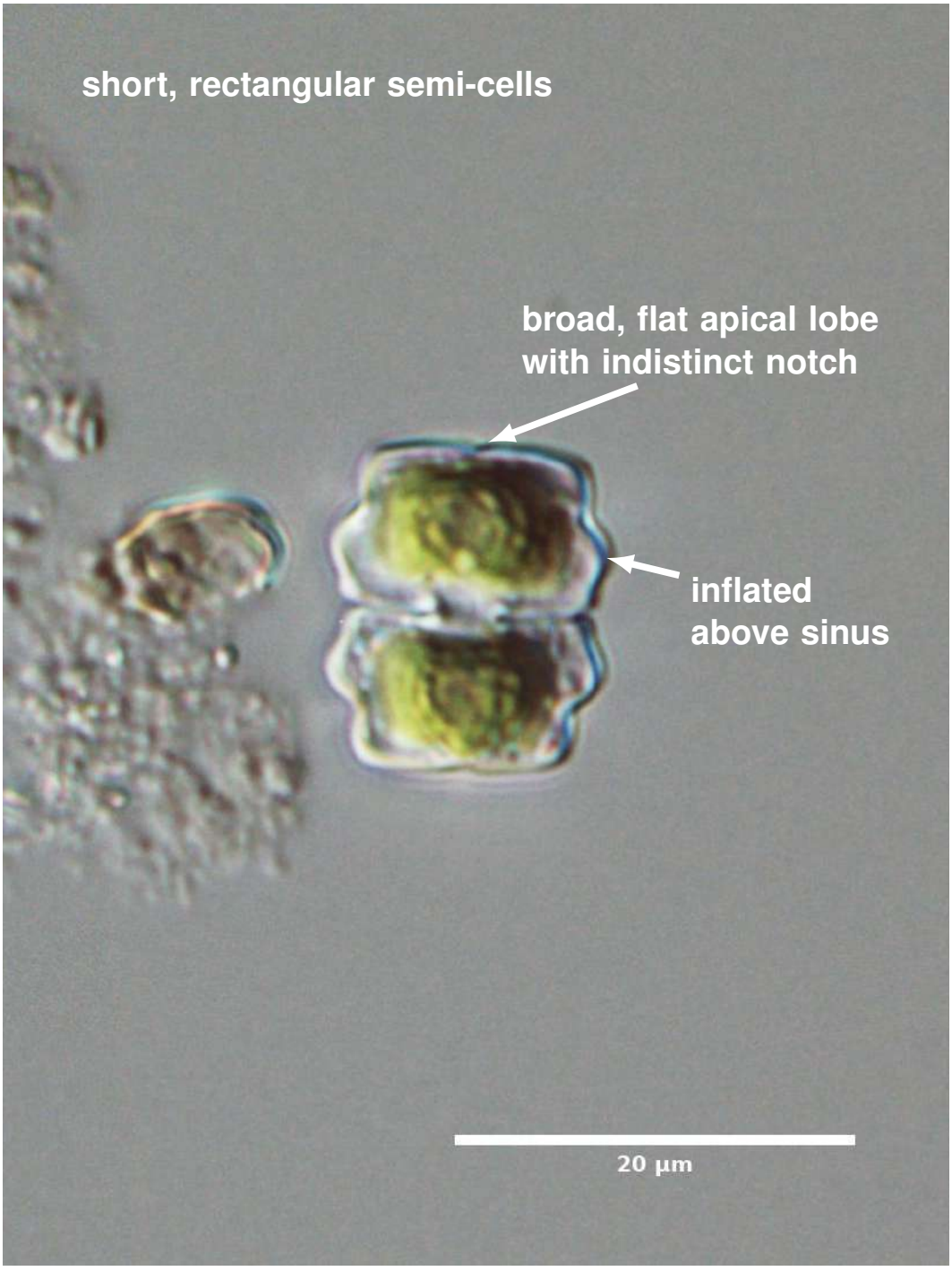
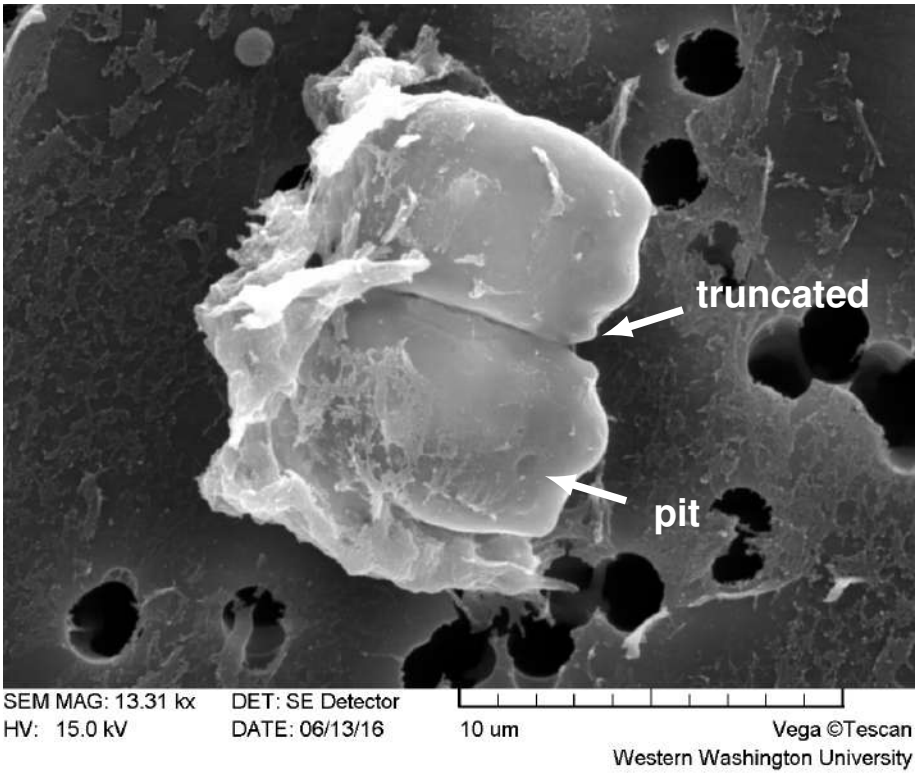


Figure 7.20: *Euastrum coeselii* (DIC), Sunday Lake, Snohomish County.



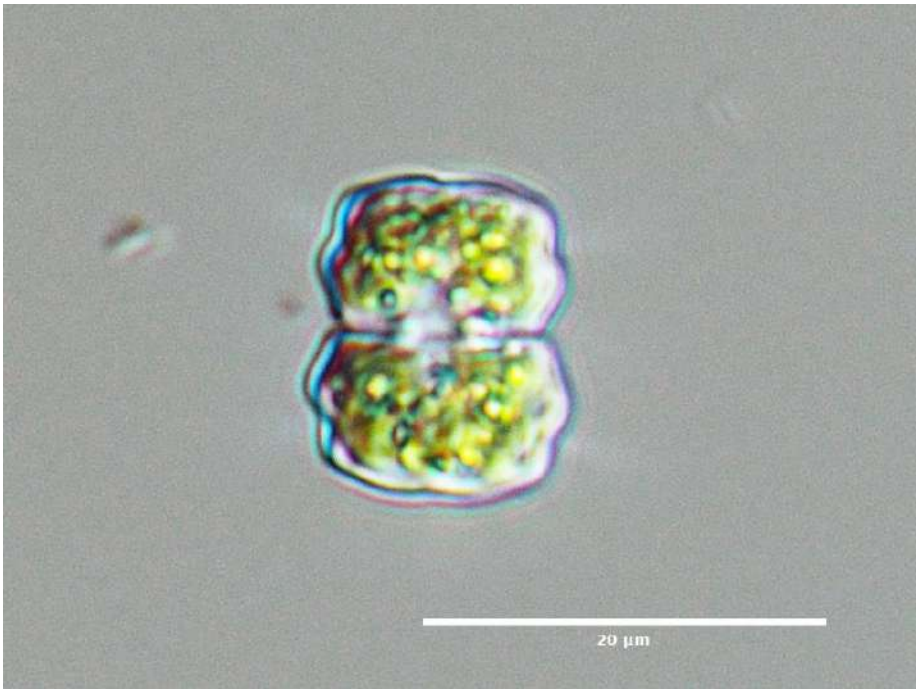


Figure 7.21: *Euastrum coeselii* (SEM/DIC), Myrtle Lake, Mountain Loop Highway, Snohomish County (upper/lower images).

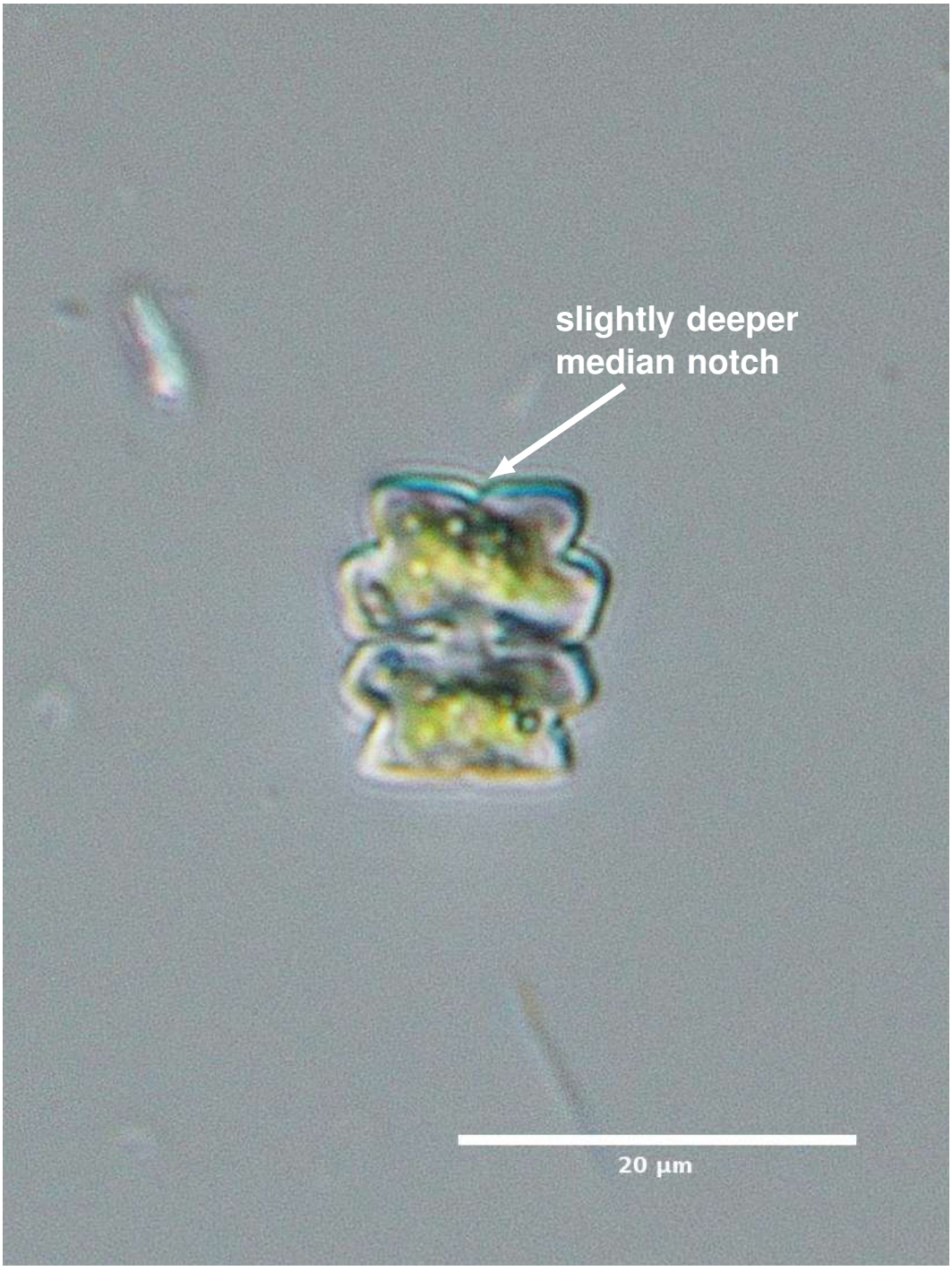


Figure 7.22: *Euastrum coeselii* var. A (DIC), small boggy pond along Morris Valley Road near Harrison, BC.

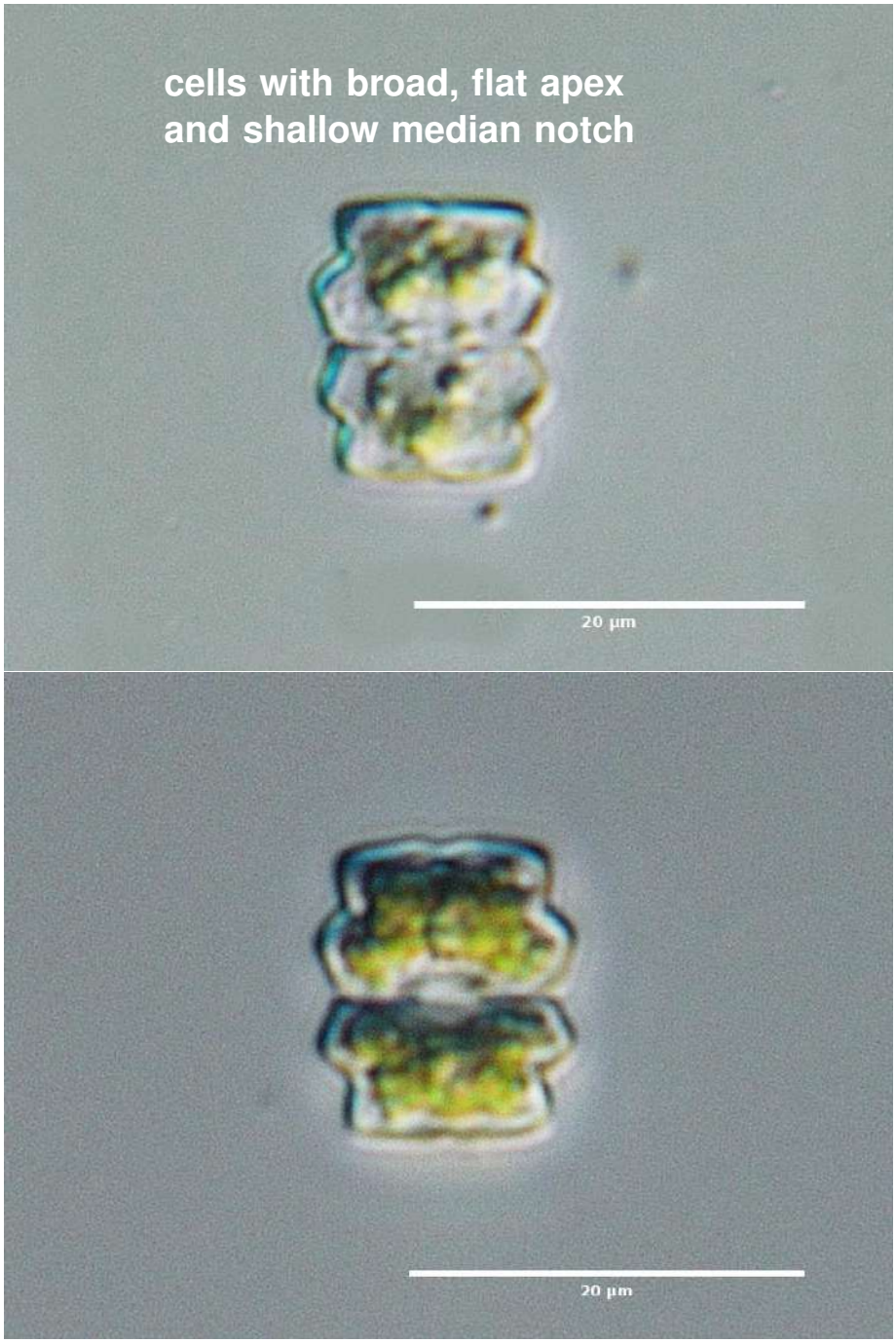


Figure 7.23: *Euastrum coeselii* var. A (DIC/DIC), small boggy pond along Morris Valley Road near Harrison, BC (upper/lower images).

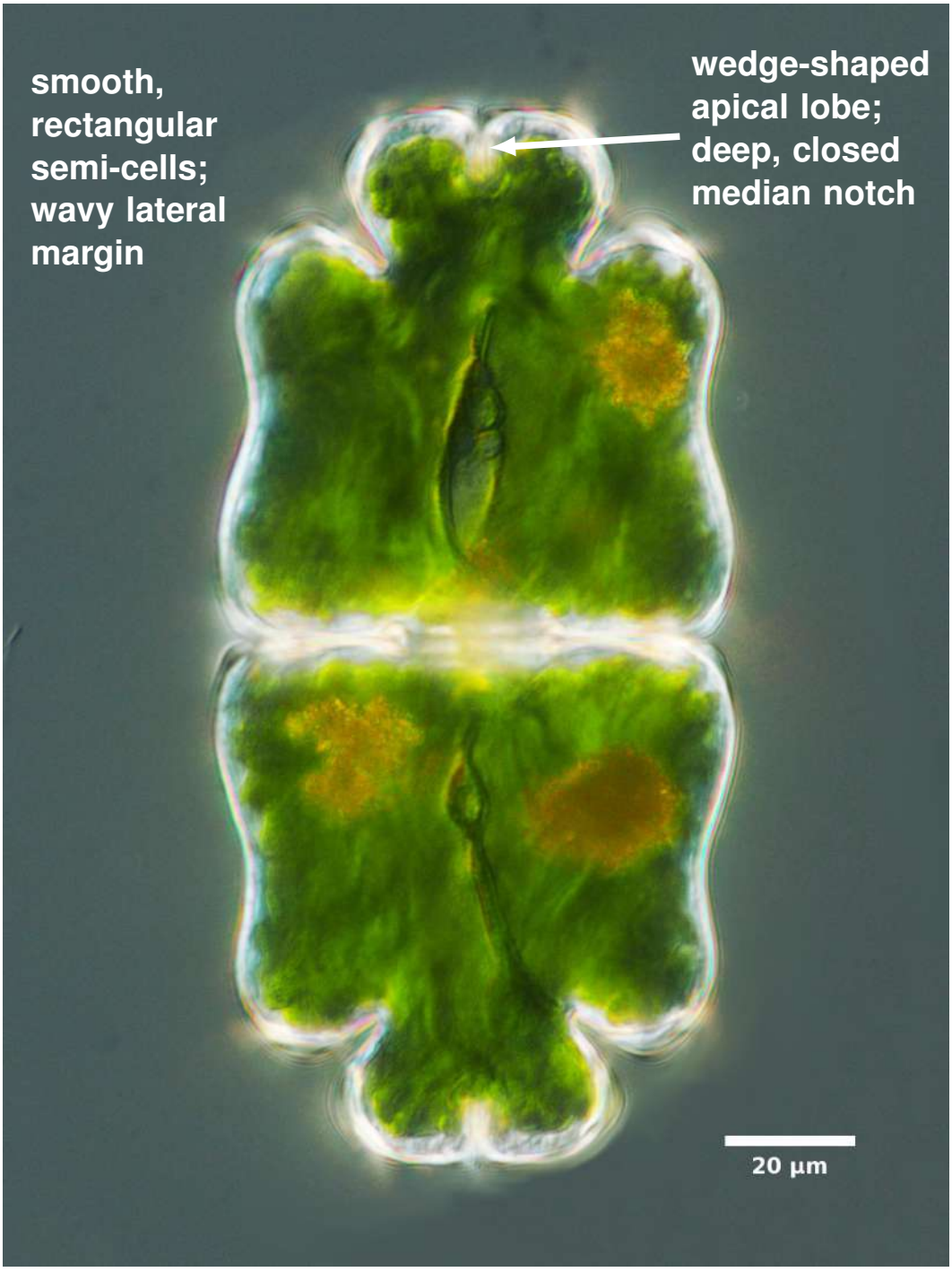


Figure 7.24: *Euastrum crassum* specimen with closed sinus (DIC), Bear Lake, Mountain Loop Highway, Snohomish County.



Figure 7.25: *Euastrum crassum* (DIC) specimen with partly open sinus, small pond near Canyon Lake, Whatcom County.

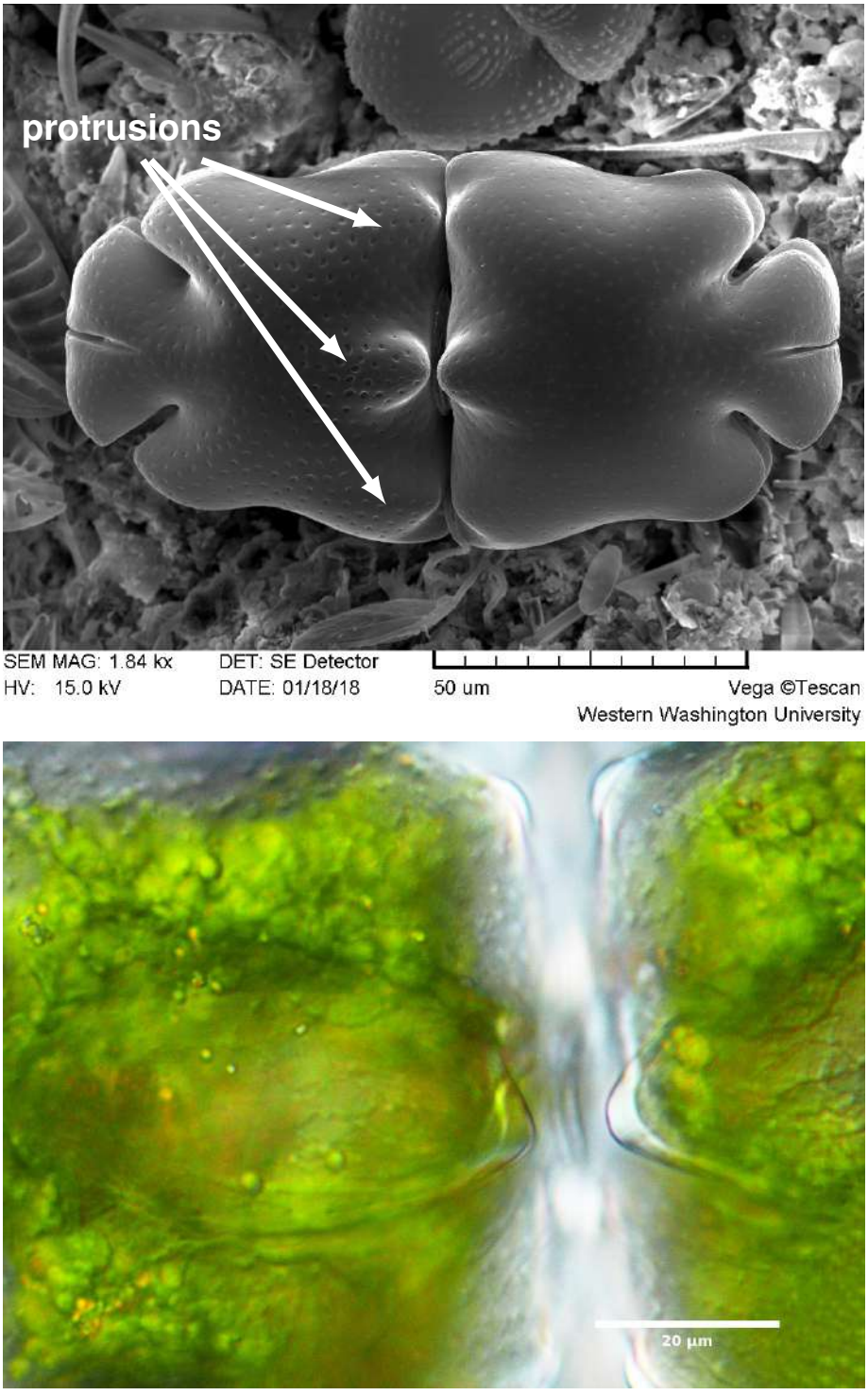


Figure 7.26: *Euastrum crassum* (SEM/DIC), Highwood Lake, Mt. Baker Area, Whatcom County (upper image); small pond near Canyon Lake, Whatcom County (lower image).

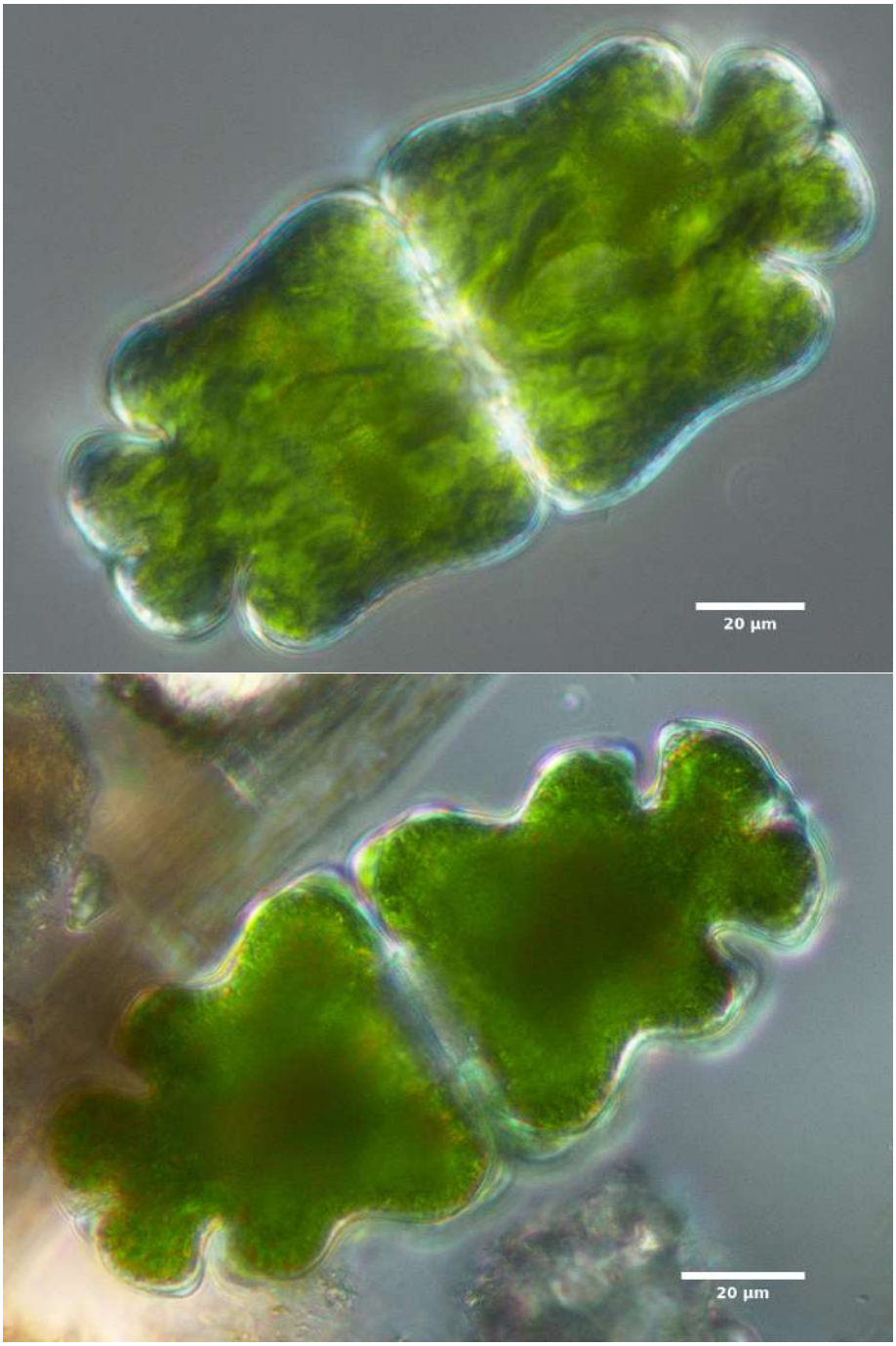


Figure 7.27: *Euastrum crassum* semi-cell variations in specimens collected on the same date (DIC/DIC), Boardman Lake, Mountain Loop Highway, Snohomish County (upper/lower images).

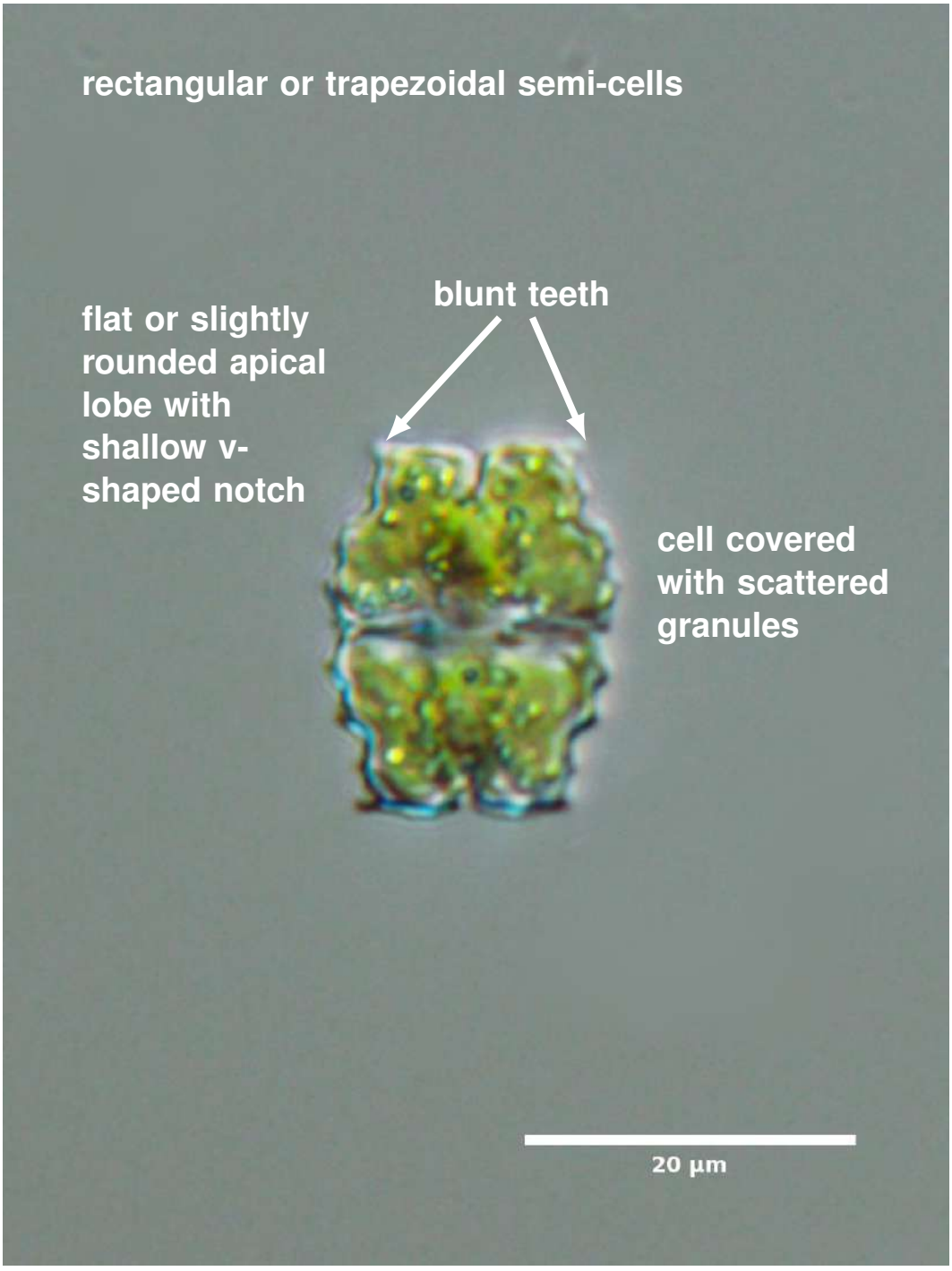


Figure 7.28: *Euastrum denticulatum* (DIC), Sunday Lake, Snohomish County.

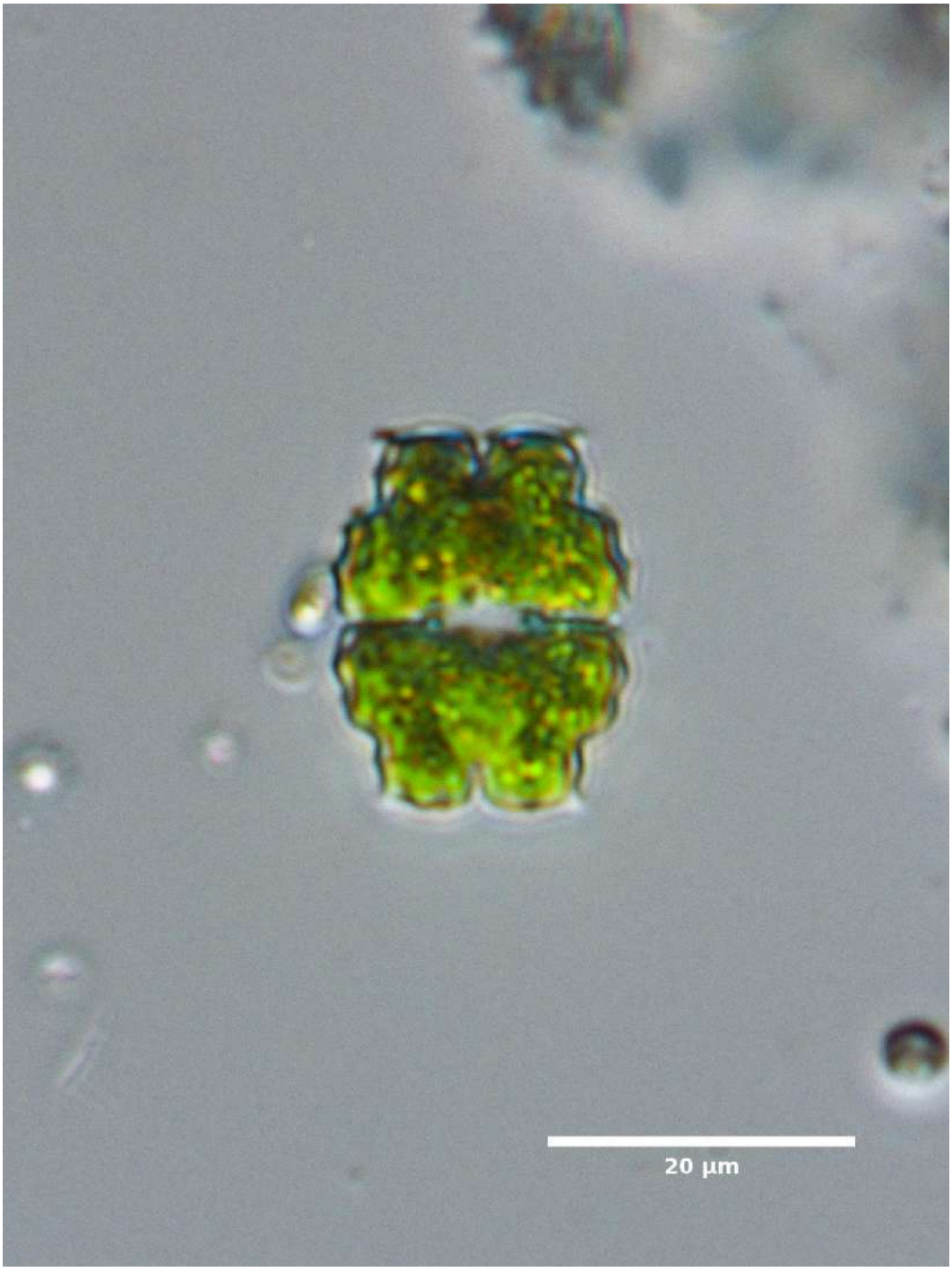


Figure 7.29: *Euastrum denticulatum* (DIC), small residential pond on Valley Circle Drive, Snohomish County.

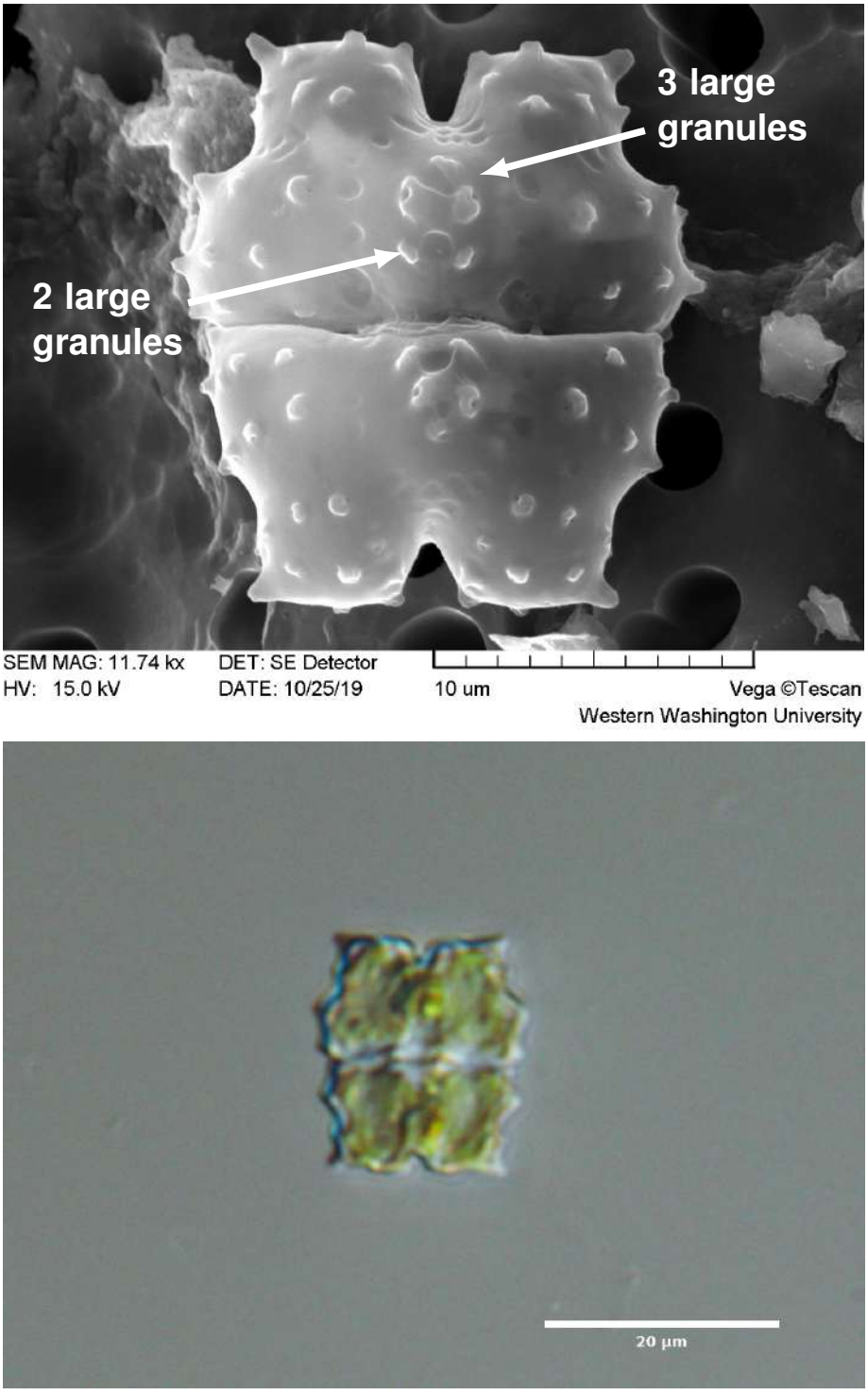


Figure 7.30: *Euastrum denticulatum* (SEM/DIC), Clear Lake, Skagit County (upper image); small pond near Lynnwood, Snohomish County (lower image).

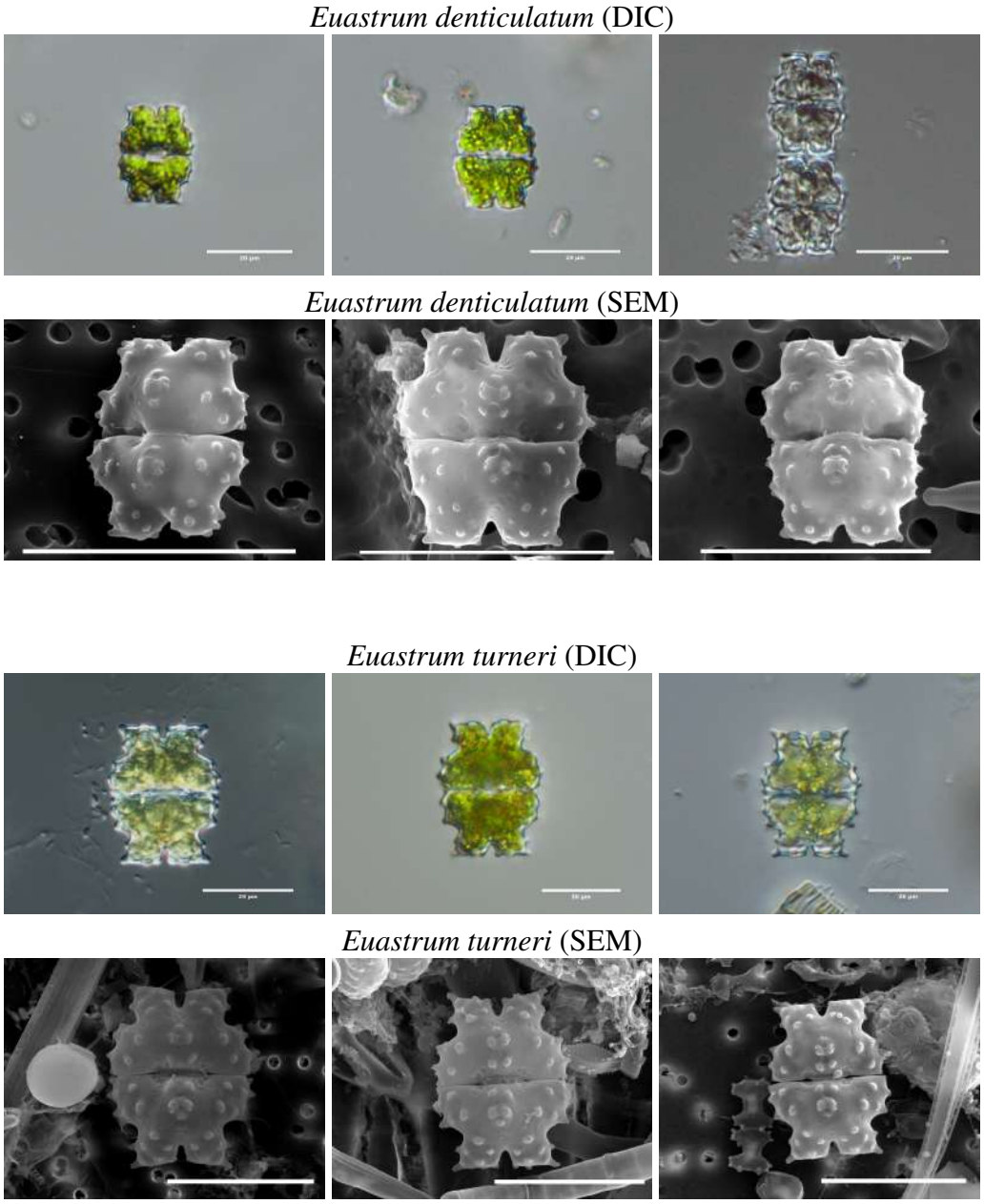


Figure 7.31: Examples of *Euastrum denticulatum* and *Euastrum turneri*. Note difference in cell size (white bars = 20 μm).

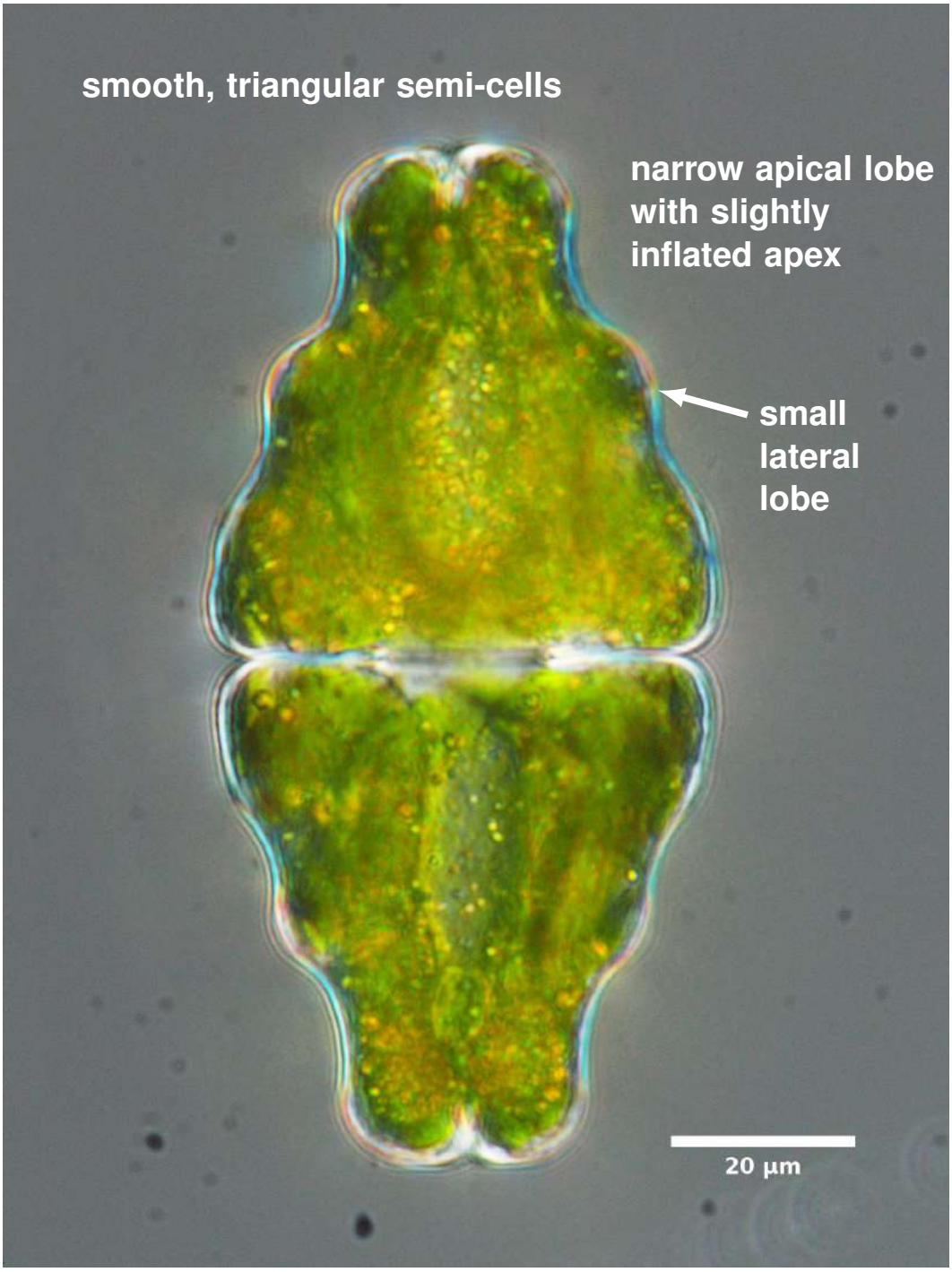


Figure 7.32: *Euastrum didelta* (DIC), Heather Meadows Pond, Mt. Baker area, Whatcom County.

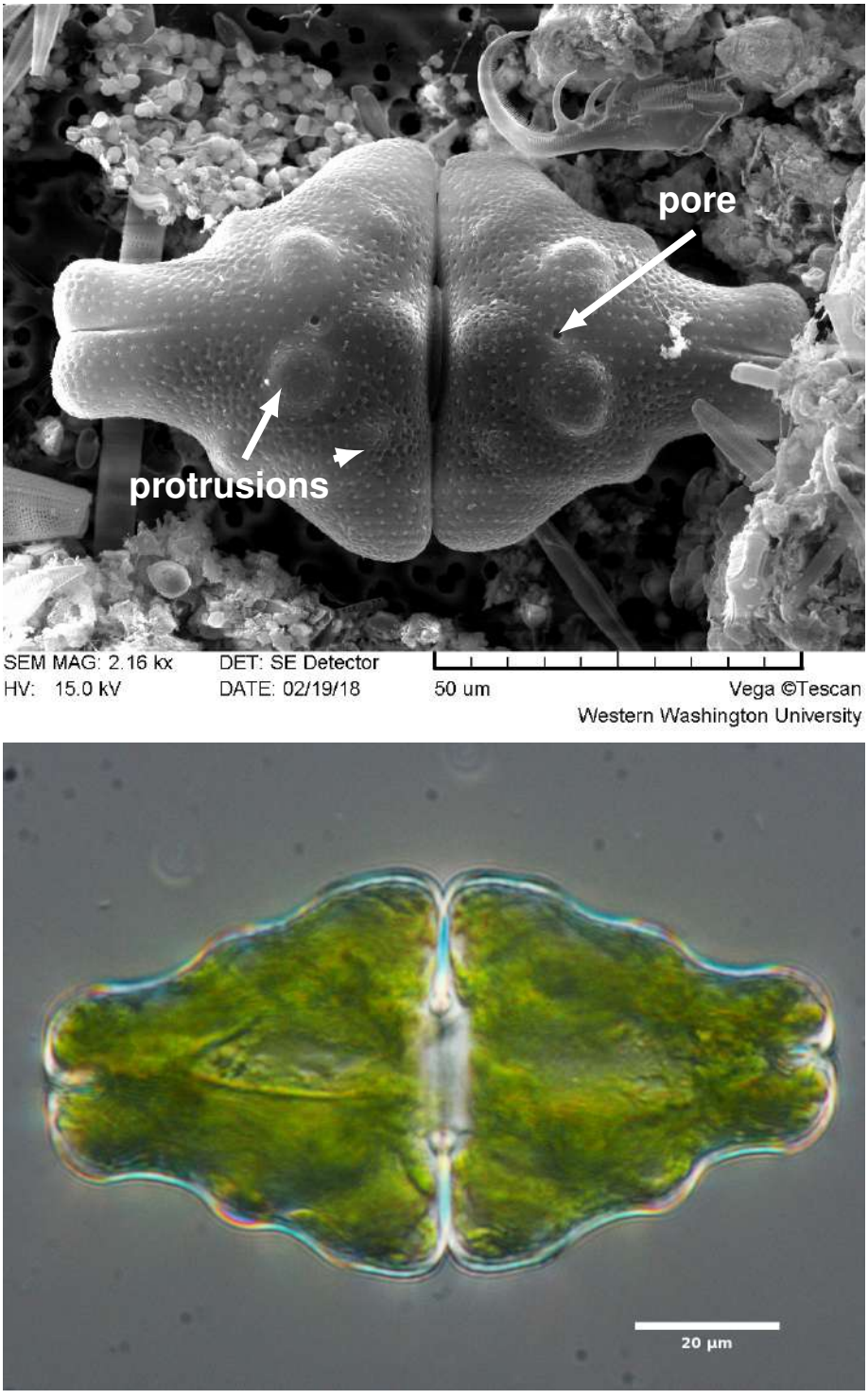


Figure 7.33: *Euastrum didelta* (SEM/DIC), Highwood Lake, Mt. Baker area, Whatcom County (upper image); Heather Meadows Pond, Mt. Baker area, Whatcom County (lower image).

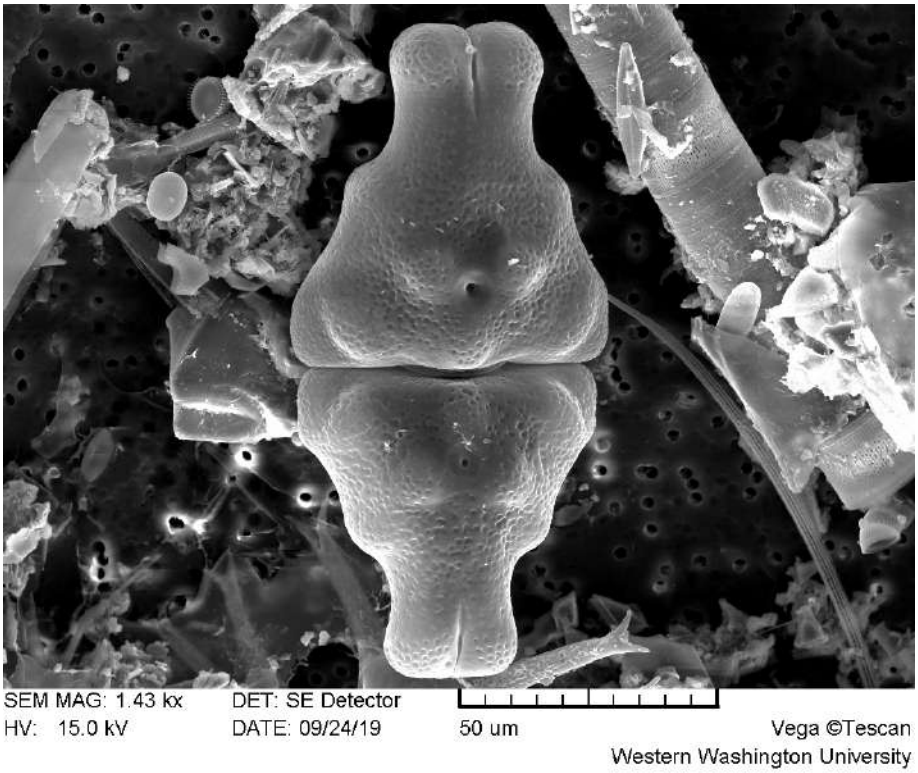




Figure 7.34: *Euastrum didelta* (SEM/DIC), Chain Lake, Gifford Pinchot National Forest, Skamania County (upper/lower images).



Figure 7.35: *Euastrum dubium* var. *ornatum* (DIC), small residential pond, Skagit County.



Figure 7.36: *Euastrum dubium* var. *ornatum* (DIC), small residential pond, Skagit County.

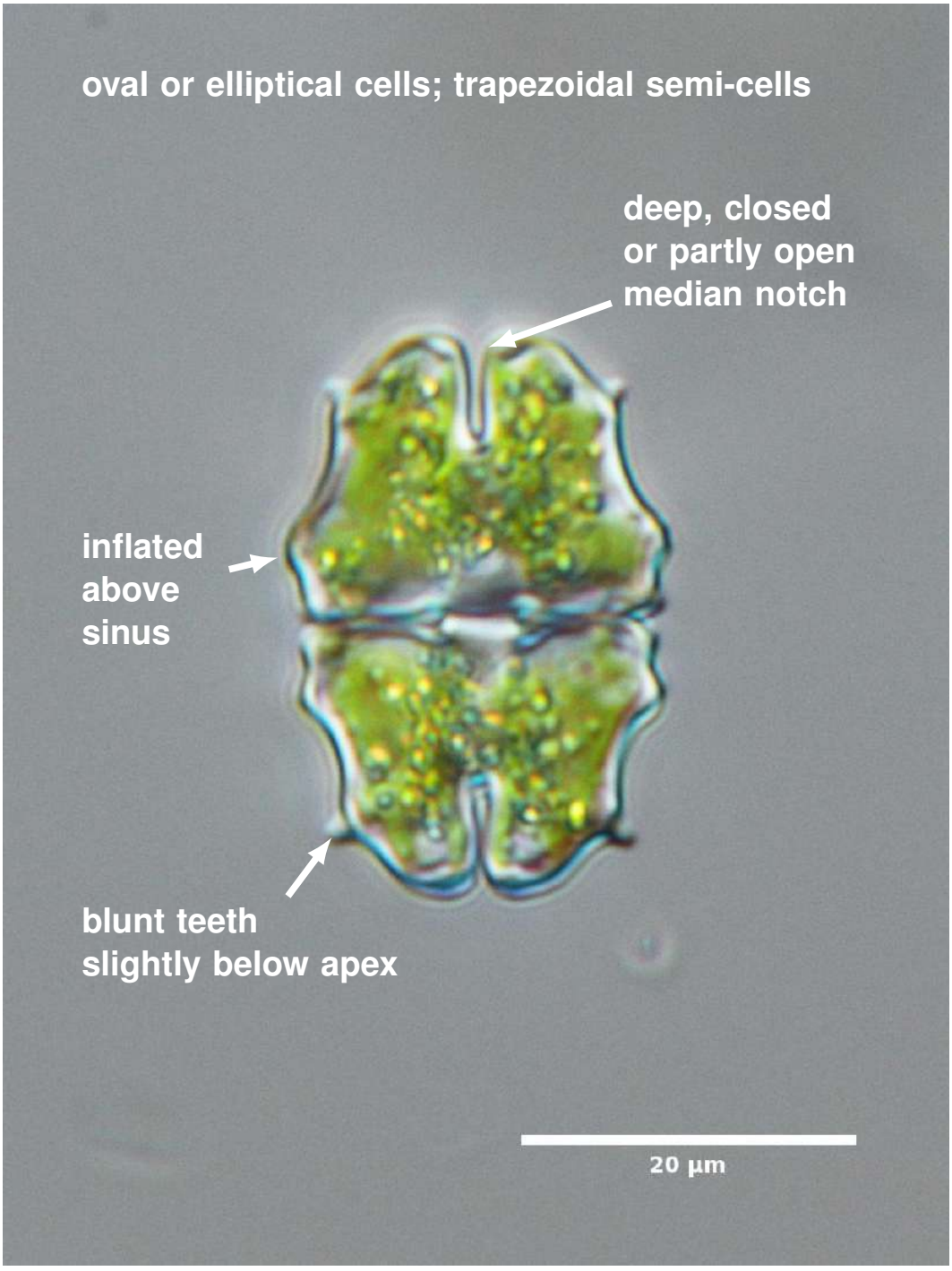


Figure 7.37: *Euastrum elegans* (DIC), Blue Lake on trail to Dock Butte, Mt. Baker area, Skagit County.

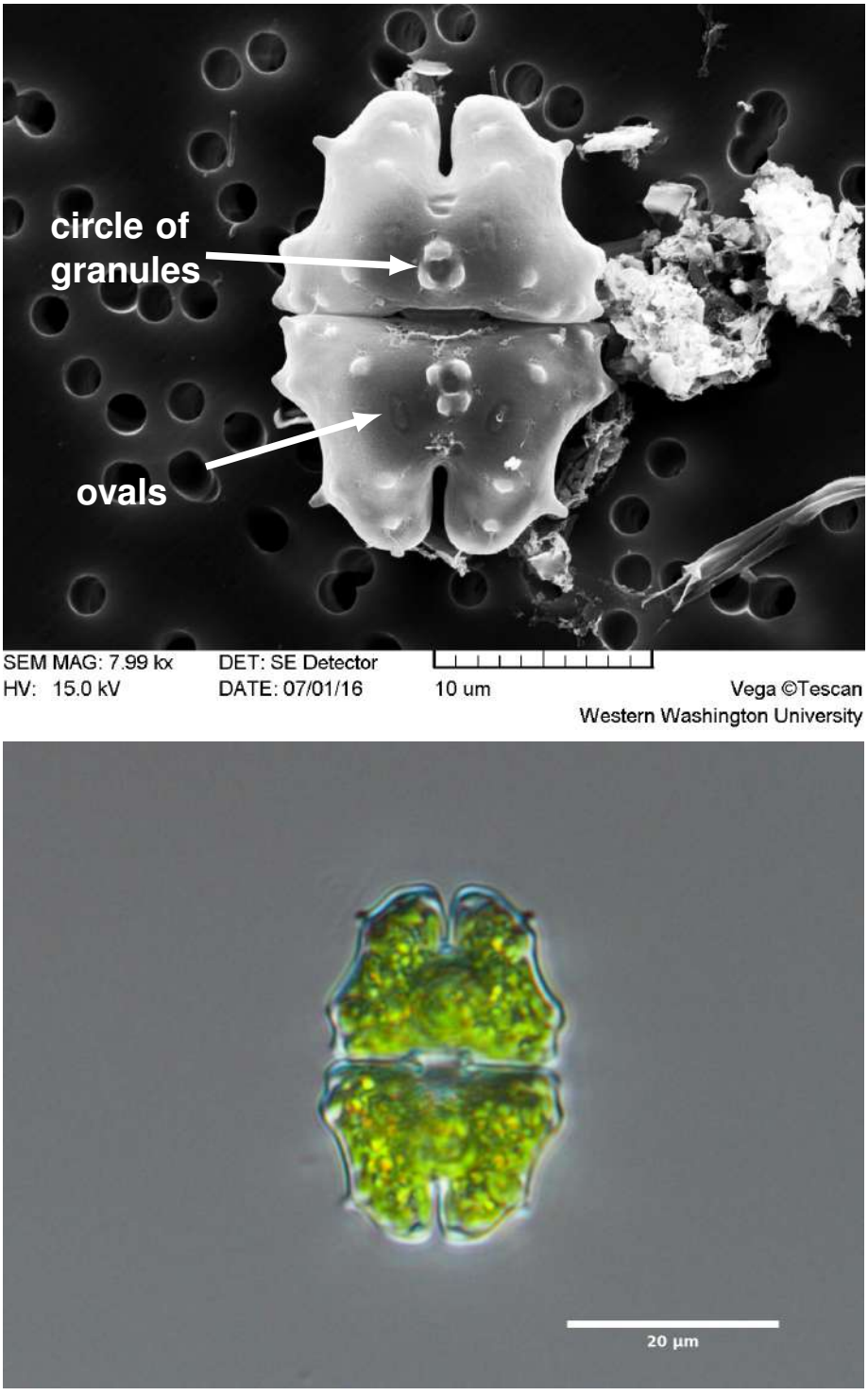
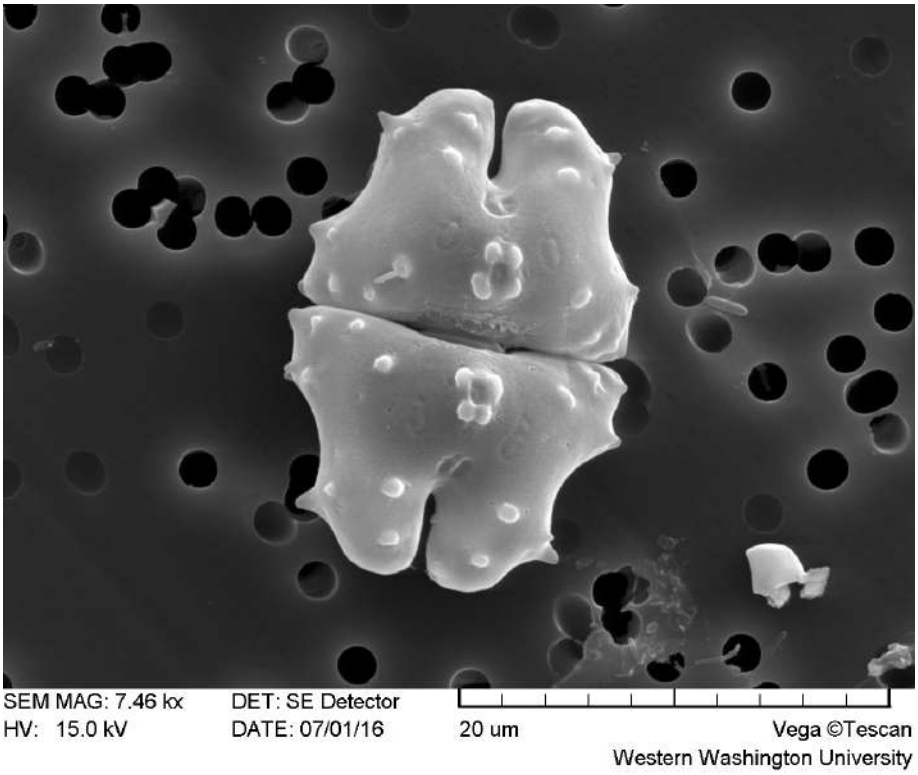


Figure 7.38: *Euastrum elegans* (SEM/DIC), Goat Lake, Mountain Loop Highway, Snohomish County (upper image); Lake Twenty-two, Mountain Loop Highway, Snohomish County (lower image).



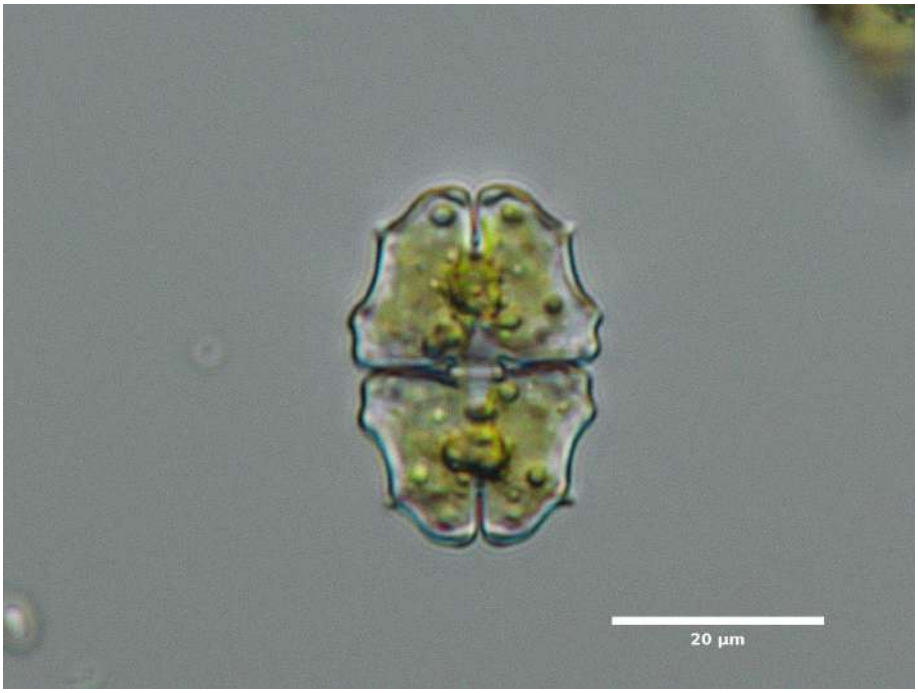


Figure 7.39: *Euastrum elegans* (SEM/DIC), Goat Lake, Mountain Loop Highway, Snohomish County (upper image); Lower Anderson Lake, Mt. Baker area, Whatcom County (lower image).

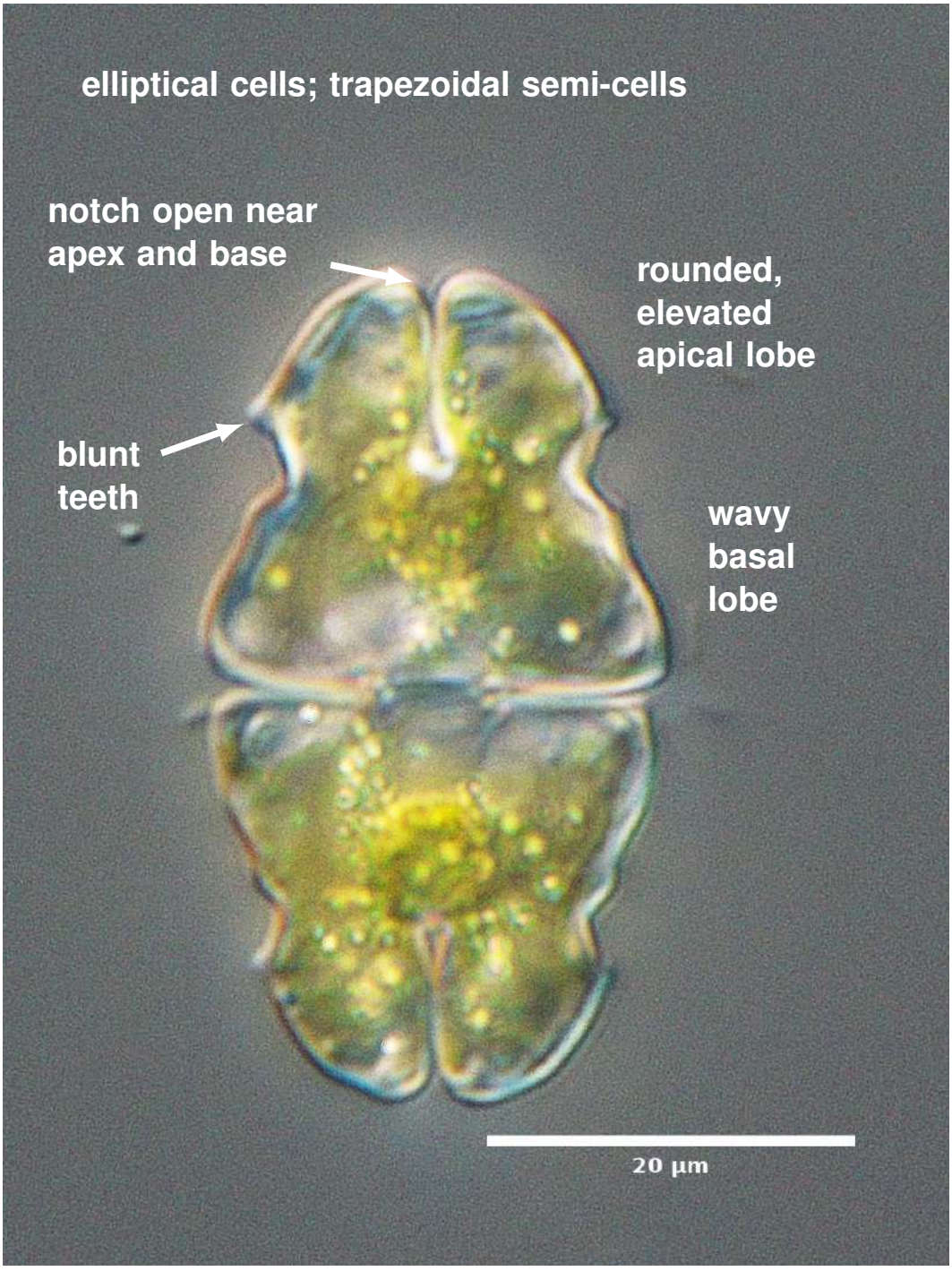


Figure 7.40: *Euastrum fissum* (DIC), Takhlakh Lake, Gifford Pinchot National Forest, Skamania County.

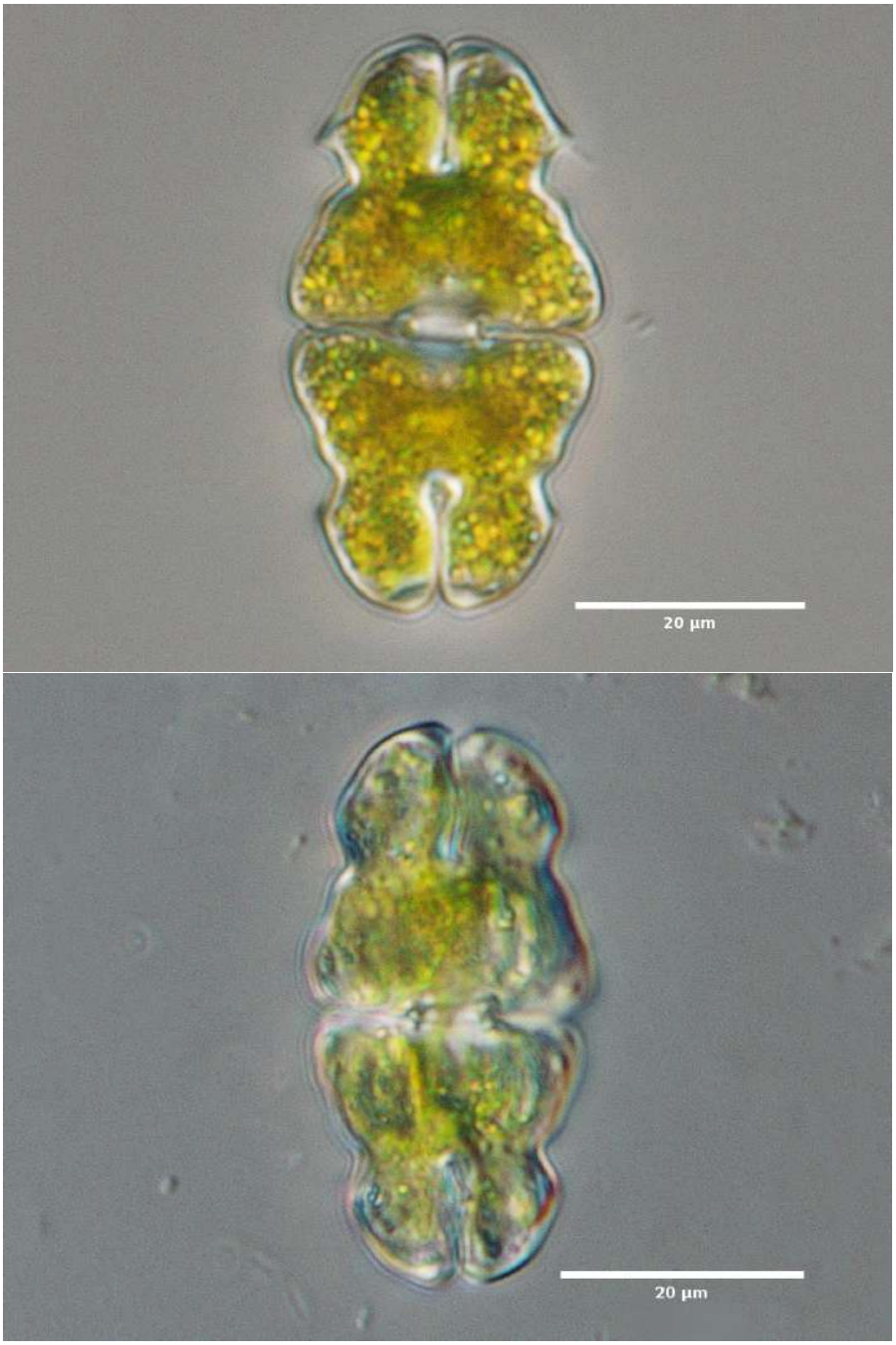


Figure 7.41: *Euastrum fissum* examples of cells with and without marginal teeth (DIC/DIC), Takhlakh Lake, Gifford Pinchot National Forest, Skamania County (upper/lower images).

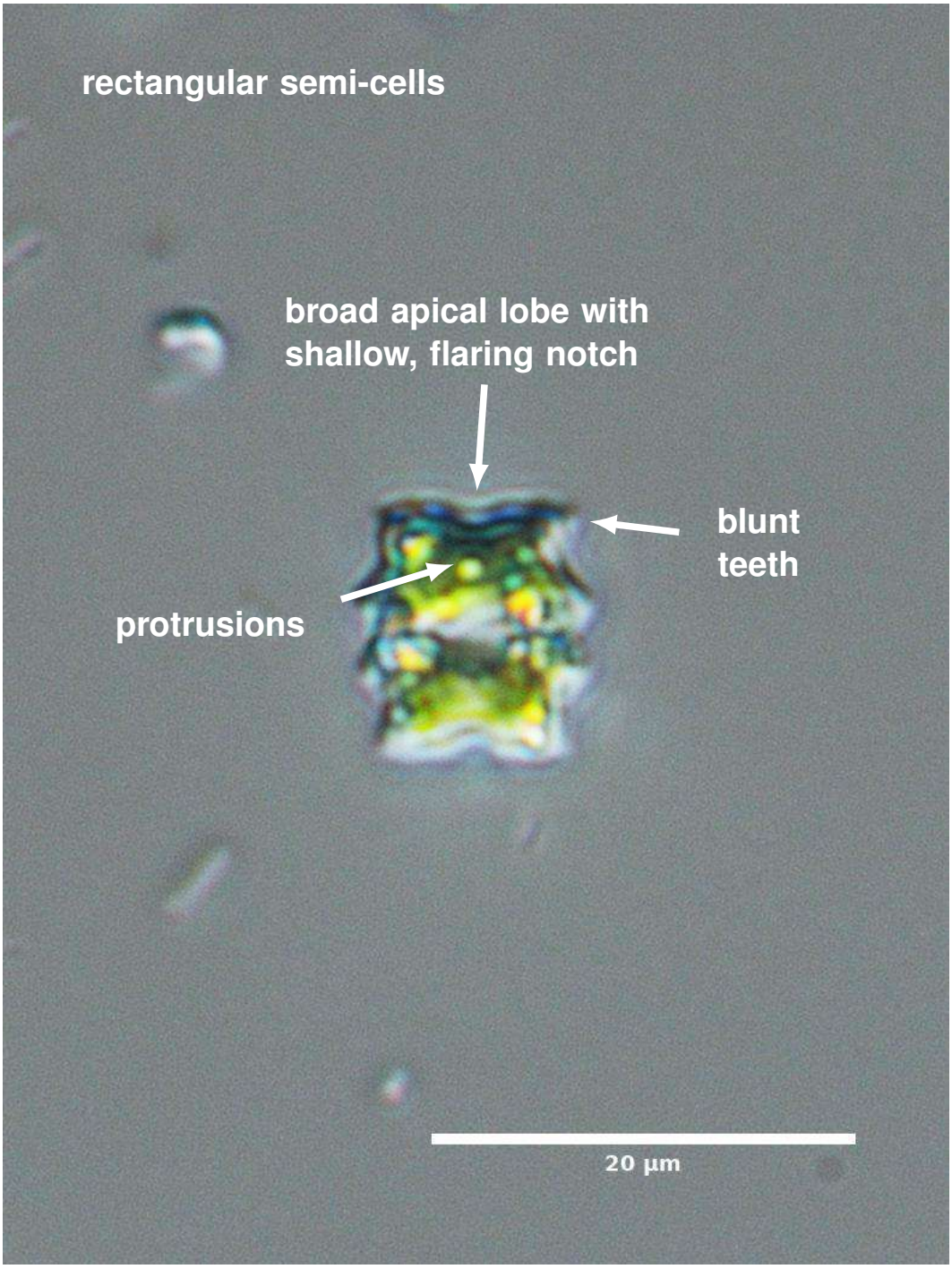


Figure 7.42: *Euastrum gayanum* (DIC), Myrtle Lake, Mountain Loop Highway, Snohomish County.



Figure 7.43: *Euastrum gayanum* (DIC), Lake Evan, Mountain Loop Highway, Snohomish County.

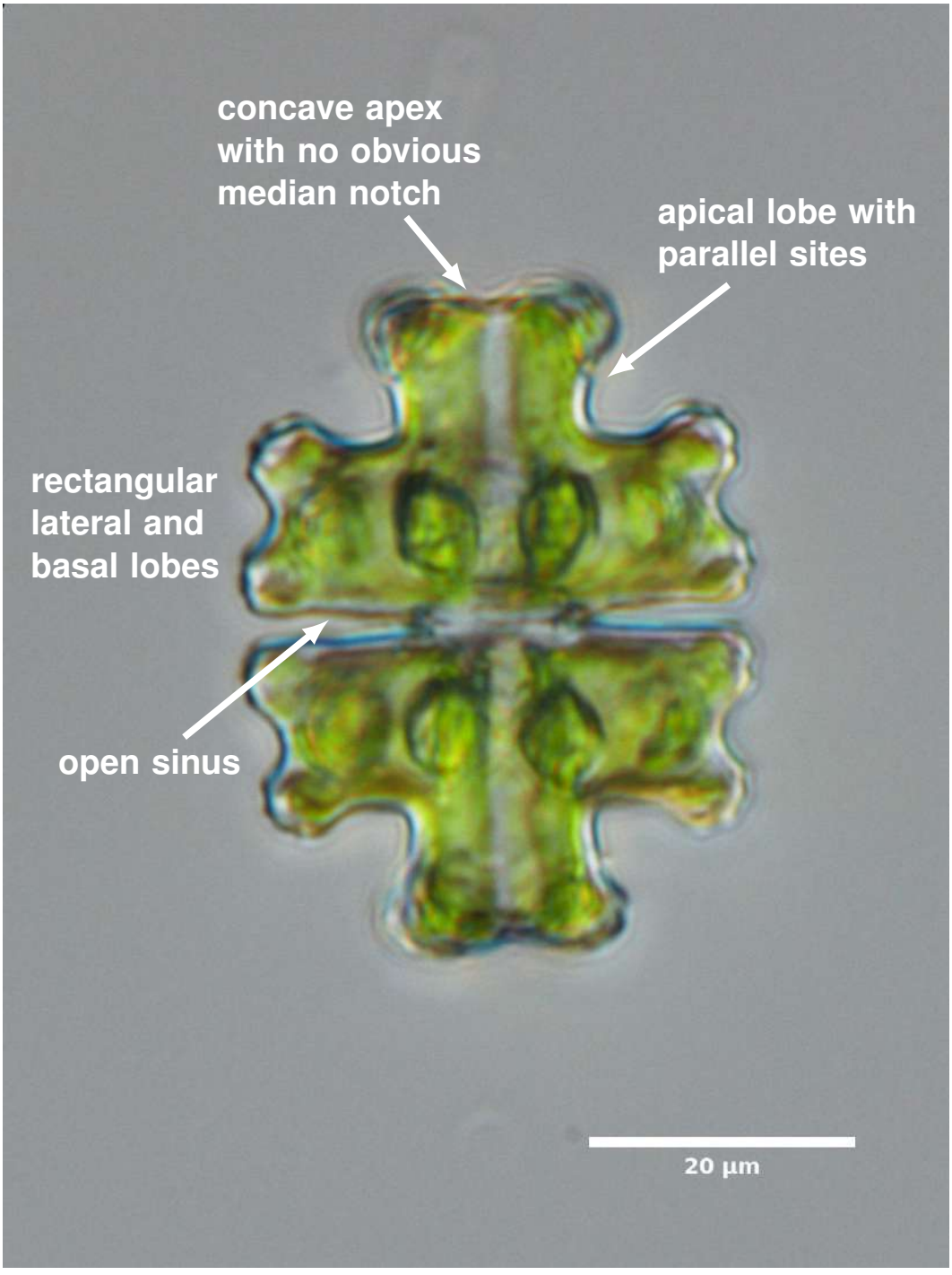


Figure 7.44: *Euastrum gemmatum* var. *taftii* (DIC), Myrtle Lake, Mountain Loop Highway, Snohomish County.

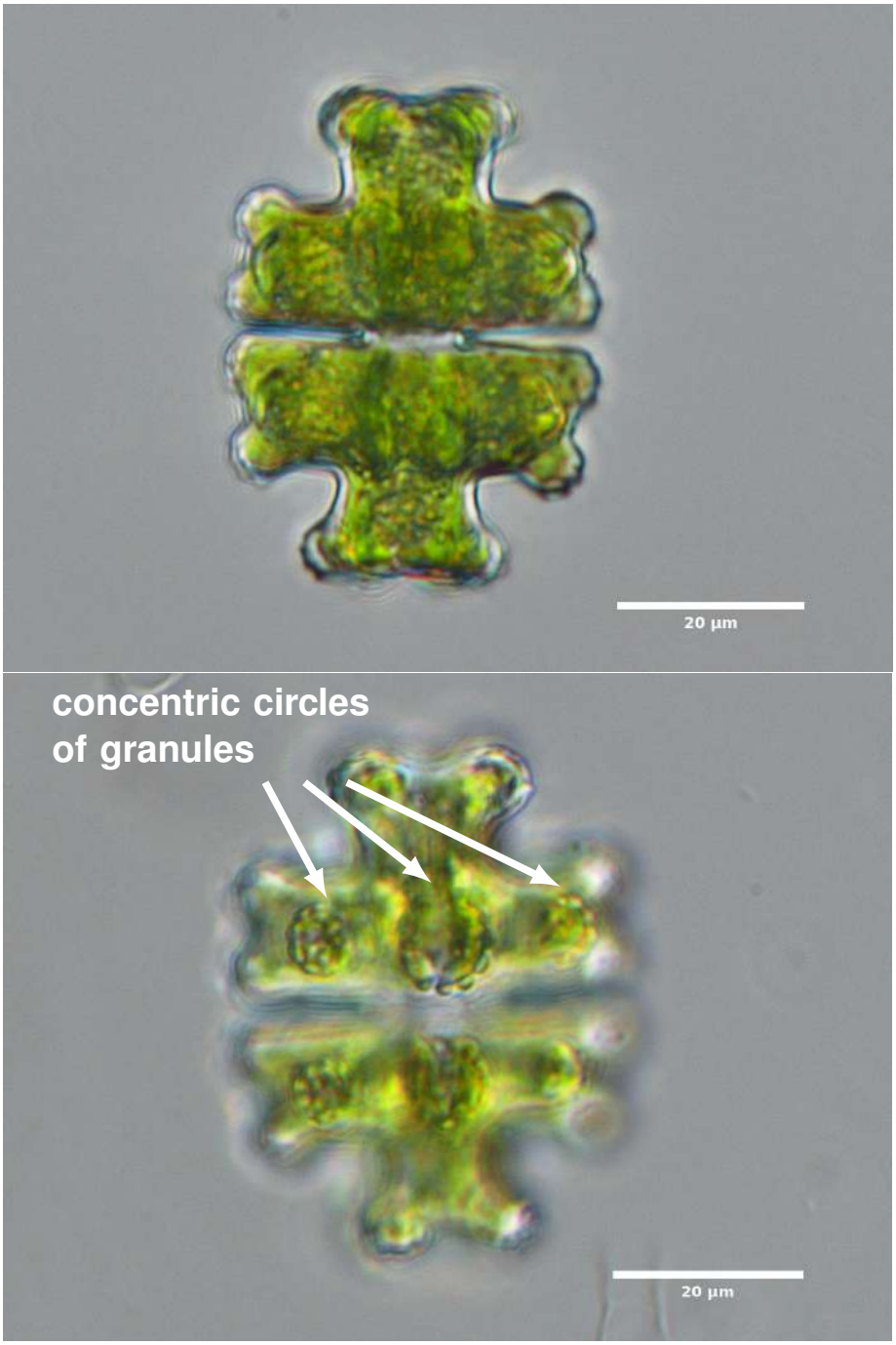
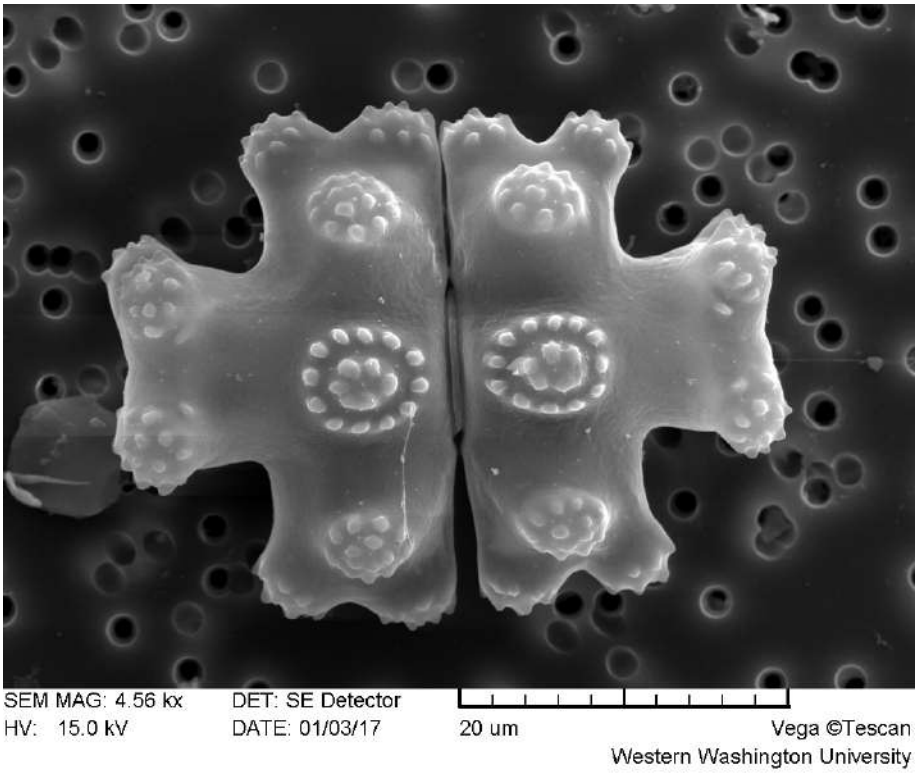


Figure 7.45: *Euastrum gemmatum* var. *taftii* (DIC/DIC), Myrtle Lake, Mountain Loop Highway, Snohomish County (upper/lower images).



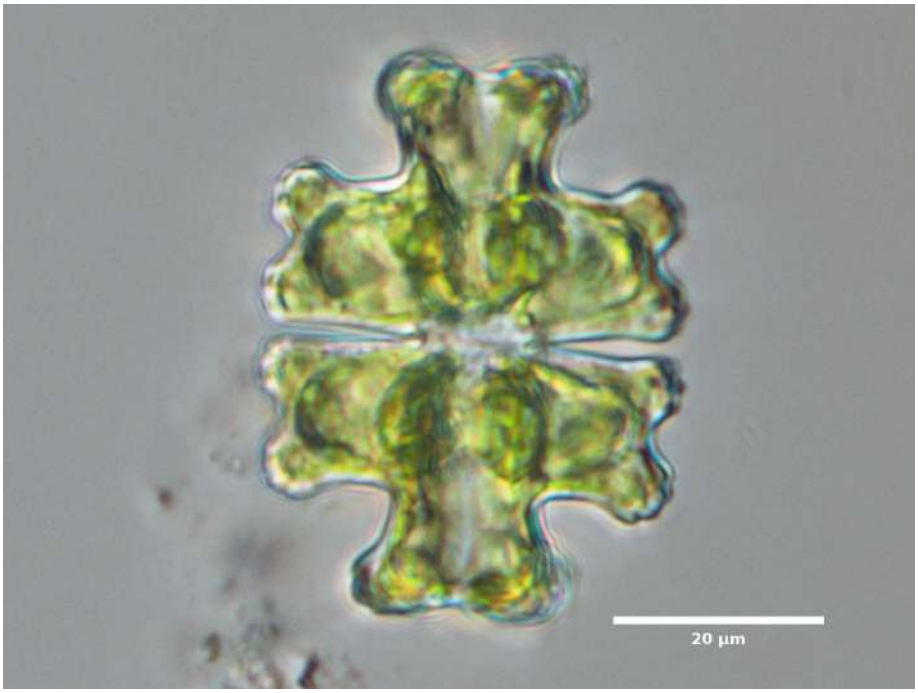


Figure 7.46: *Euastrum gemmatum* var. *taftii* (SEM/DIC), Myrtle Lake, Mountain Loop Highway, Snohomish County (upper/lower images).

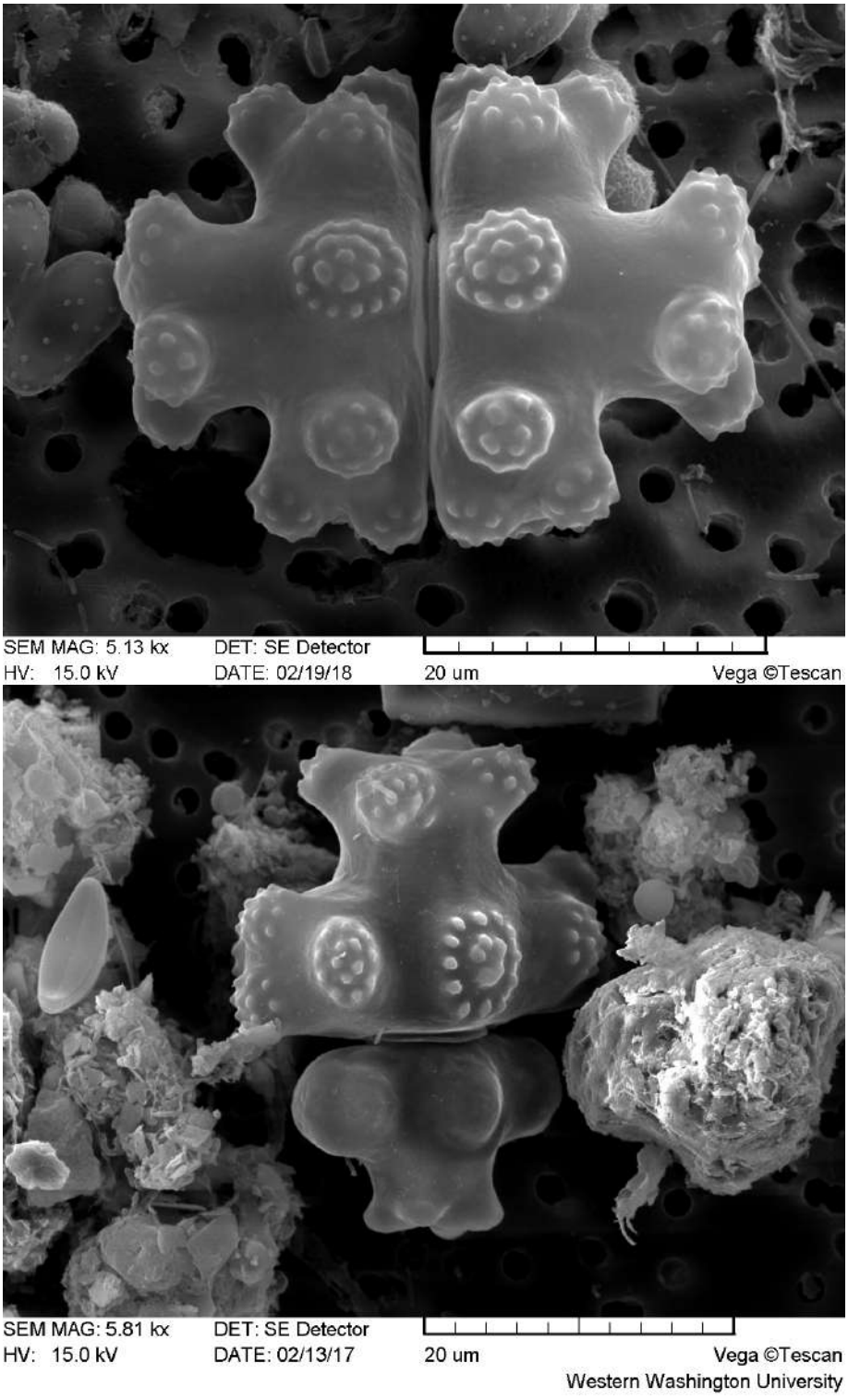


Figure 7.47: *Euastrum gemmatum* var. *taftii* (SEM/SEM), Myrtle Lake, Mountain Loop Highway, Snohomish County (upper/lower images).

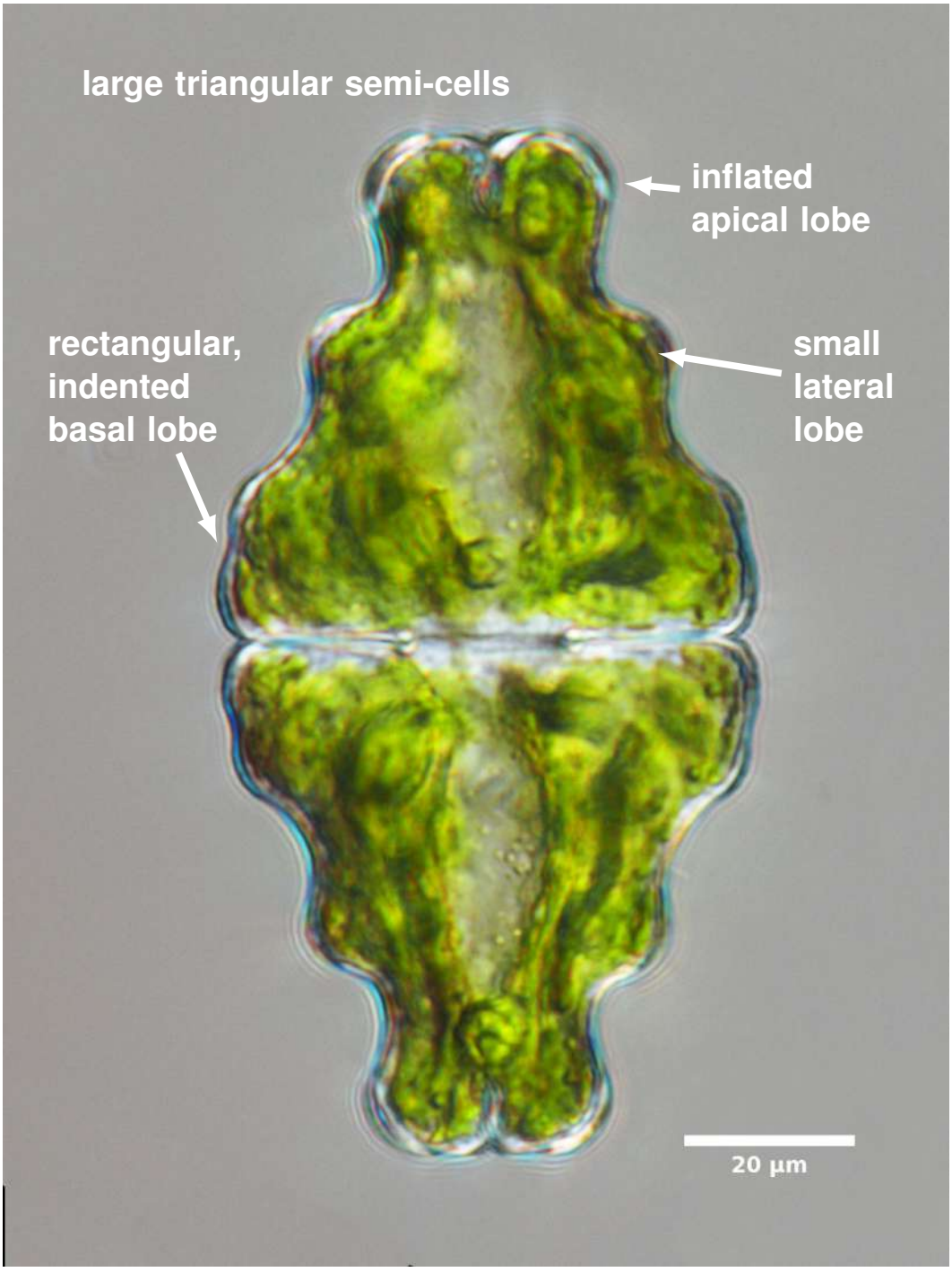


Figure 7.48: *Euastrum humerosum* (DIC), Baker Lake, Mt. Baker area, Whatcom/Skagit Counties.

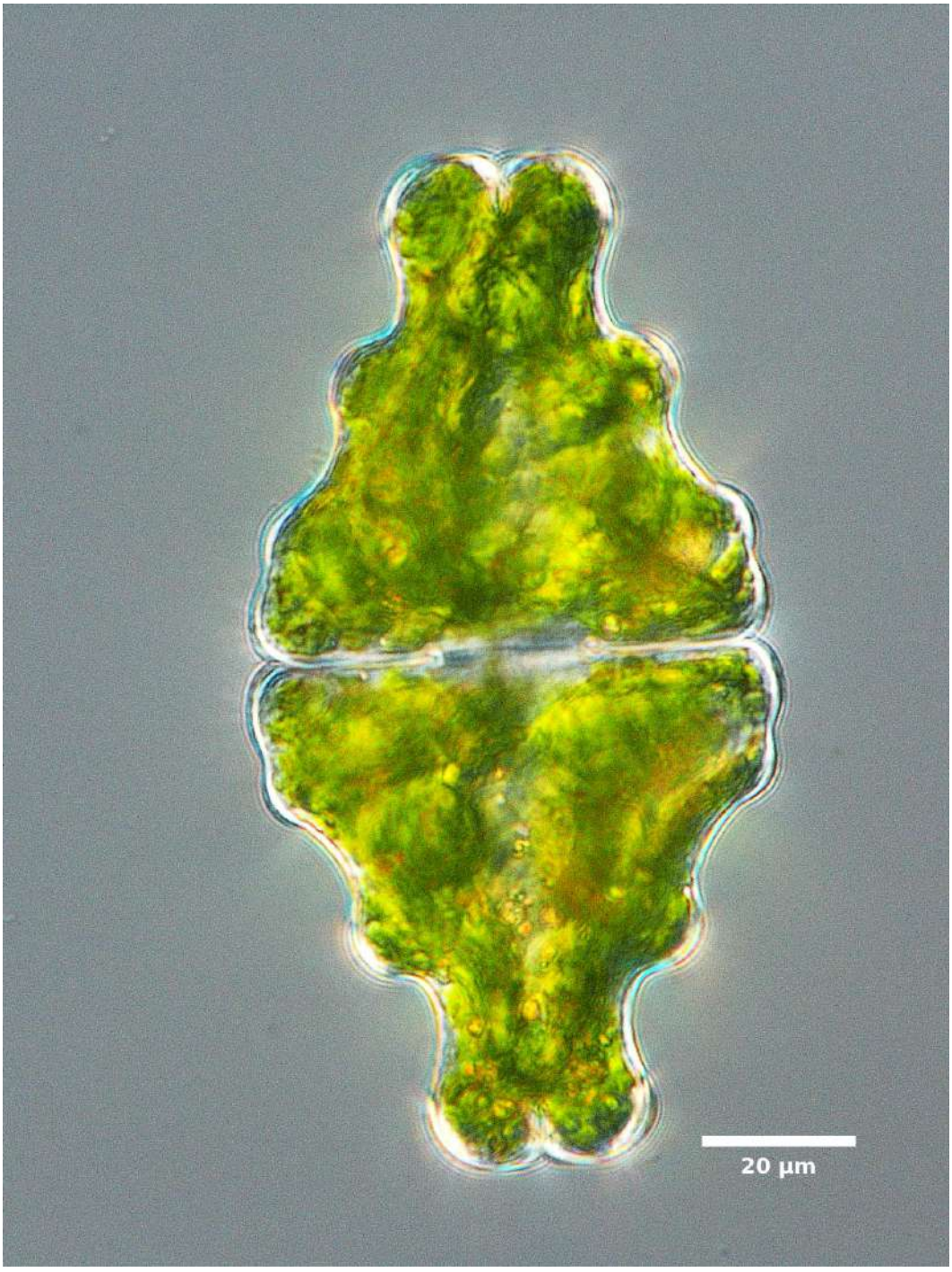


Figure 7.49: *Euastrum humerosum* (DIC), Vogler Lake, Skagit County.

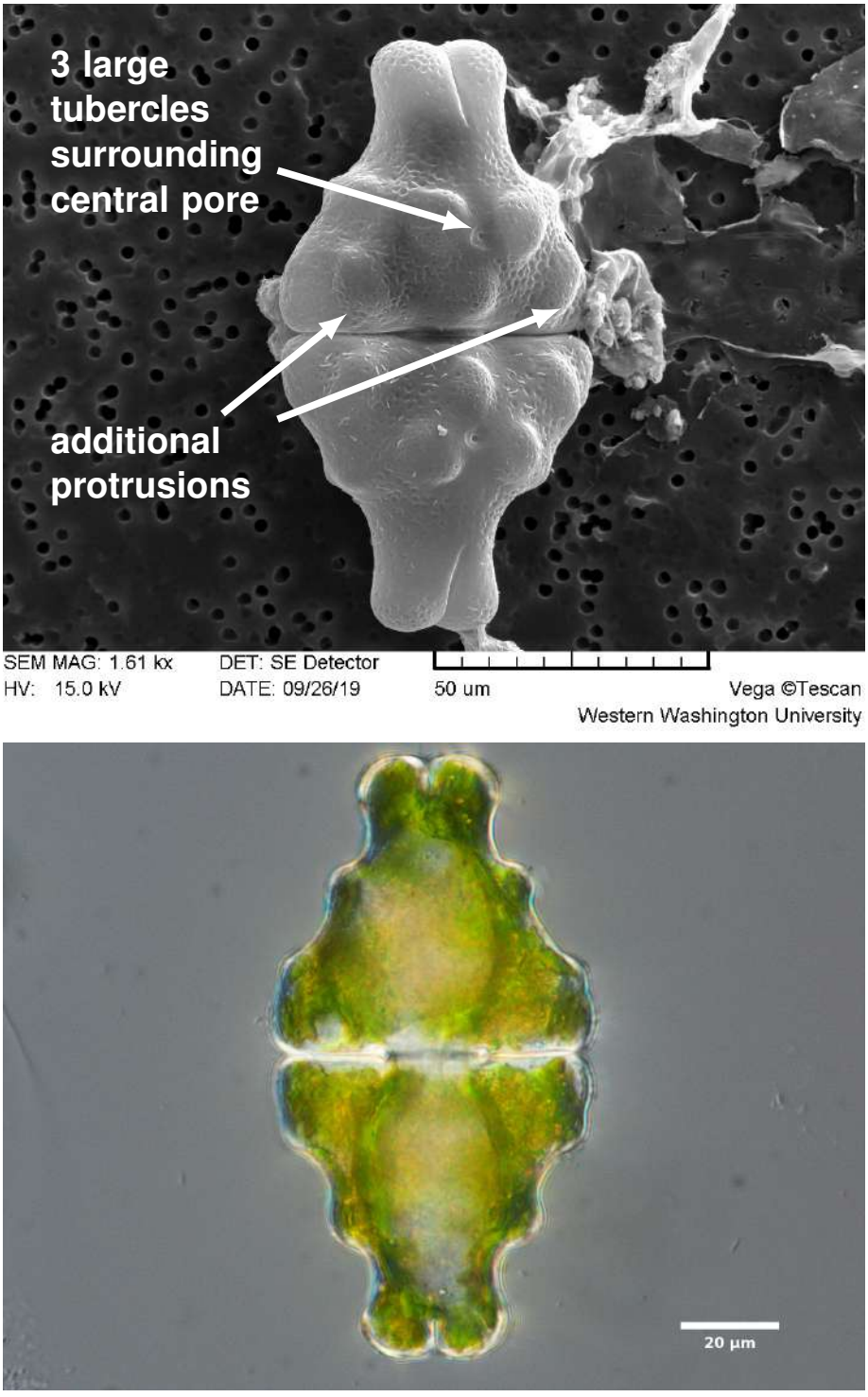


Figure 7.50: *Euastrum humerosum* (SEM/DIC), Vogler Lake, Skagit County (upper/lower images).

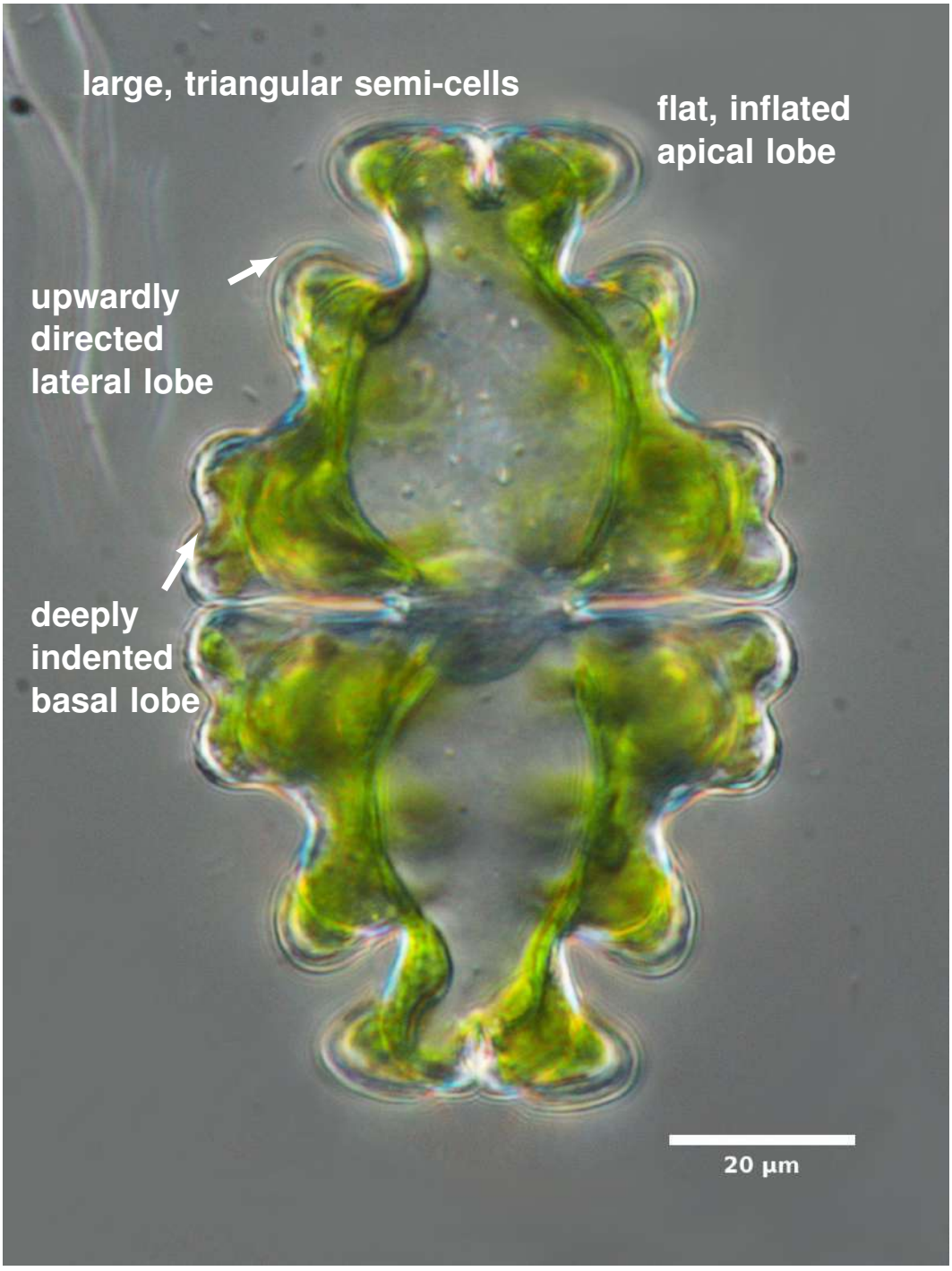


Figure 7.51: *Euastrum humerosum* var. *affine* (DIC), Heather Meadows Pond, Mt. Baker area, Whatcom County.

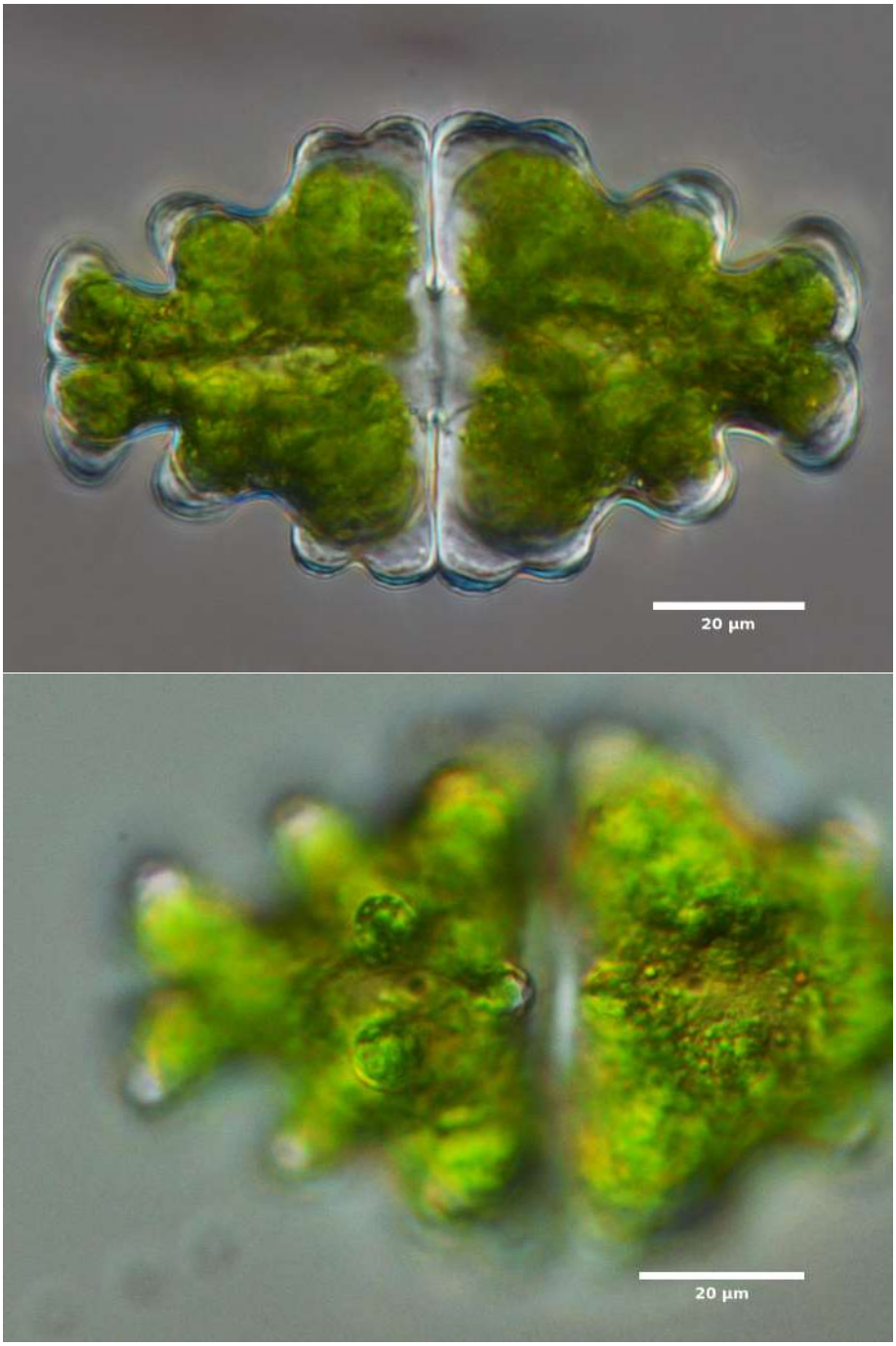
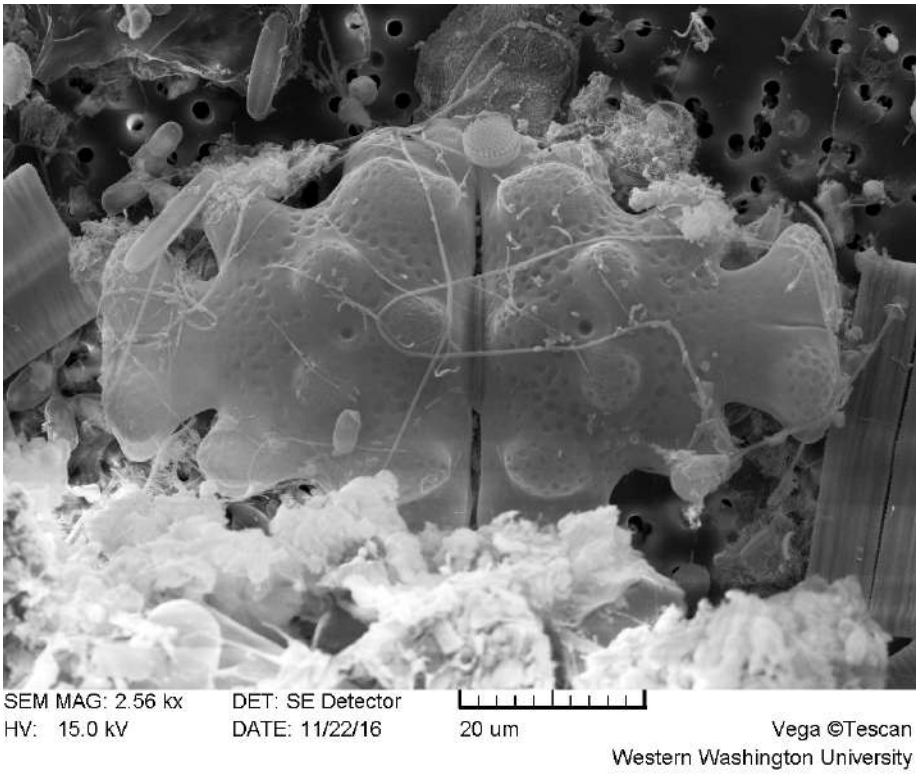


Figure 7.52: *Euastrum humerosum* var. *affine* (DIC/DIC), Heather Meadows Pond, Mt. Baker area, Whatcom County (upper/lower images).



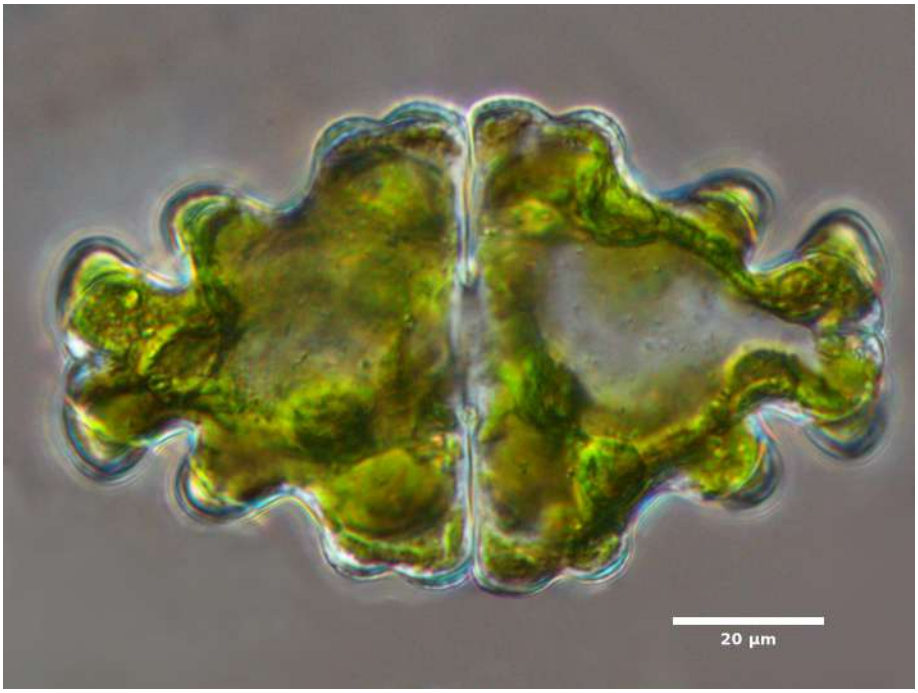


Figure 7.53: *Euastrum humerosum* var. *affine* (SEM/DIC), Picture Lake, Mt. Baker area, Whatcom County (upper/lower images).

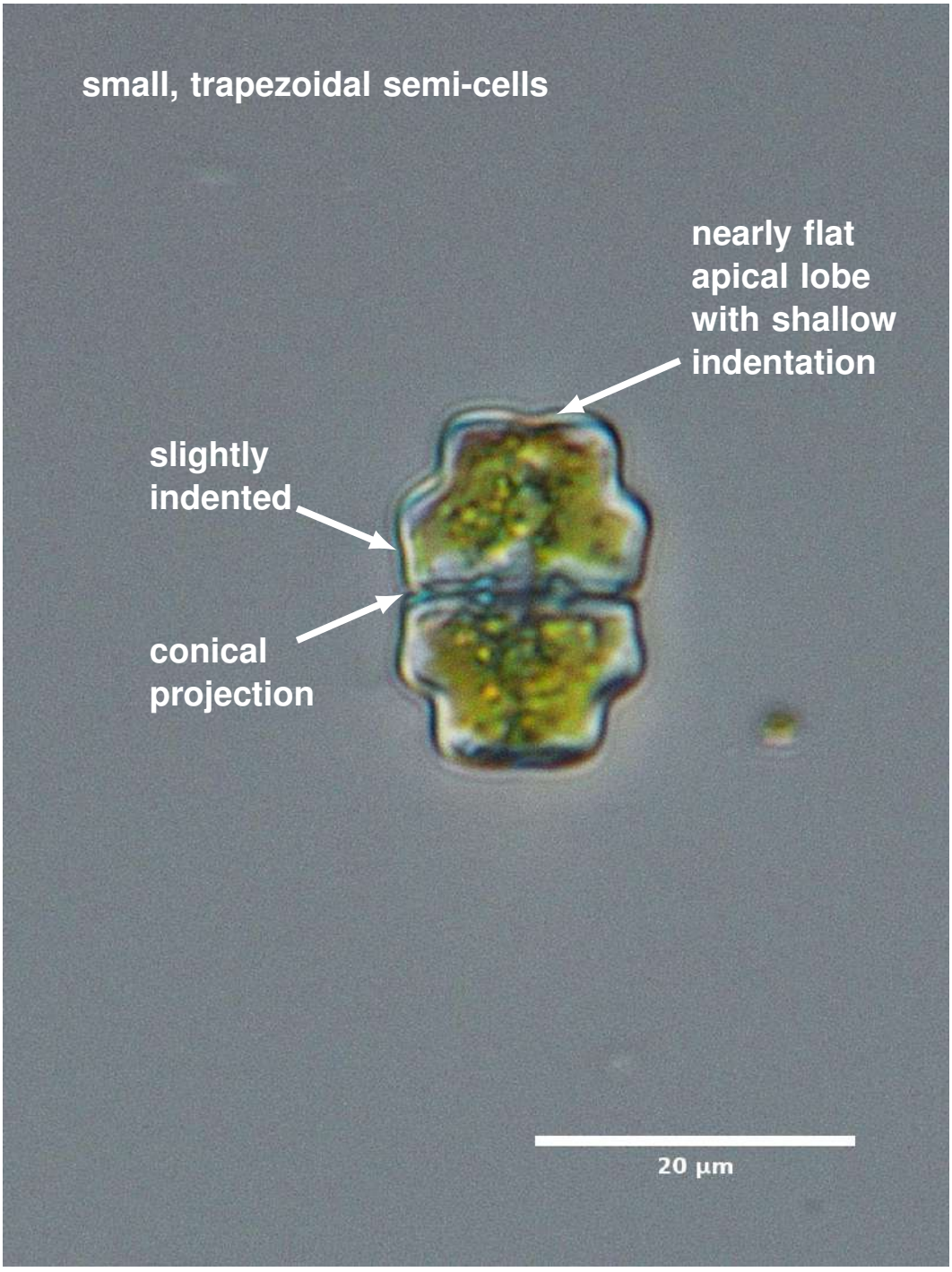


Figure 7.54: *Euastrum insulare* (DIC), small boggy pond along Morris Valley Road near Harrison, BC.

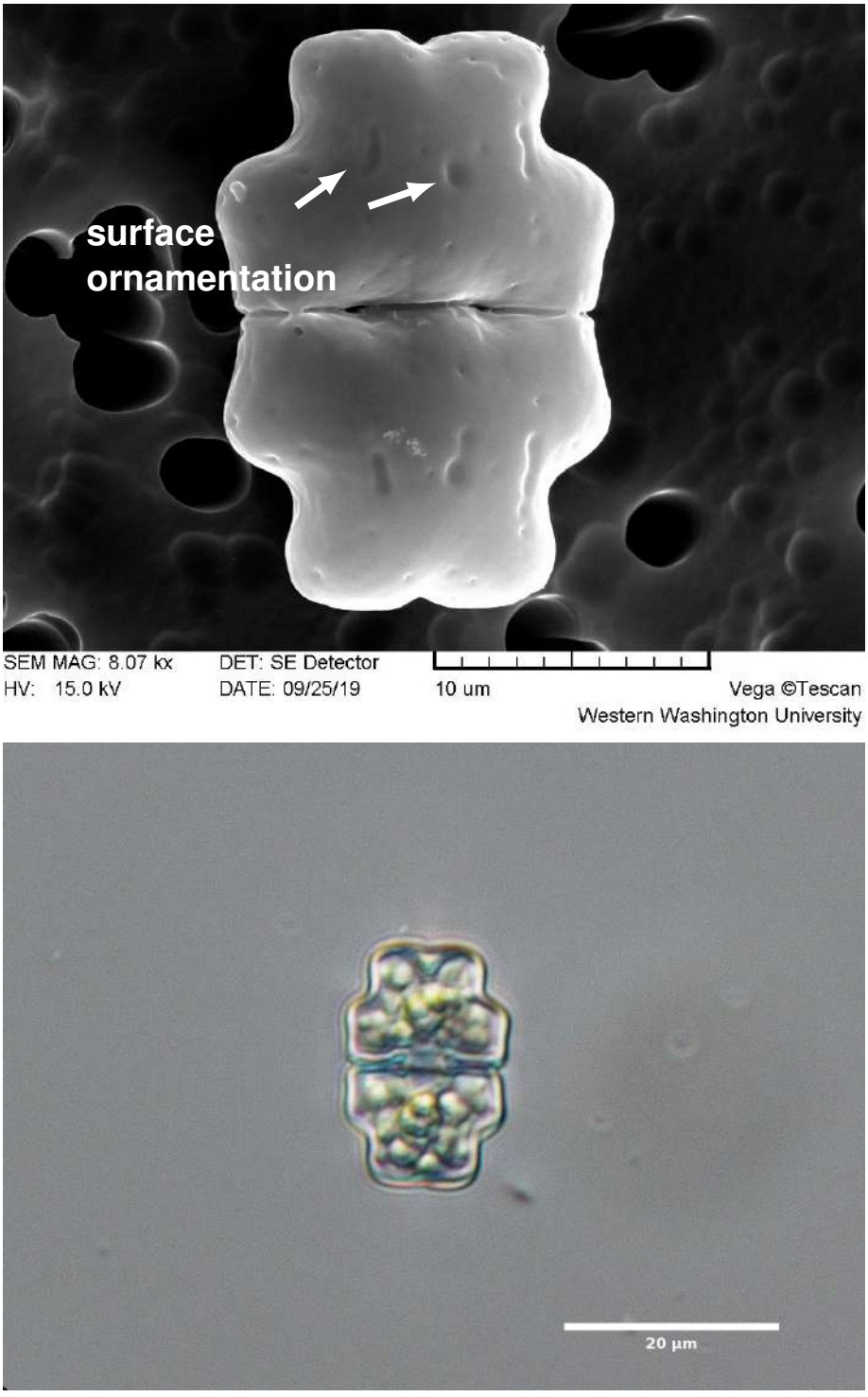


Figure 7.55: *Euastrum insulare* (SEM/DIC), small boggy pond along Morris Valley Road near Harrison, BC (upper/lower images).

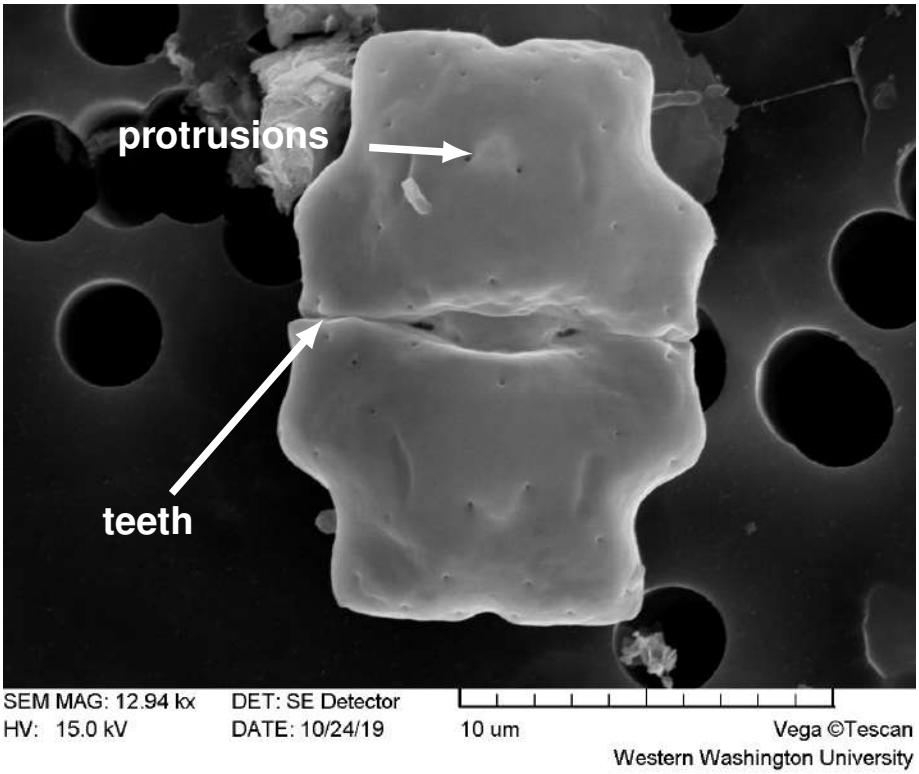




Figure 7.56: *Euastrum insulare* (SEM/DIC), Clear Lake, Skagit County (upper/lower images).

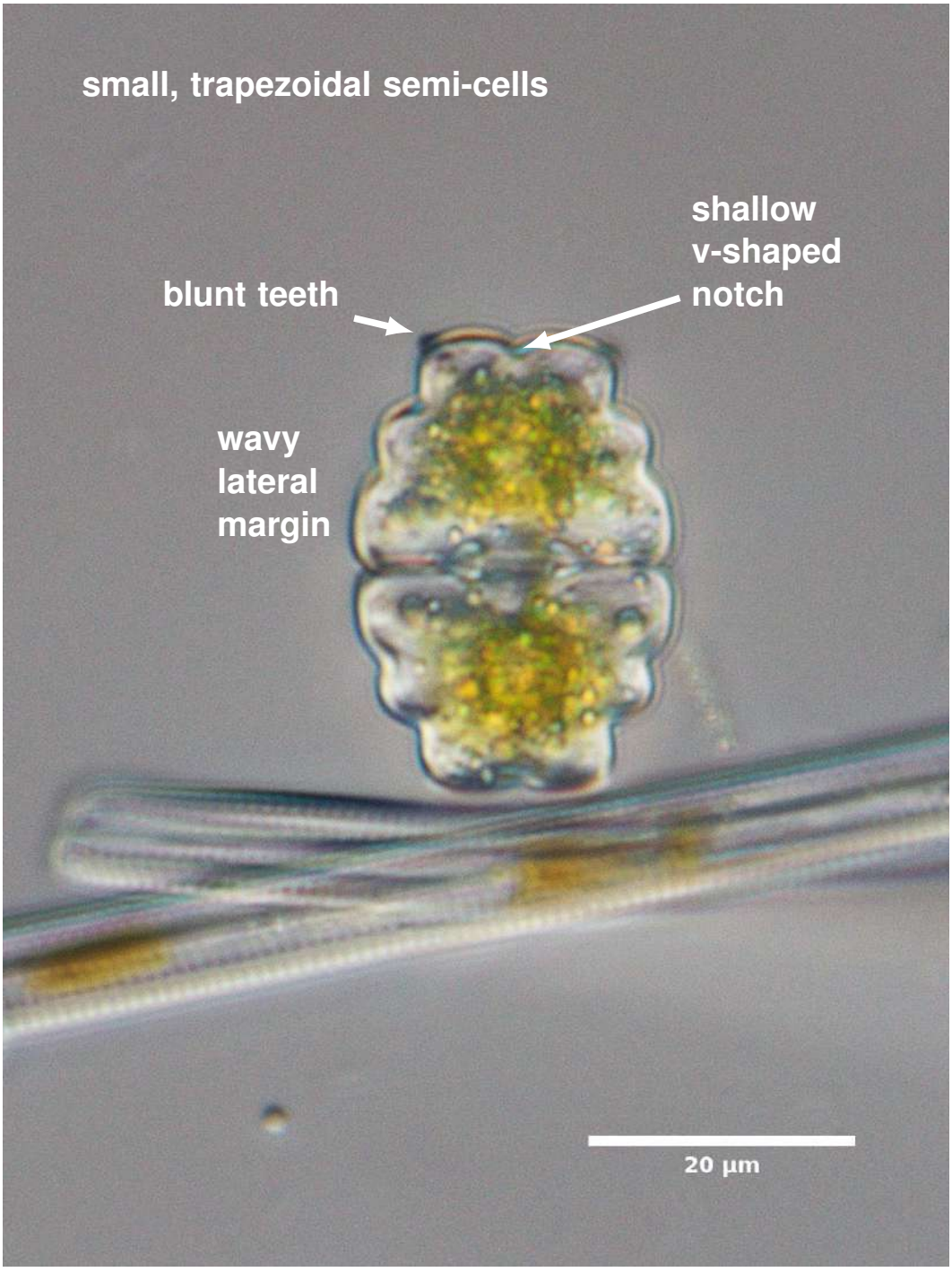


Figure 7.57: *Euastrum* cf. *lacustre* (DIC), Big Twin Lake (eastern Washington, Okanogan County.

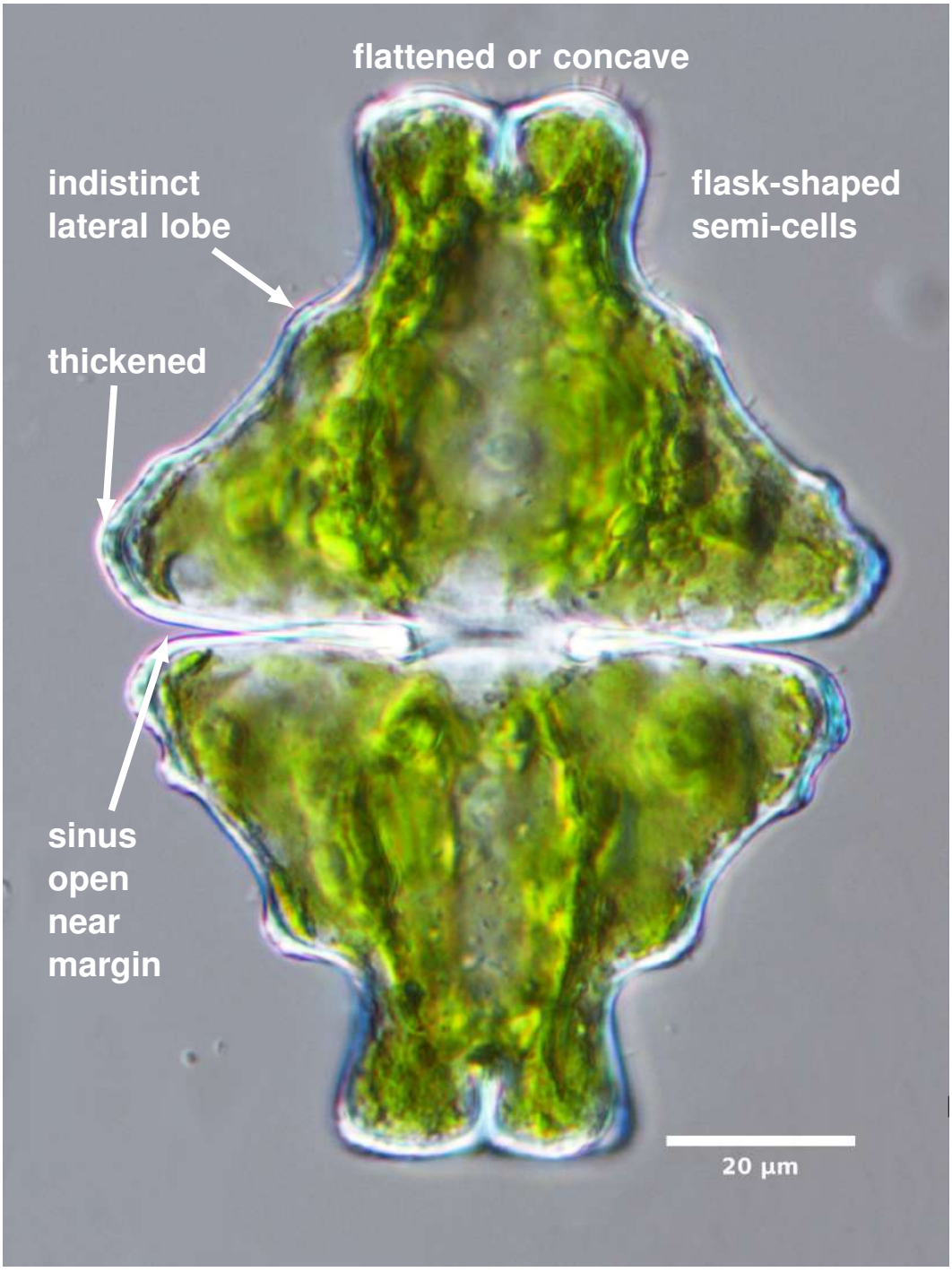


Figure 7.58: *Euastrum latipes* var. *evolutum* (DIC), Lower Ashland Lake, Mountain Loop Highway, Snohomish County.



Figure 7.59: *Euastrum latipes* var. *evolutum* (DIC), Lower Ashland Lake, Mountain Loop Highway, Snohomish County.

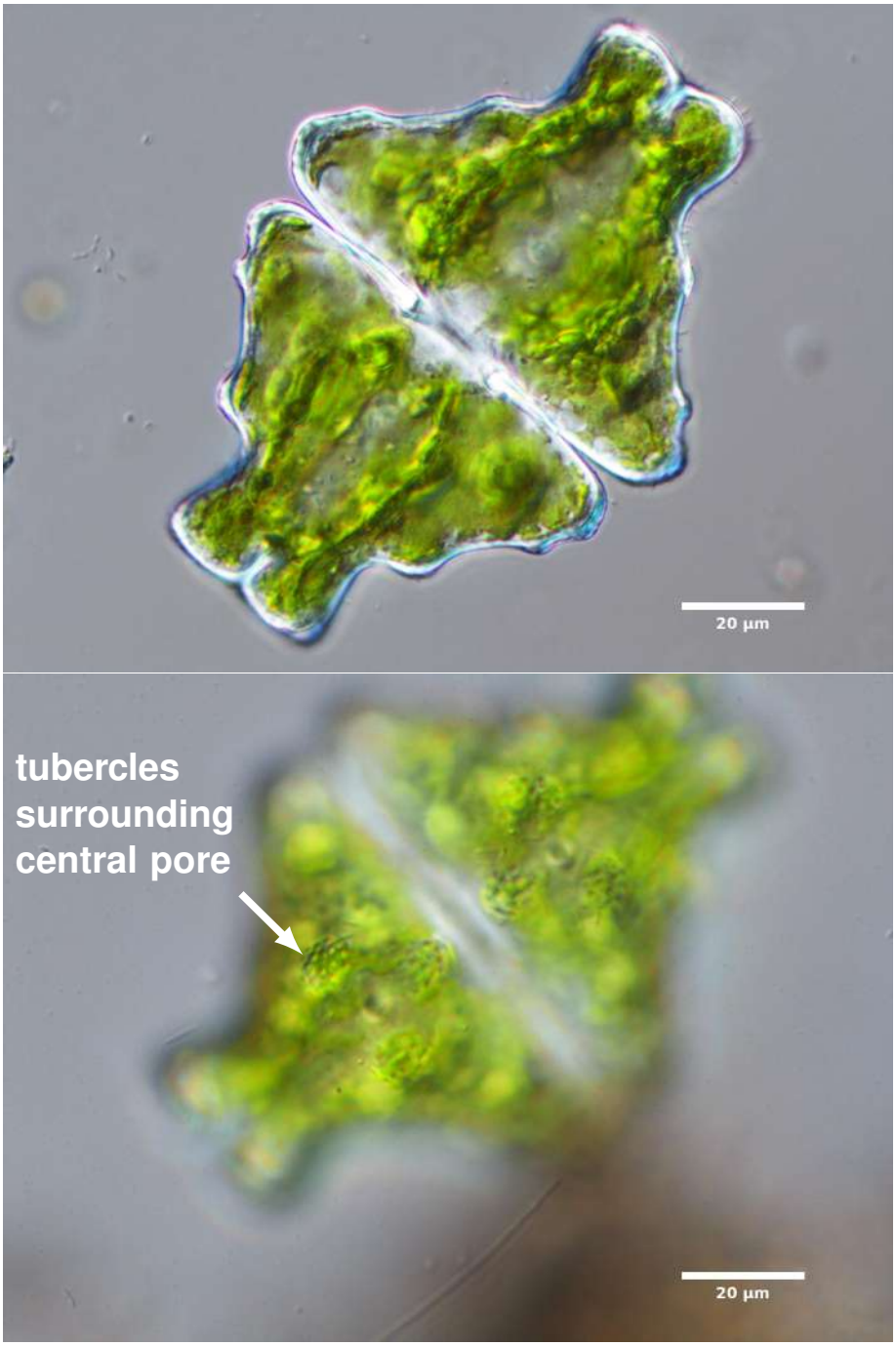


Figure 7.60: *Euastrum latipes* var. *evolutum* (DIC/DIC), Lower Ashland Lake, Mountain Loop Highway, Snohomish County (upper/lower images).

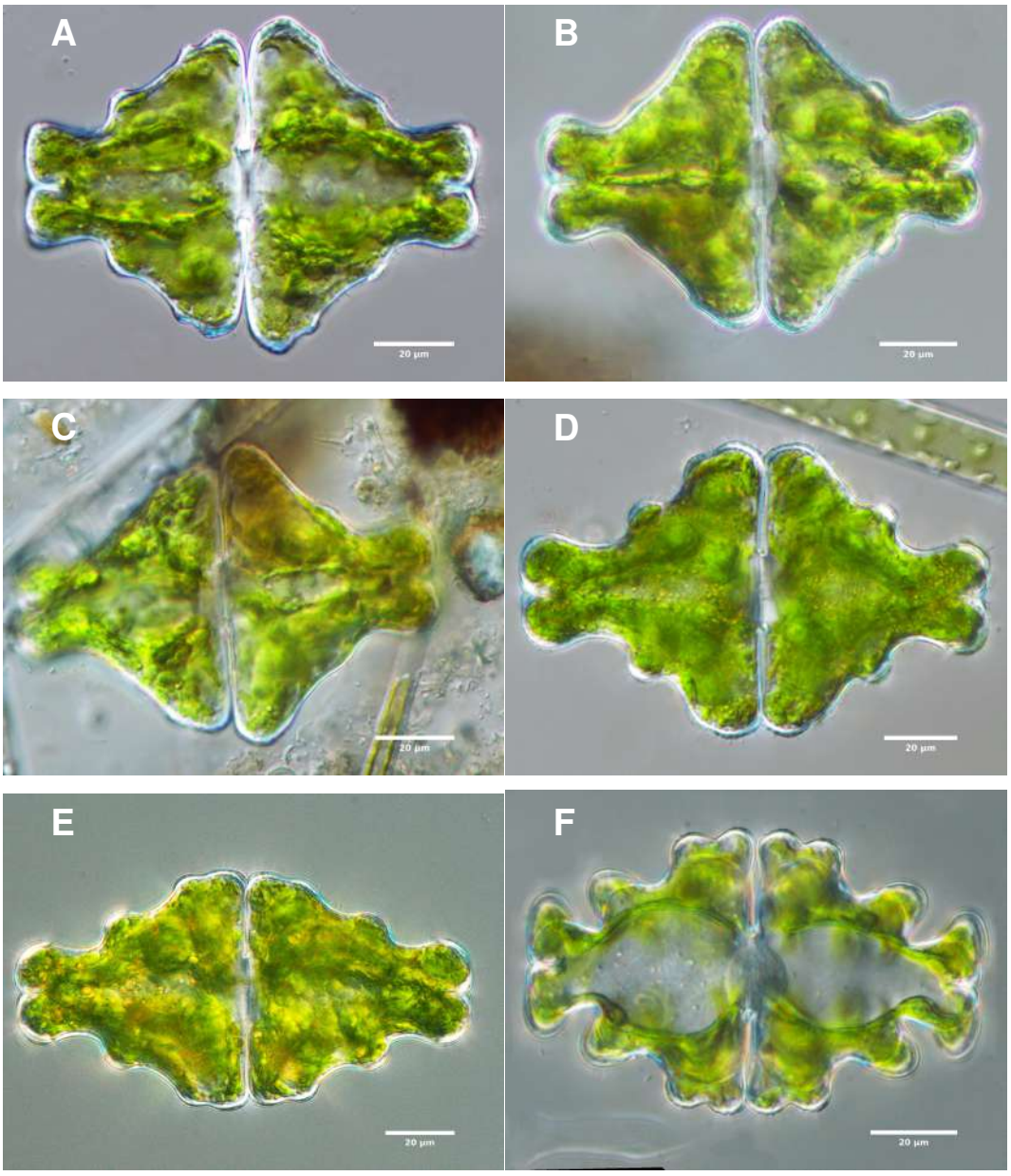


Figure 7.61: *Euastrum latipes* var. *evolutum* specimens from Lower Ashland Lake, Mountain Loop Highway, Snohomish County (A–D) vs. *Euastrum humerosum* (E) from Vogler Lake, Snohomish County, and *Euastrum humerosum* var. *affine* F) from Terminal Lake, Mt. Baker area, Whatcom County.

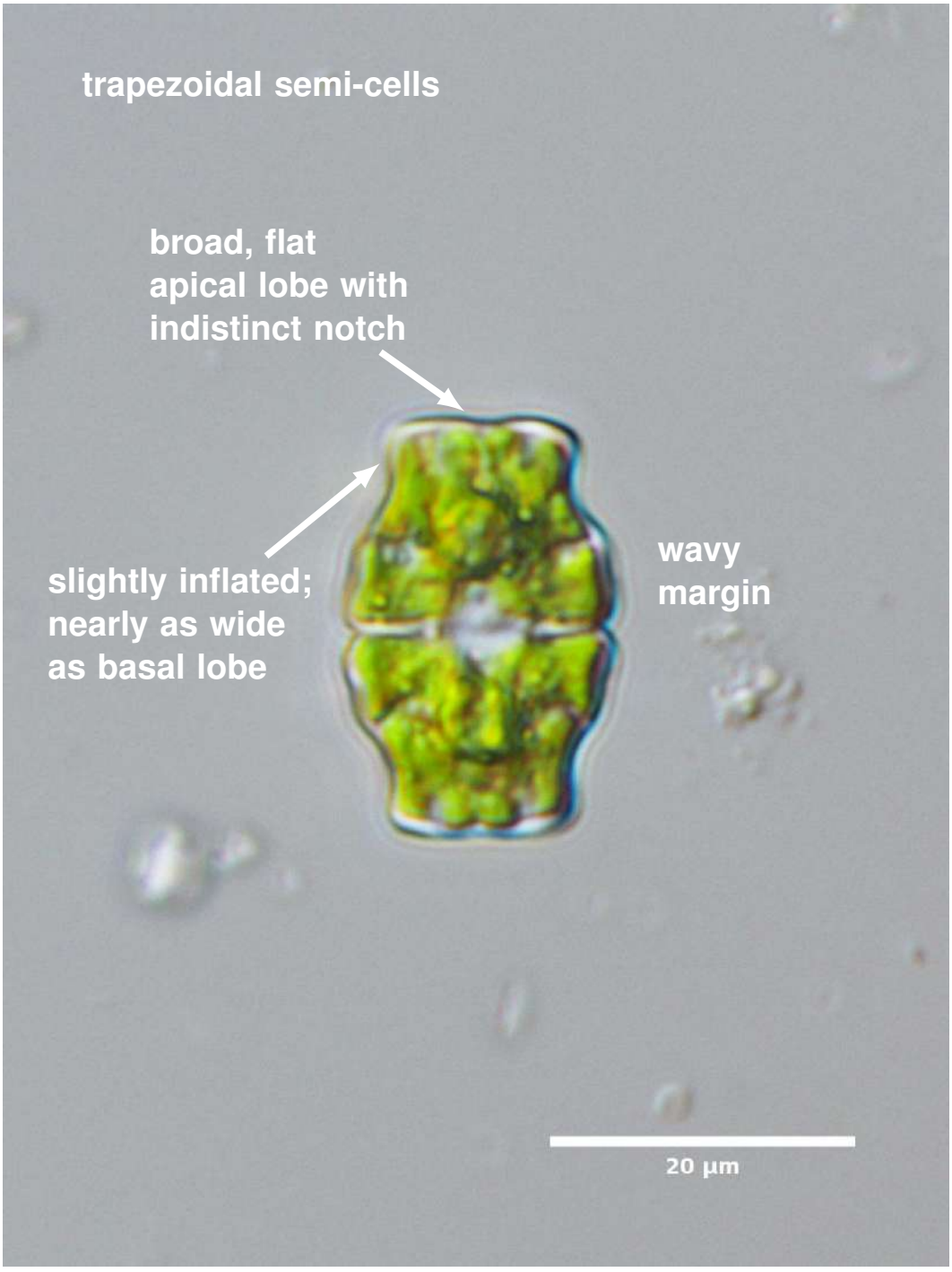


Figure 7.62: *Euastrum luetkemuelleri* var. *carniolicum* (DIC), Beaver Lake, Mountain Loop Highway, Snohomish County.

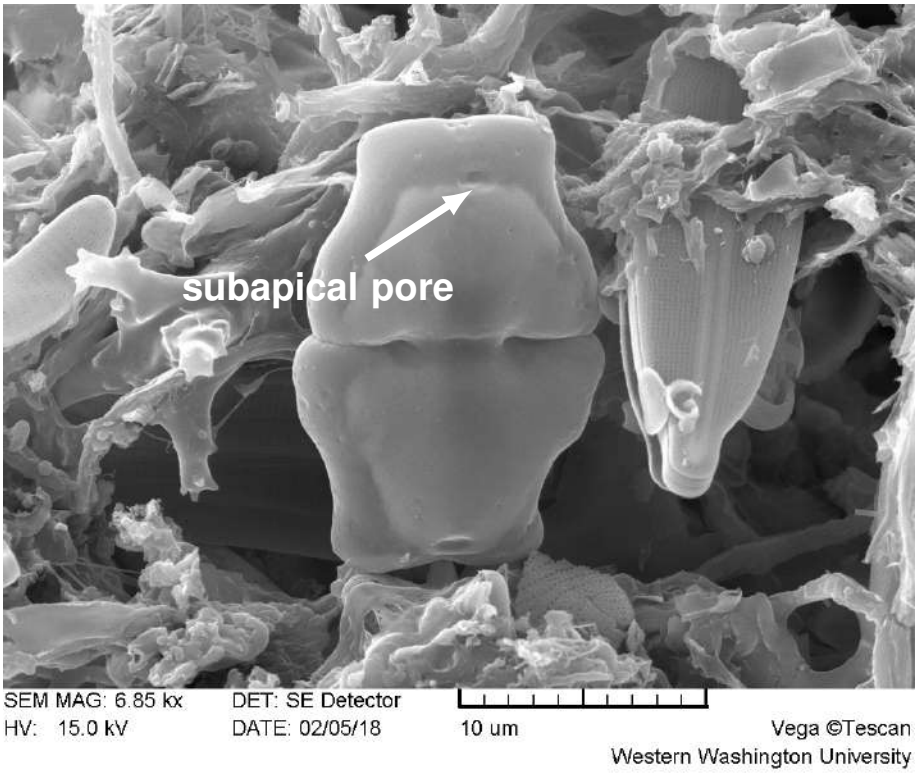




Figure 7.63: *Euastrum luetkemuelleri* var. *carniolicum* (SEM/DIC), Bear Lake, Mountain Loop Highway, Snohomish County (upper/lower images).

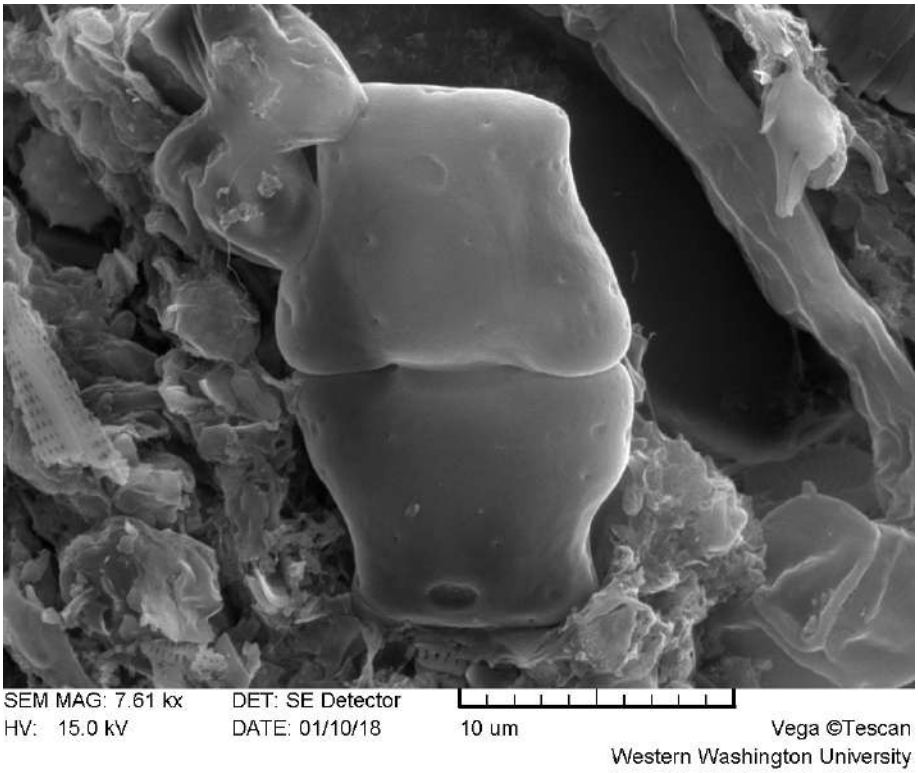




Figure 7.64: *Euastrum luetkemuelleri* var. *carniolicum* (SEM/DIC), Bear Lake, Mountain Loop Highway, Snohomish County (upper/lower images).



Figure 7.65: *Euastrum montanum* (DIC), small pond on the trail to Dock Butte, Mt. Baker area, Skagit County.

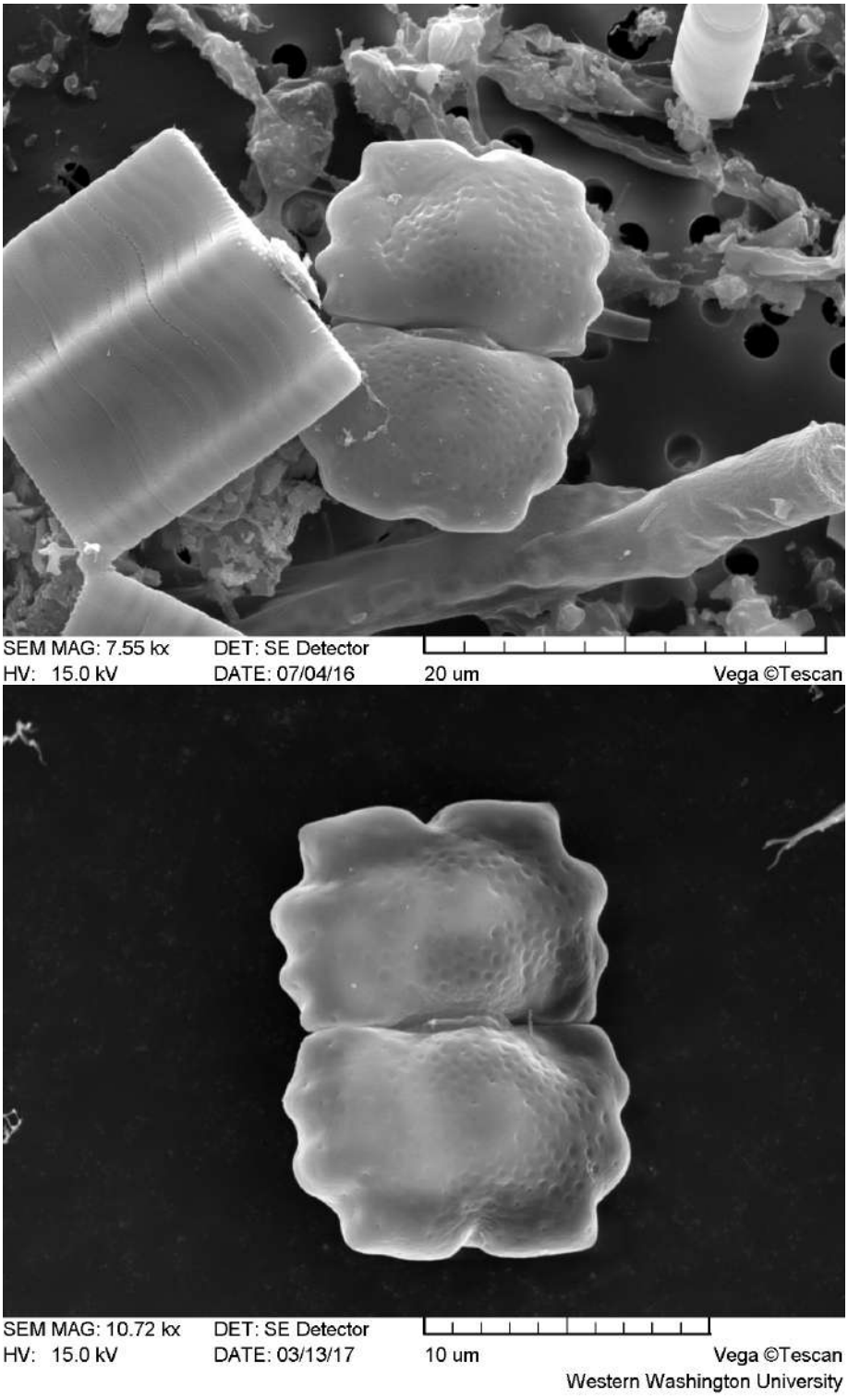


Figure 7.66: *Euastrum montanum* (SEM/SEM), Boardman Lake, Mountain Loop Highway, Snohomish County (upper image); small small pond on the trail to Dock Butte, Mt. Baker area, Skagit County (lower image).

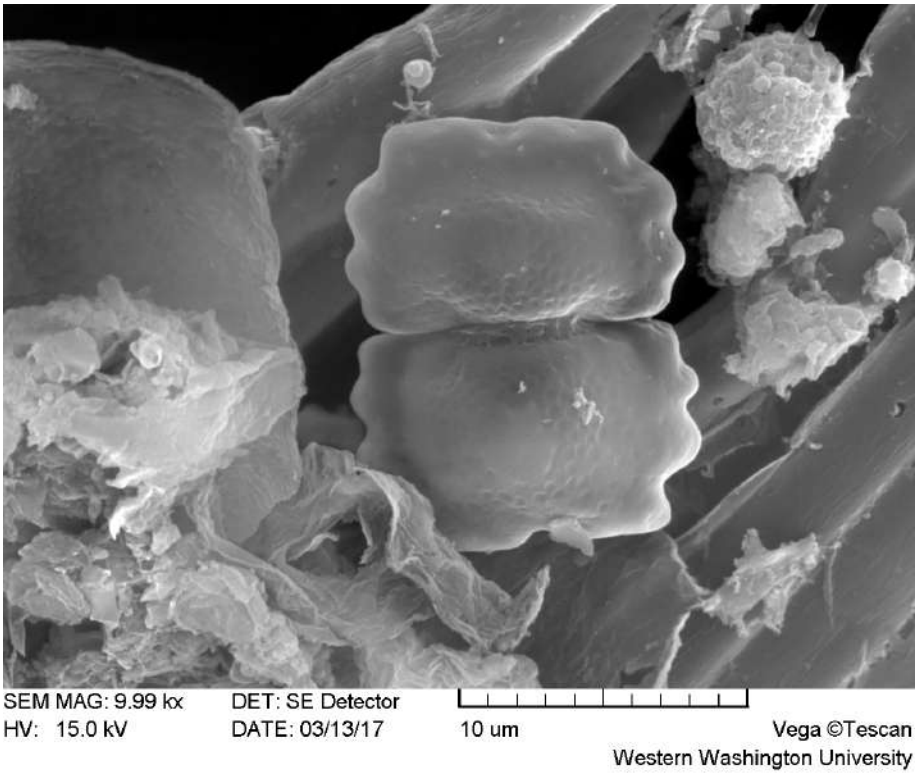




Figure 7.67: *Euastrum montanum* (SEM/DIC), small ponds on the trail to Dock Butte, Mt. Baker area, Skagit County (upper/lower images).

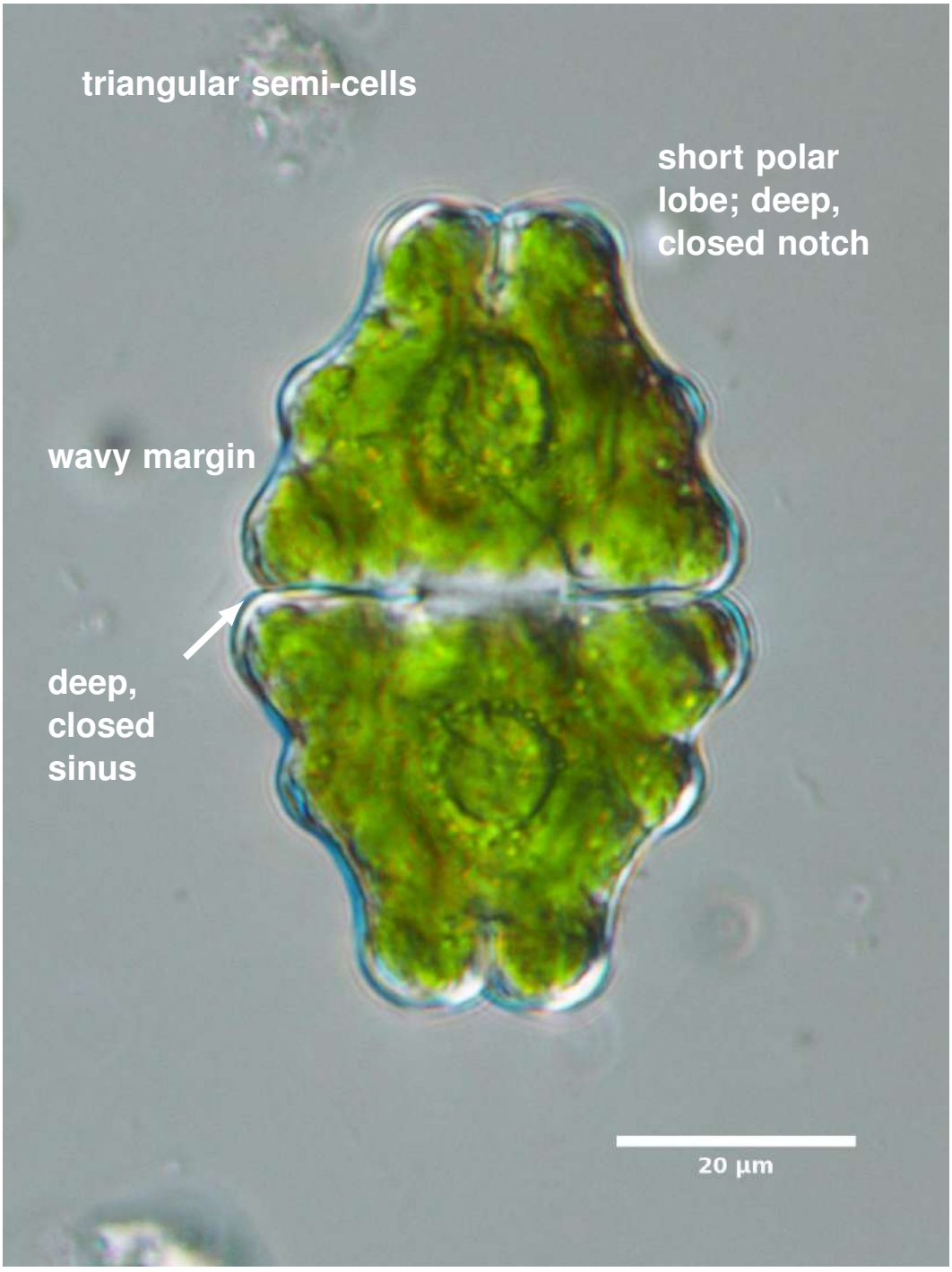


Figure 7.68: *Euastrum neosinuosum* (DIC), Lower Ashland Lake, Mountain Loop Highway, Snohomish County.

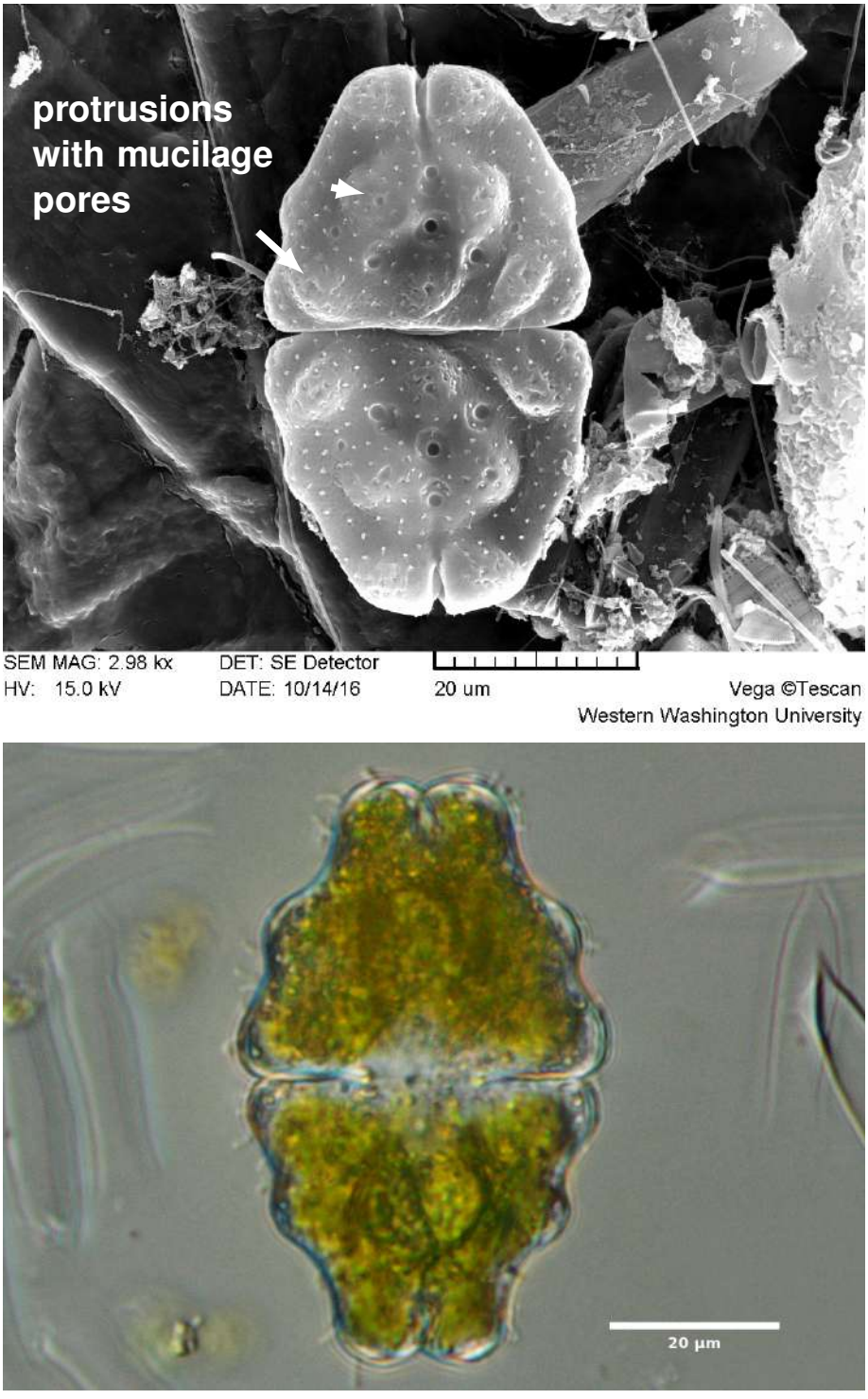


Figure 7.69: *Euastrum neosinuosum* (SEM/DIC), Bear Lake, Mountain Loop Highway, Snohomish County (upper image); Lake Evan, Mountain Loop Highway, Snohomish County (lower image).

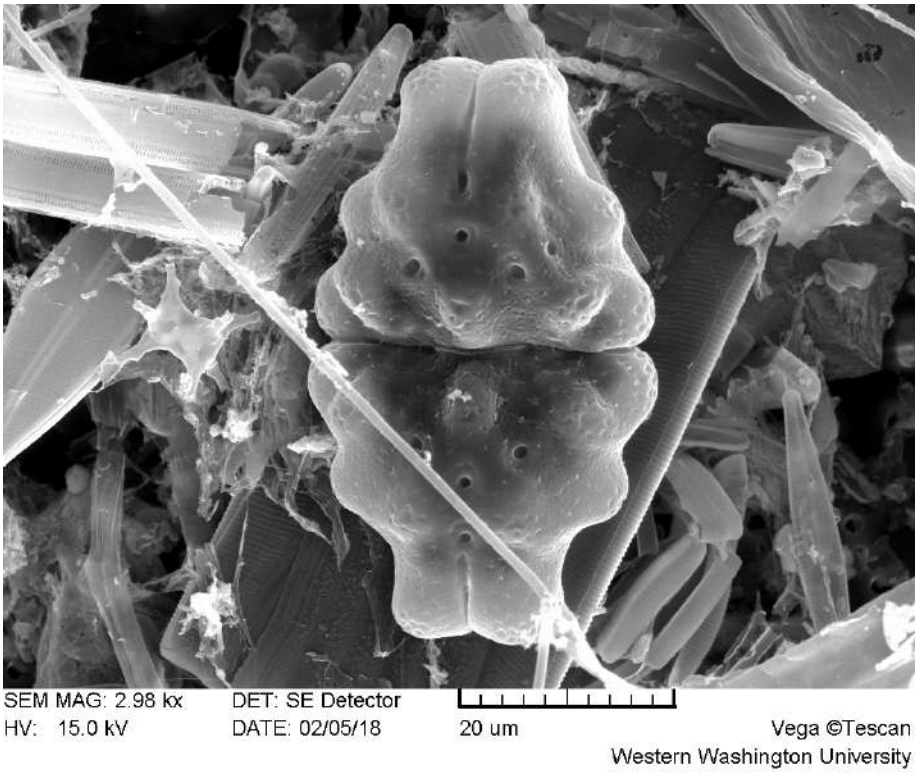




Figure 7.70: *Euastrum neosinuosum* (SEM/DIC), Bear Lake, Mountain Loop Highway, Snohomish County (upper/lower images).

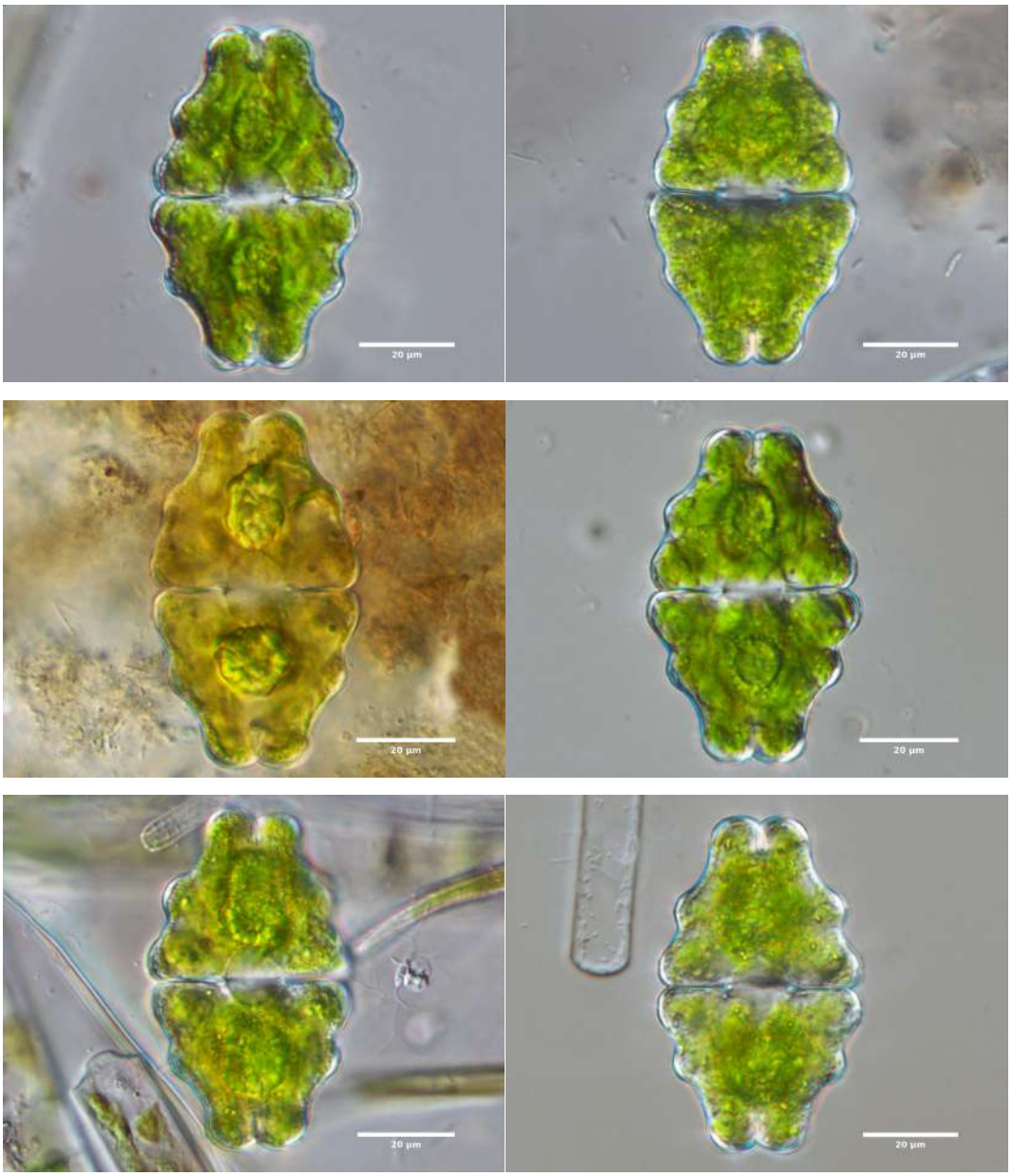


Figure 7.71: *Euastrum neosinuosum* (DIC), morphological variations for specimens collected on same date in Lower Ashland Lake, Mountain Loop Highway, Snohomish County.

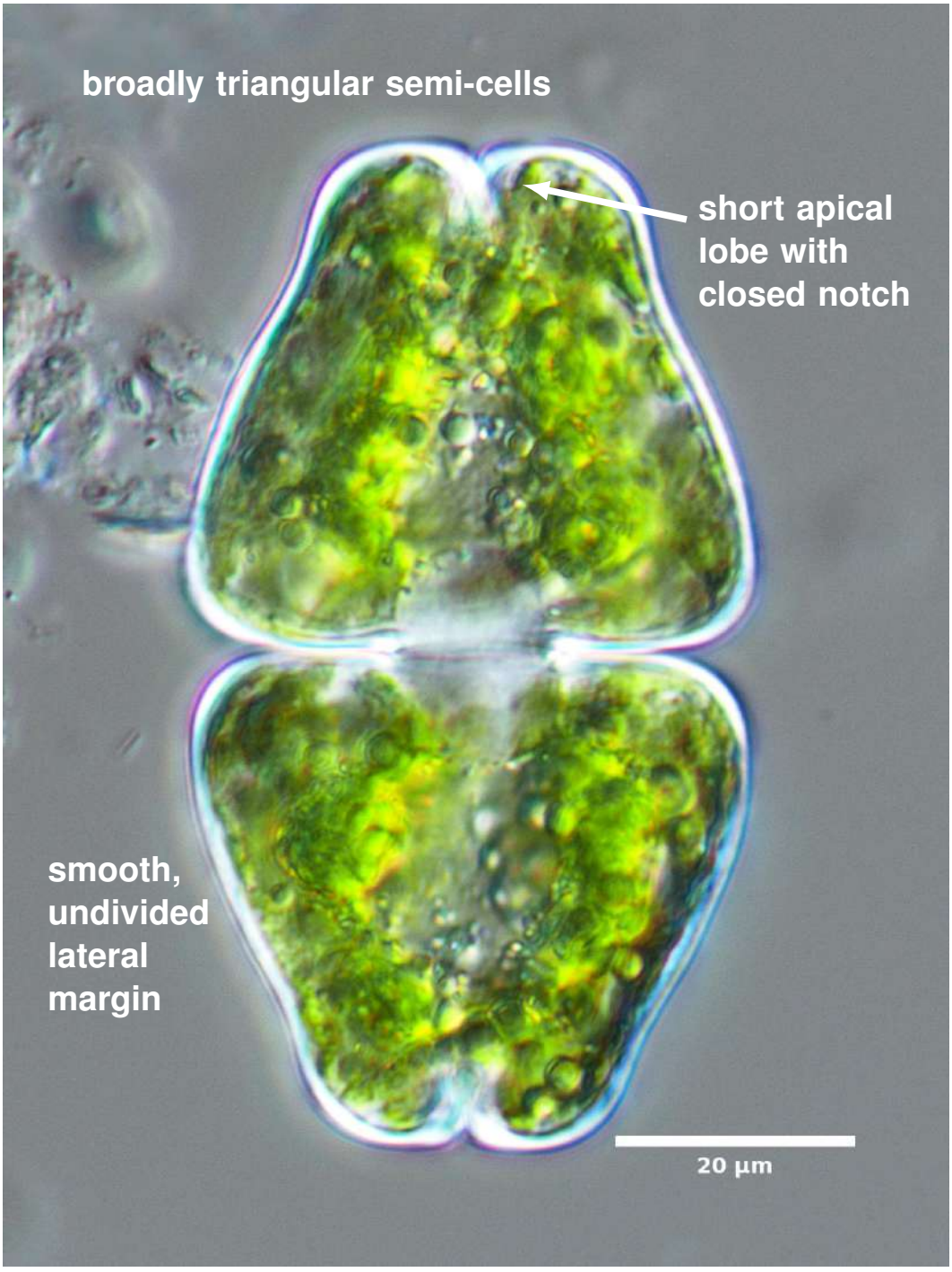


Figure 7.72: *Euastrum obesum* (DIC), small pond near Canyon Lake, Whatcom County.

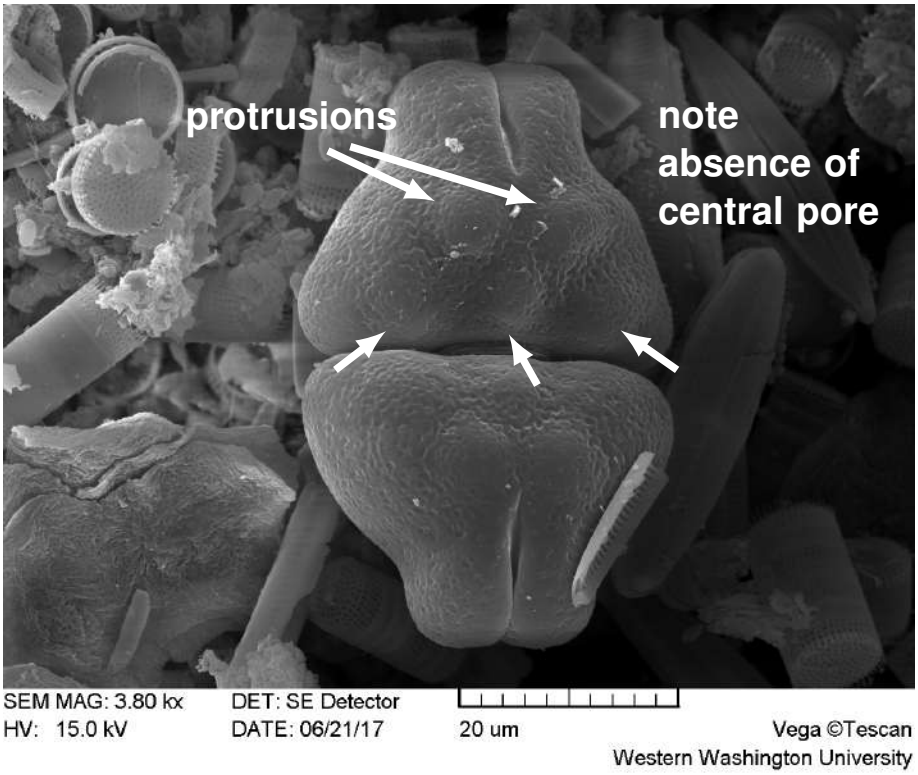




Figure 7.73: *Euastrum obesum* (SEM/DIC), small pond near Canyon Lake, Whatcom County (upper/lower images).

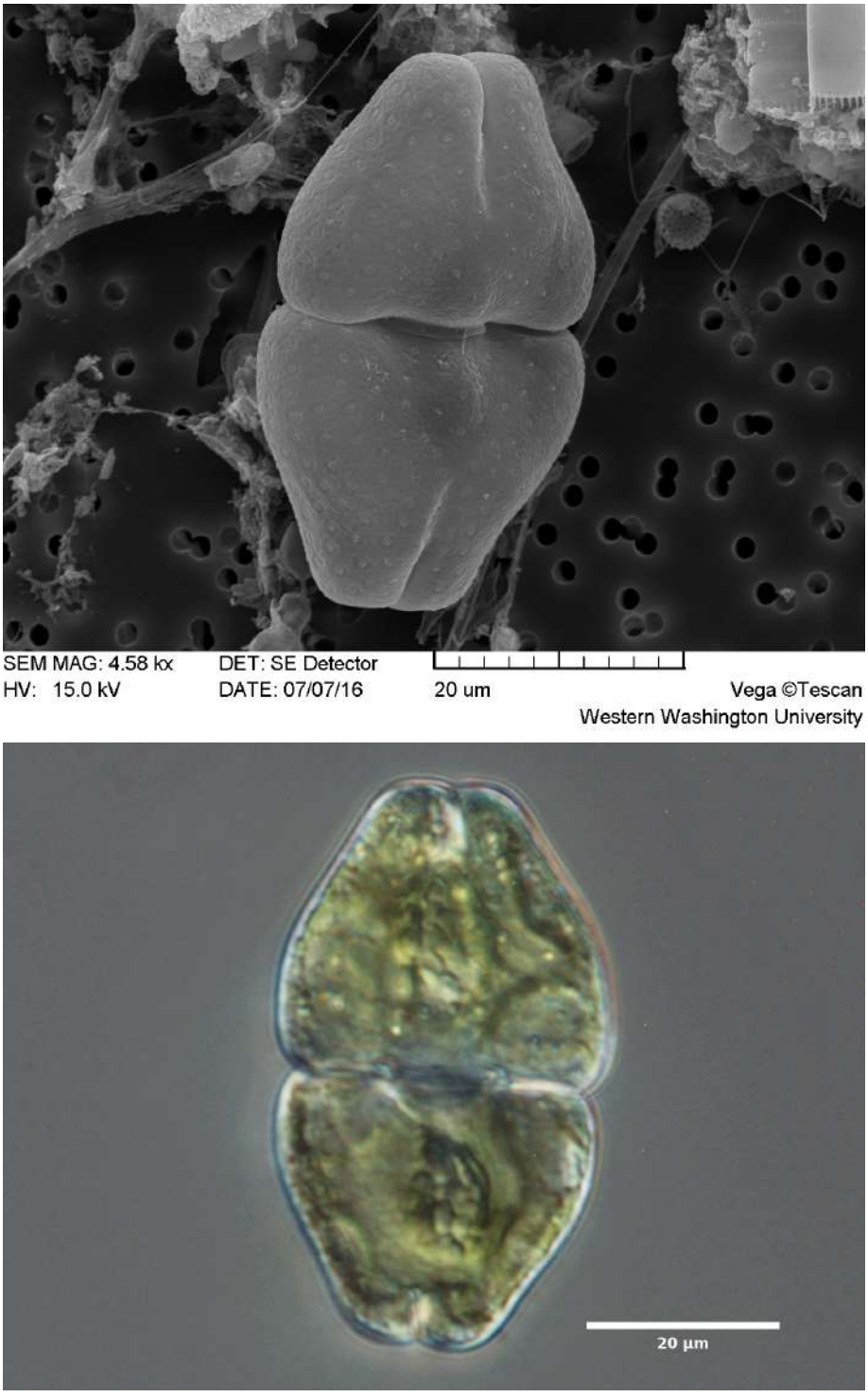


Figure 7.74: *Euastrum obesum* (SEM/DIC), Bear Lake, Mountain Loop Highway, Snohomish County (upper image); Lake Evan, Mountain Loop Highway, Snohomish County (lower image).

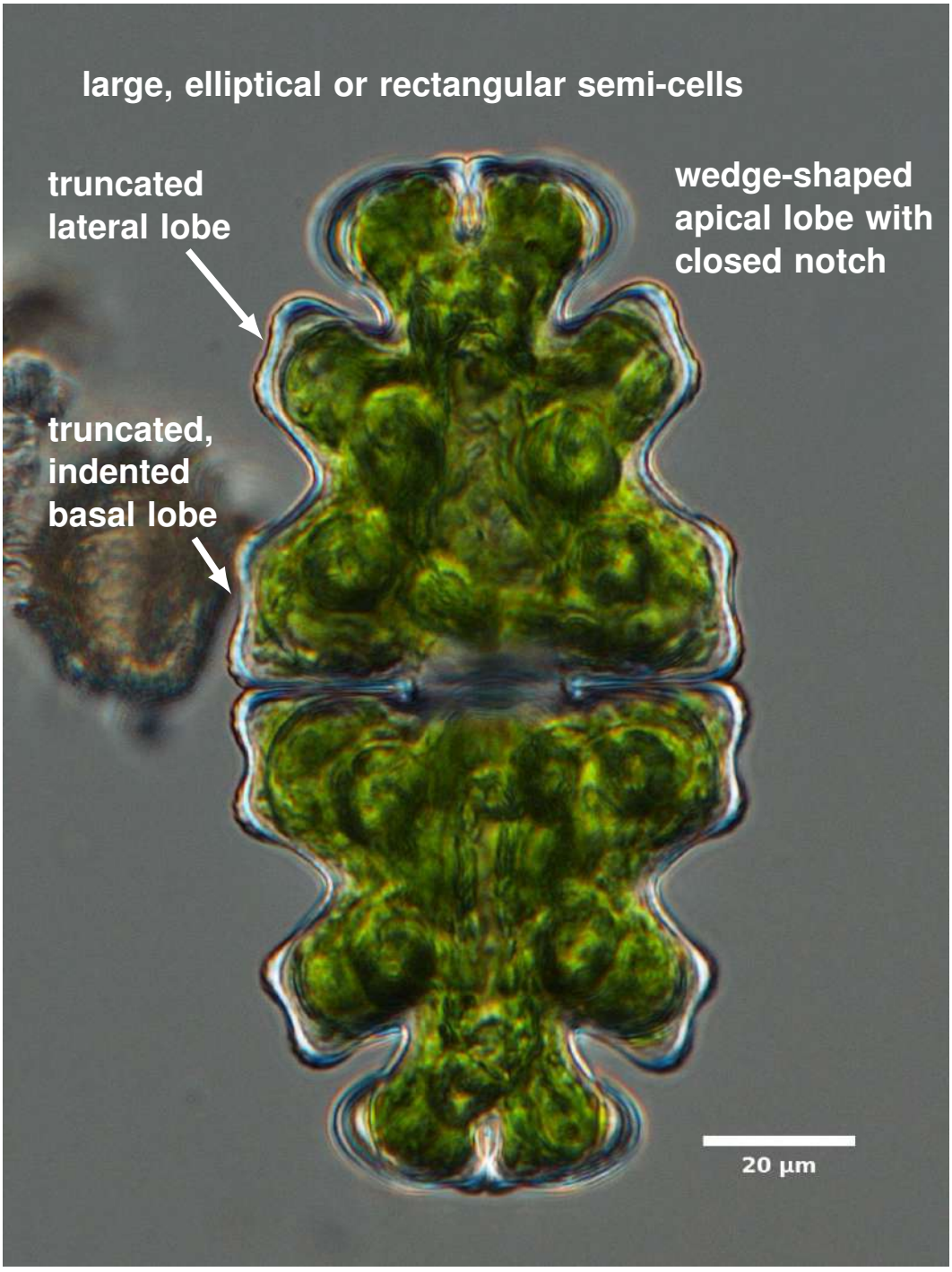


Figure 7.75: *Euastrum oblongum* (DIC), Lower Bagley Lake, Mt. Baker area, Whatcom County.

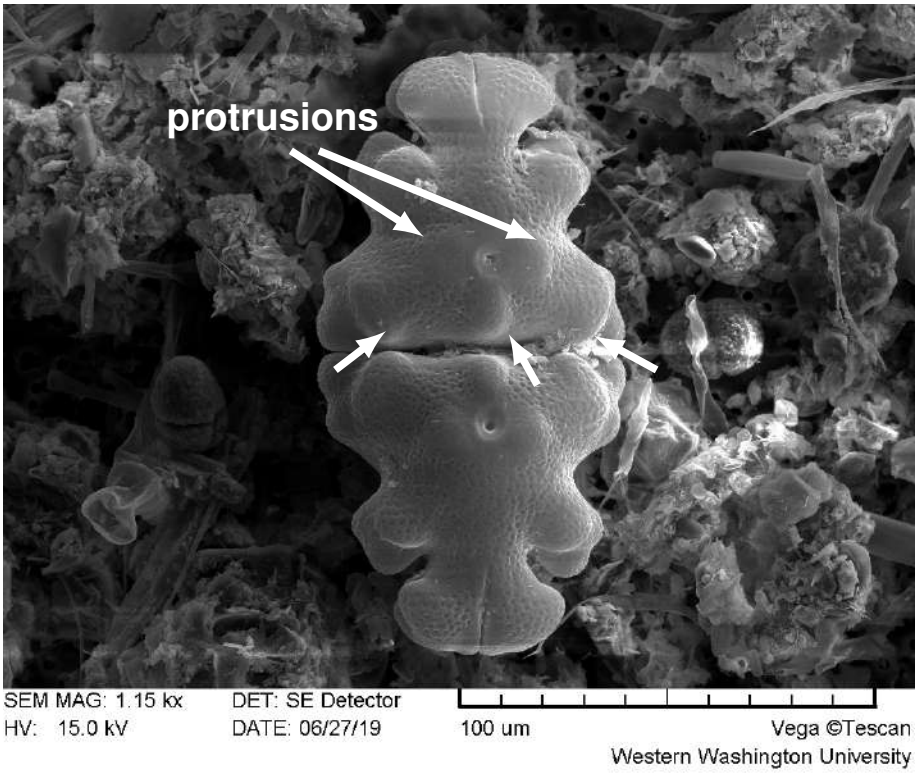
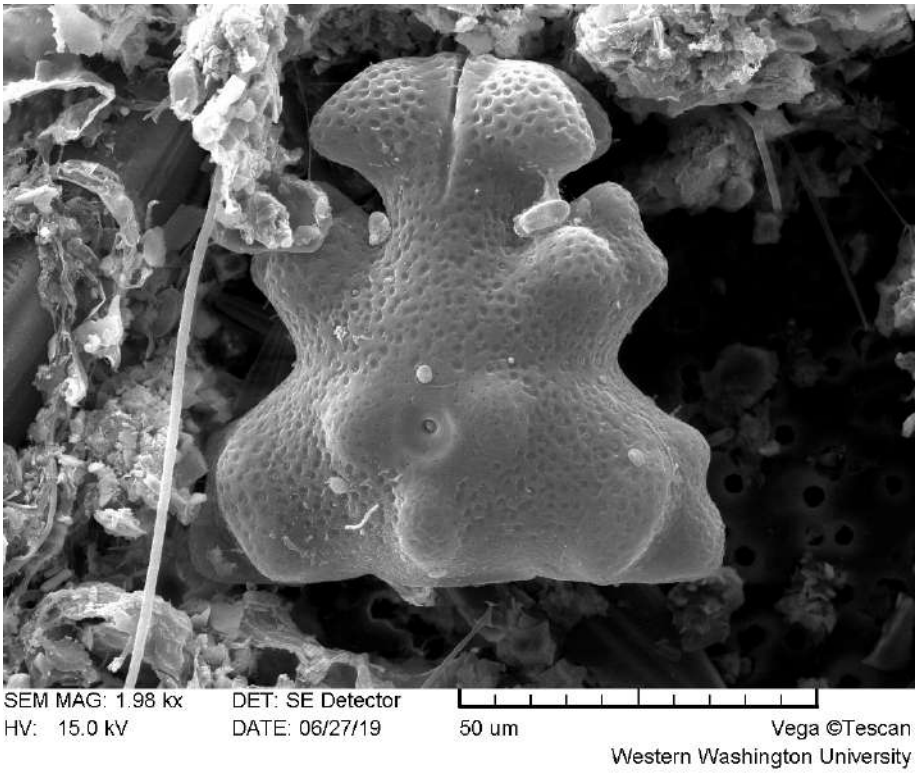




Figure 7.76: *Euastrum oblongum* (SEM/DIC), Mirror Lake, Whatcom County (upper image); Lower Bagley Lake, Mt. Baker area, Whatcom County (lower image).



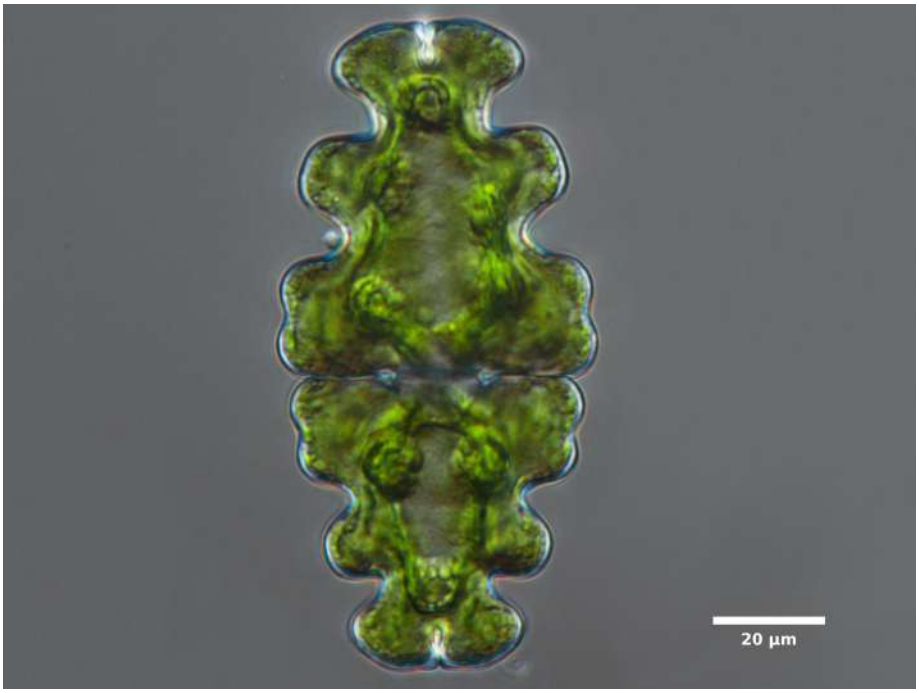


Figure 7.77: *Euastrum oblongum* (SEM/DIC), Mirror Lake, Whatcom County (upper image); small pond in Fairhaven Park, Whatcom County (lower image).

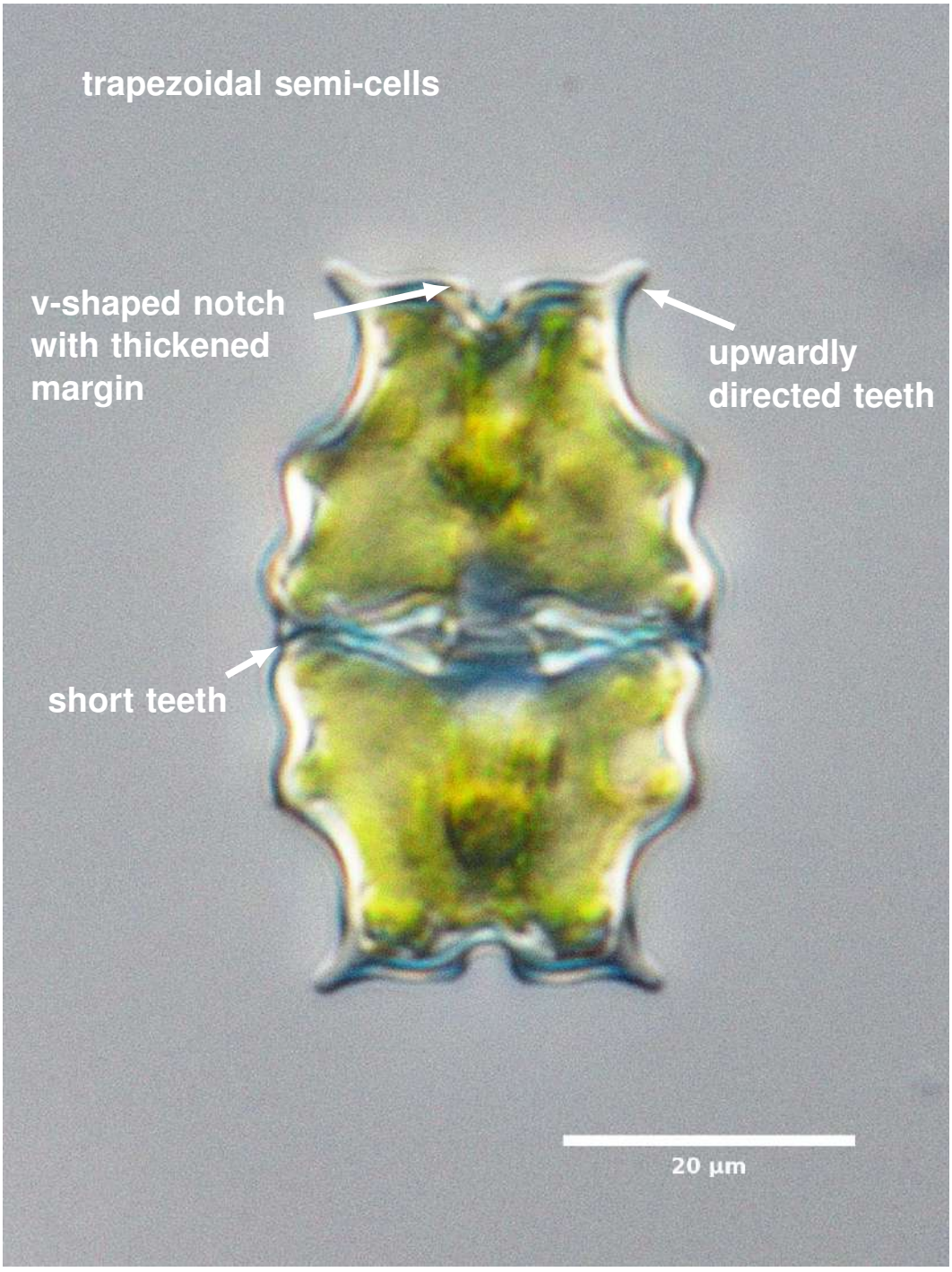
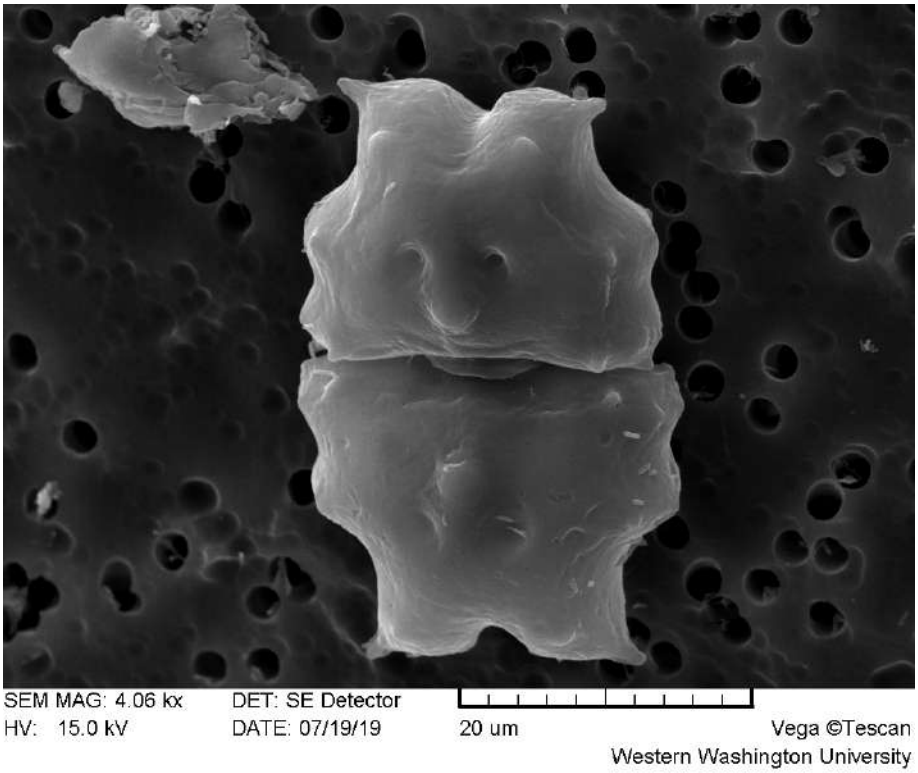


Figure 7.78: *Euastrum oculatum* (DIC), Chain Lake, Gifford Pinchot National Forest, Skamania County.



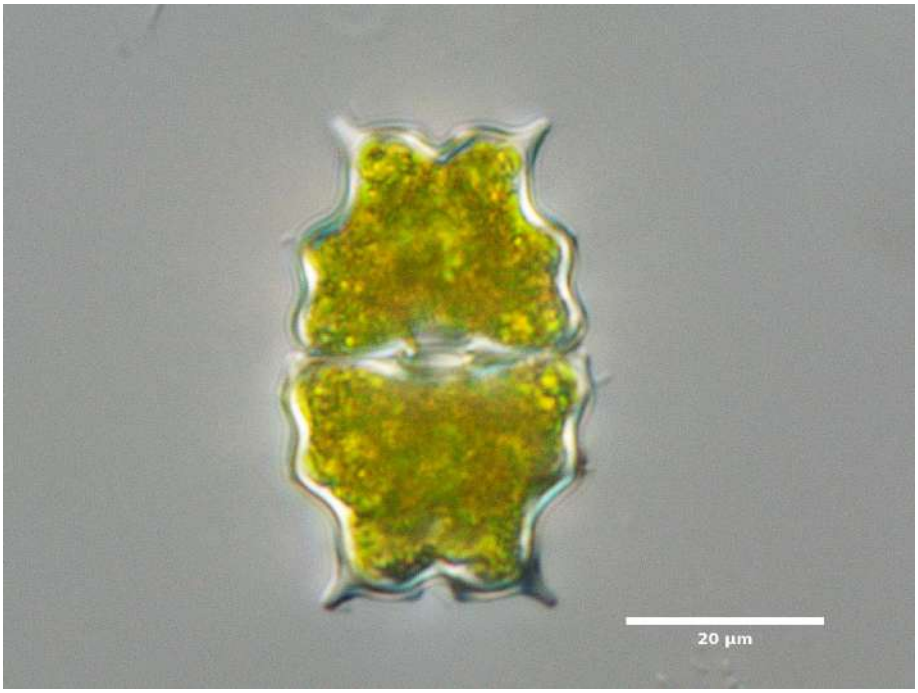


Figure 7.79: *Euastrum oculatum* (SEM/DIC), Chain Lake, Gifford Pinchot National Forest, Skamania County (upper/lower images).

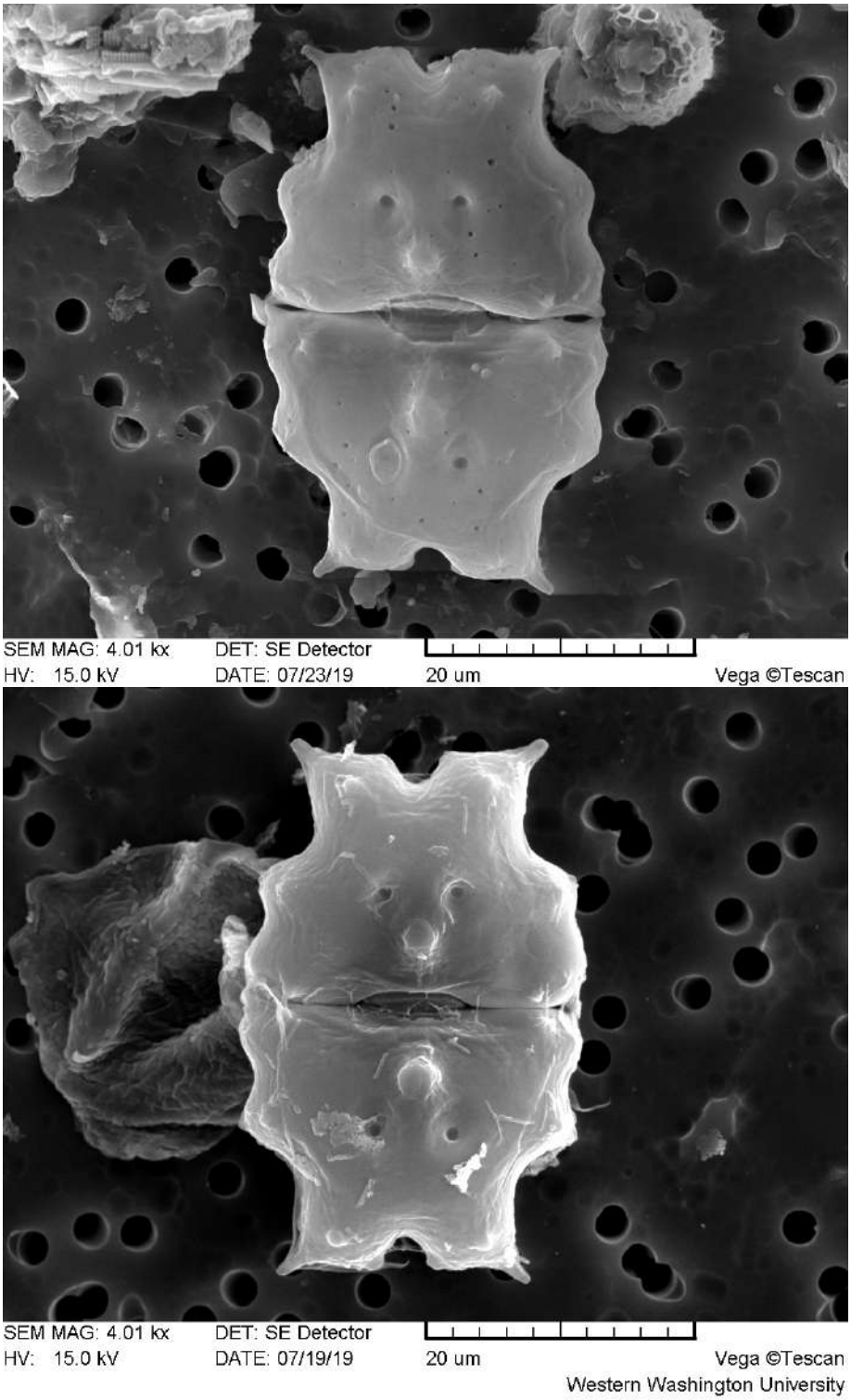


Figure 7.80: *Euastrum oculatum* (SEM/SEM), Chain Lake, Gifford Pinchot National Forest, Skamania County (upper/lower images).

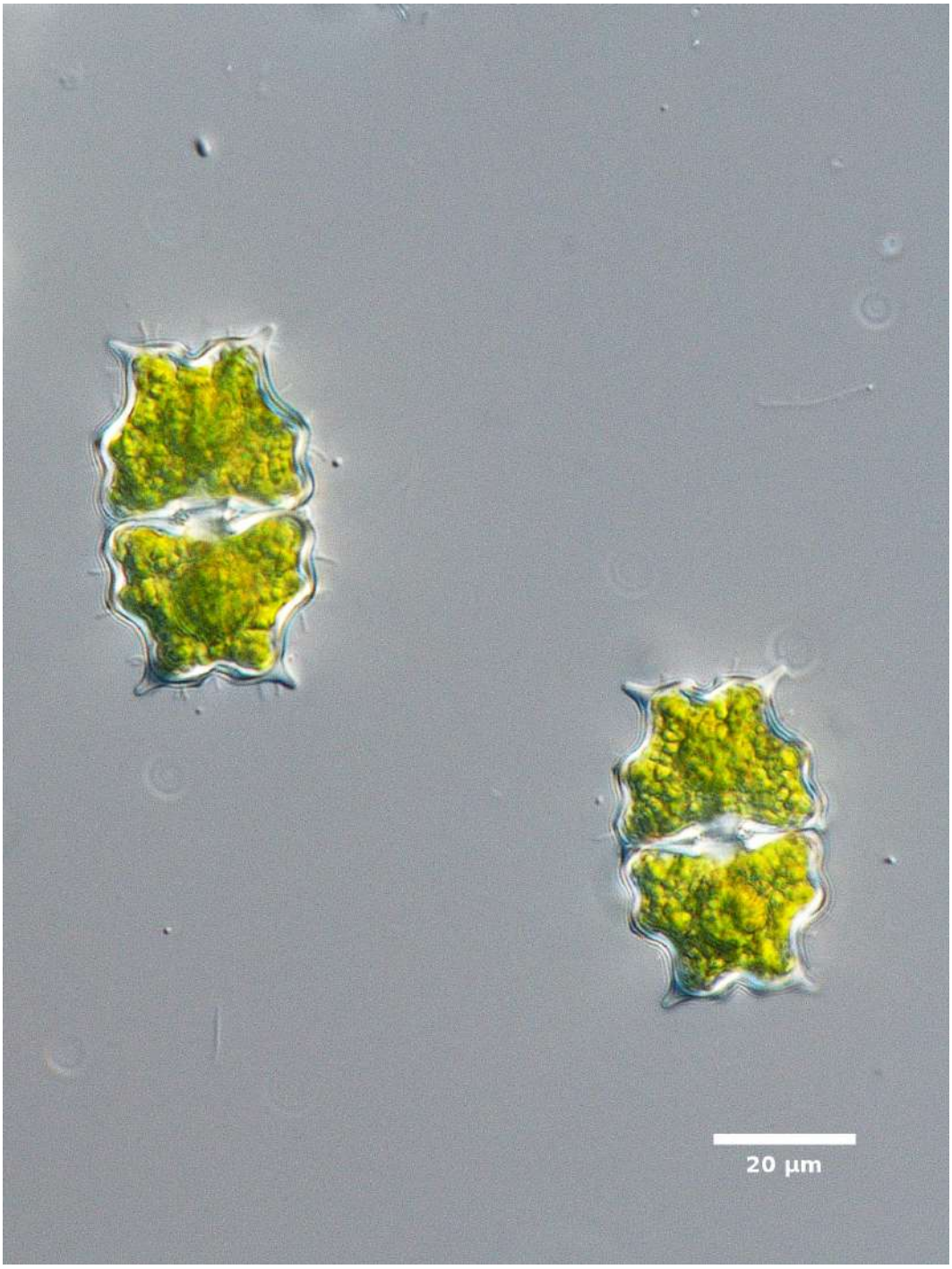


Figure 7.81: *Euastrum oculatum* (DIC), Chain Lake, Gifford Pinchot National Forest, Skamania County.

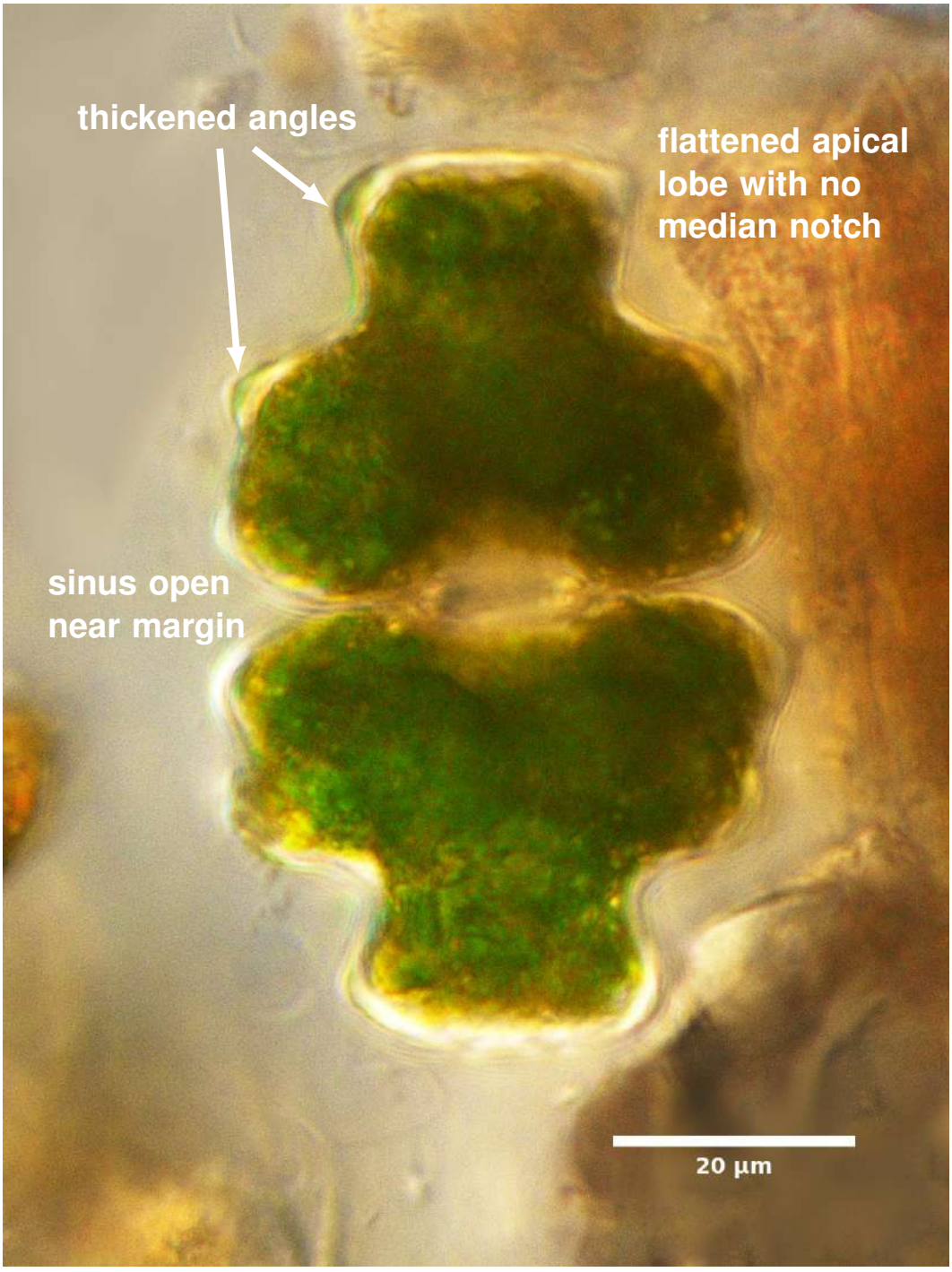


Figure 7.82: *Euastrum pectinatum* (DIC), Canyon Lake, Whatcom County.

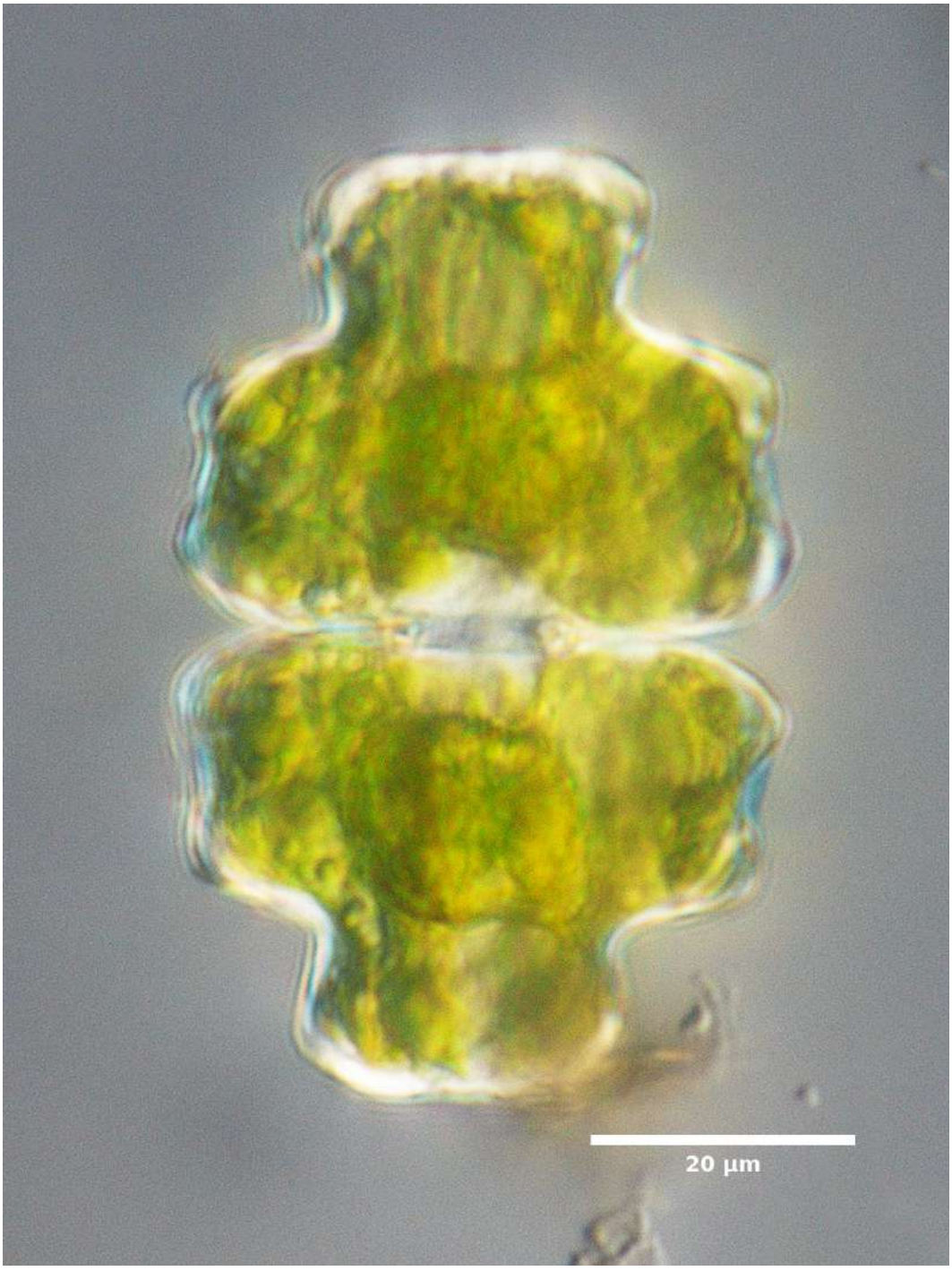


Figure 7.83: *Euastrum pectinatum* (DIC), Canyon Lake, Whatcom County.

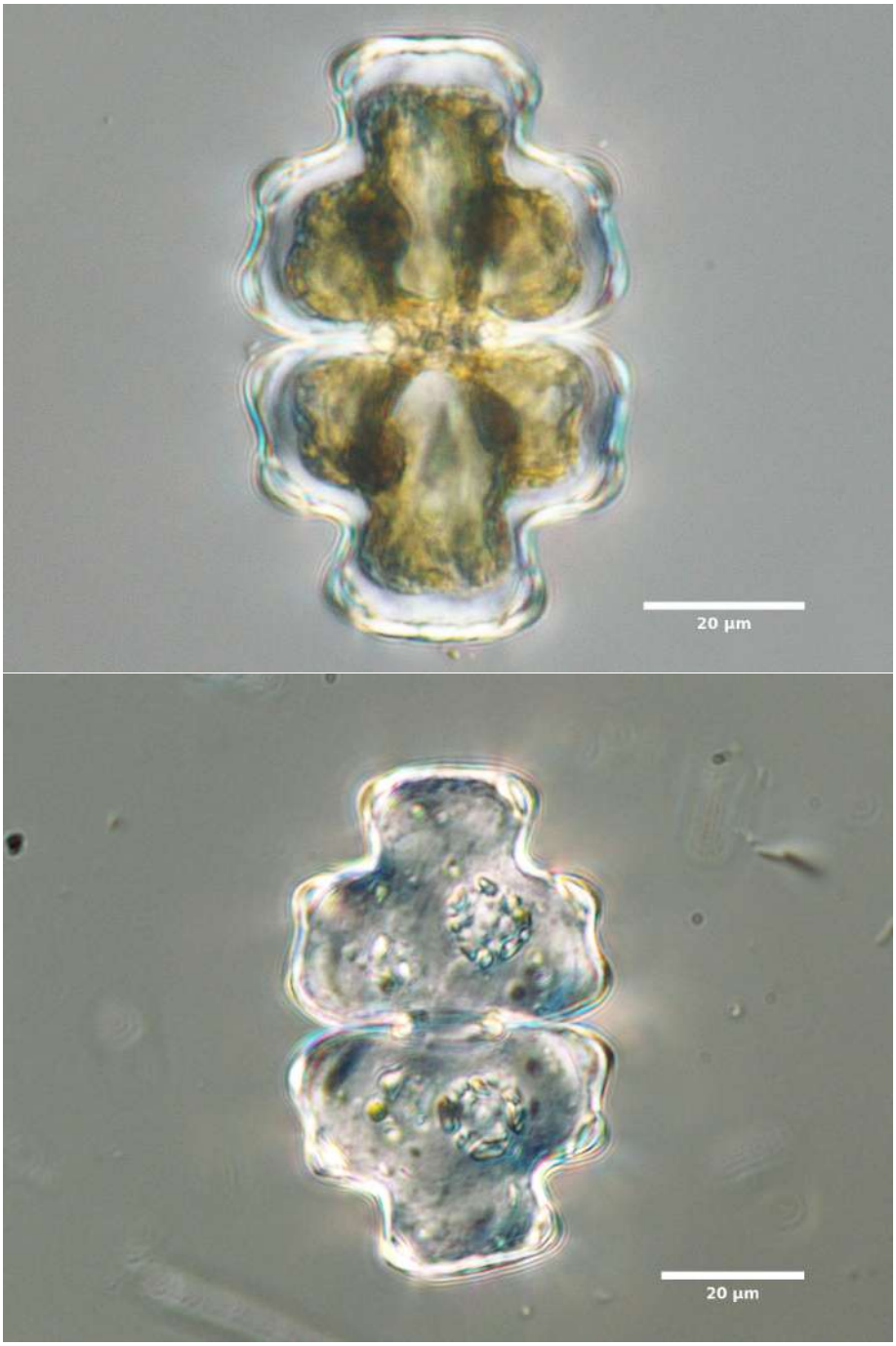


Figure 7.84: *Euastrum pectinatum* (DIC/DIC), stained with Lugol's iodine solution (upper image) or preserved in formalin (lower image), Canyon Lake, Whatcom County (upper image).

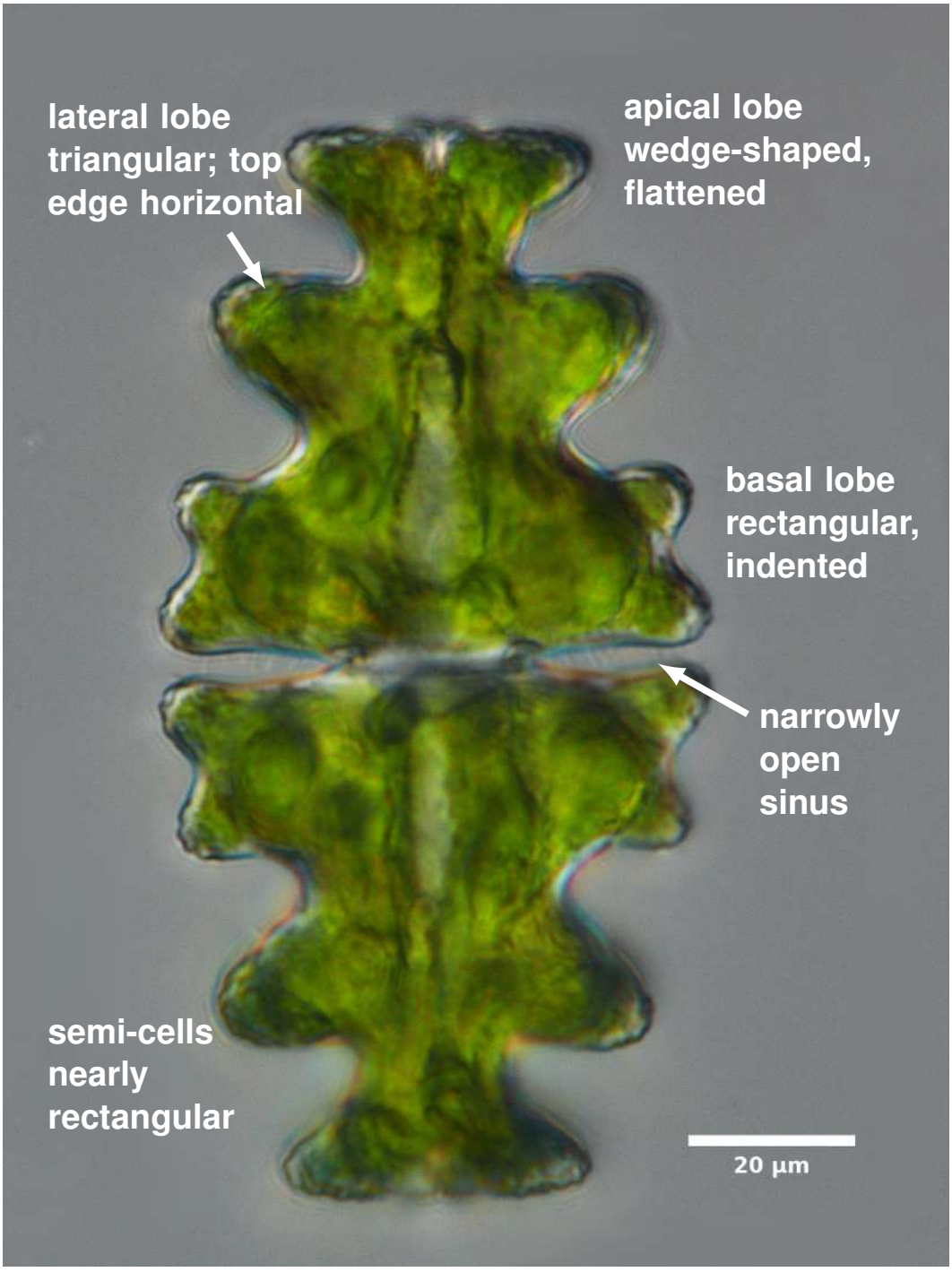


Figure 7.85: *Euastrum pinnatum* (DIC), Lake Evan, Mountain Loop Highway, Snohomish County.

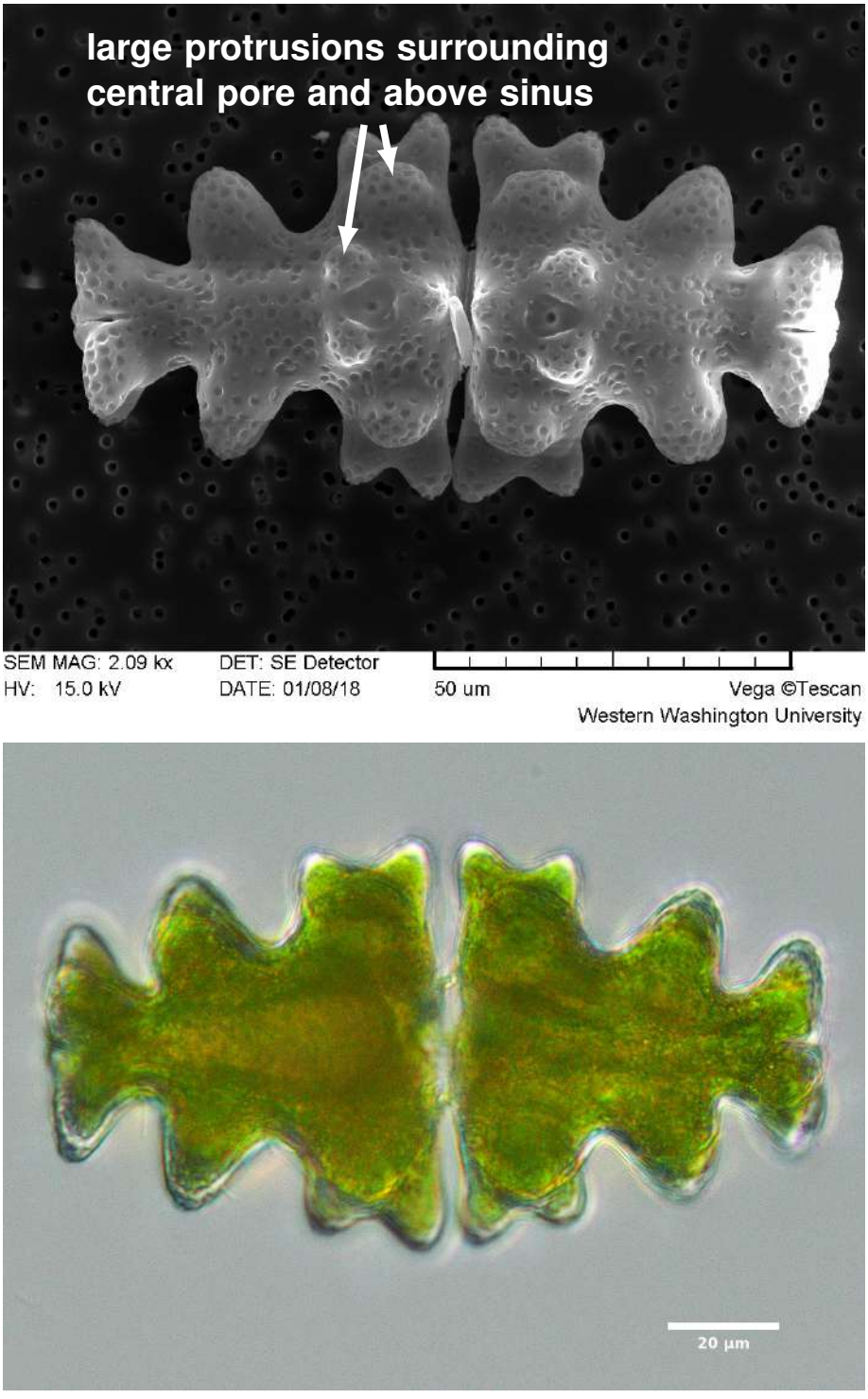
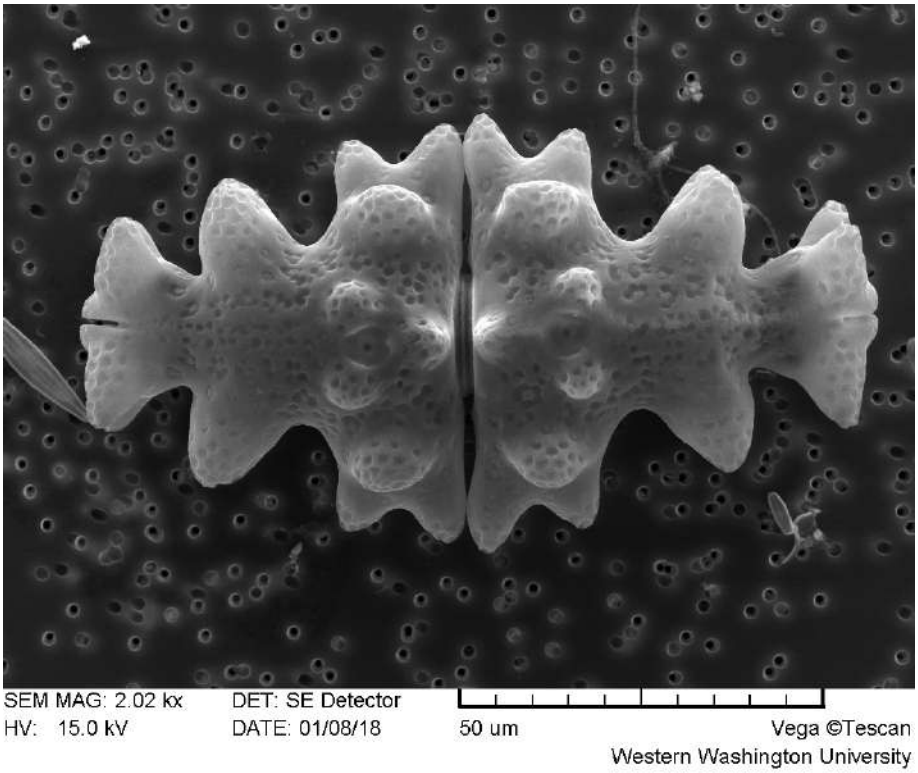


Figure 7.86: *Euastrum pinnatum* (SEM/DIC), Heather Lake, Mountain Loop Highway, Snohomish County (upper/lower images).



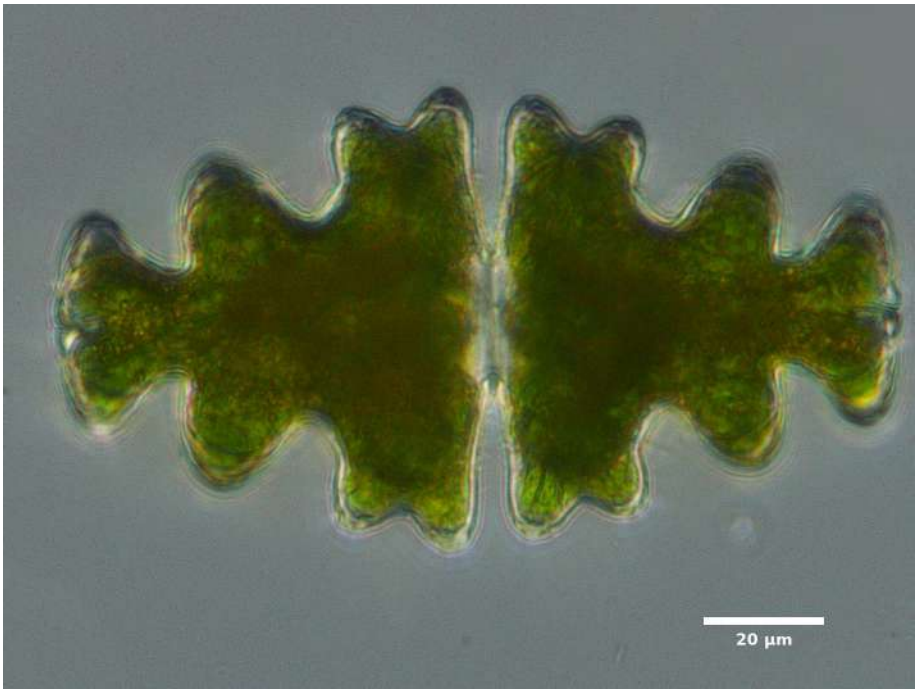


Figure 7.87: *Euastrum pinnatum* (SEM/DIC), Heather Lake, Mountain Loop Highway, Snohomish County (upper/lower images).

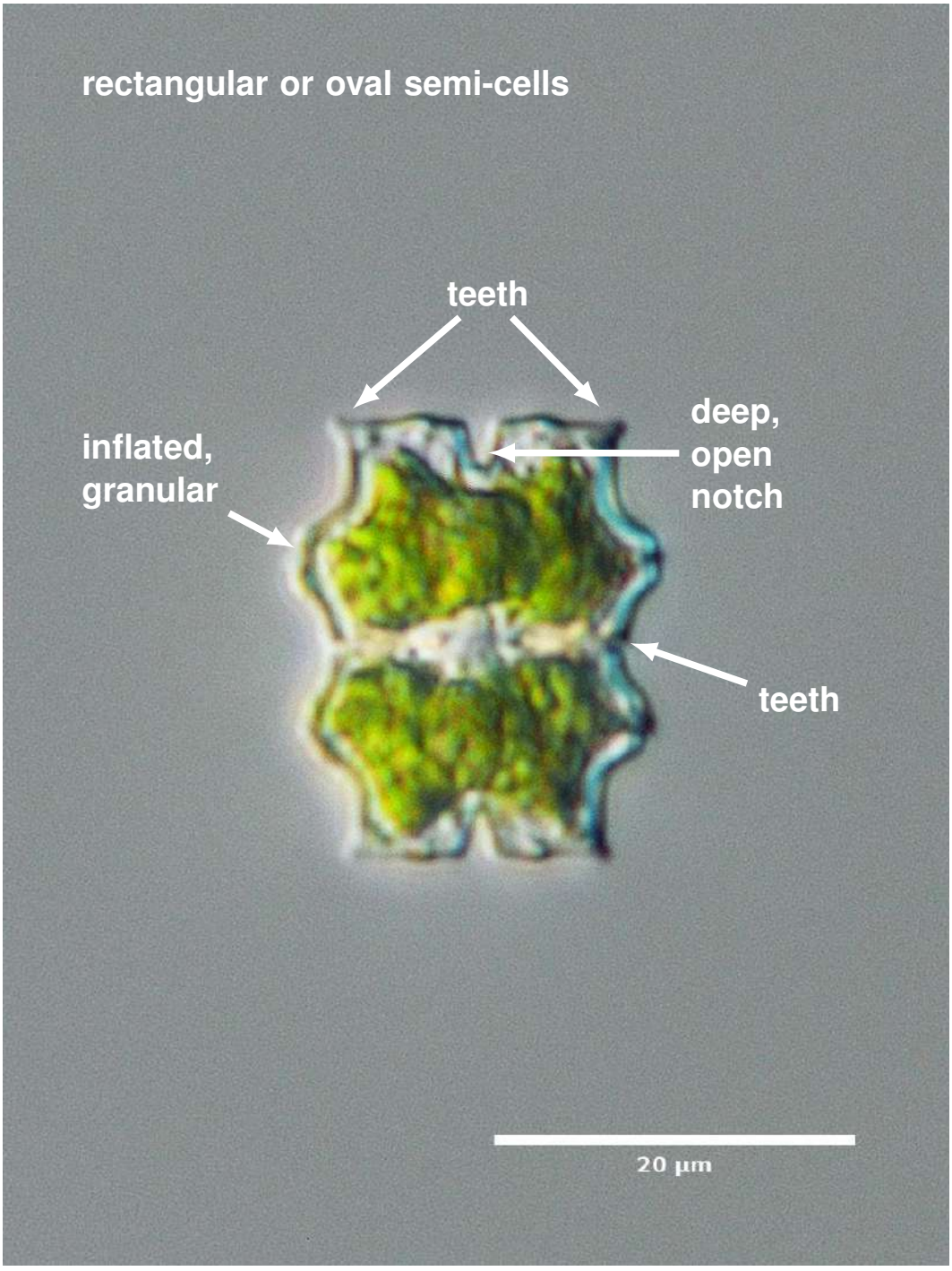


Figure 7.88: *Euastrum pulchellum* (DIC), Hoag Pond, Whatcom County.

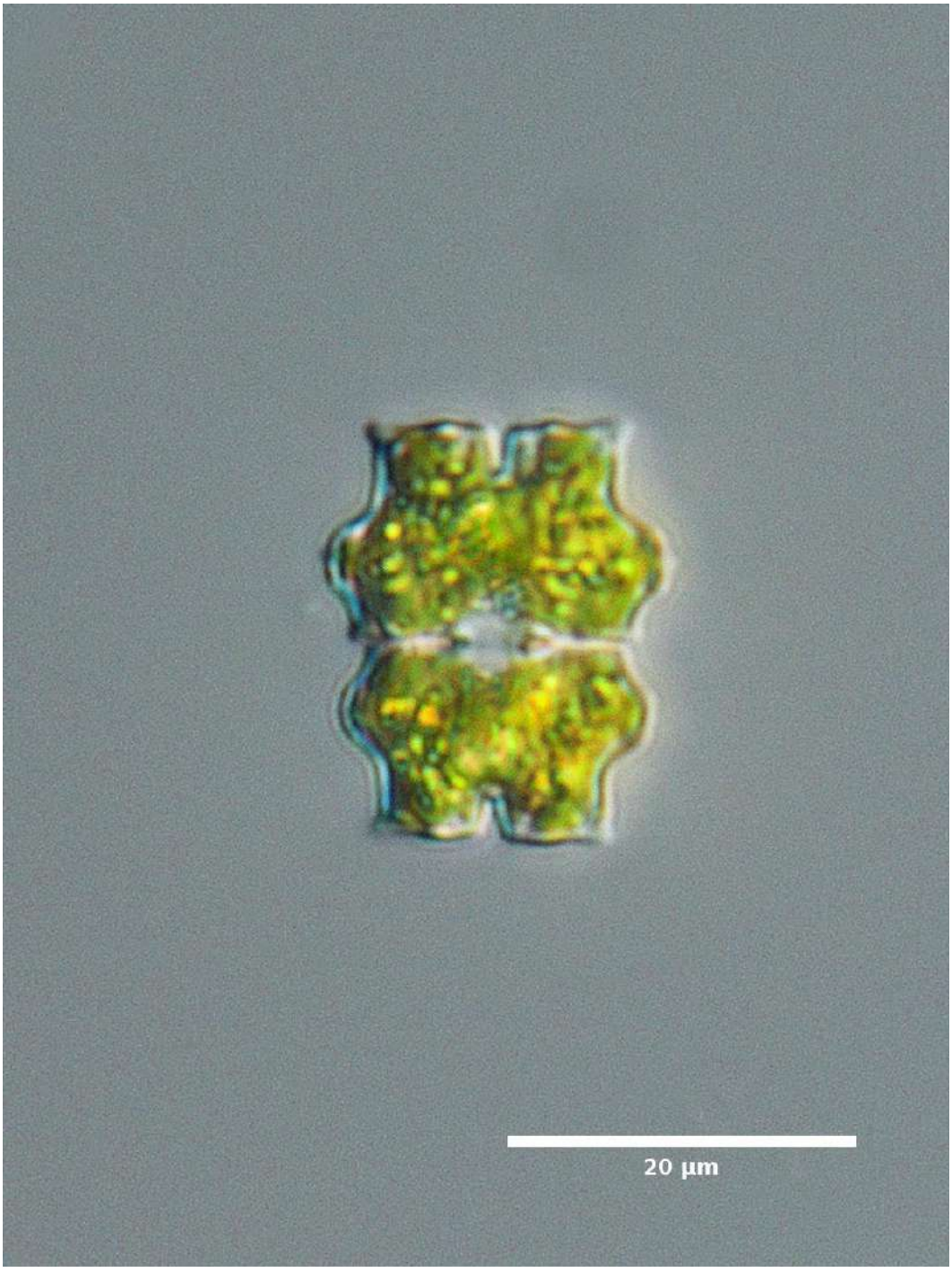


Figure 7.89: *Euastrum pulchellum* (DIC), Hoag Pond, Whatcom County.

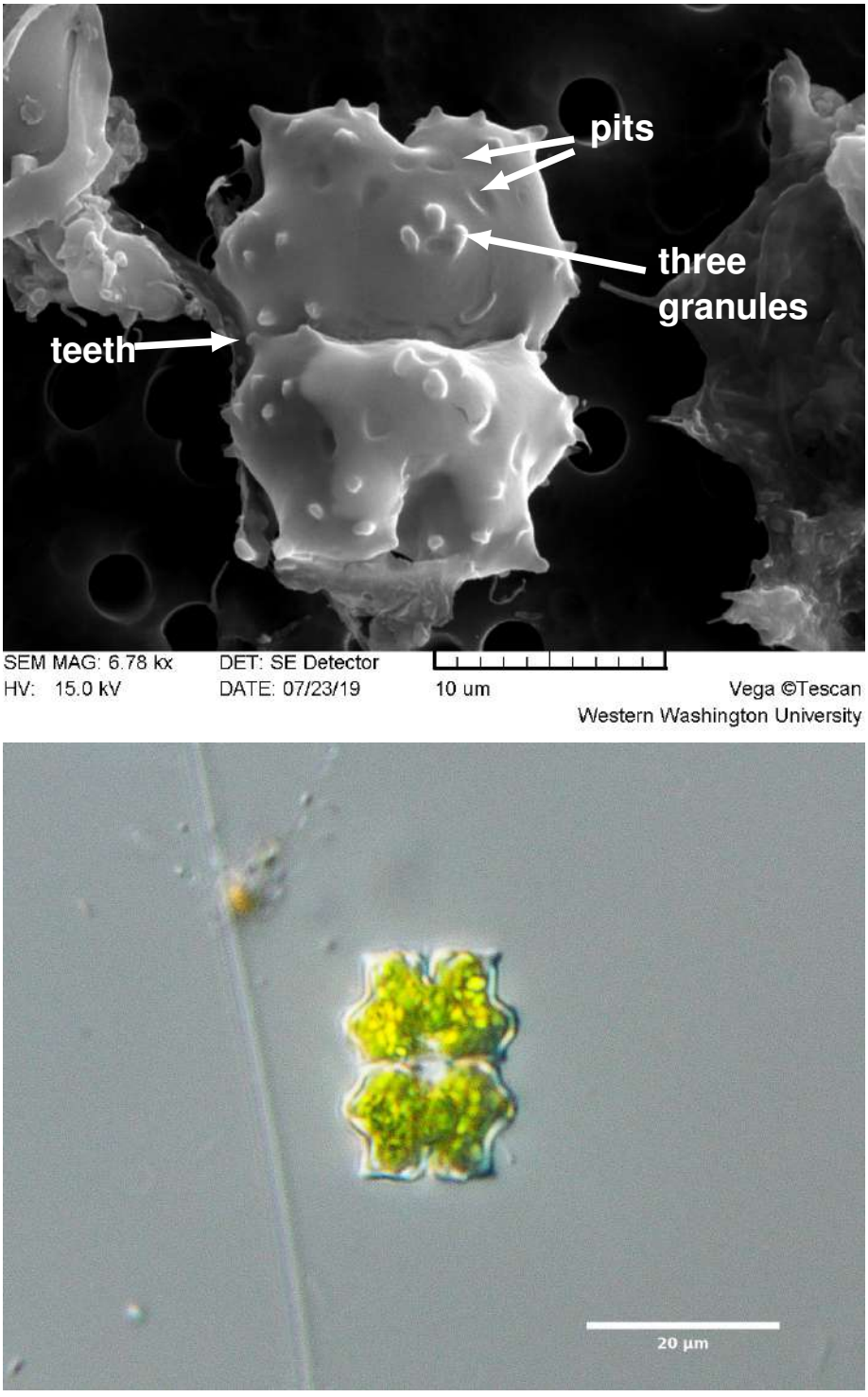


Figure 7.90: *Euastrum pulchellum* (SEM/DIC), Hoag Pond, Whatcom County (upper/lower images).

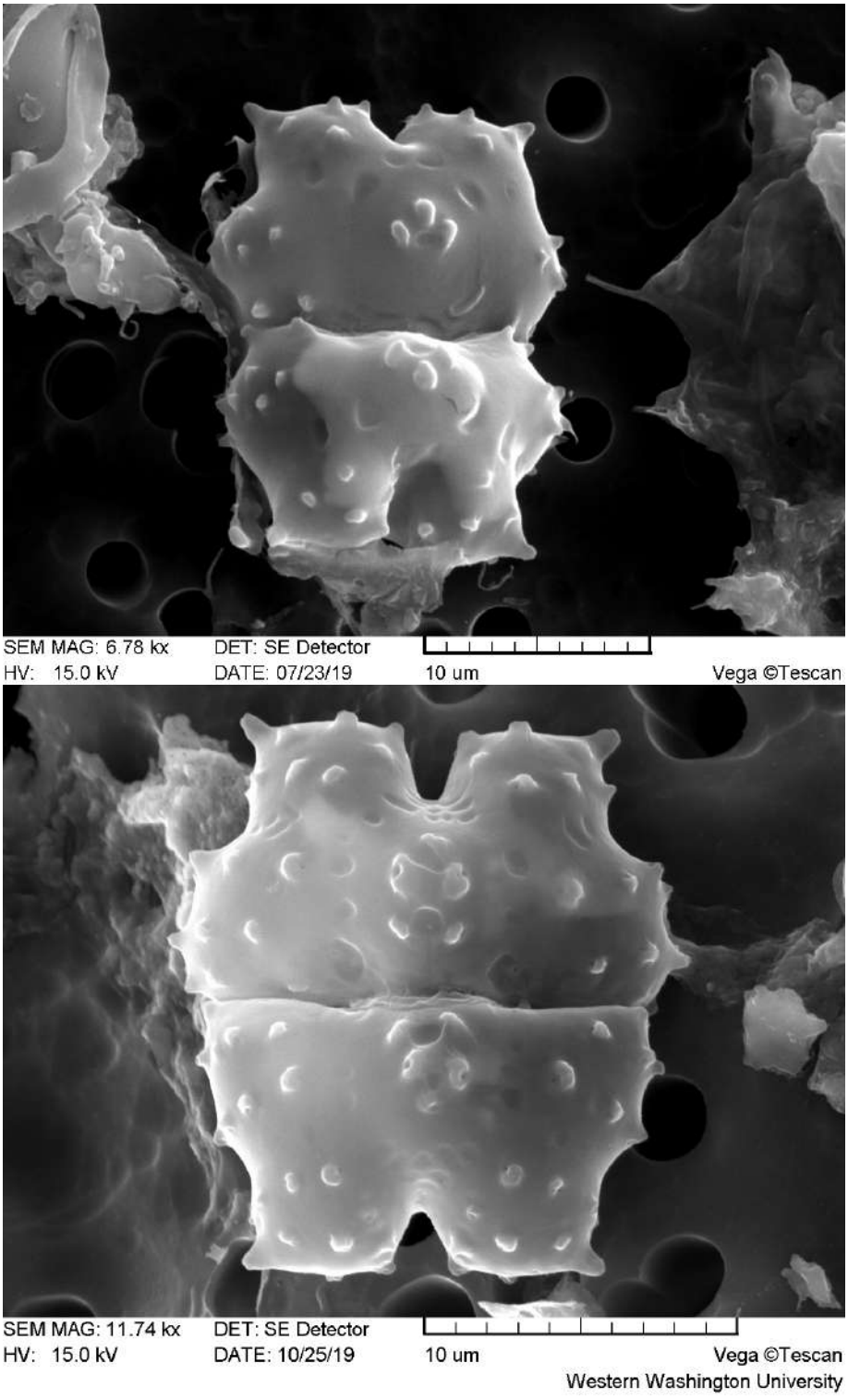


Figure 7.91: *Euastrum pulchellum* (SEM), Hoag Pond, Whatcom County (upper image); *Euastrum denticulatum* (SEM), Clear Lake, Skagit County (lower image).

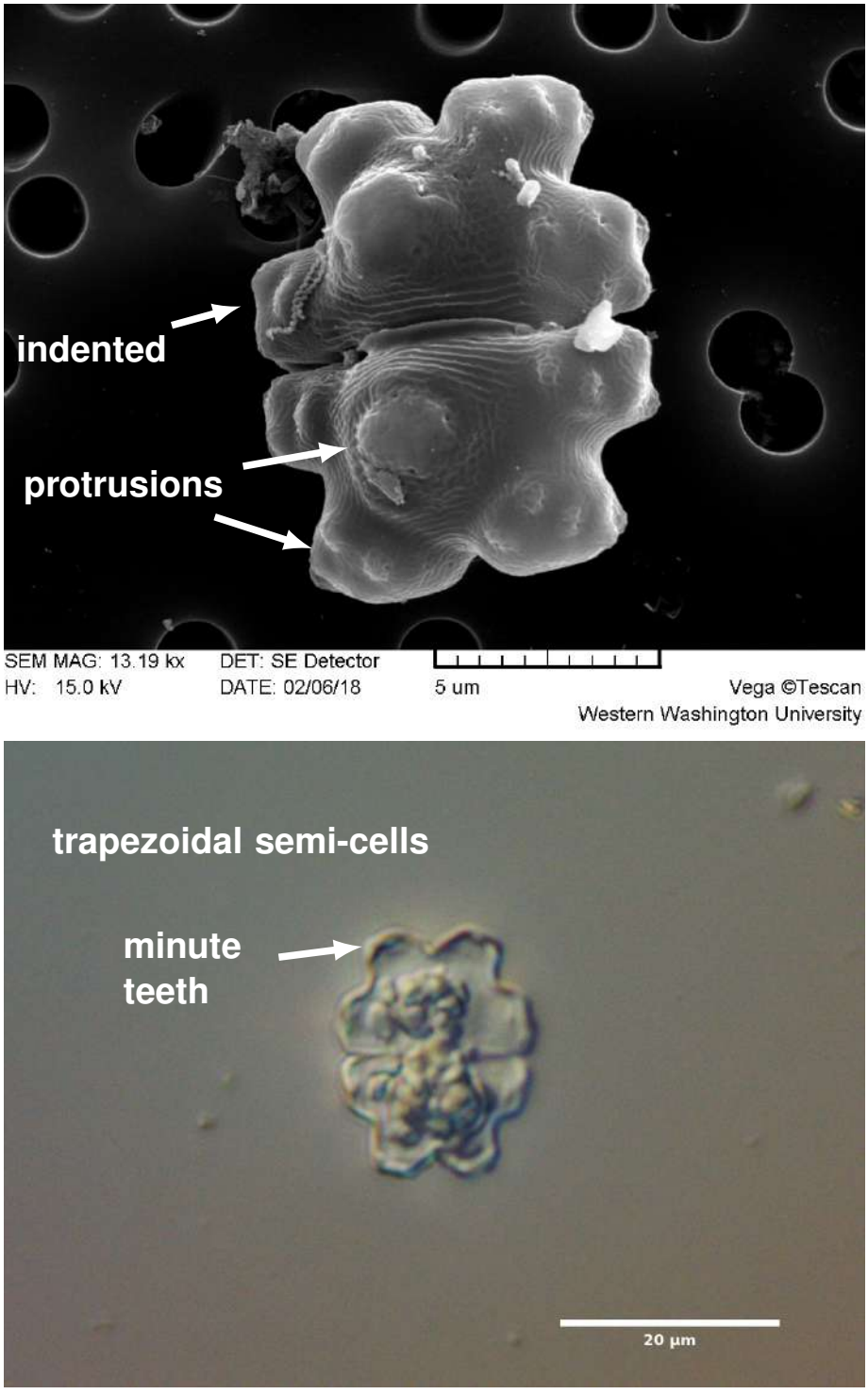


Figure 7.92: *Euastrum subalpinum* var. *crassum* (SEM/DIC), Upper Anderson Lake, Mt. Baker area, Whatcom County (upper/lower images).

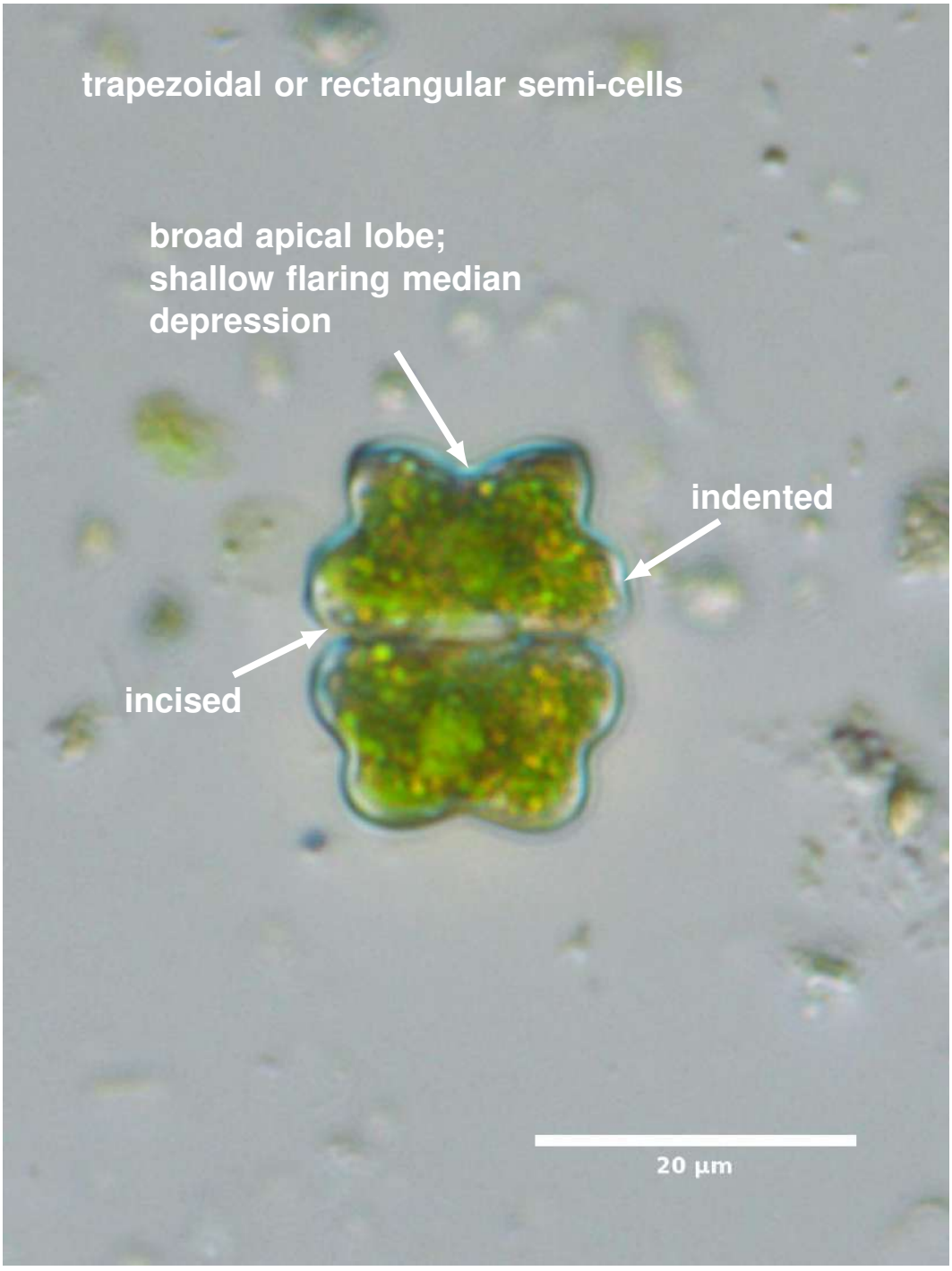


Figure 7.93: *Euastrum sublobatum* (DIC), small pond on trail to Dock Butte, Mt. Baker area, Skagit County.

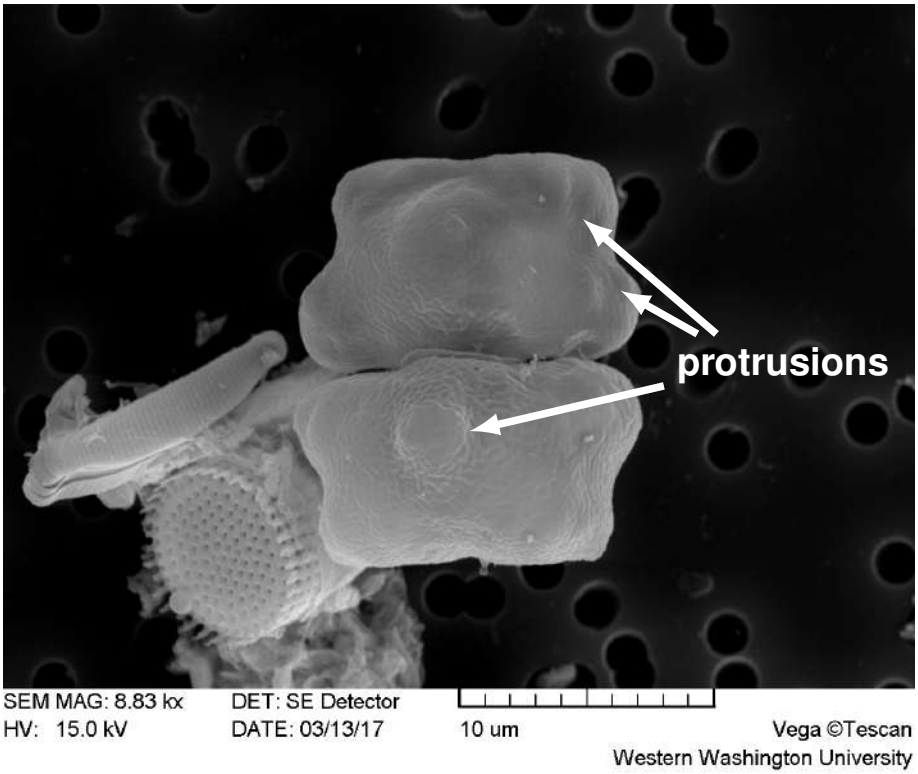




Figure 7.94: *Euastrum sublobatum* (SEM/DIC), small pond near Canyon Lake, Whatcom County (upper/lower images).

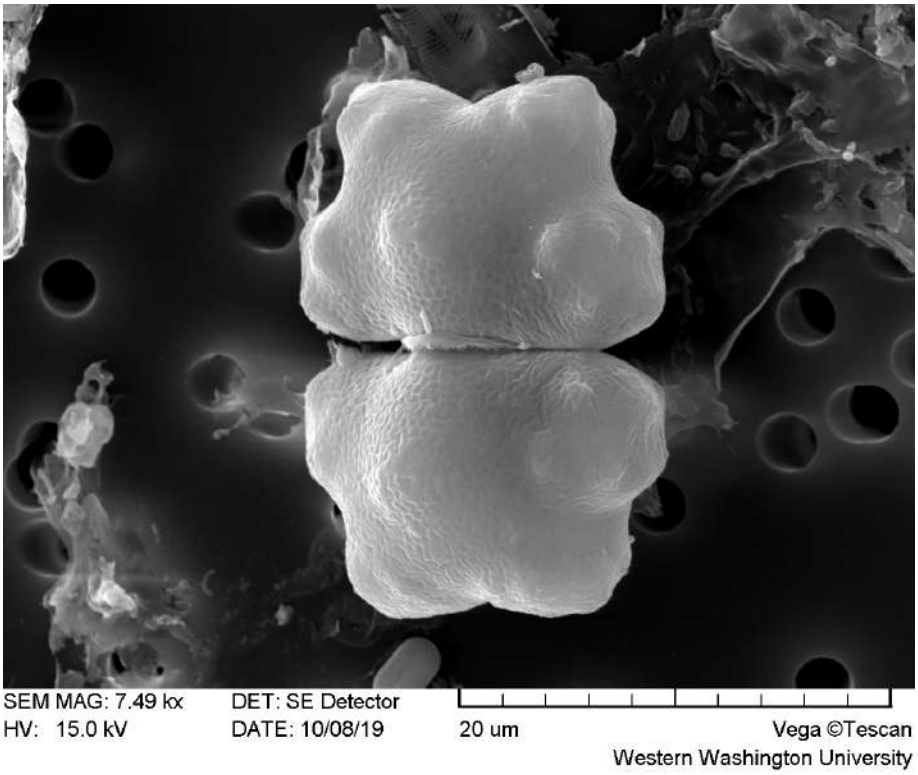




Figure 7.95: *Euastrum sublobatum* (SEM/DIC), small pond on trail to Lake Ann, Mt. Baker area, Whatcom County (upper/lower images).

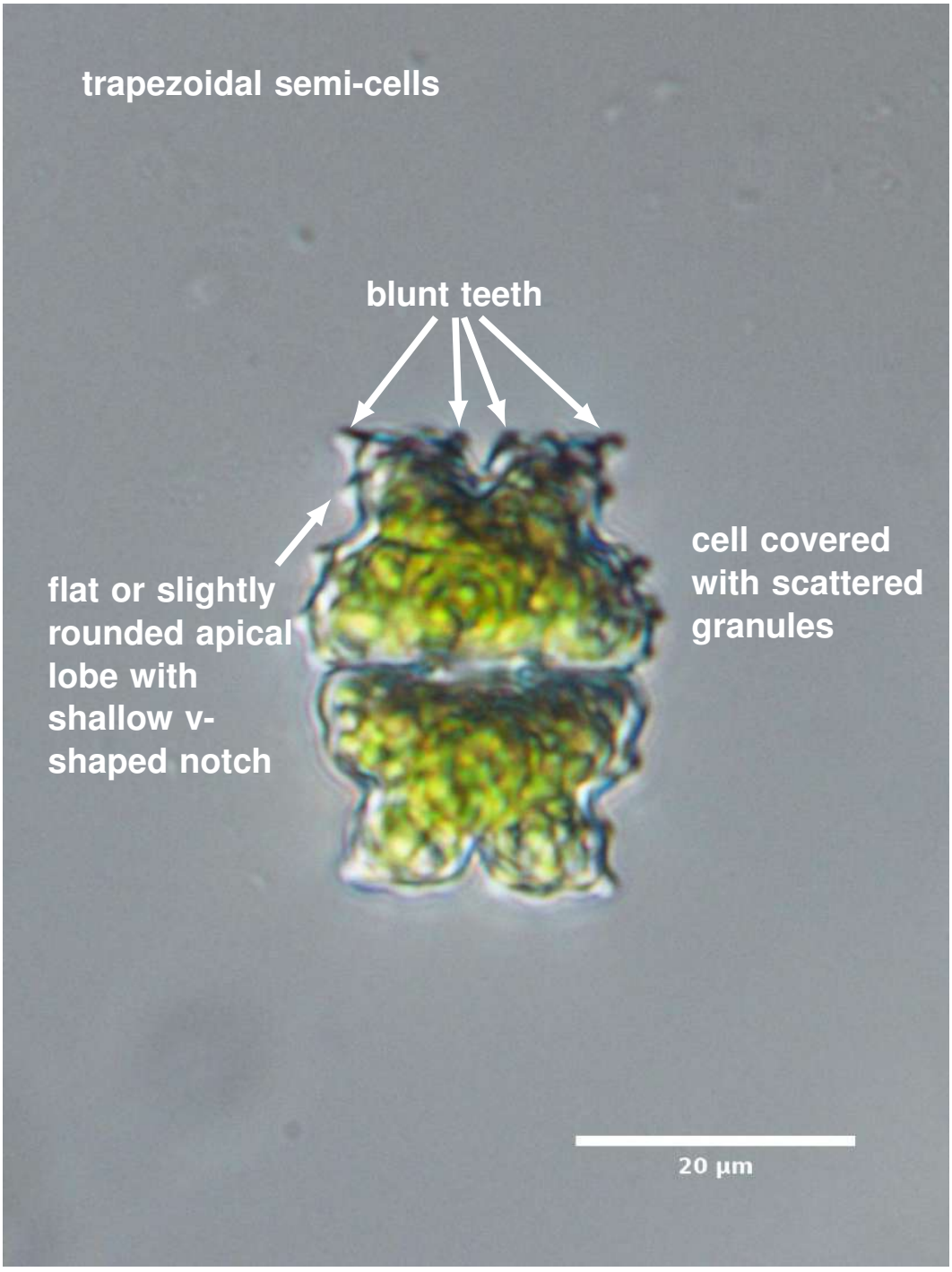


Figure 7.96: *Euastrum turneri* (DIC), Bear Lake, Mountain Loop Highway, Snohomish County.



Figure 7.97: *Euastrum turneri* (DIC), Lower Ashland Lake, Mountain Loop Highway, Snohomish County.

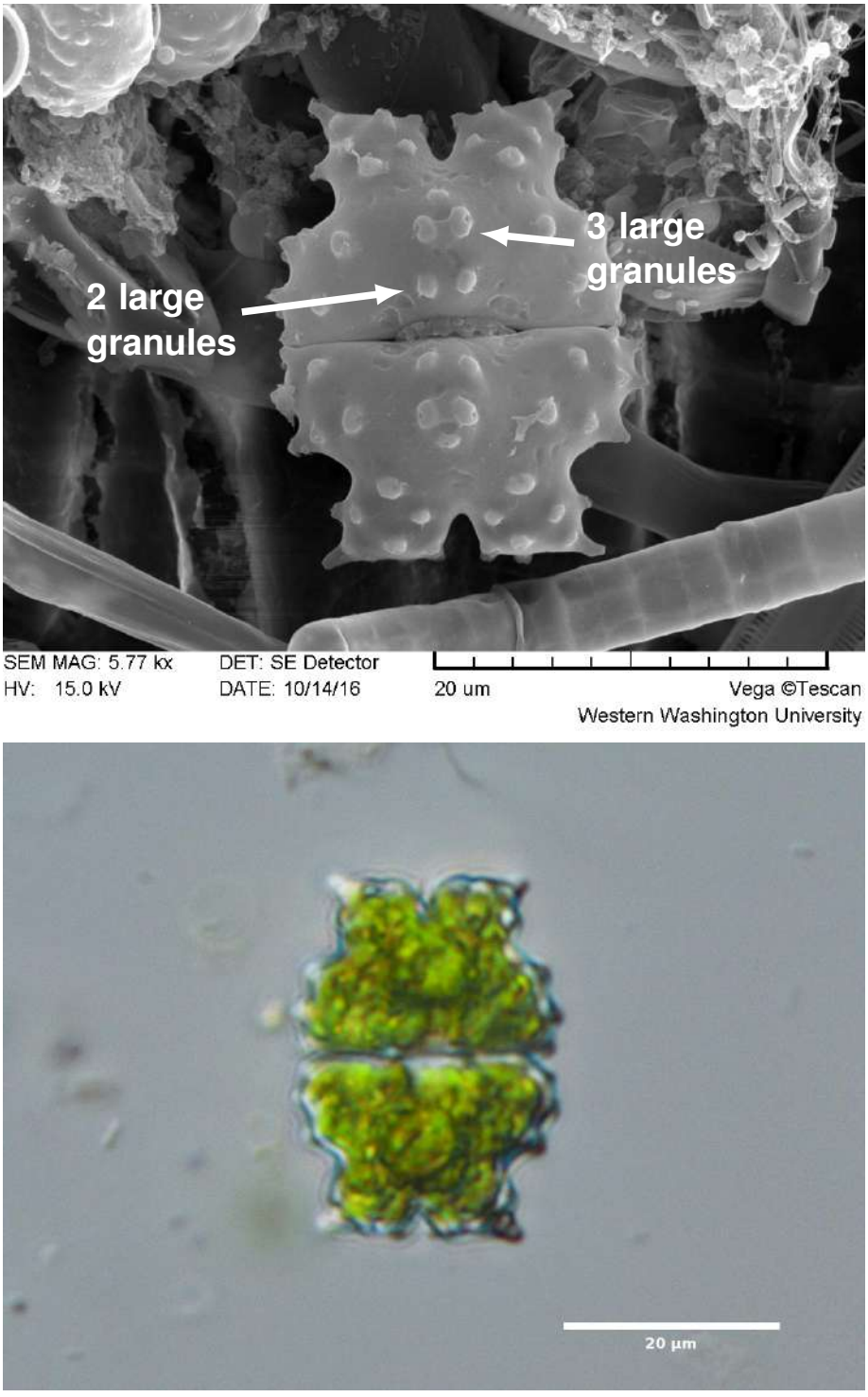


Figure 7.98: *Euastrum turneri* (SEM/DIC), Bear Lake, Mountain Loop Highway, Snohomish County (upper/lower images). See Figure 7.31 for additional DIC and SEM examples of *Euastrum turneri*.

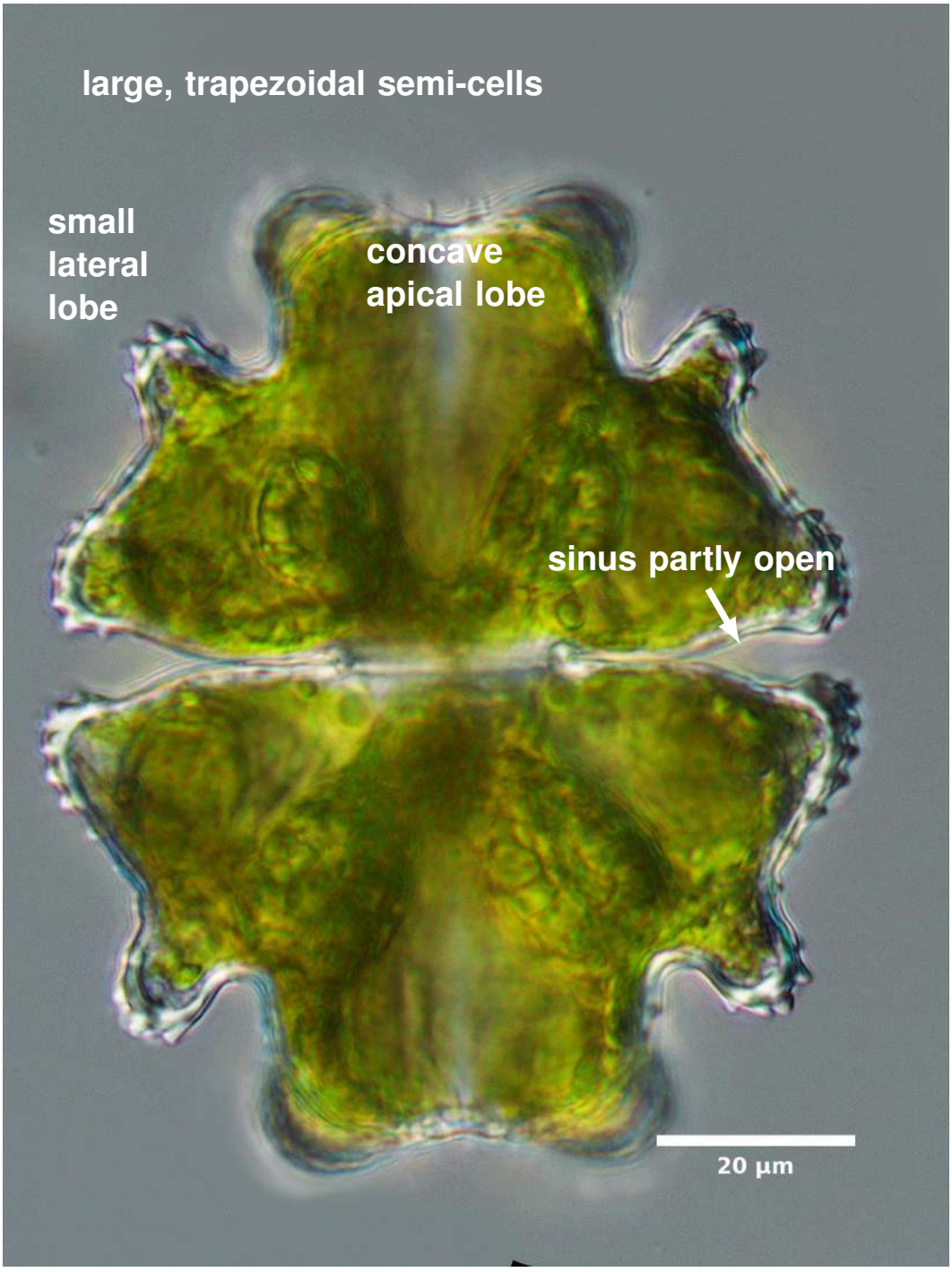


Figure 7.99: *Euastrum verrucosum* (DIC), Lower Anderson Lake, Mt. Baker area, Whatcom County.

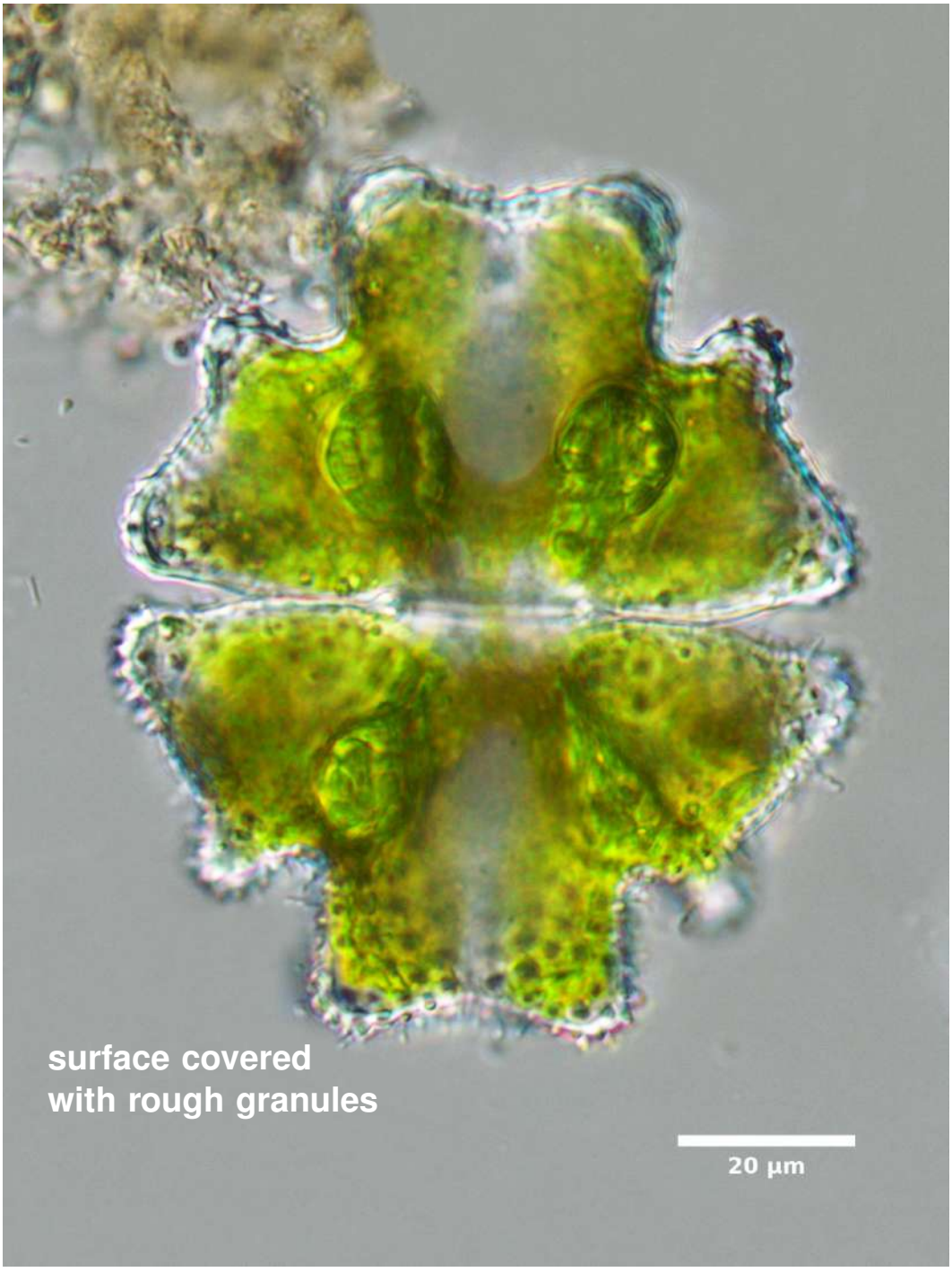


Figure 7.100: *Euastrum verrucosum* (DIC), Highwood Lake, Mt. Baker area, Whatcom County.

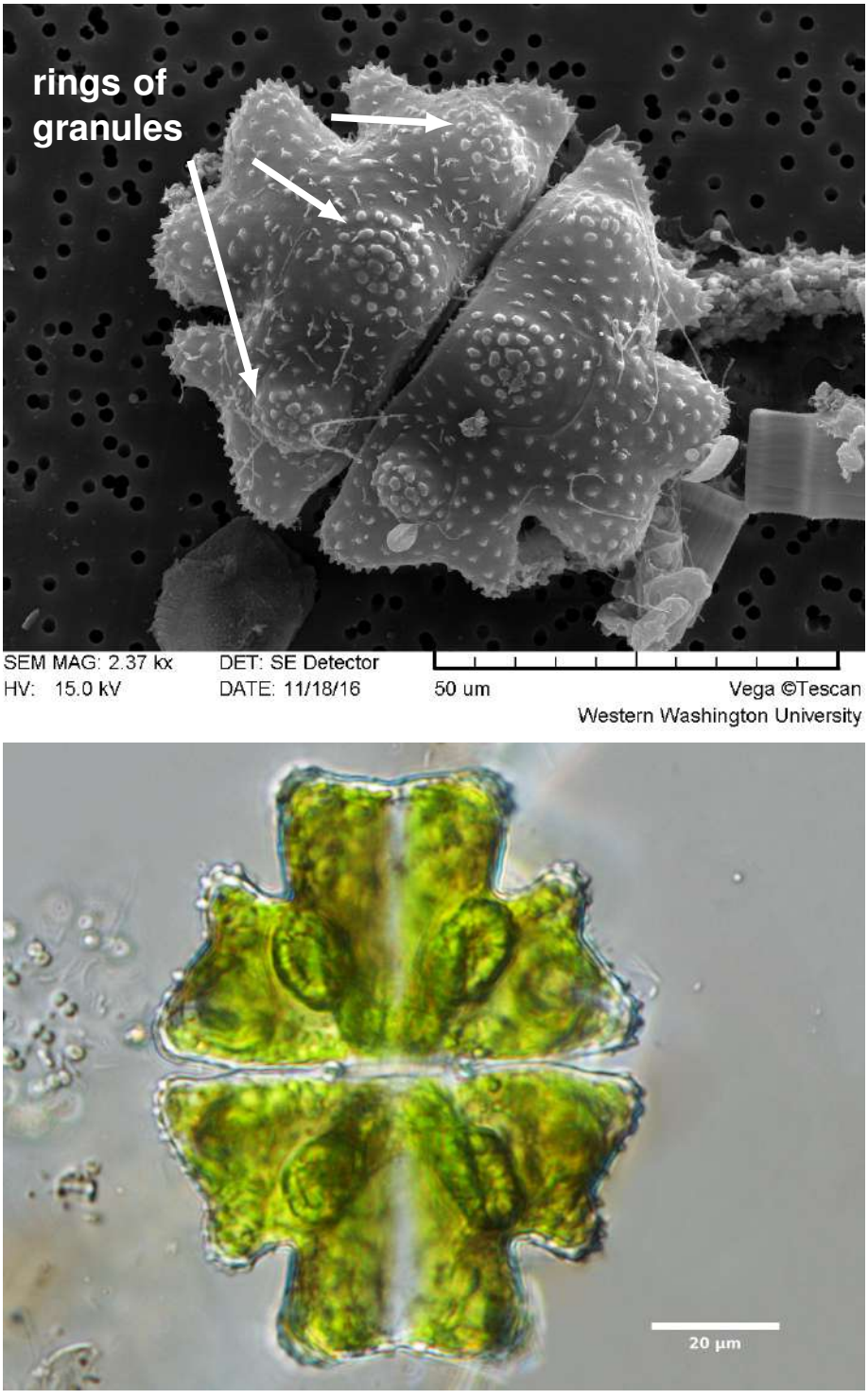


Figure 7.101: *Euastrum verrucosum* (SEM/DIC), Picture Lake, Mt. Baker area (upper/lower images).

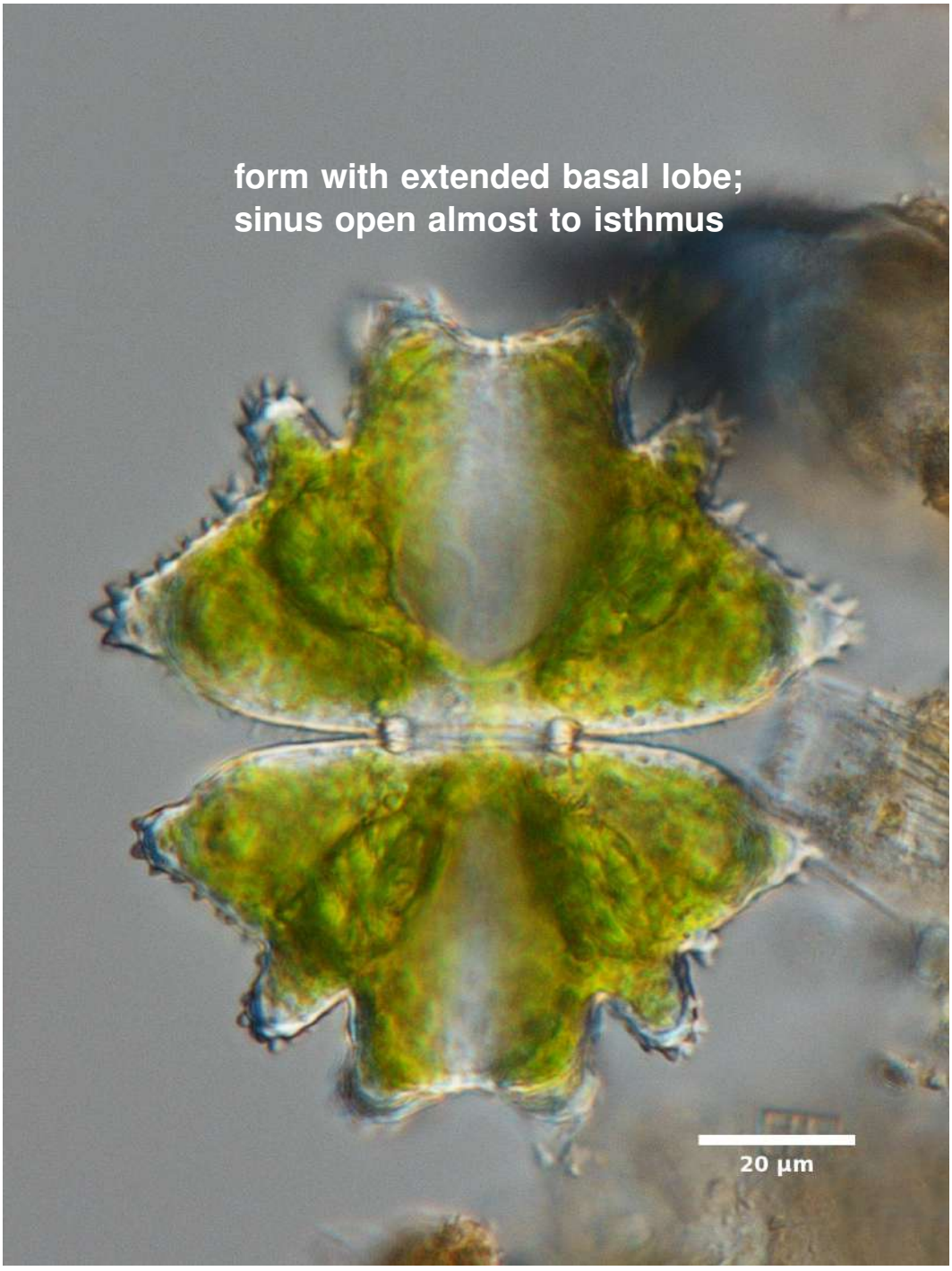


Figure 7.102: *Euastrum verrucosum* (DIC), Lower Bagley Lake, Mt. Baker area, Whatcom County.

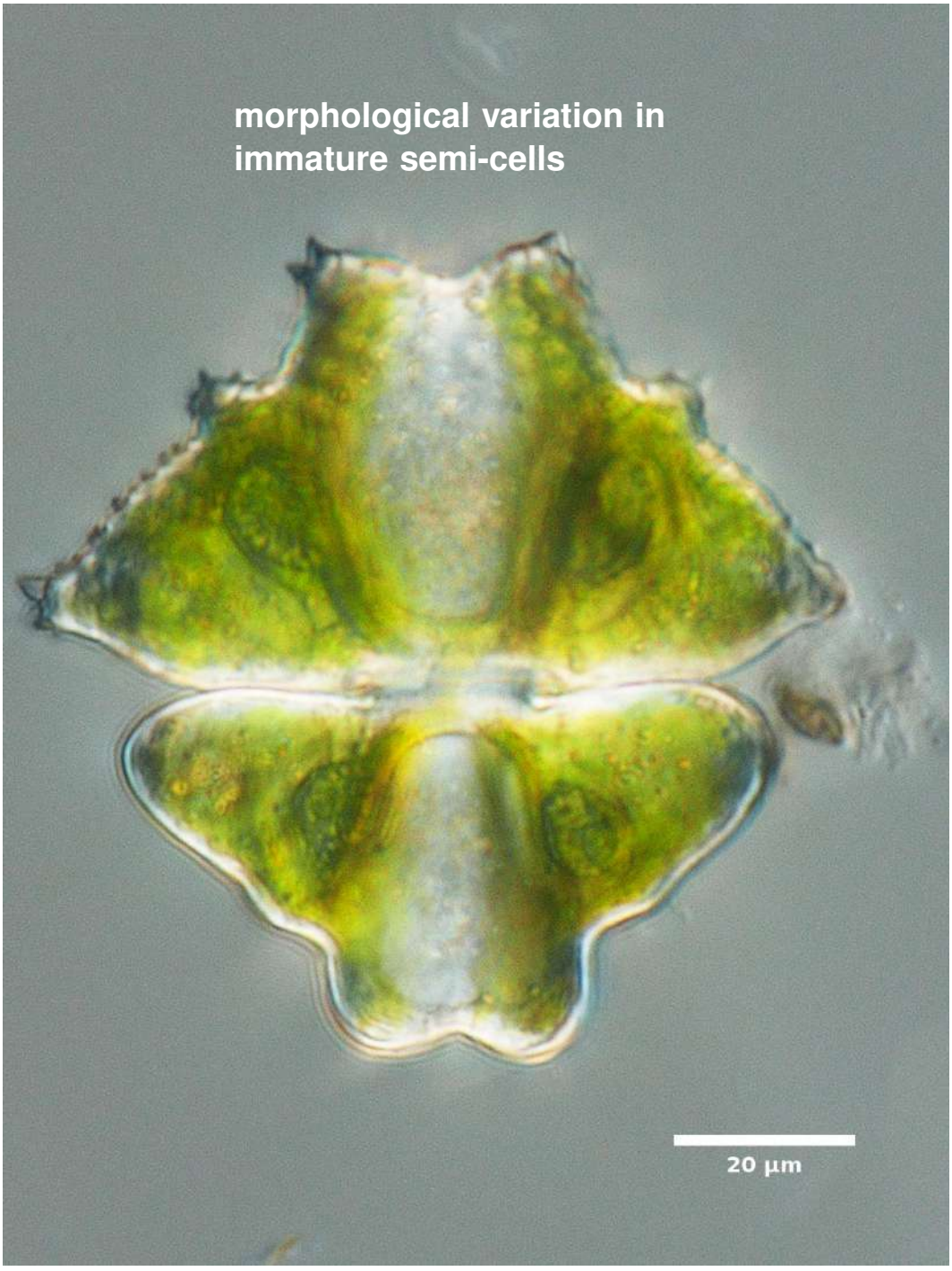


Figure 7.103: *Euastrum verrucosum* (DIC), Lower Twin Lake, Mt. Baker area, Whatcom County.

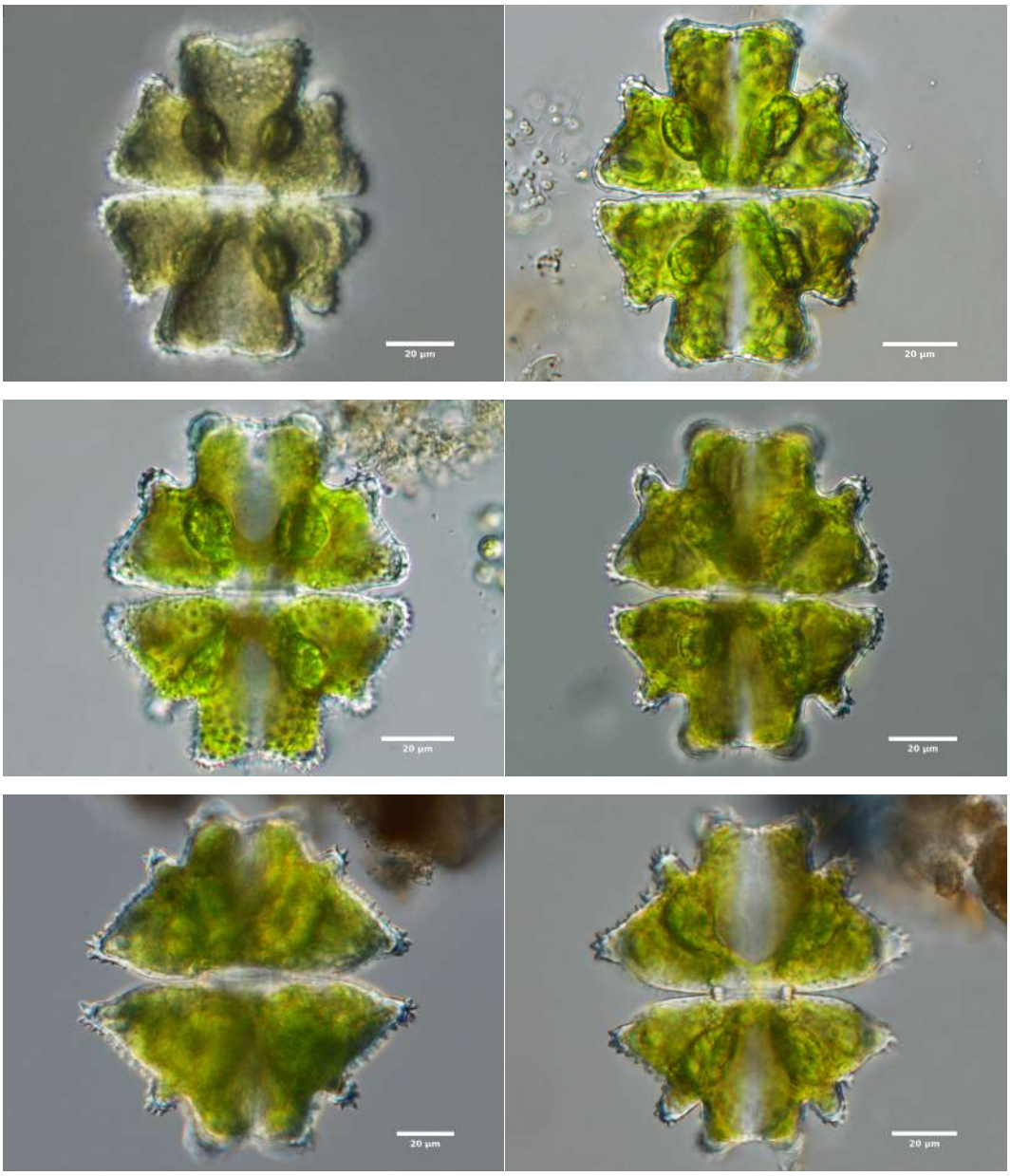


Figure 7.104: *Euastrum verrucosum* (DIC), morphological variations for specimens collected in the Mt. Baker area, Whatcom County.

Chapter 8

Genicularia De Bary and *Gonatozygon* De Bary

Northwest Washington taxa
Genicularia cf. *elegans* (West & G. S. West) Molinari & Guiry
Gonatozygon aculeatum W. N. Hastings
Gonatozygon brebissonii De Bary
Gonatozygon brebissonii var. *minutum* (West) West & G. S. West
Gonatozygon kinahanii (W. Archer) Rabenhorst
Gonatozygon monotaenium De Bary

Table 8.1: Key to *Genicularia* and *Gonatozygon* Species

A	Cells narrowly fusiform, tapering to a slightly expanded apex; cell walls distinctly granular	*Gonatozygon brebissonii* (Figures 8.7–8.10)
B	Cells cylindrical, untapered; cell walls smooth, granular, or spiny	
B.1	Cells with two spiralling chloroplasts; cells often bent; cell wall appears smooth, but has very small granules	*Genicularia* cf. *elegans* (Figures 8.1–8.2)

continued on next page

Table 8.1: Key to *Genicularia* and *Gonatozygon* Species, continued

B.2	Cells with one flat chloroplast; walls smooth; apex expanded or unexpanded; cells relatively large; often forming long filaments	*Gonatozygon kinahanii* (Figures 8.11–8.15)
B.3	Cells with one flat chloroplast; walls covered with granules or spines	
	B.3a Apex expanded then narrowed (club-shaped); cell wall covered with sharp, stout spines	*Gonatozygon aculeatum* (Figures 8.3–8.6)
	B.3b Apex slightly expanded and flattened (spatulate); cell wall covered with granules or short, conical teeth	*Gonatozygon monotaenium* (Figures 8.16–8.19)

Table 8.2: *Genicularia* and *Gonatozygon* Cell Measurements

		Cell Width	Cell Length	Isthmus Width	L/W Ratio
Genicularia cf. *elegans*	min	10.5 μm	178.0 μm	NA	12.7
	med	14.4 μm	207.6 μm	NA	17.5
	max	16.3 μm	463.6 μm	NA	29.2
Gonatozygon aculeatum	min	7.0 μm	55.1 μm	NA	7.4
	med	7.4 μm	97.8 μm	NA	12.9
	max	8.6 μm	124.7 μm	NA	17.3
Gonatozygon brebissonii	min	4.2 μm	114.6 μm	NA	17.4
	med	7.3 μm	203.1 μm	NA	26.0
	max	8.5 μm	286.7 μm	NA	43.0
Gonatozygon brebissonii var. *minutum*[†]	min	4.8 μm	64.6 μm	NA	11.9
	med	5.1 μm	64.8 μm	NA	12.8
	max	5.4 μm	65.5 μm	NA	13.6

Table 8.2: *Genicularia* and *Gonatozygon* Cell Measurements, continued

		Cell Width	Cell Length	Isthmus Width	L/W Ratio
Gonatozygon kinahanii	min	12.0 μm	131.0 μm	NA	7.6
	med	15.9 μm	284.2 μm	NA	14.1
	max	26.4 μm	593.8 μm	NA	43.0
Gonatozygon monotaenium	min	7.4 μm	93.8 μm	NA	12.7
	med	10.7 μm	203.5 μm	NA	18.6
	max	15.9 μm	311.4 μm	NA	28.3

[†]*summary statistics based on <5 cells*

Description

Genicularia and *Gonatozygon* cells are long, cylindrical or fusiform, and unconstricted at the sinus (Figures 8.1–8.19). *Gonatozygon* resembles saccoderm desmids (see discussion on page 10), but the semi-cells are separated by a faint suture line, making *Gonatozygon* a placoderm desmid. The cells may form fragile filaments that break apart easily, so solitary cells and filaments may be present in the same sample. Each semi-cell contains one or more ribbon-like chloroplasts that run the length of the cell. *Genicularia* has two (occasionally three) parietal chloroplasts that spiral around the inside of the cell. *Gonatozygon* has a single axial chloroplast that extends down the center of the cell. *Genicularia* resembles *Spirogyra* while *Gonatozygon* resembles *Mougeotia*; *Spirogyra* and *Mougeotia* are closely related filamentous green algae in the division Charophyta.[26]

Genicularia* cf. *elegans cells are long, cylindrical, and often bent (Figures 8.1–8.2). The cells often remain attached, forming long filaments. The cells contain two long, loosely spiralling chloroplasts that contain many small, round pyrenoids. The cell wall is covered with very tiny granules. This genus is described as being rare, and only a few specimens were collected in the northwest Washington samples, all from Lake Twenty-two, a rocky, high elevation lake along the Mountain Loop Highway. The species identification is uncertain because, although the cell dimensions fit the range listed by Brook and Williamson (2010) for *Genicularia elegans*, the chloroplasts appear to make more than four spirals, which is not consistent with the species description.

[26]See **Freshwater Algae in Northwest Washington, Volume II. Chlorophyta and Rhodophyta**.

Gonatozygon aculeatum cells are long and cylindrical, with an expanded, club-shaped (capitate) apex (Figures 8.3–8.6). The apical angles are truncated and thickened. The cells are covered with long, sharp spines that are about 1.5–4 μm long in northwest Washington specimens. *Gonatozygon aculeatum* may occur as solitary cells, but often forms short, bent filaments. This species resembles some forms of *Gonatozygon monotaenium* (Figure 8.16), which is covered with granules or conical teeth rather than spines.

Gonatozygon brebissonii cells are long and fusiform, tapering gradually toward the slightly expanded, club-shaped (capitate) apex (Figures 8.7–8.10). The walls may be covered with short, blunt granules or very short, sharp spines. All of the northwest Washington specimens of *Gonatozygon brebissonii* were collected in boggy mountain lakes. The cells are usually solitary, but may occasionally form very short filaments containing 2–4 cells (Figure 8.9). Some high elevation sites contained the variety ***Gonatozygon brebissonii*** var. ***minutum*** (Figure 8.10), which can be distinguished by the much shorter cell lengths and lower length to width ratios (L$<$90 μm; L/W$<$15).

Gonatozygon kinahanii cells are cylindrical, untapered, with smooth walls, and a bluntly rounded apex (Figures 8.11–8.15). Although solitary cells can be found, *Gonatozygon kinahanii* cells regularly form long filaments. Each semi-cell contains a long, ribbon-like chloroplast with 4–10 pyrenoids; the chloroplasts usually do not extend all the way to the apex. The cells also contain many large calcium sulfate crystals that are visible in the clear apical region (Brooke, 1981).[27] This species can easily be confused with *Mougeotia*, which can be distinguished by its single, undivided chloroplast (no semi-cells) and the absence of calcium sulfate crystals. *Gonatozygon kinahanii* is often found in moderately nutrient-rich, slightly acidic lakes and ponds, where it may form dense mats.

Gonatozygon monotaenium cells are long and cylindrical, with a flattened, slightly expanded "spatulate" apex (Figures 8.16–8.19). The cell wall is covered with blunt granules or very short, conical teeth; some specimens may appear nearly smooth. This species resembles *Gonatozygon aculeatum* in size and shape, but *Gonatozygon aculeatum* has a truncated, club-shaped apex with thickened angles, and long, sharp spines on the cell wall.

[27] The crystals in most other desmid species are formed from barium sulfate (Brook, 1981).



Figure 8.1: *Genicularia* cf. *elegans* (DIC), Lake Twenty-two, Mountain Loop Highway, Snohomish County.



Figure 8.2: *Genicularia* cf. *elegans* (DIC/DIC), Lake Twenty-two, Mountain Loop Highway, Snohomish County (upper/lower images).

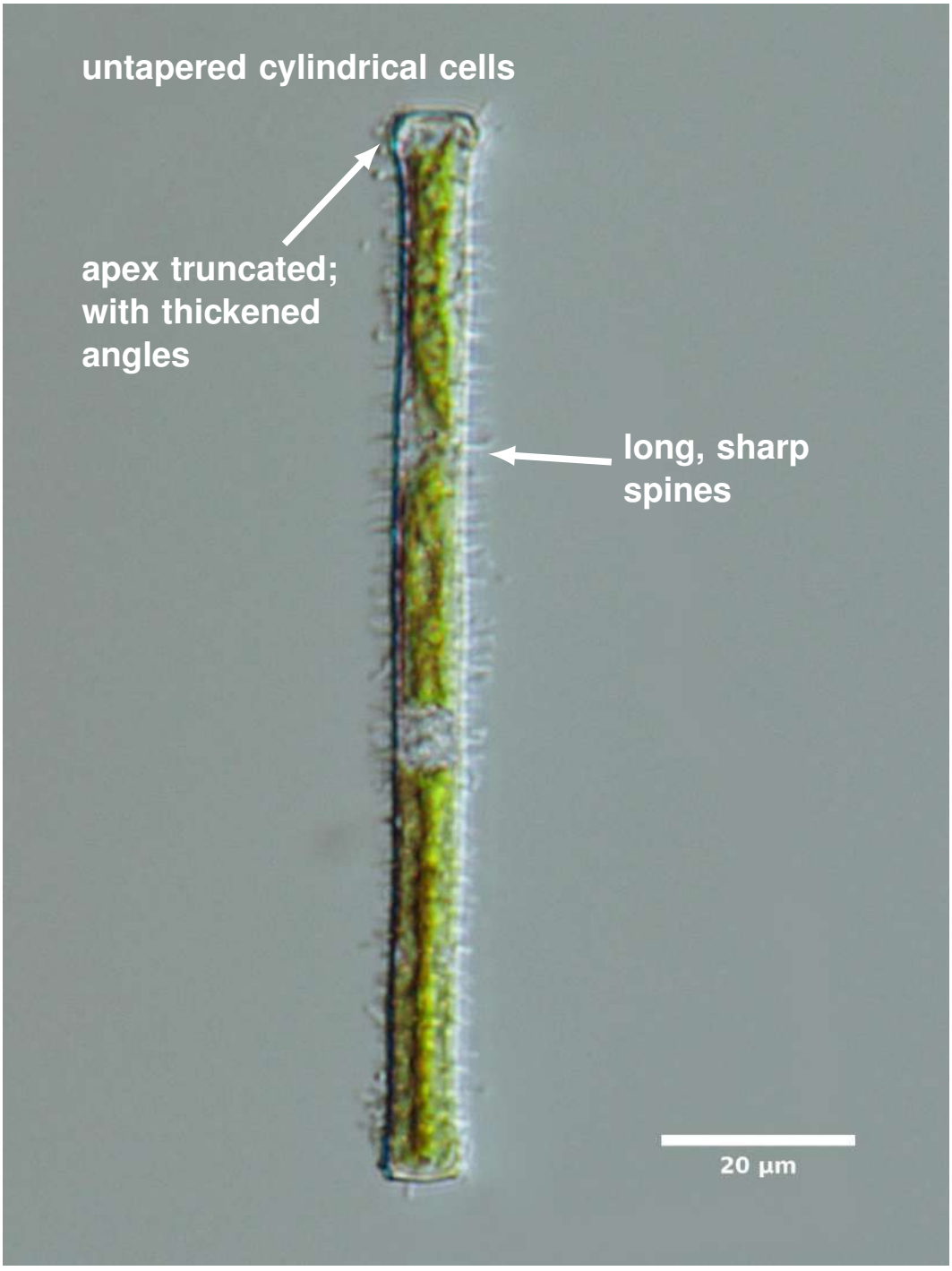


Figure 8.3: *Gonatozygon aculeatum* (DIC), Monte Cristo Lake, Mountain Loop Highway, Snohomish County.



Figure 8.4: *Gonatozygon aculeatum* (DIC), Myrtle Lake, Mountain Loop Highway, Snohomish County.



Figure 8.5: *Gonatozygon aculeatum* (DIC), Myrtle Lake, Mountain Loop Highway, Snohomish County.

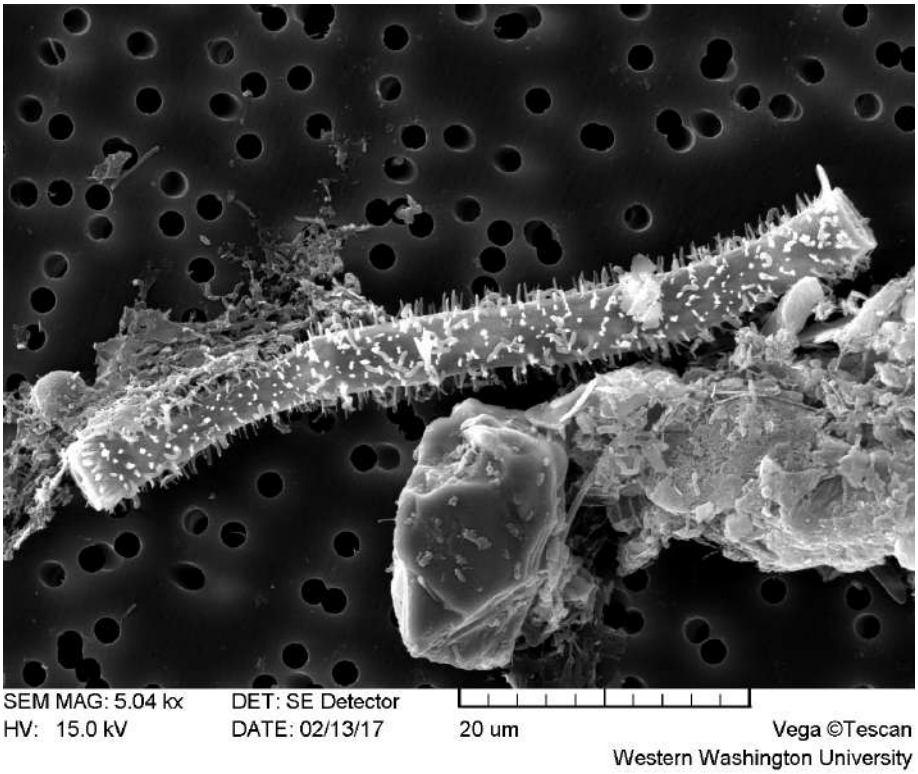




Figure 8.6: *Gonatozygon aculeatum* (SEM/DIC), Myrtle Lake, Mountain Loop Highway, Snohomish County (upper/lower images).

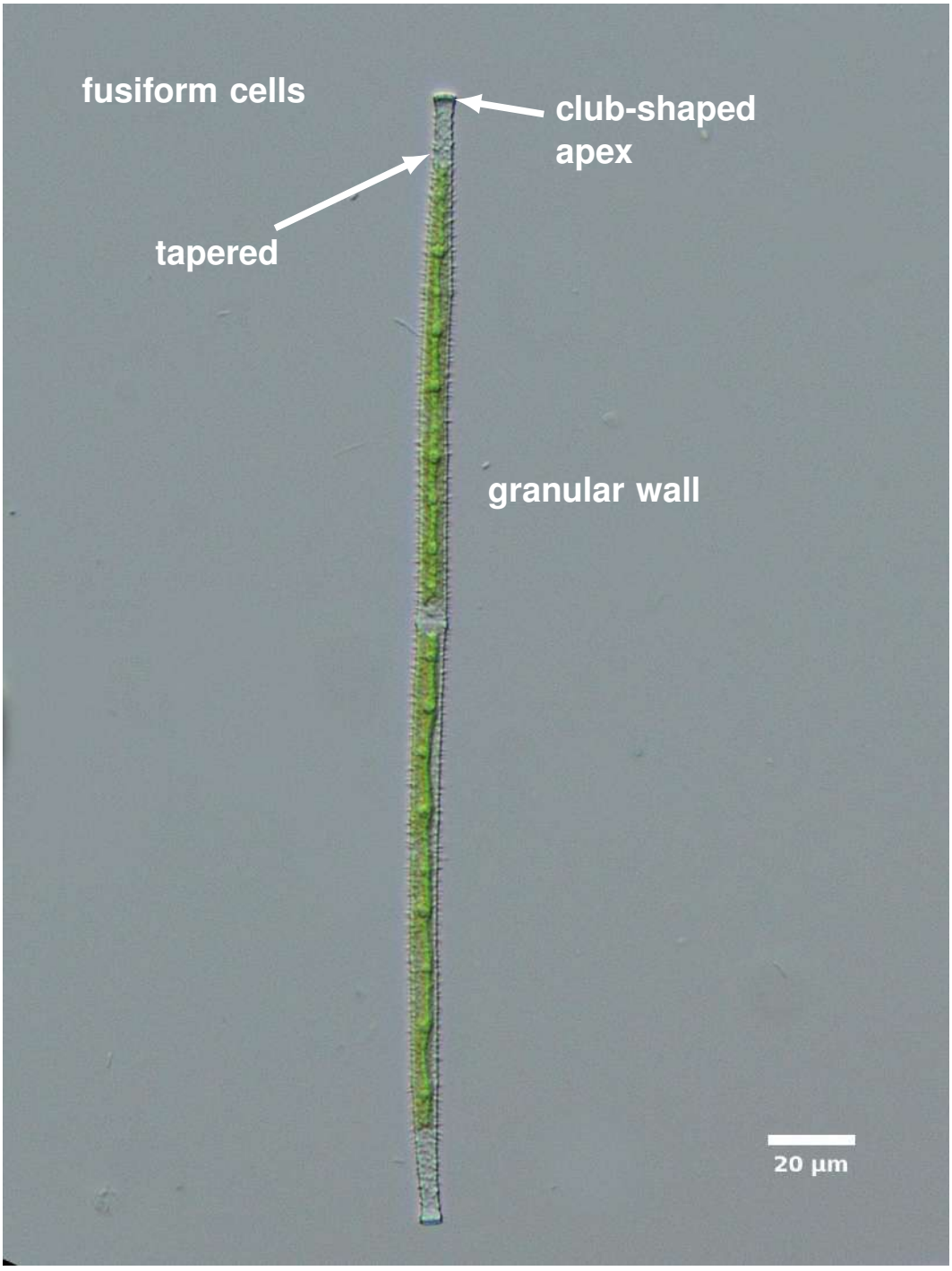


Figure 8.7: *Gonatozygon brebissonii* (DIC) Bear Lake, Mountain Loop Highway, Snohomish County.



Figure 8.8: *Gonatozygon brebissonii* (DIC), Lower Twin Lake, Mt. Baker area, Whatcom County.



Figure 8.9: *Gonatozygon brebissonii* solitary cell and two-cell filament (DIC/DIC), Lower Twin Lake, Mt. Baker area, Whatcom County (upper/lower images).



Figure 8.10: *Gonatozygon brebissonii* var. *minutum* (DIC), small pond on trail to Big Four Ice Caves, Mountain Loop Highway, Snohomish County.

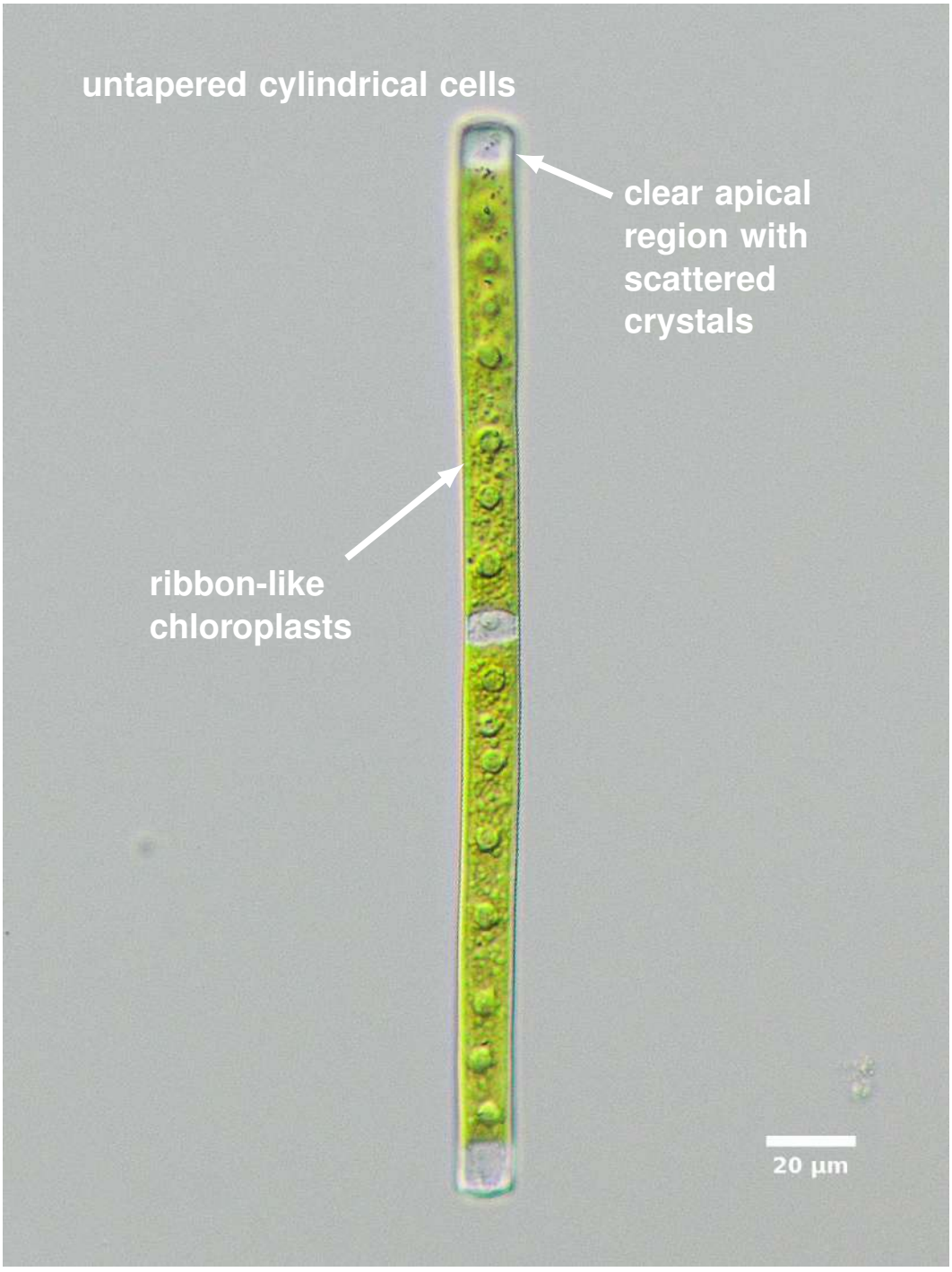


Figure 8.11: *Gonatozygon kinahanii* (DIC), Vogler Lake, Skagit County.

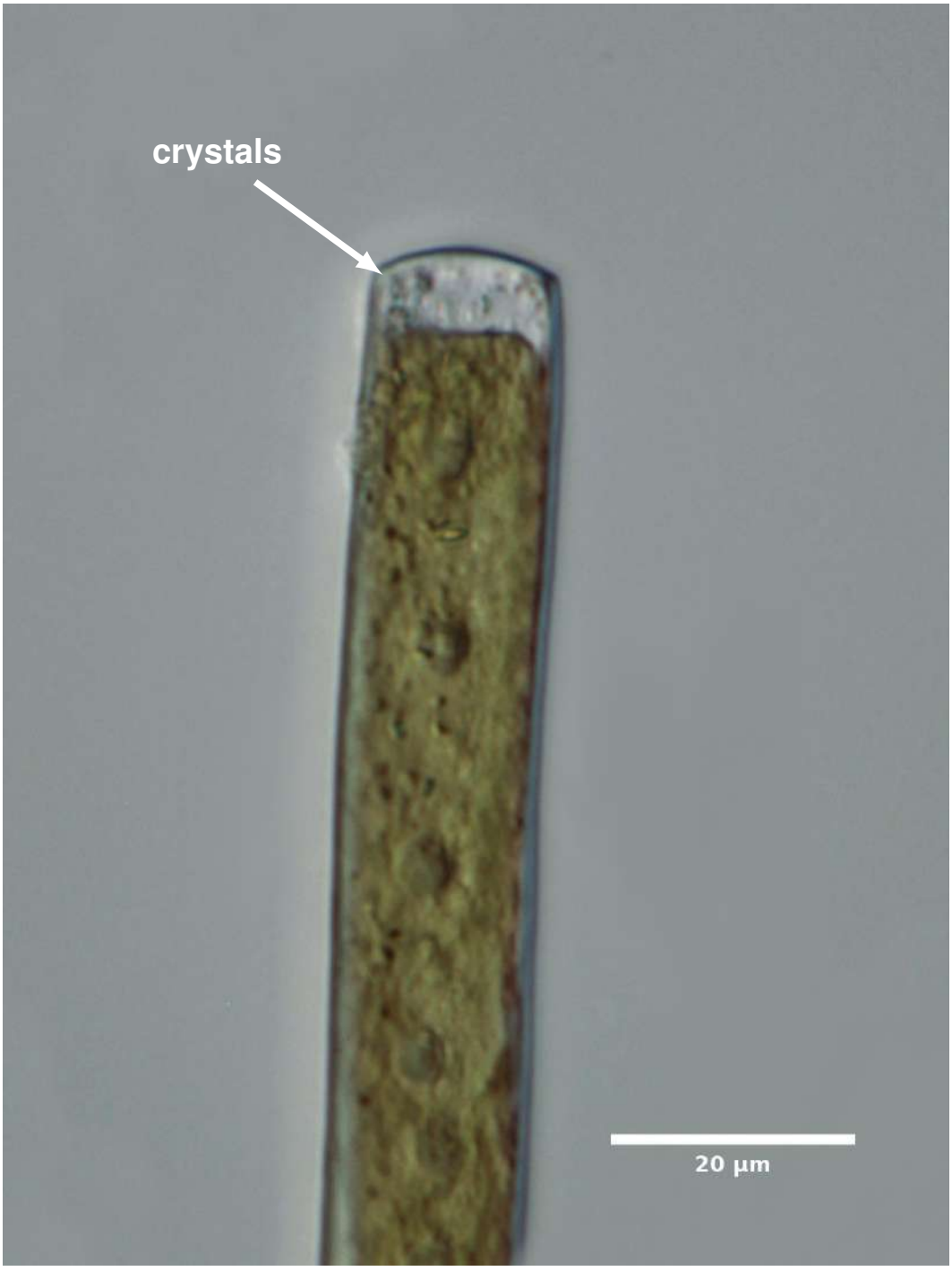


Figure 8.12: *Gonatozygon kinahanii* (DIC) Lake Fazon, Whatcom County.



Figure 8.13: *Gonatozygon kinahanii* (DIC), Boardman Lake, Mountain Loop Highway, Snohomish County



Figure 8.14: *Gonatozygon kinahanii* (DIC), Canyon Lake, Whatcom County.

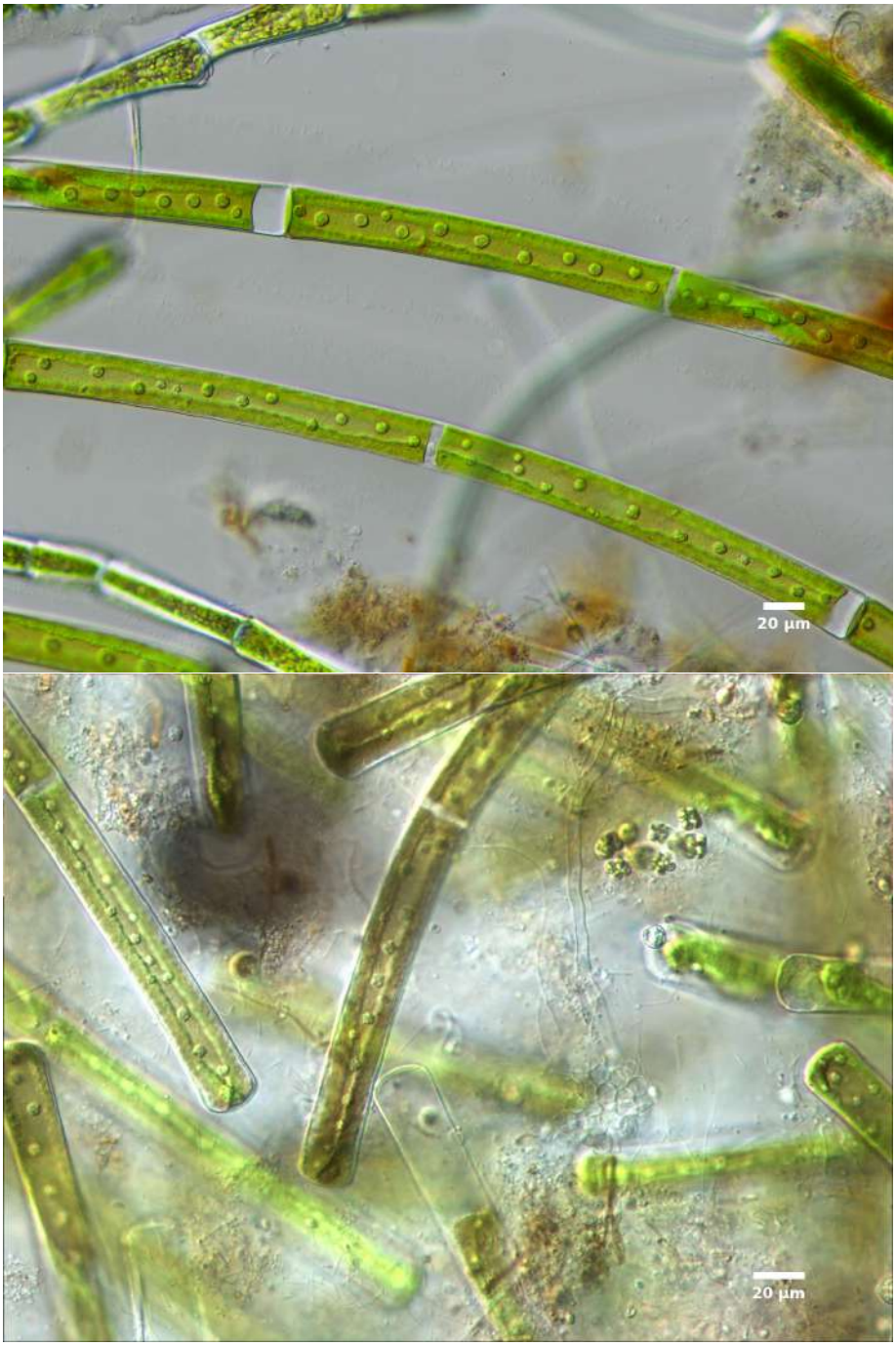


Figure 8.15: *Gonatozygon kinahanii* bloom (DIC/DIC), Summer Lake, Skagit County (upper/lower images).

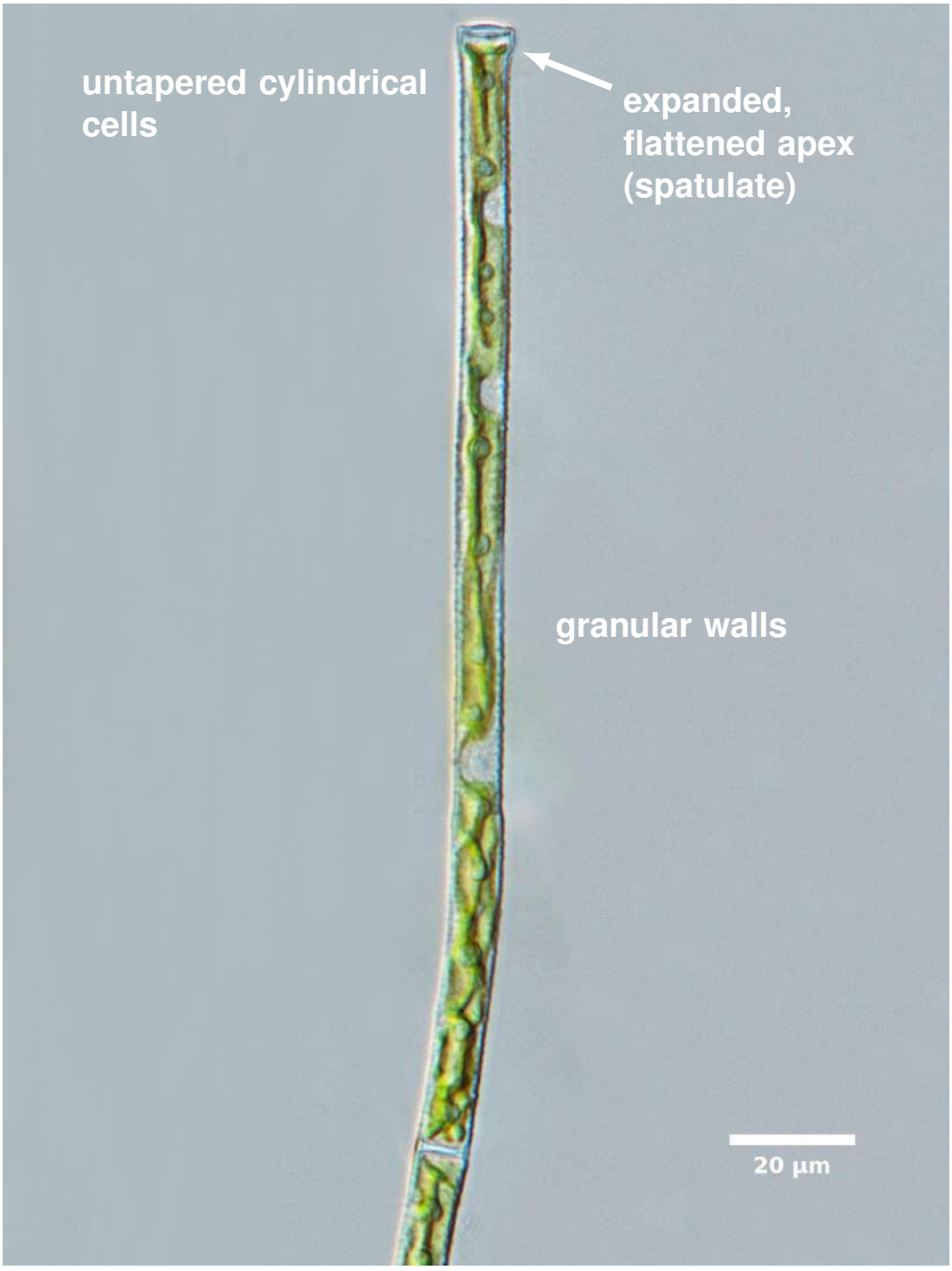


Figure 8.16: *Gonatozygon monotaenium* (DIC), Canyon Lake, Whatcom County.

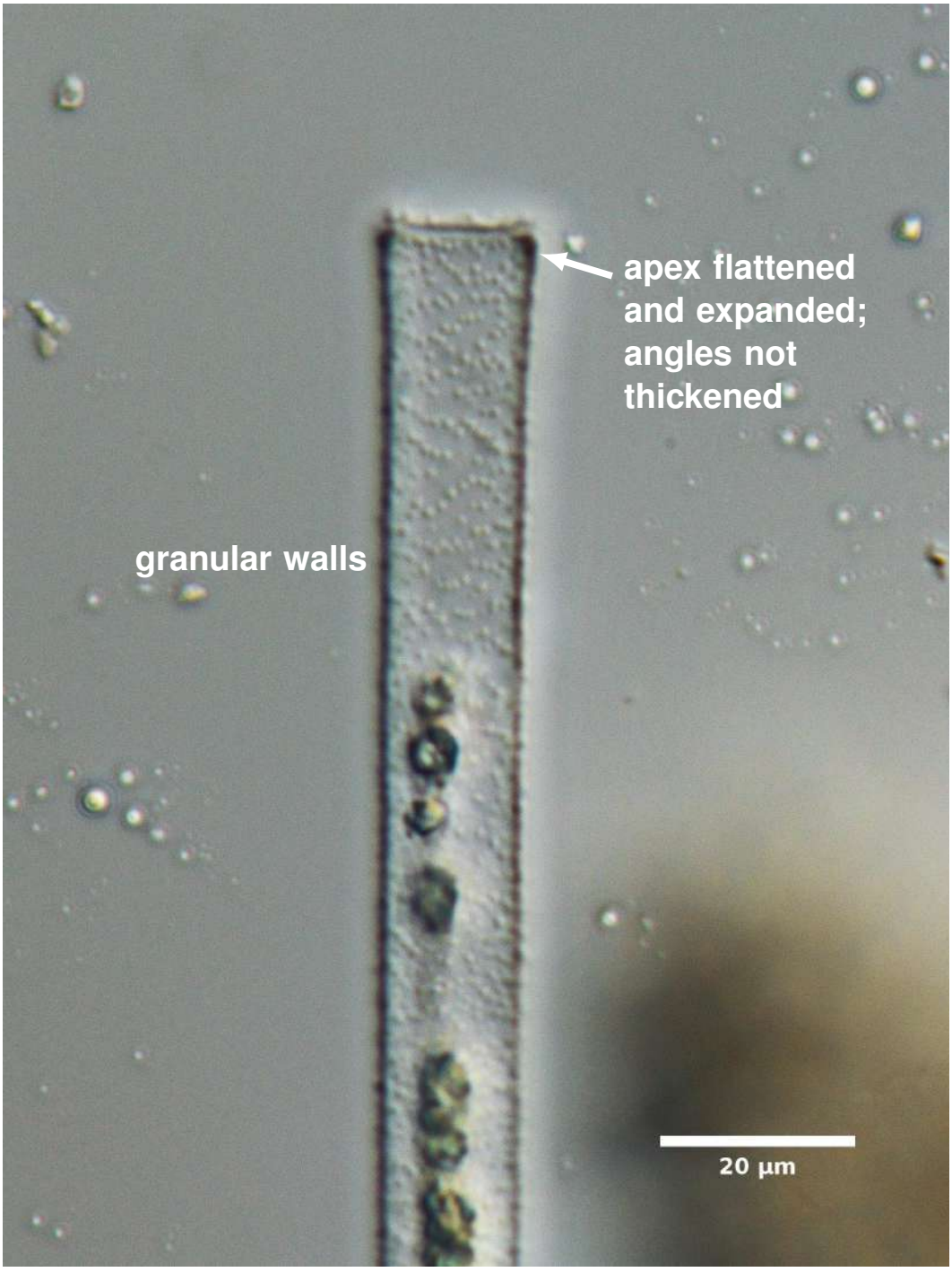


Figure 8.17: *Gonatozygon monotaenium* (DIC), Lower Bagley Lake, Mt. Baker area, Whatcom County.

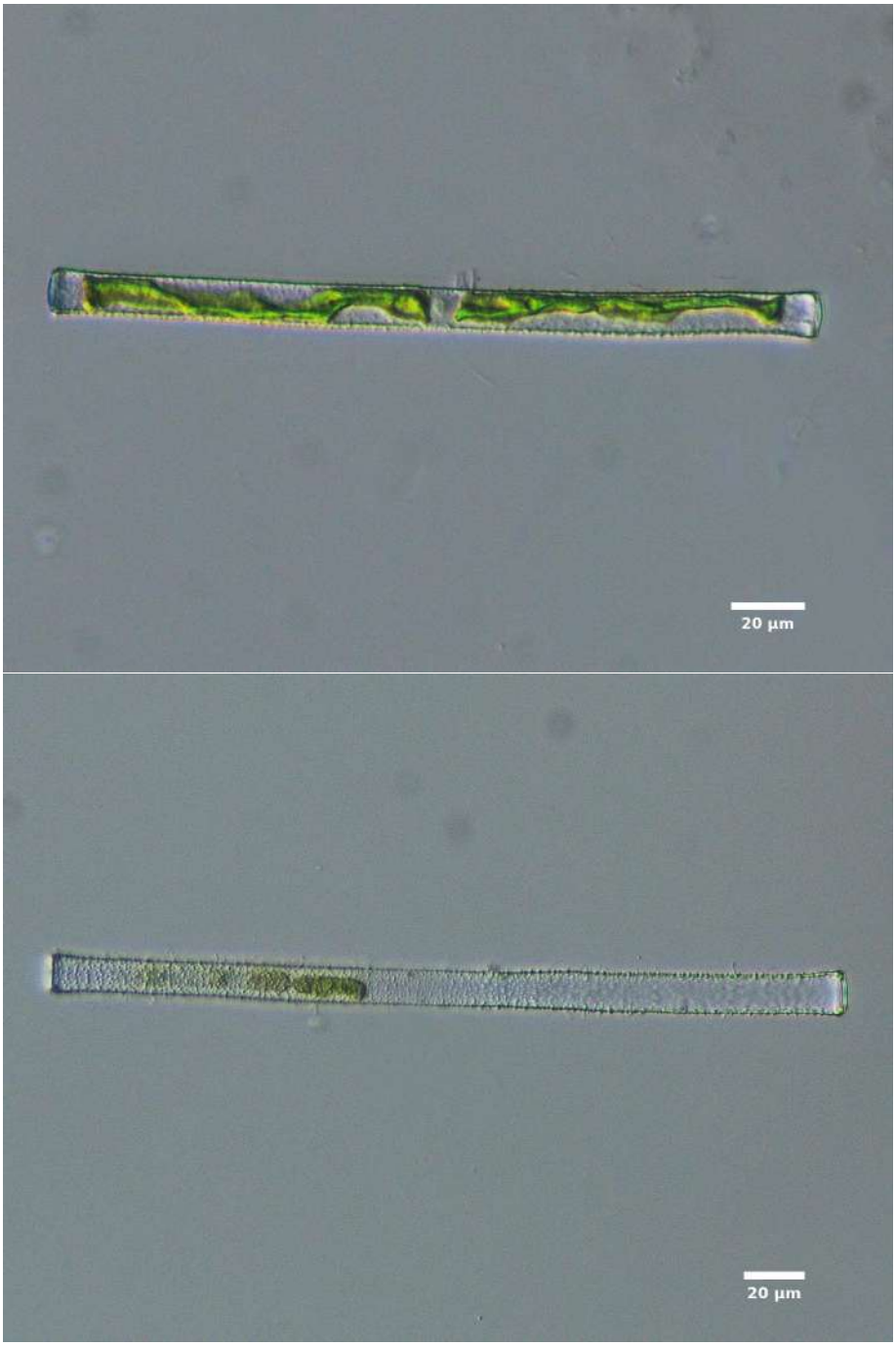


Figure 8.18: *Gonatozygon monotaenium* (DIC/DIC), small pond on trail to Big Four Ice Caves, Mountain Loop Highway, Snohomish County (upper/lower images).



Figure 8.19: *Gonatozygon monotaenium* (DIC), Sunrise Lake, Mt. Baker area, Whatcom County.

Chapter 9

Groenbladia Teiling

Northwest Washington taxa
Groenbladia neglecta (Raciborski) Teiling

Table 9.1: *Groenbladia* Cell Measurements

		Cell Width	Cell Length	Isthmus Width	L/W Ratio
Groenbladia neglecta	min	9.0 μm	23.6 μm	10.1 μm	2.3
	med	10.2 μm	29.9 μm	11.3 μm	2.9
	max	11.7 μm	34.7 μm	12.2 μm	3.6

Description
Groenbladia neglecta cells are cylindrical and slightly inflated on either side of the shallow, indistinct isthmus (Figures 9.1–9.4). The cells contain two axial, plate-like chloroplasts, which distinguishes this genus from *Hyalotheca* (Section 11, page 485), which has a star-shaped (stellate) chloroplast. The cell wall is covered with fine punctae (dots or granules) except near the isthmus, which should be smooth, but this feature is difficult to see (Figure 9.2). The filaments are surrounded by a wide, diffuse mucilage that is often colonized by epiphytes (Figures 9.3–9.4). All of the specimens from northwest Washington were collected in boggy, mountain lakes.

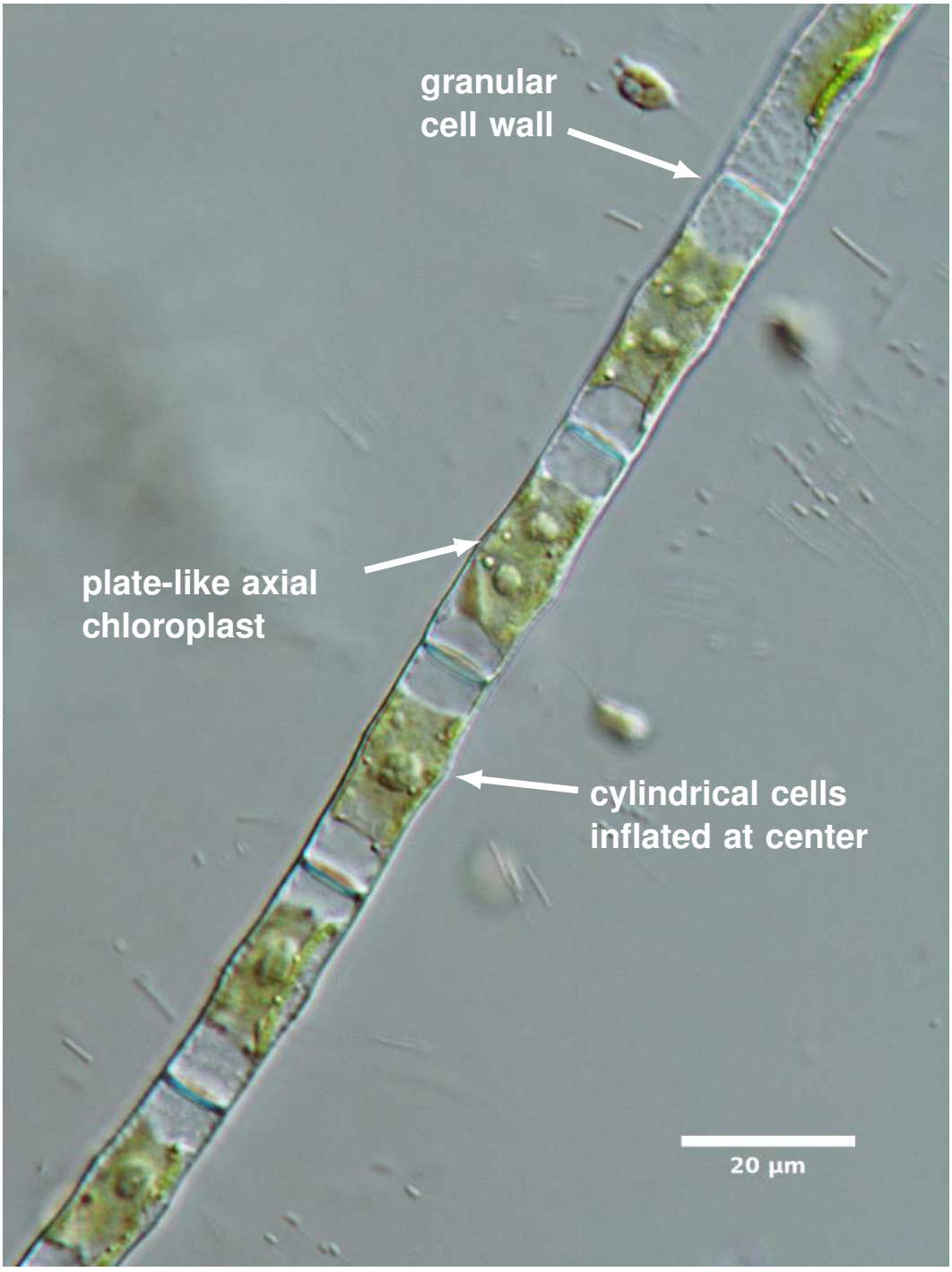


Figure 9.1: *Groenbladia neglecta* (DIC), Bear Lake, Mountain Loop Highway, Snohomish County.



Figure 9.2: *Groenbladia neglecta* surface granules (DIC), Bear Lake, Mountain Loop Highway, Snohomish County.



Figure 9.3: *Groenbladia neglecta* (DIC), Bear Lake, Mountain Loop Highway, Snohomish County.



Figure 9.4: *Groenbladia neglecta* (DIC), Bear Lake, Mountain Loop Highway, Snohomish County.

Chapter 10

Haplotaenium Bando

Northwest Washington taxa
Haplotaenium rectum (Delponte) Bando

Table 10.1: *Haplotaenium* Cell Measurements

		Cell Width	Cell Length	Isthmus Width	L/W Ratio
Haplotaenium rectum	min	18.5 μm	126.1 μm	13.4 μm	5.8
	med	20.6 μm	283.6 μm	16.1 μm	13.8
	max	24.6 μm	359.5 μm	18.8 μm	16.9

Description
Haplotaenium cells are long and cylindrical, with a rounded apex and a shallow but distinct sinus (Figures 10.1–10.3). The semi-cells are smooth-walled, with a small basal swelling adjacent to the sinus. Each semi-cell contains a long, ridged, chloroplast that contains several large, axial pyrenoids. The genus closely resembles *Pleurotaenium* (Section 17, page 661), which can be distinguished by its numerous parietal, ribbon-like chloroplasts and terminal vacuoles.

Haplotaenium rectum was formerly named *Pleurotaenium trabecula* var. *rectum* or *Pleurotaenium rectum*, and closely resembles other varieties of *Pleurotaenium trabecula*. *Haplotaenium rectum* is characterized by long, straight, narrow ($\leq$25 μm wide), smooth-walled cells that have a single basal swelling on either side of the sinus. The most important distinction is the ridged chloroplast with axial pyrenoids, and absence of terminal vacuoles; *Pleurotaenium* species have numerous ribbon-like, parietal chloroplasts, each with many small pyrenoids, and terminal vacuoles.

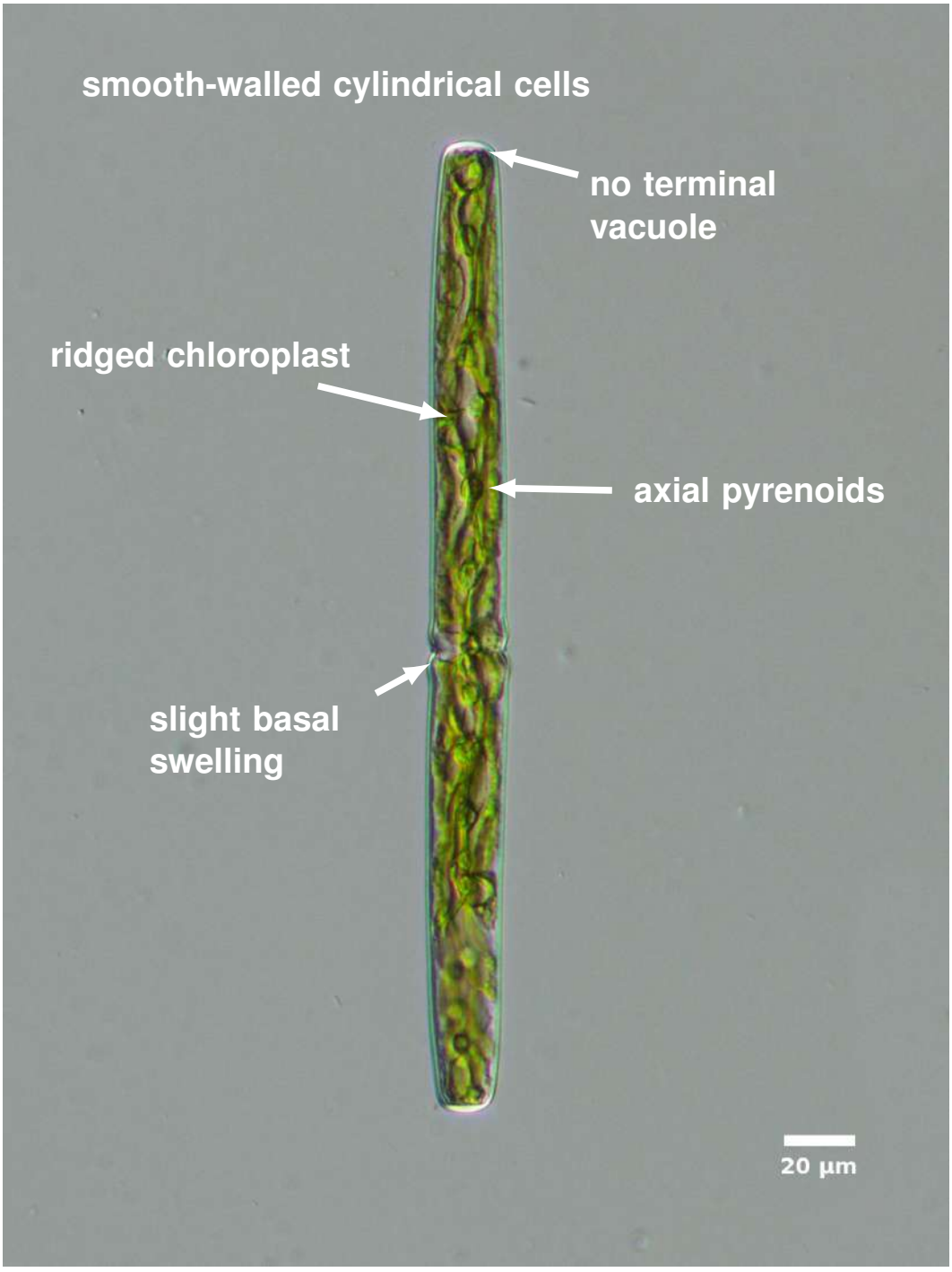


Figure 10.1: *Haplotaenium rectum* (DIC), Summer Lake, Skagit County.



Figure 10.2: *Haplotaenium rectum* (DIC), Summer Lake, Skagit County.

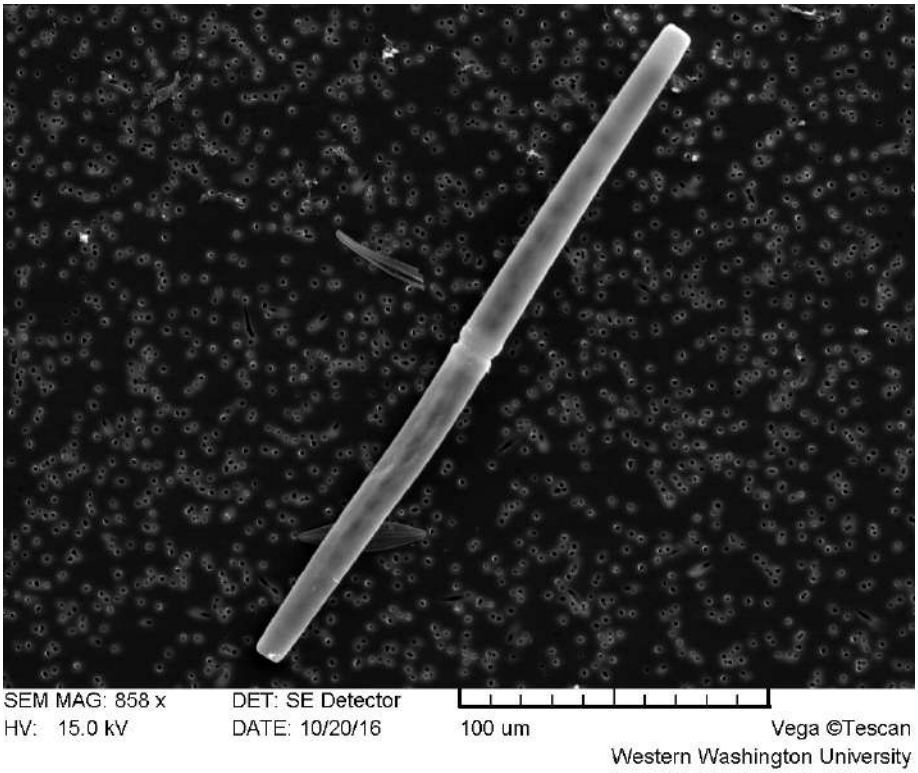




Figure 10.3: *Haplotaenium rectum* (SEM/DIC), Bear Lake, Mountain Loop Highway, Snohomish County (upper/lower images).

Chapter 11

Hyalotheca Ehrenberg ex Ralfs

Northwest Washington taxa
Hyalotheca dissiliens Brébisson ex Ralfs
Hyalotheca dissiliens cf. var. *tatrica* Raciborski
Hyalotheca mucosa Ralfs

Table 11.1: Key to *Hyalotheca* Species

A	Cells unconstricted (no sinus); length and width nearly equal; rings of granules present on both ends of cell	*Hyalotheca mucosa* (Figures 11.9–11.13)
B	Cells with shallow but distinct sinus; cell wall smooth (granules may be visible using SEM)	
	B.1 Cells shorter than wide, with thick mucilage layer surrounding filaments	*Hyalotheca dissiliens* (Figures 11.1–11.4)
	B.2 Cells about equal in length and width; mucilage layer indistinct	*Hyalotheca dissiliens* cf. var. *tatrica* (Figures 11.6–11.8)

Table 11.2: *Hyalotheca* Cell Measurements

		Cell Width	Cell Length	Isthmus Width	L/W Ratio
Hyalotheca dissiliens	min	14.3 μm	8.0 μm	13.6 μm	0.4
	med	29.1 μm	16.2 μm	27.2 μm	0.6
	max	34.0 μm	22.7 μm	32.1 μm	0.8
Hyalotheca dissiliens	min	16.7 μm	15.9 μm	14.4 μm	0.8
cf. var. *tatrica*	med	19.2 μm	20.0 μm	17.1 μm	1.1
	max	21.0 μm	24.1 μm	19.9 μm	1.3
Hyalotheca mucosa	min	15.5 μm	12.1 μm	16.3 μm	0.6
	med	18.6 μm	16.5 μm	16.9 μm	1.0
	max	20.7 μm	24.5 μm	18.6 μm	1.4

Description

Hyalotheca forms long, straight or gently curved filaments of cylindrical or barrel-shaped cells (Figures 11.1–11.13). Depending on the species, the cells are either unconstricted, or have a very shallow sinus. The cells contain two star-shaped (stellate) chloroplasts that can be seen by looking at the end view of a cell. From this angle, the *Hyalotheca* cells can easily be misidentified as *Asterococcus*.[28] *Hyalotheca* is quite common in northwest Washington lakes and ponds, and can be found in boggy mountain lakes as well as eutrophic low elevation sites.

Hyalotheca dissiliens cells are cylindrical or barrel-shaped, usually shorter than wide, smooth-walled, with a shallow but distinct sinus (Figures 11.1–11.4). *Hyalotheca dissiliens* filaments are long, straight or gently curved, and usually surrounded by a thick mucilage layer that is visible without staining. The cells exhibit a substantial size variation, even within a single sample (Figure 11.2). The SEM images reveal 3–4 concentric rings of tiny mucilage pores near the apex, with a smooth region at the sinus (Figure 11.3); however, these pores are too small to be clearly visible in the DIC images. The filament in Figure 11.5 has atypically long, barrel-shaped cells, so although the sample was collected at the same location where other *Hyalotheca dissiliens* filaments were collected (Lake Evan), the species

[28] See **Freshwater Algae in Northwest Washington, Volume II. Chlorophyta and Rhodophyta**.

identification is uncertain. The cells in Figure 11.5 resemble *Hyalotheca dissiliens* cf. var. *tatrica* (see description below), but have a more acutely rounded sinus and larger cell dimensions.

Hyalotheca dissiliens* cf. var. *tatrica is characterized by narrow, barrel-shaped cells that are usually longer than wide (Figures 11.6–11.8). Some taxonomic guides state that the filaments lack a mucilage layer (e.g., Croasdale et al., 1983), but most of the DIC images showed a wide, but very faint mucilage layer surrounding the filaments. This variety resembles *Hyalotheca mucosa* (Figure 11.9), which also has long, cylindrical cells, but *Hyalotheca dissiliens* cf. var. *tatrica* lacks the distinctive rings of coarse granules present on both ends of *Hyalotheca mucosa* cells. Instead, this variety appears to have smooth cell walls or small scattered granules that do not form obvious rings. The variety identification is uncertain because many of the features seen in the northwest Washington specimens (e.g., mucilage layer, smooth walls or irregularly scattered granules) are not described in the taxonomic literature (e.g., Croasdale, et al., 1983).

Hyalotheca mucosa is characterized by cylindrical cells that do not have a distinct sinus constriction (Figures 11.9–11.13). The cells are about equal in the width and length, or slightly longer than wide. One of the most distinctive features is the presence of 2–3 rows of coarse granules that form concentric rings near one or both ends of the cell. The filaments are usually surrounded by mucilage that may be visible or indistinct.

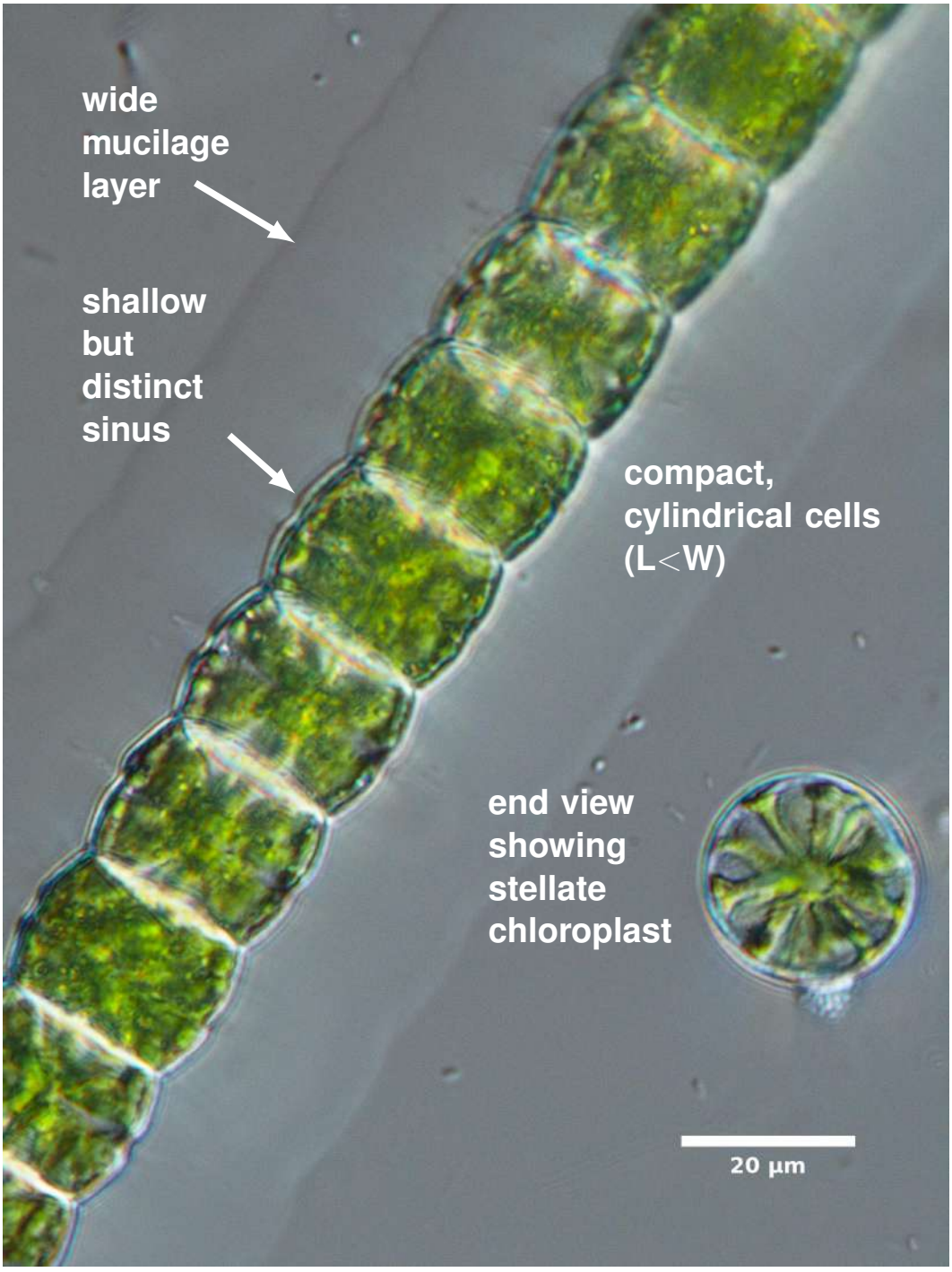


Figure 11.1: *Hyalotheca dissiliens* (DIC), Lake Evan, Mountain Loop Highway, Snohomish County.

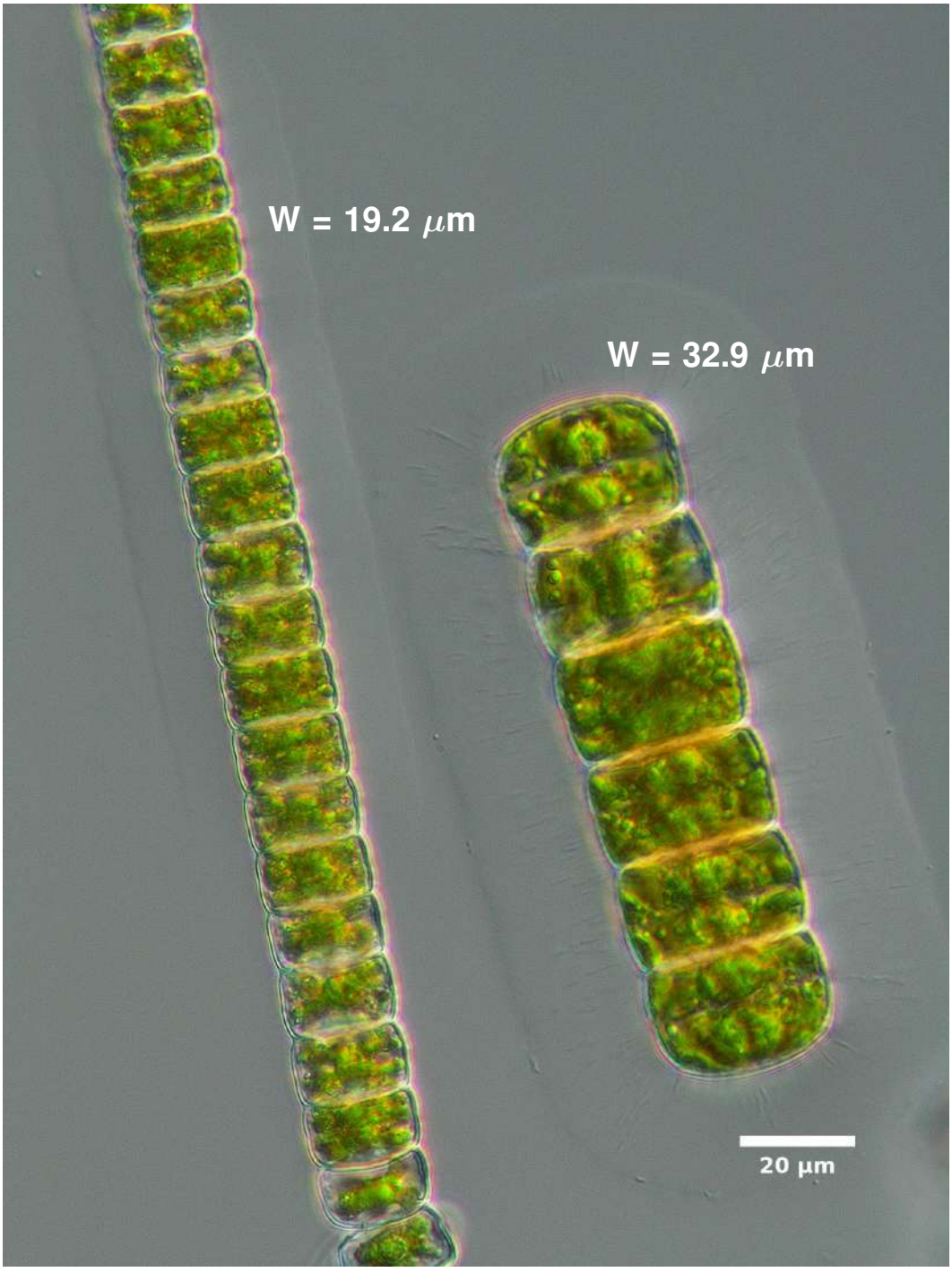


Figure 11.2: *Hyalotheca dissiliens* filament size variation (DIC), Heather Lake, Mountain Loop Highway, Snohomish County.

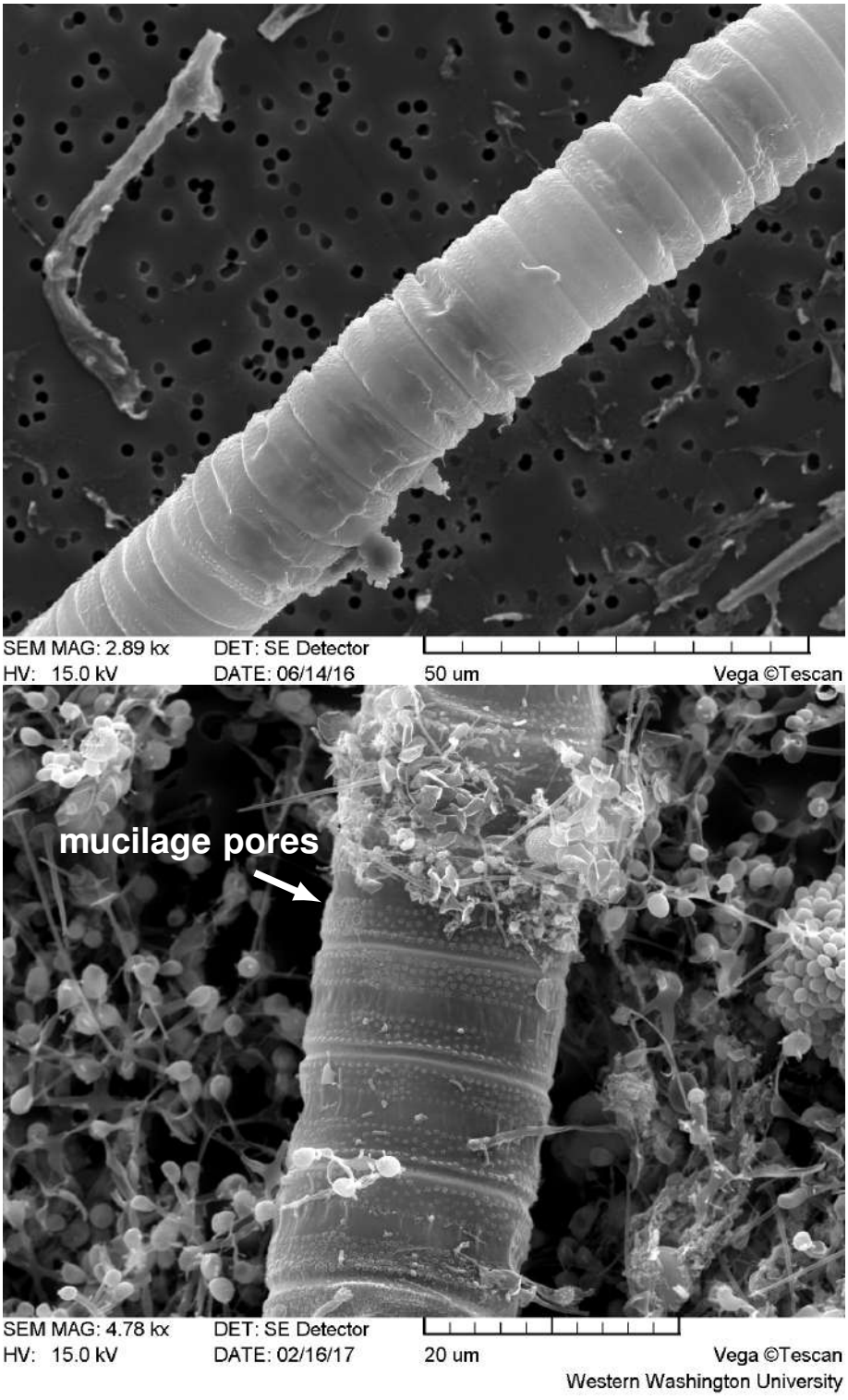


Figure 11.3: *Hyalotheca dissiliens* (SEM/SEM), Myrtle Lake, Mountain Loop Highway, Snohomish County (upper image); Sunrise Lake, Mt. Baker area, Whatcom County (lower image).

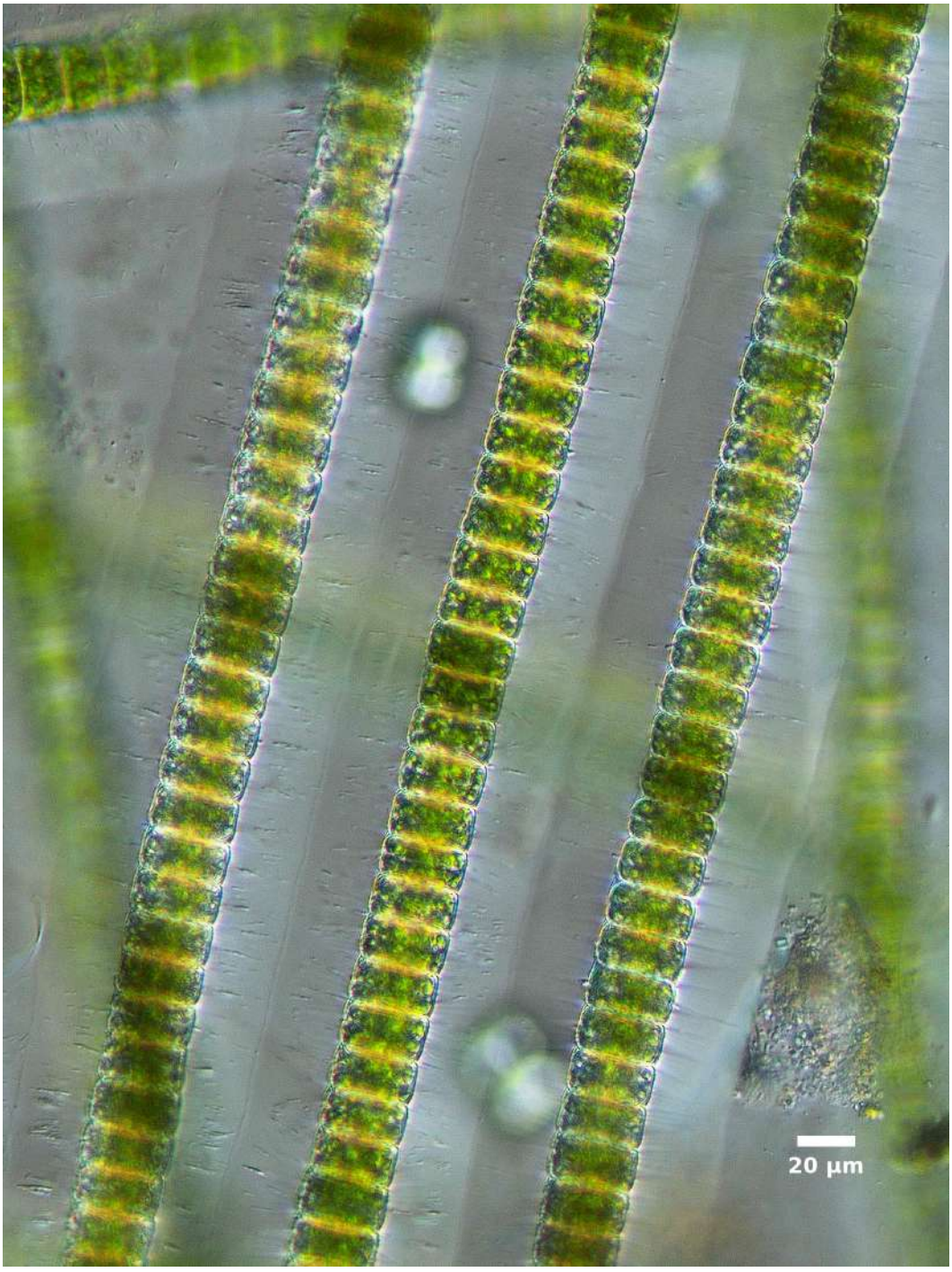


Figure 11.4: *Hyalotheca dissiliens* bloom (DIC), small residential pond, Whatcom County, Whatcom County.

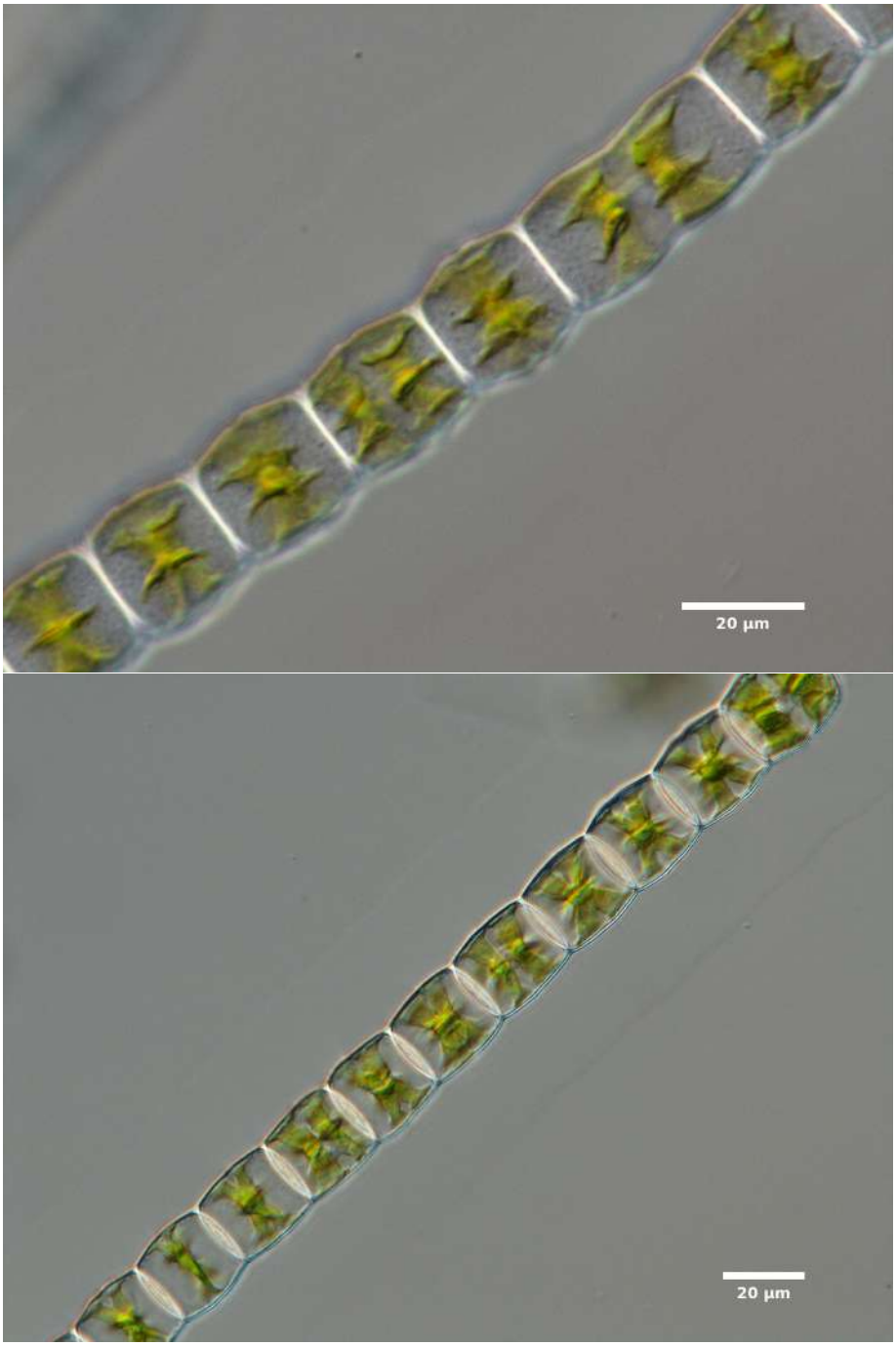


Figure 11.5: *Hyalotheca* cf. *dissiliens* (DIC/DIC), Lake Evan, Mountain Loop Highway, Snohomish County (upper/lower images).

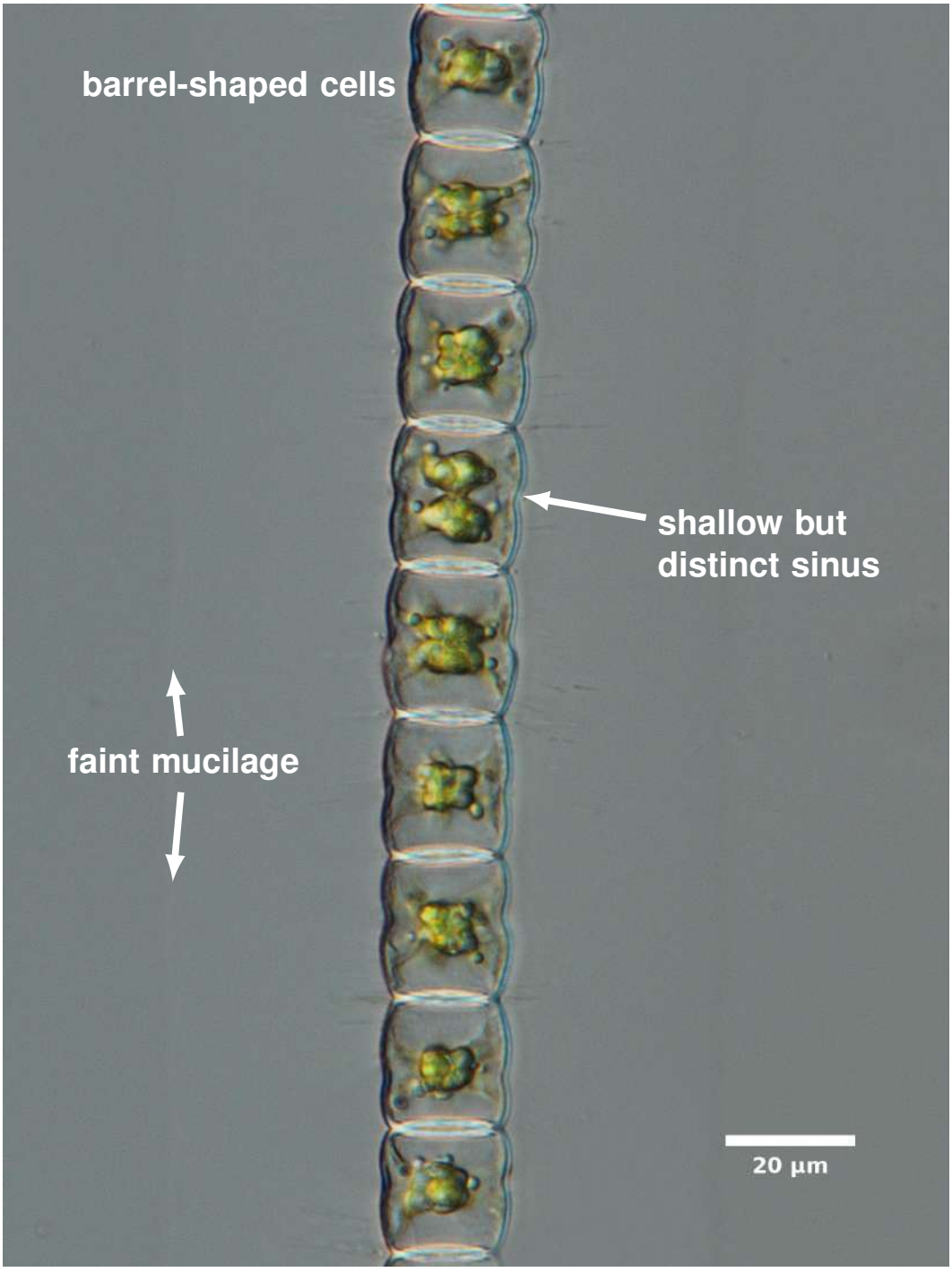


Figure 11.6: *Hyalotheca dissiliens* cf. var. *tatrica* (DIC), Heather Meadows Pond, Mt. Baker area, Whatcom County.



Figure 11.7: *Hyalotheca dissiliens* cf. var. *tatrica* (DIC), Bear Lake, Alpine Lakes Wilderness, King County.

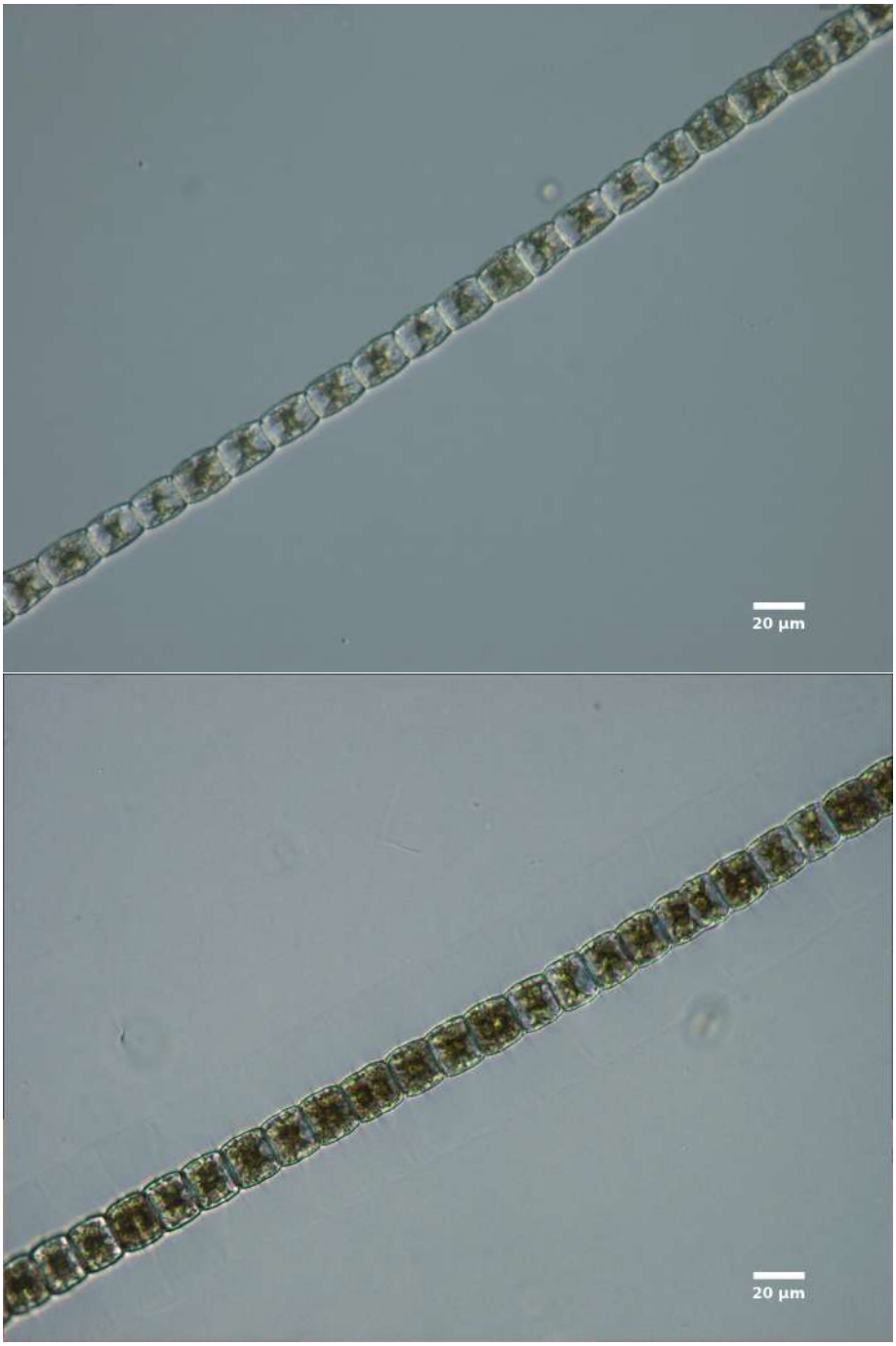


Figure 11.8: *Hyalotheca* cf. *dissiliens* (DIC/DIC), Bear Lake, Alpine Lakes Wilderness, King County (upper image); Ross Lake, Ross Lake National Recreation Area, Whatcom/Skagit Counties (lower image).

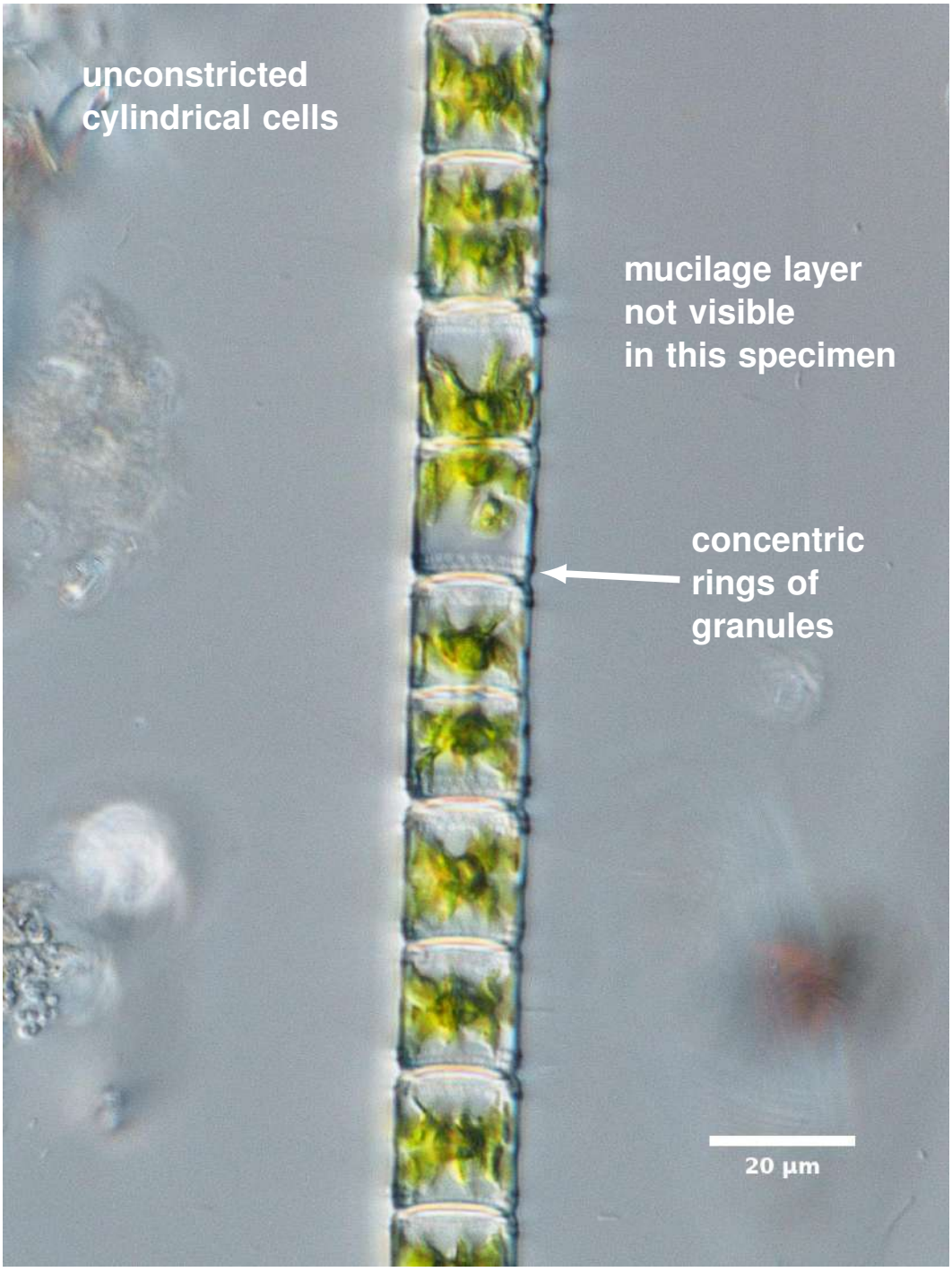
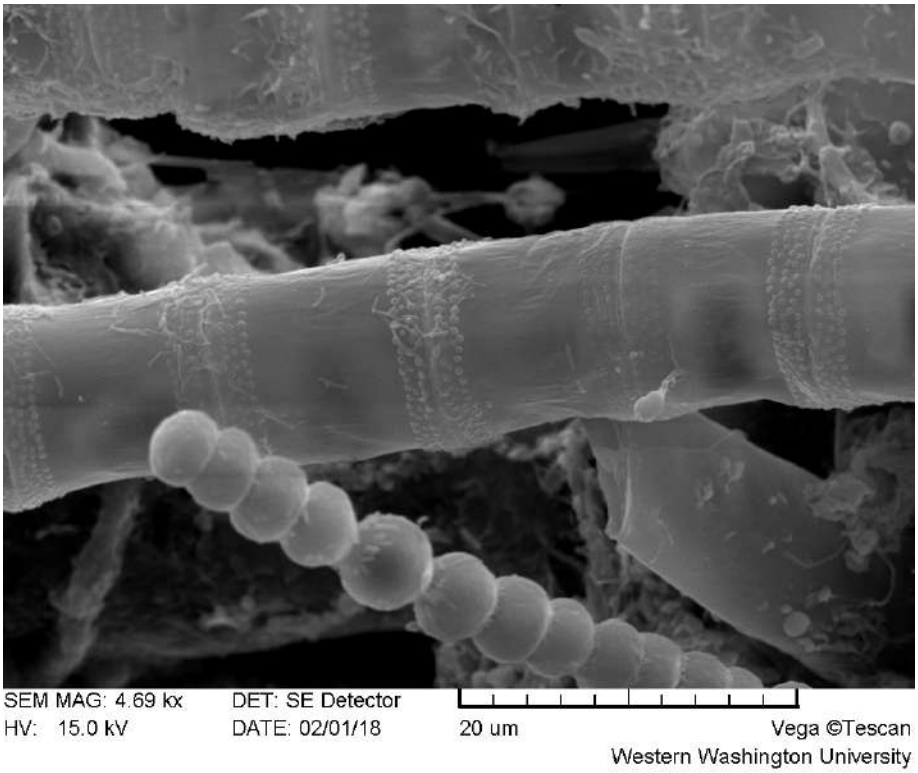


Figure 11.9: *Hyalotheca mucosa* (DIC), small floating bog along Morris Valley Road near Harrison, BC.



Figure 11.10: *Hyalotheca mucosa* (DIC) Clear Lake, Skagit County.



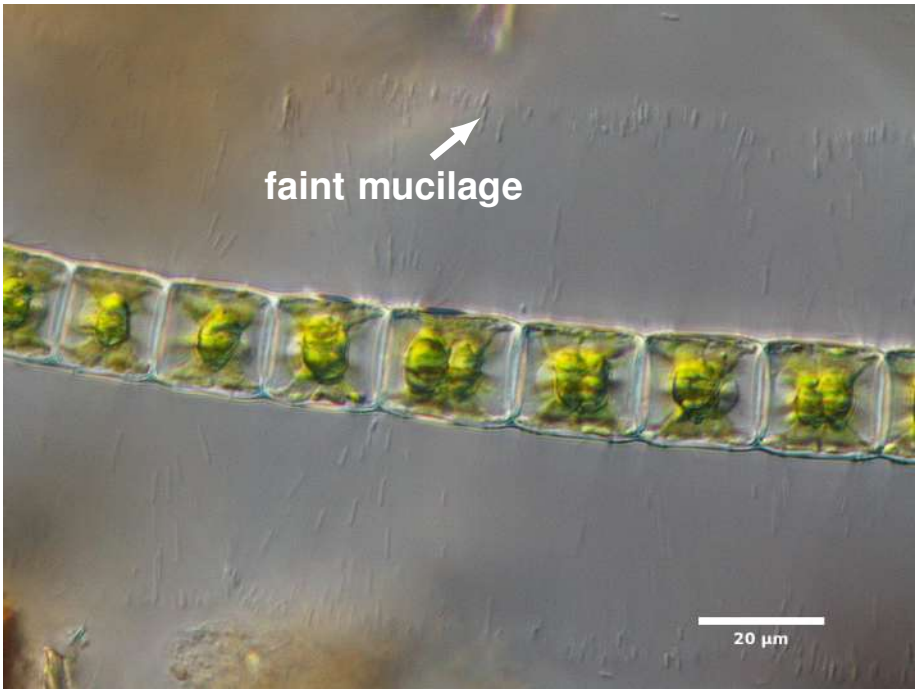


Figure 11.11: *Hyalotheca mucosa* (SEM/DIC), Myrtle Lake, Mountain Loop Highway, Snohomish County (upper/lower images).

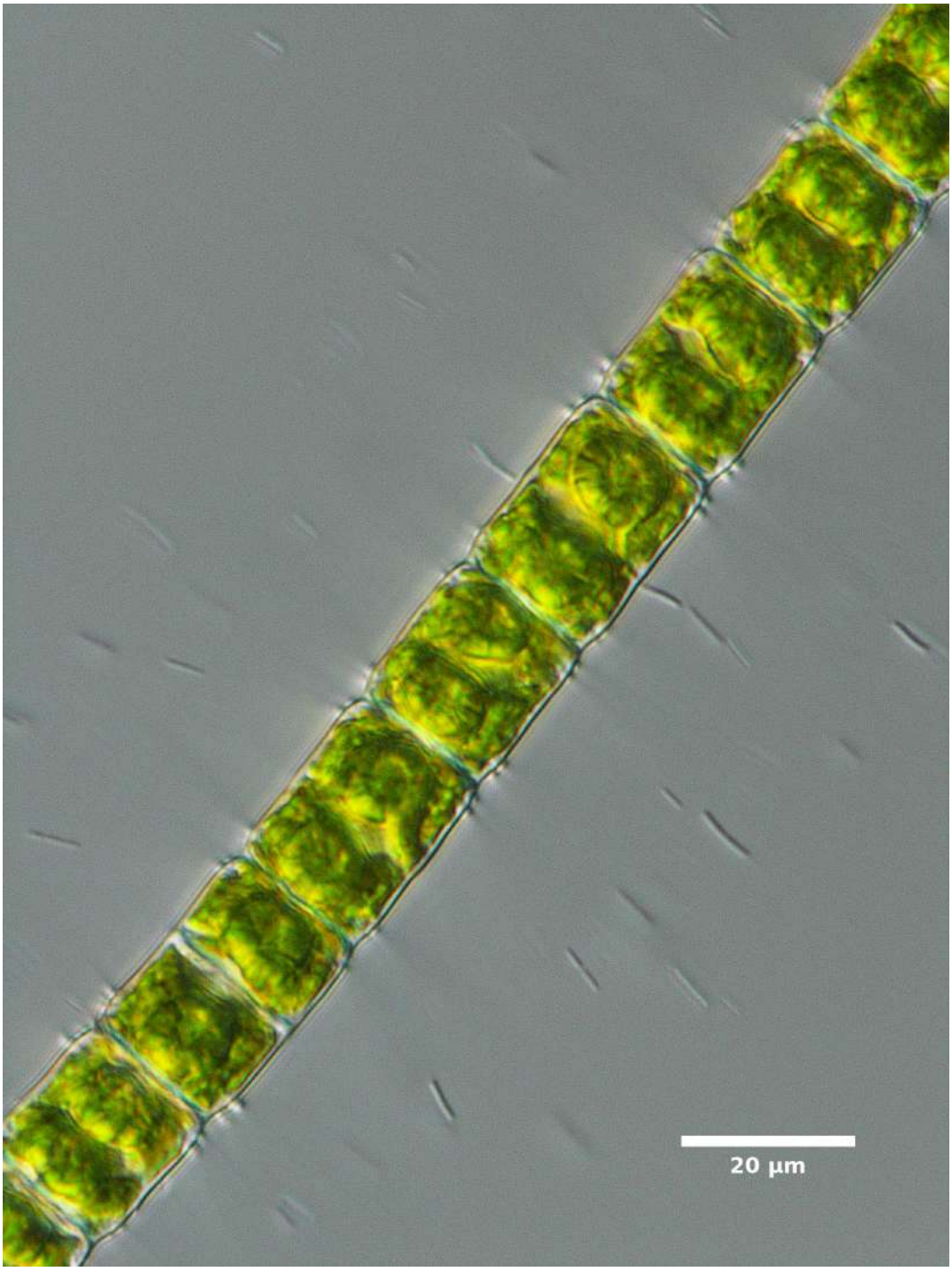


Figure 11.12: *Hyalotheca mucosa* (DIC) Lake Twenty-Two, Mountain Loop Highway, Snohomish County.



Figure 11.13: *Hyalotheca mucosa* (DIC) Summer Lake, Skagit County.

Chapter 12

Mesotaenium Nägeil

Northwest Washington taxa
Mesotaenium macrococcum (Kützing ex Kützing) J. Roy & Bisset
Mesotaenium macrococcum cf. var. *minus* (De Bary) Compère

Table 12.1: *Mesotaenium* Cell Measurements

		Cell Width	Cell Length	Isthmus Width	L/W Ratio
Mesotaenium	min	11.1 μm	16.8 μm	–	1.5
macrococcum	med	15.1 μm	25.7 μm	–	1.7
	max	18.0 μm	31.4 μm	–	1.9
Mesotaenium	min	7.4 μm	9.1 μm	–	1.2
macrococcum	med	7.8 μm	10.3 μm	–	1.3
cf. var. *minus*	max	8.6 μm	11.5 μm	–	1.5

Description

Mesotaenium is a saccoderm desmid characterized by small, oval or bluntly cylindrical cells and no discernible sinus (Figures 12.1–12.7). The cells usually contain a single, axial, plate-like chloroplast with a large central pyrenoid; two chloroplasts may be present in cells that are about to divide. The genus is poorly studied and the species and variety descriptions encompasses a wide range of features, so future taxonomic revisions are likely.

Mesotaenium macrococcum is characterized by short, oval cells with parallel sides and broadly rounded apices (Figures 12.1–12.5). The chloroplast is massive when viewed from the top, often extending to the cell margin, and has a fringed or toothed margin. Viewed from the side the chloroplast appears lens-shaped due to its plate-like structure. The cells are surrounded by thick layers of mucilage, forming gelatinous agglomerations along the shoreline of boggy, acidic mountain lakes and ponds or on mossy soils.

Purple staining was observed in the mucilage from some of the northwest Washington *Mesotaenium macrococcum* agglomerations (Figure 12.2–12.3). Coesel and Meesters (2007) state that purple stained cell sap is often seen in the genus *Mesotaenium* and Brook and Williamson (2010) list purple stained mucilage as a common feature in *Mesotaenium macrococcum*. The purpose of this pigmentation is not known; however, Busch and Hess (2022) found that purple pigmented mucilage provided protection from excessive sunlight in *Serritaenia*, a closely related genus.[29]

The specimens tentatively identified as ***Mesotaenium macrococcum* var. *minus*** were collected along the shoreline of Bear Lake in the Alpine Lakes Wilderness Area (Figures 12.6–12.7). This variety is characterized by smaller cells with a lower L/W ratio. While the northwest Washington specimens fit the size and L/W ranges for this variety (Brook and Williamson, 2010), the chloroplast does not appear to have a fringed or toothed margin. In addition, none of the agglomerations had purple stained mucilage. It is possible that the samples from the Alpine Lakes Wilderness Area represent a different, possibly undescribed species.

[29] Several species of *Mesotaenium* have been moved to *Serritaenia* based on genetic analyses and *Mesotaenium macrococcum* is likely to be moved to *Serritaenia* in the future (A. Busch, pers. comm., Cologne Biocenter, Cologne, DE).



Figure 12.1: *Mesotaenium macrococcum* (DIC), Blackman Lake, Snohomish County.



Figure 12.2: *Mesotaenium macrococcum* (DIC), Boardman Lake, Mountain Loop Highway, Snohomish County.

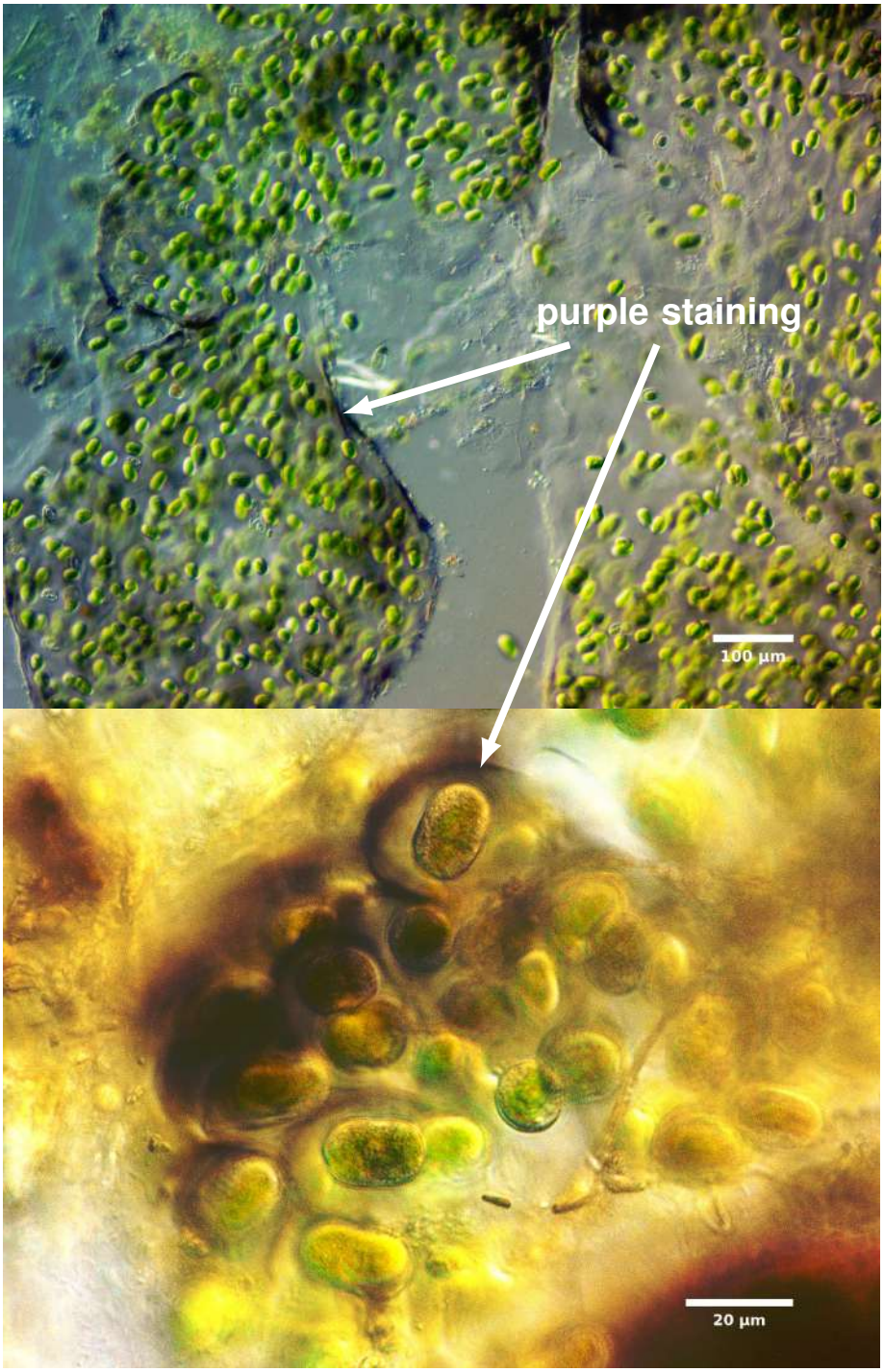


Figure 12.3: *Mesotaenium macrococcum* with purple-stained mucilage (DIC/DIC), Blackman Lake, Snohomish County (upper image); small pond along trail to Big Four Ice Caves, Mountain Loop Highway, Snohomish County (lower image).



Figure 12.4: *Mesotaenium macrococcum* dividing (DIC), Boardman Lake, Mountain Loop Highway, Snohomish County.

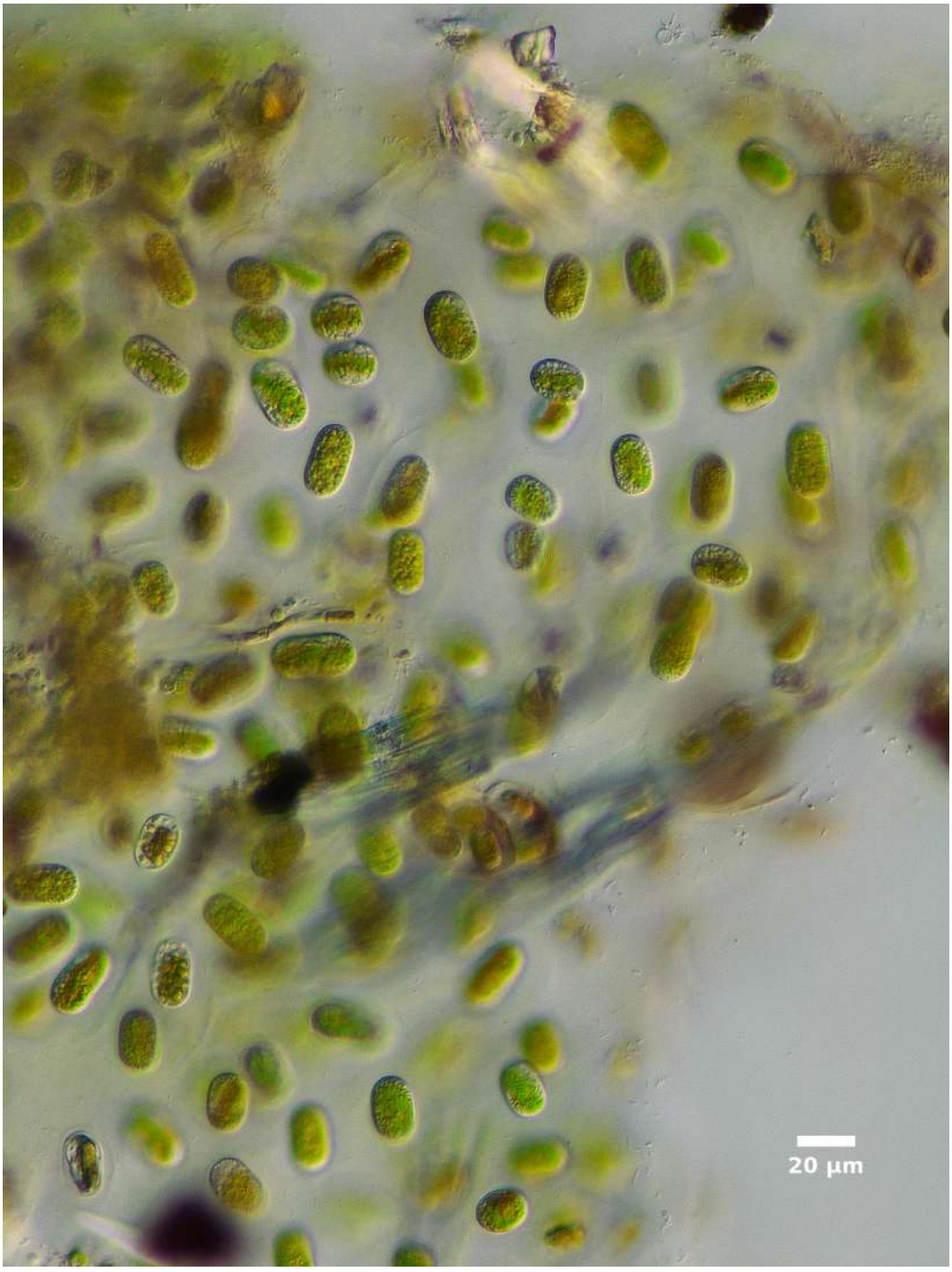


Figure 12.5: *Mesotaenium macrococcum* agglomeration (DIC), Boardman Lake, Mountain Loop Highway, Snohomish County.

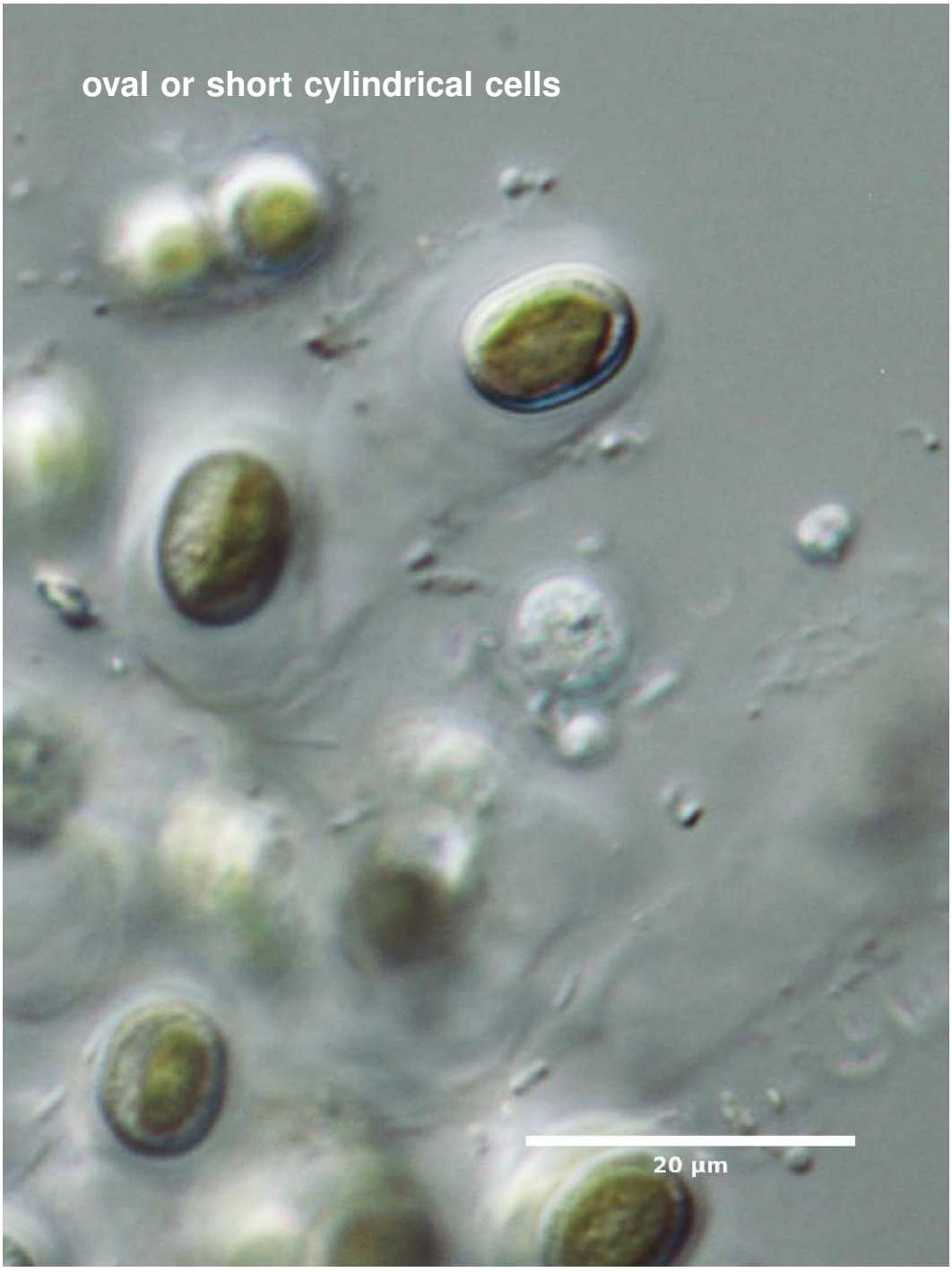


Figure 12.6: *Mesotaenium macrococcum* cf. var. *minus* (DIC), Bear Lake, Mountain Loop Highway, Snohomish County.

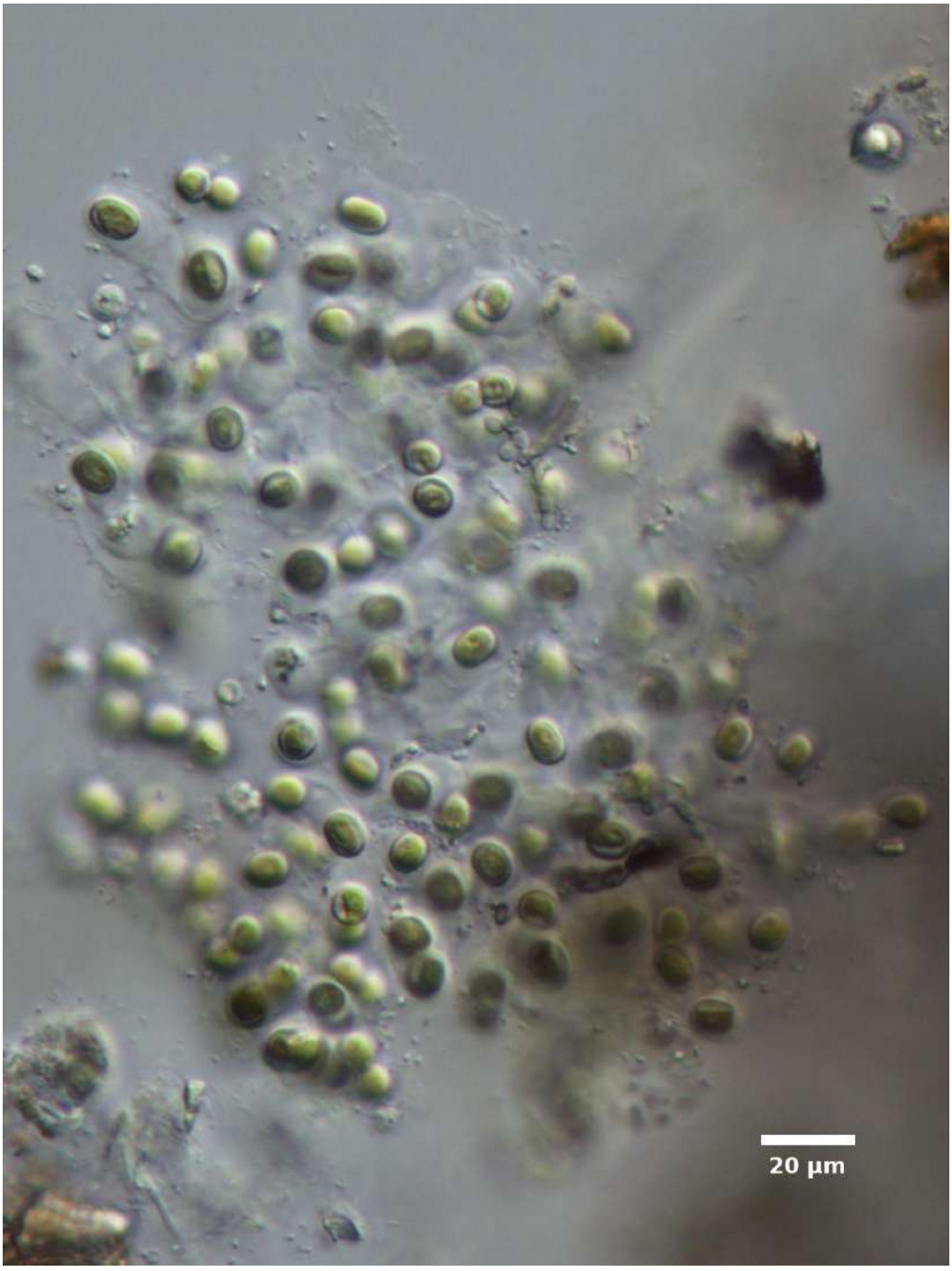


Figure 12.7: *Mesotaenium macrococcum* cf. var. *minus* agglomeration (DIC), Bear Lake, Mountain Loop Highway, Snohomish County.

Chapter 13

Micrasterias C. Agardh ex Ralfs

Northwest Washington taxa
Micrasterias americana Ehrenberg ex Ralfs
Micrasterias americana var. *lewisiana* West
Micrasterias apiculata Meneghini ex Ralfs
Micrasterias brachyptera Lundell
Micrasterias compereana Neustupa, Šťastný & Škaloud
Micrasterias conferta Lundell
Micrasterias denticulata Brébisson ex Ralfs
Micrasterias depauperata var. *wollei* J. A. Cushman
Micrasterias furcata C. Agardh ex Ralfs
Micrasterias laticeps Nordstedt
Micrasterias mahabuleshwarensis J. Hobson
Micrasterias muricata Bailey ex Ralfs
Micrasterias nordstedtiana Wolle
Micrasterias papillifera Brébisson ex Ralfs
Micrasterias pinnatifida Ralfs
Micrasterias radiosa var. *elegantior* (G. S. West) Croasdale
Micrasterias rotata Ralfs
Micrasterias thomasiana W. Archer
Micrasterias thomasiana var. *notata* (Nordstedt) Grönblad
Micrasterias truncata Brébisson ex Ralfs
Micrasterias truncata var. *semiradiata* Wolle
Micrasterias verrucosa Bisset

Table 13.1: Key to *Micrasterias* Species

A	Lateral lobe undivided or 1x divided	See below
B	Lateral lobe usually 2x divided; may have shallow, indistinct 3x division	Go to page 513
C	Lateral lobe divided 3–4x	Go to page 514
A	Lateral lobe undivided or 1x divided	
	A.1 Lateral lobe undivided	
	A.1a Apical lobe convex, wide, resembling lateral lobes, ending in single tooth; lateral lobes ending in paired teeth	*Micrasterias laticeps* (Figures 13.34–13.36)
	A.1b Apical lobe flat or slightly convex, narrower than lateral lobes; apical and lateral lobes ending in paired teeth	*Micrasterias pinnatifida* (Figures 13.50–13.52)
	A.2 Lateral lobe very shallowly 1x divided	
	A.2a Semi-cells trapezoidal; apical lobe slightly elongated, broadly wedge-shaped; sinus widely open	*Micrasterias depauperata* (Figures 13.26–13.29)
	A.2b Cells circular or broadly oval; apical lobe compressed, continuous with cell outline; sinus closed or narrowly open; polymorphic!	*Micrasterias truncata* (including varieties) (Figures 13.70–13.76)
	A.3 Lateral lobe deeply 1x divided; semi-cells rectangular; apical lobe and lateral lobules form horn-like processes	

continued on next page

Table 13.1: Key to *Micrasterias* Species, continued

	A.3a Lateral lobe incision extends nearly to center of cell; apical lobe flat, extended horizontally, with no vertical processes	*Micrasterias muricata* (Figures 13.38–13.40)
	A.3b Lateral lobe incision extends about half way to center of cell; apical lobe flat, with horizontal horn-like processes	*Micrasterias nordstedtiana* (Figures 13.41–13.44)
	A.3c Lateral lobe incision extends about half way to center of cell; apical lobe with long, upwardly directed, horn-like processes and short, vertical processes	*Micrasterias mahabuleshwarensis* (Figure 13.37)
B	Lateral lobe usually divided 2x; may have shallow, indistinct 3x division	
	B.1 Apical lobe with horn-like or knobby processes	
	B.1a Apical lobe with four vertical, horn-like processes; outer lateral lobules distinctly longer than inner lobules	*Micrasterias americana* (Figures 13.4–13.7)
	B.1b Apical lobe wedge-shaped, apically flattened, with four very short, knob-like processes; outer lateral lobules slightly longer than inner lobules	*Micrasterias americana* var. *lewisiana* (Figure 13.8)
	B.1c Apical lobe with two long, horn-like processes; lateral lobules equal in length	*Micrasterias furcata* (Figures 13.30–13.33)
	B.2 Apical lobe without horn-like or knobby processes	

continued on next page

Table 13.1: Key to *Micrasterias* Species, continued

	B.2a Apical lobe with long neck, flared near apex and widely separated from lateral lobes; lateral lobes 2x divided, with open incisions; apical lobe and lateral lobules ending in sharp, recurved spines	*Micrasterias brachyptera* (Figure 13.13)
	B.2b Apical lobe with short neck, flared near apex, with apical and subapical teeth on outer angles and either side of midline; lateral lobe 2–3x divided, with mostly closed incisions, ending in paired teeth	*Micrasterias conferta* (Figures 13.19–13.21)
	B.2c Apical lobe compressed, lacking neck, with 1–2 teeth on outer angles, but otherwise smooth; sinus closed or narrowly open; lateral lobe 1–3x divided, ending in paired teeth; polymorphic!	*Micrasterias truncata* (including varieties) (Figures 13.70–13.76)
C	Lateral lobe divided 3–5x	
C.1	Sinus open from isthmus to margin; lateral lobe deeply divided 4–5x; delicate marginal spines on apical lobe and lateral lobules	*Micrasterias radiosa* var. *elegantior* (Figures 13.53–13.56)
C.2	Sinus narrowly open, then closed at margin; lateral lobe divided 3–4x; coarse marginal spines on apical lobe and lateral lobules	*Micrasterias papillifera* (Figures 13.45–13.49)
C.3	Sinus partly closed but open near margin	
	C.3a Lateral lobe divided 3x; cell surface covered with coarse spines; apical lobe and lateral lobules end in sharp spines	*Micrasterias apiculata* (Figures 13.9–13.12)

continued on next page

Table 13.1: Key to *Micrasterias* Species, continued

	C.3b Lateral lobe divided 4x; coarse marginal spines on apical and lateral lobules; apical lobe and lateral lobules end in recurved spines	*Micrasterias compereana* (Figures 13.14–13.18)
	C.3c Lateral lobe divided 4x; cell surface smooth; apical lobe and lateral lobules end in paired teeth	*Micrasterias rotata* (Figures 13.57–13.59)
C.4	Sinus closed to margin	
	C.4a Semi-cells with three large, curved, centrally located tubercles above isthmus; apical lobe with paired teeth on the outer angles and subapical teeth on either side of notch; lateral lobe divided 4x	*Micrasterias thomasiana* (Figures 13.60–13.63)
	C.4b Semi-cells with three small, centrally located nodules above isthmus; apical lobe with paired teeth on the outer angles and subapical teeth on either side of notch; lateral lobe divided 4x	*Micrasterias thomasiana* var. *notata* (Figures 13.64–13.69)
	C.4c Semi-cells with three centrally located rings of granules above isthmus; apical lobe with thickened inner angles but without teeth or spines; lateral lobe divided 3–4x	*Micrasterias verrucosa* (Figures 13.77–13.79)
	C.4d Semi-cells without tubercles, nodules, or granules above isthmus; apical lobe with thickened inner angles but without teeth or spines; lateral lobe divided 3–4x	*Micrasterias denticulata* (Figures 13.22–13.24)

Table 13.2: *Micrasterias* Cell Measurements

		Cell Width	Cell Length	Isthmus Width	Apex Width	L/W Ratio
Micrasterias	min	118.4 μm	131.6 μm	26.8 μm	58.8 μm	1.1
americana	med	123.5 μm	148.8 μm	32.5 μm	64.9 μm	1.2
	max	131.9 μm	156.1 μm	43.0 μm	71.0 μm	1.3
Micrasterias	min	86.6 μm	100.9 μm	23.1 μm	49.2 μm	1.1
americana	med	88.8 μm	110.3 μm	26.9 μm	62.0 μm	1.1
var. lewisiana	max	100.0 μm	111.8 μm	27.8 μm	65.3 μm	1.3
Micrasterias	min	189.8 μm	198.6 μm	31.7 μm	75.8 μm	1.0
apiculata	med	202.1 μm	234.7 μm	36.7 μm	82.3 μm	1.1
	max	229.8 μm	265.0 μm	44.8 μm	94.1 μm	1.2
Micrasterias	min	–	–	–	–	–
brachyptera†	med	159.1 μm	195.1 μm	29.0 μm	59.7 μm	1.2
	max	–	–	–	–	–
Micrasterias	min	189.2 μm	213.3 μm	27.2 μm	45.6 μm	1.0
compereana	med	212.8 μm	235.9 μm	30.0 μm	53.8 μm	1.1
	max	228.8 μm	246.3 μm	34.8 μm	60.7 μm	1.2
Micrasterias	min	76.8 μm	84.4 μm	14.1 μm	40.2 μm	1.1
conferta	med	90.9 μm	98.9 μm	15.6 μm	43.1 μm	1.1
	max	106.8 μm	118.5 μm	20.3 μm	59.8 μm	1.2
Micrasterias	min	177.8 μm	207.6 μm	26.7 μm	48.9 μm	1.1
denticulata	med	223.6 μm	258.4 μm	32.8 μm	60.9 μm	1.2
	max	260.4 μm	292.4 μm	55.6 μm	65.4 μm	1.2
Micrasterias	min	114.4 μm	123.8 μm	22.6 μm	68.7 μm	1.0
depauperata	med	125.0 μm	136.7 μm	28.1 μm	79.1 μm	1.1
var. *wollei*	max	151.2 μm	148.5 μm	40.1 μm	94.9 μm	1.2

†*summary statistics based on <5 cells*

continued on next page

Table 13.2: *Micrasterias* Cell Measurements, continued

		Cell Width	Cell Length	Isthmus Width	Apex Width	L/W Ratio
Micrasterias furcata	min	114.8 μm	133.5 μm	18.8 μm	57.9 μm	1.1
	med	144.2 μm	154.9 μm	23.4 μm	75.2 μm	1.1
	max	164.3 μm	180.1 μm	29.3 μm	92.9 μm	1.2
Micrasterias laticeps	min	143.2 μm	129.8 μm	24.9 μm	139.5 μm	0.8
	med	161.6 μm	137.6 μm	28.4 μm	150.1 μm	0.9
	max	174.9 μm	151.0 μm	36.0 μm	168.6 μm	0.9
Micrasterias mahabule-shwarensis†	min	–	–	–	–	–
	med	146.9 μm	188.4 μm	20.2 μm	76.6 μm	1.2
	max	–	–	–	–	–
Micrasterias muricata	min	98.7 μm	141.4 μm	21.6 μm	70.2 μm	1.1
	med	113.1 μm	155.4 μm	24.4 μm	83.2 μm	1.4
	max	150.2 μm	192.7 μm	32.2 μm	119.6 μm	1.9
Micrasterias nordstedtiana	min	130.0 μm	131.5 μm	22.3 μm	84.2 μm	0.9
	med	146.2 μm	139.0 μm	24.0 μm	99.2 μm	0.9
	max	161.2 μm	141.4 μm	29.2 μm	106.3 μm	1.1
Micrasterias papillifera	min	123.9 μm	129.8 μm	17.8 μm	34.9 μm	1.0
	med	137.8 μm	149.4 μm	20.9 μm	39.3 μm	1.1
	max	165.8 μm	184.7 μm	27.2 μm	46.6 μm	1.2
Micrasterias pinnatifida	min	59.7 μm	54.4 μm	10.1 μm	41.5 μm	0.8
	med	67.0 μm	58.1 μm	11.9 μm	45.3 μm	0.9
	max	75.3 μm	63.1 μm	14.1 μm	54.9 μm	0.9
Micrasterias radiosa var. *elegantior*	min	161.4 μm	163.8 μm	16.3 μm	19.1 μm	1.0
	med	177.0 μm	179.5 μm	17.9 μm	29.1 μm	1.0
	max	201.3 μm	209.4 μm	23.4 μm	35.3 μm	1.1

†*summary statistics based on <5 cells*

continued on next page

Table 13.2: *Micrasterias* Cell Measurements, continued

		Cell Width	Cell Length	Isthmus Width	Apex Width	L/W Ratio
Micrasterias	min	236.4 μm	261.3 μm	30.0 μm	50.0 μm	1.0
rotata	med	277.4 μm	296.0 μm	38.3 μm	58.9 μm	1.1
	max	307.2 μm	340.8 μm	48.7 μm	67.1 μm	1.2
Micrasterias	min	191.5 μm	226.0 μm	28.0 μm	48.5 μm	1.0
thomasiana	med	214.9 μm	241.6 μm	32.6 μm	52.4 μm	1.1
	max	265.9 μm	278.2 μm	40.0 μm	56.8 μm	1.2
Micrasterias	min	202.2 μm	229.2 μm	26.9 μm	46.2 μm	1.1
thomasiana	med	234.9 μm	259.0 μm	32.9 μm	52.3 μm	1.1
var. *notata*	max	264.1 μm	284.4 μm	37.2 μm	63.5 μm	1.2
Micrasterias	min	71.1 μm	77.1 μm	14.0 μm	37.5 μm	1.0
truncata	med	104.0 μm	107.2 μm	21.0 μm	79.7 μm	1.0
	max	117.3 μm	123.7 μm	27.7 μm	90.0 μm	1.2
Micrasterias	min	94.9 μm	83.7 μm	15.0 μm	57.1 μm	0.8
truncata	med	100.9 μm	85.8 μm	16.3 μm	64.8 μm	0.9
var. *semiradiata*	max	104.6 μm	92.8 μm	21.6 μm	70.0 μm	0.9
Micrasterias	min	73.9 μm	80.5 μm	18.4 μm	63.4 μm	1.0
truncata	med	85.9 μm	93.6 μm	20.0 μm	73.3 μm	1.1
var. A	max	89.9 μm	97.6 μm	21.2 μm	77.9 μm	1.1
Micrasterias	min	–	–	–	–	–
verrucosa[†]	med	199.8 μm	237.4 μm	32.1 μm	54.5 μm	1.1
	max	–	–	–	–	–

[†]*summary statistics based on <5 cells*

Description

Micrasterias cells are large, showy, and often have distinctive features that make the easy to recognize, at least at the genus level. Most species of *Micrasterias* are associated with boggy mountain lakes, but a few species are widely distributed can be found in low elevation lakes and ponds.

Micrasterias cells are usually circular, elliptical, or rectangular in outline and flattened in cross-section, with a slightly raised center (Figures 13.1–13.3). Each semi-cell contains a single, large chloroplast containing many large pyrenoids. The semi-cells are separated by an incision (sinus) that may be open, partly open, or closed from the isthmus to the cell margin. Each semi-cell is divided into segments consisting of an apical lobe[30] and lateral lobes; the lateral lobes are often subdivided into lobules. One of the semi-cells often has deeper incisions between the lobules; this semi-cell should be used when matching species descriptions because the other semi-cell may not have fully developed features. The lateral lobe divisions may be asymmetric, with the upper segment (closer to the apex) containing more lobules than the lower segment (Figure 13.3). For taxonomic purposes, use the highest number of lateral lobe divisions present in the cell. Finally, be aware that many of the species are morphologically variable, so examine several specimens before attempting to identify the species.

Micrasterias americana cells are broadly elliptical in outline, with trapezoidal semi-cells that are serrated or toothed along the cell margin (Figures 13.4–13.7). The semi-cells are separated by a deep, mostly open, V-shaped sinus. The apical lobe is wedge-shaped and may have an elongated neck with parallel sides. The apex of the apical lobe has four horn-like processes that lie in different planes. The lateral lobes are divided 2x, with the second division represented by a shallow, open notch. The outer (distal) lateral lobules are longer than the inner (proximal) lobules. The cell surface may appear smooth, but is sparsely covered with scattered granules or tiny spines that can be seen in the SEM image (Figure 13.5). This species is widely distributed. In addition to being collected in mountain lakes, it is one of the most common species found in low elevation lakes in northwest Washington. *Micrasterias americana* resembles *Micrasterias mahabuleshwarensis* (Figure 13.37) and *Micrasterias nordstedtiana* (Figure 13.41), both of which have single lateral lobe divisions; it also resembles *Micrasterias furcata* (Figure 13.30), which has only two horn-like apical processes.

[30]The apical lobe may be called the "polar" lobe in some taxonomic guides.

The specimens in Figure 13.7 resembles descriptions for ***Micrasterias americana*** **var.** ***americana*** **f.** ***boldtii*** (Prescott, et al., 1977), which has shallow but distinct incisions and short, knob-like apical projections. But the northwest Washington specimens appear to be a reduced form of the nominate variety[31] (see discussion by Coesel and Meesters, 2007). This can be seen in the SEM image in Figure 13.7 where the lower semi-cell is a reduced form and the upper semi-cell is fully developed.

Micrasterias americana **var.** ***lewisiana*** (Figure 13.8) is a slightly smaller variety that is characterized by a short, flat apical lobe with greatly reduced, knobby apical processes. The lateral lobes are divided 2x, but the second division is usually just a shallow indentation. This variety is relatively uncommon but has been collected in several lakes and ponds in northwest Washington. It is important to examine both semi-cells and more than one specimen to make sure you are not looking at a reduced form of the nominate variety (see discussion above).

Micrasterias apiculata cells are nearly circular to broadly elliptical in outline, with a deep sinus that is closed near the center, then open and V-shaped near the margin (Figures 13.9–13.12). The apical lobe has parallel sides near the base, then flares broadly from the shallow apical notch. The lateral lobes are divided 3x and each lobule ends with stout, paired spines. The apical lobe also has paired spines on the outer angles, with additional spines extending vertically on both sides of the apical notch. The surface of the cell is covered with short, evenly spaced spines. There is a row of spines along the sinus, separated by a central tuft of spines just above the isthmus (Figures 13.10–13.12). The distribution of spines on the northwest Washington specimens is characteristic of the nominal variety.[32]

Micrasterias brachyptera cells are nearly circular to broadly elliptical in outline, with a partly open sinus (Figure 13.13). The apical lobe has an elongated neck, with parallel sides near the base and a shallow, flaring apical notch. The upper and lower lateral lobules are approximately equal in size, and the incisions are widely open. The apical lobe and lateral lobules end in stout, paired spines that may be recurved. The face of the cell may have scattered spines, but this feature is difficult to see without SEM imagery. *Micrasterias brachyptera* resembles *Micrasterias apiculata* (Figure 13.9), which can be distinguished by its 3x lateral lobe divisions and dense, clearly visible surface spines.

[31] *Micrasterias americana* var. *americana*
[32] *Micrasterias apiculata* var. *apiculata*

Micrasterias compereana cells are spherical or broadly elliptical in outline, with a deep sinus that is mostly closed, then open near the margin (Figures 13.14–13.18). The apical lobe is narrow, usually with undulating sides, and flares slightly on either side of the shallow apical notch. The lateral lobe subdivisions are asymmetric: the upper lateral lobe segment is incised four times, while the lower lateral lobe segment is incised three times. The lateral lobules end in stout, paired spines or teeth that are often recurved, especially near the sinus. The apical lobe has paired, recurved spines on the outer angles and small subapical spines on either side of the median notch. Additional rows of spines are present along the edges of the apical lobe, above the sinus, and sometimes along the edges of the lateral lobules (see SEM images in Figure 13.15).

Micrasterias compereana was recently separated from a closely related species, *Micrasterias fimbriata* Ralfs, based on molecular and morphological differences (Neustupa, et al., 2014). *Micrasterias fimbriata* is primarily a European species and no specimens were collected in the northwest Washington samples. *Micrasterias compereana* also resembles *Micrasterias rotata* (Figure 13.57), but *M. rotata* lacks spines on the surface of the cell, and has simple teeth, not recurved spines, on the outer angles of the apical lobe.

Micrasterias conferta cells are nearly circular in outline, with a deep, closed sinus (Figures 13.19–13.21). The apical lobe is broad, flaring at the apex, with a shallow median notch and 3–4 blunt, apical and subapical teeth on either side of the median notch. The upper and lower lateral lobe segments have symmetric subdivisions and are incised 2–3x, with each lobule ending in paired teeth. The cell surface may be smooth or covered with fine spines. *Micrasterias conferta* is morphologically variable, and cells can be found that have a smooth appearance, with reduced denticulation and shallow lateral lobe incisions. Figure 13.21 shows examples of atypical cells; these forms could be confused with *Micrasterias jenneri* Ralfs (no image available), which is more elliptical and much larger.

Micrasterias denticulata cells are large and broadly elliptical in outline, with a deep, closed sinus (Figures 13.22–13.24). The apical lobe is narrow and wedge-shaped, with a V-shaped notch that is thickened along the inner margin, but lacks teeth or spines. The upper and lower lateral lobe segments are equally divided (3–4x); the divisions are closed except for the final division, which is a shallow, slightly open notch. The cell margin may appear rough or granular, but will not have marginal teeth or spines. The cell surface also lacks spines, giving the cell has a smoothly rounded appearance. *Micrasterias denticulata* closely resembles

Micrasterias rotata and *Micrasterias thomasiana* var. *notata*, which are about the same size and may be present in the same sample. *Micrasterias denticulata* can be distinguished by its broadly elliptical outline, equally divided lateral lobe segments, and absence of marginal teeth or spines (see comparisons on Figure 13.25).

Micrasterias depauperata* var. *wollei cells are rectangular in outline, with trapezoidal semi-cells and a deep, open sinus (Figures 13.26–13.29). The apical lobe is broad, flat or very slightly indented, lacks a distinct median notch, and is edged with stout, paired spines. The apical lobe is separated from the lateral lobes by a short, wide, rounded neck, The lateral lobe is very shallowly divided (1x); each lateral lobule ends in paired or single spines. The species is distinctive and easily recognized, but uncommon in northwest Washington lakes. As with so many desmid species, the cells are morphologically variable.

The specimen in Figure 13.29 was collected in Lake Evan on the same date when typical cells of *Micrasterias depauperata* var. *wollei* were present, so it is probably an poorly developed specimen of var. *wollei*. The lower semi-cell has individual, peg-like teeth on the apical lobe angles, and both semi-cells have relatively long lateral lobes (>half the length of the semi-cell). These features fit the description for *Micrasterias depauperata* f. *apiculata* Irénée-Marie (=*Micrasterias depauperata* var. *wollei* f. *apiculata* Irénée-Mari); however, the upper semi-cell shows the presence of two under-developed marginal teeth on the apical lobe angles. The specimen also resembles some of the morphological forms of *Micrasterias truncata* (see discussion below), but can be distinguished by the open, rounded separation between the apical and lateral lobes.

Micrasterias furcata cells are nearly circular or broadly elliptical in outline, with an open sinus, and wide separations between the apical and lateral lobes (Figures 13.30–13.33). The apical lobe has parallel sides near the base, then separates into two long, divergent, horn-like processes that end in paired teeth. The lateral lobes are deeply incised (2x), diverging into long, narrow, processes that also end in paired teeth. Along with *Micrasterias americana*, this species is often collected in both mountain and low elevation lakes and ponds in northwest Washington. *Micrasterias furcata* resembles *Micrasterias mahabuleshwarensis* (Figure 13.37) and *Micrasterias nordstedtiana* (Figure 13.41), both of which have single lateral lobe divisions; it also resembles *Micrasterias americana* (Figure 13.4), which has four horn-like apical processes.

Micrasterias laticeps cells are rectangular in outline, with a greatly expanded apical lobe that resembles the undivided lateral lobes (Figures 13.34–13.36). The semi-cells are separated by a deep, open, V-shaped sinus. The apical lobe is approximately as wide that the lateral lobes and tapers into a single tooth, while the lateral lobes taper gradually into paired teeth. Although not highly ornamental, this desmid is one of the easiest species of *Micrasterias* to identify because of its simple shape that is, for the most part, morphologically consistent for specimens collected at different sites.

Micrasterias mahabuleshwarensis cells are rectangular in outline, with trapezoidal semi-cells and a widely open sinus (Figure 13.37). The apical lobe has a long, narrow neck that flares near the apex, ending in two long, upwardly divergent, horn-like processes. Two additional short, vertical processes are positioned on either side of the center of the apical lobe. The lateral lobe is divided 1x (2x for some varieties), with each lobule forming long, horn-like processes. The margins of the apical lobe and lateral lobules are lined with small teeth. This species is not frequently encountered and has only been photographed in SEM preparations from samples collected in Clear Lake. *Micrasterias mahabuleshwarensis* resembles *Micrasterias nordstedtiana* (Figure 13.41), which lacks the upwardly divergent, horn-like apical processes. It also resembles *Micrasterias americana* (Figure 13.4) and *Micrasterias furcata* (Figure 13.30), both of which have 2x lateral lobe divisions.

Micrasterias muricata cells do not resemble most other species of *Micrasterias*. The cells are cylindrical in outline, with deeply incised, 1x divided lateral lobes (Figures 13.38–13.40). The lateral lobules extend into long horn-like processes that form whorls around the main axis of the cell. The apical lobe is flattened, slightly indented at the apex, and extended on both sides to form horn-like processes that resemble the lateral lobules. This species was collected in several mountain lakes, and is particularly common in Vogler Lake. *Micrasterias muricata* resembles *Micrasterias nordstedtiana* (Figure 13.41), which has shallower lateral lobe incisions and a longer apical lobe base.

Micrasterias nordstedtiana semi-cells are rectangular or trapezoidal in outline, with a flattened apical lobe that has a whorl of long, horizontal, horn-like processes (Figures 13.41–13.44). The base of the apical lobe is long and cylindrical. Prescott, et al. (1977) states that there are conical projections near the middle of the cylindrical section, but this feature was not evident in any of the northwest Washington specimens. The lateral lobes are divided 1x, with the lobules forming horn-like processes similar to those on the apical lobe. This species resembles

Micrasterias muricata (Figure 13.38), but has shallower lateral lobe incisions and a longer, more cylindrical apical lobe base. The cells also resemble *Micrasterias mahabuleshwarensis* (Figure 13.37), which can be distinguished by the presence of a second set of short, vertical processes on the apical lobe.

Micrasterias papillifera cells are nearly circular in outline, but should be slightly longer than wide (Figures 13.45–13.49). The wedge-shaped apical lobe is deeply incised, with two short teeth on each of the outer angles of the apex, and one additional upwardly directed, subapical tooth on each side of the median notch. The semi-cells are separated by a deep sinus that may be closed, but is more often slightly separated in the center and closed near the margin. The lateral lobes are deeply incised, divided 3–4x in the upper segment of the lateral lobe, and 2–3x in the lower segment. The first incision is often closed, but high order incisions are usually open. The lateral lobules end in paired teeth, and there are coarse spines or teeth along the sinus and margins of the lateral lobules. *Micrasterias papillifera* is a highly polymorphic species that can be difficult to distinguish from *Micrasterias rotata* (Figure 13.57), which has a smooth cell wall.

Micrasterias pinnatifida is characterized by small, rectangular cells that are slightly longer than wide (Figures 13.50–13.52). The apical lobe is slightly narrower than the lateral lobes and broadly flared, with a nearly flat or slightly convex apex. The lateral lobe is undivided and gradually tapered. Both the apical and lateral lobes end in paired teeth. The sinus is closed near the isthmus, then widely open. The separation between the apical and lateral lobes is open and broadly U-shaped. Most of the northwest Washington specimens had a flattened or slightly concave apical lobe, but the cells from Myrtle Lake had convex, slightly domed apical lobes (Figure 13.52).

Micrasterias radiosa* var. *elegantior is a large, showy species with nearly circular cells that are very deeply incised (Figures 13.53–13.56). The apical lobe is long and narrow, with nearly parallel sides and a slightly flared apex. The apical lobe has paired teeth on the outer angles and individual, short, subapical teeth on either side of the notch. The lateral lobes are deeply incised (4–5x in the upper lateral lobe segment; 3–4x in the lower segment), with the last incision represented by a V-shaped notch. All lobules end in paired teeth. The sinus and all lateral lobe incisions are open to the base. The cell surface is smooth except for scattered, widely spaced tooth-like spines along the edges of the apical lobe and some of the lateral lobules.

Micrasterias rotata cells are large, circular or very slightly elliptical in outline, with a deep sinus that is closed near the isthmus and slightly open near the margin (Figures 13.57–13.59). The apical lobe is narrow, gradually expanding toward the apex, which has a wide, flaring median notch and paired teeth on the outer angles. The lateral lobes are deeply and unequally divided, with 4x divisions in the upper lateral lobe segment and only 3x divisions in the lower segment. All lateral lobules end in paired teeth similar to those on the apical lobe. The sinus and lateral lobe incisions are closed except for the higher order subdivisions (3–4x), which are slightly open. The cell surface is smooth except for the marginal teeth, which helps distinguish this species from similar, but spiny species like *Micrasterias compereana* (Figure 13.14) and *Micrasterias papillifera* (Figure 13.45). *Micrasterias rotata* closely resembles *Micrasterias denticulata* and *Micrasterias thomasiana* var. *notata*, which are about the same size and may be present in the same sample. *Micrasterias rotata* can be distinguished from these two species by its nearly circular outline, unequally divided lateral lobes, and paired teeth on the outer angles of the apical lobe (see comparisons on Figure 13.25).

Micrasterias thomasiana cells are large, nearly circular to broadly elliptical in outline, with a deep, closed sinus (Figures 13.60–13.69). The apical lobe is narrow, cylindrical in the lower portion, with a slightly inflated, concave apex, and a deep, V-shaped median notch. The apical lobe has paired teeth on the outer angles and short, subapical teeth on either side of the notch. The lateral lobes are deeply and equally divided with 4x divisions in both the upper and lower segments. The sinus and lateral lobe incisions are closed except for the higher order lateral lobules (3–4x), which may be slightly open. The lateral lobules end in short, paired teeth similar to the apical lobe. The cells have blunt, transparent tubercles or hooks adjacent to the isthmus that may be difficult to see unless you move through several planes of focus or use SEM. Except for *Micrasterias thomasiana* var. *notata* (see below), the cell surface is covered with large, conical teeth arranged in one or more concentric circles. ***Micrasterias thomasiana* var. *notata*** has a smooth cell surface except for inconspicuous nodules or small tubercles on either side of the isthmus (Figures 13.64–13.69). *Micrasterias thomasiana* var. *notata* closely resembles *Micrasterias denticulata* and *Micrasterias rotata*, which are about the same size and may be present in the same sample. *Micrasterias thomasiana* var. *notata* can be distinguished by the equally divided lateral lobes; paired teeth on the outer angles of the apical lobe, with subapical teeth on either side of the apical notch; and (look carefully!) the presence of the small transparent nodules on either side of the isthmus (see comparisons on Figure 13.25).

Micrasterias truncata cells are relatively small, oval in outline, with a deep, open or closed sinus (Figures 13.70–13.76). The apical lobe is broad and tapered, relatively short (compressed), and ends with 1–2 blunt teeth. The apical lobe lacks a median notch, but the center may be slightly flattened or concave. The lateral lobes are shallowly divided (1–3x); each lobule ends in two marginal teeth or spines. The species is extremely polymorphic, displaying variations in the number and length of the marginal teeth, and the number and depth of lateral lobe incisions, which may be nothing more than a shallow notch). As an illustration, Figure 13.72 shows four *Micrasterias truncata* specimens collected on the same date in Summer Lake; note the differences in the depth of lateral lobe incisions and degree of marginal roughness.

The morphological variability of this species makes is difficult to identify varieties with confidence. However, two possible varieties were found that were present on multiple dates and in sufficient numbers to warrant further investigation into whether they represent genetically reproducible variations. The specimens in Figures 13.73–13.74 fit the description for ***Micrasterias truncata* var. *semiradiata***, which is characterized by having nearly circular cells and unusually robust marginal teeth. The lateral lobes are divided 2x, with a wider, more deeply incised lower lateral lobe segment.[33] This variety was present on numerous occasions in several lakes in eastern Washington. The specimens of ***Micrasterias truncata* var. A** (Figures 13.75–13.76) were collected from multiple high elevation sites in northwest Washington. The cells are relatively small (W$\leq$90 μm, L$\leq$100 μm), with shallow, open, rounded incisions between the apical and lateral lobes. The lateral lobe is divided 1x. The lateral lobules are truncated and have two short, blunt, marginal teeth on each angle. The apical lobe has one or two blunt teeth along the outer angles.

Micrasterias verrucosa cells are large, oval in outline, with a deep, closed sinus (Figures 13.77–13.79). The apical lobe is narrow near the base, then slightly expanded at the apex. The apex is flattened or slightly concave, with a deep, open notch. The angles of the apical notch are thickened, but the apical lobe lacks spines or teeth. The upper segment of the lateral lobe is divided 3–4x into nearly equal lobules, resulting in wedge-shaped segments separated by closed incisions except at the fourth incision, which is a simple notch. The margins of the lobules may appear smooth or granular, but close inspection should reveal the presence of very short teeth. The surface of the cell has radially arranged circular swellings containing

[33] Most species of *Micrasterias* with asymmetric lateral lobe divisions will have a wider, more deeply incised upper lateral lobe segment.

radiating granules (Figure 13.78–13.79). These swellings are prominent near the isthmus and decrease in size near the margins. *Micrasterias verrucosa* looks very similar to *Micrasterias denticulata* (Figure 13.22), which lacks the circular swellings on the cell face and near the isthmus. These separation features are very subtle, so it will be important to examine the cell face under high magnification.

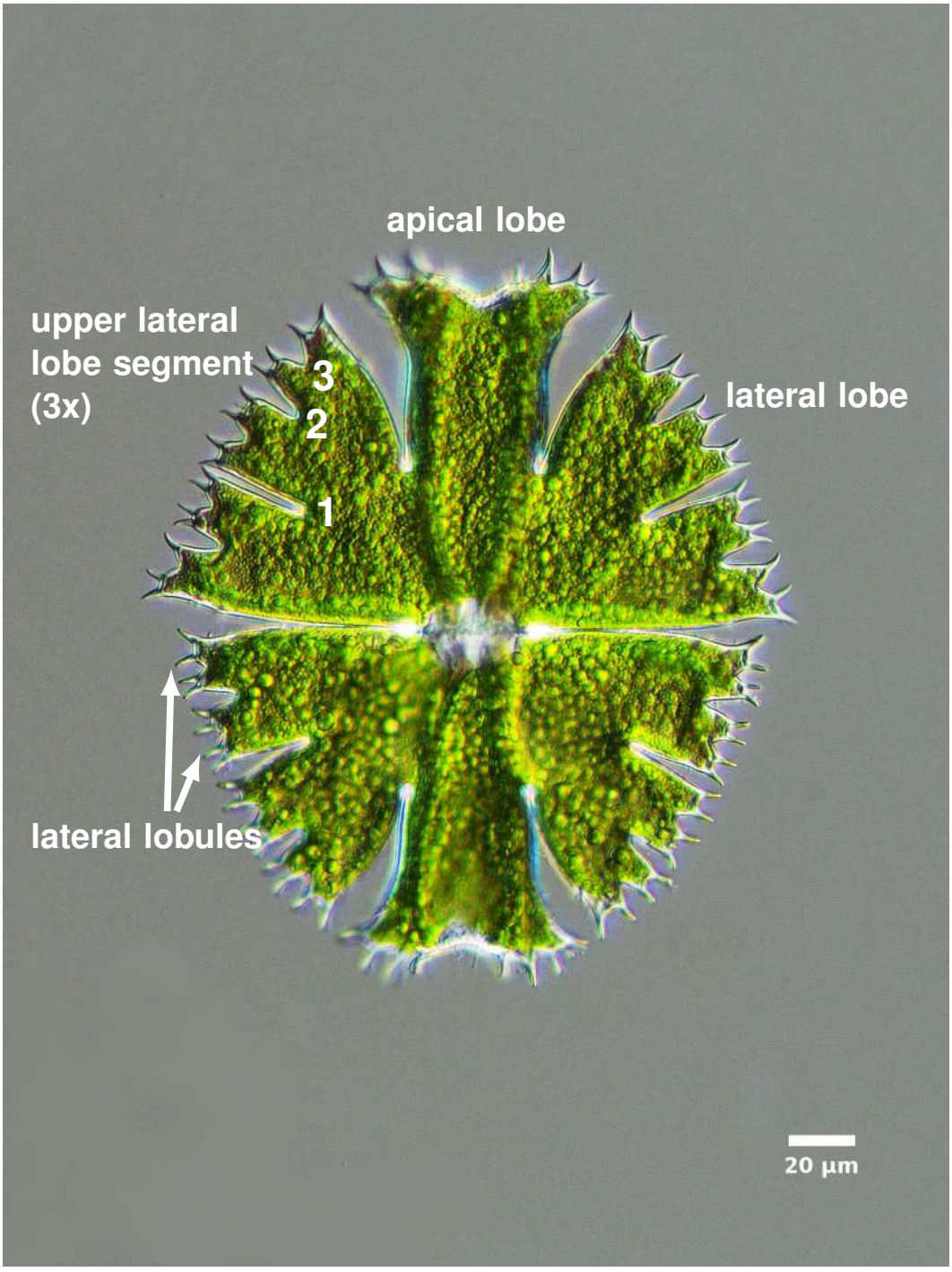


Figure 13.1: *Micrasterias* basic morphological features (*Micrasterias apiculata*).

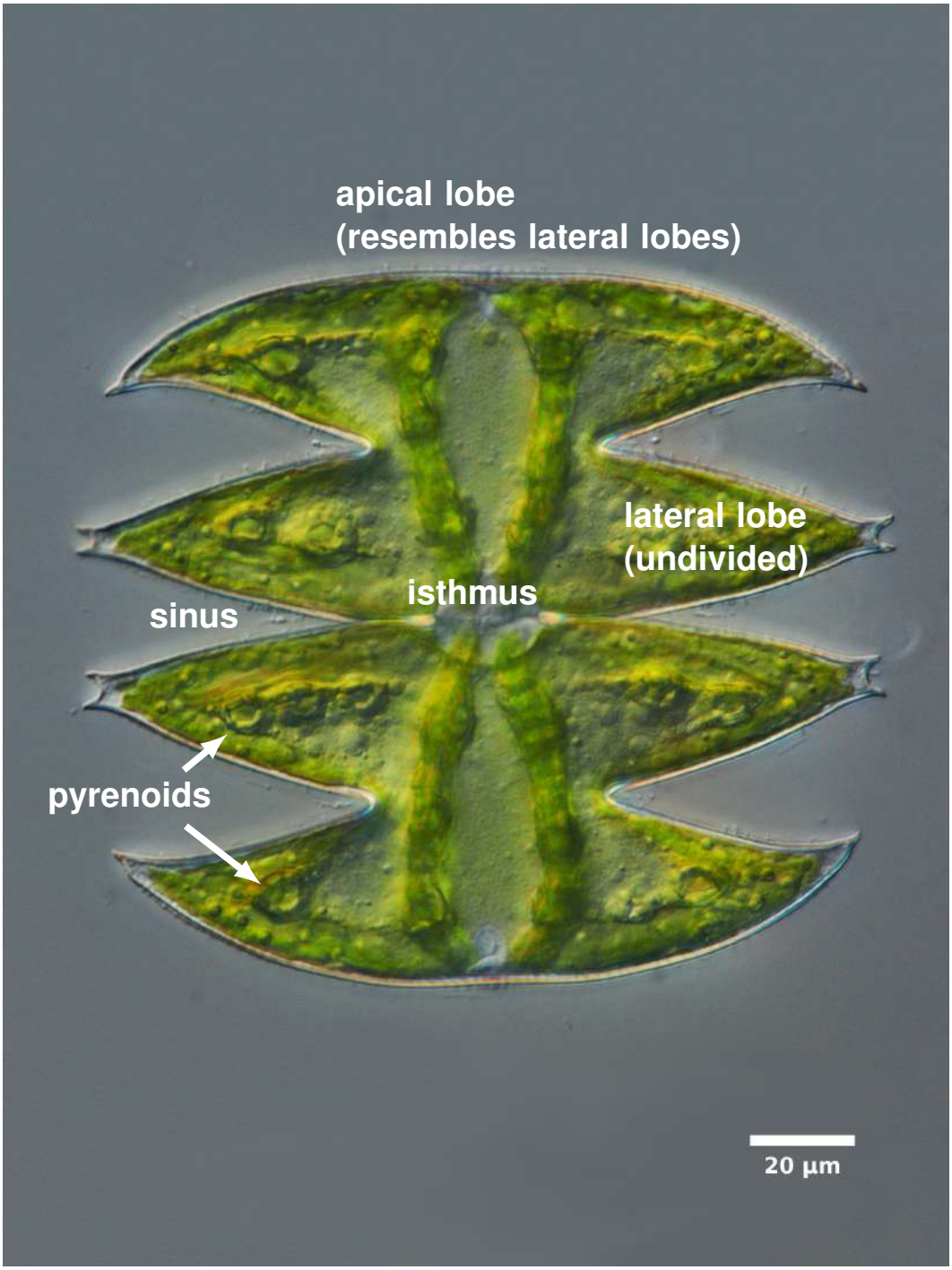


Figure 13.2: *Micrasterias* basic morphological features, continued (*Micrasterias laticeps*).

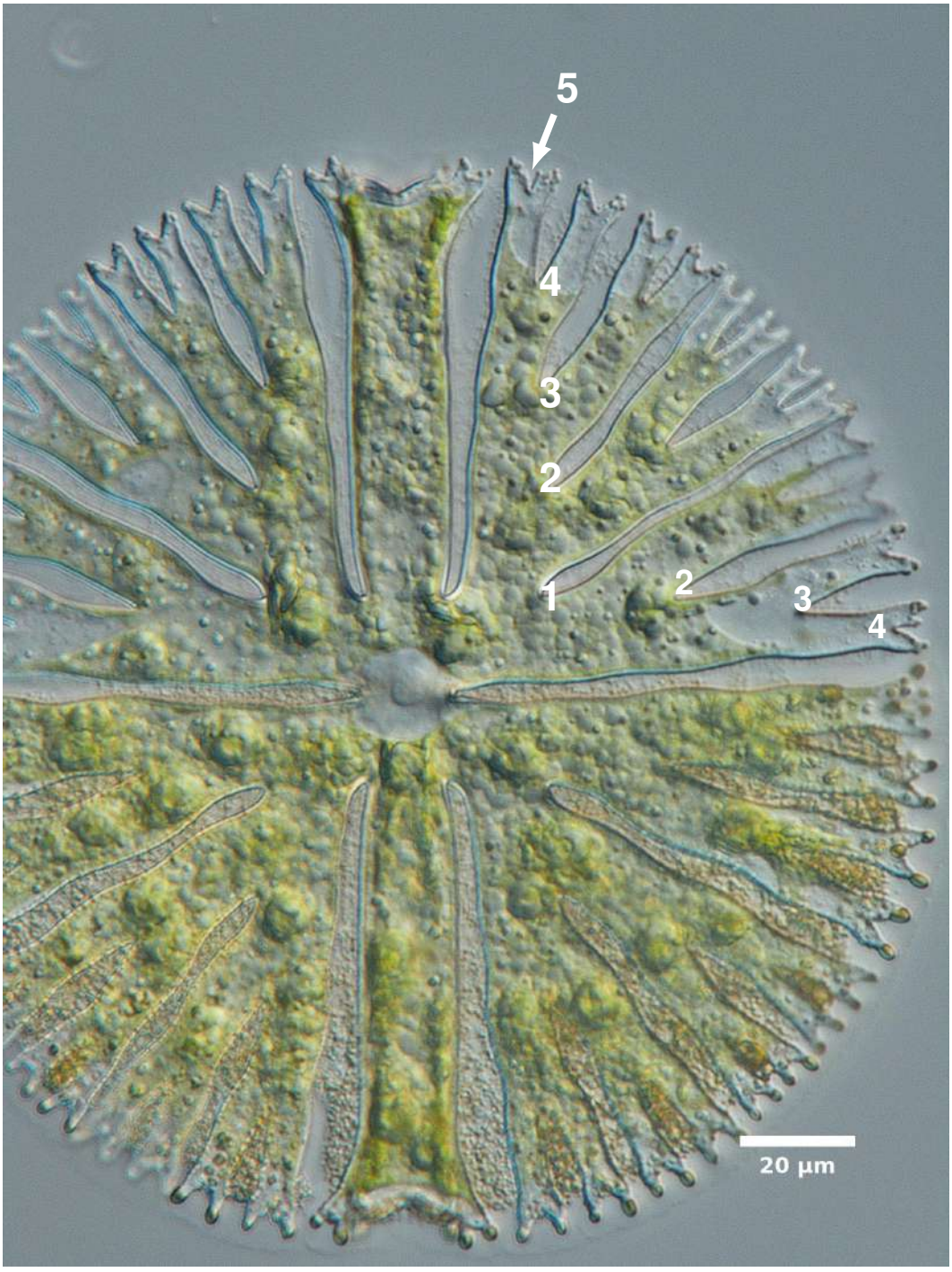


Figure 13.3: Example of asymmetric lateral lobe division (*Micrasterias radiosa* var. *elegantior*). Upper segment of the lateral lobe is divided 5x; lower segment is divided 4x and is not as wide as the upper segment.

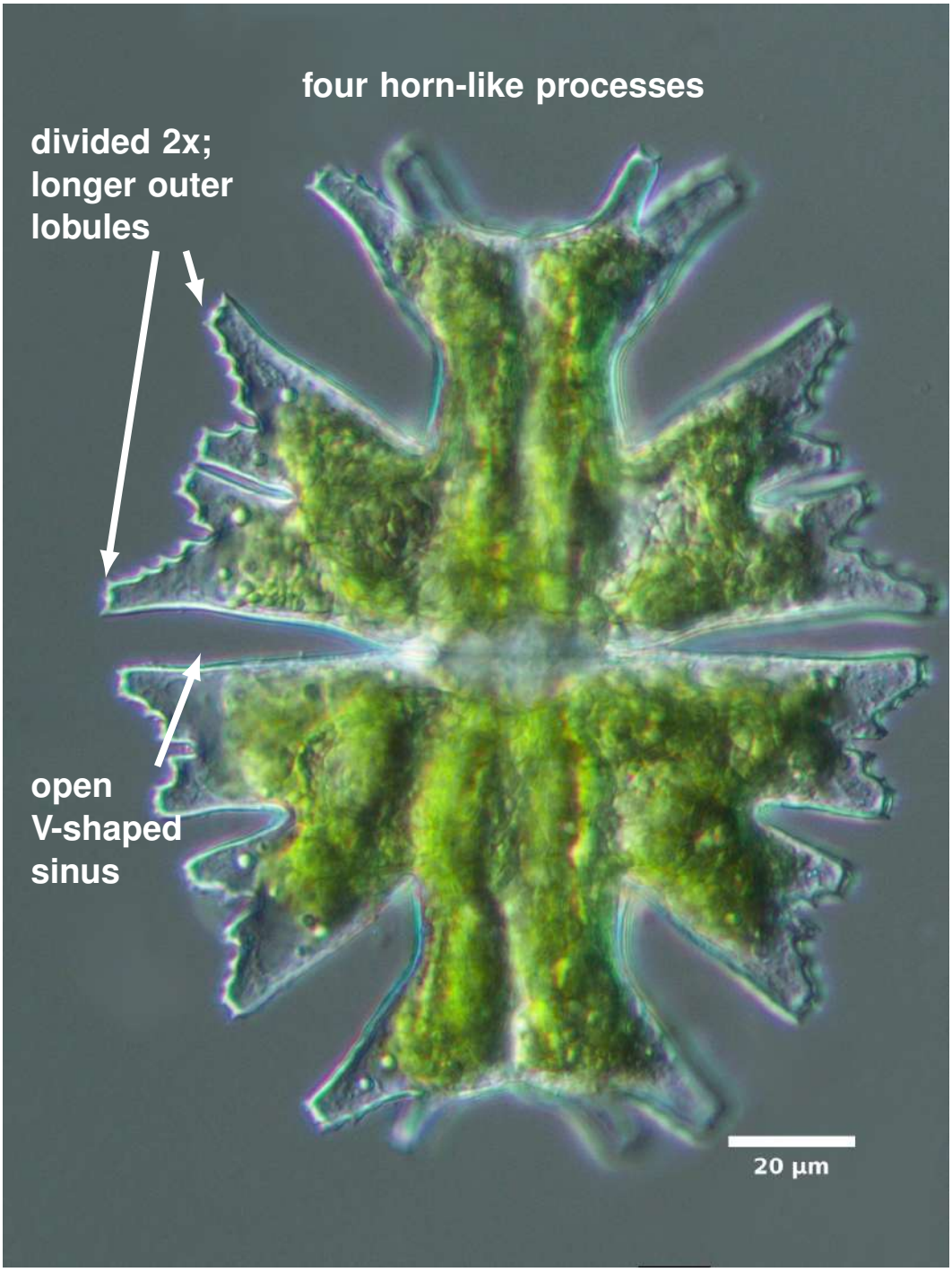


Figure 13.4: *Micrasterias americana* (DIC), small pond near Fairhaven College, Whatcom County.

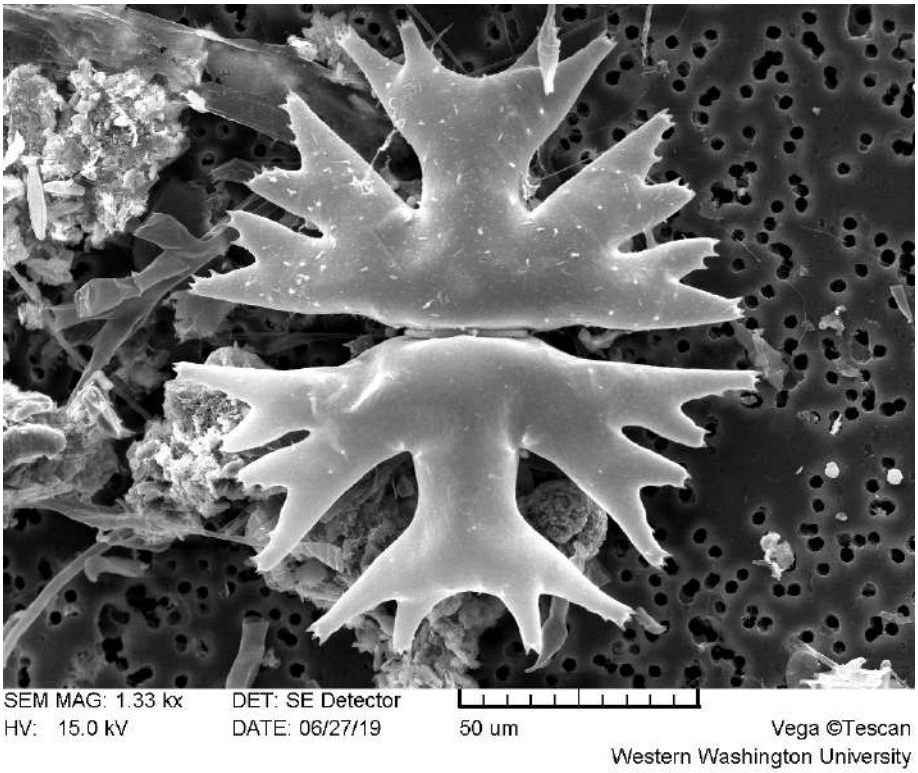




Figure 13.5: *Micrasterias americana* (SEM/DIC), Mirror Lake, Whatcom County (upper/lower images).



Figure 13.6: *Micrasterias americana* apical lobe variations (DIC/DIC), Mirror Lake, Whatcom County (upper image); small pond near Fairhaven College, Whatcom County (lower image).

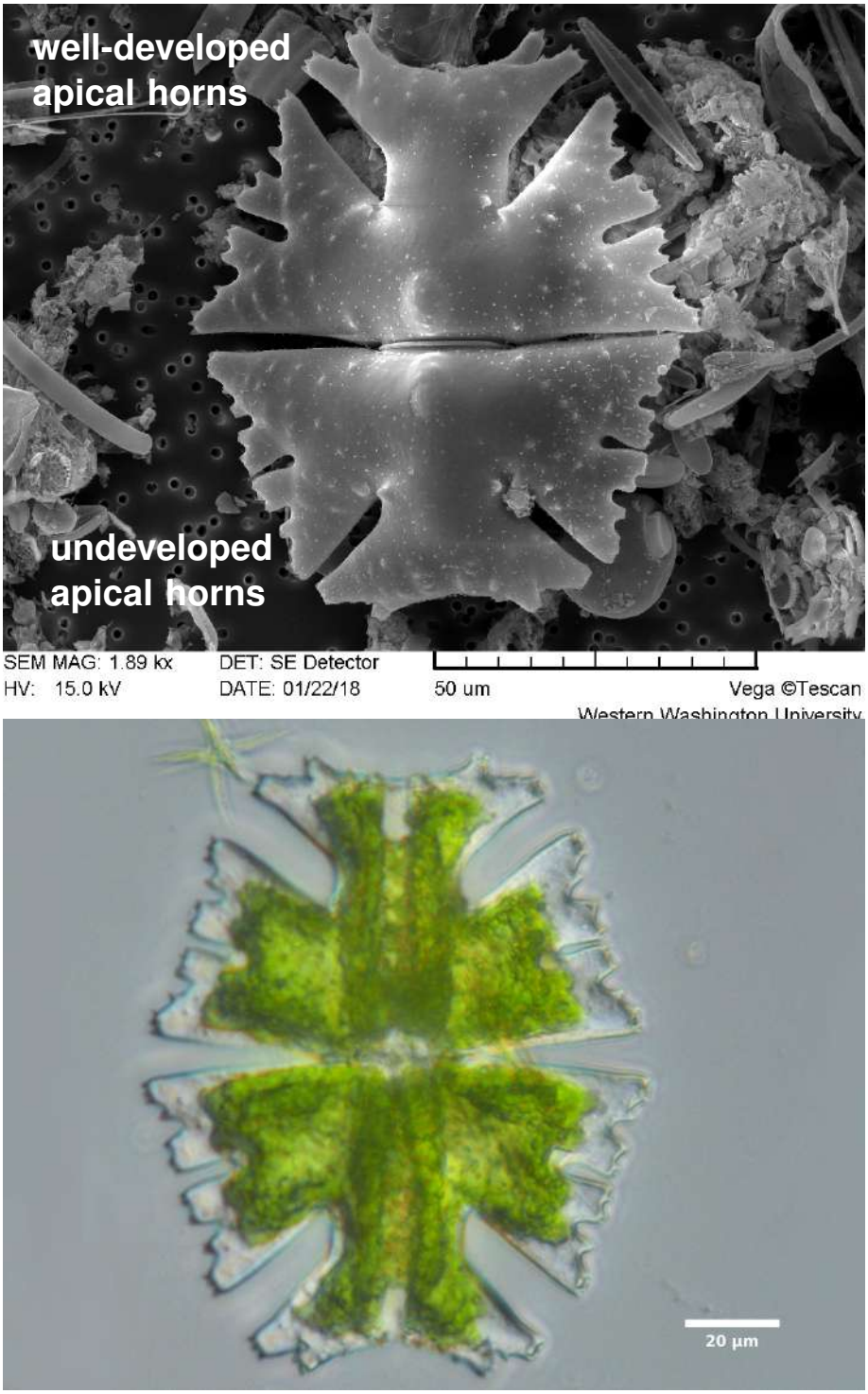


Figure 13.7: *Micrasterias americana* reduced form (SEM/DIC), Lake Evan, Mountain Loop Highway, Snohomish County (upper image); Gold Basin Mill Pond, Mountain Loop Highway, Snohomish County (lower image).

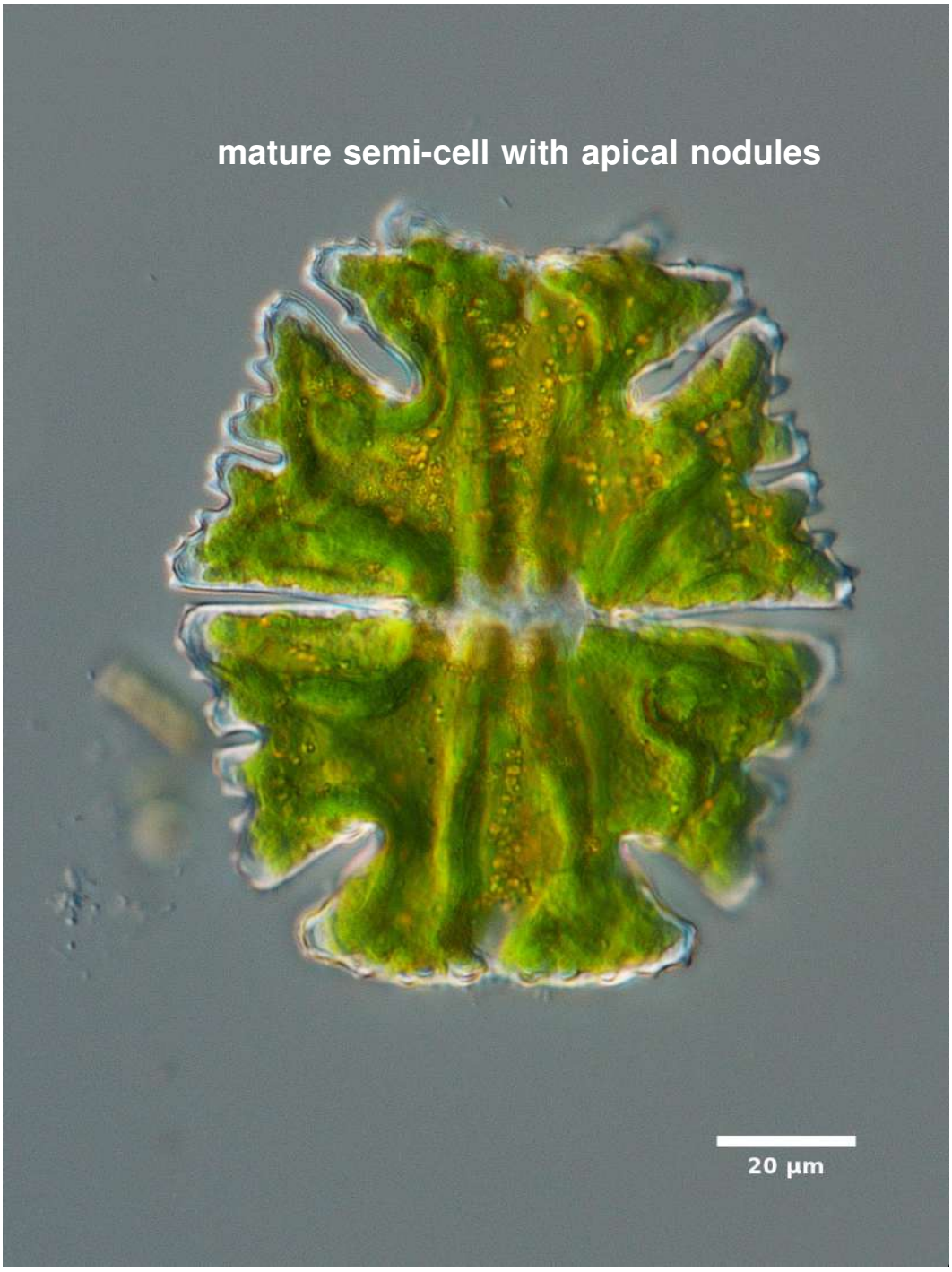


Figure 13.8: *Micrasterias americana* var. *lewisiana* (DIC), small pond along Military Road south of Tacoma, Pierce County.

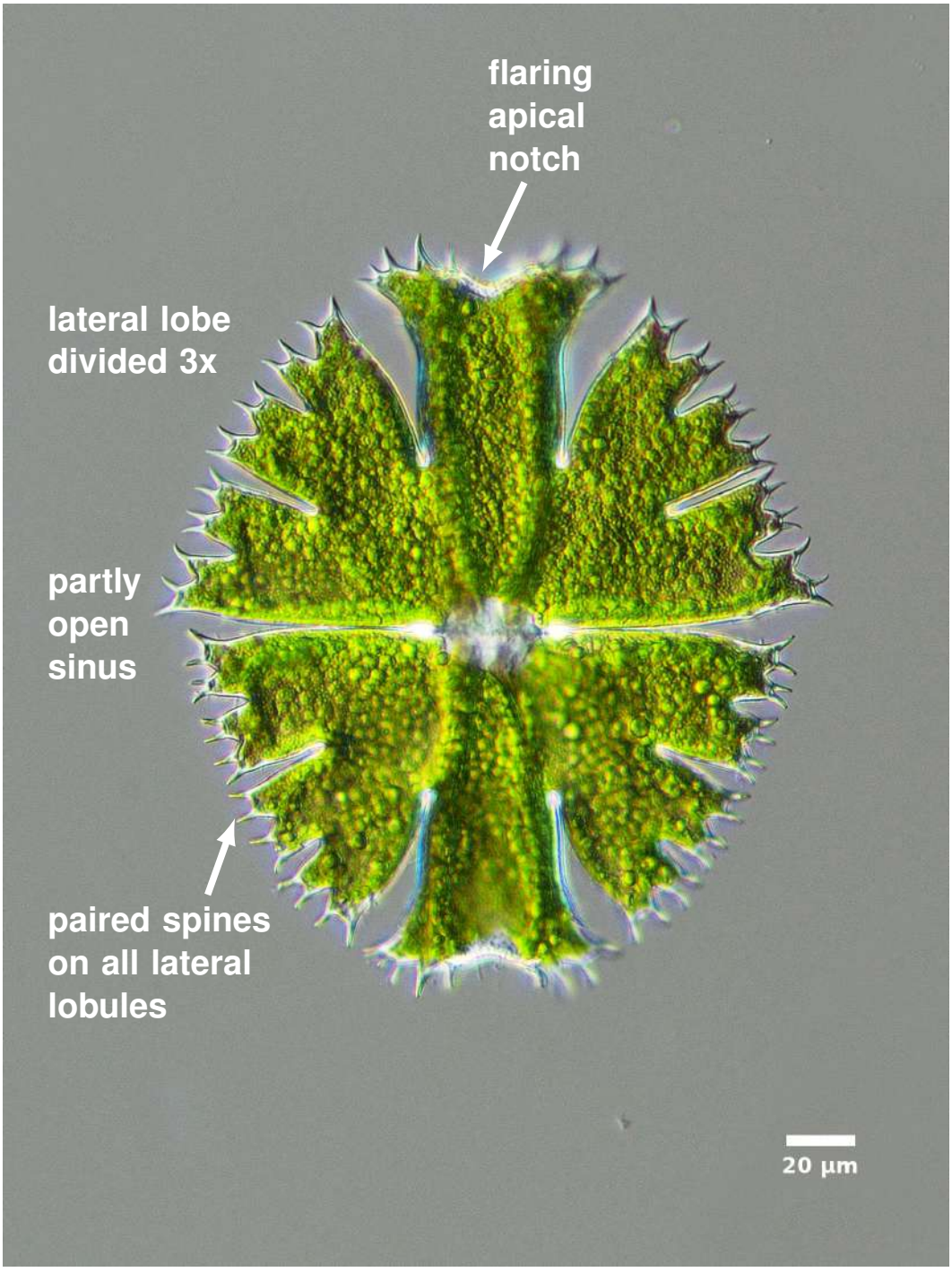


Figure 13.9: *Micrasterias apiculata* (DIC), Myrtle Lake, Mountain Loop Highway, Snohomish County.

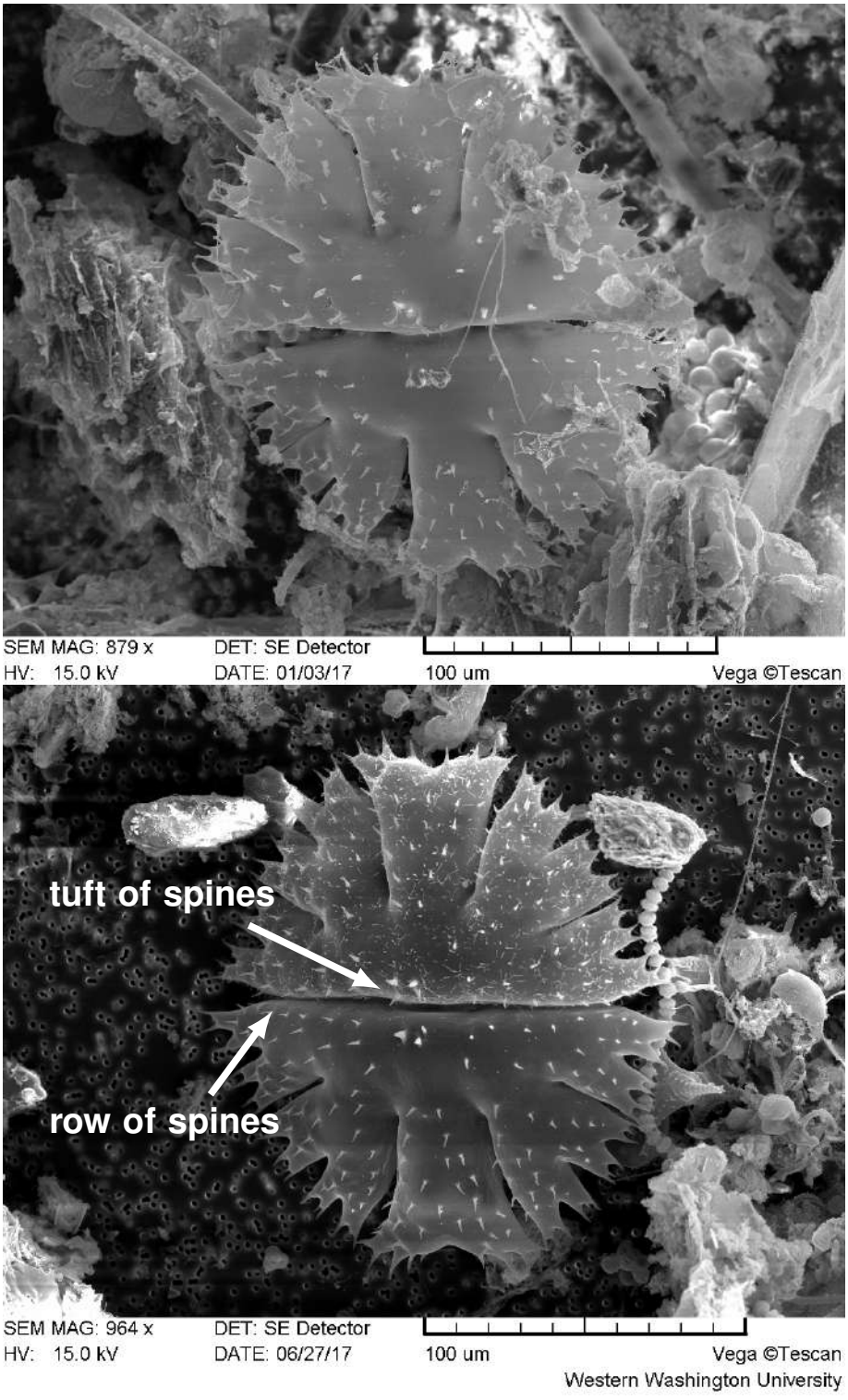


Figure 13.10: *Micrasterias apiculata* (SEM/SEM), Vogler Lake, Skagit County (upper image); Myrtle Lake, Mountain Loop Highway, Snohomish County (lower image).



Figure 13.11: *Micrasterias apiculata* spines (DIC), Vogler Lake, Skagit County.

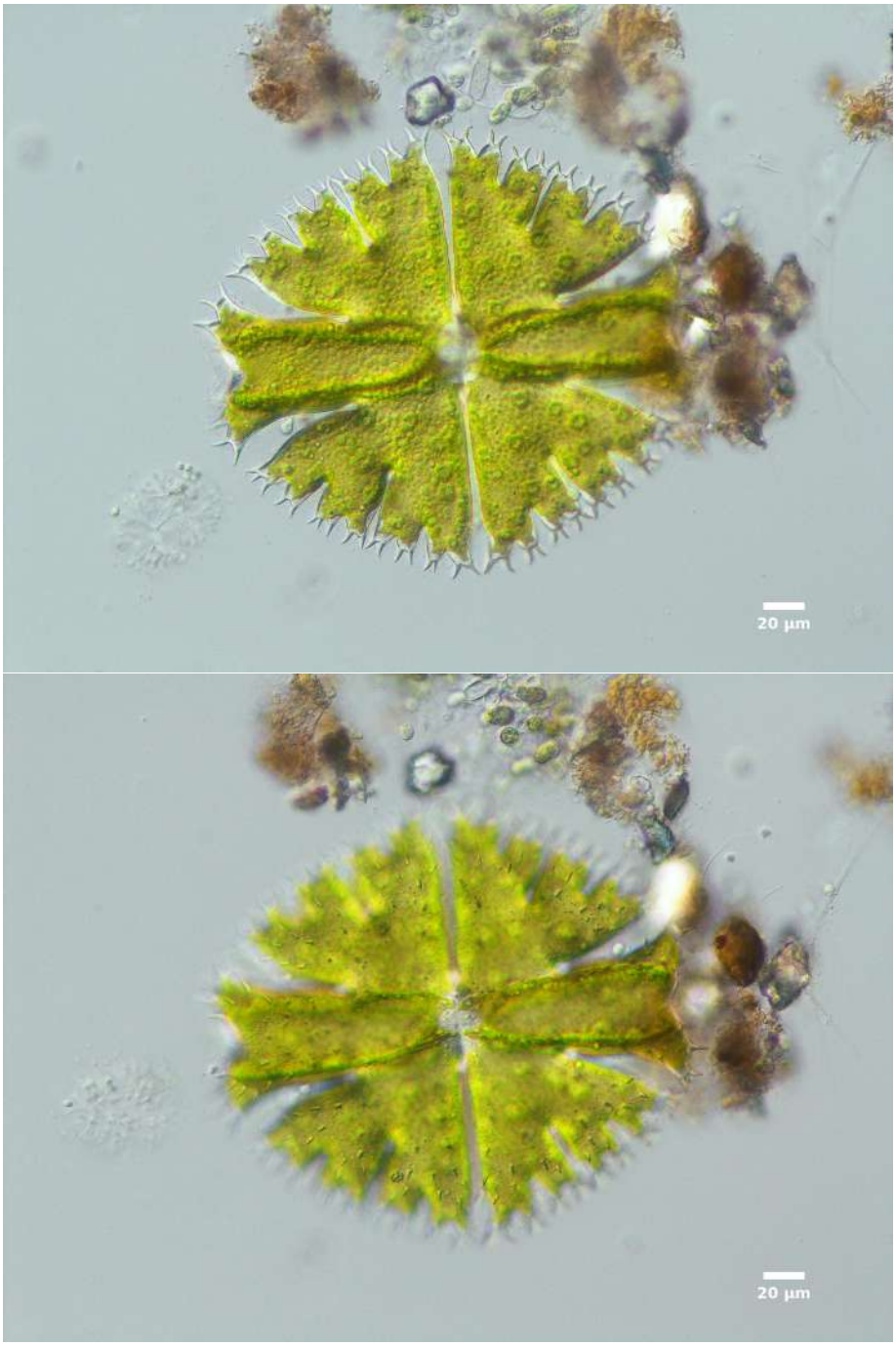


Figure 13.12: *Micrasterias apiculata* spines (DIC/DIC), Clear Lake, Skagit County (upper/lower images).

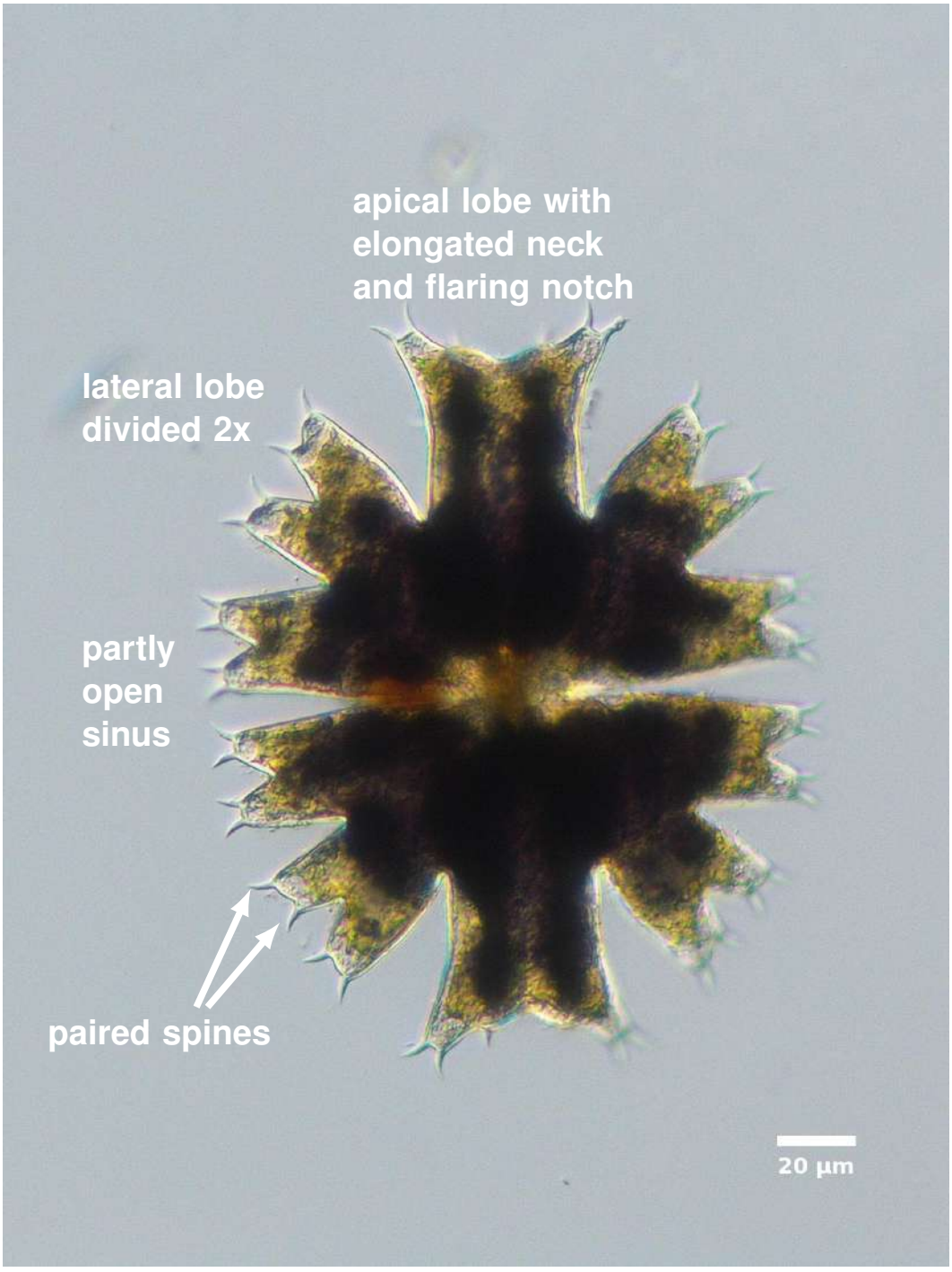


Figure 13.13: *Micrasterias brachyptera* (DIC), stained with Lugol's iodine solution, Canyon Lake, Whatcom County.

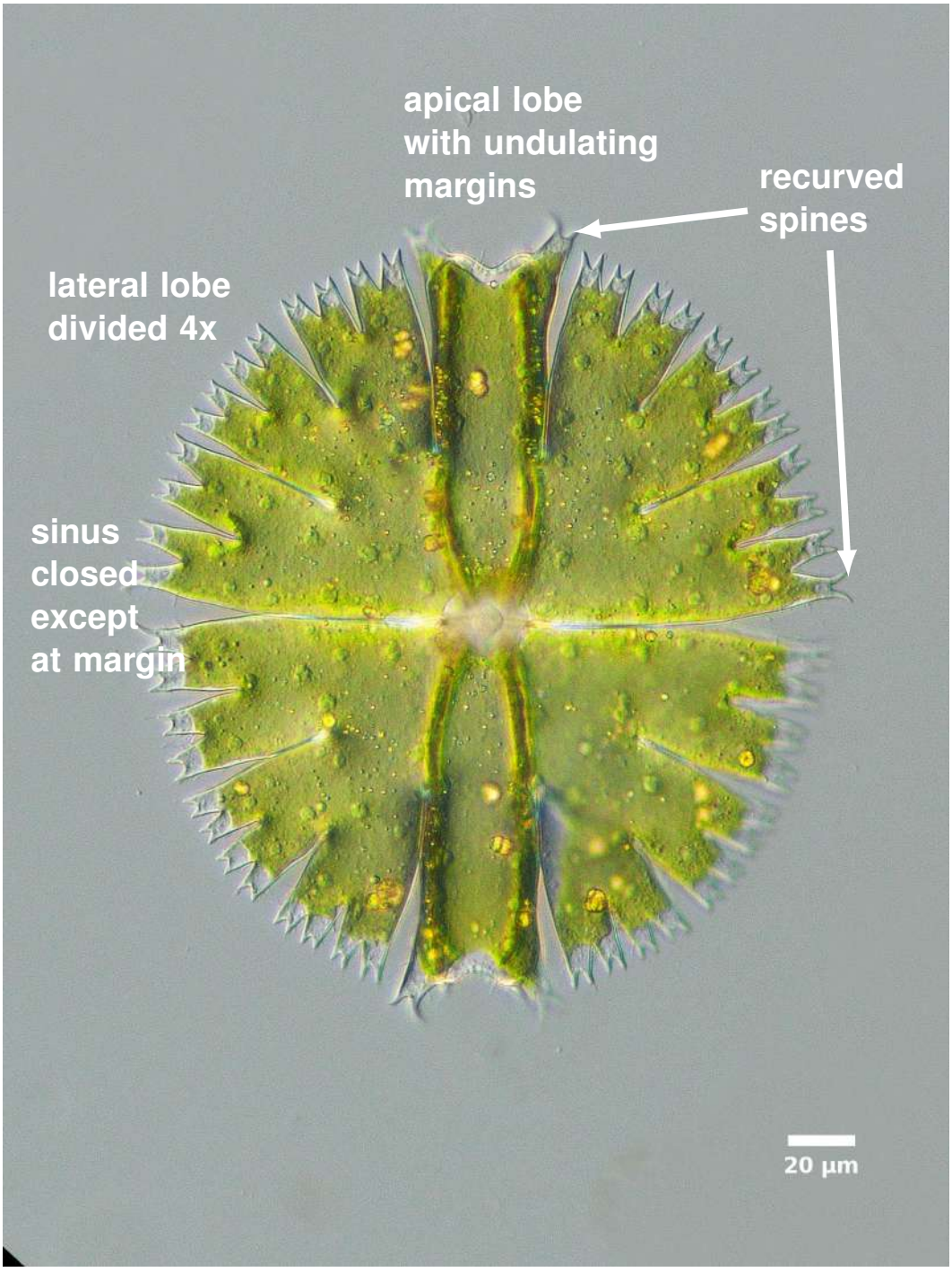


Figure 13.14: *Micrasterias compereana* (DIC), Clear Lake, Skagit County.

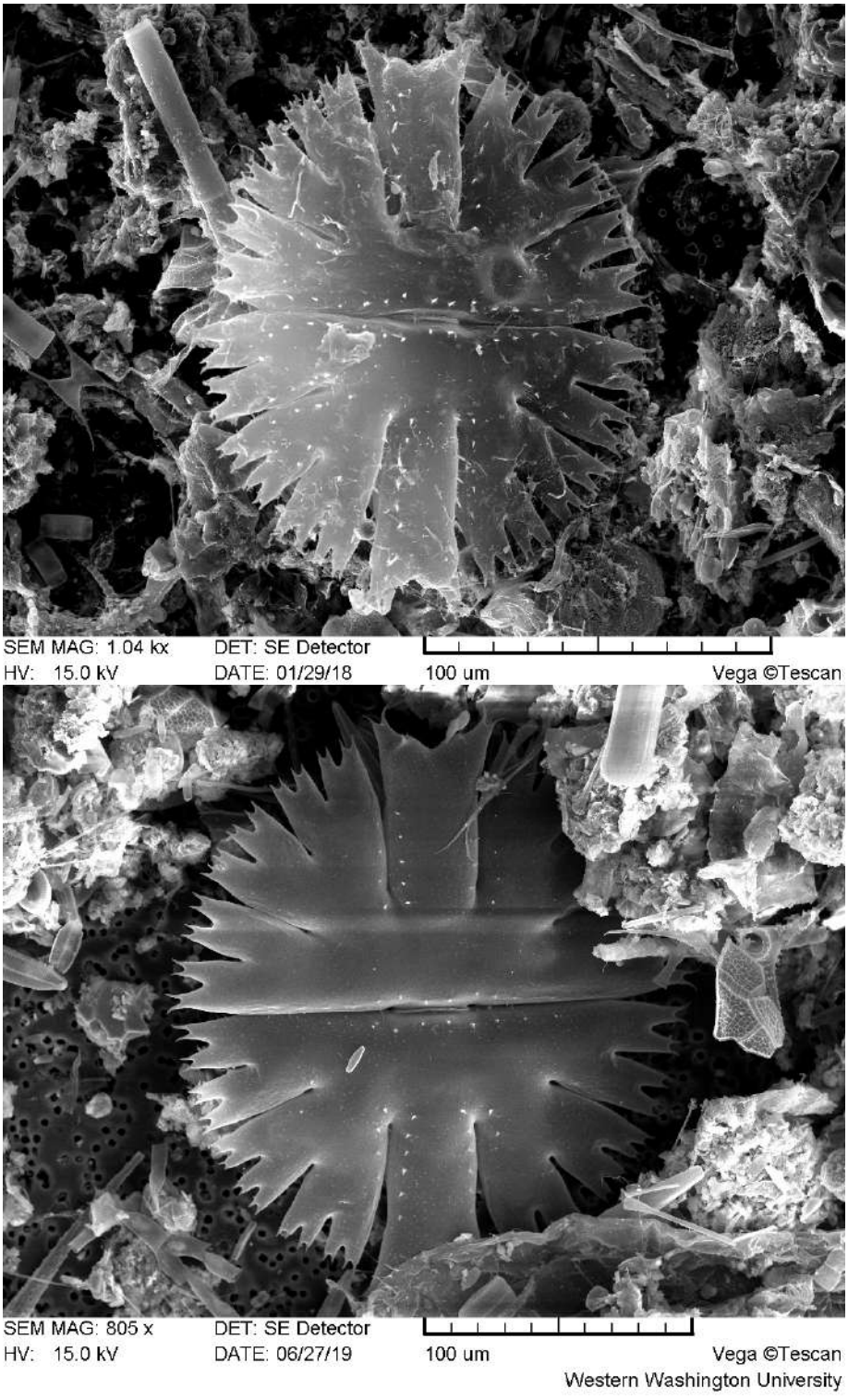


Figure 13.15: *Micrasterias compereana* (SEM/SEM), Vogler Lake, Skagit County (upper image); Mirror Lake, Whatcom County (lower image).



Figure 13.16: *Micrasterias compereana* (DIC), Vogler Lake, Skagit County.



Figure 13.17: *Micrasterias compereana* spines (DIC/DIC), Lake Louise, Whatcom County (upper/lower images).



Figure 13.18: *Micrasterias compereana* immature semi-cells (DIC/DIC), Mirror Lake, Whatcom County (upper image); Pine Lake, Whatcom County (lower image).

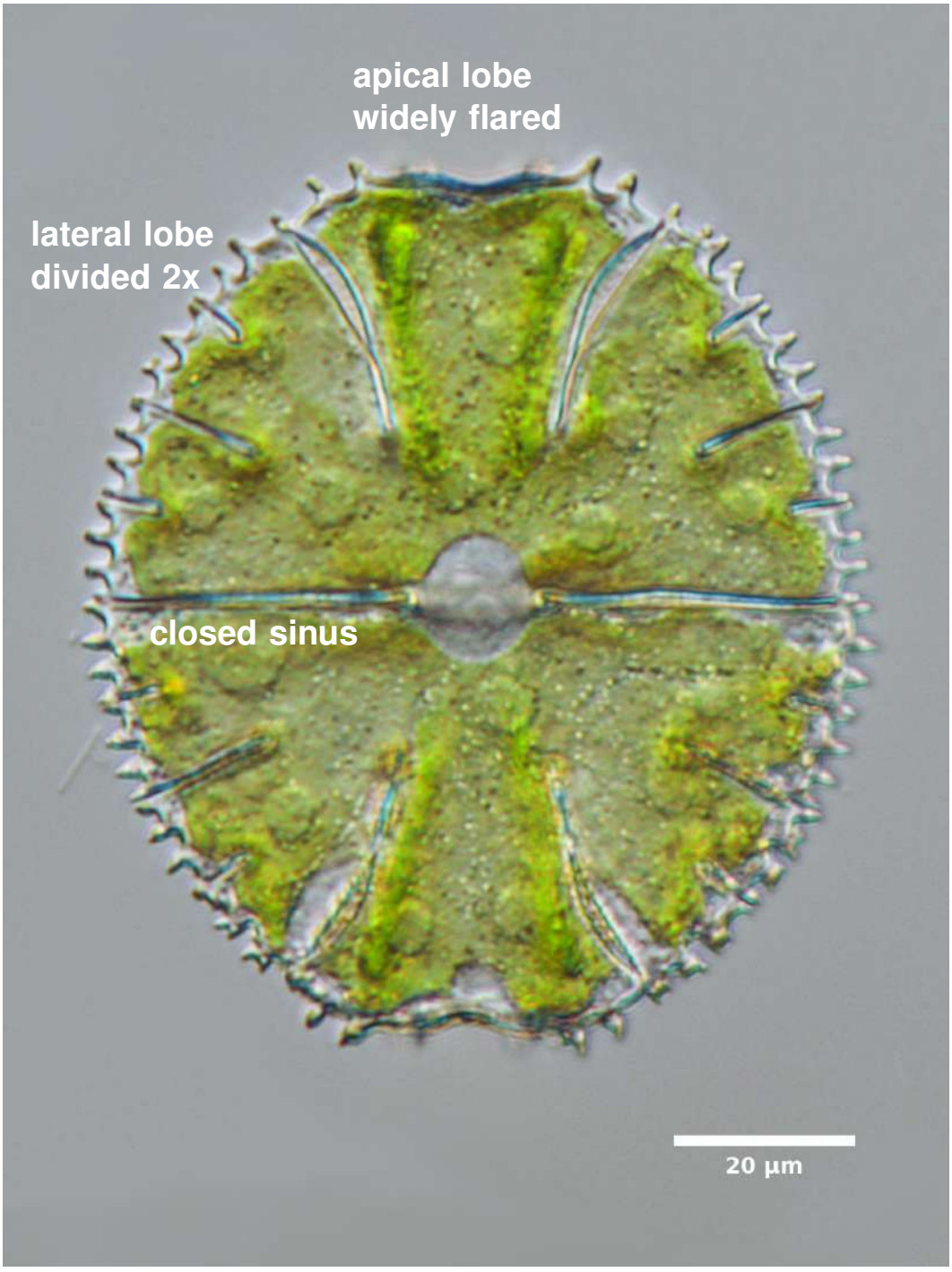


Figure 13.19: *Micrasterias conferta* (DIC), Lower Ashland Lake, Mountain Loop Highway, Snohomish County.

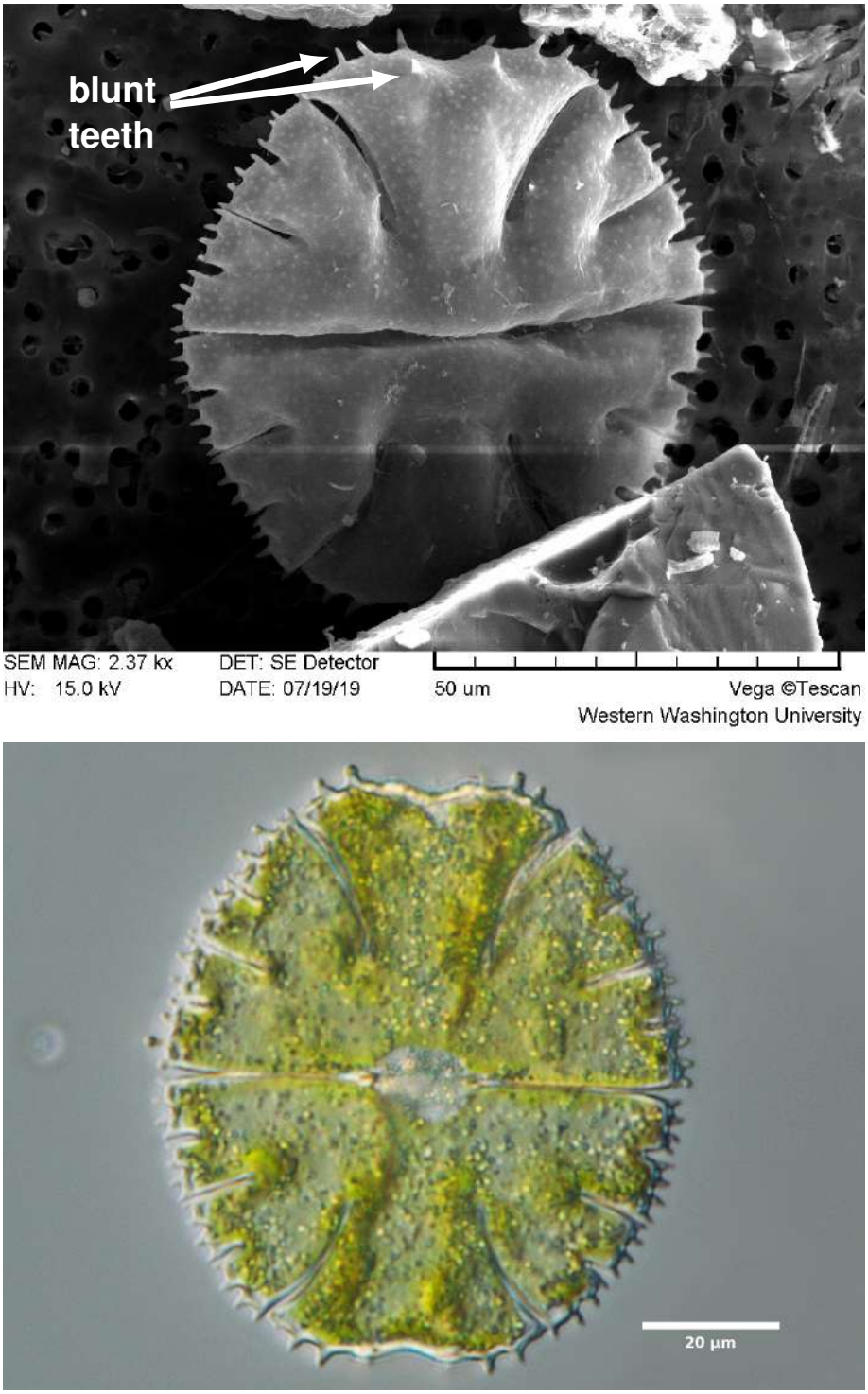


Figure 13.20: *Micrasterias conferta* (SEM/DIC), Chain Lake, Gifford Pinchot National Forest, Skamania County (upper/lower images).

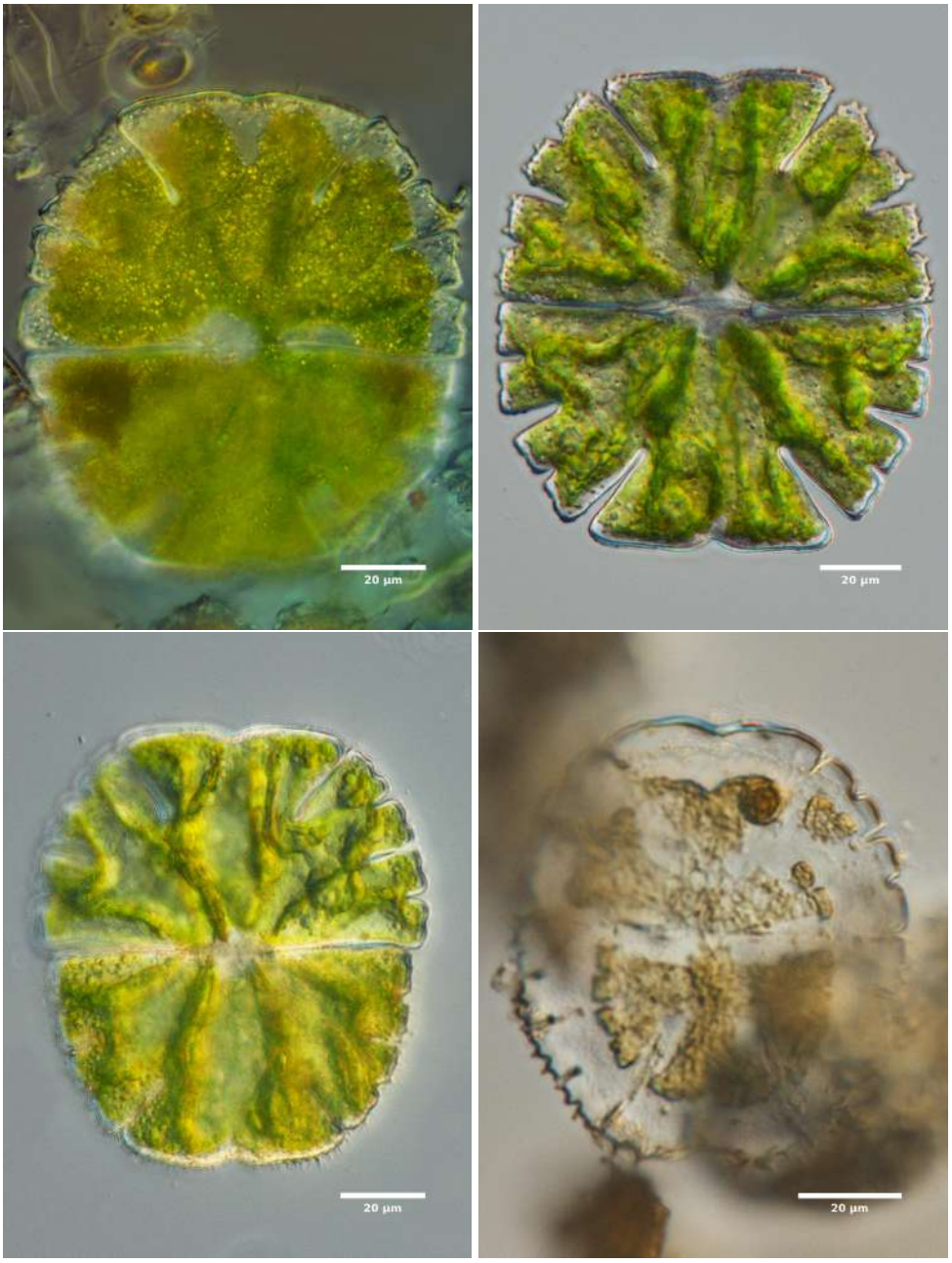


Figure 13.21: *Micrasterias conferta* atypical semi-cells, Terminal Lake, Mt. Baker area, Whatcom County (upper left image); Upper Bagley Lake, Mt. Baker area, Whatcom County (upper right image); small floating bog near Baby Shoe Pass on road to Takhlakh Lake, Gifford Pinchot National Forest, Skamania County (lower left image); Chain Lake, Gifford Pinchot National Forest, Skamania County (lower right image).

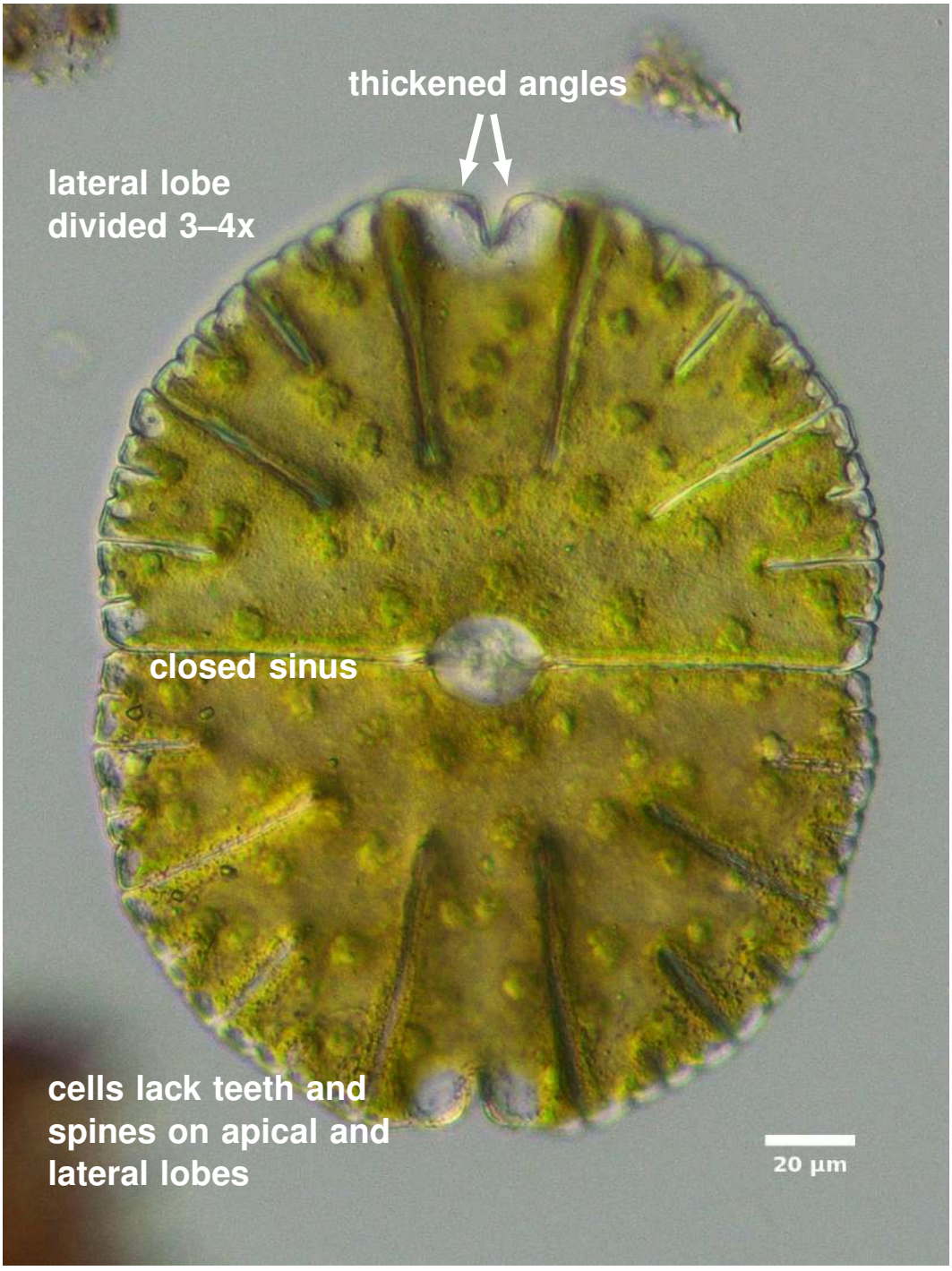


Figure 13.22: *Micrasterias denticulata* (DIC), Lake Evan, Mountain Loop Highway, Snohomish County.

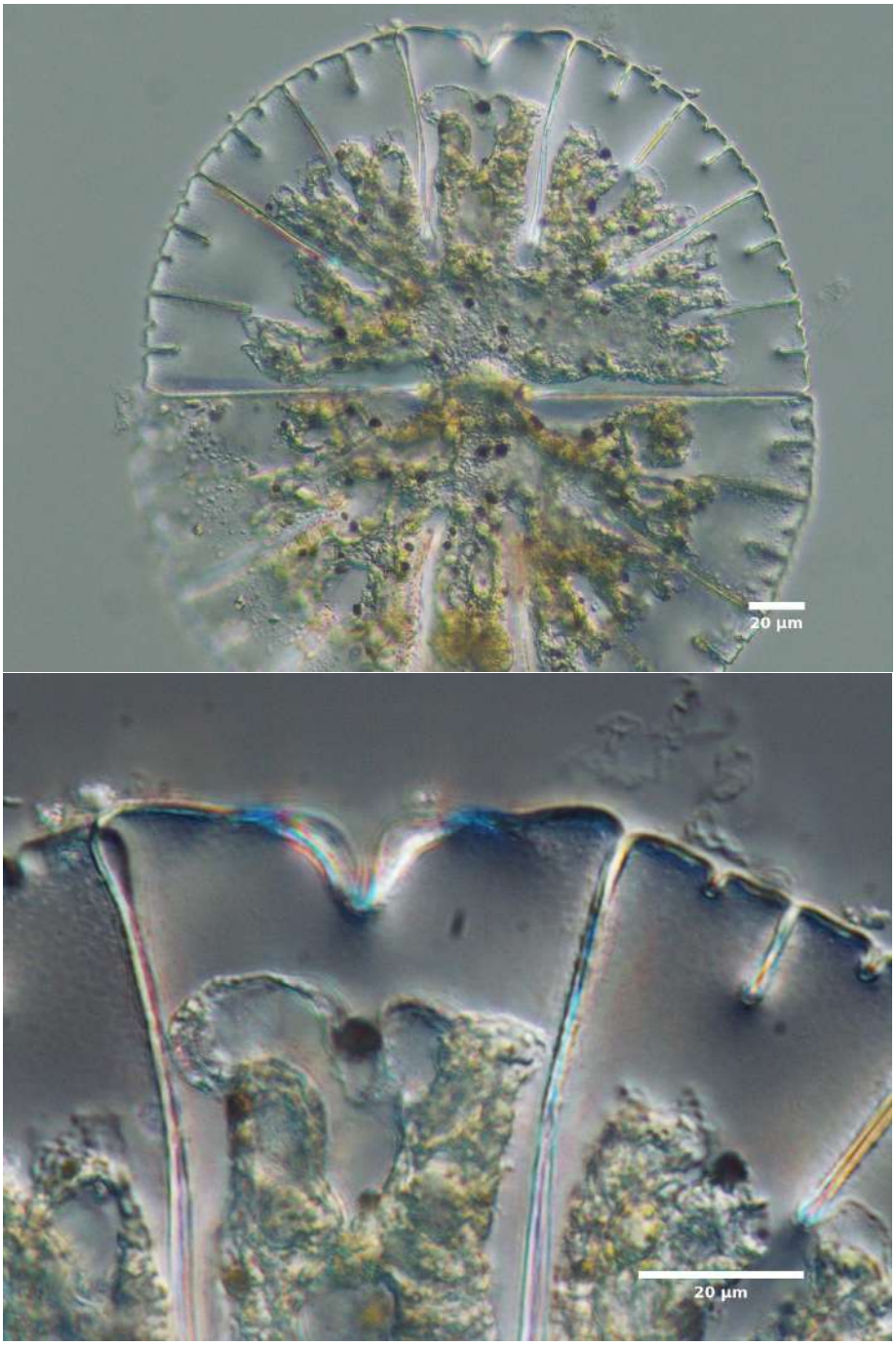


Figure 13.23: *Micrasterias denticulata* (DIC/DIC), preserved in formalin, Lower Bagley Lake, Mt. Baker area, Whatcom County (upper/lower images).



Figure 13.24: *Micrasterias denticulata* (DIC), Lower Bagley Lake, Mt. Baker area, Whatcom County.

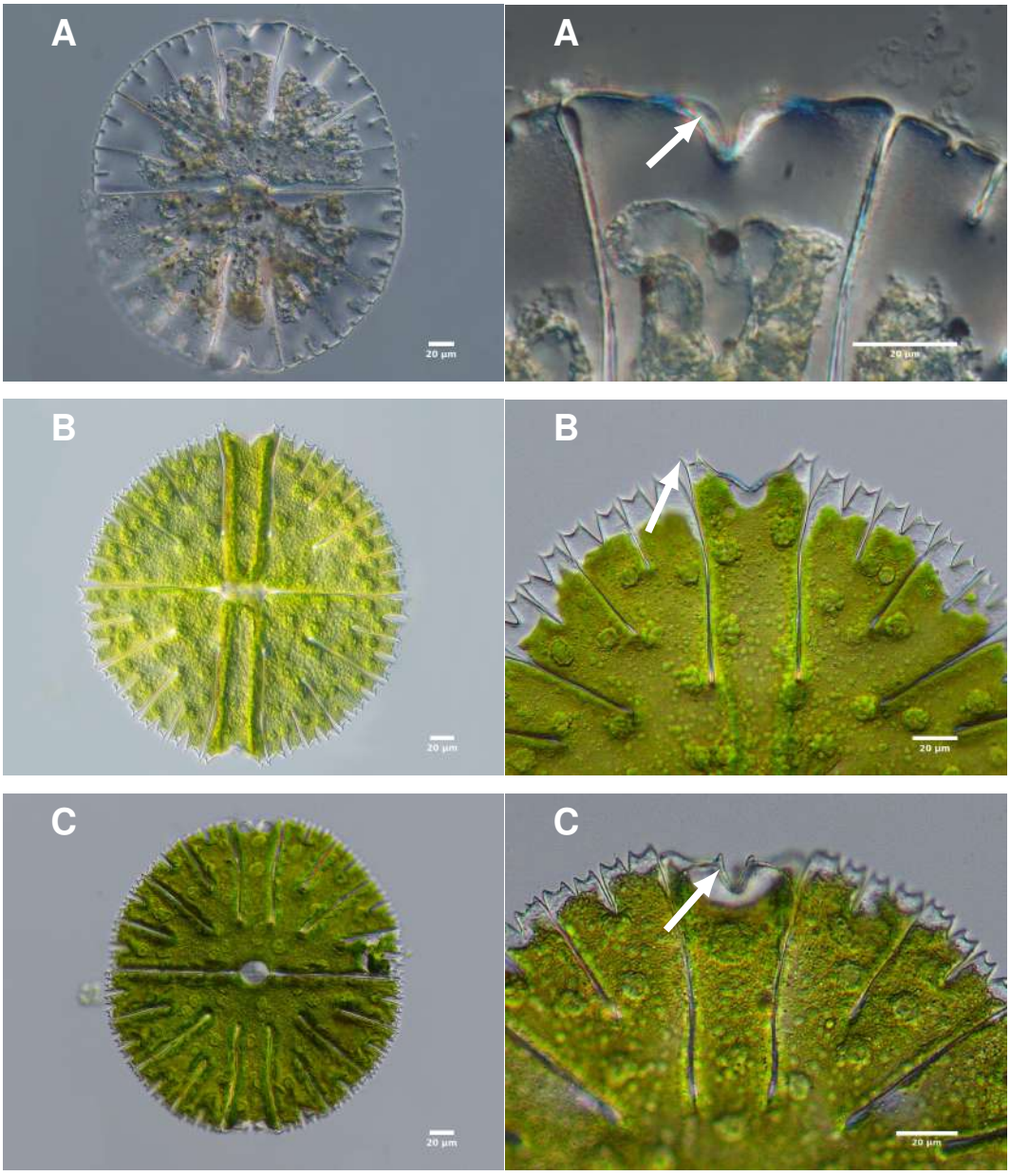


Figure 13.25: Cell shape and apical lobe differences between (A) *Micrasterias denticulata*, Lower Bagley Lake, Mt. Baker area, Whatcom County; (B) *Micrasterias rotata*, Vogler Lake, Skagit County; and (C) *Micrasterias thomasiana* var. *notata*, Picture Lake, Mt. Baker area, Whatcom County. White arrows point to distinguishing features.

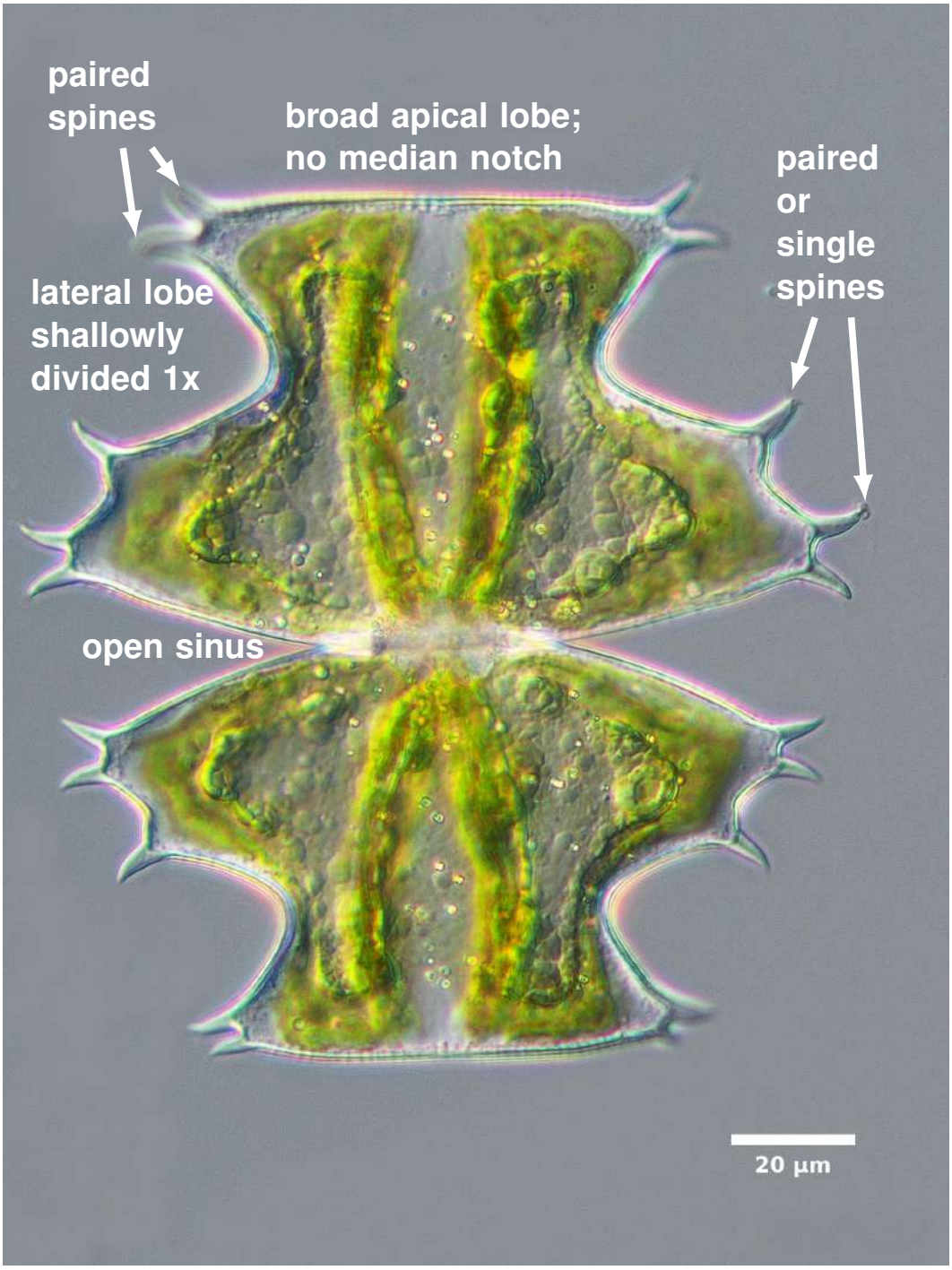


Figure 13.26: *Micrasterias depauperata* var. *wollei* (DIC), Lake Evan, Mountain Loop Highway, Snohomish County.

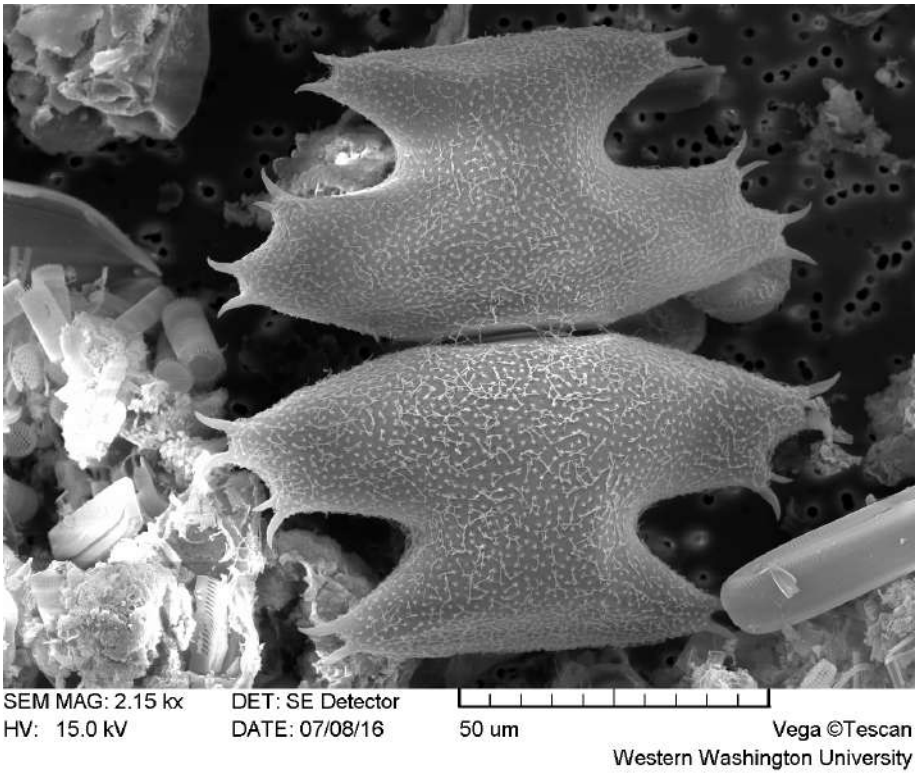


Figure 13.27: *Micrasterias depauperata* var. *wollei* (SEM/DIC), Island Lake Mountain Loop Highway, Snohomish County (upper/lower images).

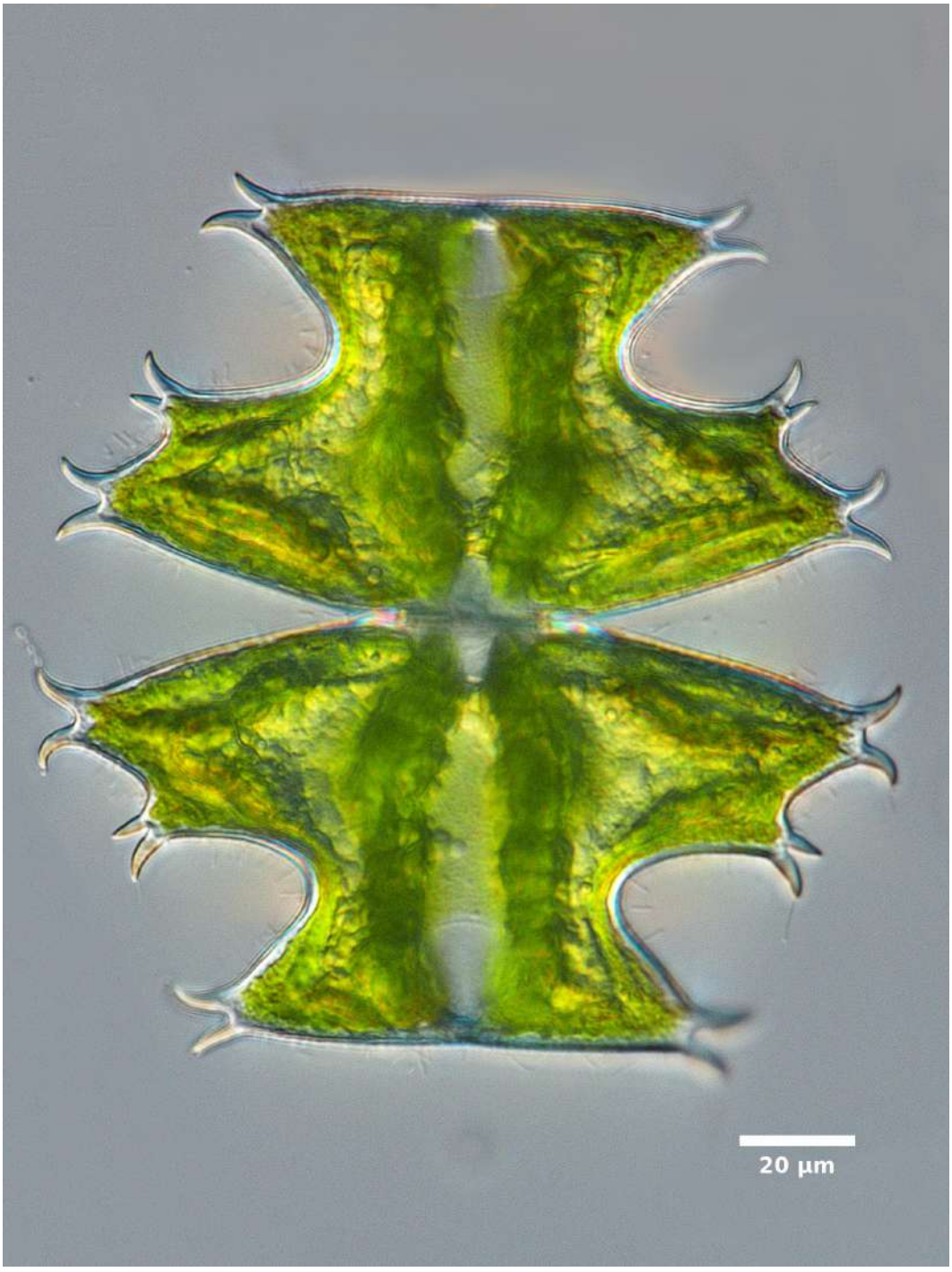


Figure 13.28: *Micrasterias depauperata* var. *wollei* (DIC), Wood Lake, Morris Valley Rd. near Harrison, BC.

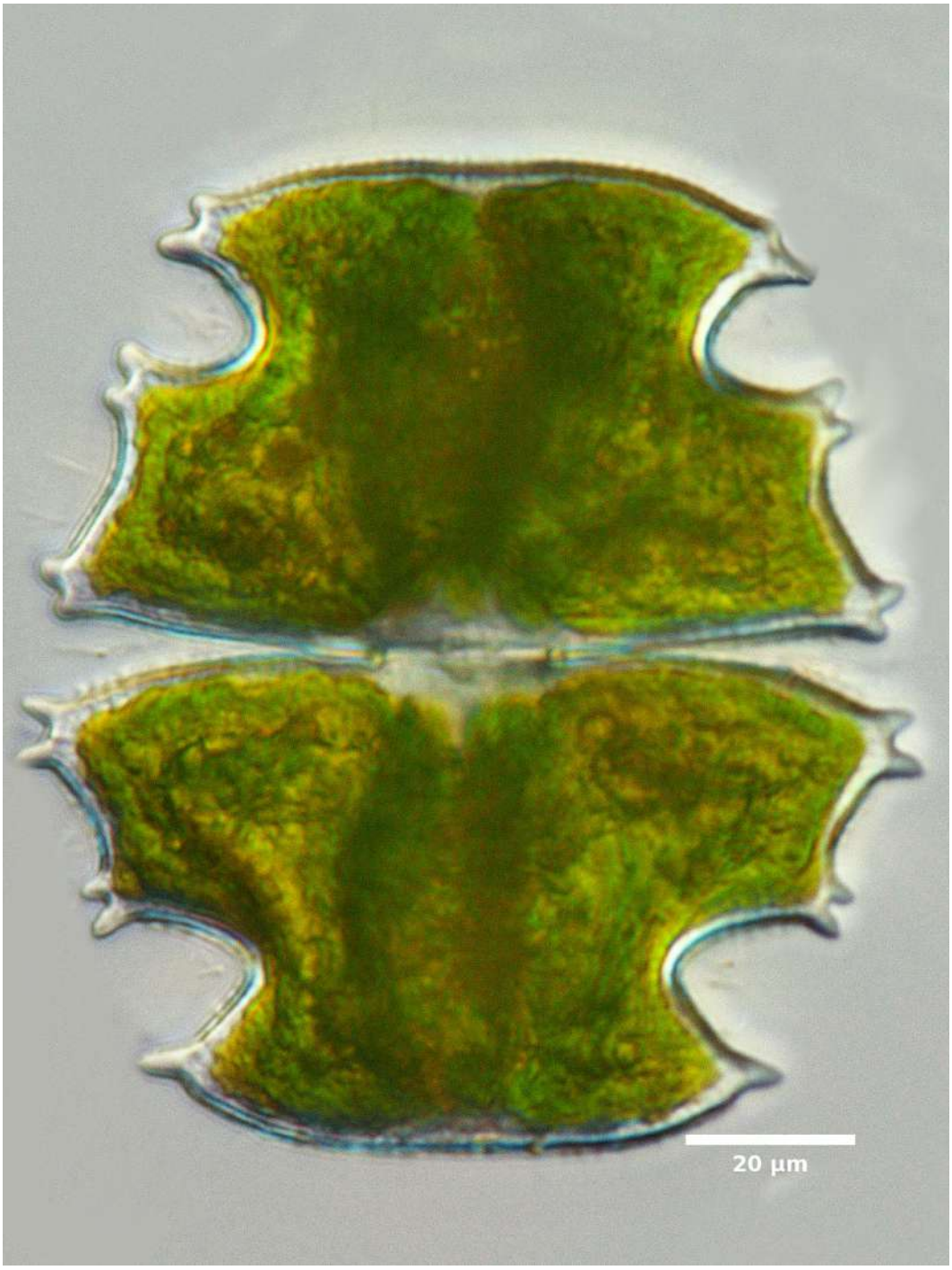


Figure 13.29: *Micrasterias depauperata* atypical (DIC), Lake Evan, Mountain Loop Highway, Snohomish County.

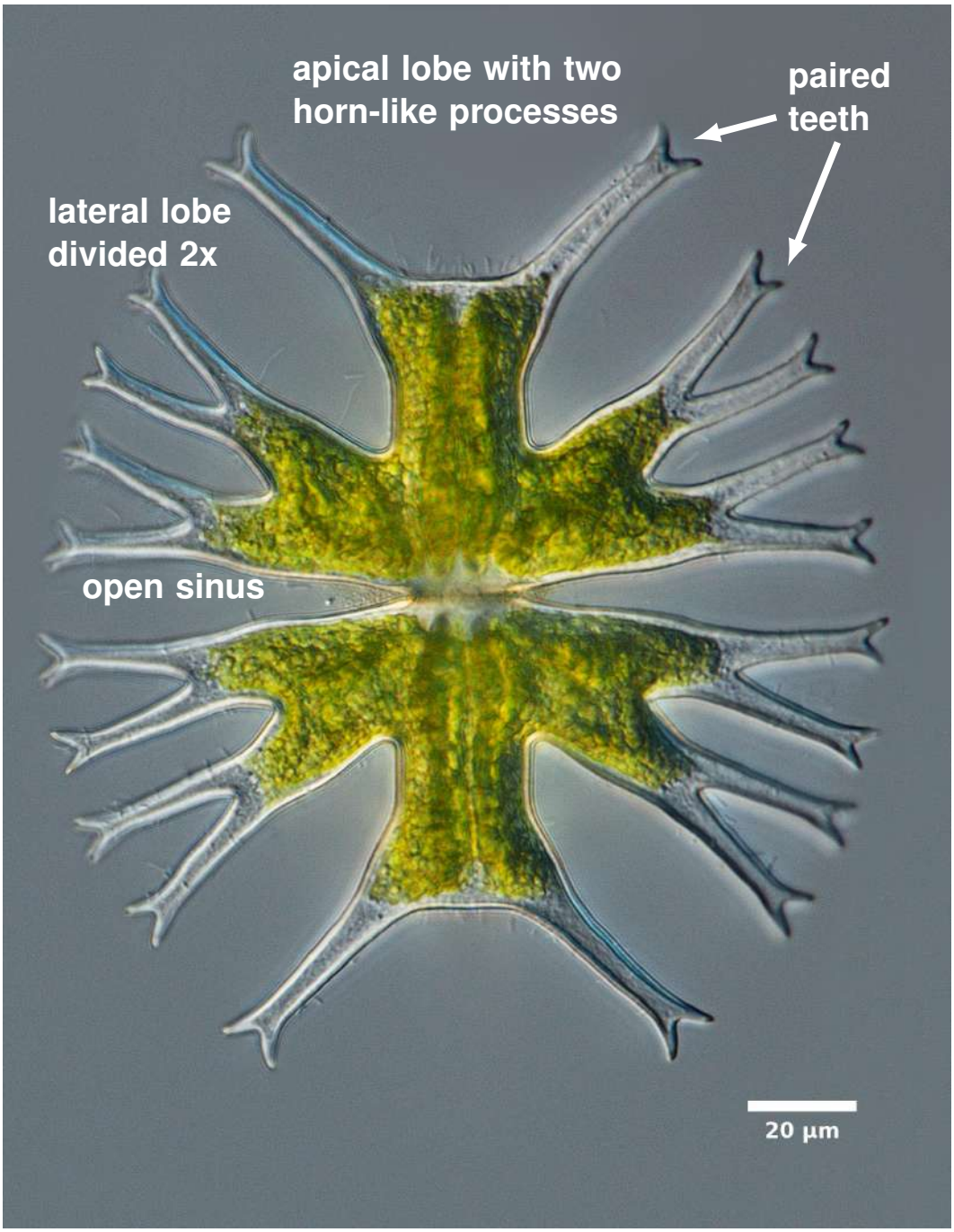


Figure 13.30: *Micrasterias furcata* (DIC), Chain Lake, Gifford Pinchot National Forest, Skamania County.

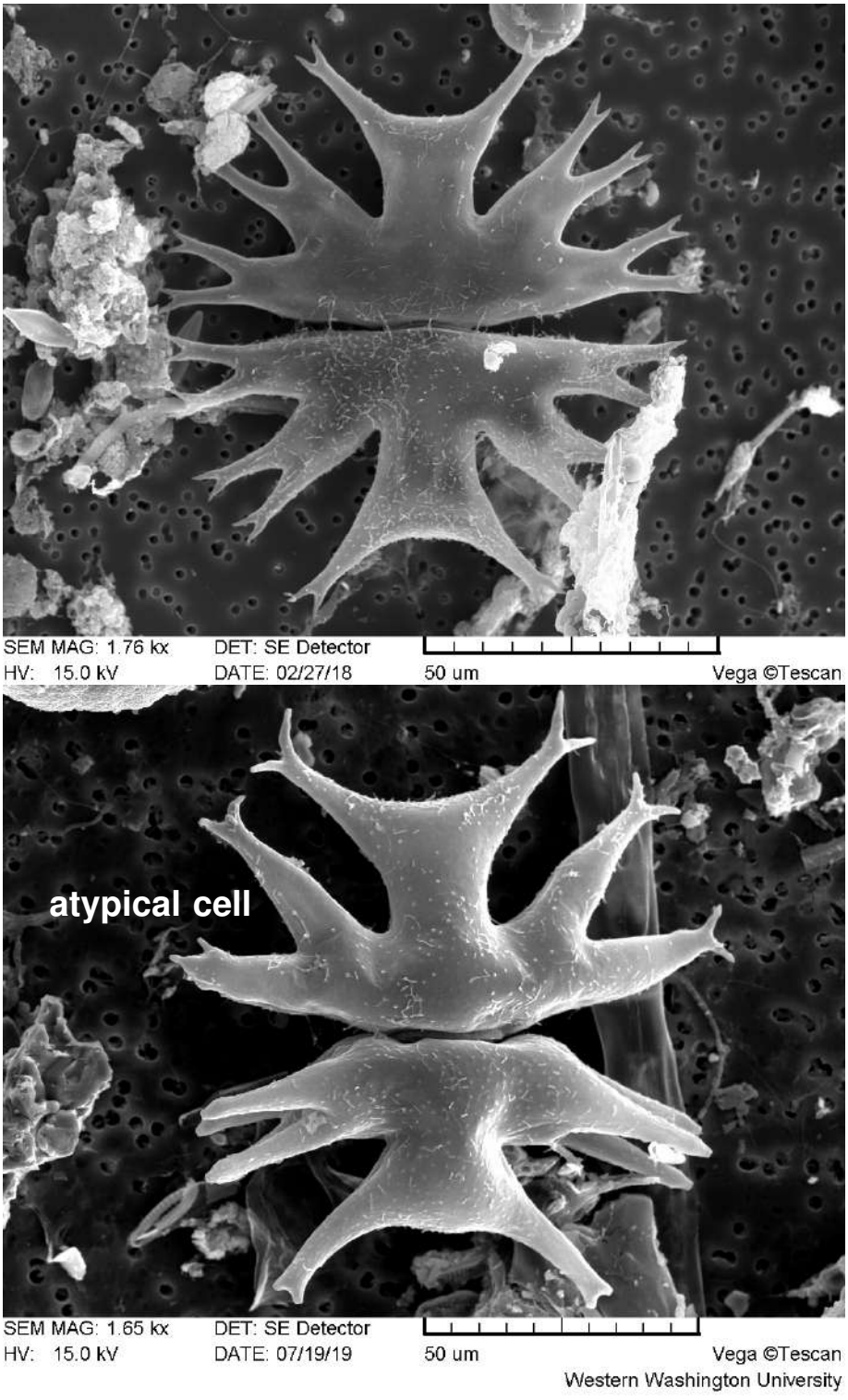


Figure 13.31: *Micrasterias furcata* (SEM/SEM), Hoag Pond, Whatcom County (upper image); atypical cell, Chain Lake, Gifford Pinchot National Forest, Skamania County (lower image).



Figure 13.32: *Micrasterias furcata* (DIC), Myrtle Lake, Mountain Loop Highway, Snohomish County.



Figure 13.33: *Micrasterias furcata* bloom (DIC/DIC), Chain Lake, Gifford Pinchot National Forest, Skamania County (upper image); recently divided cells, Takhlakh Lake, Gifford Pinchot National Forest, Skamania County (lower image).

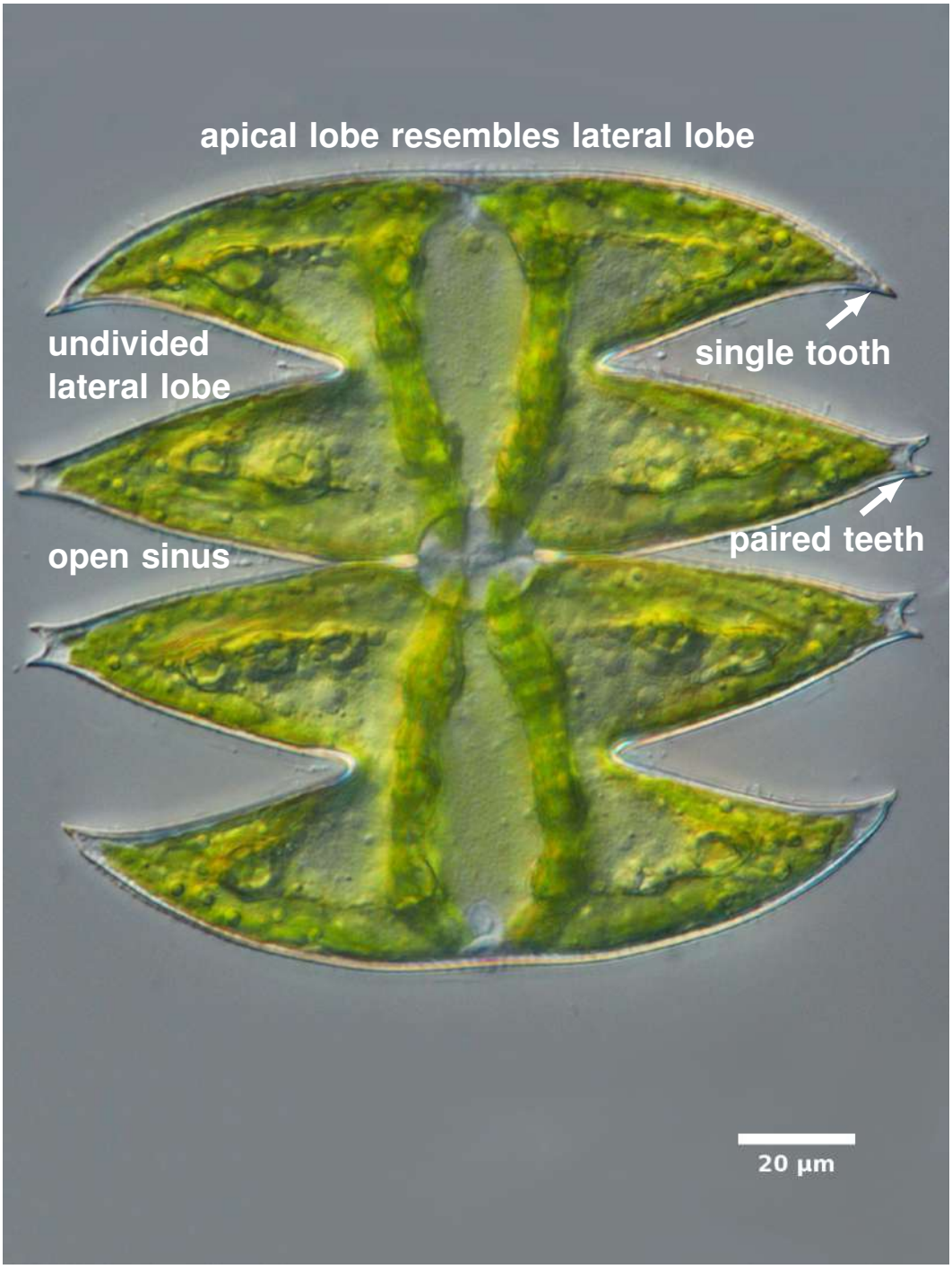


Figure 13.34: *Micrasterias laticeps* (DIC) Myrtle Lake, Mountain Loop Highway, Snohomish County.

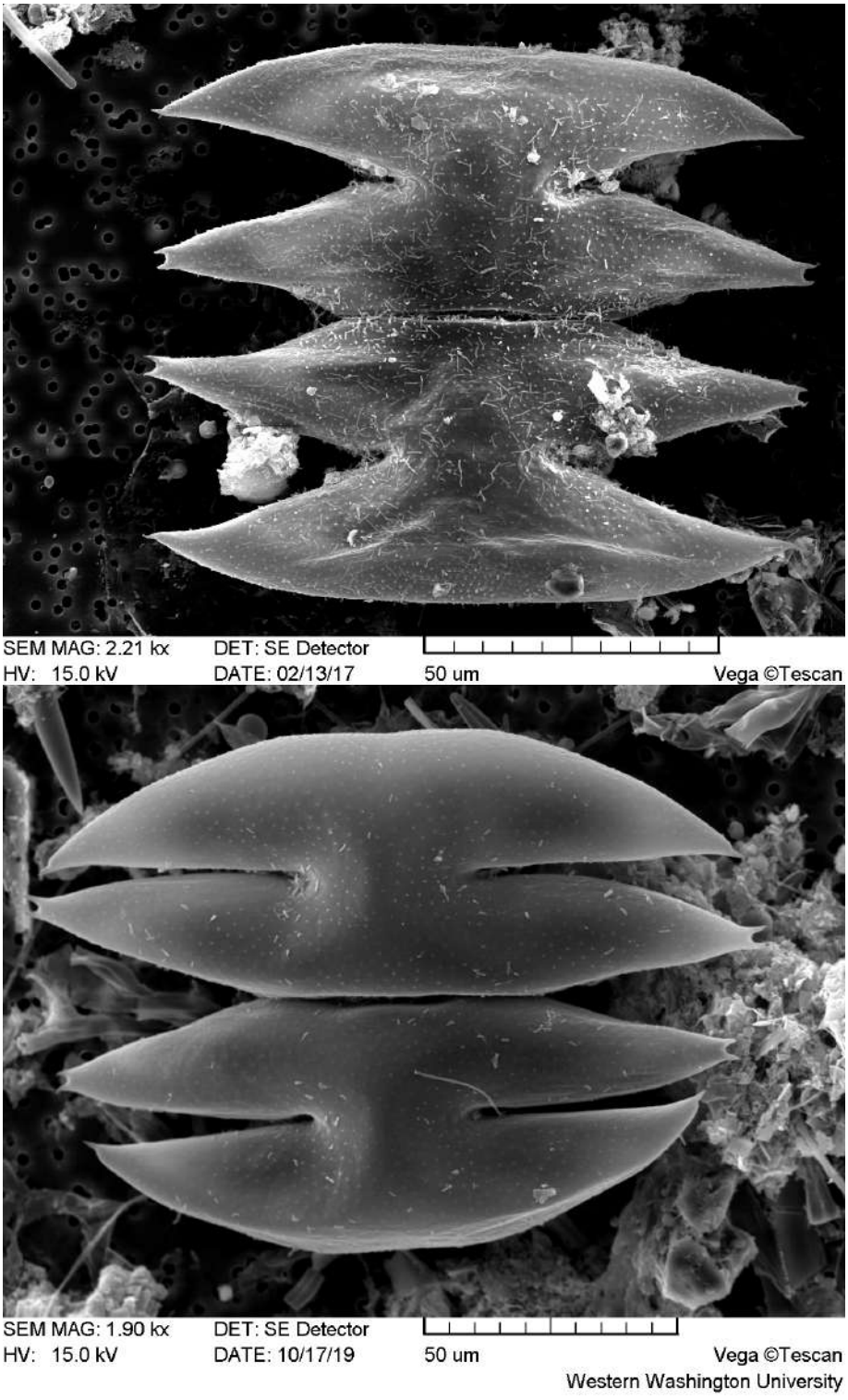


Figure 13.35: *Micrasterias laticeps* (SEM/SEM), Myrtle Lake, Mountain Loop Highway, Snohomish County (upper image); Pine Lake, Whatcom County (lower image).



Figure 13.36: *Micrasterias laticeps* (DIC), Myrtle Lake, Mountain Loop Highway, Snohomish County.

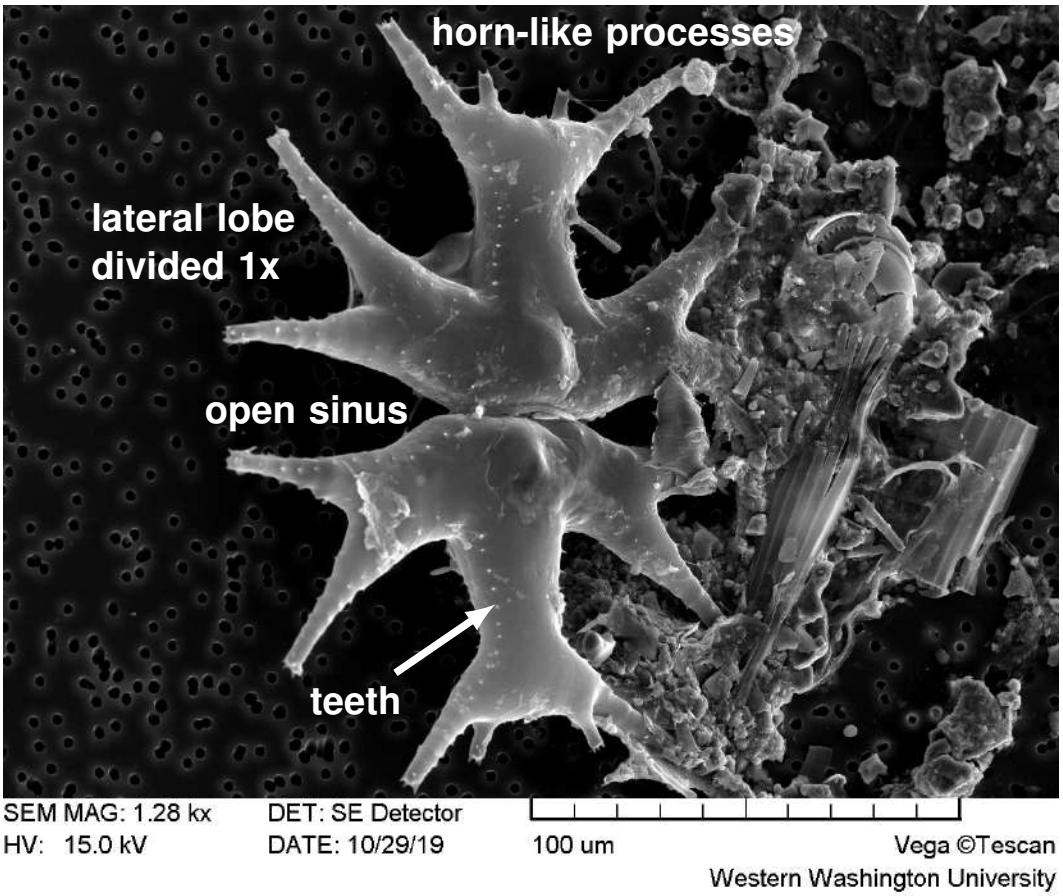


Figure 13.37: *Micrasterias mahabuleshwarensis* (SEM), Clear Lake, Skagit County.

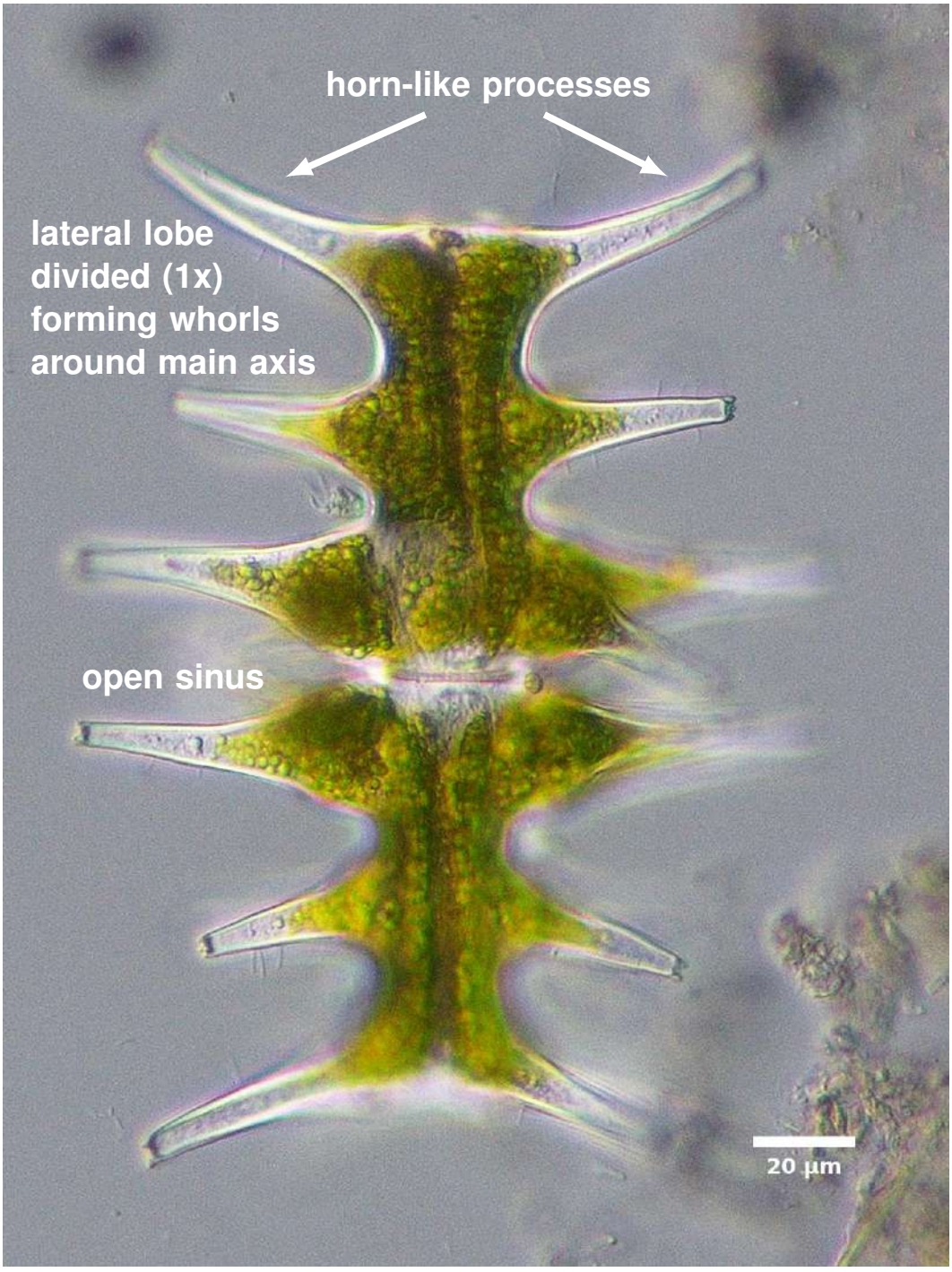
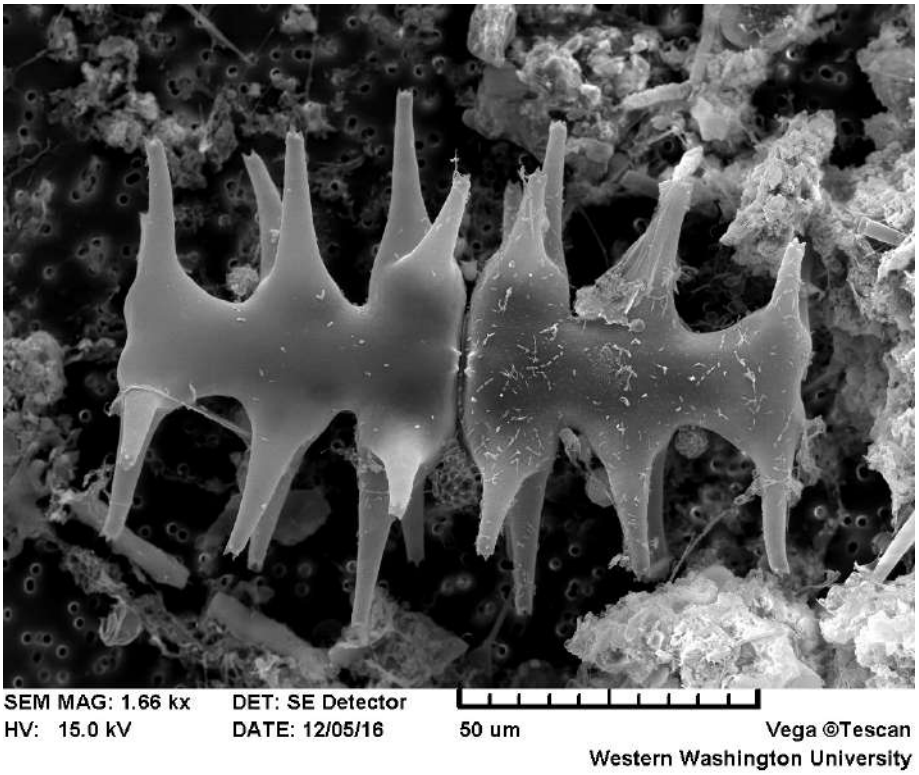


Figure 13.38: *Micrasterias muricata* (DIC), Chain Lake, Gifford Pinchot National Forest, Skamania County.



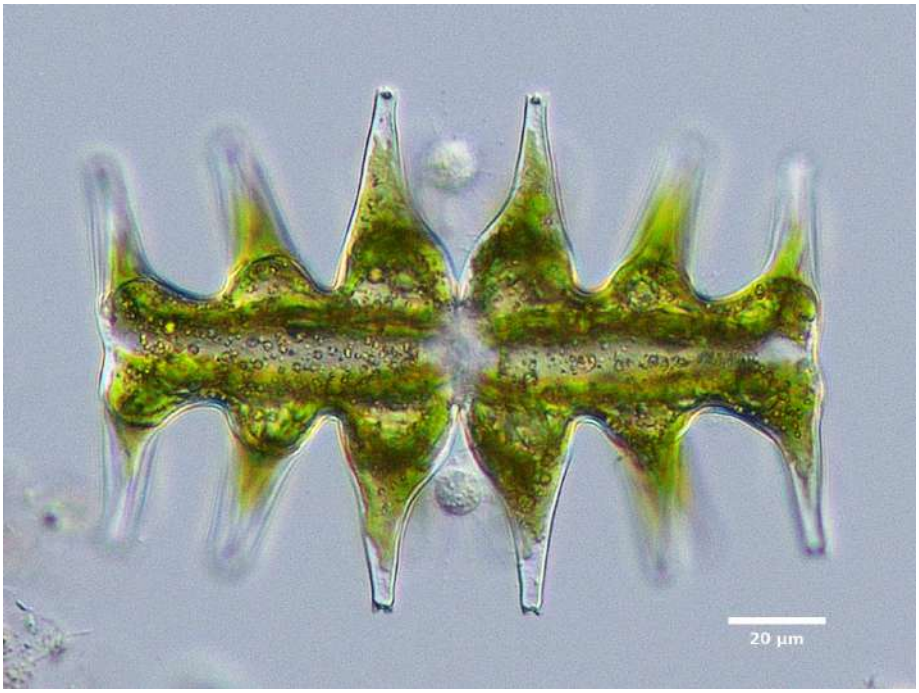


Figure 13.39: *Micrasterias muricata* (SEM/DIC), Vogler Lake, Skagit County (upper/lower images).

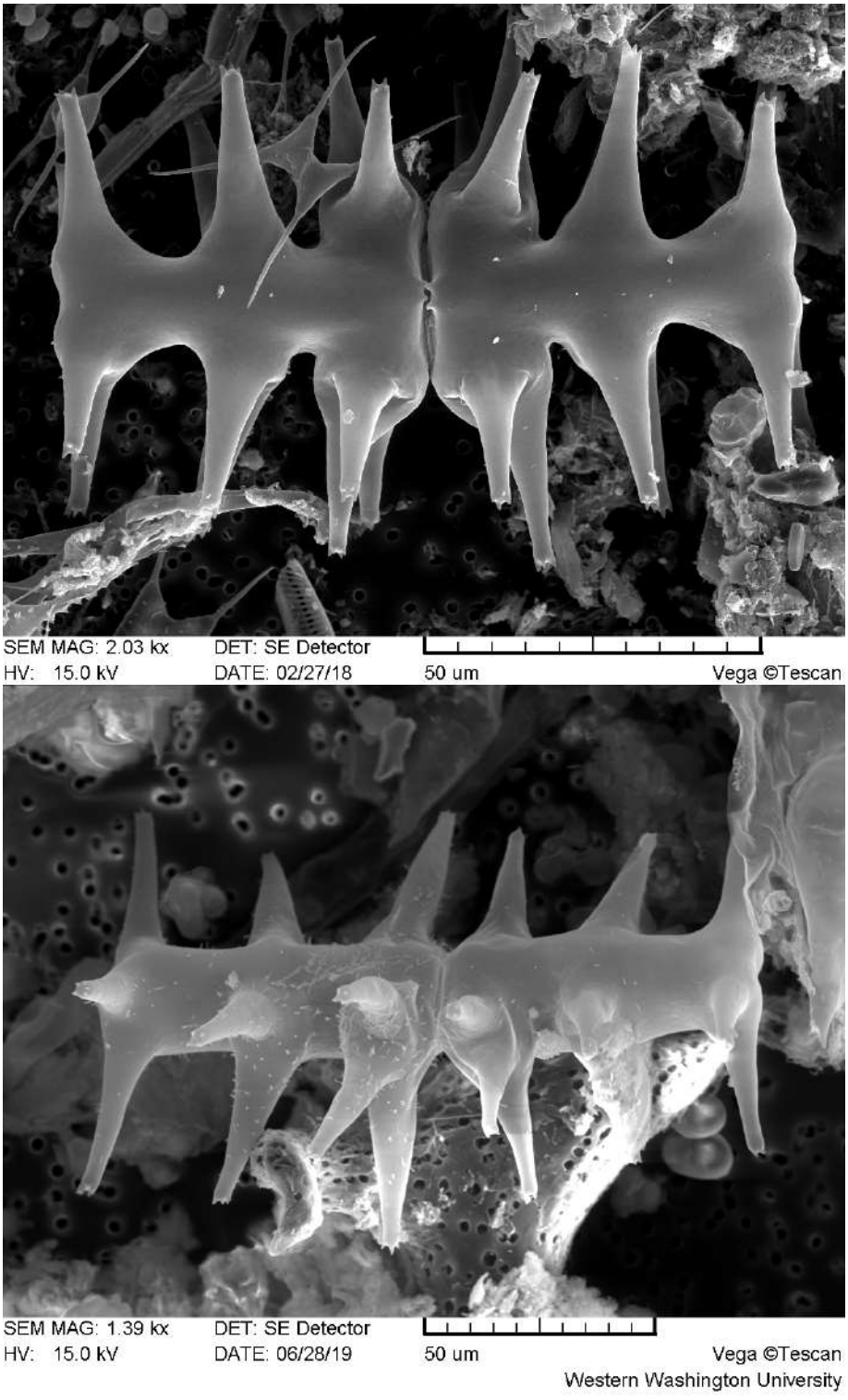


Figure 13.40: *Micrasterias muricata* (SEM/SEM), Vogler Lake, Skagit County (upper/lower images).

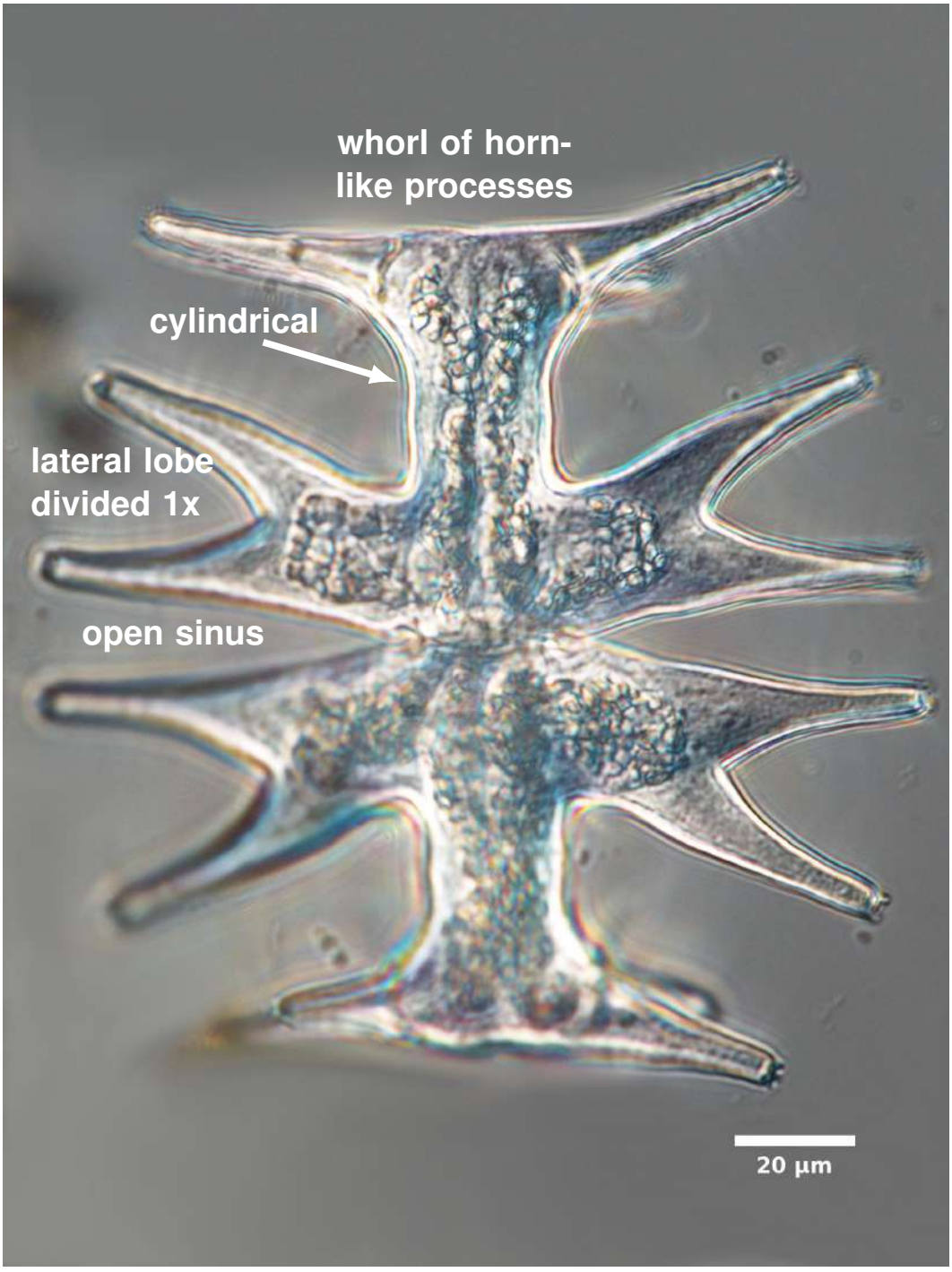


Figure 13.41: *Micrasterias nordstedtiana* (DIC), preserved in formalin, Canyon Lake, Whatcom County.

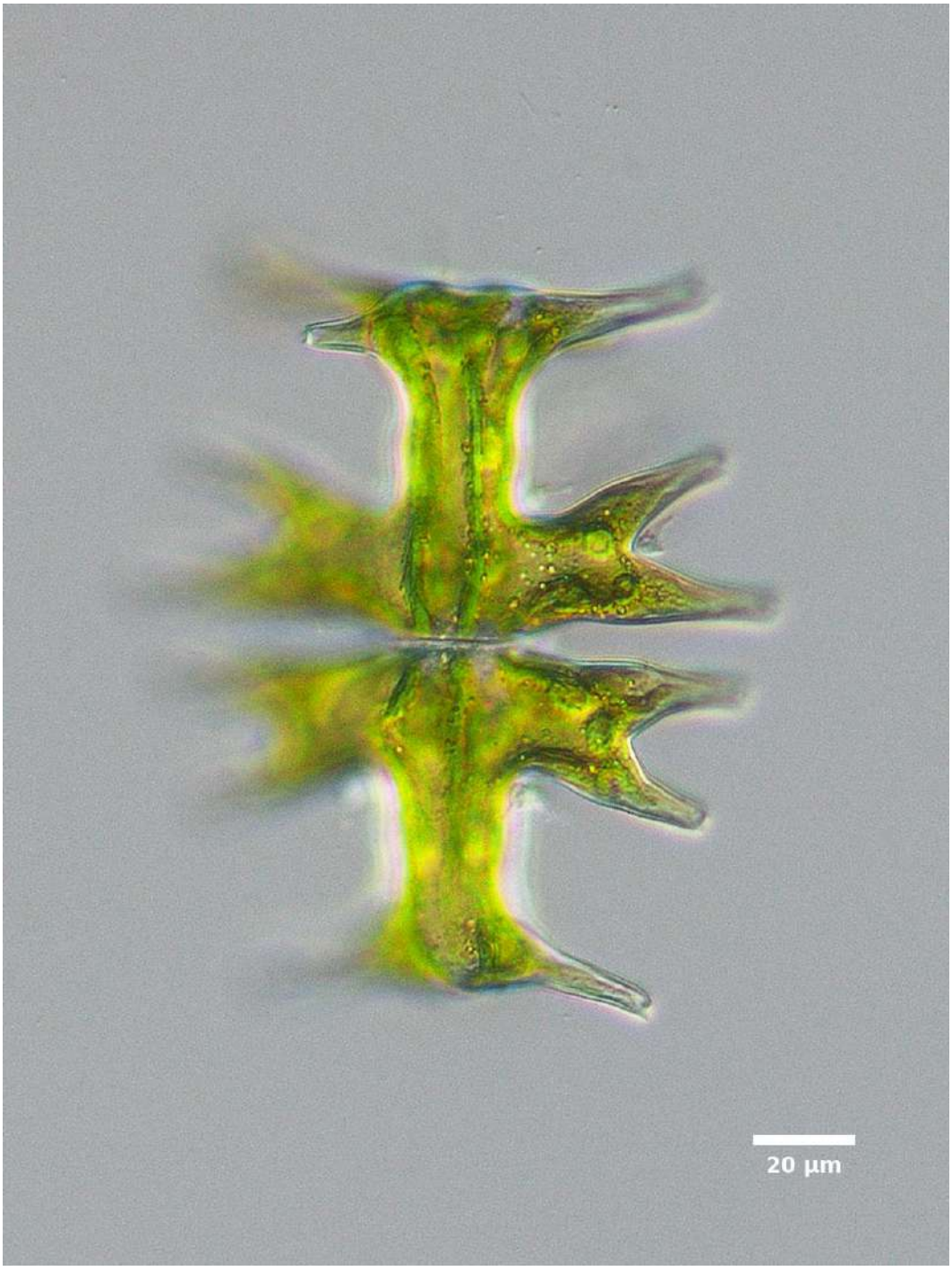


Figure 13.42: *Micrasterias nordstedtiana* (DIC), Wood Lake, Morris Valley Rd near Harrison, BC.

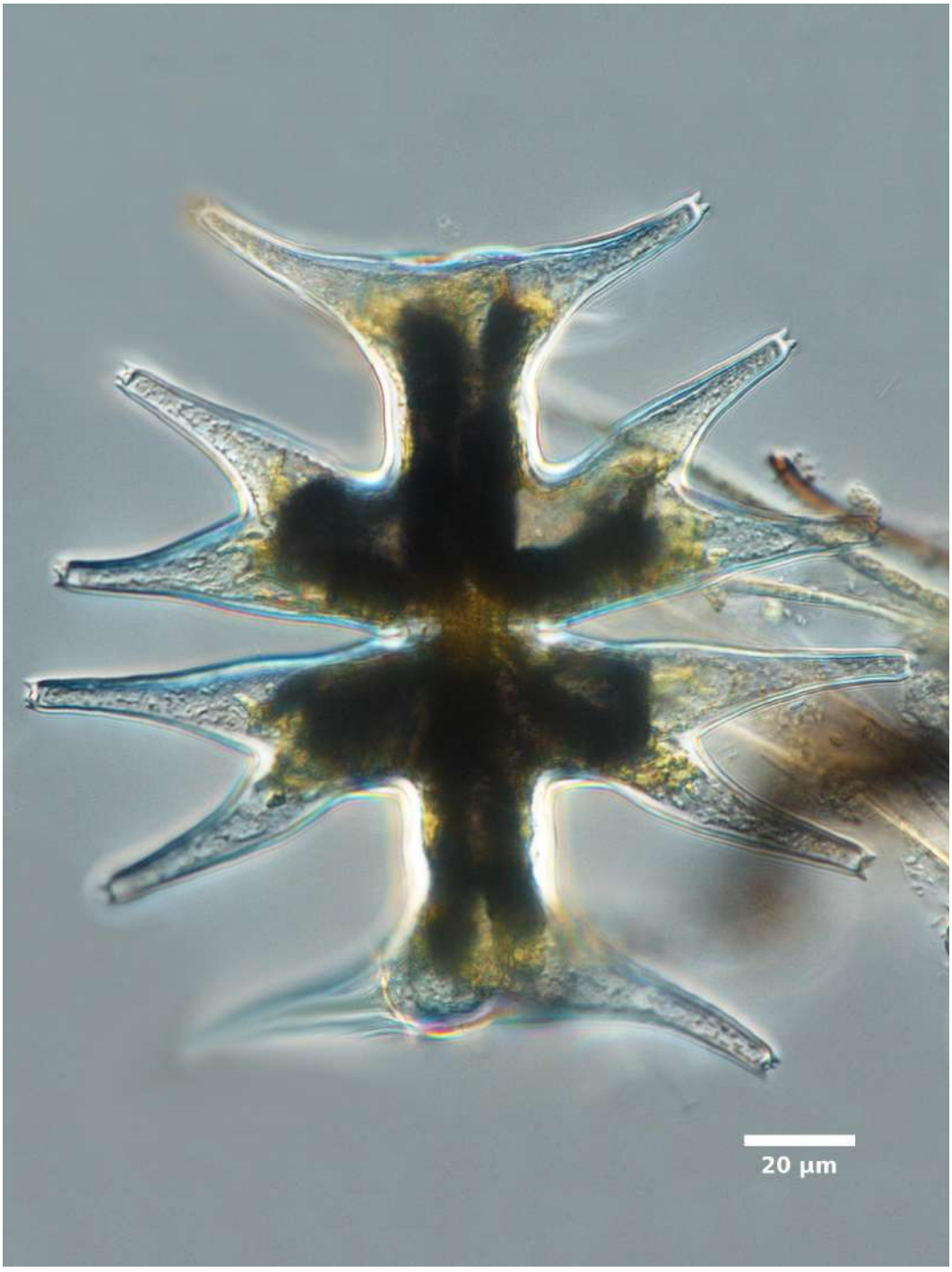


Figure 13.43: *Micrasterias nordstedtiana* (DIC), stained with Lugol's iodine solution (DIC), Canyon Lake, Whatcom County.

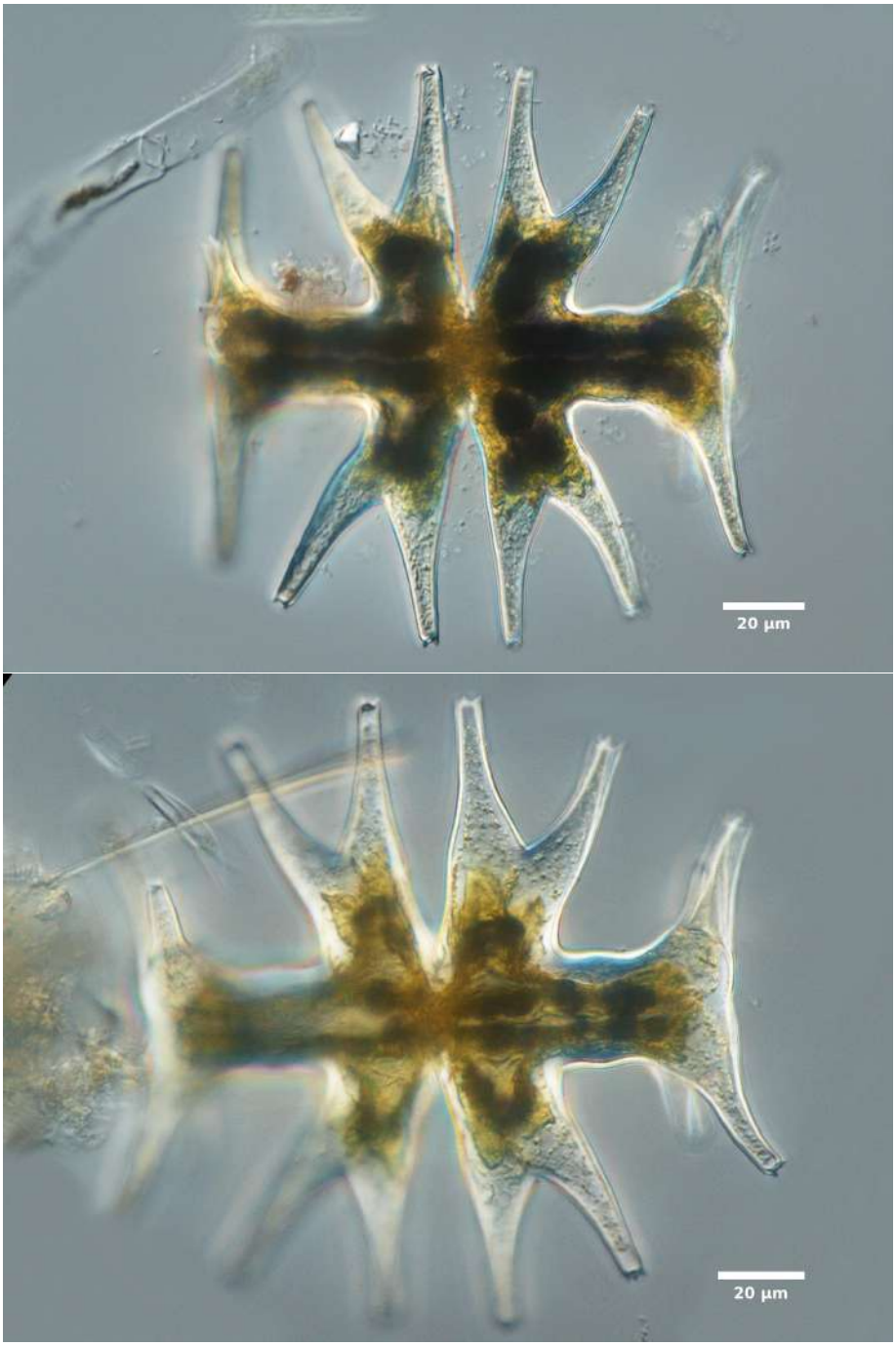


Figure 13.44: *Micrasterias nordstedtiana* (DIC/DIC), stained with Lugol's iodine solution, Canyon Lake, Whatcom County (upper/lower images).

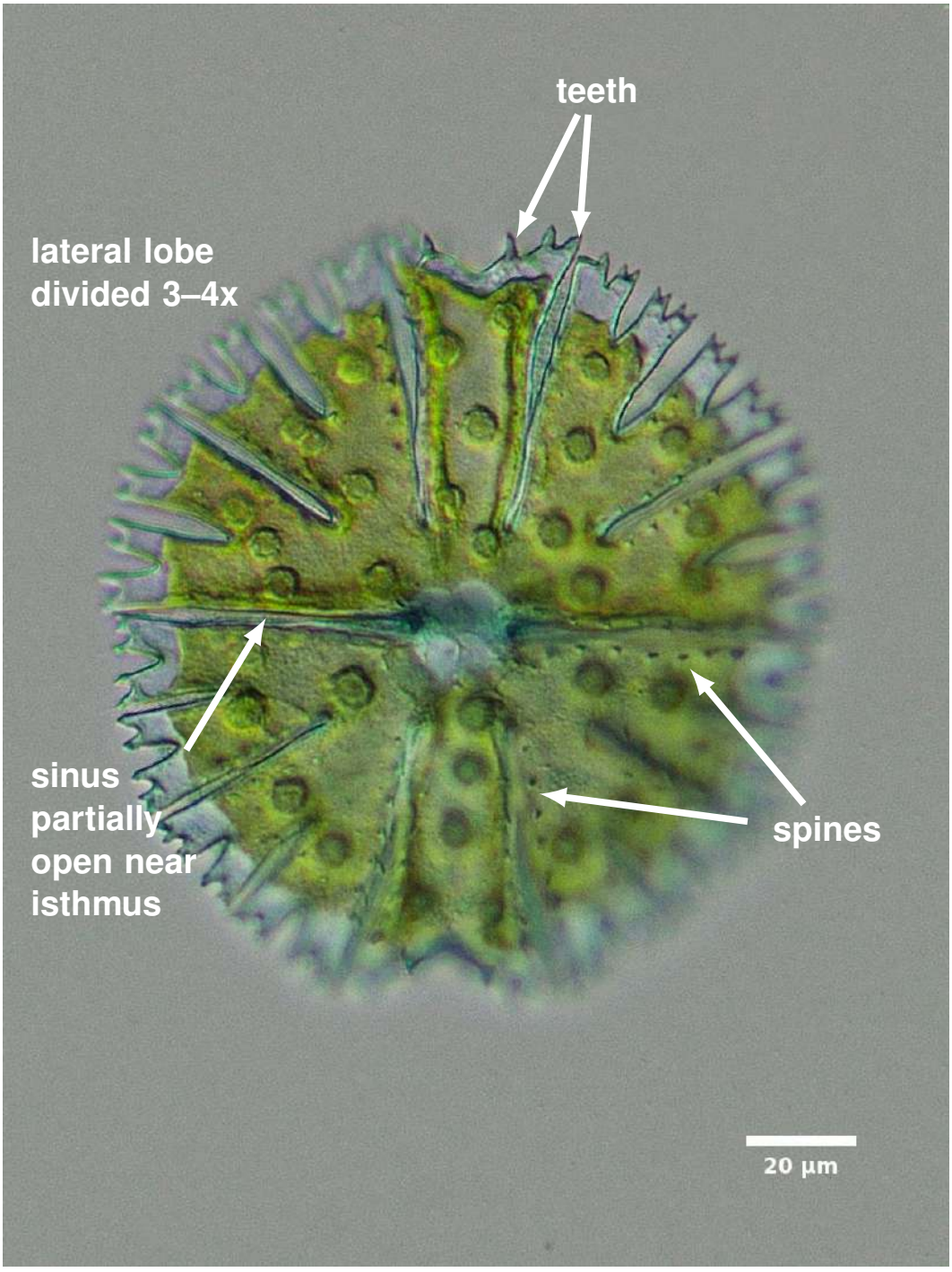


Figure 13.45: *Micrasterias papillifera* (DIC), stained with methylene blue, Lake Evan, Mountain Loop Highway, Snohomish County.

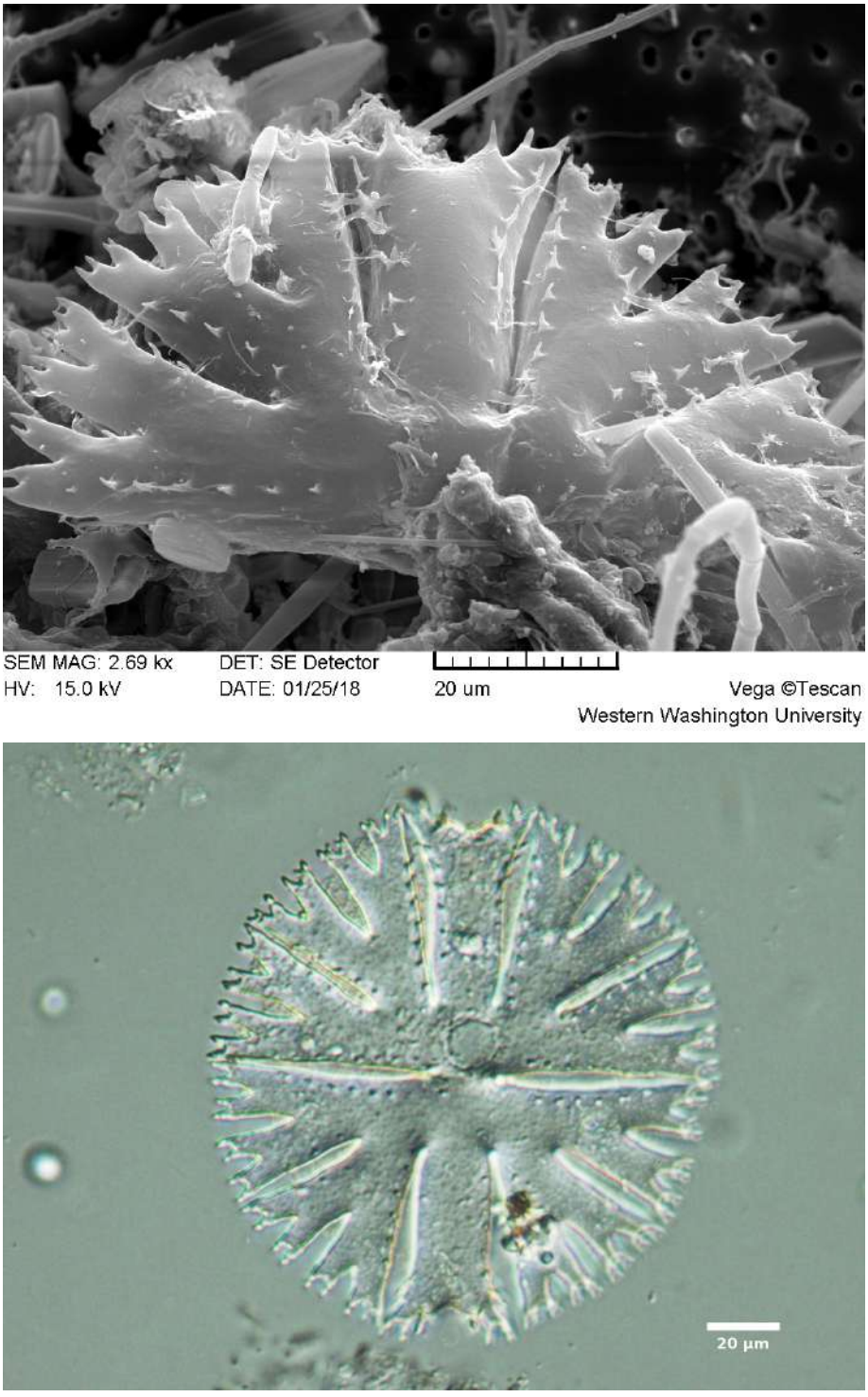


Figure 13.46: *Micrasterias papillifera* (SEM/DIC), Lake Evan, Mountain Loop Highway, Snohomish County (upper image); Bear Lake, Mountain Loop Highway, Snohomish County (lower image).

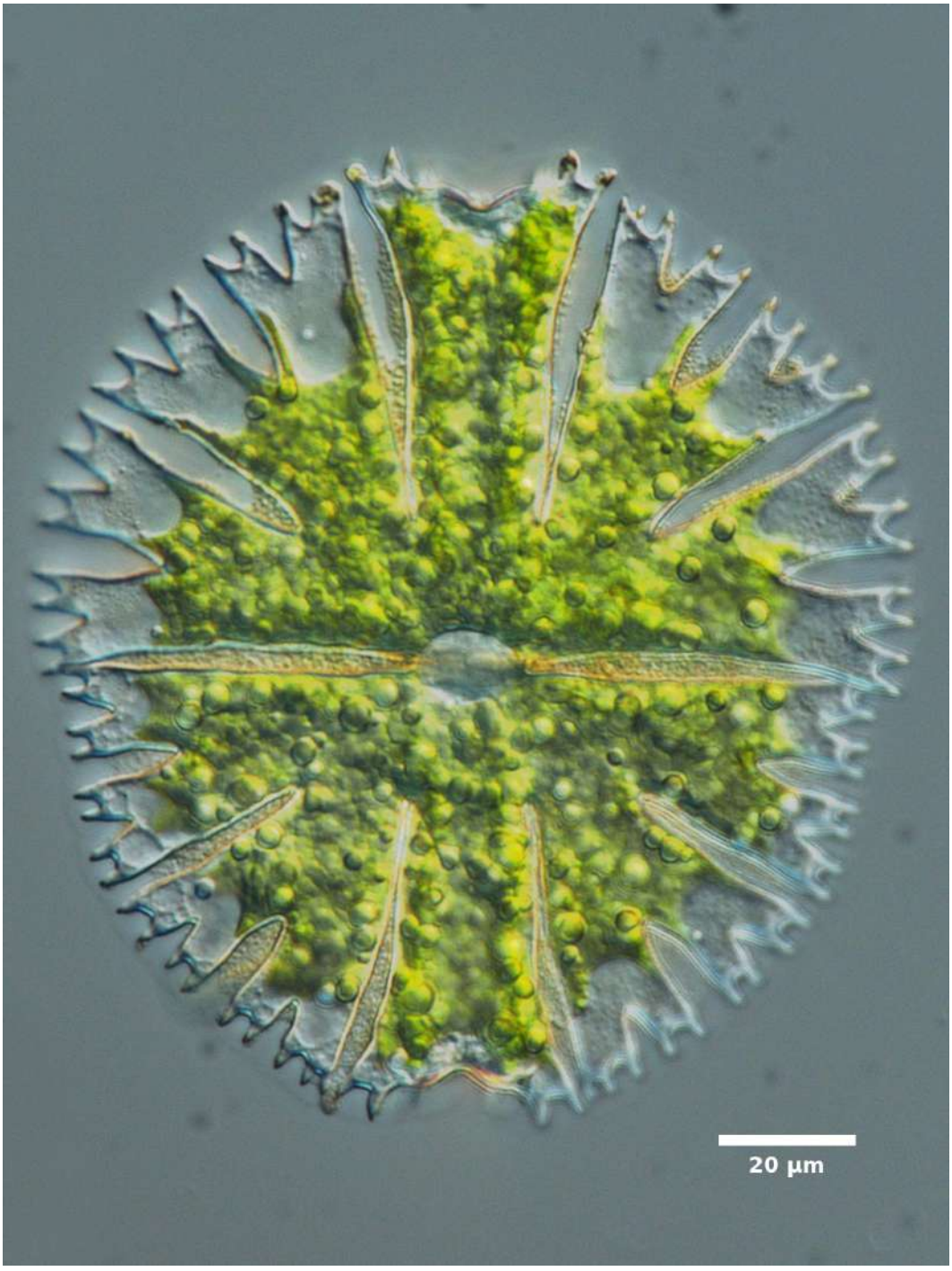


Figure 13.47: *Micrasterias papillifera* (DIC), small pond on trail to Big Four Ice Caves, Mountain Loop Highway, Snohomish County.

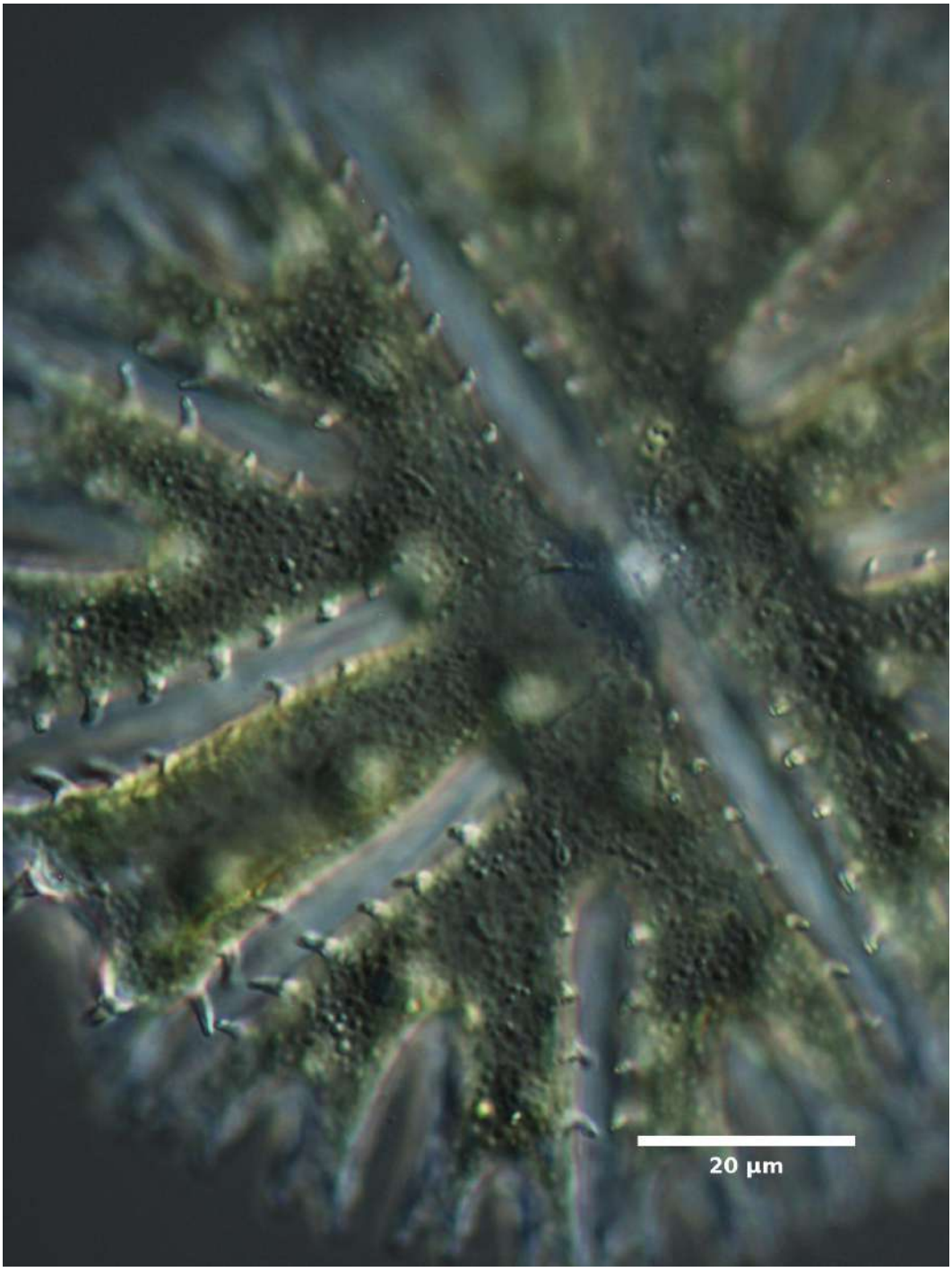


Figure 13.48: *Micrasterias papillifera* spines (DIC), Bear Lake, Mountain Loop Highway, Snohomish County.

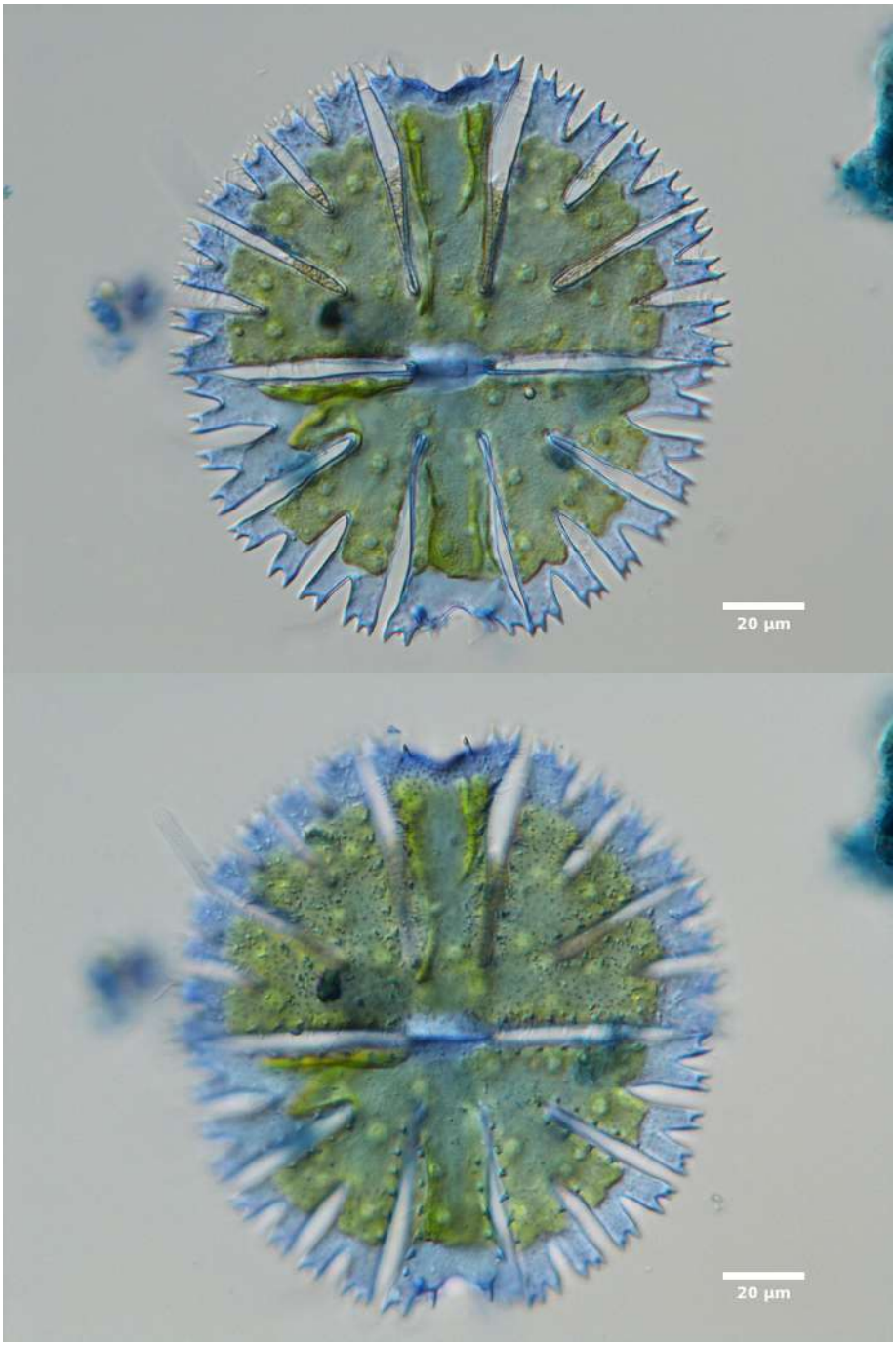


Figure 13.49: *Micrasterias papillifera* stained with methylene blue (DIC/DIC) Lake Evan, Mountain Loop Highway, Snohomish County (upper/lower images).

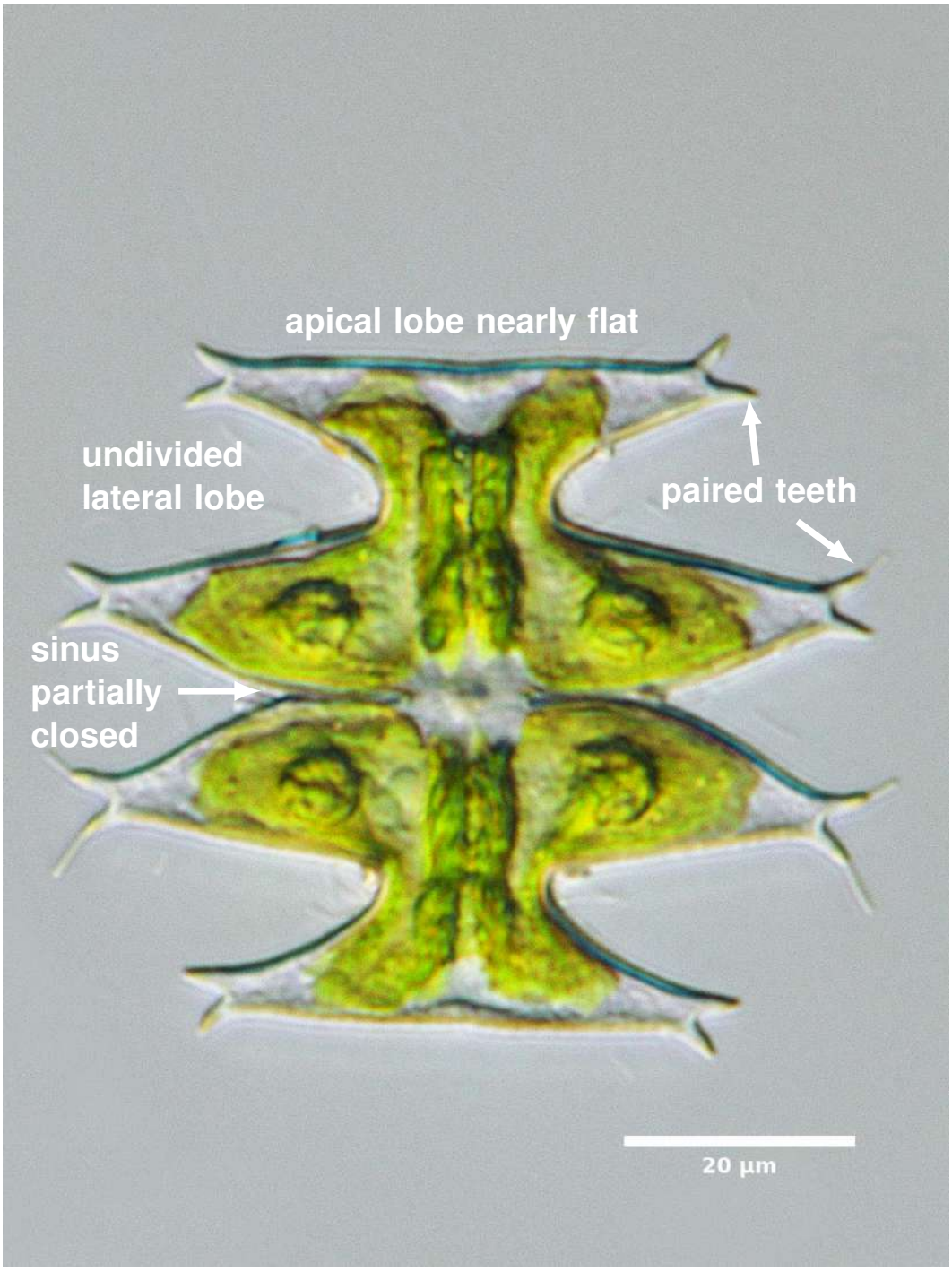
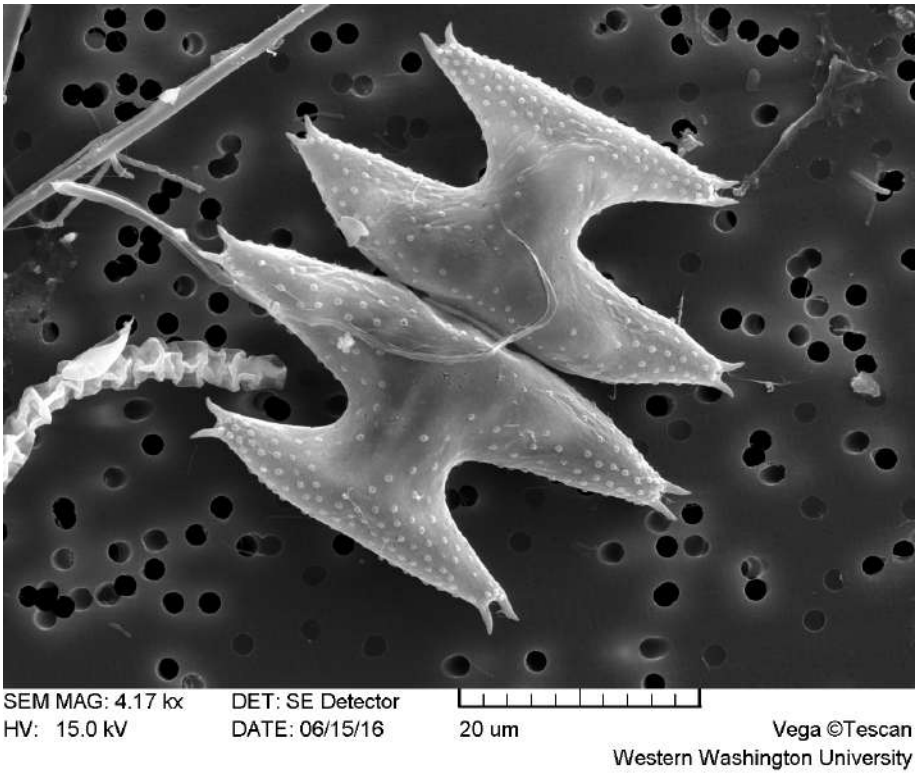


Figure 13.50: *Micrasterias pinnatifida* (DIC), stained with methylene blue, Lake Evan, Mountain Loop Highway, Snohomish County.



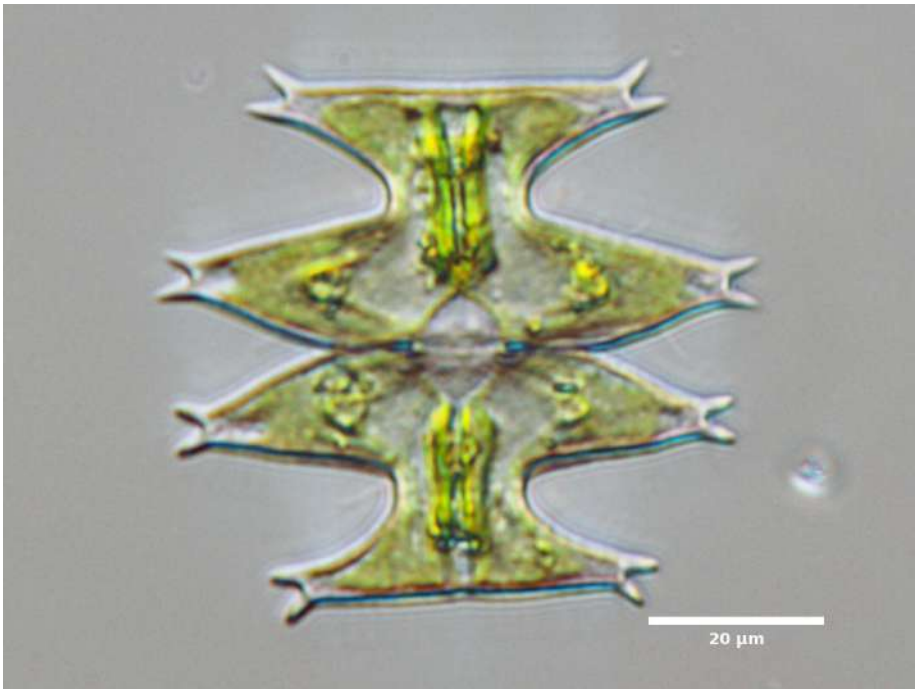


Figure 13.51: *Micrasterias pinnatifida* (SEM/DIC), Bear Lake, Mountain Loop Highway, Snohomish County (upper/lower images).

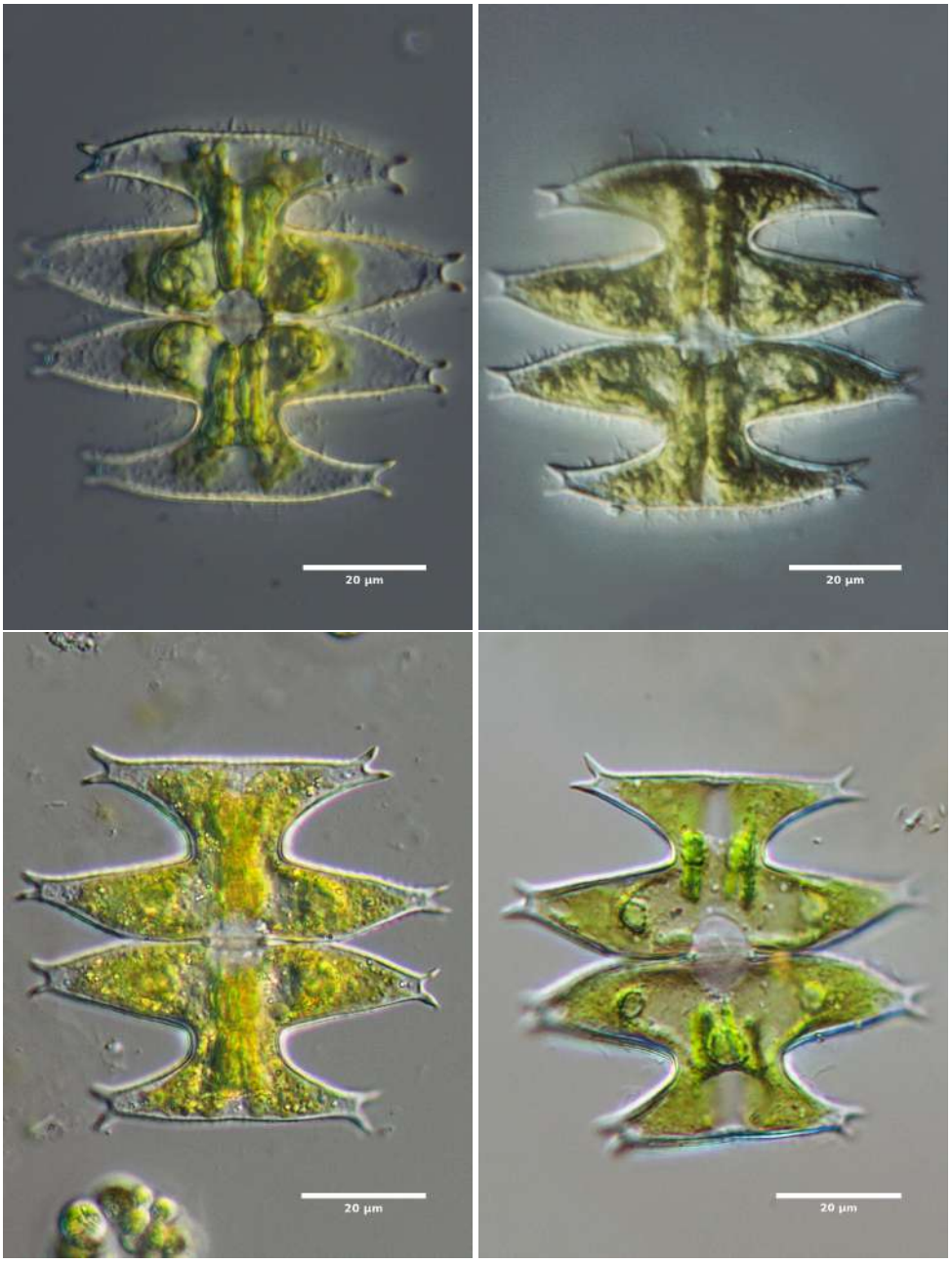


Figure 13.52: *Micrasterias pinnatifida* apical lobe variations (DIC), Myrtle Lake, Mountain Loop Highway, Snohomish County (upper images); Lake Evan, Mountain Loop Highway, Snohomish County (lower left image); Bear Lake, Mountain Loop Highway, Snohomish County (lower right image).

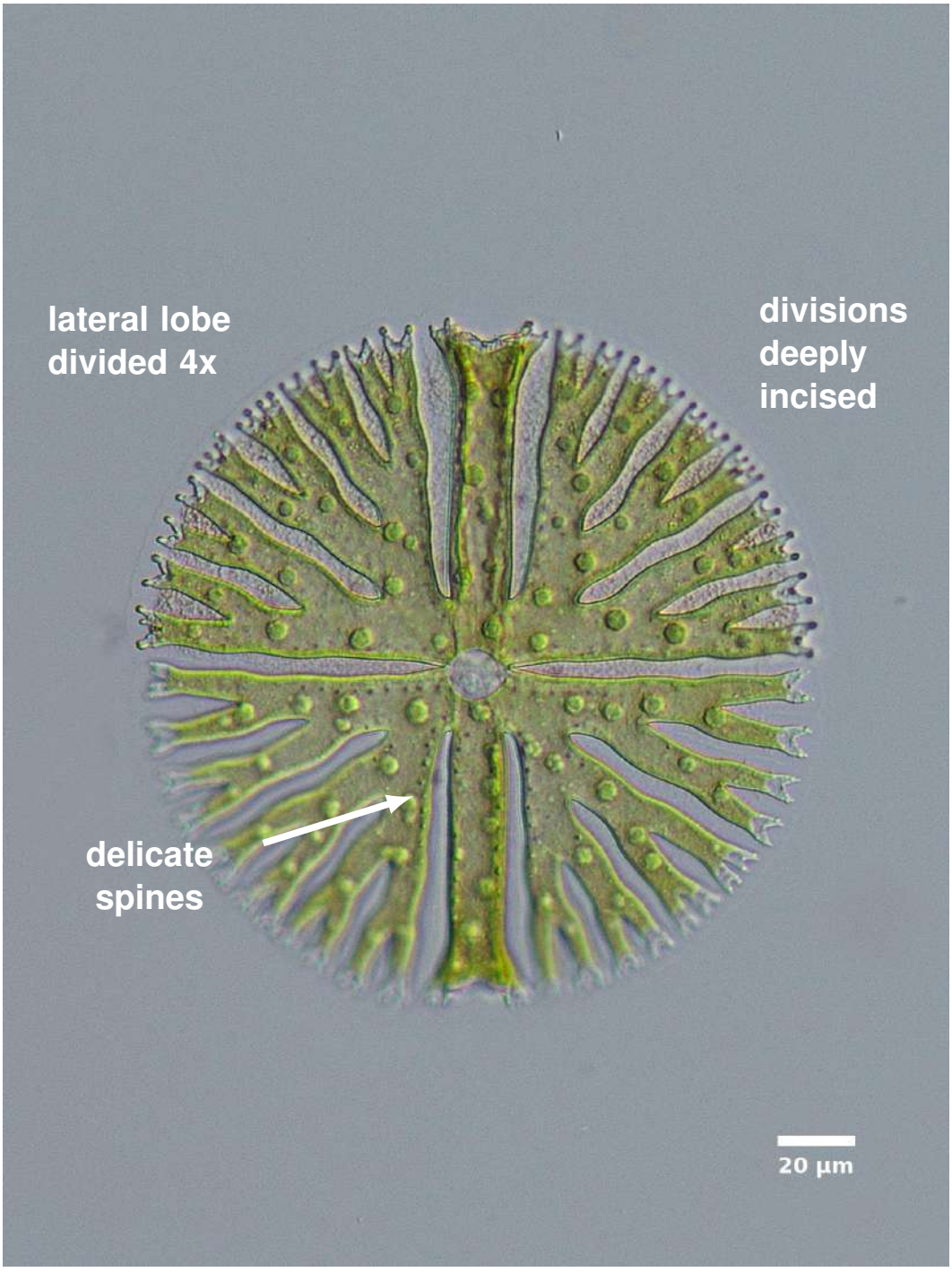


Figure 13.53: *Micrasterias radiosa* var. *elegantior* (DIC), Vogler Lake, Skagit County.

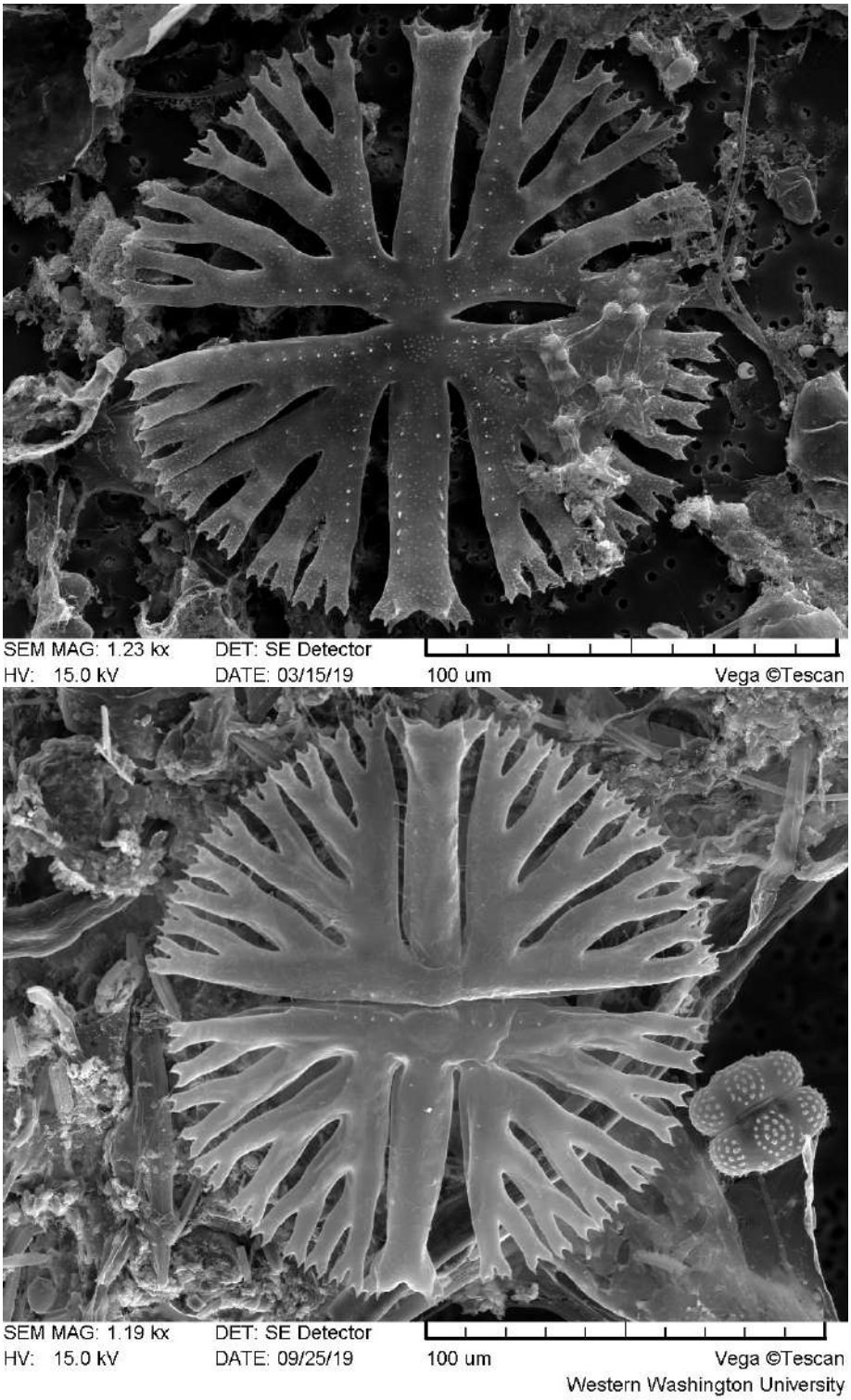


Figure 13.54: *Micrasterias radiosa* var. *elegantior* (SEM/SEM), Vogler Lake, Skagit County (upper image); small bog along Morris Valley Rd near Harrison, BC. (lower image)

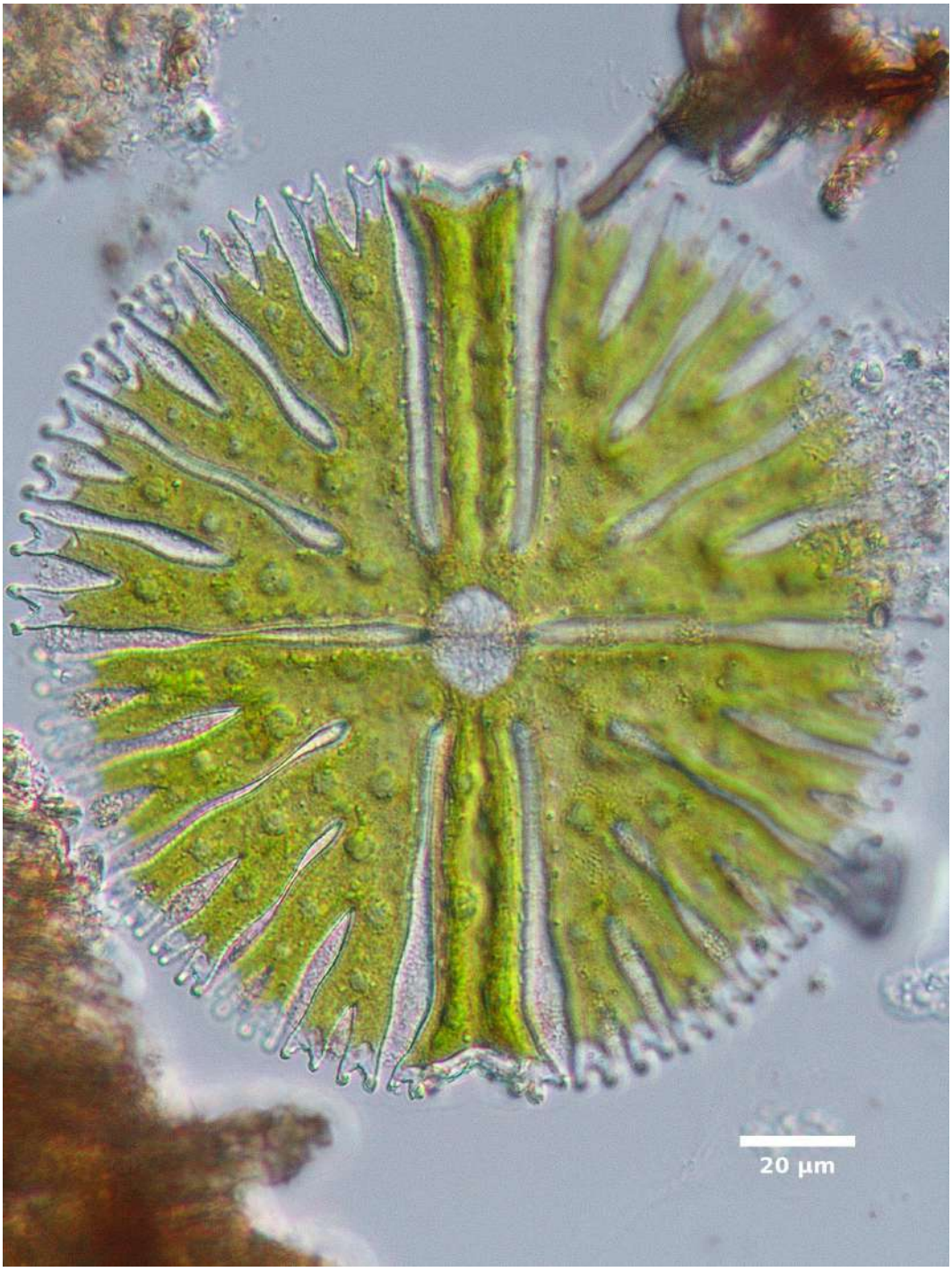


Figure 13.55: *Micrasterias radiosa* var. *elegantior* spines (DIC), Vogler Lake, Skagit County.

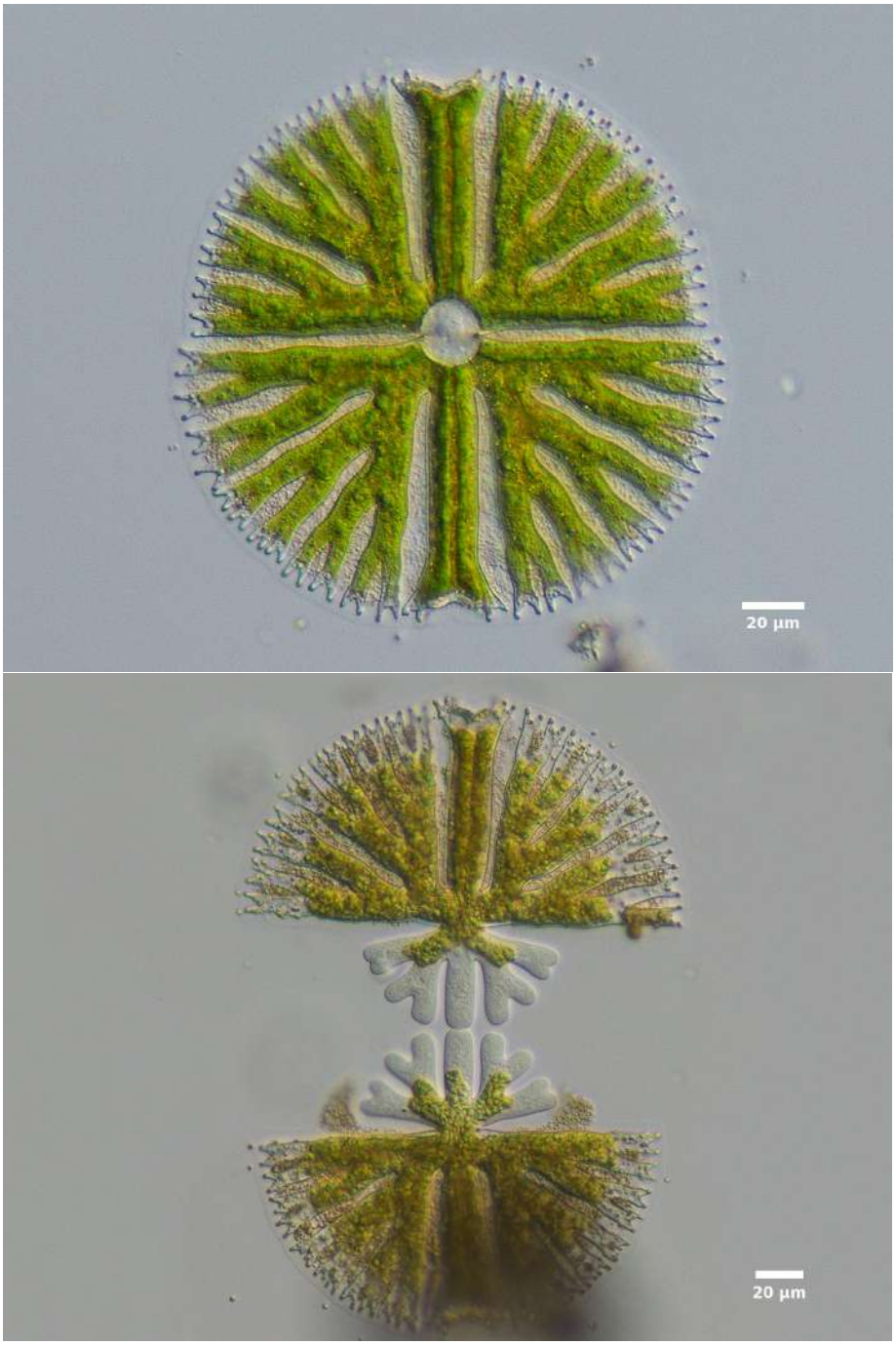


Figure 13.56: *Micrasterias radiosa* var. *elegantior* (DIC/DIC), Vogler Lake, Skagit County (upper/lower images).

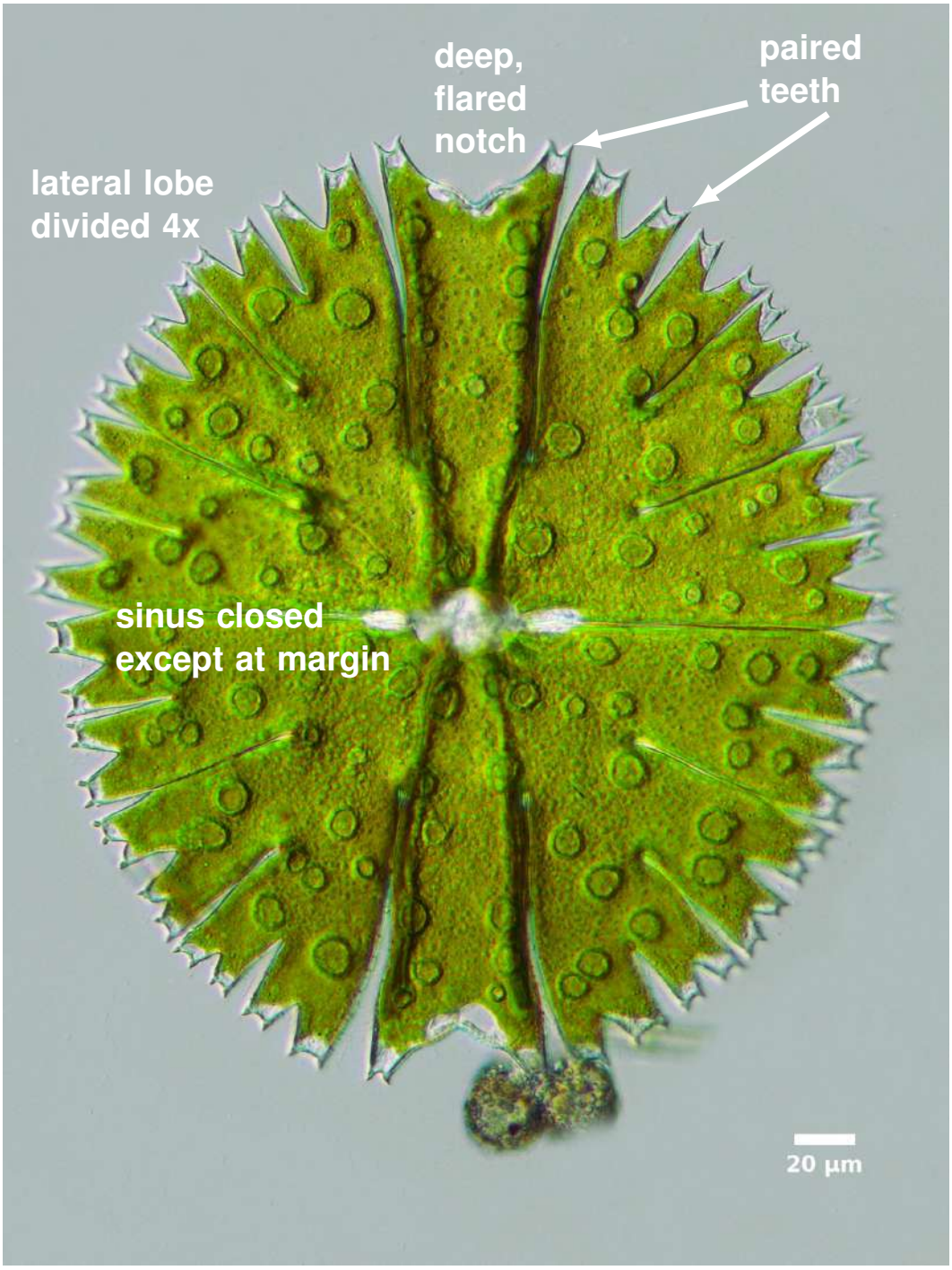


Figure 13.57: *Micrasterias rotata* (DIC), Highwood Lake, Mt. Baker area, Whatcom County.

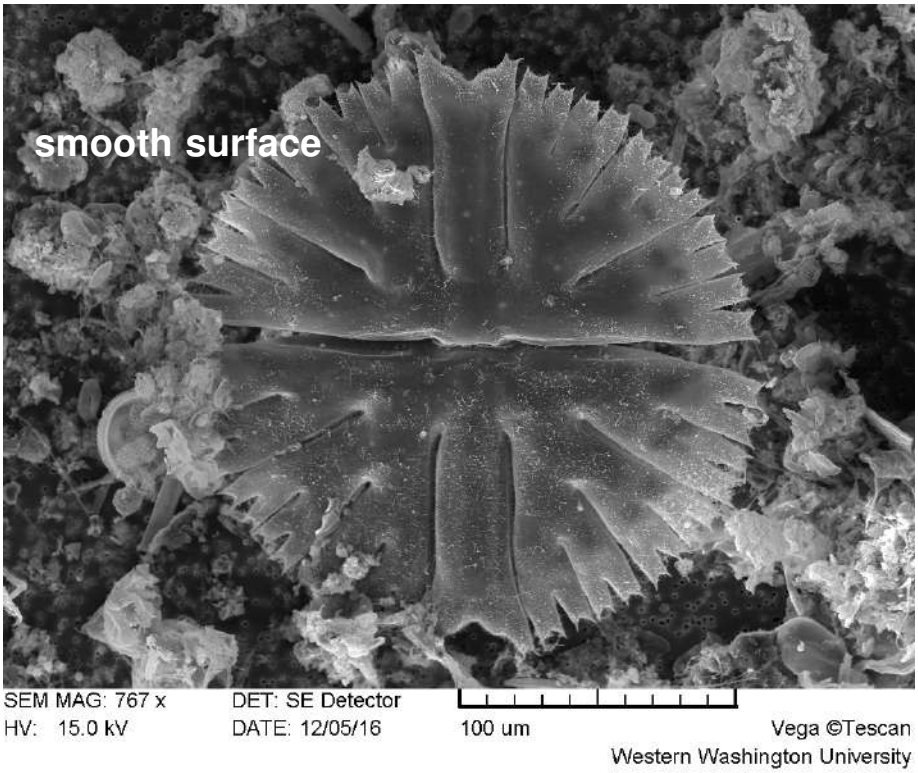




Figure 13.58: *Micrasterias rotata* (SEM/DIC), Vogler Lake, Skagit County (upper/lower images).

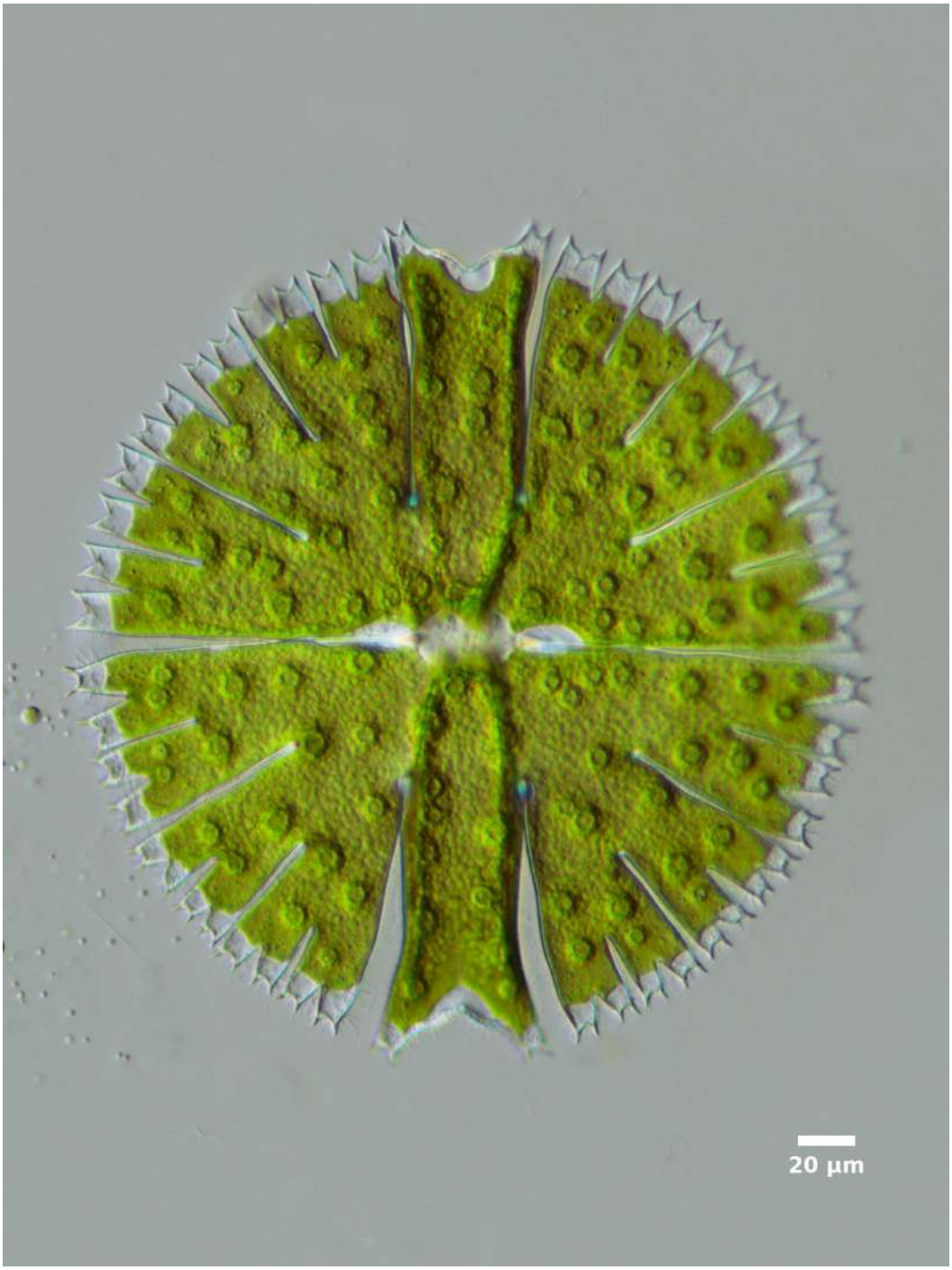


Figure 13.59: *Micrasterias rotata* (DIC), Vogler Lake, Skagit County.

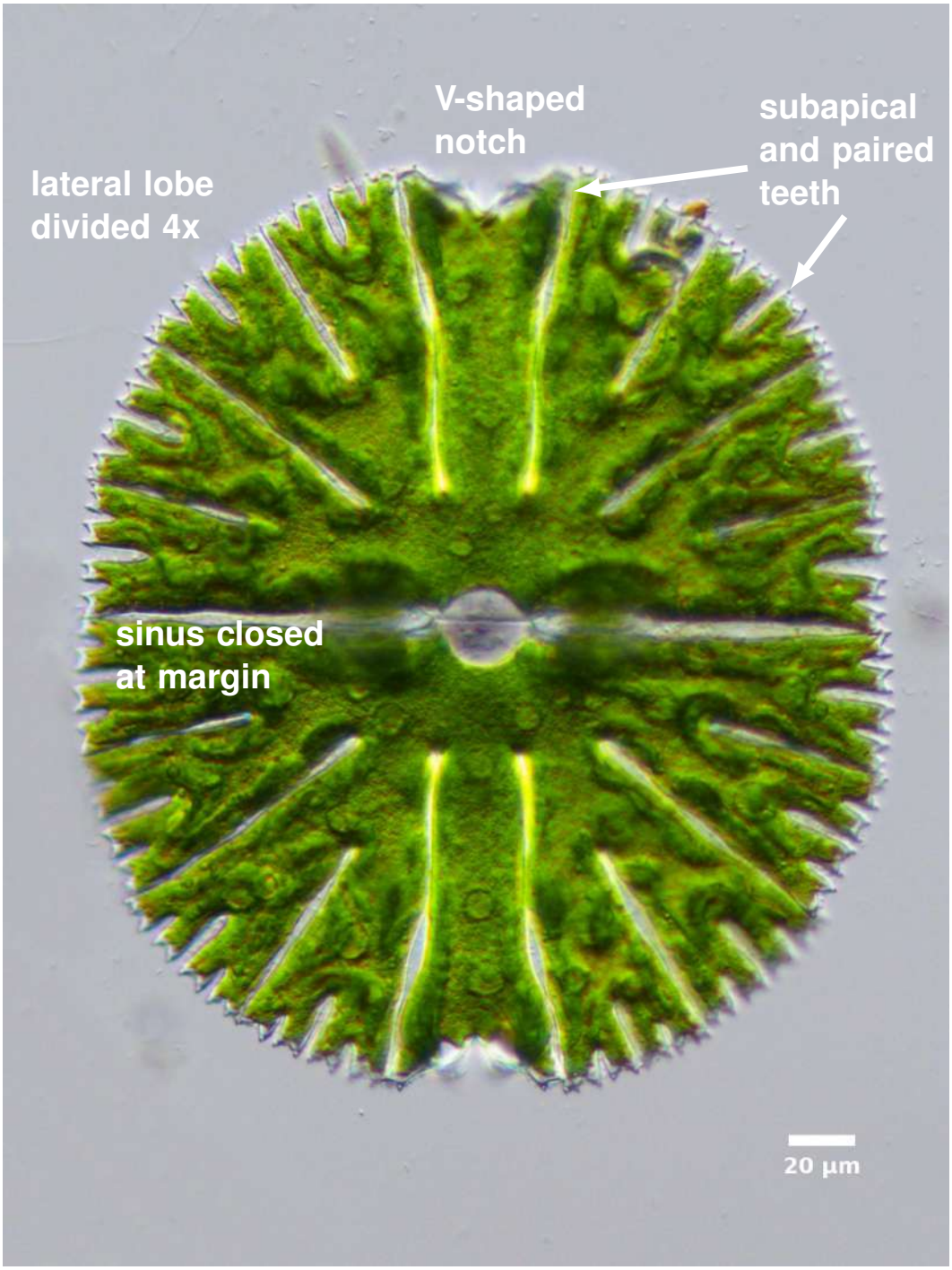
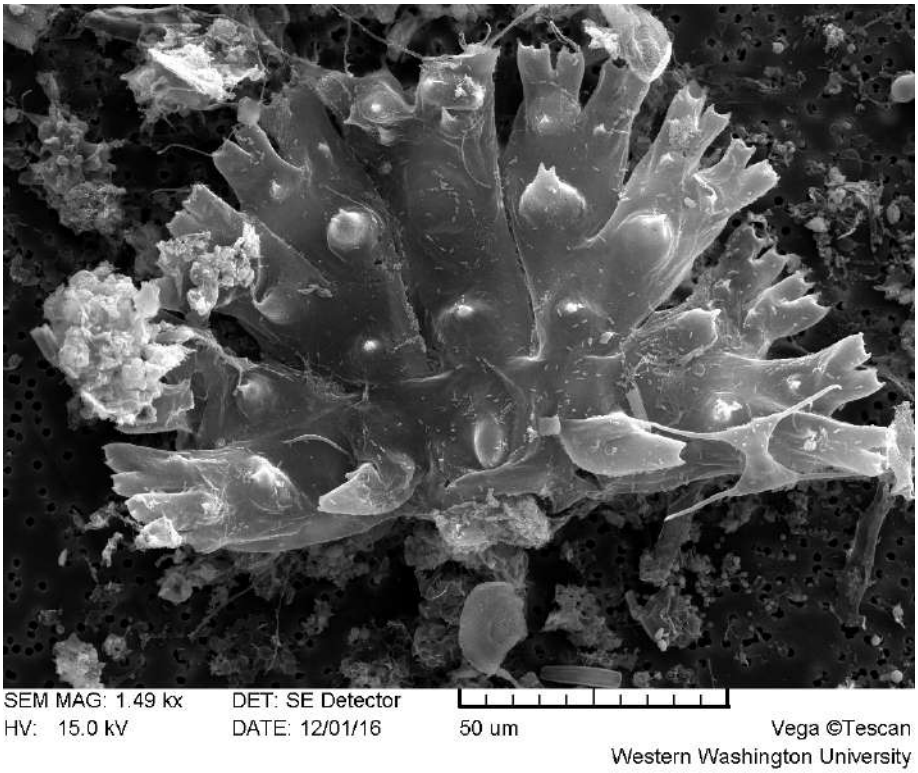


Figure 13.60: *Micrasterias thomasiana* (DIC), Vogler Lake, Skagit County.



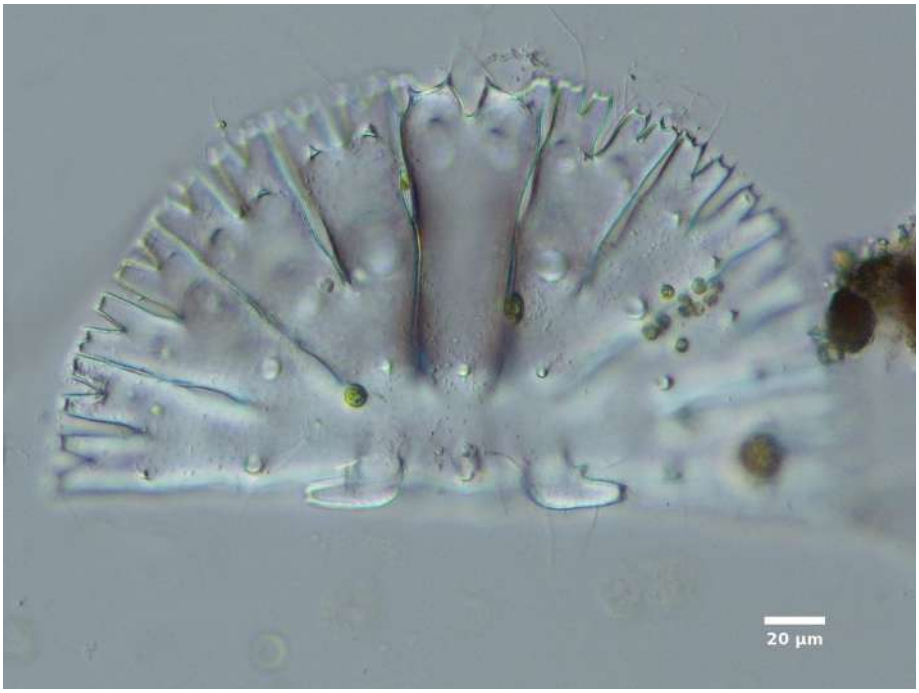


Figure 13.61: *Micrasterias thomasiana* (SEM/DIC), Vogler Lake, Skagit County (upper/lower images).

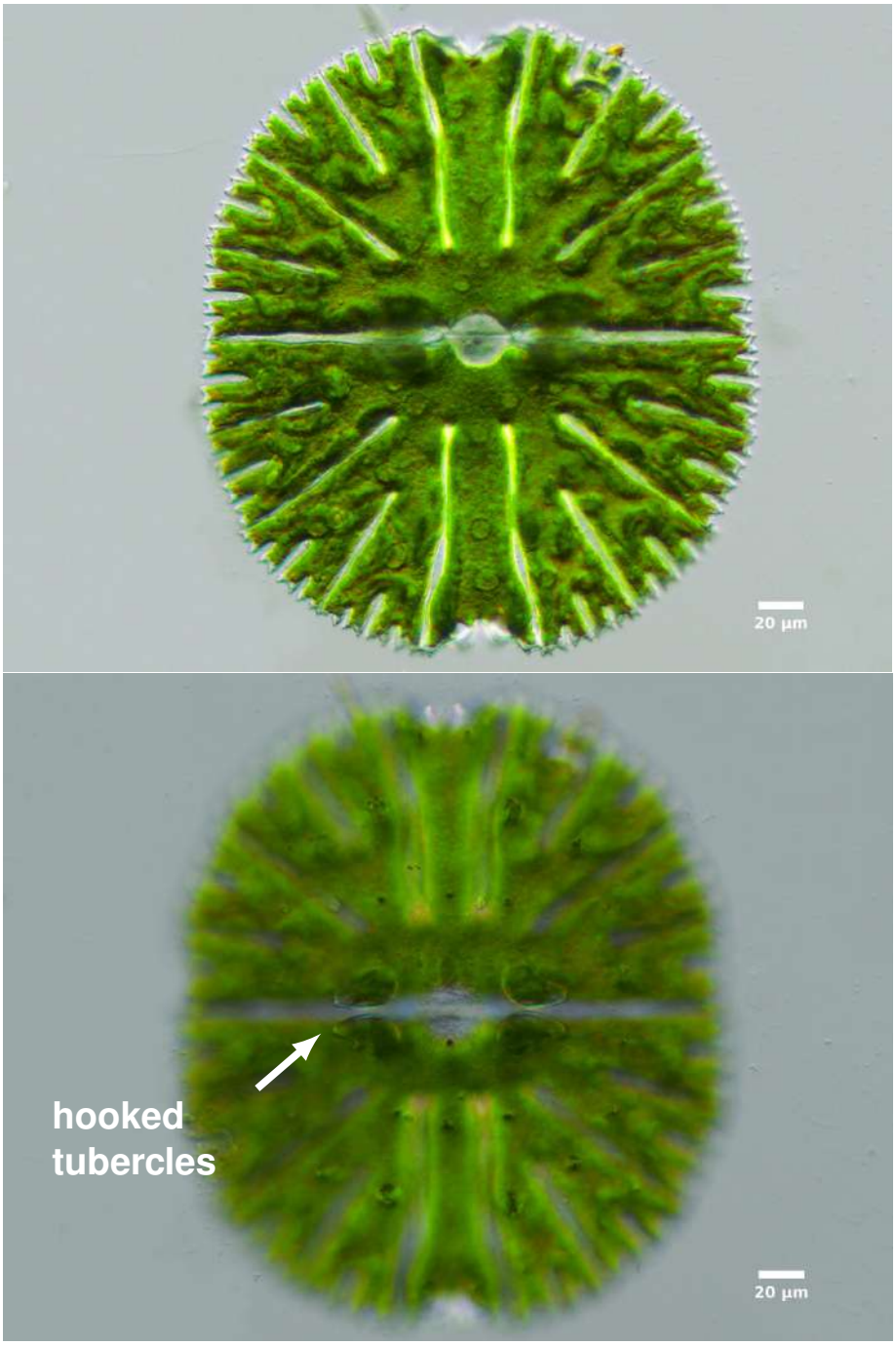


Figure 13.62: *Micrasterias thomasiana* (DIC/DIC), Vogler Lake, Skagit County (upper/lower images).



Figure 13.63: *Micrasterias thomasiana* (DIC/DIC), Vogler Lake, Skagit County (upper/lower images).

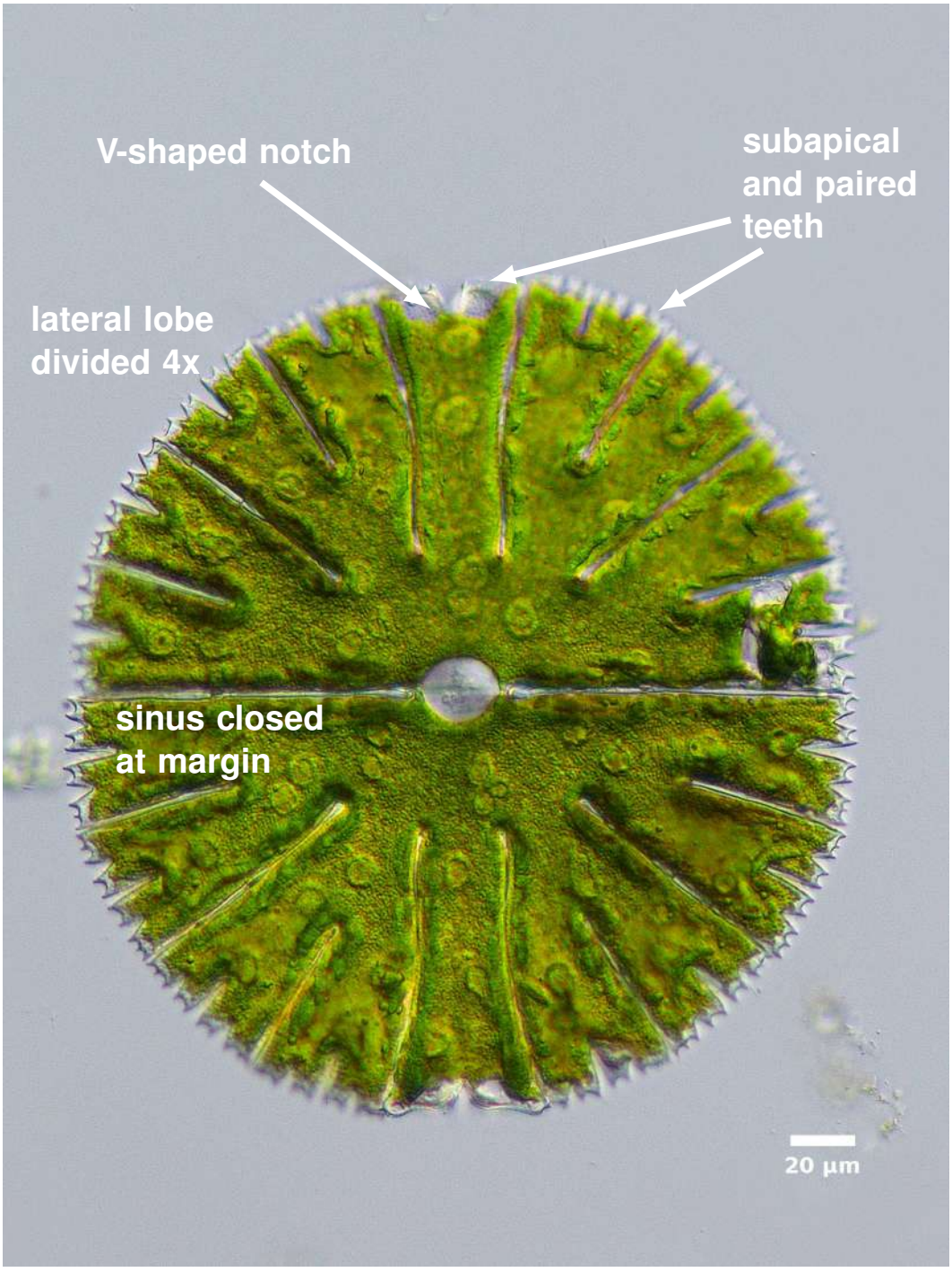


Figure 13.64: *Micrasterias thomasiana* var. *notata* (DIC), Picture Lake, Mt. Baker area, Whatcom County.

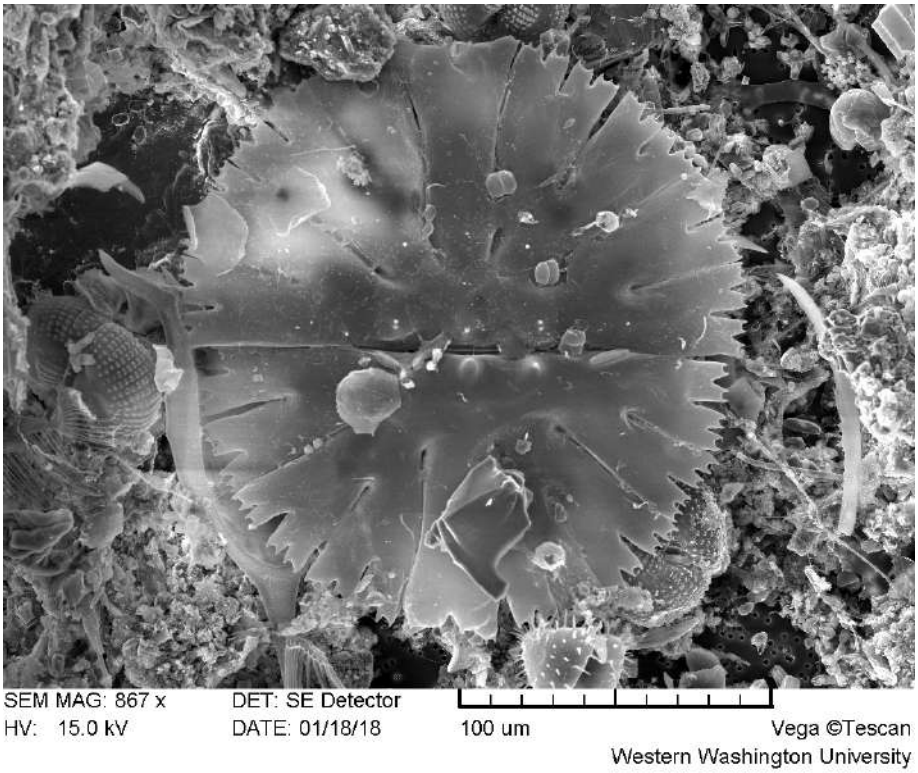




Figure 13.65: *Micrasterias thomasiana* var. *notata* (SEM/DIC), Highwood Lake, Mt. Baker area, Whatcom County (upper/lower images).

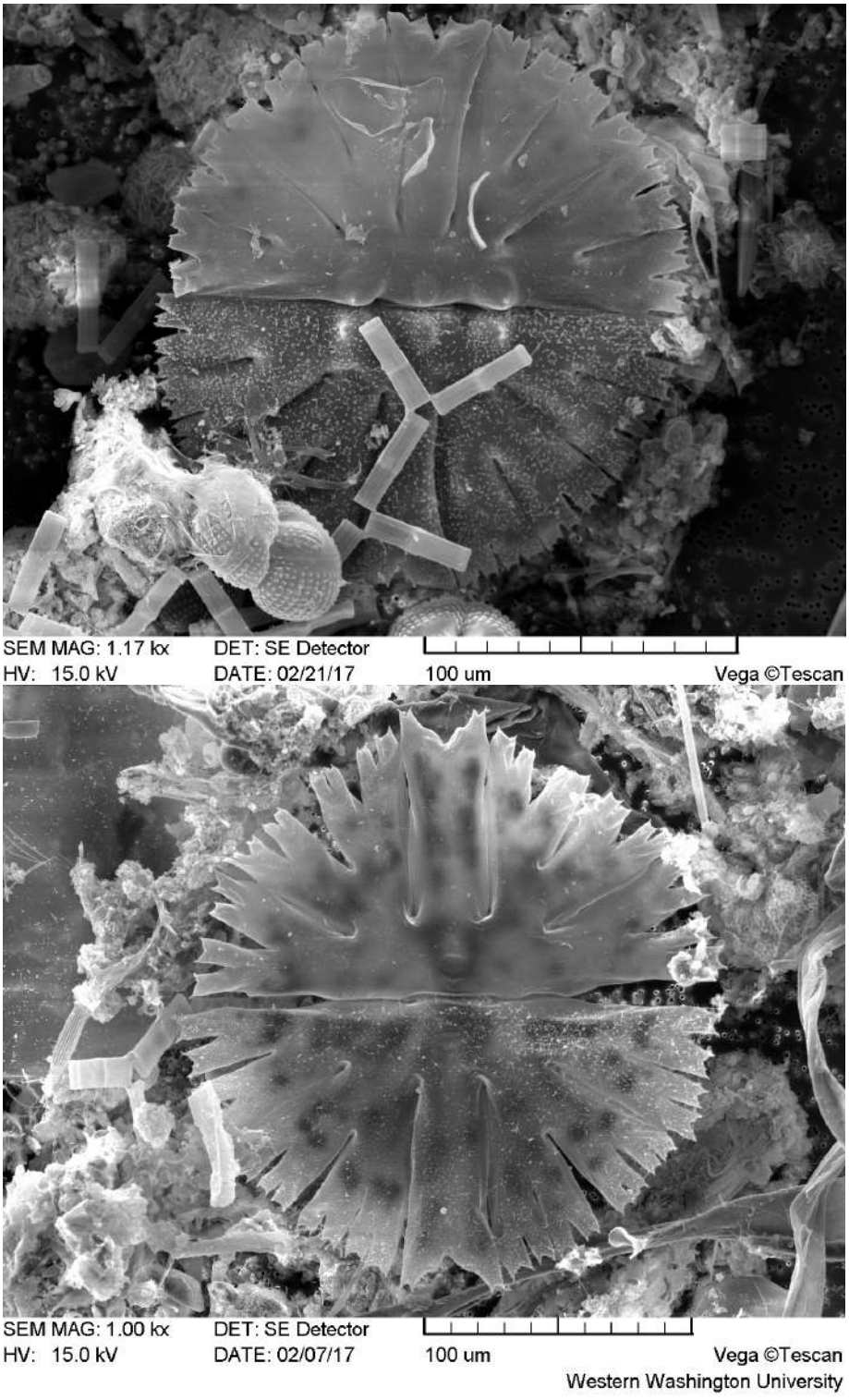


Figure 13.66: *Micrasterias thomasiana* var. *notata* (SEM/SEM), Highwood Lake, Mt. Baker area, Whatcom County (upper image); *Micrasterias rotata*, Vogler Lake, Skagit County (lower image).

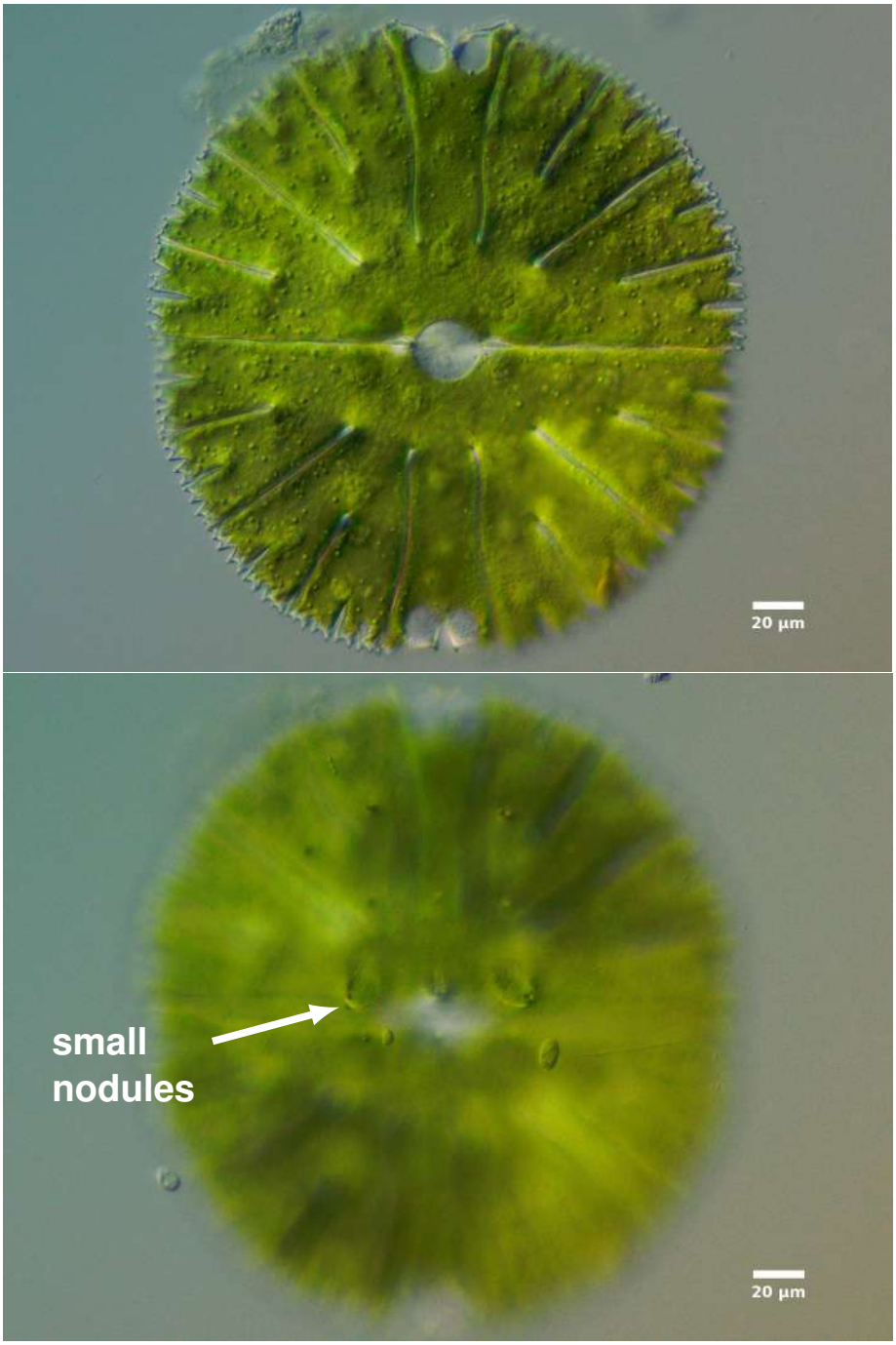


Figure 13.67: *Micrasterias thomasiana* var. *notata* (DIC/DIC), Picture Lake, Mt. Baker area, Whatcom County (upper/lower images).

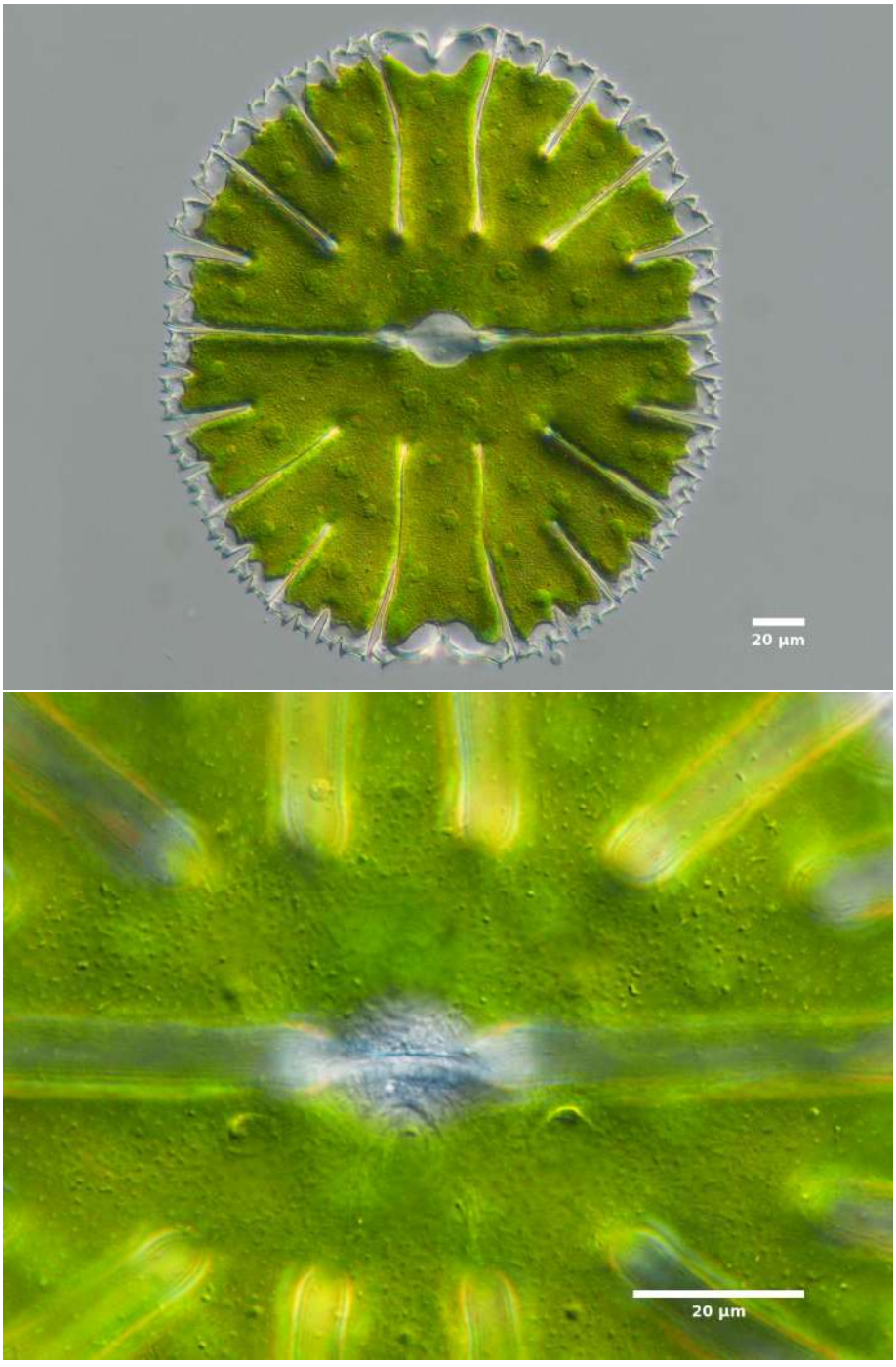


Figure 13.68: *Micrasterias thomasiana* var. *notata* (DIC/DIC), Lake Stevens, Snohomish County (upper/lower images).



Figure 13.69: *Micrasterias thomasiana* var. *notata* (DIC/DIC) Highwood Lake, Mt. Baker area, Whatcom County (upper/lower images).

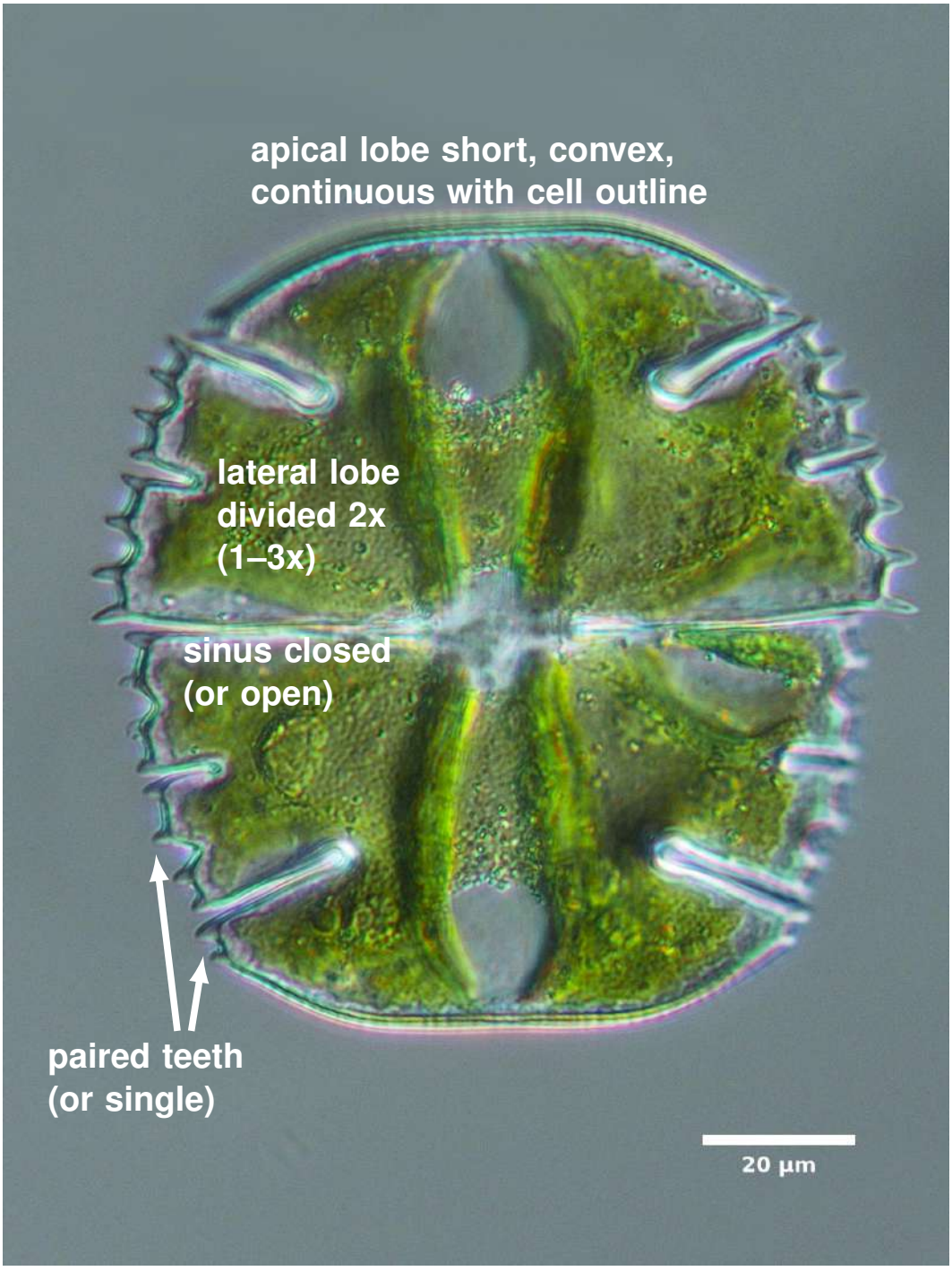
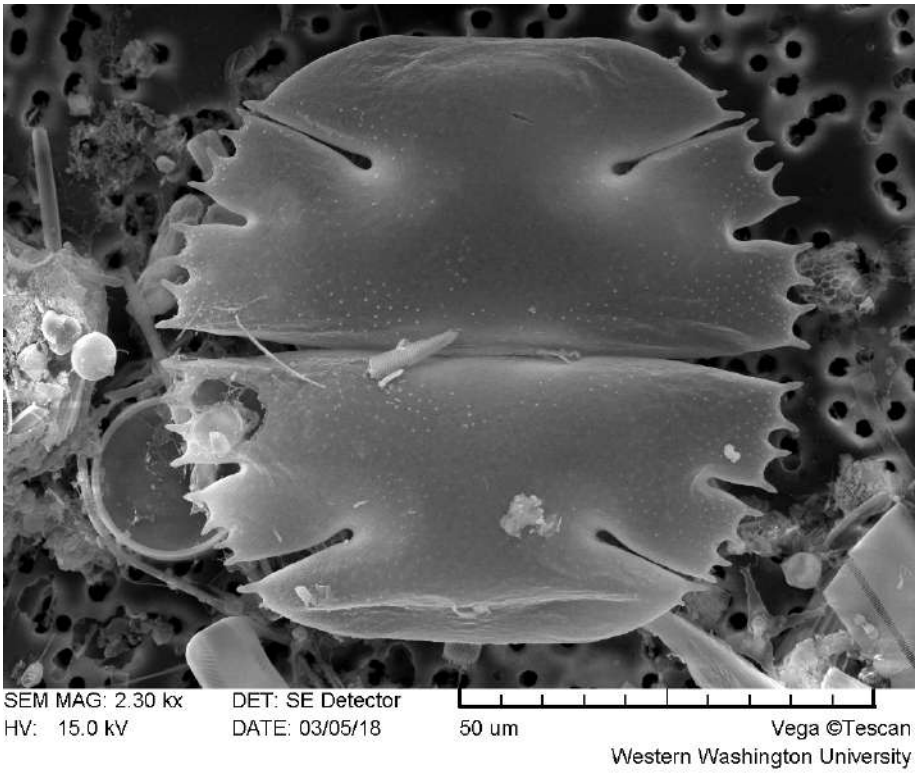


Figure 13.70: *Micrasterias truncata* (DIC), Lake Twenty-two, Mountain Loop Highway, Snohomish County.



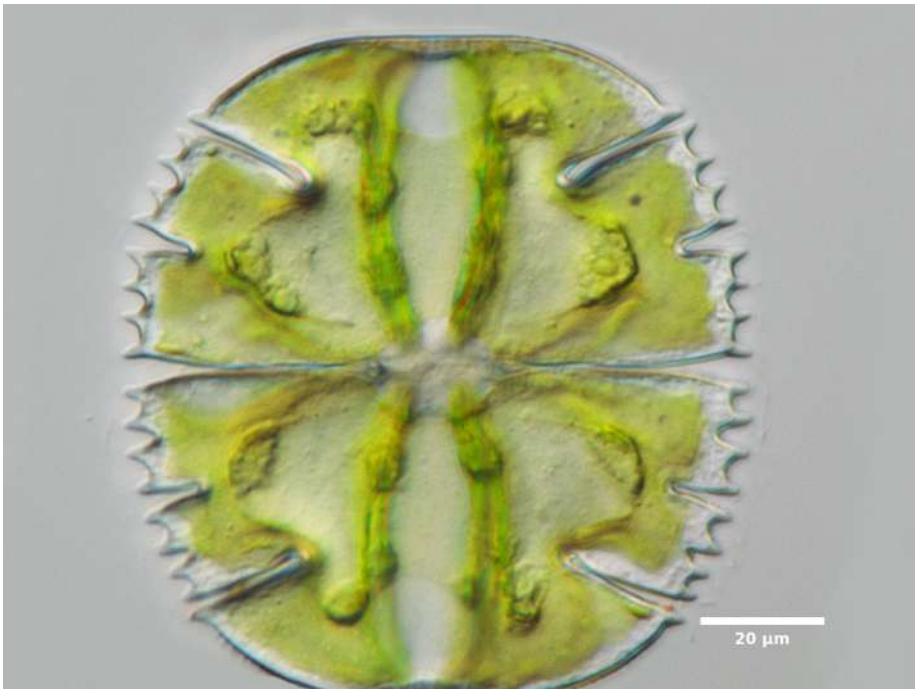


Figure 13.71: *Micrasterias truncata* (SEM/DIC), Lake Evan, Mountain Loop Highway, Snohomish County (upper/lower images).

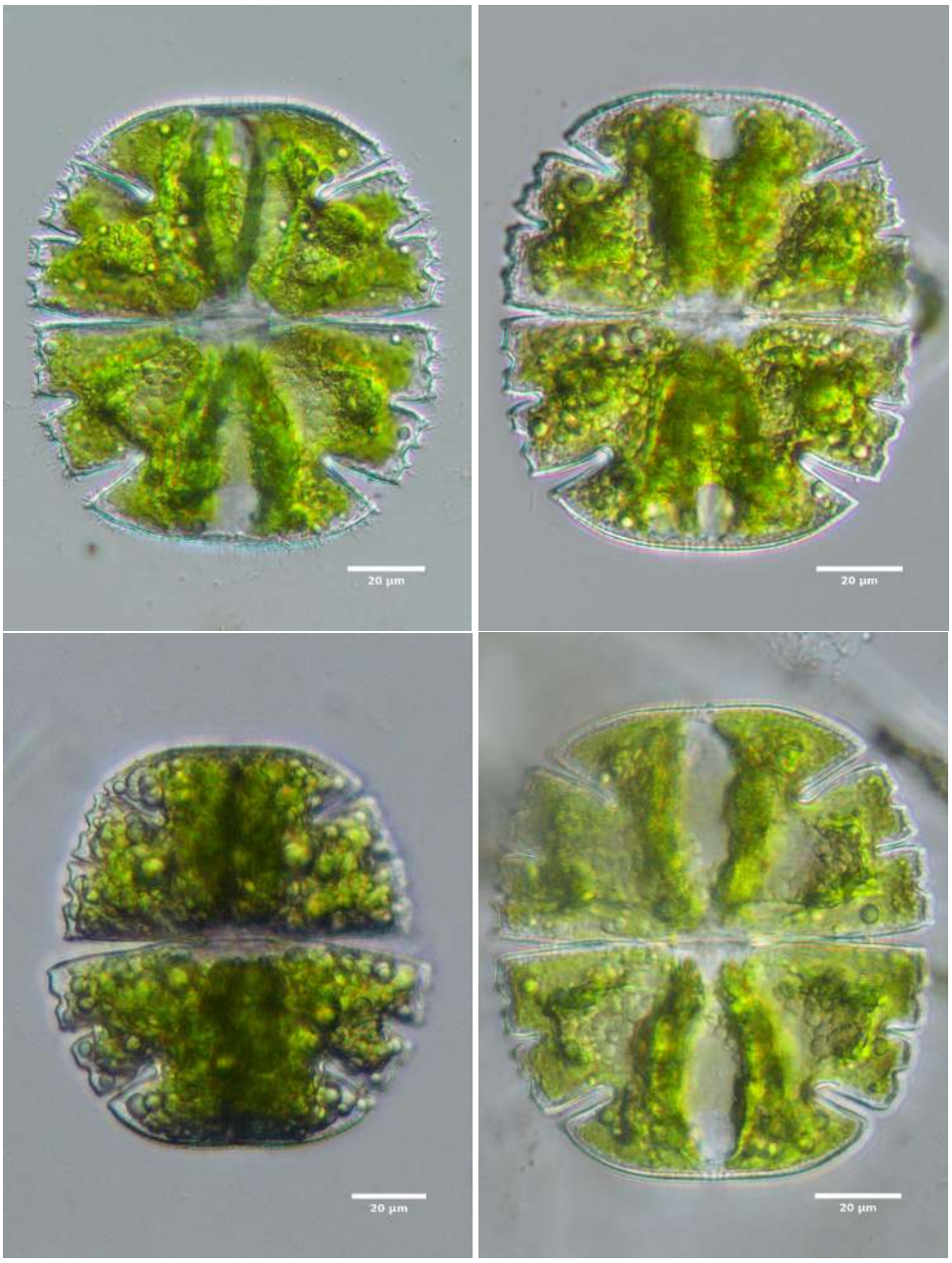


Figure 13.72: *Micrasterias truncata* morphological variations; specimens were collected on the same date in Summer Lake, Skagit County.

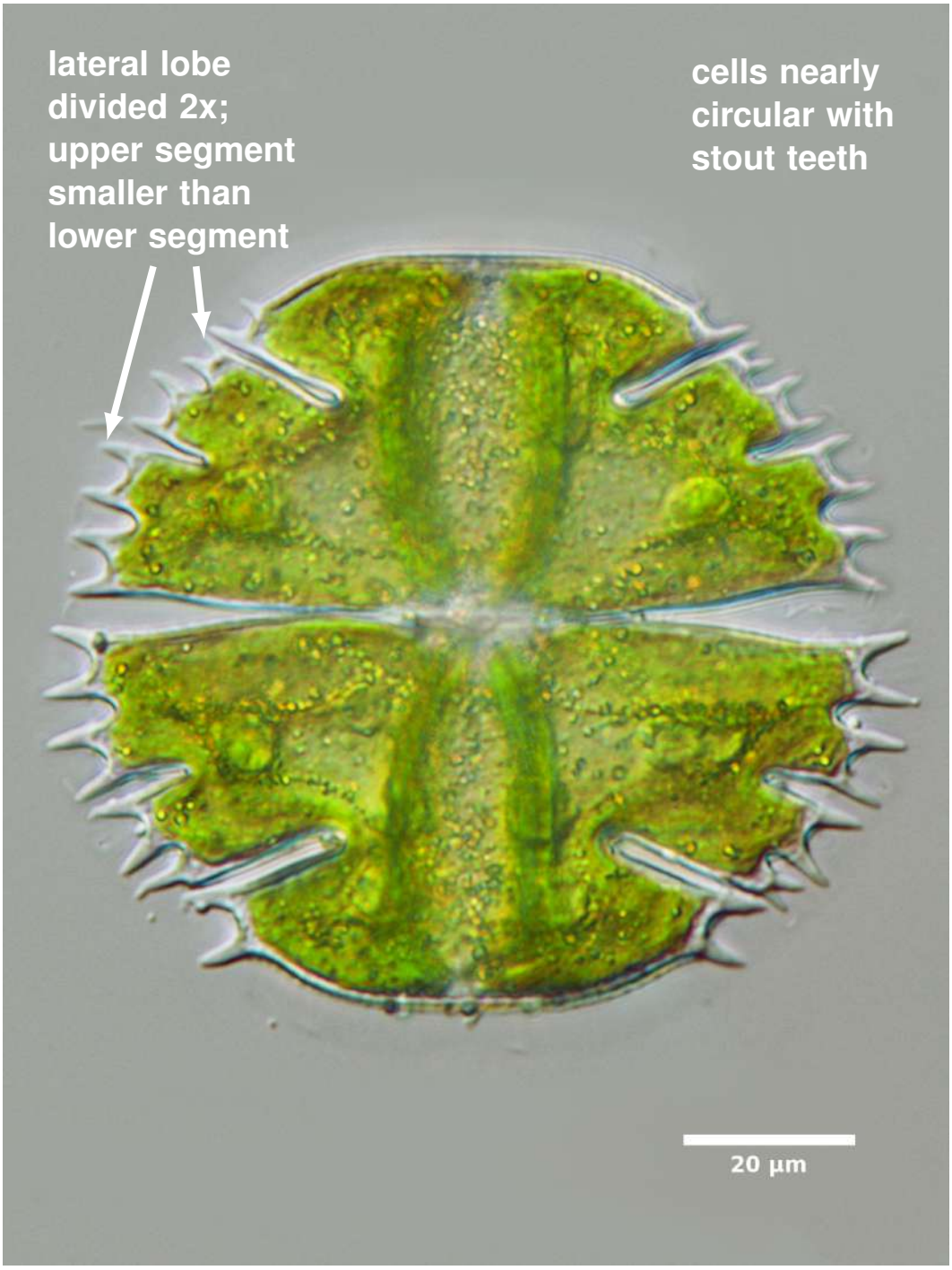


Figure 13.73: *Micrasterias truncata* var. *semiradiata* (DIC), Big Twin Lake (eastern Washington), Okanogan County.

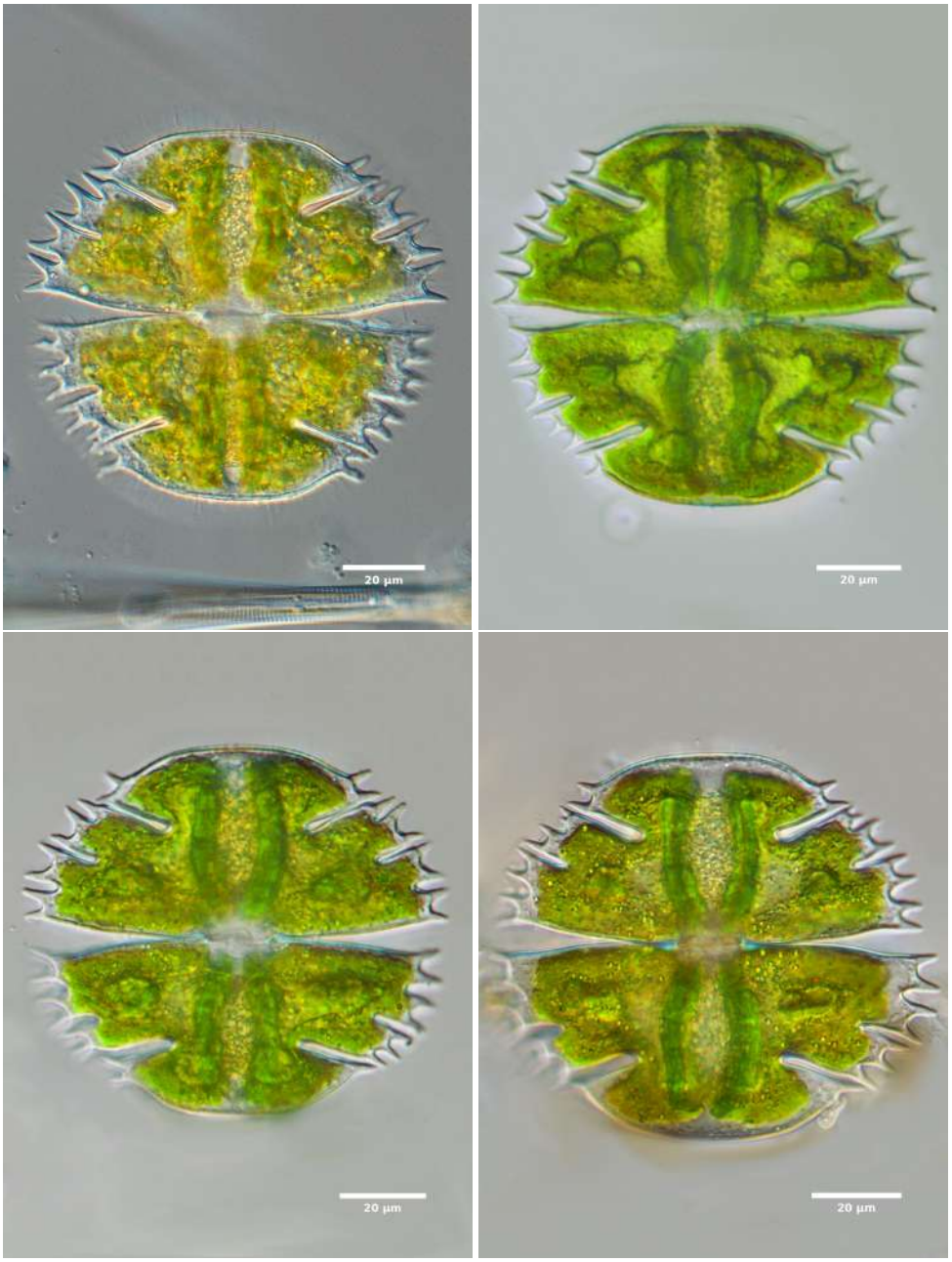


Figure 13.74: *Micrasterias truncata* var. *semiradiata* morphological variations; specimens were collected on multiple dates in Big Twin Lake (eastern Washington), Okanogan County.



Figure 13.75: *Micrasterias truncata* var. A (DIC), Heather Meadows Pond, Mt. Baker area, Whatcom County.

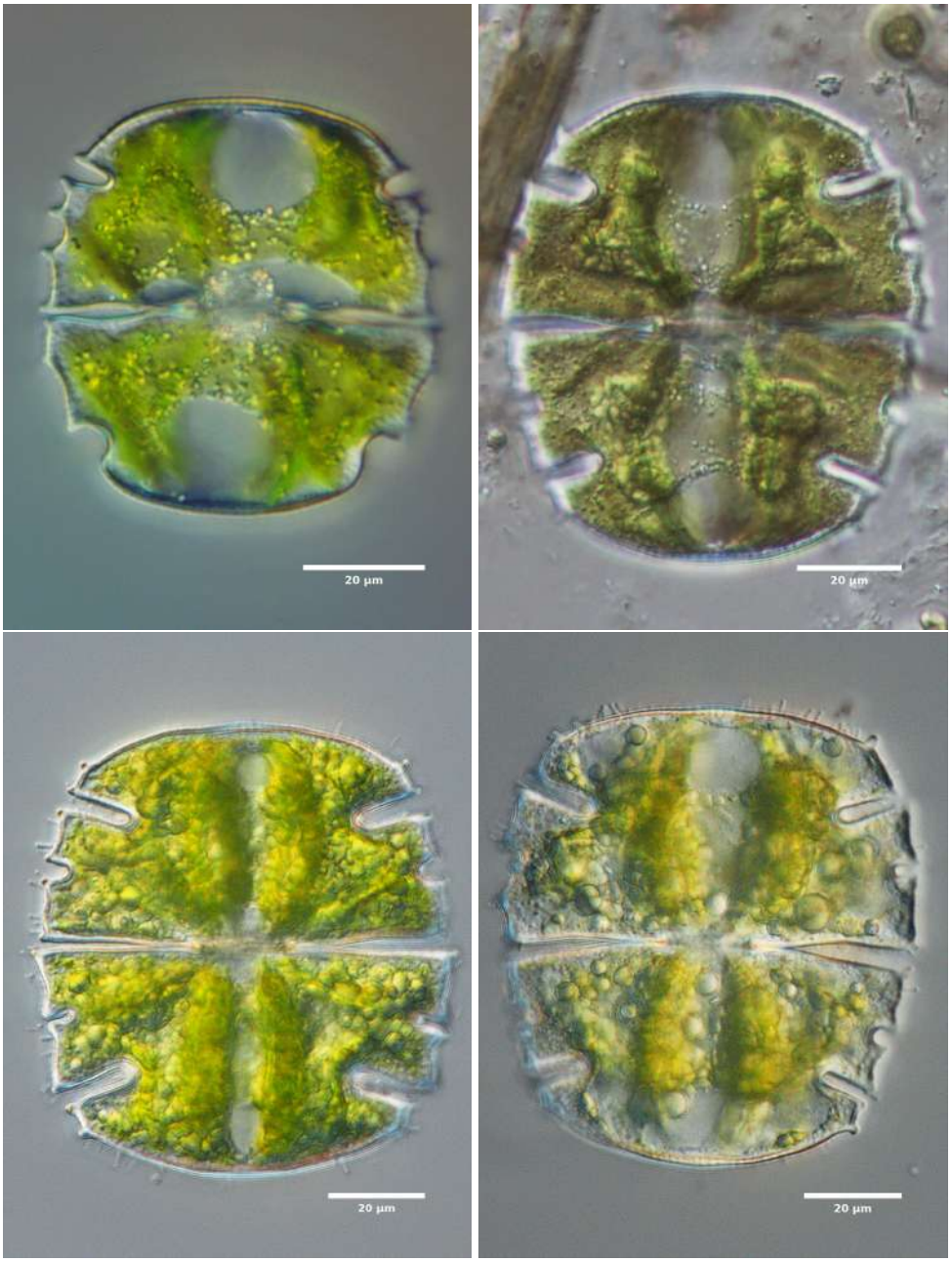


Figure 13.76: *Micrasterias truncata* var. A morphological variations, Terminal Lake, Mt.Baker area, Whatcom County (upper left); small pond on trail to Big Four Ice Caves, Mountain Loop Highway, Snohomish County (upper right); small floating bog near Baby Shoe Pass on road to Takhlakh Lake, Gifford Pinchot National Forest, Skamania county (lower images).

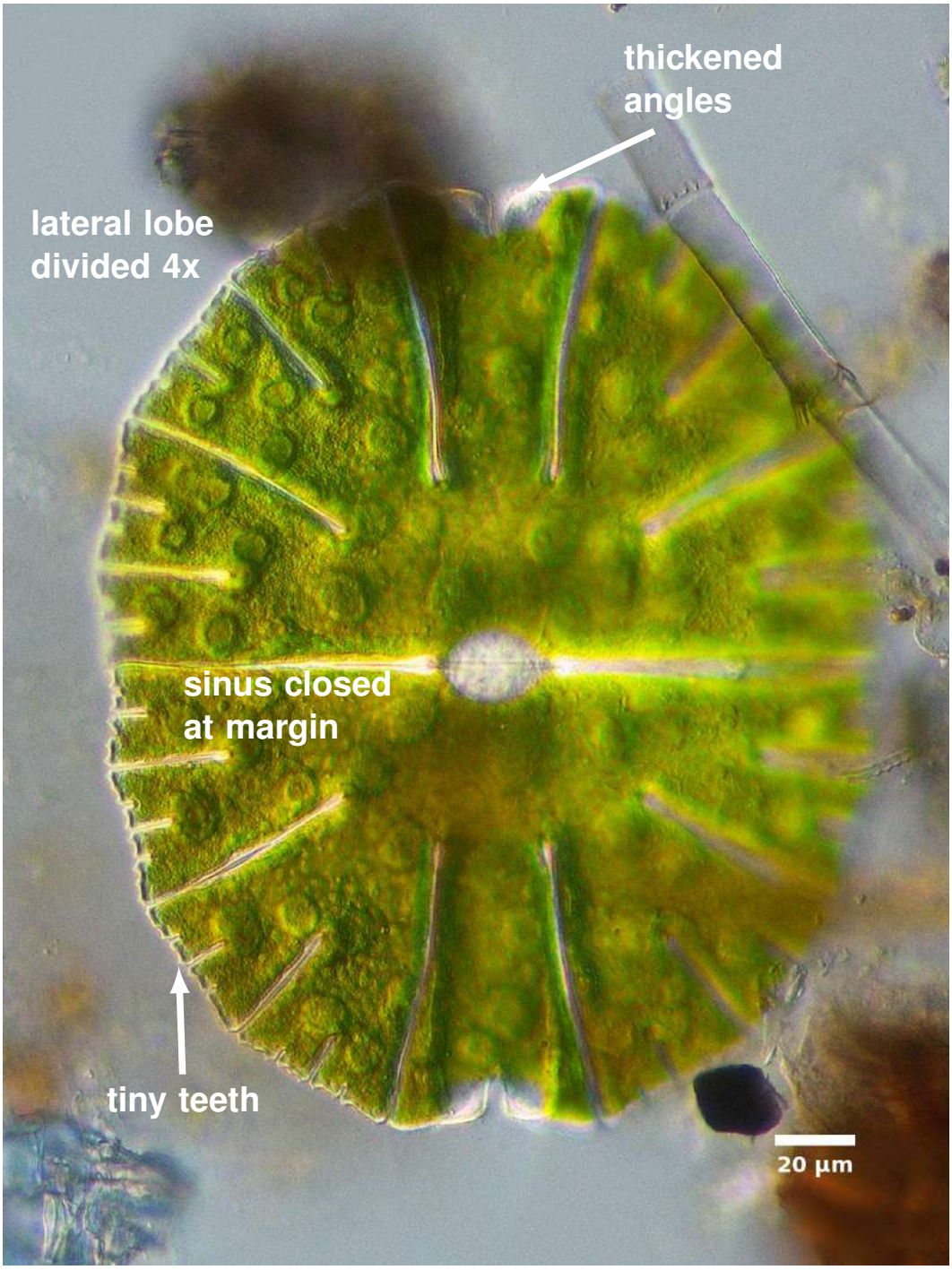


Figure 13.77: *Micrasterias verrucosa* (DIC), Vogler Lake, Skagit County.

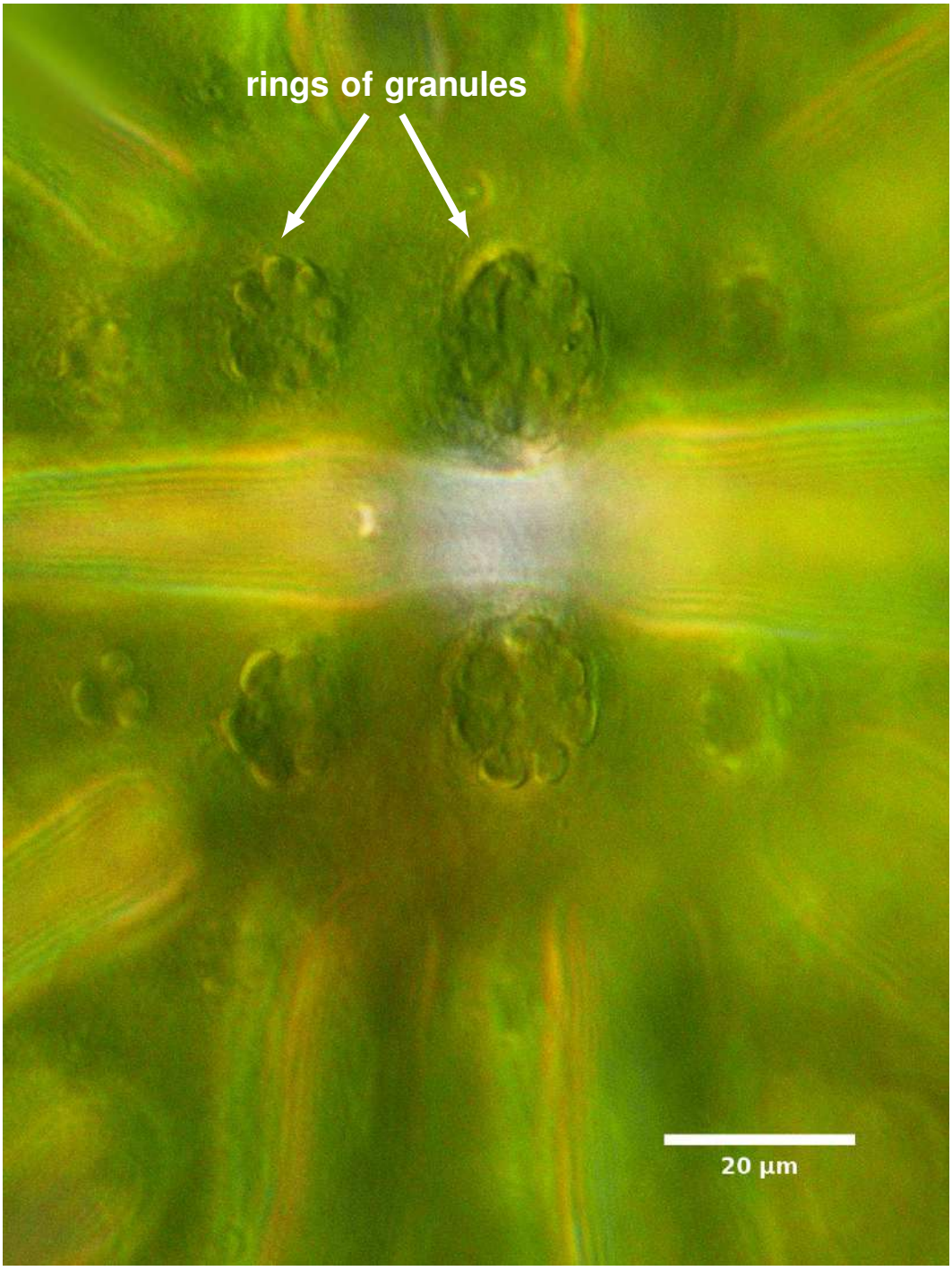


Figure 13.78: *Micrasterias verrucosa* surface (DIC), Vogler Lake, Skagit County.

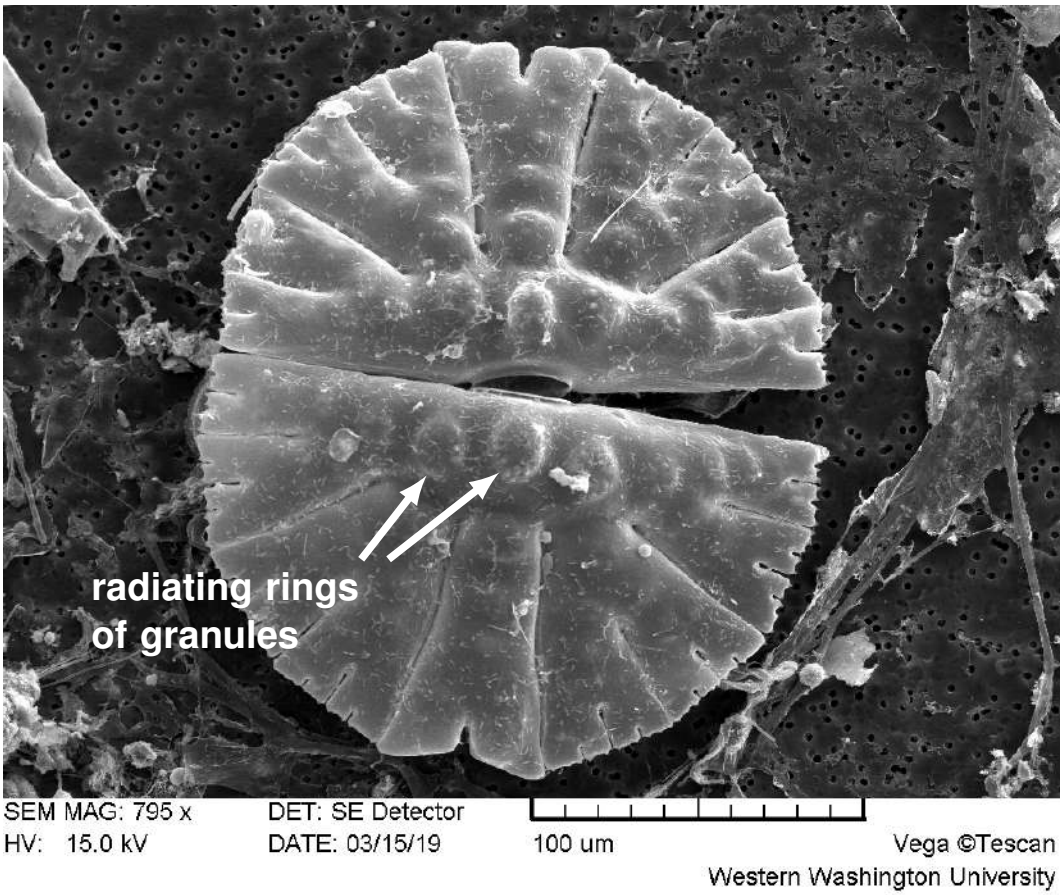


Figure 13.79: *Micrasterias verrucosa* (SEM), Vogler Lake, Skagit County.

Chapter 14

Netrium (Nägeli) Itzigsohn & Rothe and *Planotaenium* (Ohtani) Petlovany & Palamar-Mordvintseva

Northwest Washington taxa
Netrium digitus (Brébisson ex Ralfs) Itzigsohn & Rothe
Netrium sp.1
Planotaenium interruptum (Brébisson ex Ralfs) Petlovany & Palamar-Mordvintseva
(=*Netrium interruptum* [Brébisson ex Ralfs] Lütkemüller)
Planotaenium ohtanii Gontcharov & Melkonian

Table 14.1: Key to *Netrium* and *Planotaenium* Species

A	Semi-cell without terminal vacuoles; margin of chloroplast notched, serrated, or ragged	

continued on next page

Table 14.1: Key to *Netrium* and *Planotaenium* Species, continued

	A.1 Cells relatively large (L≥90 μm); chloroplast notched or serrated	*Netrium digitus* (Figures 14.1–14.6)
	A.2 Cells relatively small (L<90 μm); chloroplast ragged but not notched or serrated	*Netrium* sp.1 (Figures 14.7–14.9)
B	Semi-cell with spherical terminal vacuole containing a single crystal; margin of chloroplast smooth	
	B.1 Cells relatively large (L≥100 μm); chloroplasts divided to form 2 segments per semi-cell	*Planotaenium interruptum* (Figures 14.10–14.12)
	B.2 Cells relatively small (L≤75 μm); chloroplasts may be grooved, but not divided into segments within the semi-cell	*Planotaenium ohtanii* (Figures 14.13–14.14)

Table 14.2: *Netrium* and *Planotaenium* Cell Measurements

		Cell Width	Cell Length	Isthmus Width	L/W Ratio
Netrium digitus	min	35.9 μm	94.6 μm	–	2.2
	med	58.4 μm	203.8 μm	–	3.2
	max	97.9 μm	279.4 μm	–	4.6
Netrium sp. 1	min	17.8 μm	62.2 μm	–	1.8
	med	31.3 μm	69.2 μm	–	2.2
	max	38.1 μm	82.8 μm	–	3.6

[†]*summary statistics based on <5 cells*

continued on next page

Table 14.2: *Netrium* and *Planotaenium* Cell Measurements, continued

		Cell Width	Cell Length	Isthmus Width	L/W Ratio
Planotaenium interruptum	min	34.5 μm	113.8 μm	–	3.1
	med	40.1 μm	178.1 μm	–	4.2
	max	49.6 μm	232.4 μm	–	5.3
Planotaenium ohtanii†	min	17.8 μm	55.9 μm	–	2.9
	med	18.4 μm	58.8 μm	–	3.2
	max	19.0 μm	61.6 μm	–	3.5

†*summary statistics based on <5 cells*

Description

Netrium cells are oval, broadly elliptical, or broadly fusiform, with no discernible sinus (saccoderm desmid; Figures 14.1–14.9). The chloroplasts are usually very large, filling most of the cell volume, and each chloroplast usually contains one or more large, spherical or elongated pyrenoid. The chloroplasts may have conspicuous ridges and a ragged, notched, or serrated margin. Small species of *Netrium* are difficult to distinguish from *Cylindrocystis*[34] (see Chapter 5, page 289).

Planotaenium is a recently described genus that contains several species formerly assigned to the genus *Netrium*.[35] Like *Netrium*, *Planotaenium* cells are broadly elliptical or broadly fusiform, with no discernible sinus. Each *Planotaenium* semi-cell contains one or two large, ridged chloroplasts that have a smooth margin rather than a notched or serrated edge. *Planotaenium* semi-cells have a large, spherical terminal vacuole that contains a single large crystal; *Netrium* semi-cells will not have a terminal vacuole.

Netrium digitus cells are elliptical or broadly fusiform and relatively large, usually with cell lengths $\geq$90 μm (Figures 14.1–14.6). Each semi-cell contains one chloroplast that has four or more longitudinal ridges and a serrated or forked (bifurcate) margin. *Netrium digitus* is found in many northwest Washington

[34] According to Brook and Williamson 2010), there is no clear division between the small types of *Cylindrocystis* and *Netrium*.

[35] *Planotaenium* was included in this chapter because *Planotaenium* species are likely to be listed as species of *Netrium* in most taxonomic keys.

mountain lakes and ponds and was reported to be one of the most common desmids collected in peat bogs in mountain regions of the Czech Republic (Štěpánková, et al., 2008). Some of the specimens were broadly elliptical and relatively small (e.g., Figure 14.4), fitting descriptions for *Netrium digitus* var. *curtum* (Brook and Williamson, 2010); however, *Netrium digitus* is known to be morphologically variable. The *Netrium digitus* specimens from northwest Washington exhibited a gradient of lengths and widths, with large, medium, and small cells often collected at the same or similar locations (Figure 14.5), so it seems likely that these smaller cells may not be a unique variety. Recently divided cells often have asymmetric semi-cells, adding to the identification challenges (Figure 14.6).

***Netrium* sp.1** is characterized by small, oval or broadly elliptical, smooth-walled cells containing two chloroplasts with ragged edges (Figures 14.7–14.9). The cells resemble *Cylindrocystis* (see Section 5, page 289), but the chloroplast is flattened rather than star-shaped. The specimens are somewhat similar to *Netrium oblongum* (De Bary) Lütkemüller (no image available), but many of the morphological features are not a good fit for that species. All of the specimens were collected in mossy substrates along the shorelines of mountain lakes or in the spray zone of a mountain waterfall. Because of the uncertainty surrounding identification of small species of *Netrium*, it is possible that the specimens in Figures 14.7–14.9 represent more than one species.

Planotaenium interruptum will be listed as *Netrium interruptum* in many older taxonomic sources, but the semi-cells have large, spherical terminal vacuoles (Figures 14.10–14.12) Each semi-cell appears to contain two chloroplasts due to transverse partitioning, and while the chloroplast is ridged like *Netrium* species, the margin is smooth rather than notched or serrated. Similar to *Netrium*, recently divided *Planotaenium interruptum* semi-cells may be asymmetric (Figure 14.12).

Planotaenium ohtanii is characterized by small elliptical cells with large terminal vacuoles, each containing a single large crystal, and smooth-edged chloroplasts, each with one large, elongated pyrenoid (Figures 14.13–14.14). This species resembles *Planotaenium interruptum*, but can be distinguished by the chloroplasts, which may have shallow transverse grooves, but are not divided into two segments in each semi-cell.

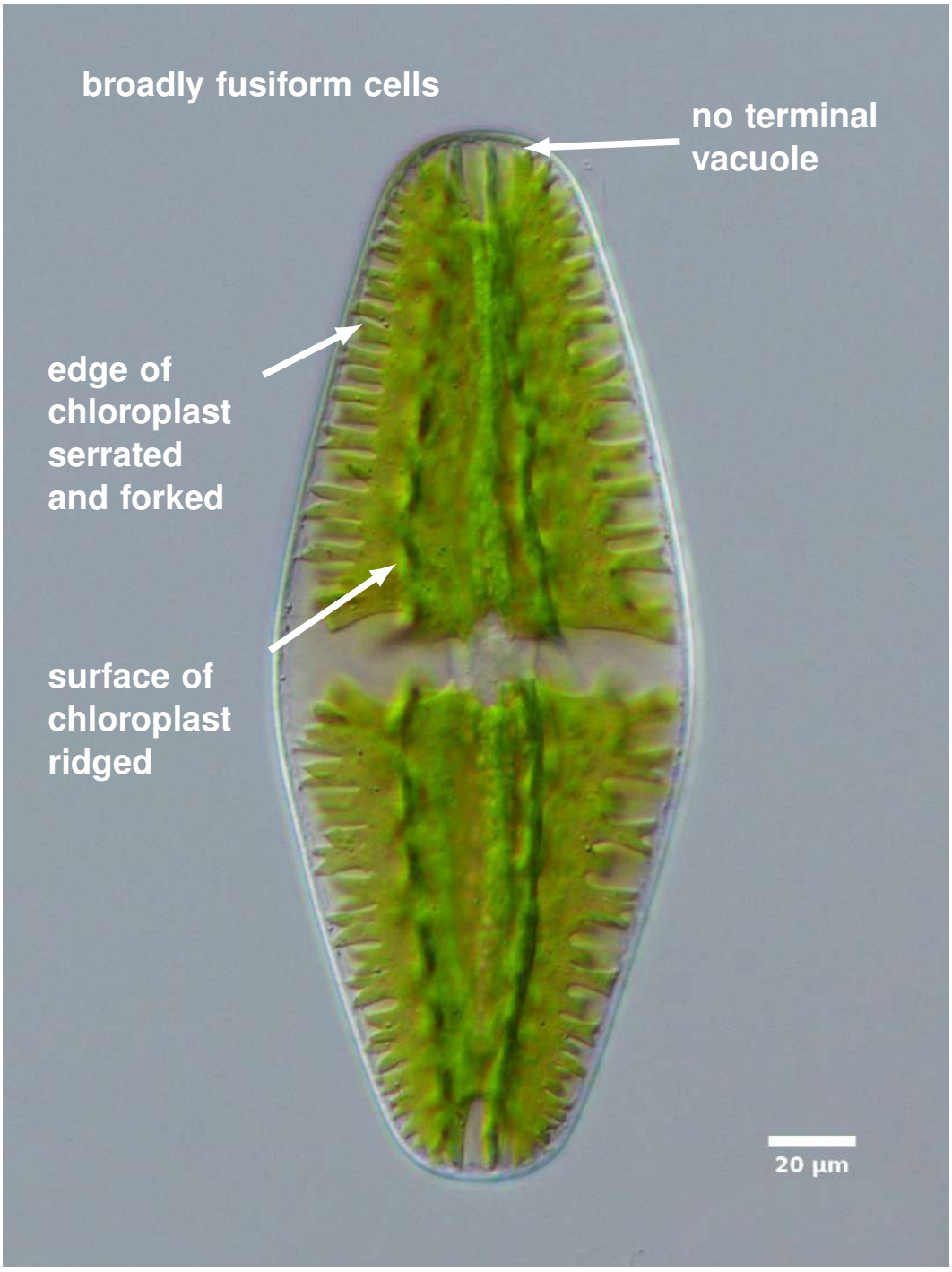


Figure 14.1: *Netrium digitus* (DIC), Lower Ashland Lake, Mountain Loop Highway, Snohomish County.



Figure 14.2: *Netrium digitus* (DIC), Bear Lake, Mountain Loop Highway, Snohomish County.



Figure 14.3: *Netrium digitus* chloroplast ridges (DIC), Lower Ashland Lake, Mountain Loop Highway, Snohomish County.

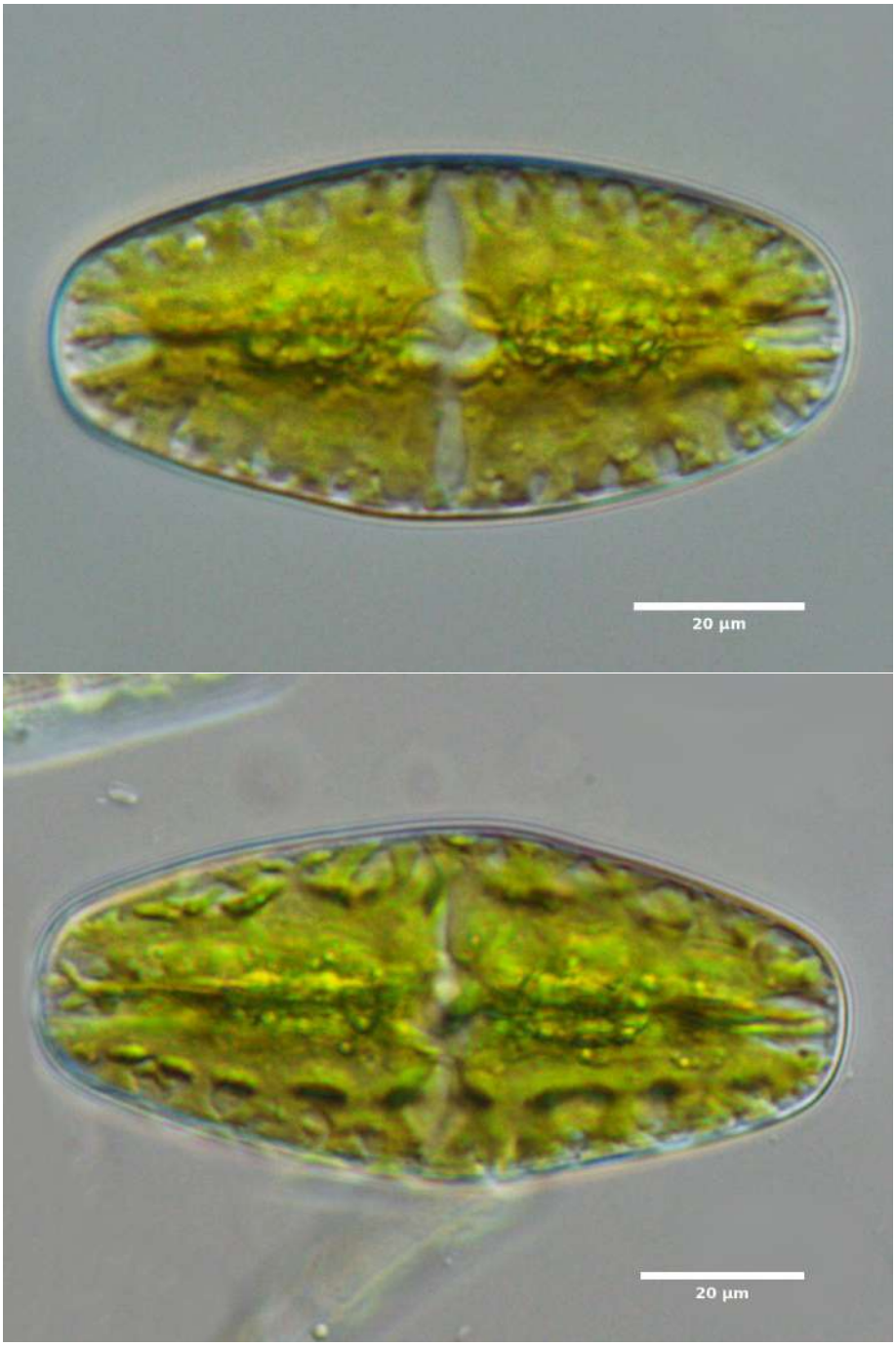


Figure 14.4: *Netrium digitus* (DIC/DIC), example of small specimens from ponds on trail to Lake Ann, Mt. Baker area, Whatcom County (upper/lower images).

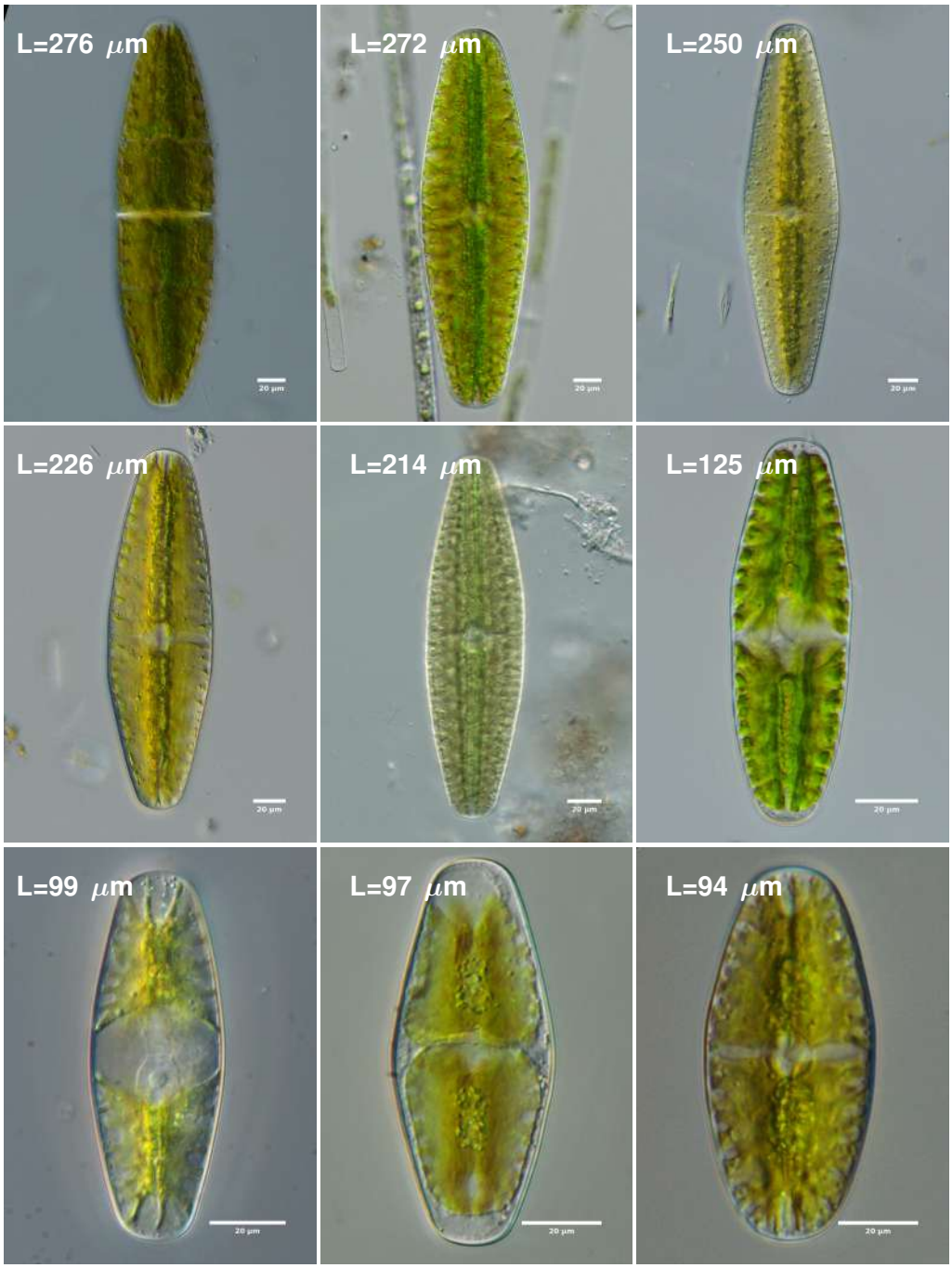


Figure 14.5: Examples of *Netrium digitus* morphological variability.



Figure 14.6: *Netrium digitus* (DIC), recently divided cell with asymmetric semi-cells, Highwood Lake, Mt. Baker area, Whatcom County.

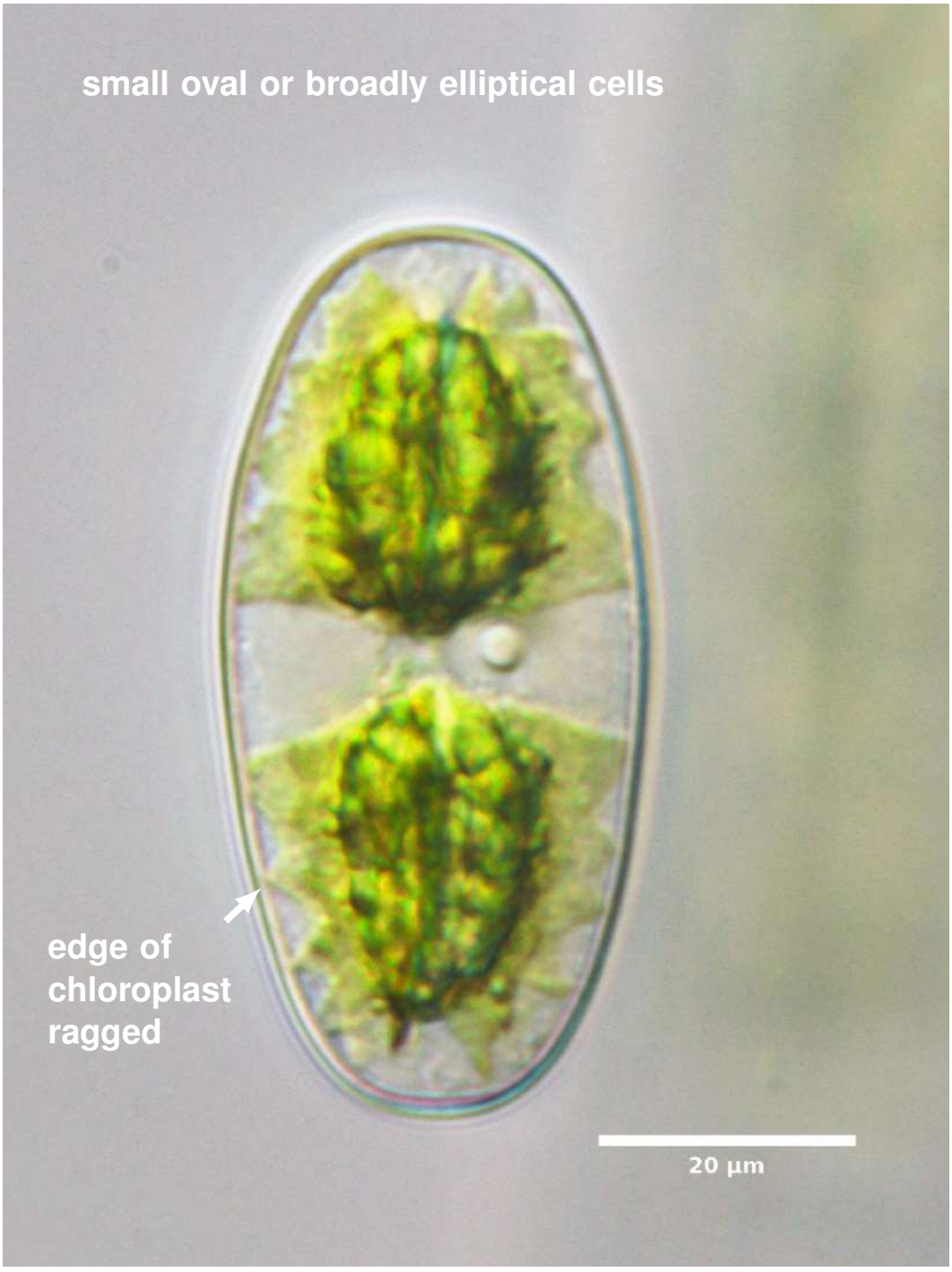


Figure 14.7: *Netrium* sp. 1 (DIC), Lower Bagley Lake, Mt. Baker area, Whatcom County.

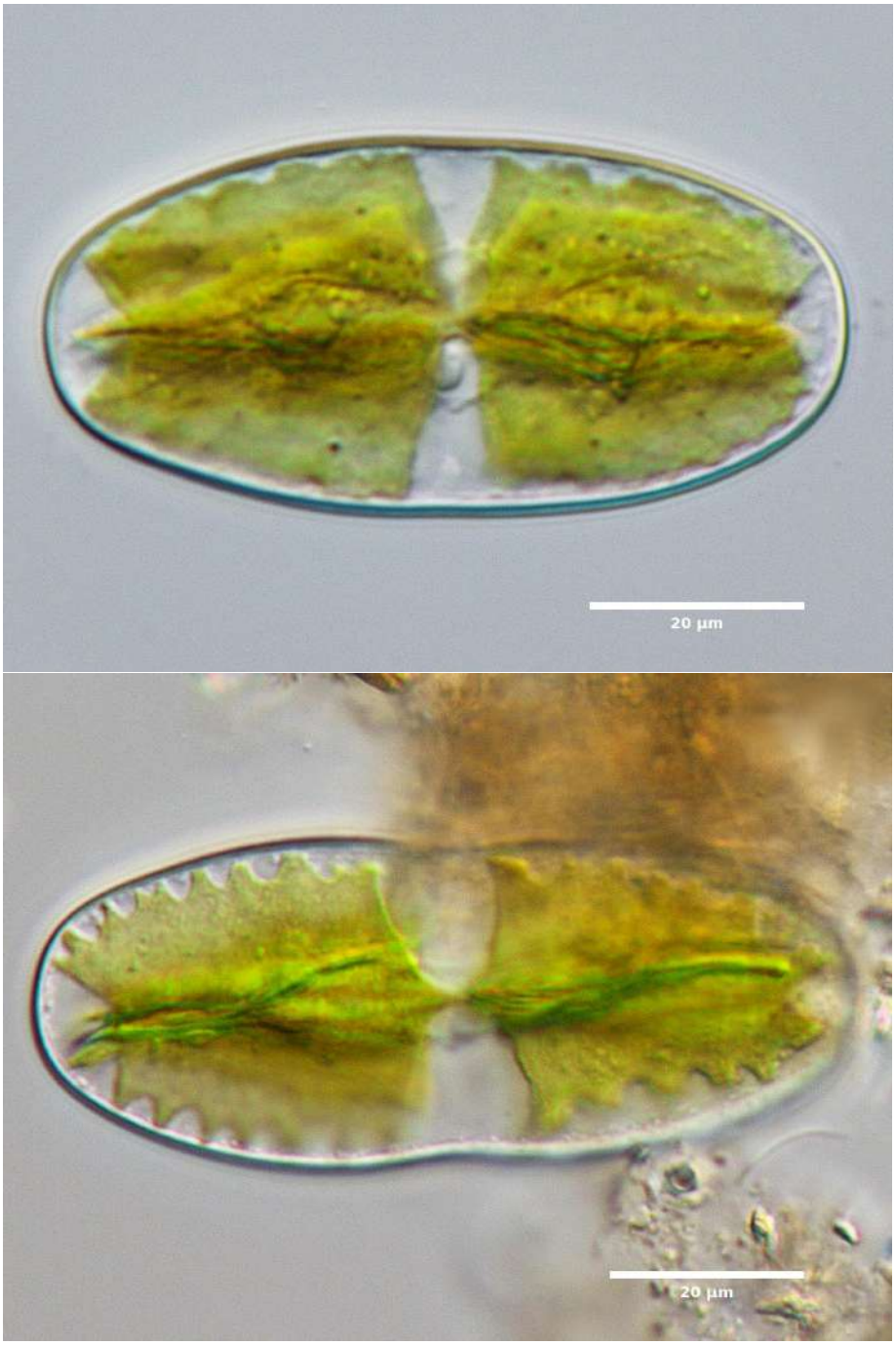


Figure 14.8: *Netrium* sp. 1 (DIC/DIC), tributary between sections of Upper Anderson Lake, Mt. Baker area, Whatcom County (upper/lower images).



Figure 14.9: *Netrium* sp. 1 (DIC), spray zone from waterfall near Rainy Pass, North Cascades Highway (Hwy 20).

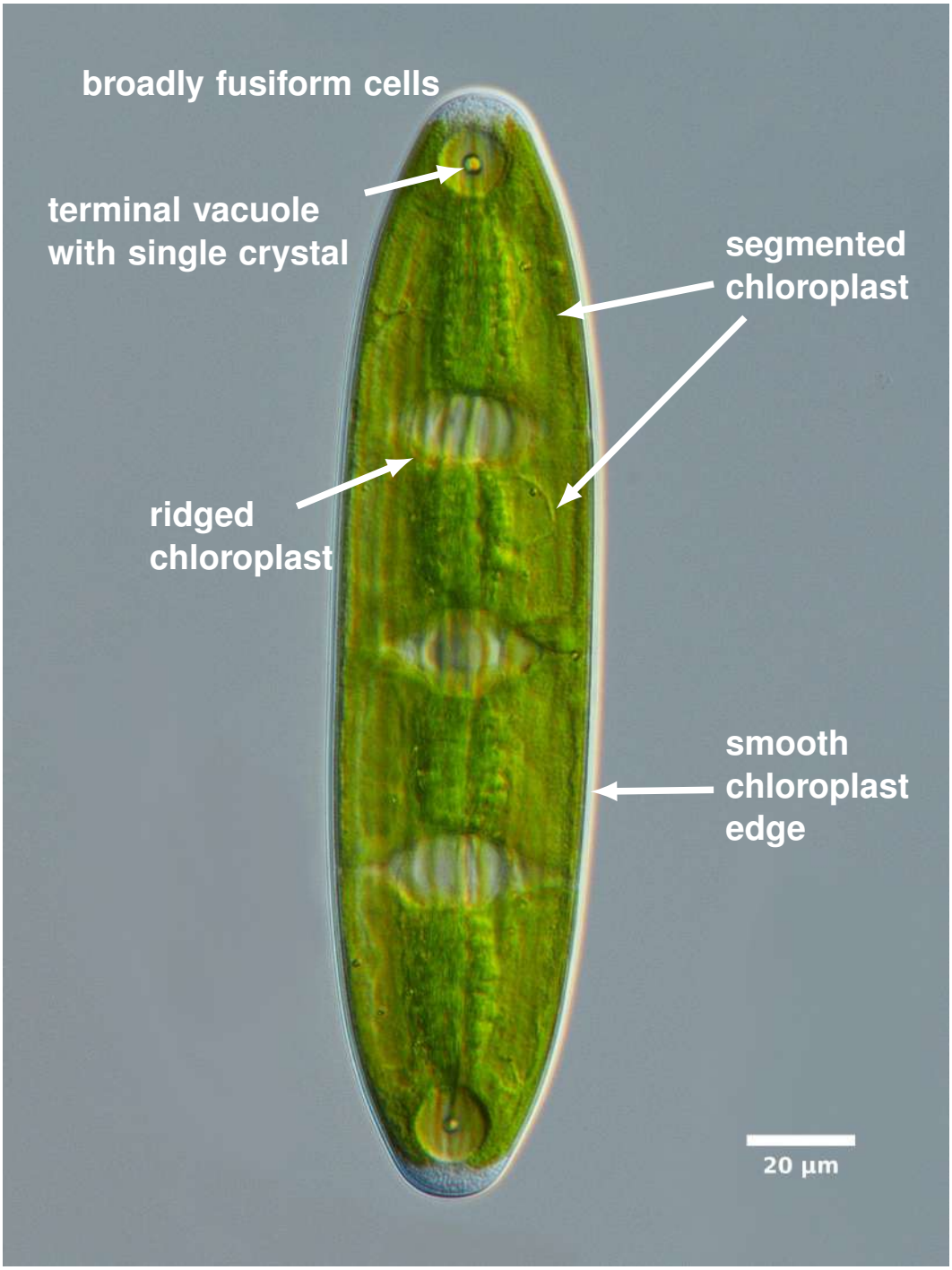


Figure 14.10: *Planotaenium interruptum* (DIC), Vogler Lake, Skagit County.



Figure 14.11: *Planotaenium interruptum* (DIC), Lower Ashland Lake, Mountain Loop Highway, Snohomish County.



Figure 14.12: *Planotaenium interruptum* (DIC/DIC), recently divided cell with asymmetric semi-cells, Lake Evan, Mountain Loop Highway, Snohomish County (upper image); Blue Lake on trail to Dock Butte, Mt. Baker area, Skagit County (lower image).

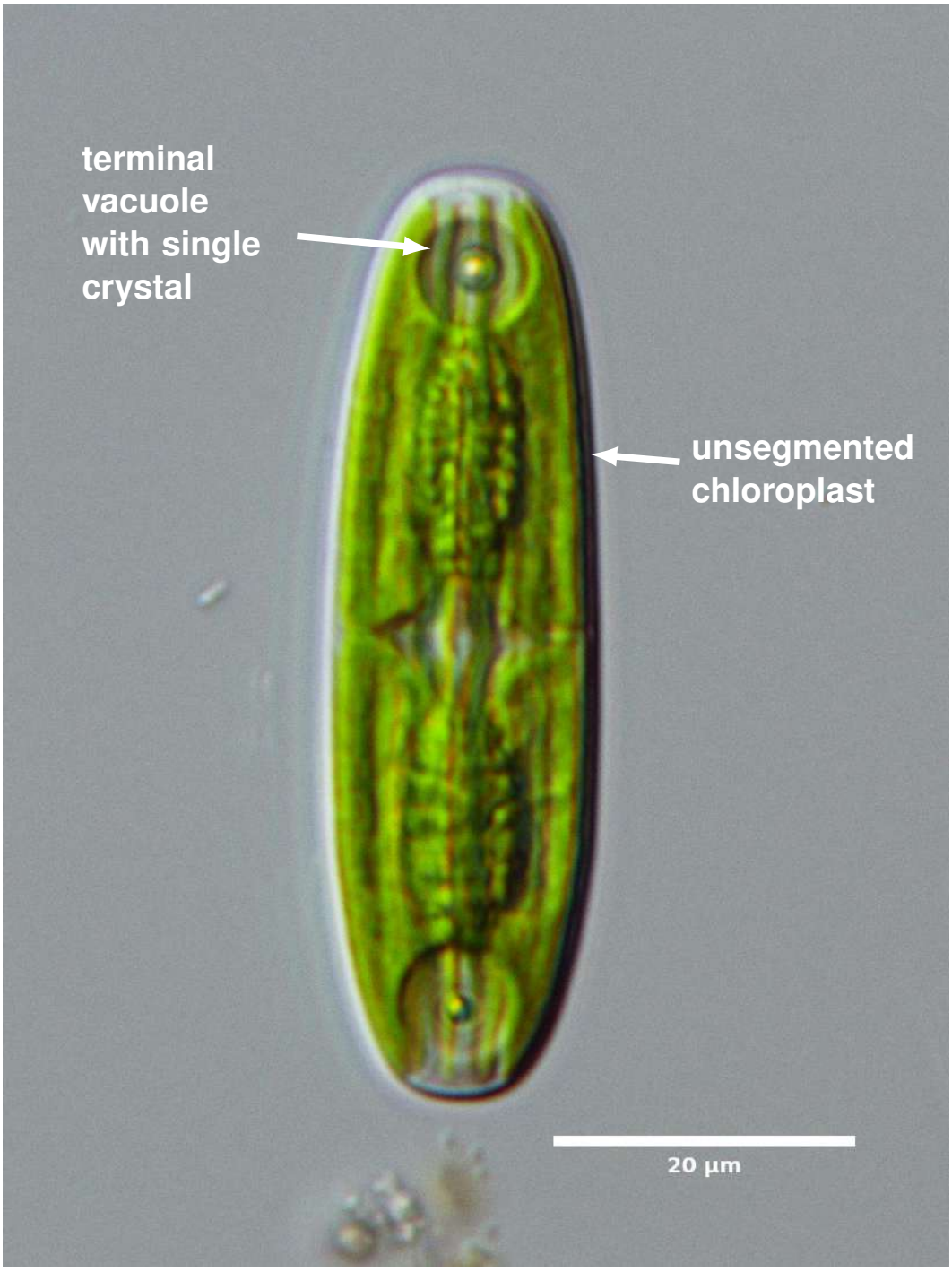


Figure 14.13: *Planotaenium ohtanii* (DIC), Gold Basin Mill Pond, Mountain Loop Highway, Snohomish County.



Figure 14.14: *Planotaenium ohtanii* (DIC), Gold Basin Mill Pond, Mountain Loop Highway, Snohomish County.

Chapter 15

Onychonema Wallich

Northwest Washington taxa
Onychonema filiforme (Ralfs) J. Roy & Bisset

Table 15.1: *Onychonema* Cell Measurements

		Cell Width	Cell Length	Isthmus Width	L/W Ratio
Onychonema filiforme	min	12.6 μm	11.3 μm	3.0 μm	0.9
	med	13.6 μm	12.5 μm	3.3 μm	0.9
	max	14.5 μm	13.1 μm	4.1 μm	1.0

Description
Onychonema filiforme cells are small, nearly equal in length and width, with kidney-shaped semi-cells that have a deep, closed or narrowly open sinus (Figures 15.1–15.4). The cells are joined by widely separated, rod-like or knob-shaped apical extensions that overlap with the extensions from adjacent cells to form flat, untwisted filaments.

Onychonema can be difficult to distinguish from *Sphaerozosma* (Section 19, page 707), *Spondylosium* (Section 21, page 735), and *Teilingia* (Section 24, page 1207). Not surprisingly, many of the species in each genus have synonyms from one or

more of the other genera in this group; *Onychonema filiforme*, for example, was previously described as *Sphaerozosma filiforme* Ralfs. The distinction between *Onychonema*, *Sphaerozosma*, *Spondylosium*, and *Teilingia* is based primarily on the way in which the cells are separated in the filament (Figure 15.1). *Onychonema* cells are joined by widely spaced apical rods while *Sphaerozosma* cells are joined by narrowly spaced apical rods. *Spondylosium* and *Teilingia* cells lack the distinctive rod-like apical projections, and instead have a smooth or granular apical surface.

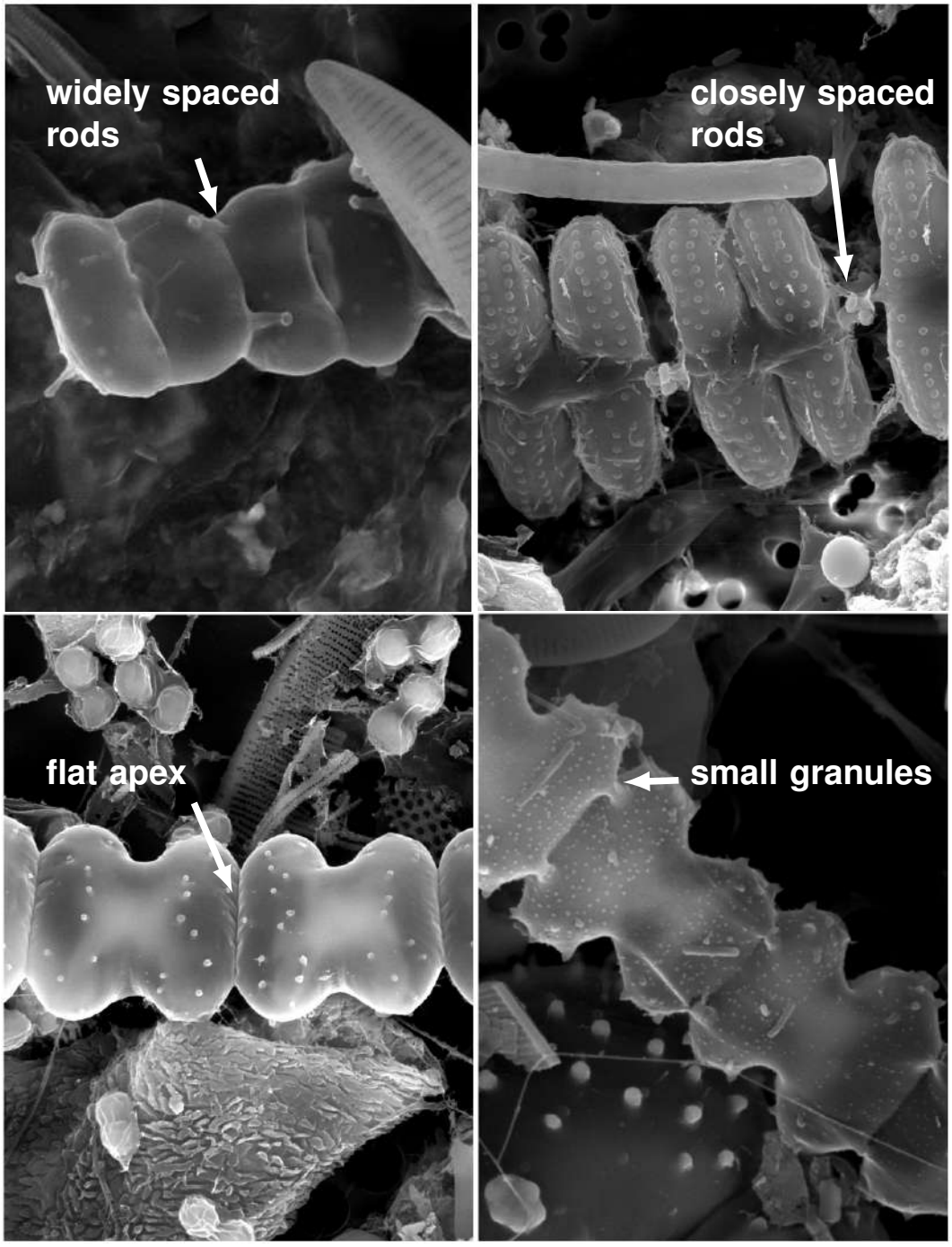


Figure 15.1: Comparison between cell linkages for *Onychonema* (upper left image), *Sphaerozosma* (upper right image), *Spondylosium* (lower left image), and *Teilingia* (lower right image).

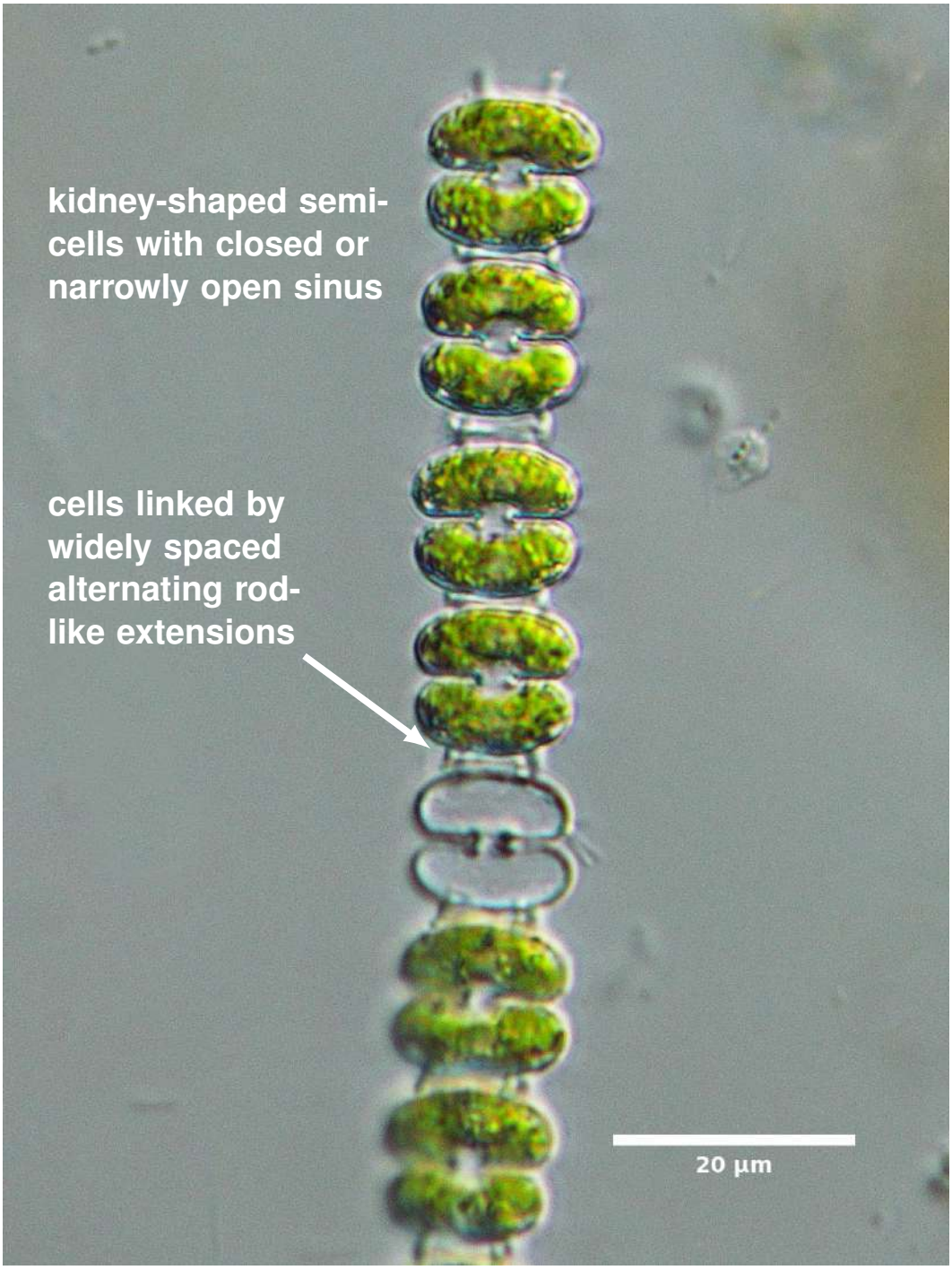
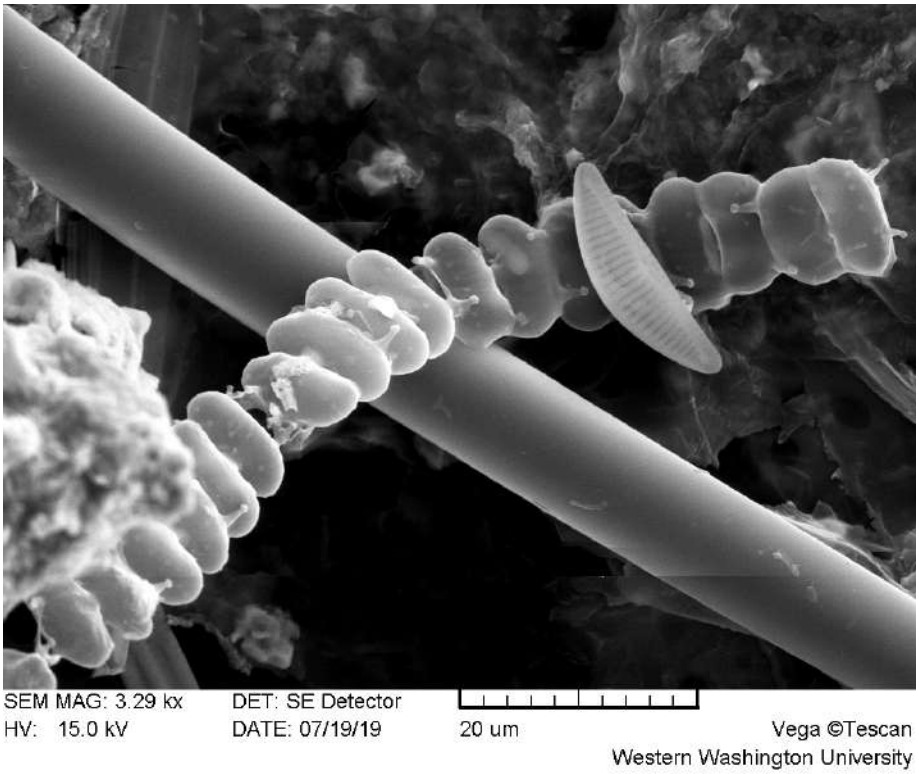


Figure 15.2: *Onychonema filiforme* (DIC), Myrtle Lake, Mountain Loop Highway, Snohomish County.



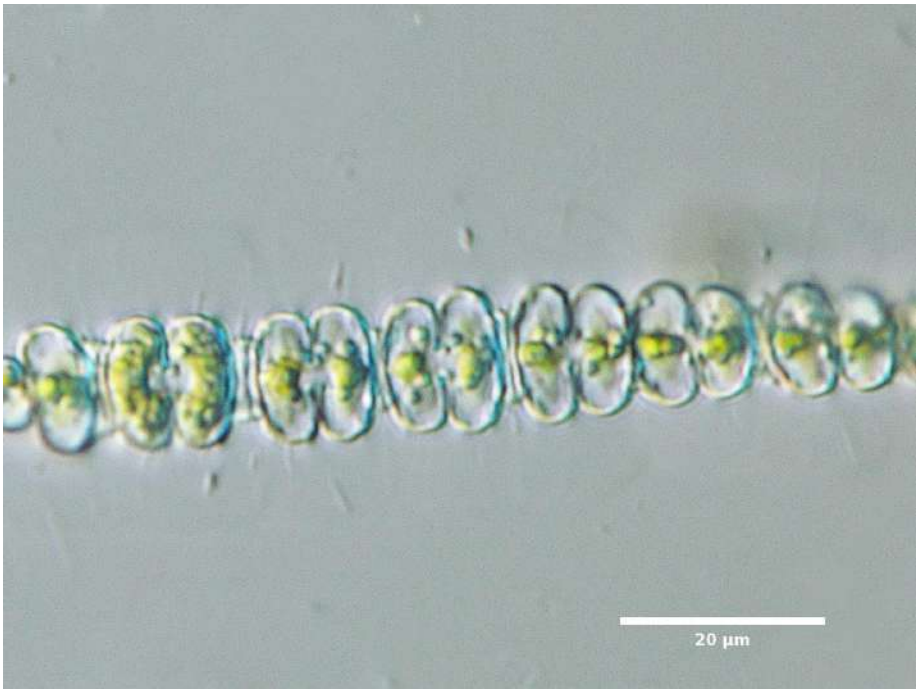


Figure 15.3: *Onychonema filiforme* (SEM/DIC), small boggy pond along Morris Valley Road near Harrison, BC (upper/lower images).

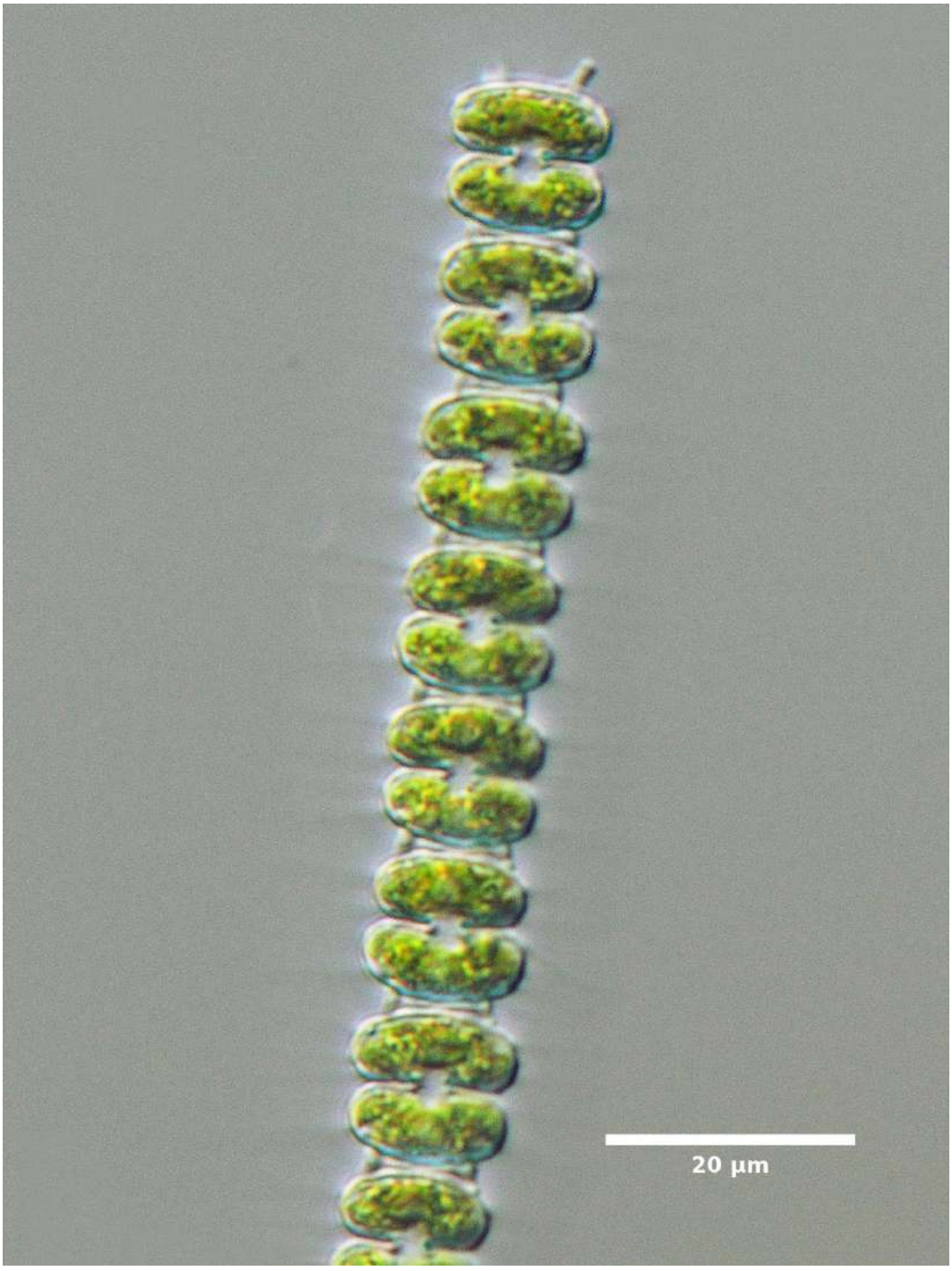


Figure 15.4: *Onychonema filiforme* (DIC) Myrtle Lake, Mountain Loop Highway, Snohomish County.

Chapter 16

Penium Brébisson ex Ralfs

Northwest Washington taxa
Penium cylindrus Brébisson ex Ralfs
Penium exiguum West
Penium margaritaceum Brébisson
Penium margaritaceum var. *papilliferum* Whelden
Penium polymorphum (Perty) Perty
Penium spinulosum (Wolle) Gerrath
Penium spirostriolatum J. Barker

Table 16.1: Key to *Penium* Species

A	Cells robust (length >250 μm); cell wall spiny; apex with ring of teeth	*Penium spinulosum* (Figures 16.16–16.20)
B	Cells large (length≥100 μm); cell wall striated, rough, or granular, but lacks sharp spines	
B.1	Cells very long and tapered; sinus indistinct; cell wall covered with fine, indistinct, spiralling striations	*Penium spirostriolatum* (Figures 16.21–16.25)

continued on next page

Table 16.1: Key to *Penium* Species, continued

	B.2	Cells untapered except near apex; sinus shallow but distinct; chloroplast ridged and subdivided	
		B.2a Cell wall covered with blunt, rod-like papillae	*Penium margaritaceum* var. *papilliferum* (Figures 16.10–16.11)
		B.2b Cell wall covered with fine or coarse granules (not rod-like)	*Penium margaritaceum* (Figures 16.7–16.9)
C	Cells small (length $\leq$60–70 μm)		
	C.1	Cells oval or broadly elliptical, with faintly striated walls (indistinct) and rounded apex	*Penium polymorphum* (Figures 16.12–16.15)
	C.2	Cells cylindrical, with rough walls and blunt, flattened apex	
		C.2a Cells short relative to width (L/W=2–4), with flattened apex; sinus indistinct	*Penium cylindrus* (Figures 16.1–16.4)
		C.2b Cells somewhat longer relative to width (L/W=4–5), with slightly inflated apex (capitate); sinus shallow but distinct	*Penium exiguum* (Figures 16.5–16.6)

Table 16.2: *Penium* Cell Measurements

		Cell Width	Cell Length	Isthmus Width	L/W Ratio
Penium cylindrus	min	9.8 μm	28.7 μm	9.5 μm	2.0
	med	12.1 μm	35.8 μm	11.3 μm	2.9
	max	17.1 μm	53.5 μm	17.1 μm	4.6
Penium exiguum[†]	min	11.6 μm	59.2 μm	10.8 μm	4.7
	med	12.1 μm	59.8 μm	11.2 μm	5.0
	max	12.5 μm	60.3 μm	11.7 μm	5.2
Penium margaritaceum	min	18.5 μm	60.4 μm	17.3 μm	3.4
	med	20.4 μm	112.2 μm	18.6 μm	5.0
	max	26.0 μm	162.9 μm	23.5 μm	6.3
Penium margaritaceum	min	23.3 μm	126.1 μm	19.8 μm	4.9
var. *papilliferum*	med	24.8 μm	141.9 μm	22.0 μm	5.8
	max	27.8 μm	180.5 μm	24.2 μm	7.6
Penium polymorphum	min	16.0 μm	38.5 μm	–	1.8
	med	20.9 μm	45.4 μm	–	2.2
	max	24.2 μm	57.1 μm	–	2.8
Penium spinulosum	min	40.5 μm	269.0 μm	34.0 μm	5.7
	med	48.4 μm	329.0 μm	37.8 μm	6.9
	max	52.8 μm	446.5 μm	44.4 μm	8.7
Penium spirostriolatum	min	17.4 μm	125.1 μm	16.0 μm	5.8
	med	22.8 μm	193.3 μm	21.4 μm	8.2
	max	26.7 μm	300.0 μm	26.7 μm	12.8

[†]Summary statistics based on $<$5 cells

Description

Penium cells are oval, elliptical, or cylindrical, and may be unconstricted or have a very shallow sinus (Figures 16.1–16.25). Despite the indistinct sinus, *Penium* is not a saccoderm desmid. The cells have a median suture and may have girdle bands, similar to *Closterium* (Section 3, page 55). Each semi-cell contains one ridged chloroplast that may be dissected, giving the appearance of two chloroplasts in the semi-cell.

Penium cylindrus is characterized by small, cylindrical cells with blunt, flat apices (Figures 16.1–16.4). The sinus may be unconstricted or very shallowly constricted. The cell wall is covered with small granules and is often brownish. The chloroplast in each semi-cell is ridged but not dissected, and usually contains one large pyrenoid. *Penium cylindrus* cells resemble *Penium exiguum* (Figure 16.5) in size and habitat, but *Penium cylindrus* can be distinguished by its flattened, unexpanded apex.

Penium exiguum cells are small, with a shallow but distinct sinus and slightly inflated (capitate) apex (Figures 16.5–16.6). The walls appear rough or granular (punctate, according to Prescott et al., 1975) and are often brownish. The chloroplasts should be ridged, but the chloroplast features were not clearly visible in any of the northwest Washington specimens. *Penium exiguum* resembles *Penium cylindrus* (Figure 16.1) in size and habitat, but *Penium exiguum* can be distinguished by its capitate apex.

Penium margaritaceum cells are relatively large and cylindrical, with a broadly rounded apex and very shallow sinus (Figures 16.7–16.11). The chloroplasts are distinctly ridged and dissected, with each semi-cell appearing to contain two chloroplasts. Each of the chloroplast segments usually contains a single, large, pyrenoid. The cell wall is covered with small, scattered granules that may form irregular vertical rows (Figure 16.9). One variety, ***Penium margaritaceum* var. *papilliferum***, was collected from several high elevation lakes (Figures 16.10–16.11). The cell wall in this variety is covered with coarse, rod-shaped papilla except at the isthmus and center of the apex, where the papilla may be smaller or absent.

Penium polymorphum cells are small, oval or broadly elliptical, with finely striated walls (Figures 16.12–16.15). The cells are unconstricted, but have a median suture that is occasionally visible using DIC illumination (Figure 16.13), and is clearly evident in SEM images (Figure 16.14). Each semi-cell contains a single, ridged chloroplasts with a large, central pyrenoid.

Penium spinulosum cells are large and robust ($\geq$250 μm long), cylindrical, with a shallow but distinct sinus (Figures 16.16–16.20). The semi-cells have 2–4 shallow undulations above the isthmus, then taper gradually to the apex, which is ringed by sharp teeth. The cell wall are covered with short spines, and is often dark brown. Each semi-cell contains one large, ridged or banded chloroplast with numerous pyrenoids embedded in the longitudinal bands. This is the only species of *Penium* collected in the northwest Washington samples that is covered with spines.

Penium spirostriolatum cells are long ($\geq$200 μm long), narrowly cylindrical, and tapered toward the apex (Figures 16.21–16.25). The cells look relatively slender, with a length/width ratio $>$5. The chloroplast is dissected, so each semi-cell appears to contain two chloroplasts; the chloroplast segments contain several large, central pyrenoids. The cell wall is often yellowish or brown and may have several series of girdle bands. The wall is covered with faint longitudinal striations that spiral *very* slightly. These striations are only clearly visible in empty cells or SEM images (Figures 16.22–16.24).

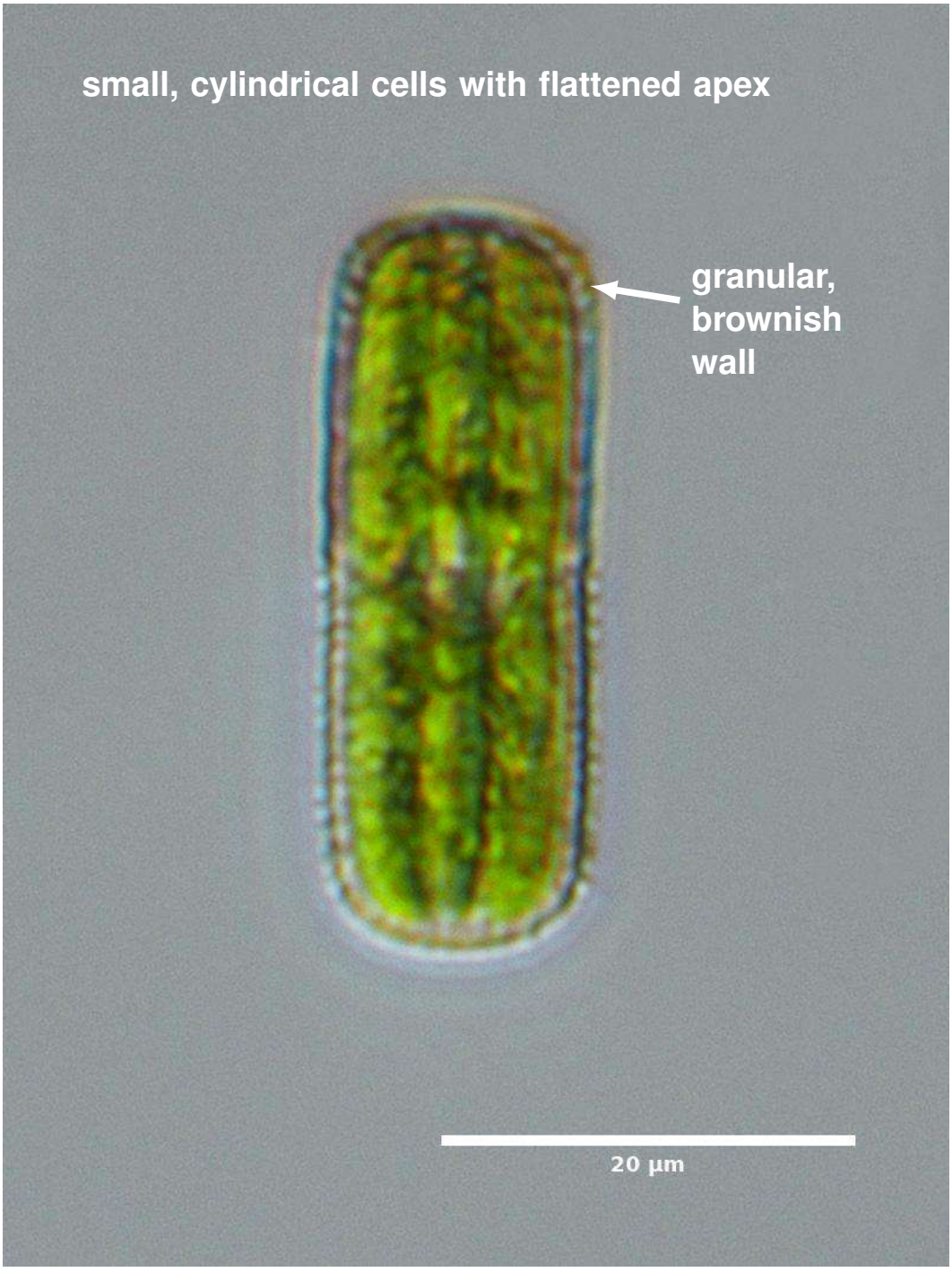


Figure 16.1: *Penium cylindrus* (DIC), Gold Basin Mill Pond, Mountain Loop Highway, Snohomish County.



Figure 16.2: *Penium cylindrus* (DIC), small pond on trail to Dock Butte, Mt. Baker area, Skagit County.

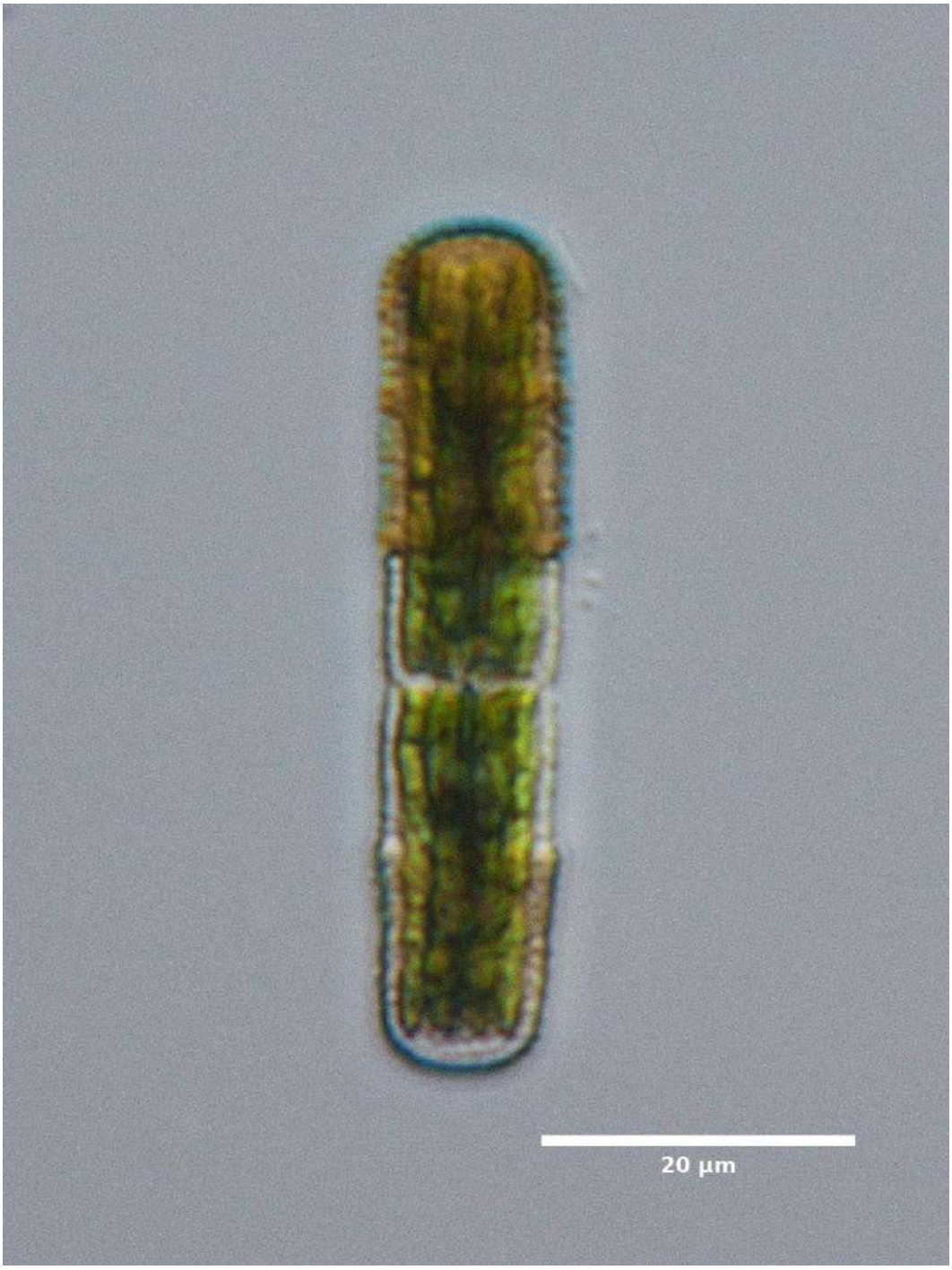


Figure 16.3: *Penium cylindrus* (DIC), Lake Twenty-two, Mountain Loop Highway, Snohomish County.



Figure 16.4: *Penium cylindrus* (DIC), stained with Lugol's iodine solution, Lake Evan, Mountain Loop Highway, Snohomish County.

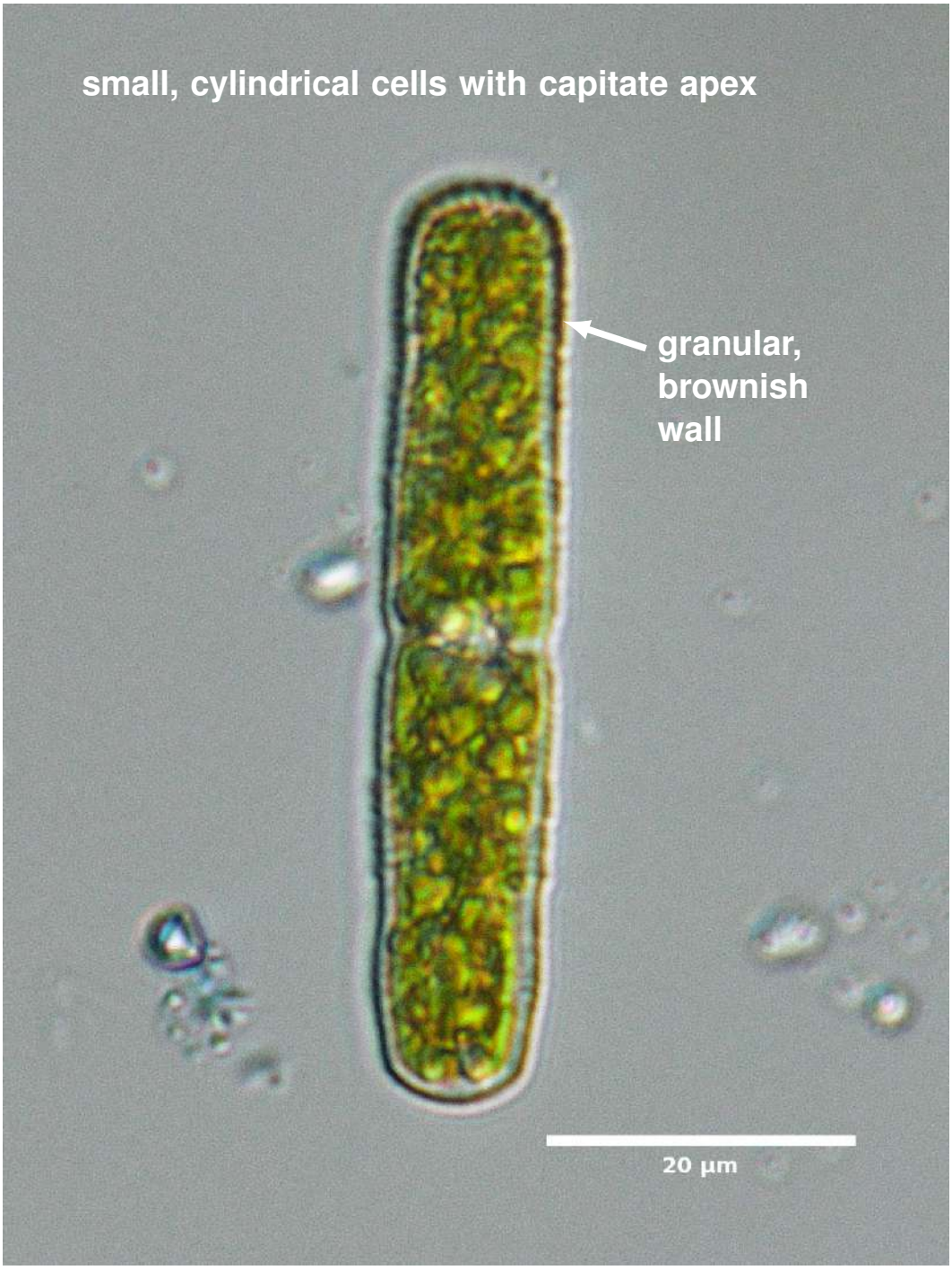


Figure 16.5: *Penium exiguum* (DIC) stained with methylene blue, Boardman Lake, Mountain Loop Highway, Snohomish County, WA.



Figure 16.6: *Penium exiguum* (DIC) stained with methylene blue, Boardman Lake, Mountain Loop Highway, Snohomish County, WA.



Figure 16.7: *Penium margaritaceum* (DIC), Lake Ketchum, Snohomish County.



Figure 16.8: *Penium margaritaceum* (DIC), Grandy Lake, Skagit County.

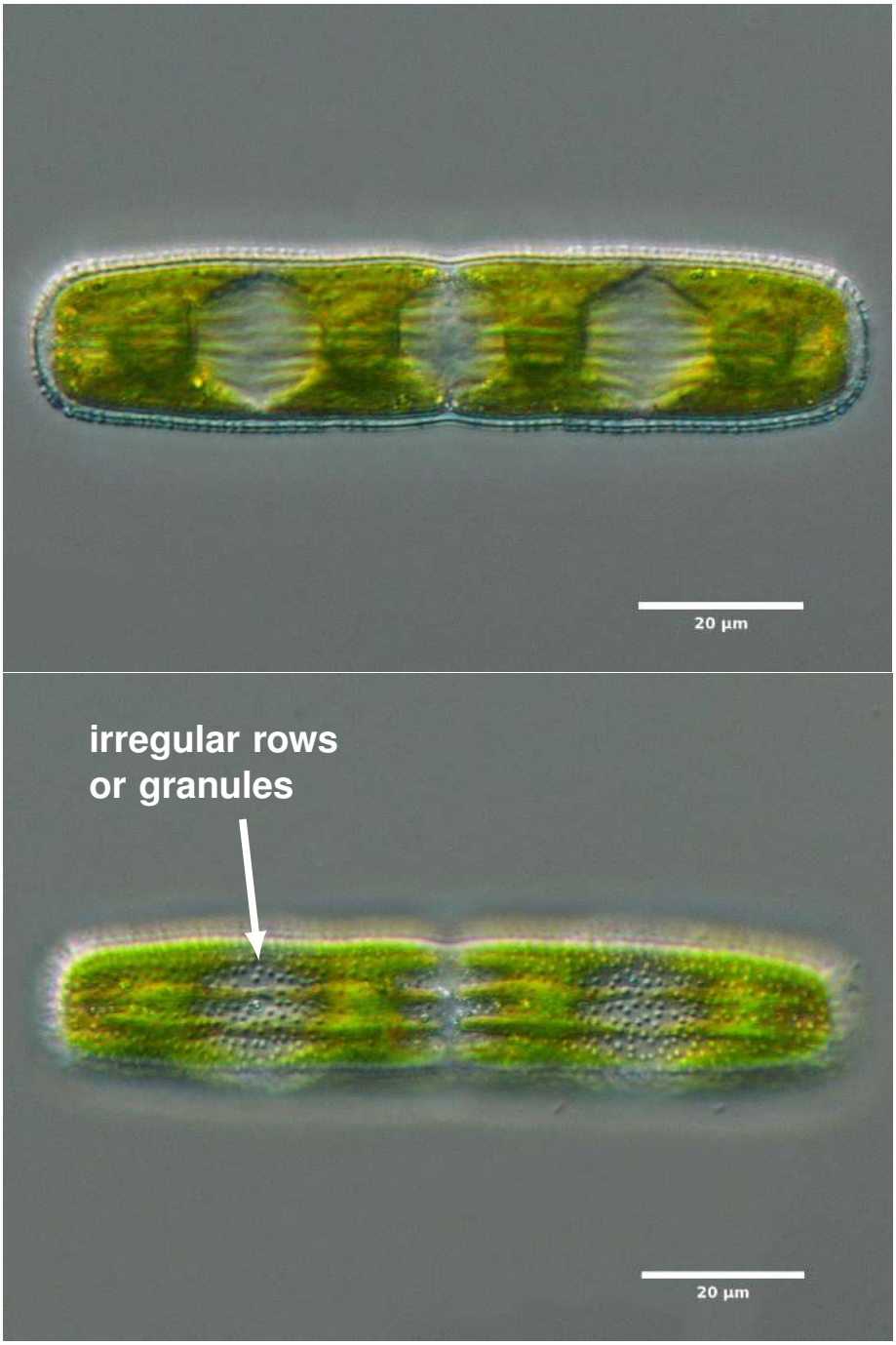


Figure 16.9: *Penium margaritaceum* wall detail (DIC/DIC), small pond along Military Road south of Tacoma, Pierce County (upper/lower images).

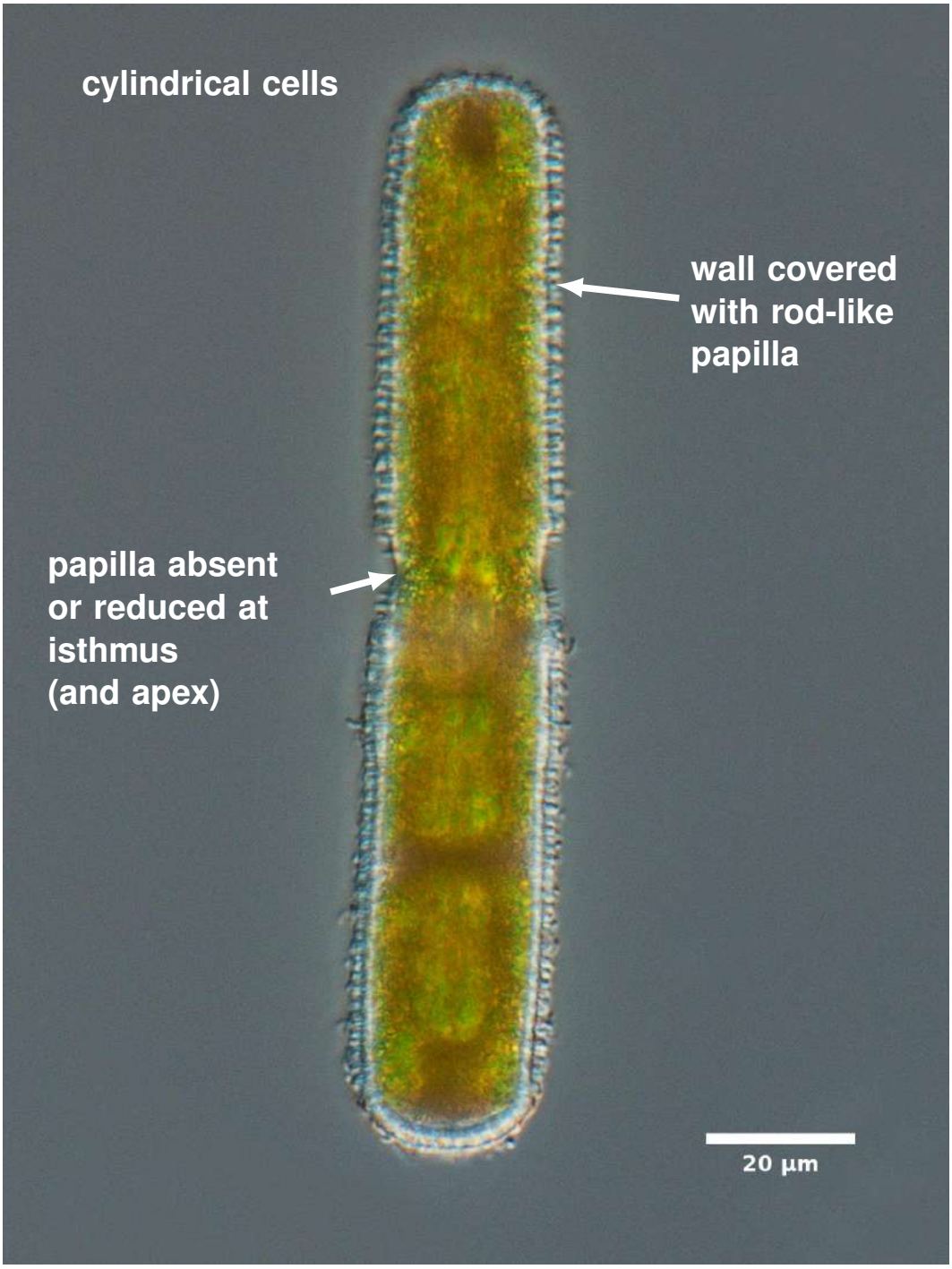


Figure 16.10: *Penium margaritaceum* var. *papilliferum* (DIC), Cutthroat Lake, North Cascades Highway (Hwy 20).



Figure 16.11: *Penium margaritaceum* var. *papilliferum* (DIC), Cutthroat Lake, North Cascades Highway (Hwy 20).

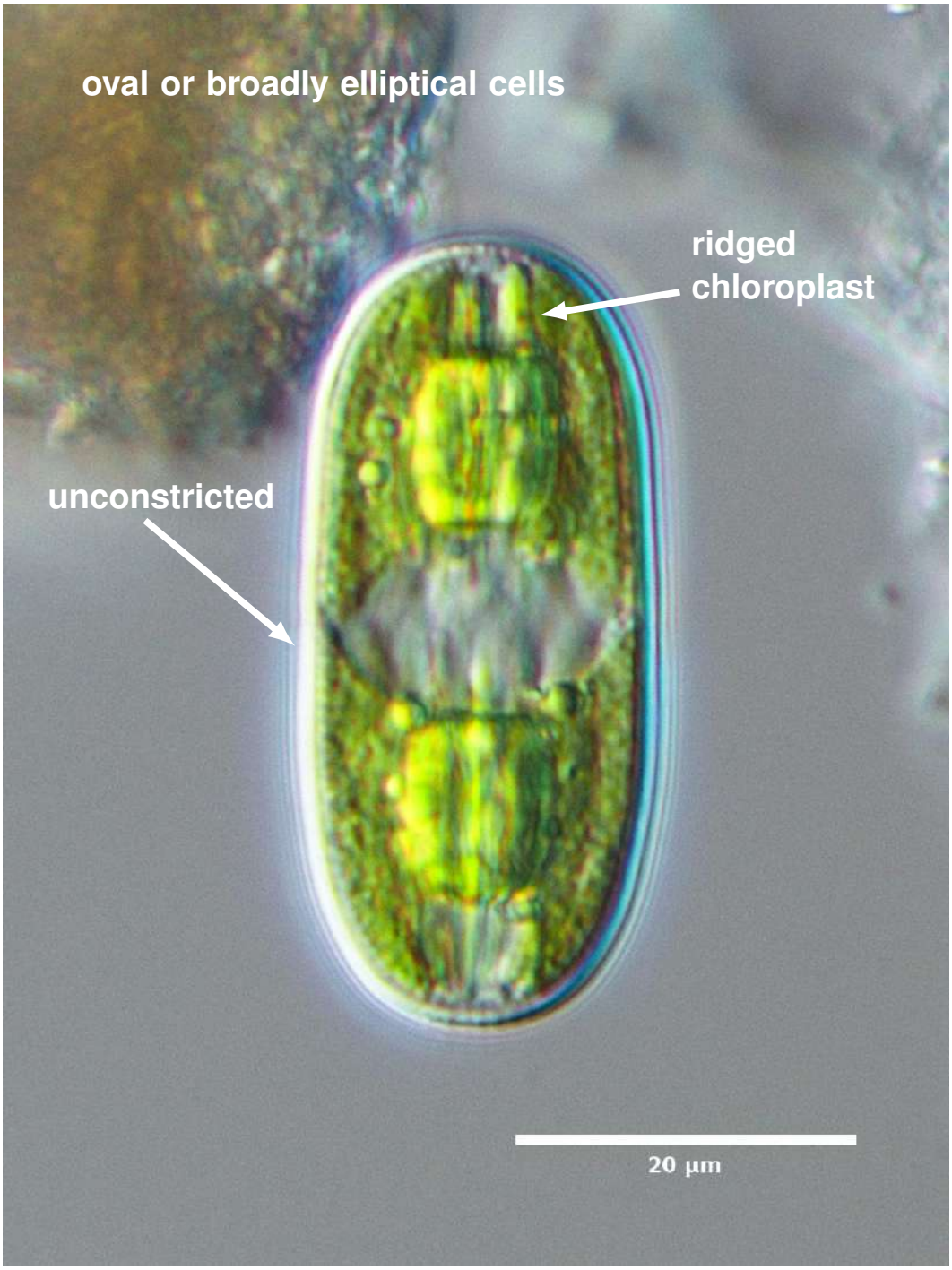


Figure 16.12: *Penium polymorphum* (DIC), small pond near Canyon Lake, Whatcom County.

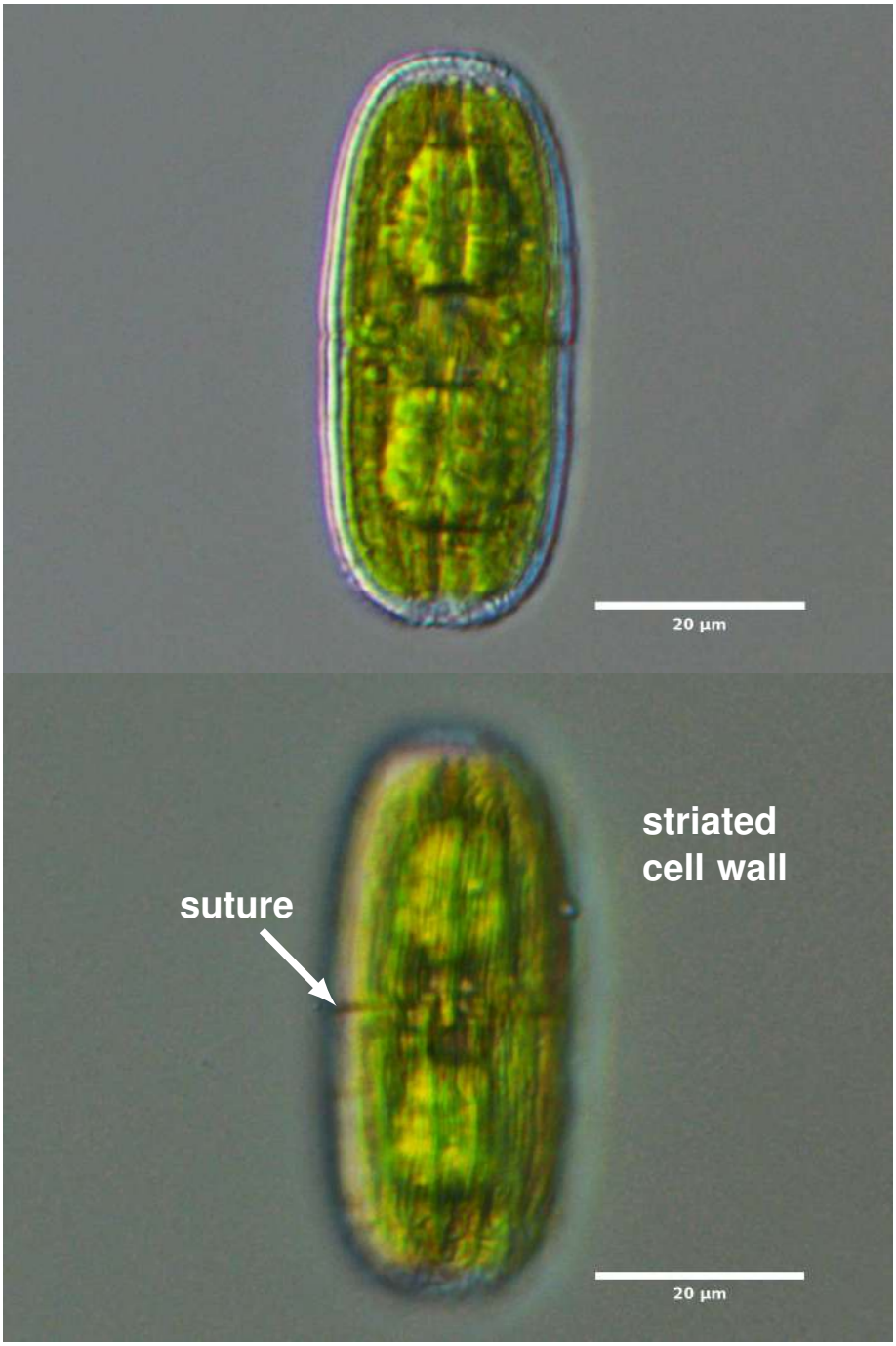


Figure 16.13: *Penium polymorphum* (DIC/DIC), small ponds on trail to Lake Ann, Mt. Baker area, Whatcom County (upper/lower images).



Figure 16.14: *Penium polymorphum* wall detail (SEM/DIC), small ponds on trail to Dock Butte, Mt. Baker area, Skagit County (upper image); Bear Lake, Mountain Loop Highway, Snohomish County (lower image).



Figure 16.15: *Penium polymorphum* (DIC), Lake Evan, Mountain Loop Highway, Snohomish County.

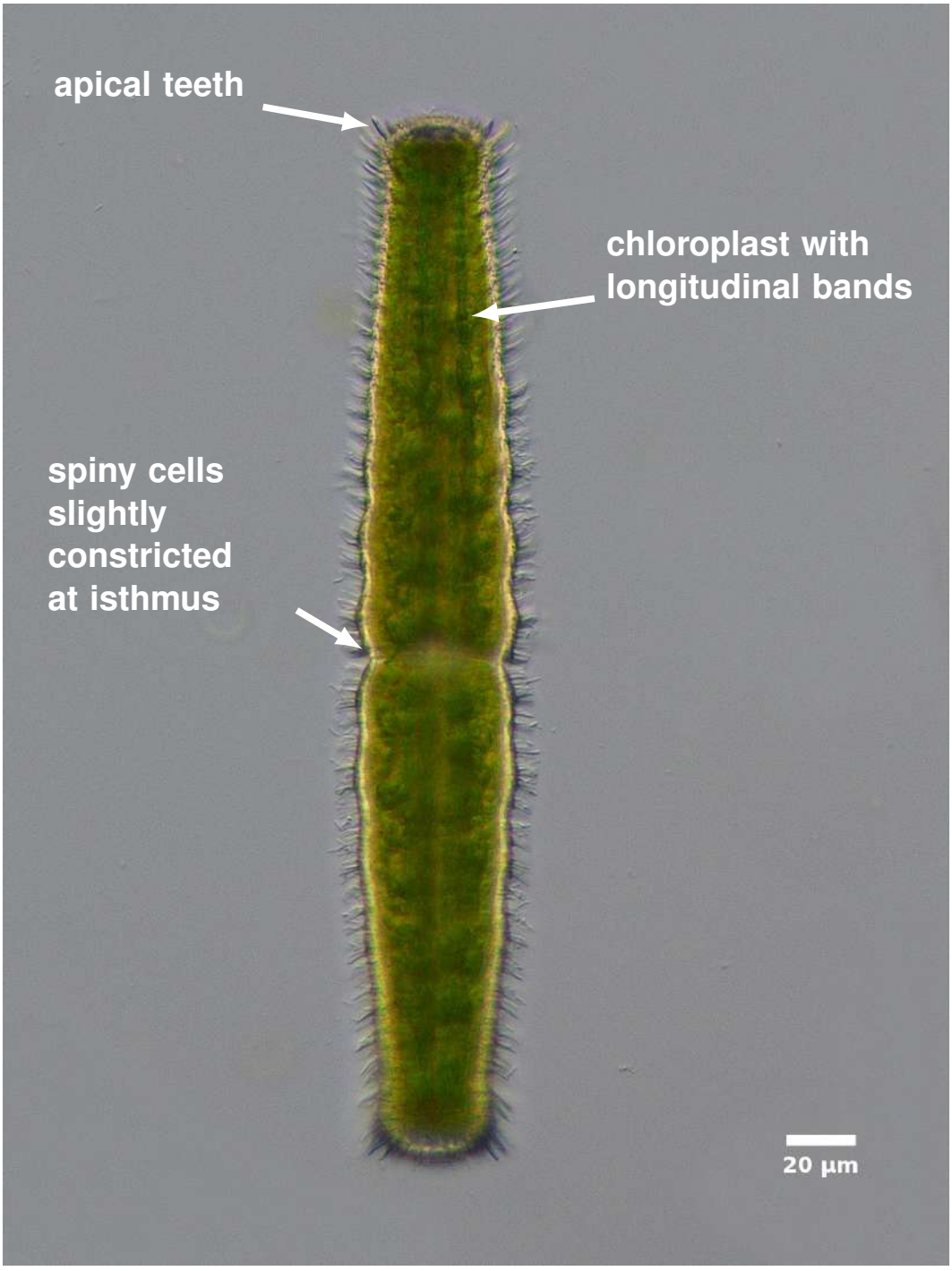


Figure 16.16: *Penium spinulosum* (DIC), Lake Evan, Mountain Loop Highway, Snohomish County.

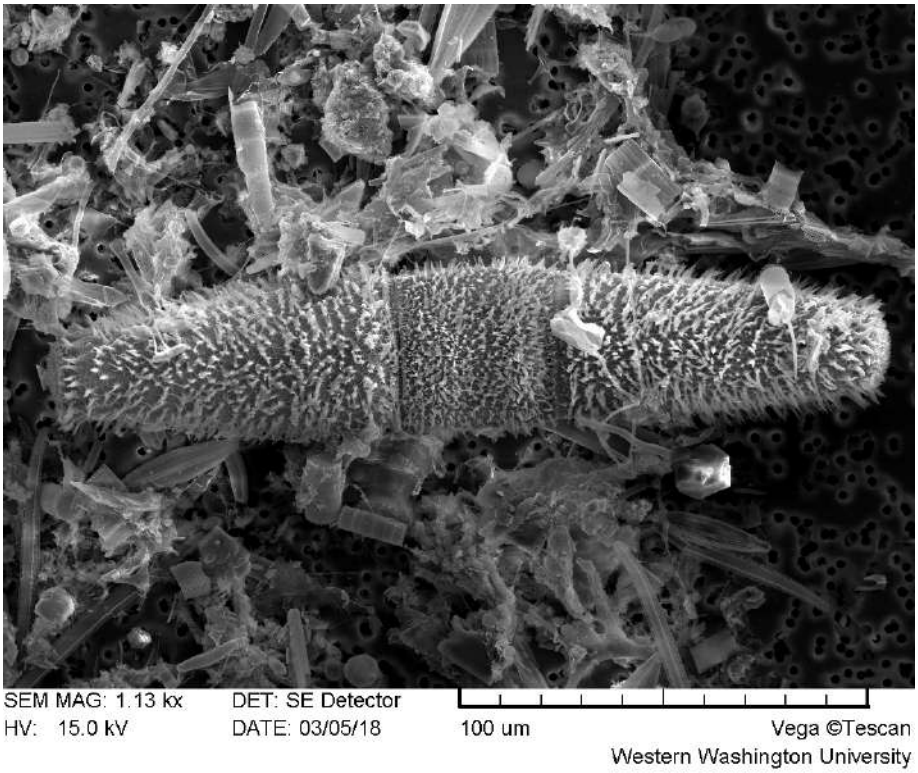




Figure 16.17: *Penium spinulosum* (SEM/DIC), Lake Evan, Mountain Loop Highway, Snohomish County (upper/lower images).

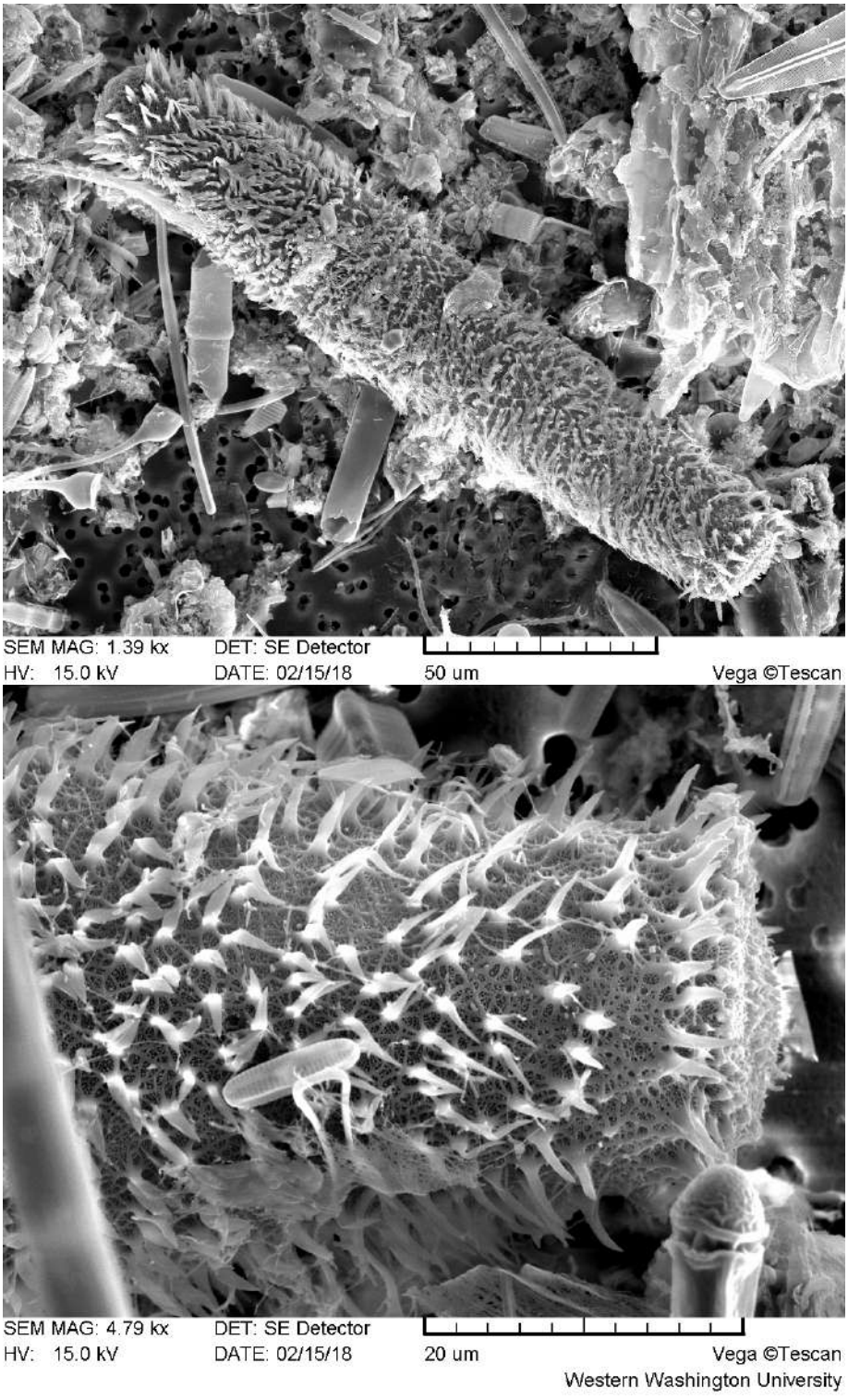


Figure 16.18: *Penium spinulosum* wall detail (SEM/SEM), Lake Evan, Mountain Loop Highway, Snohomish County (upper/lower images).



Figure 16.19: *Penium spinulosum* (DIC), Chain Lake, Gifford Pinchot National Forest, Skamania County.

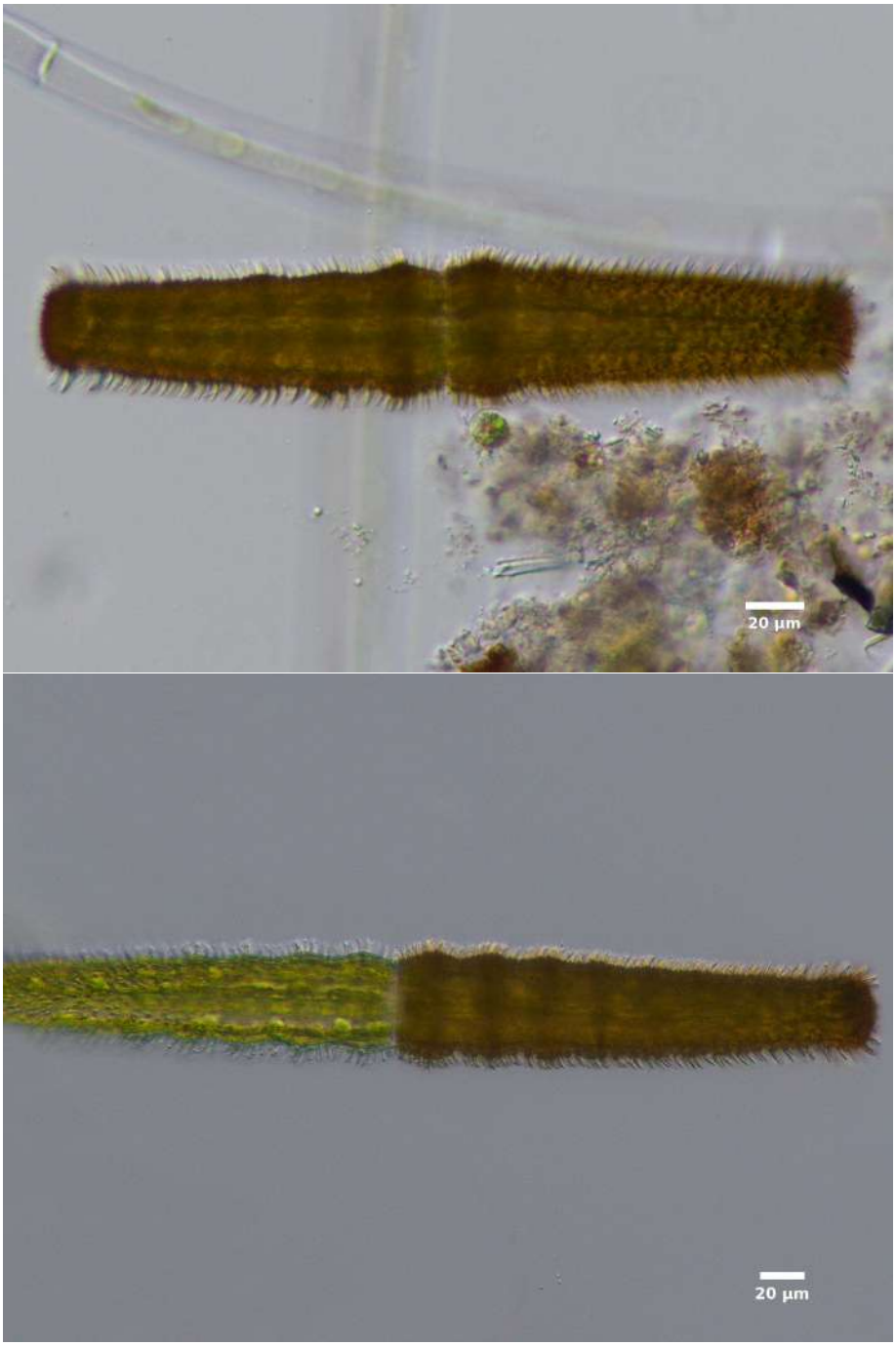


Figure 16.20: *Penium spinulosum* wall color variations (DIC/DIC), Beaver Lake, Mountain Loop Highway, Snohomish County (upper image); Chain Lake, Gifford Pinchot National Forest, Skamania County (lower image).



Figure 16.21: *Penium spirostriolatum* (DIC), Lower Anderson Lake, Mt. Baker area, Whatcom County.

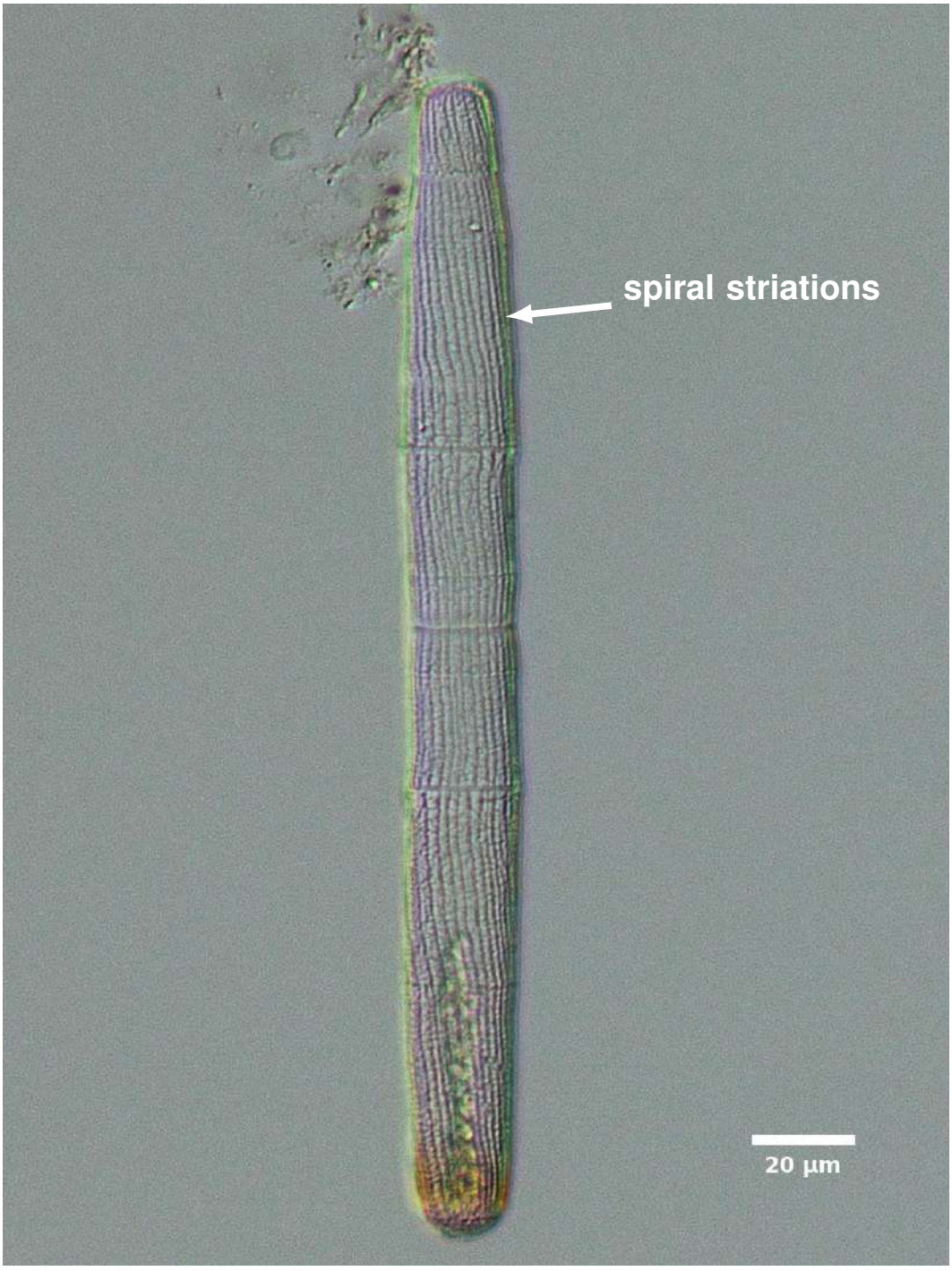


Figure 16.22: *Penium spirostriolatum* wall detail (DIC), Picture Lake, Mt. Baker area, Whatcom County.

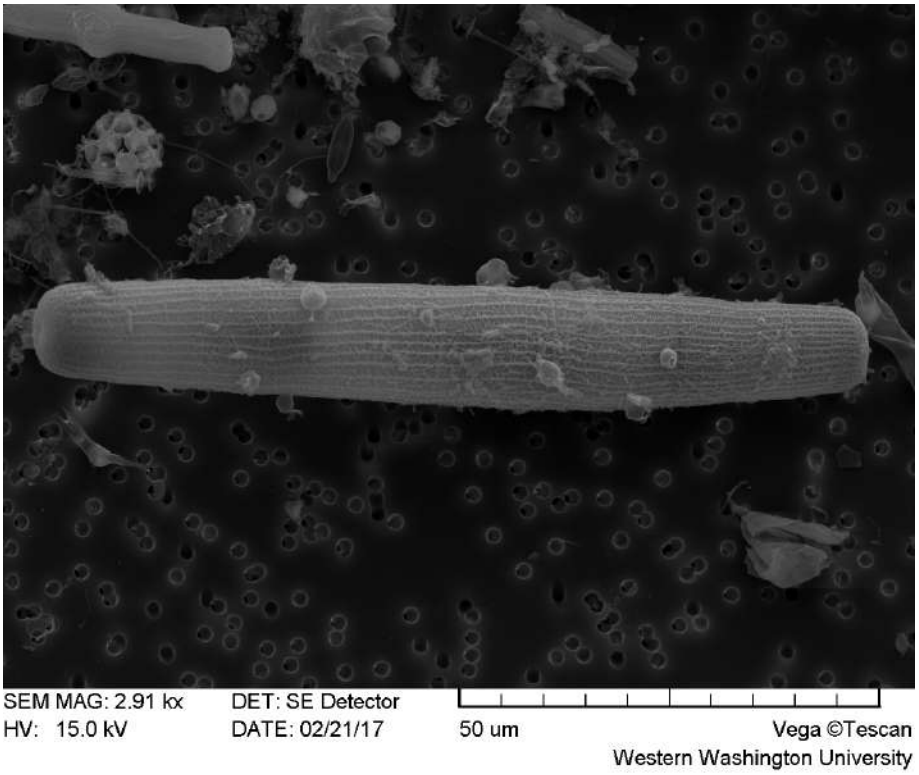




Figure 16.23: *Penium spirostriolatum* wall detail (SEM/DIC), Highwood Lake, Mt. Baker area, Whatcom County (upper/lower images).

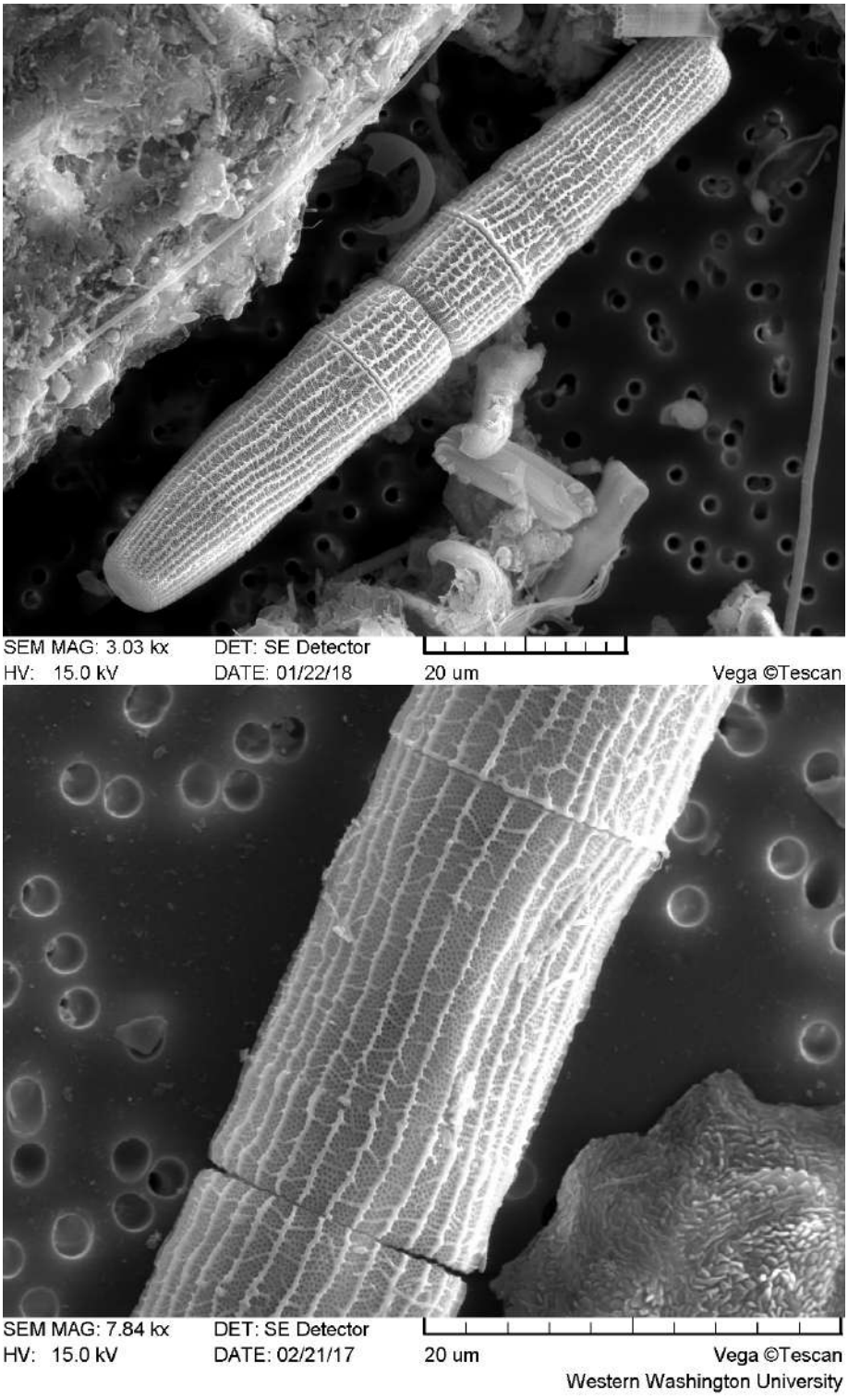


Figure 16.24: *Penium spirostriolatum* wall detail (SEM/SEM), Lake Evan, Mountain Loop Highway, Snohomish County (upper image); Highwood Lake, Mt. Baker area, Whatcom County (lower image).



Figure 16.25: *Penium spirostriolatum* (DIC/DIC), Myrtle Lake, Mountain Loop Highway, Snohomish County (upper/lower images).

Chapter 17

Pleurotaenium Nägeli

Northwest Washington taxa
Pleurotaenium archeri Delponte
Pleurotaenium coronatum (Brébisson) Rabenhorst
Pleurotaenium ehrenbergii (Ralfs) De Bary
Pleurotaenium nodosum (Bailey ex Ralfs) Lundell
Pleurotaenium nodulosum (Brébisson ex Ralfs) Rabenhorst
Pleurotaenium trabecula Nägeli
Pleurotaenium sp.1

Table 17.1: Key to *Pleurotaenium* Species

A	Lateral margin of semi-cell with 4 evenly spaced, inflated rings of large nodules	*Pleurotaenium nodosum* (Figures 17.17–17.20)
B	Lateral margin of semi-cell with undulations extending at least halfway to apex; cells robust (L/W$\leq$15)	
	B.1 Semi-cells cylindrical, only slightly tapered at apex; apex flat with ring of large, blunt teeth	*Pleurotaenium coronatum* (Figures 17.9–17.12)

continued on next page

Table 17.1: Key to *Pleurotaenium* Species, continued

	B.2 Semi-cells cylindrical, only slightly tapered at apex; apex flat with ring of small nodules	*Pleurotaenium nodulosum* (Figures 17.21–17.24)
	B.3 Semi-cells gradually tapered to apex; apex rounded and smooth, lacking ring of nodules	*Pleurotaenium* sp. 1 (Figures 17.29–17.32)
C	Lateral margin with 0–2 faint undulations above basal swelling; cells slender (most cells with L/W>15)	
	C.1 Semi-cells cylindrical, only slightly tapered at apex; apex flat with ring of small but distinct nodules	*Pleurotaenium ehrenbergii* (Figures 17.13–17.16)
	C.2 Semi-cells gradually tapered to apex; cells narrowed above basal swelling, then wider to just below apex; apex rounded and smooth or with inconspicuous nodules	*Pleurotaenium archeri* (Figures 17.5–17.8)
	C.3 Semi-cells gradually tapered to apex; basal swelling not distinctly narrowed; apex narrowed, rounded, smooth (without nodules)	*Pleurotaenium trabecula* (Figures 17.25–17.28)

Table 17.2: *Pleurotaenium* Cell Measurements

		Cell Width	Cell Length	Isthmus Width	L/W Ratio
Pleurotaenium archeri	min	30.1 μm	698.7 μm	28.6 μm	15.2
	med	45.6 μm	818.3 μm	34.1 μm	17.9
	max	50.1 μm	1059 μm	40.5 μm	26.3
Pleurotaenium coronatum	min	49.9 μm	507.2 μm	37.8 μm	8.3
	med	61.7 μm	582.4 μm	42.9 μm	9.6
	max	76.8 μm	721.8 μm	60.8 μm	11.7
Pleurotaenium ehrenbergii	min	24.1 μm	437.4 μm	18.2 μm	13.4
	med	35.7 μm	608.8 μm	28.8 μm	17.3
	max	46.0 μm	898.0 μm	35.6 μm	20.3
Pleurotaenium nodosum	min	43.0 μm	283.8 μm	23.4 μm	6.3
	med	47.2 μm	326.1 μm	27.1 μm	6.8
	max	54.5 μm	377.2 μm	30.7 μm	7.5
Pleurotaenium nodulosum	min	43.6 μm	407.8 μm	34.3 μm	9.1
	med	54.8 μm	551.2 μm	39.0 μm	10.1
	max	63.3 μm	670.6 μm	47.1 μm	12.3
Pleurotaenium trabecula	min	30.0 μm	396.8 μm	24.5 μm	12.2
	med	35.46 μm	612.4 μm	27.9 μm	15.1
	max	54.3 μm	970.6 μm	43.0 μm	20.1
Pleurotaenium sp.1	min	58.0 μm	716.4 μm	39.4 μm	11.7
	med	62.4 μm	846.8 μm	48.2 μm	13.4
	max	67.1 μm	984.6 μm	54.1 μm	15.8

Description

Pleurotaenium cells are long and narrow, with a flat or rounded apex, a shallow, open sinus, and numerous ribbon-like parietal chloroplasts that contain many small pyrenoids (Figures 17.1–17.4). The semi-cell apex may be smooth or have a ring of nodules, and will contain a terminal vacuole with visible (moving) crystals (Figure 17.2). The semi-cells have a basal swelling above the isthmus, which may be accompanied by additional lateral undulations that diminish in size with increasing distance from the basal swelling (Figure 17.3). *Pleurotaenium* cells occasionally link to form short filaments, but the connection between cells is weak and the cells separate easily. Compare small, smooth-walled specimens to *Haplotaenium* (Section 10, page 479), which can be distinguished by its ribbed chloroplast, large, axial pyrenoids, and lack of terminal vacuoles (Figure 17.4). The cell wall usually appears smooth, but has scattered pores that are visible in empty cells and SEM.

Pleurotaenium archeri cells are long and narrow, reaching up to 1 mm in length. The semi-cell is constricted above the prominent basal swelling and has numerous additional inconspicuous, lateral undulations above the basal swelling (Figures 17.5–17.8). The semi-cell narrows slightly near the apex, which is flattened or slightly rounded, with an inconspicuous ring of small nodules. The lateral undulations and apical nodules are difficult to see even with SEM (Figures 17.6–17.7), so this species resembles *Pleurotaenium trabecula* (Figure 17.25), which lacks apical granules. *Pleurotaenium archeri* also resembles *Pleurotaenium ehrenbergii* (Figure 17.13), which is more cylindrical, with fewer lateral undulations and slightly more prominent apical granules.

Pleurotaenium coronatum semi-cells are large and robust, with a basal swelling and diminishing lateral undulations that usually extend about half way up the semi-cell (Figures 17.9–17.12). The semi-cells are cylindrical, with little to no narrowing near the apex. The apex is flattened and ringed by large, conspicuous, protruding nodules (Figures 17.10–17.11). *Pleurotaenium coronatum* can be difficult to distinguish from *Pleurotaenium nodulosum*, which has a narrowed apex with a ring of small granules (see comparison in Figure 17.24).

Pleurotaenium ehrenbergii is characterized by long, narrow semi-cells that taper very slightly near the apex and have one or two lateral undulations above the basal swelling (Figures 17.13–17.16). The apex is flattened and edged with a ring of small but distinct nodules. *Pleurotaenium ehrenbergii* closely resembles *Pleurotaenium trabecula* (Figure 17.25), and collectively these two species are the most common *Pleurotaenium* taxa found in northwest Washington lakes. *Pleurotaenium*

ehrenbergii can be distinguished relatively easily by the apical ring of small nodules, which is absent in *Pleurotaenium trabecula*. *Pleurotaenium ehrenbergii* also resembles *Pleurotaenium archeri* (Figure 17.5), which is constricted above the basal inflation and usually has more lateral undulations; however, these undulations may be very faint.

Pleurotaenium nodosum semi-cells are relatively short and robust (length $<$400 μm; L/W $<$12). This species is easily identified by the presence of four large, evenly-spaced, inflated, transverse rings, each covered with 6–10 large nodules, and a flattened apex ringed by 10–12 blunt teeth (Figures 17.17–17.20). The nodules on the transverse rings are best seen using SEM (Figures 17.18–17.19). This species resembles *Triploceras* (Figure 26.1), which is much longer relative to width (L/W $\geq$19) and has 10–15 spiny transverse whorls.

Pleurotaenium nodulosum semi-cells are robust, with a large basal swelling and diminishing lateral undulations that extend nearly to the apex (Figures 17.21–17.24). The apex is slightly narrowed and flattened, with a ring of inconspicuous nodules. This species is difficult to distinguish from *Pleurotaenium coronatum*, which has a flat, cylindrical apex (not narrowed) surrounded by a ring of large nodules that extend slightly beyond the lateral edge of the semi-cell (see comparison in Figure 17.24).

Pleurotaenium trabecula is characterized by long, narrow semi-cells that taper very slightly near the apex and have a fairly small basal swelling above the sinus (Figures 17.25–17.28). The apex is smooth and broadly rounded, resembling *Haplotaenium* (Section 10, page 479), which was formerly listed as a variety of *Pleurotaenium trabecula* (see comparison in Figure 17.4). *Pleurotaenium trabecula*, however, should have an apical vacuole containing numerous small crystals (*Haplotaenium* lacks this feature). *Pleurotaenium trabecula* is morphologically diverse and has many identified varieties, some of which may have additional inconspicuous lateral undulations above the basal swelling.

***Pleurotaenium* sp. 1** semi-cells are large and cylindrical, with a smooth, slightly narrowed apex, distinct basal swelling, and diminishing wall undulations that extent almost to the apex (Figures 17.29–17.32). The cells resemble *Pleurotaenium nodulosum* (Figure 17.21), but are larger and have a completely smooth apex. This species is moderately common in northwest Washington lakes. Prescott, et al. (1975) describe a similar species, *Pleurotaenium repandum*, which has much narrower semi-cells (width = 25–34 μm).

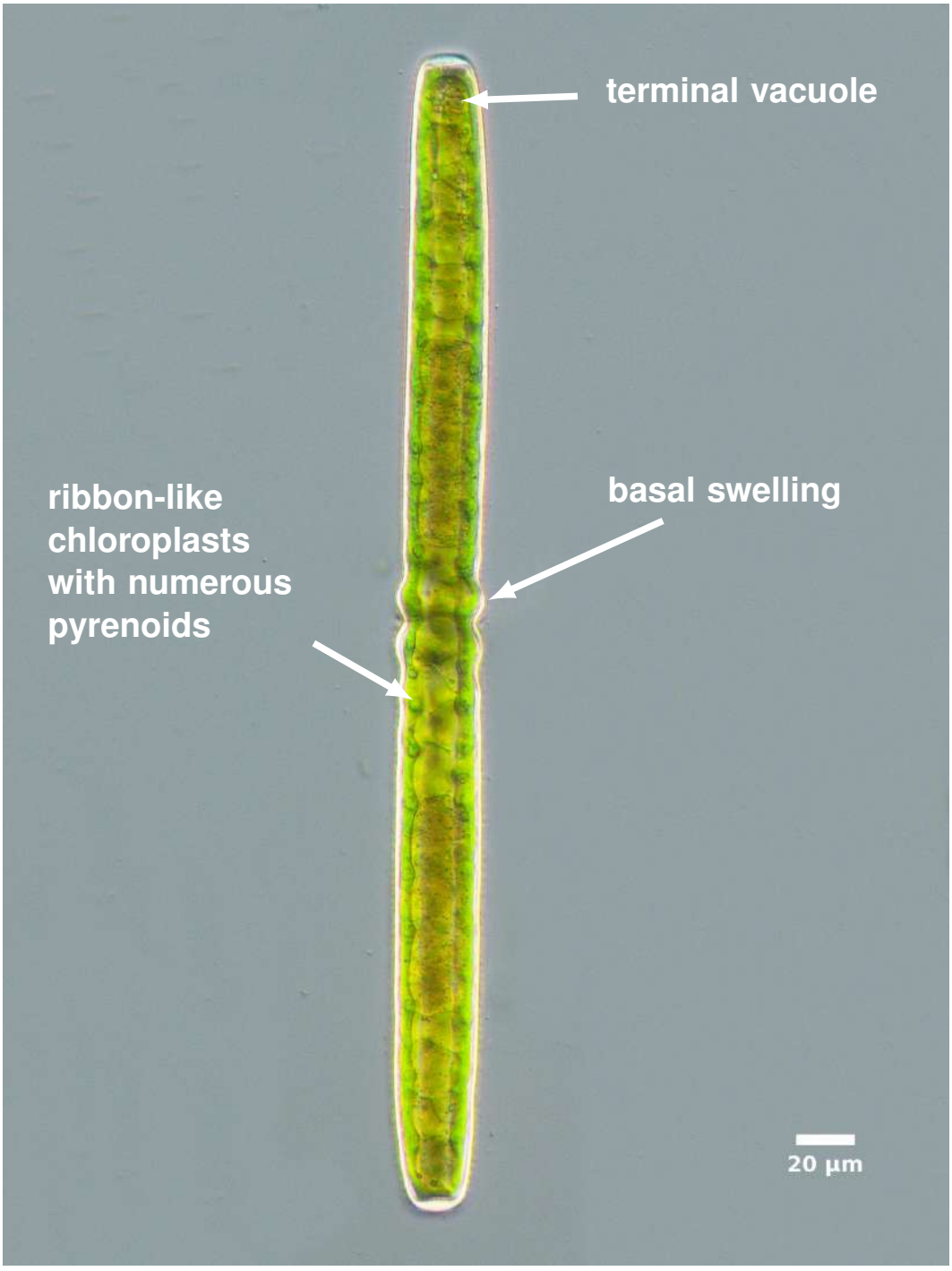


Figure 17.1: *Pleurotaenium* basic morphological features (*Pleurotaenium archeri*).

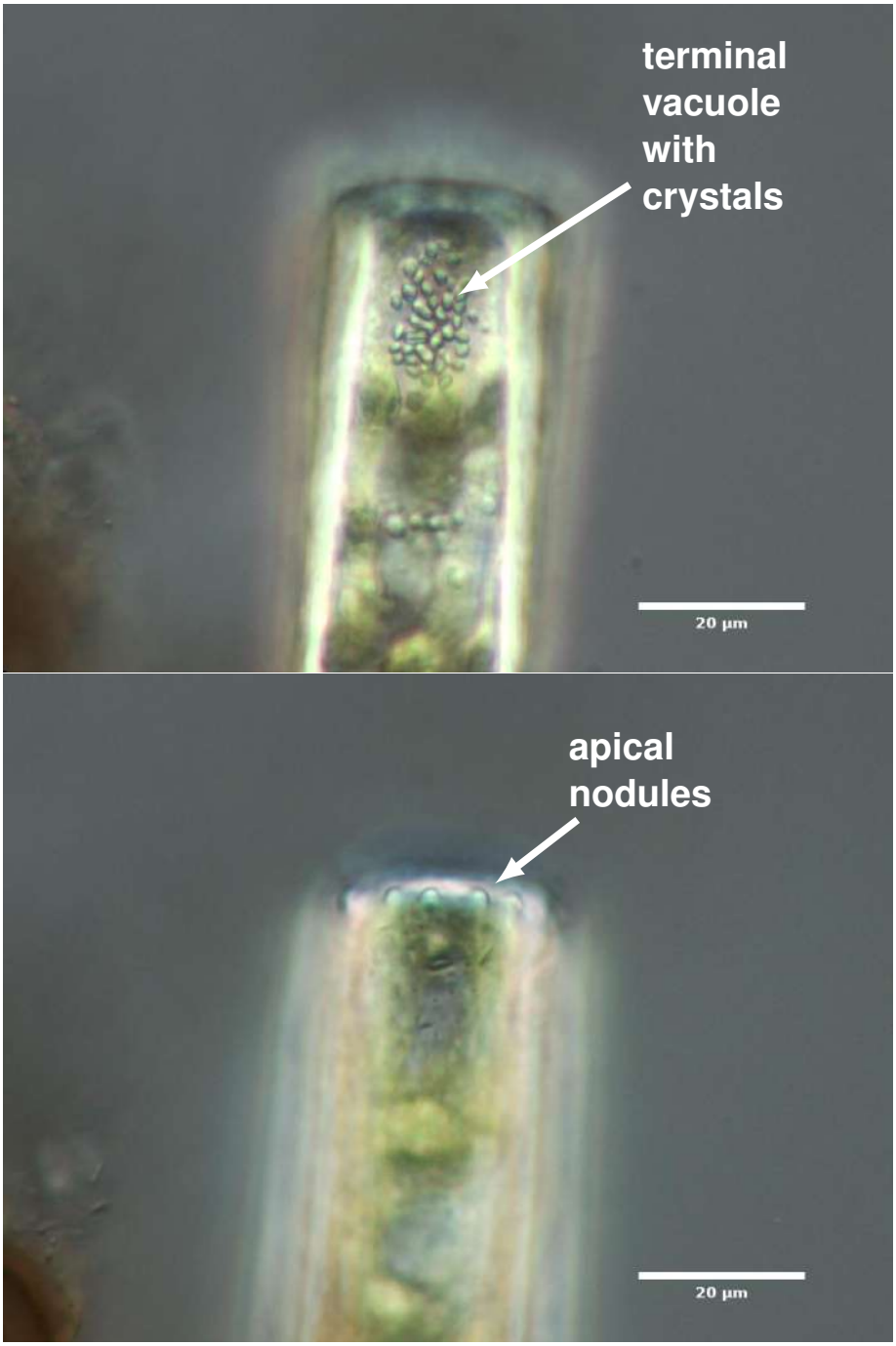


Figure 17.2: *Pleurotaenium* terminal vacuole and apical nodules (*Pleurotaenium ehrenbergii*).



Figure 17.3: *Pleurotaenium* lateral wall features (*Pleurotaenium nodulosum* (upper image); *Pleurotaenium nodosum* (lower image).

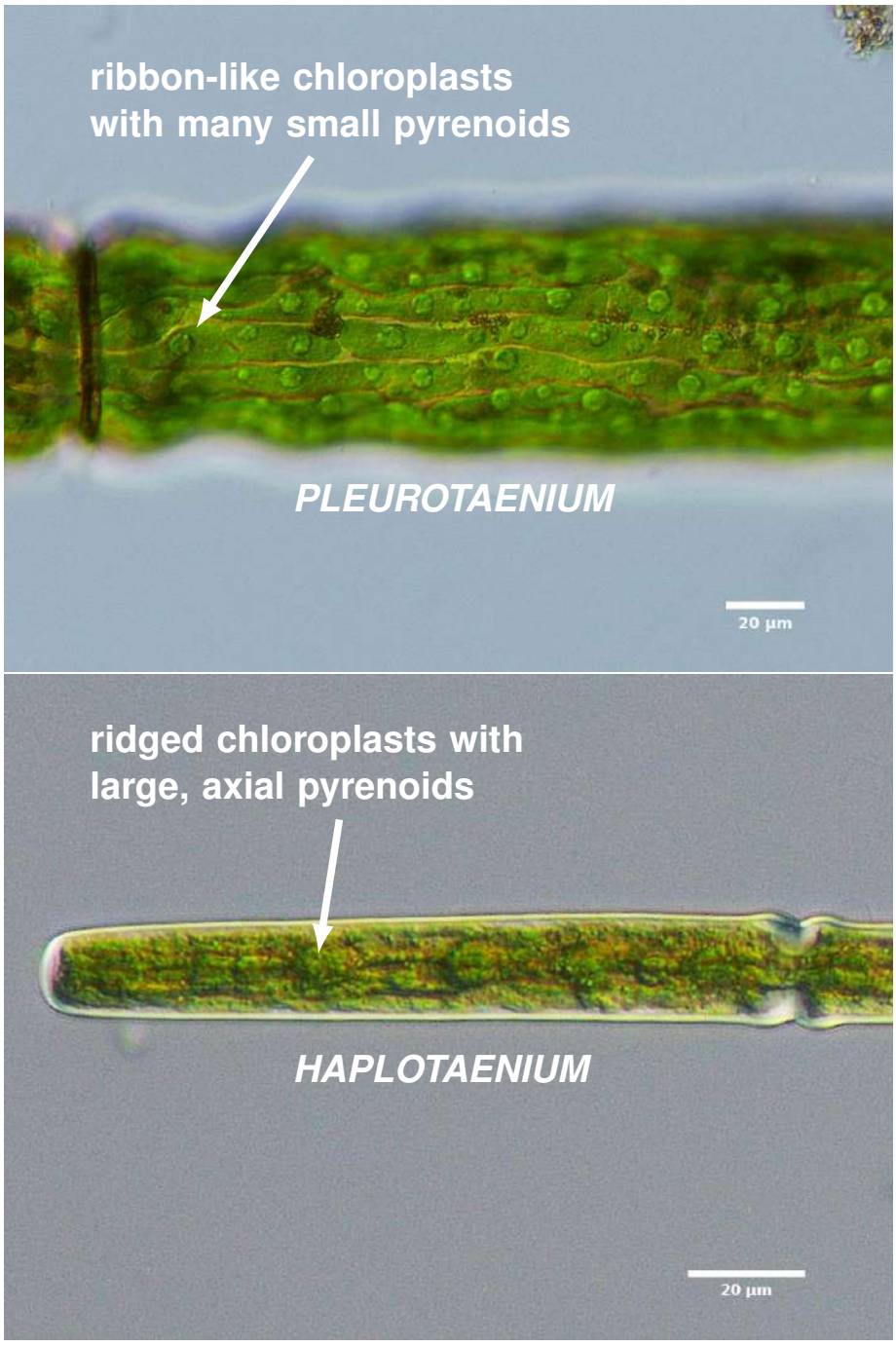


Figure 17.4: *Pleurotaenium* vs. *Haplotaenium* chloroplasts.

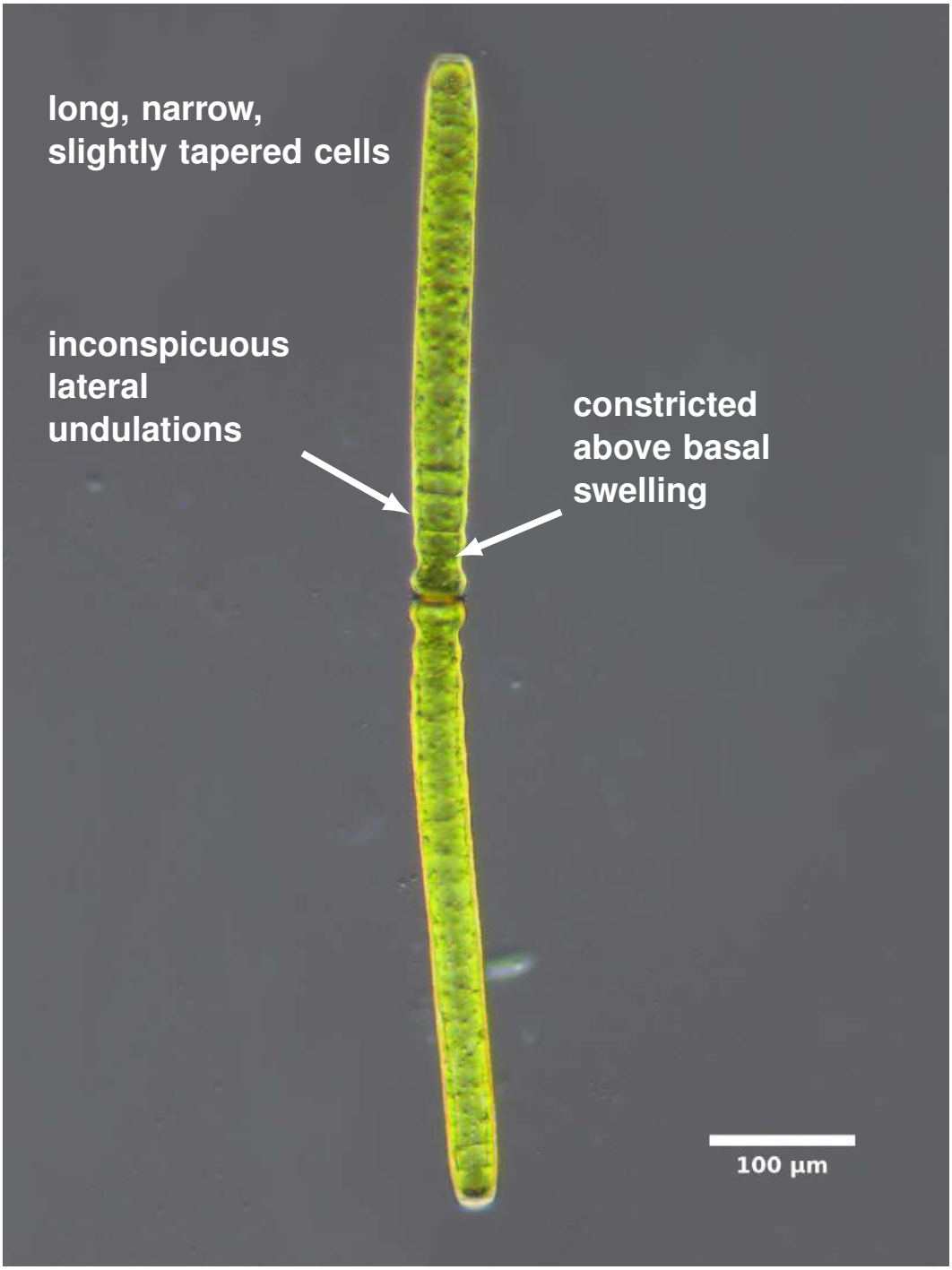


Figure 17.5: *Pleurotaenium archeri* (DIC), Summer Lake, Skagit County.

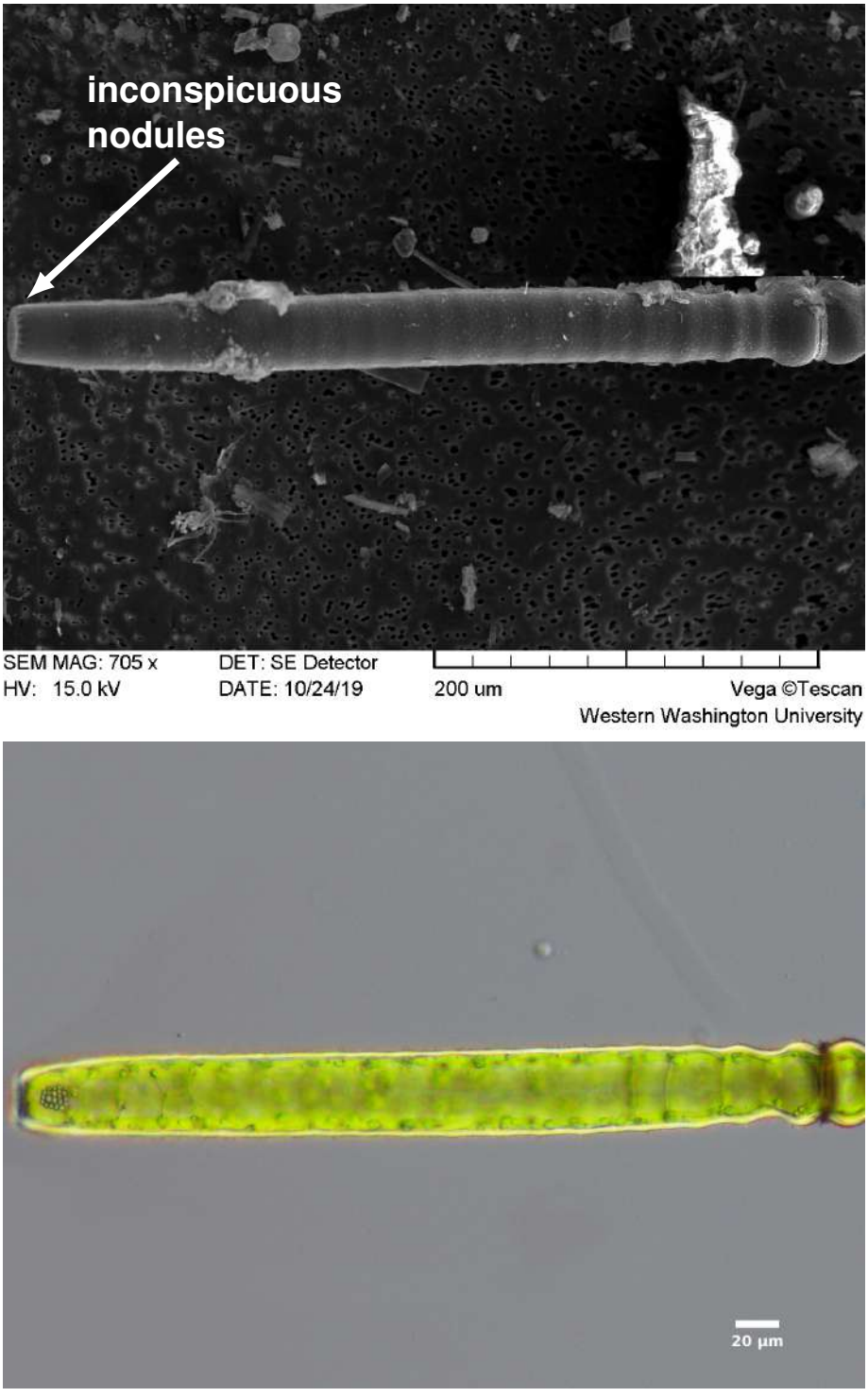


Figure 17.6: *Pleurotaenium archeri* (SEM/DIC), Lake Everett, Skagit County (upper image); Summer Lake, Skagit County (lower image).

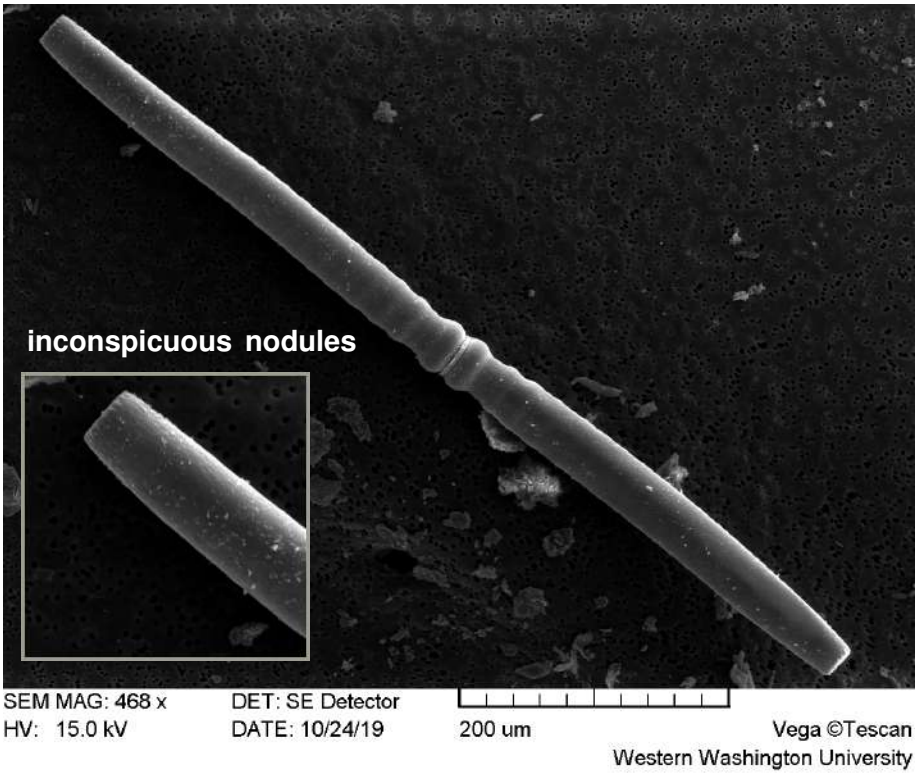




Figure 17.7: *Pleurotaenium archeri* (SEM/DIC), Lake Everett, Skagit County (upper/lower images).

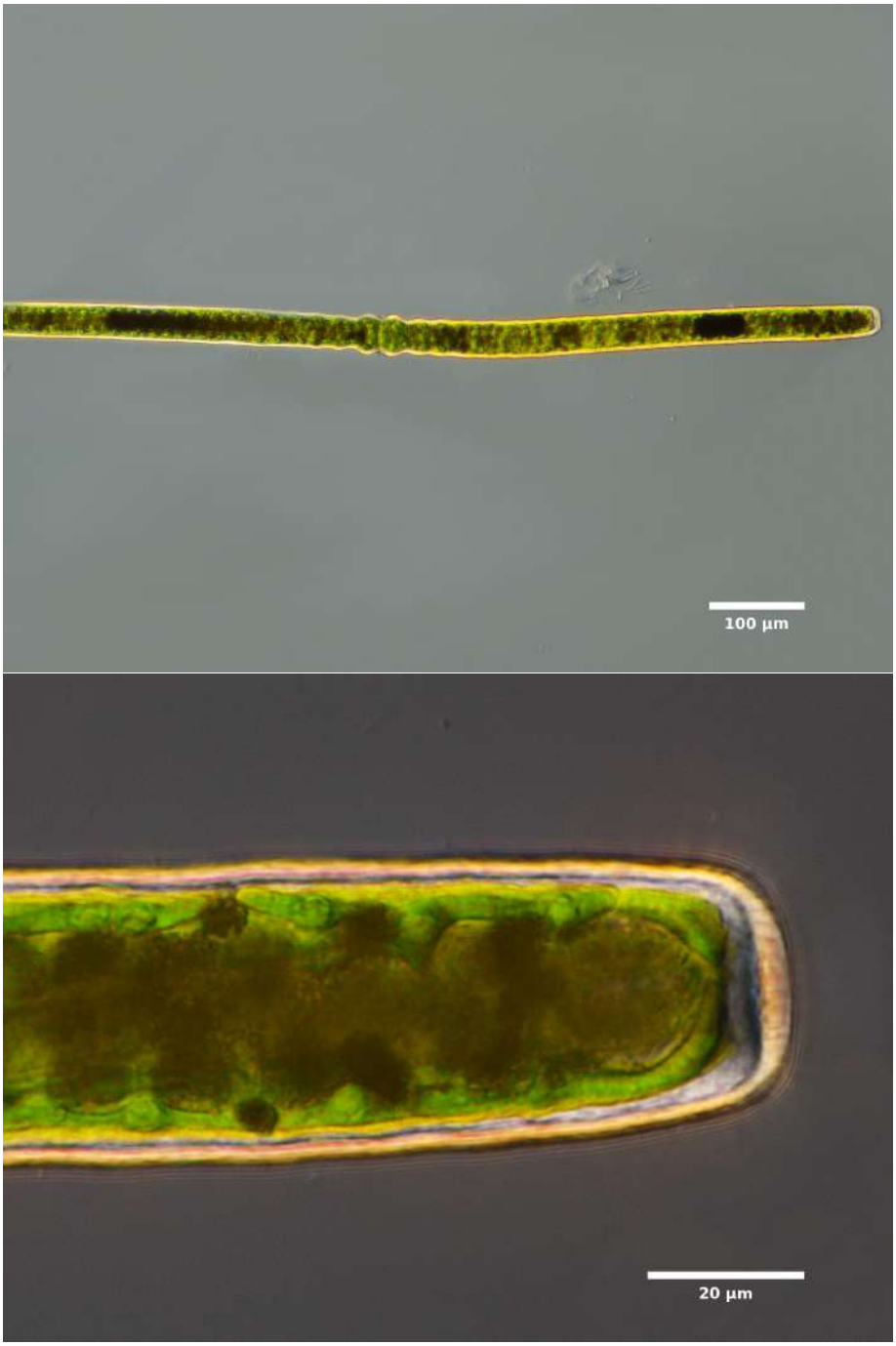


Figure 17.8: *Pleurotaenium archeri* (DIC/DIC), Sunday Lake, Snohomish County (upper/lower images). Note that the apical nodules are not visible in these images.



Figure 17.9: *Pleurotaenium coronatum* (DIC), Canyon Lake, Whatcom County.

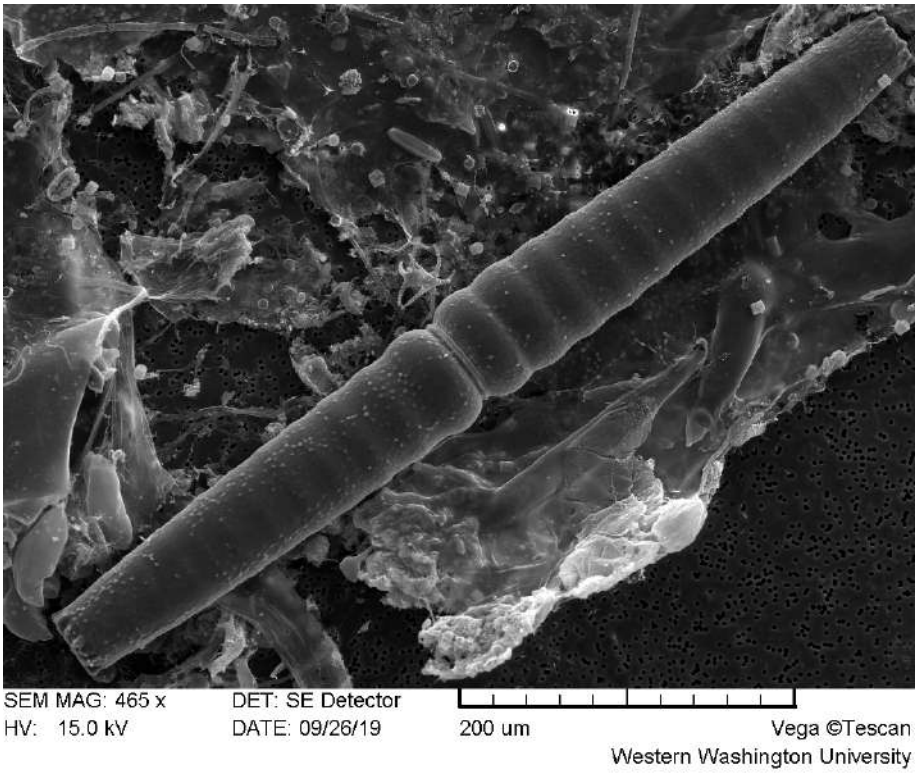




Figure 17.10: *Pleurotaenium coronatum* (SEM/DIC), floating bog along Morris Valley Road near Harrison, BC (upper/lower images).

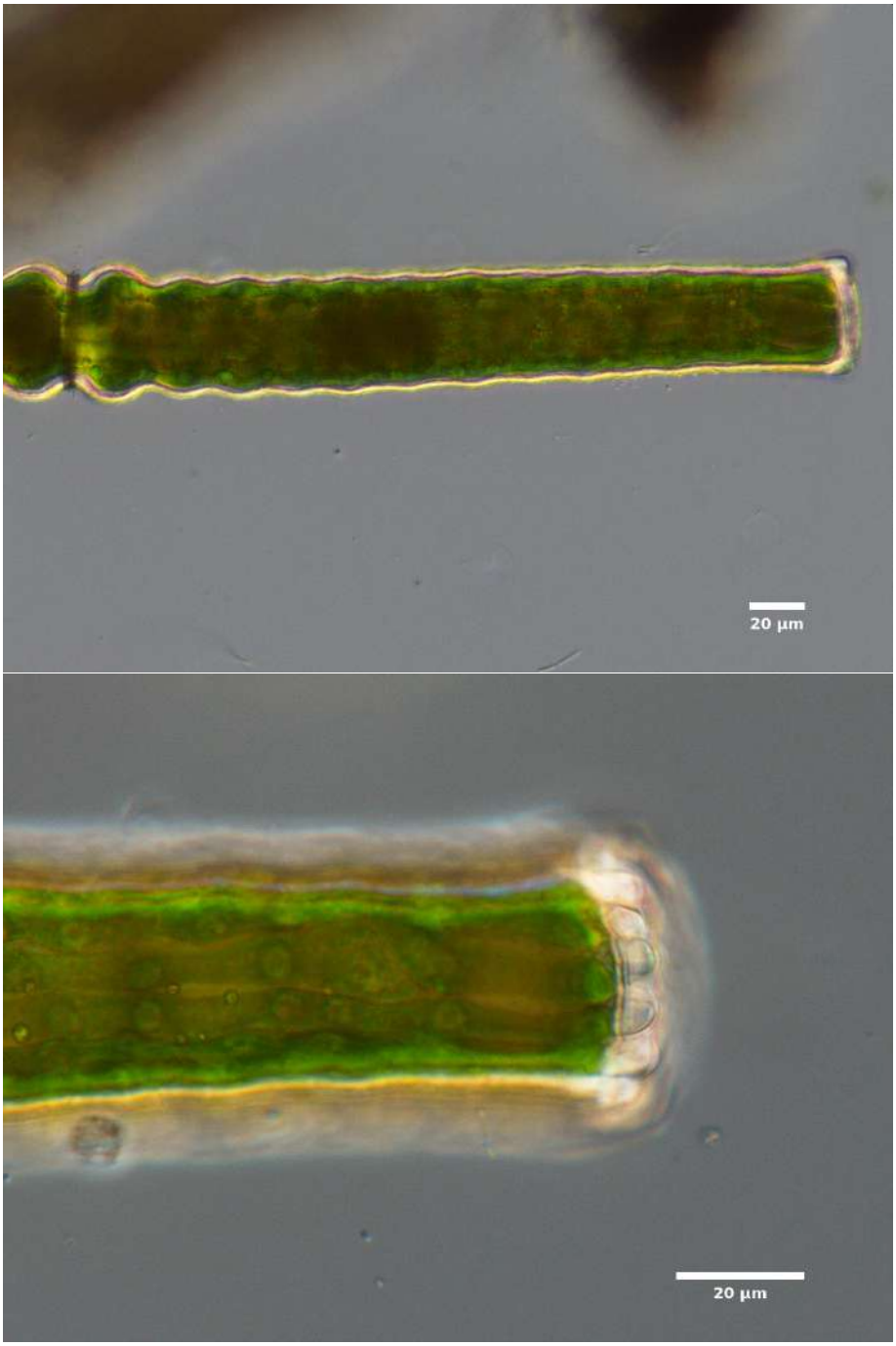


Figure 17.11: *Pleurotaenium coronatum* (DIC/DIC), Pine Lake, Whatcom County (upper/lower images).



Figure 17.12: *Pleurotaenium coronatum* (DIC) with *Mougeotia* (non-desmid Charophyta) and other desmids, floating bog along Morris Valley Road near Harrison, BC.

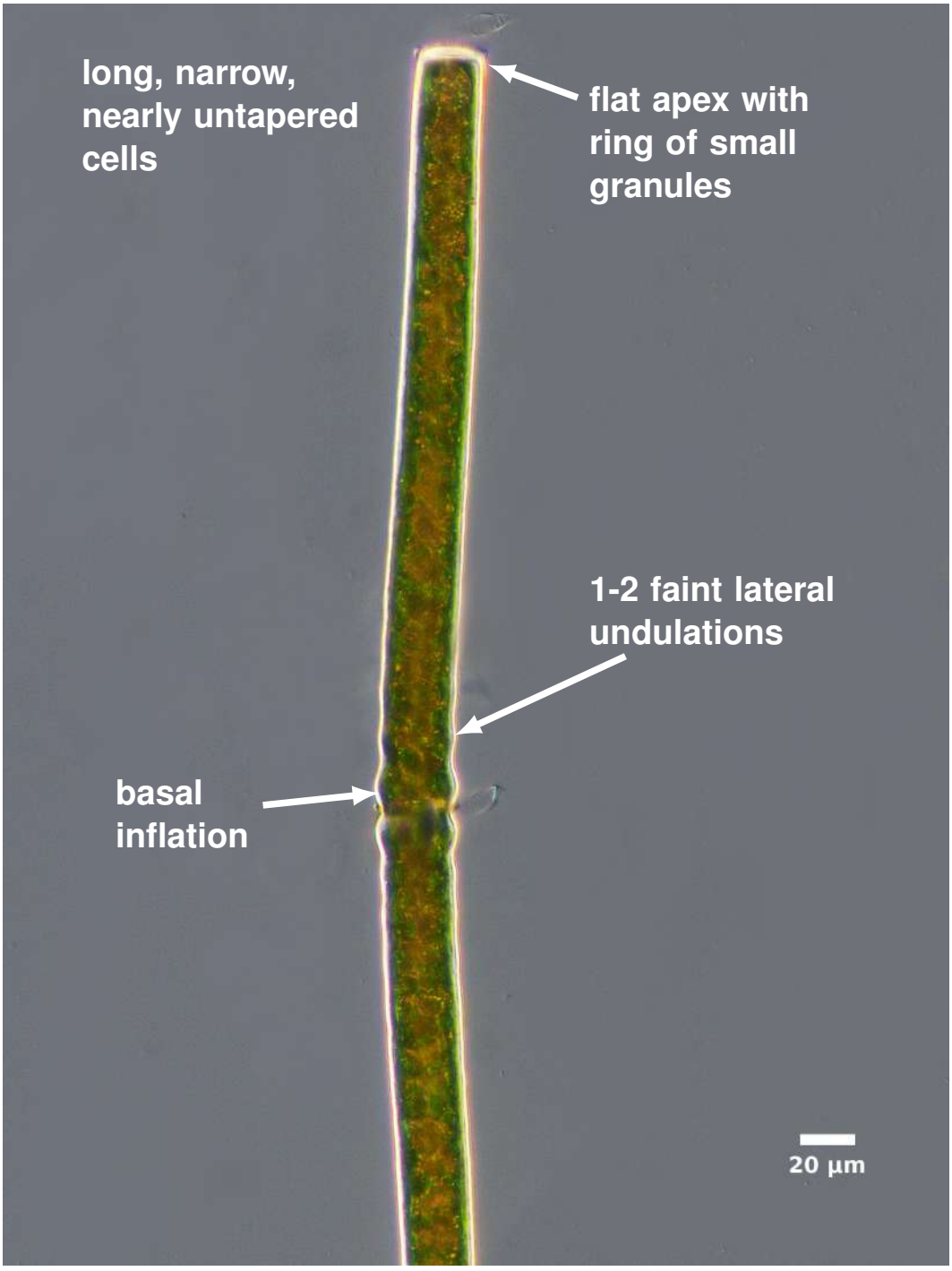


Figure 17.13: *Pleurotaenium ehrenbergii* (DIC), Lake Evan, Mountain Loop Highway, Snohomish County.

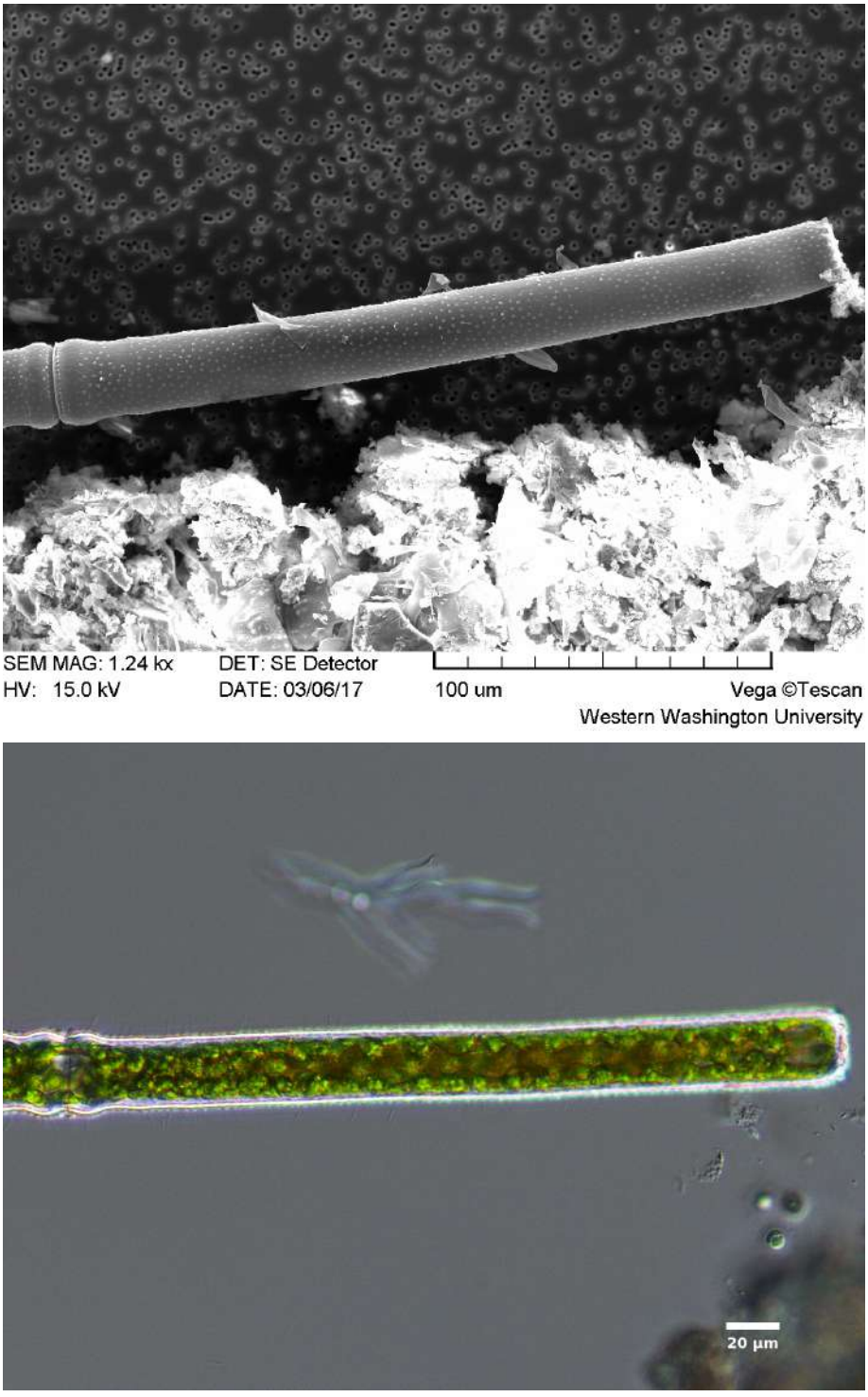


Figure 17.14: *Pleurotaenium ehrenbergii* (SEM/DIC), Heather Meadows Pond, Mt. Baker area, Whatcom County (upper/lower images).

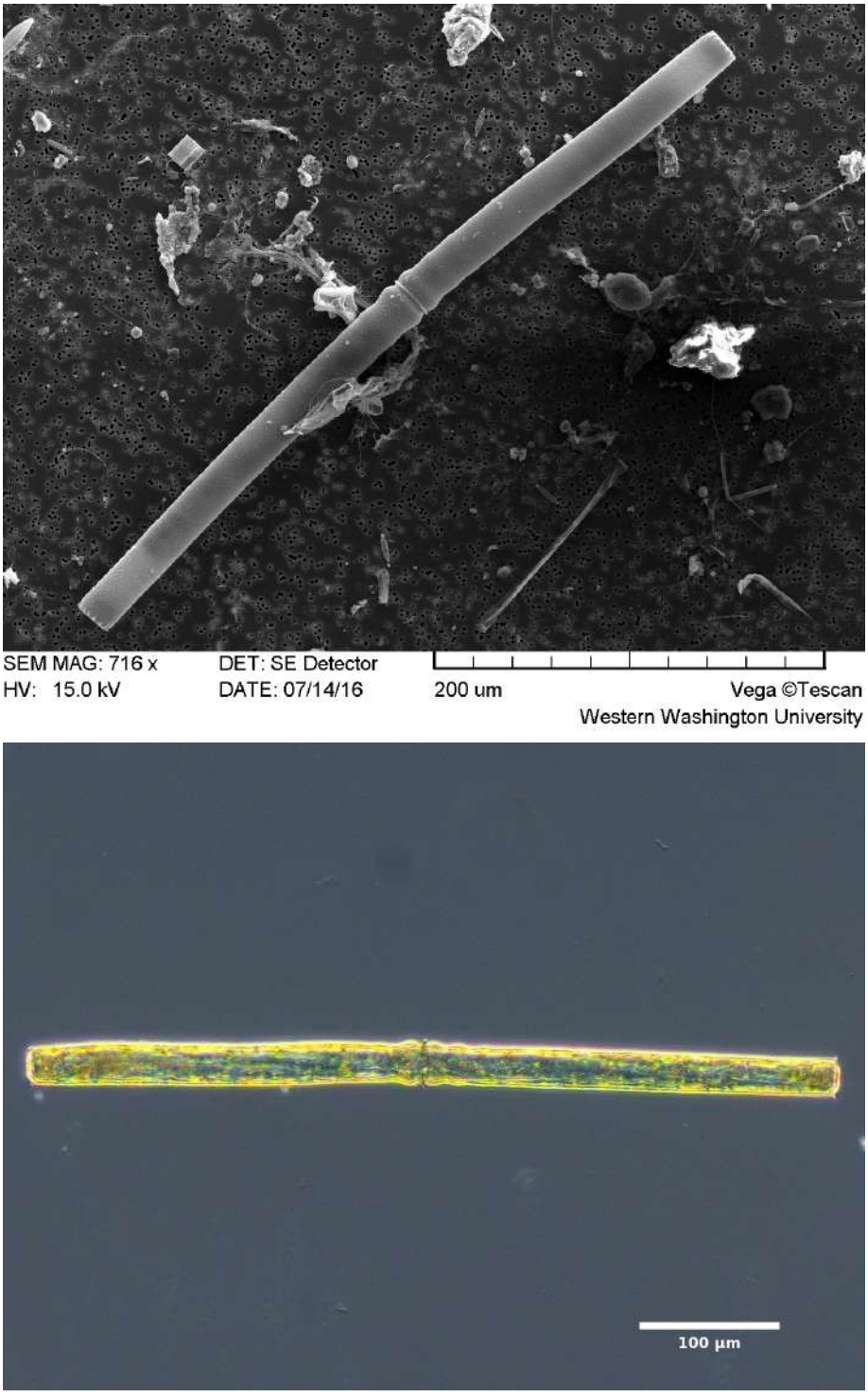


Figure 17.15: *Pleurotaenium ehrenbergii* (SEM/DIC), Boardman Lake, Mountain Loop Highway, Snohomish County (upper/lower images).

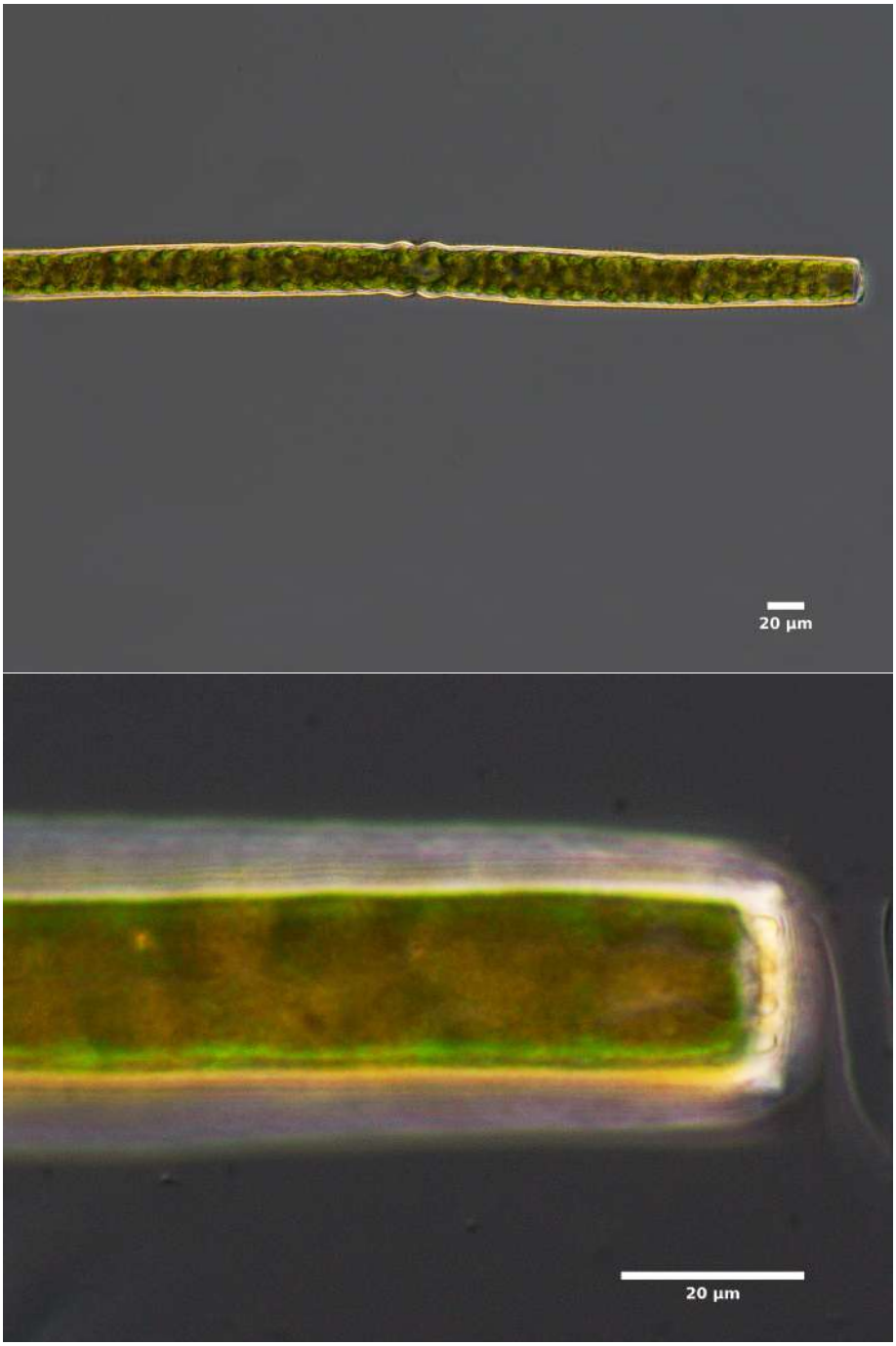


Figure 17.16: *Pleurotaenium ehrenbergii* (DIC/DIC), Lake Evan, Mountain Loop Highway, Snohomish County (upper/lower images).

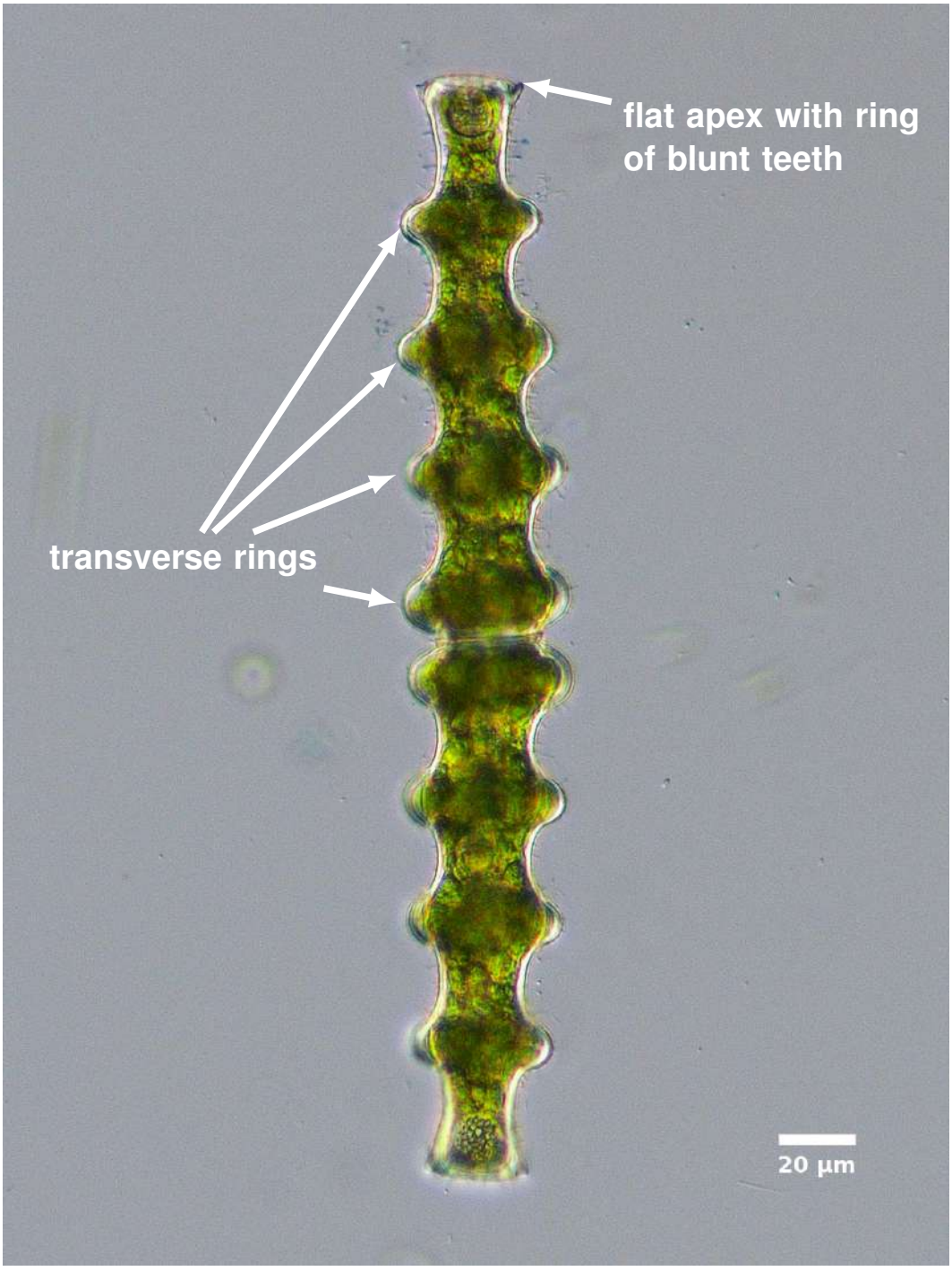
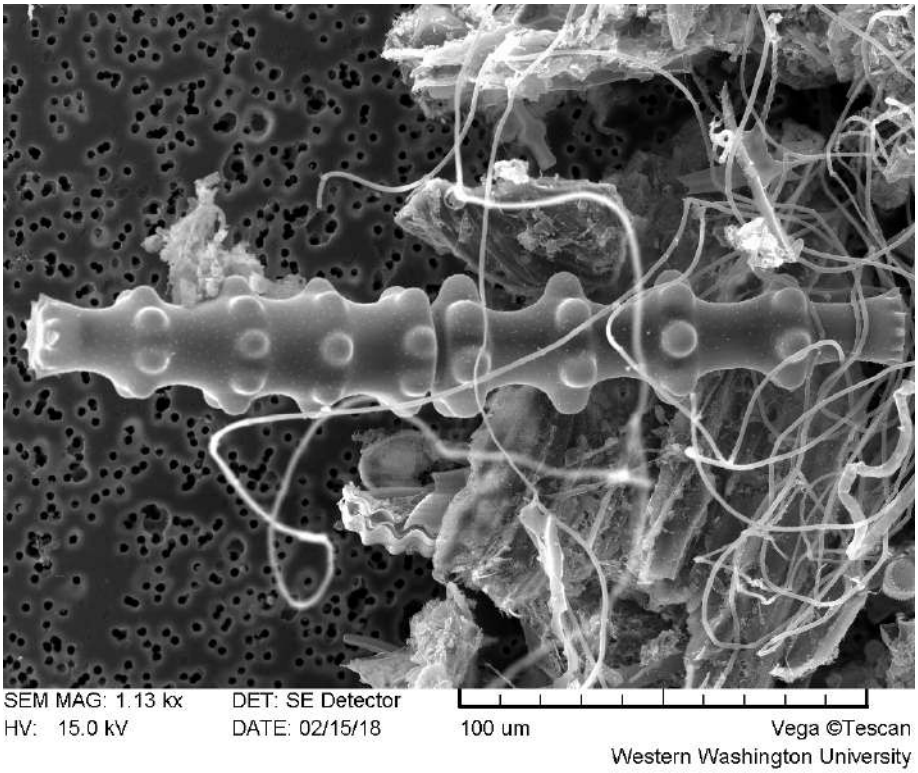


Figure 17.17: *Pleurotaenium nodosum* (DIC), Lake Evan, Mountain Loop Highway, Snohomish County.



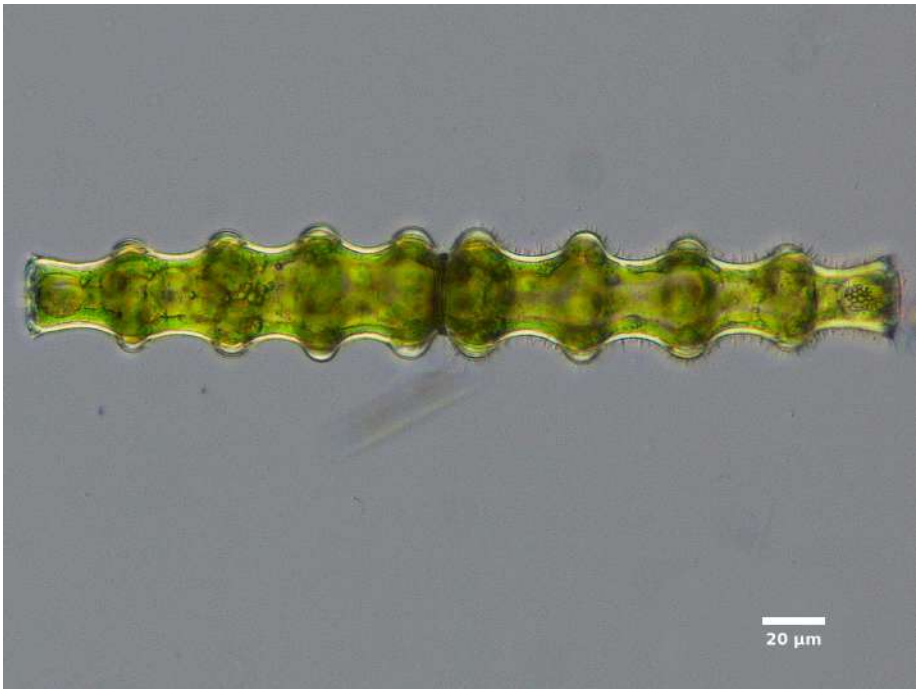


Figure 17.18: *Pleurotaenium nodosum* (SEM/DIC), Lake Evan, Mountain Loop Highway, Snohomish County (upper/lower images).

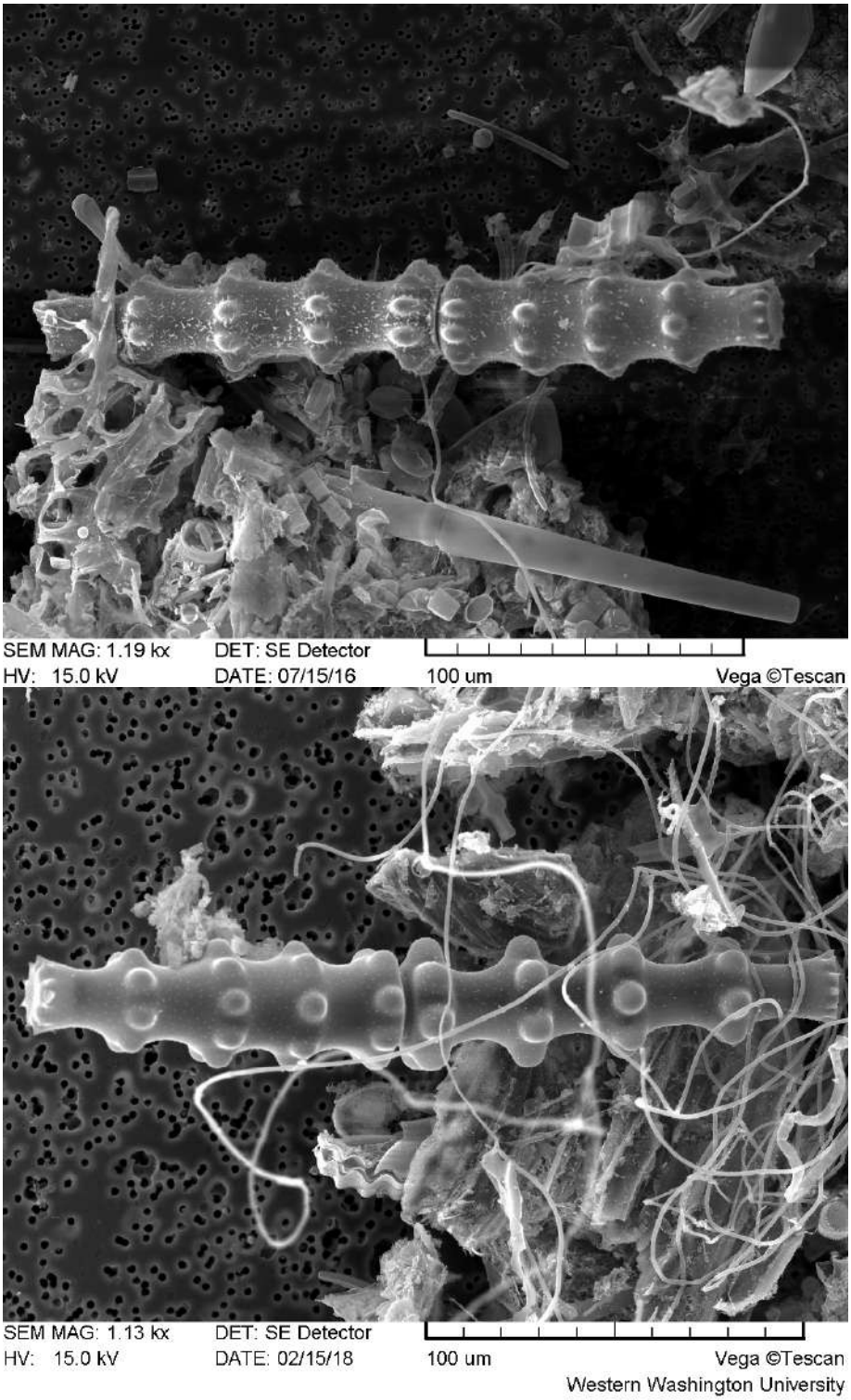


Figure 17.19: *Pleurotaenium nodosum* (SEM/SEM), Bear Lake, Mountain Loop Highway, Snohomish County (upper image); Lake Evan, Mountain Loop Highway, Snohomish County (lower image).



Figure 17.20: *Pleurotaenium nodosum* (DIC), Chain Lake, Gifford Pinchot National Forest, Skamania County.

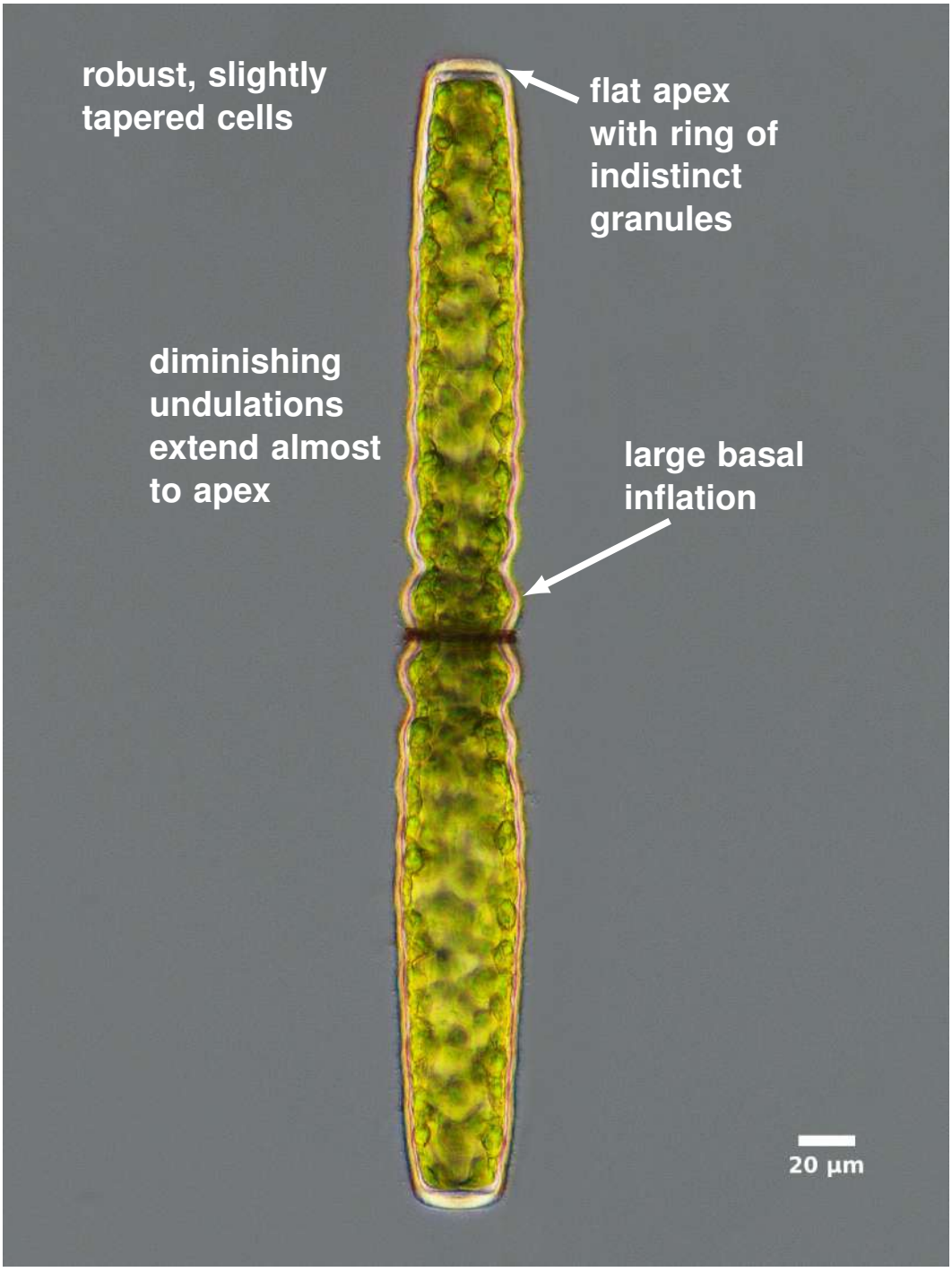


Figure 17.21: *Pleurotaenium nodulosum* (DIC), Beaver Pond Lake, Whatcom County.

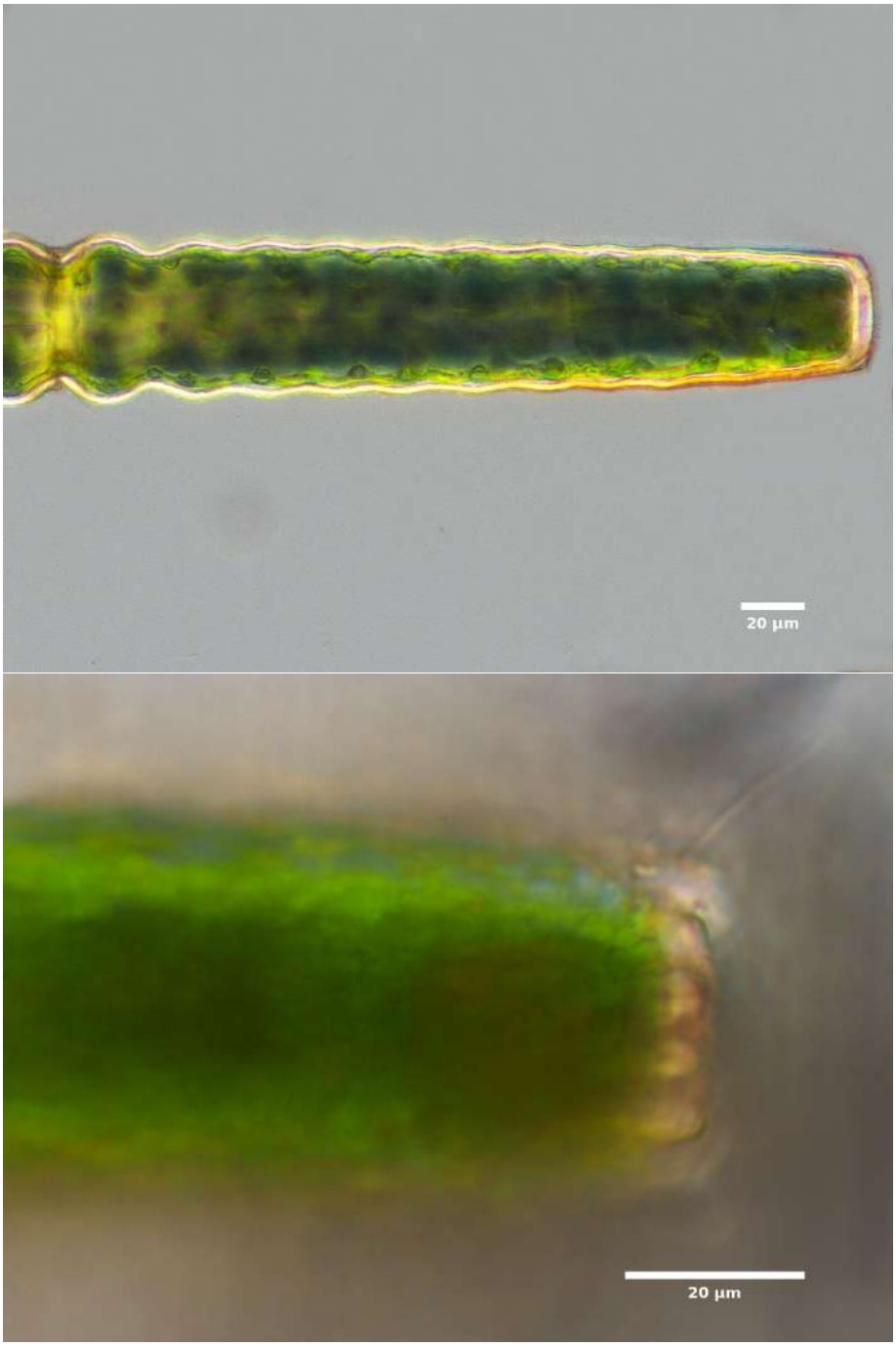


Figure 17.22: *Pleurotaenium nodulosum* (DIC/DIC), Mirror Lake, Whatcom County (upper/lower images).

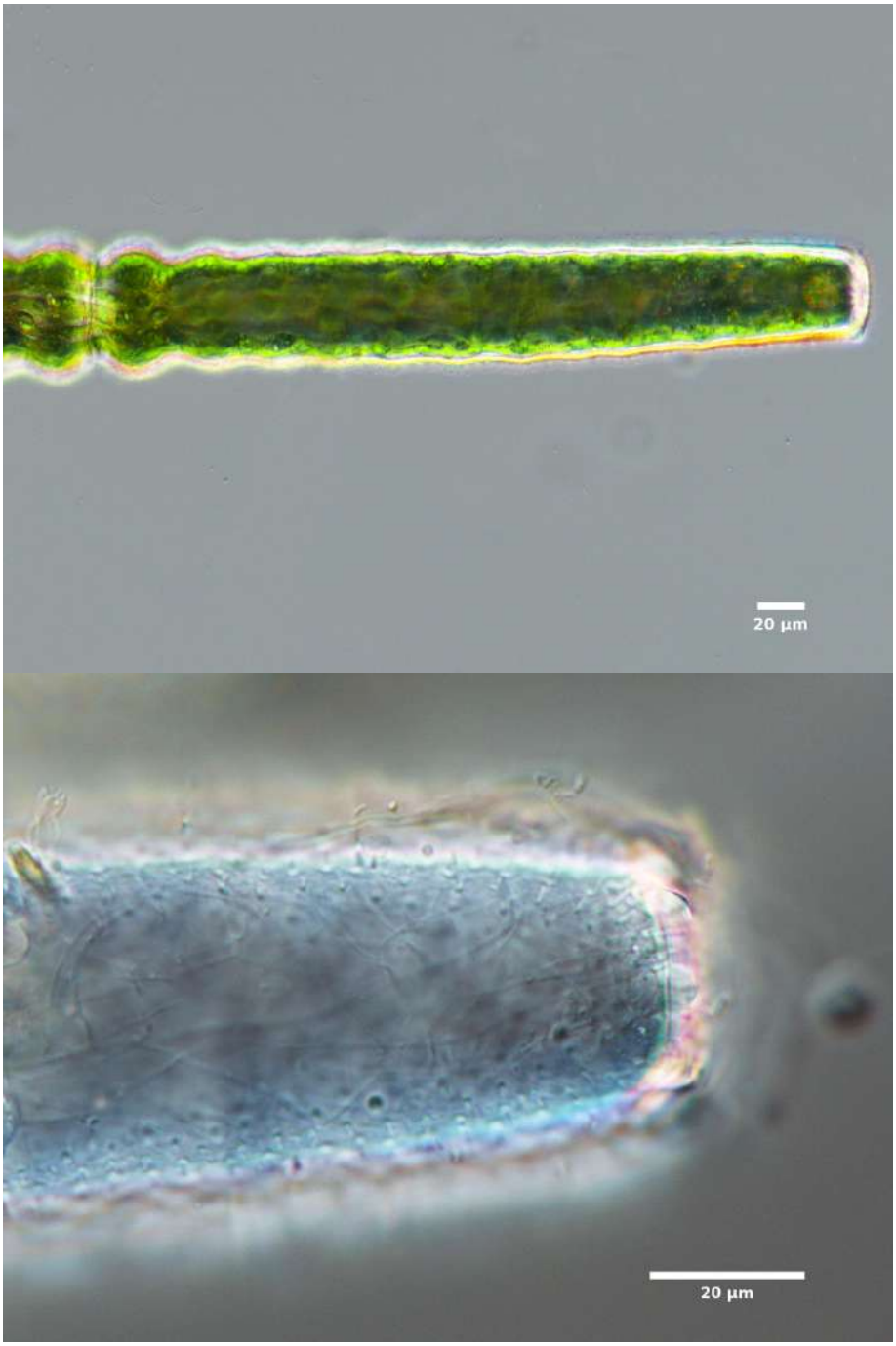


Figure 17.23: *Pleurotaenium nodulosum* (DIC/DIC), Blue Lake on trail to Dock Butte, Mt. Baker area, Skagit County (upper/lower images).

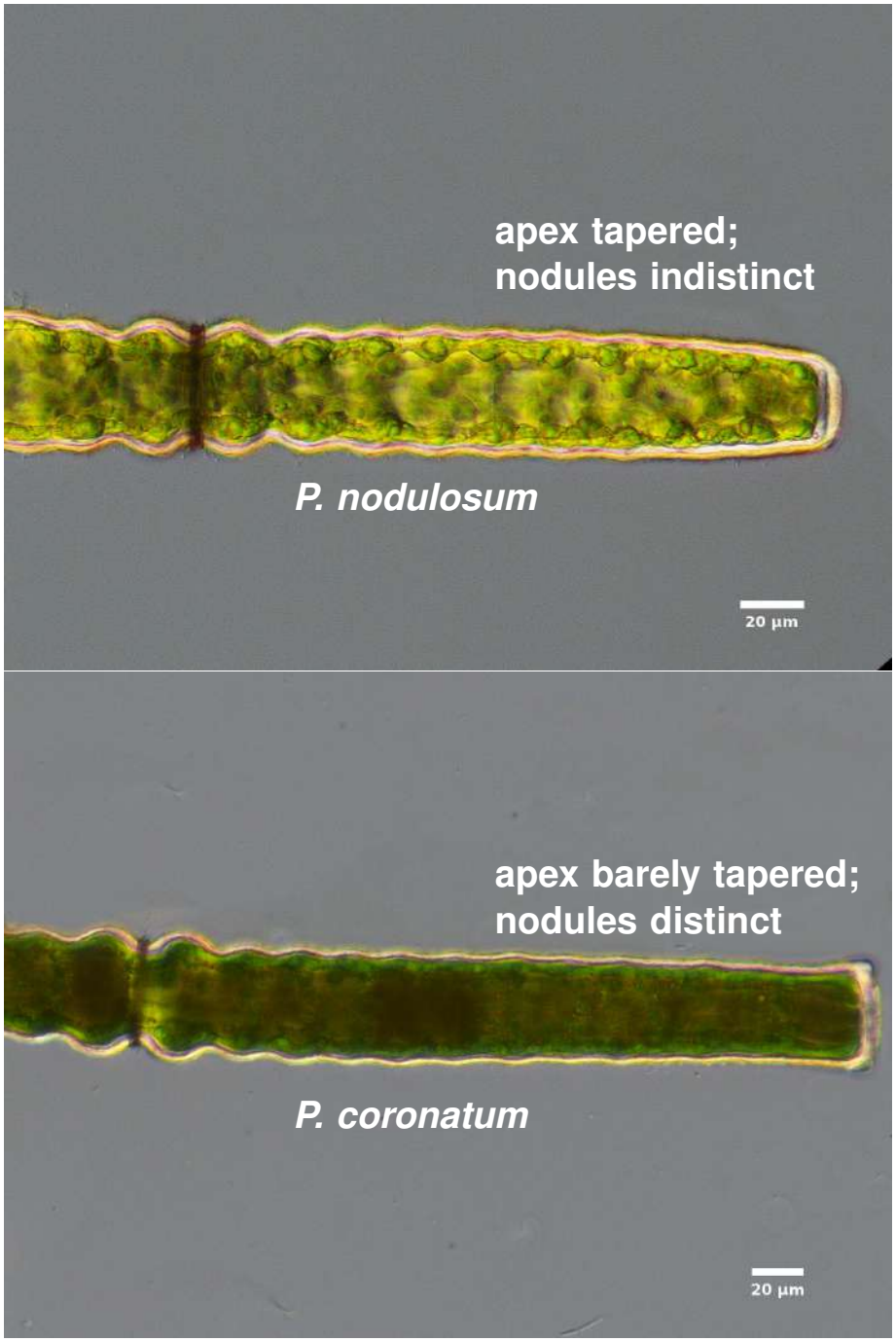


Figure 17.24: *Pleurotaenium nodulosum* (upper image) vs. *Pleurotaenium coronatum* (lower image).

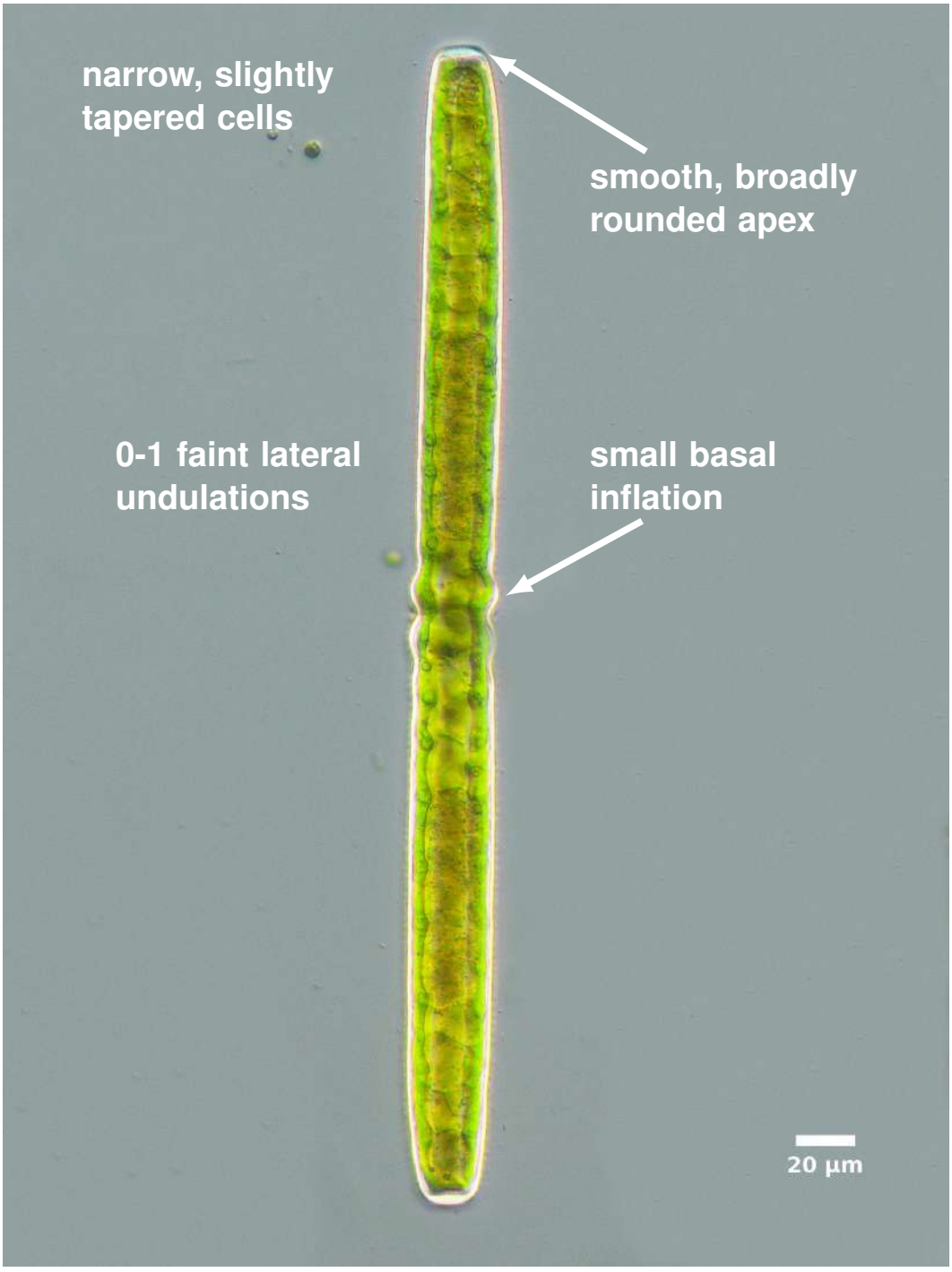


Figure 17.25: *Pleurotaenium trabecula* (DIC), Big Twin Lake (eastern Washington), Okanogan County.

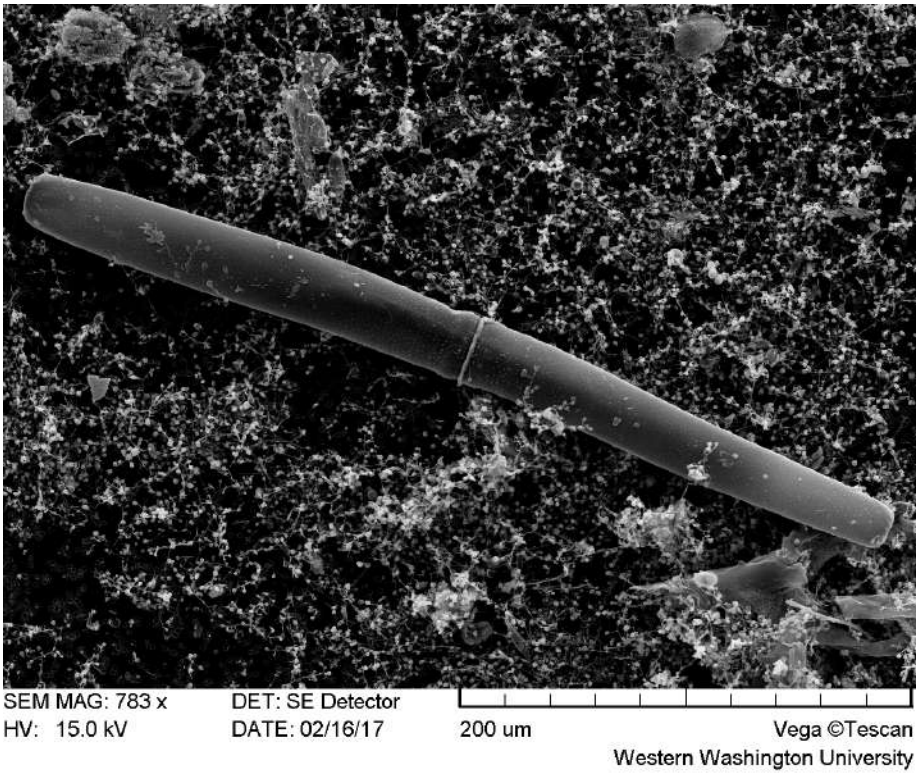




Figure 17.26: *Pleurotaenium trabecula* (SEM/DIC), Sunrise Lake, Mt. Baker area, Whatcom County (upper image); Sunset Lake, Whatcom County (lower image).



Figure 17.27: *Pleurotaenium trabecula* (DIC), Lake Everett, Skagit County.



Figure 17.28: *Pleurotaenium trabecula* (DIC), small pond near Fairhaven College, Whatcom County.

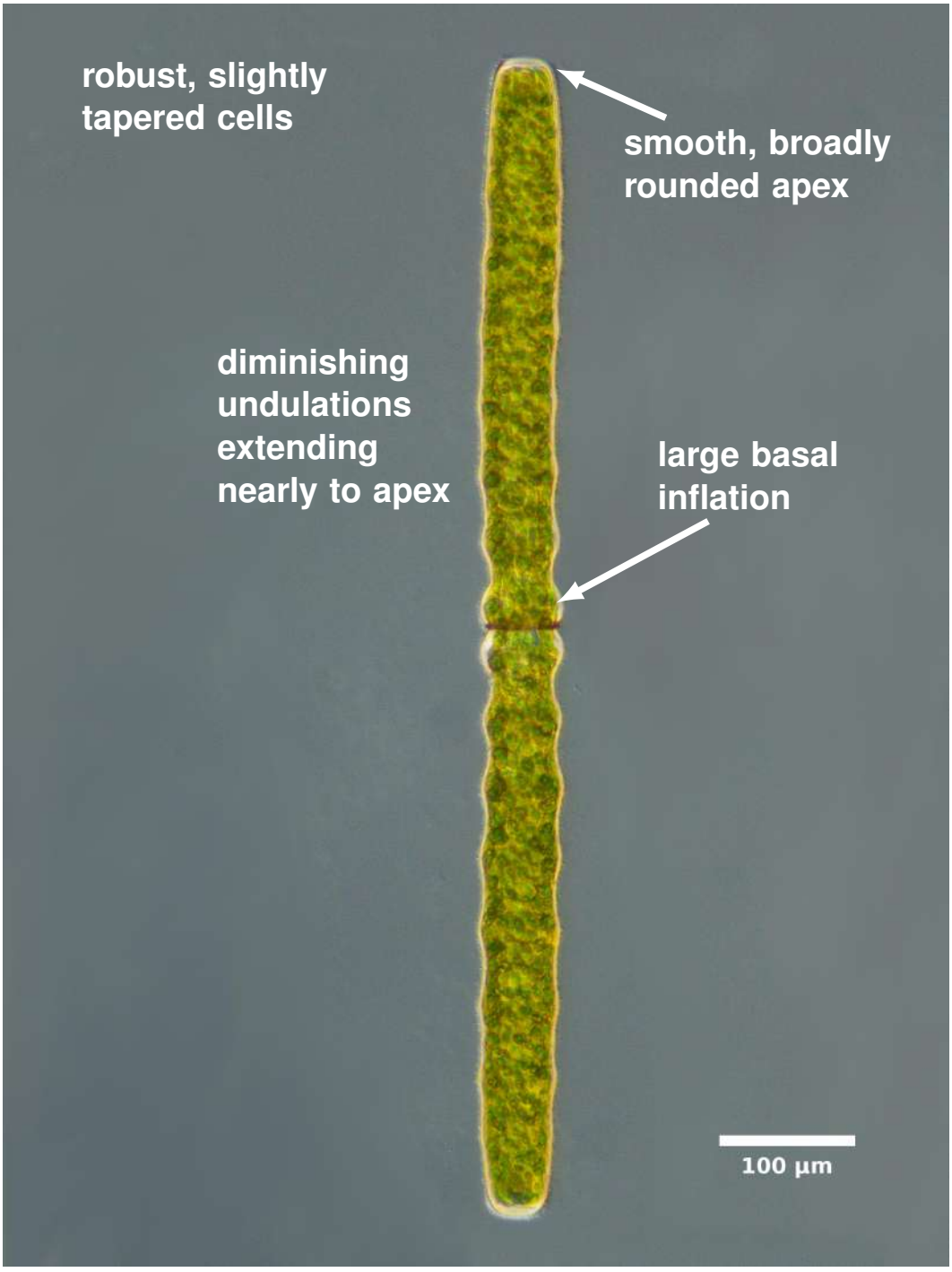


Figure 17.29: *Pleurotaenium* sp. 1 (DIC), Highwood Lake, Mt. Baker area, Whatcom County.

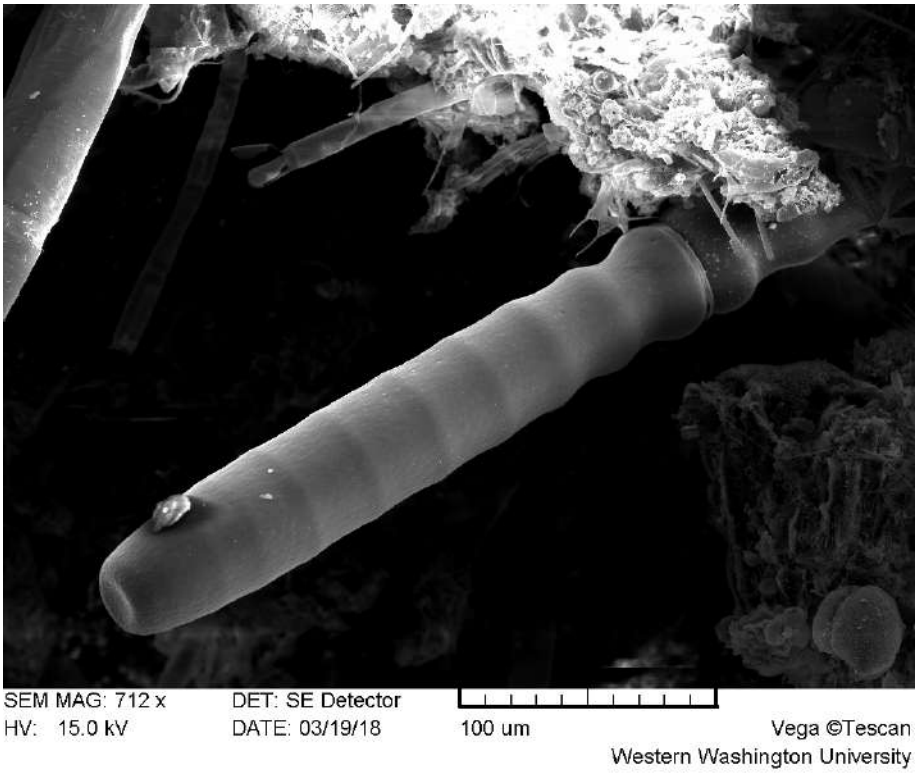




Figure 17.30: *Pleurotaenium* sp. 1 (SEM/DIC), Vogler Lake, Skagit County (upper/lower images).

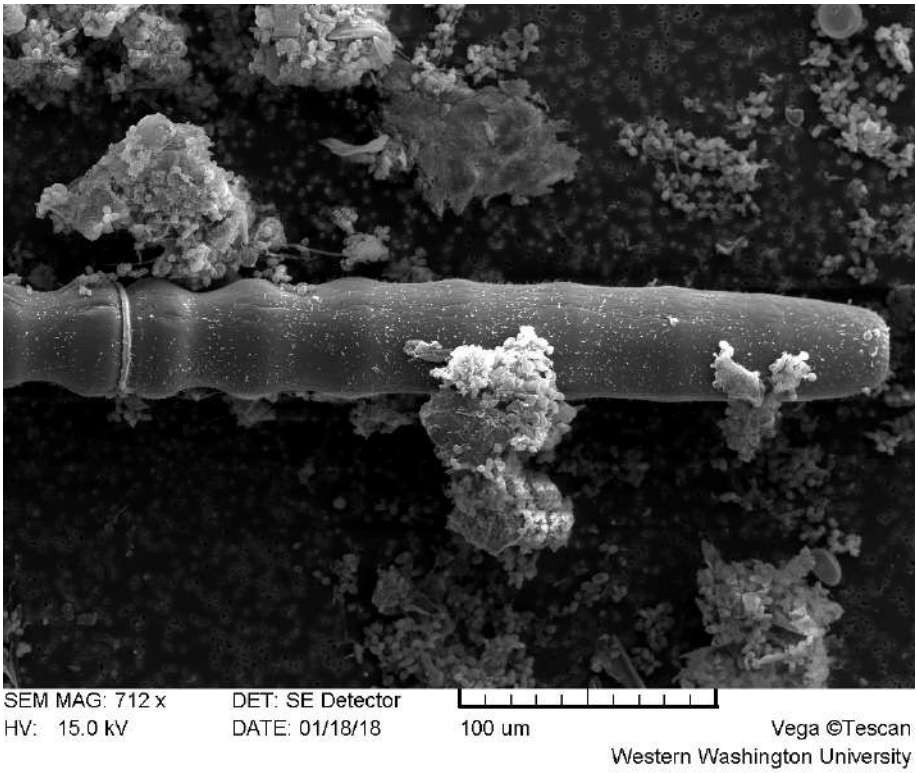




Figure 17.31: *Pleurotaenium* sp. 1 (SEM/DIC), Picture Lake, Mt.Baker area, Whatcom County (upper/lower images).



Figure 17.32: *Pleurotaenium* sp. 1 (DIC), Mirror Lake, Whatcom County.

Chapter 18

Roya West & G. S. West

Northwest Washington taxa
Roya anglica G. S. West
Roya cambrica West & G. S. West

Table 18.1: Key to *Roya* Species

B	Cell length <100 μm; L/W <20	*Roya anglica* (Figures 18.1–18.3)
A	Cell length >100 μm; L/W ≥20	*Roya cambrica* (Figures 18.4–18.6)

Table 18.2: *Roya* Cell Measurements

		Cell Width	Cell Length	Isthmus Width	L/W Ratio
Roya anglica[†]	min	6.2 μm	68.6 μm	–	11.1
	med	6.5 μm	73.2 μm	–	11.3
	max	6.6 μm	75.5 μm	–	11.4

[†]*summary statistics based on <5 cells*

continued on next page

Table 18.2: *Roya* Cell Measurements, continued

		Cell Width	Cell Length	Isthmus Width	L/W Ratio
Roya cambrica	min	5.5 μm	113.1 μm	–	19.9
	med	6.0 μm	157.7 μm	–	26.3
	max	6.4 μm	194.2 μm	–	32.4

†Summary statistics based on <5 cells

Description

Roya cells are long, cylindrical, unconstricted, and either straight or slightly curved (Figures 18.1–18.6). The cells lack a discernible sinus (saccoderm desmid), and have a single, ribbon-like chloroplast that extends the full length of the cell. The chloroplast is usually notched at the center of the cell, with the cell nucleus located inside the notch. Only a few specimens of *Roya* were collected in northwest Washington and all were found in small, boggy mountain lakes or ponds.

Roya anglica cells are short and relatively robust (L<100 μm; L/W≤20), gently curved, and slightly narrowed near the apex. The single chloroplast is ridged along its entire length. The cells are described as often possessing terminal vacuoles, although this feature is not always present (Brook and Williamson, 2010). It can be difficult to distinguish terminal vacuoles from cells where the chloroplast ends below the apex, leaving an empty region at the apex. The specimen in Figure 18.1 appears to have distinct, spherical terminal vacuoles, but terminal vacuoles are not visible in Figures 18.2–18.3. Coesel and Meester (2007) state that it is common to find transitional forms between *Roya obtusa* var. *obtusa*, which lacks terminal vacuoles, and *Roya obtusa* var. *anglica*,[36] which may have vacuoles.

Roya cambrica cells are long and narrow (L>100 μm; L/W≥20), untapered, and straight or nearly straight, with a rounded, truncate apex (Figures 18.4–18.6). The single chloroplast has a median notch that partly surrounds the nucleus. Some specimens had chloroplasts that ended slightly below the apex, leaving spaces that resemble terminal vacuoles but may instead indicate chloroplast damage and shrinkage (Figure 18.6). The variability of terminal vacuoles in *Roya anglica* makes vacuoles an unreliable diagnostic feature for separating the species so identification was based on differences in length and L/W ratios.

[36]synonym for *Roya anglica*

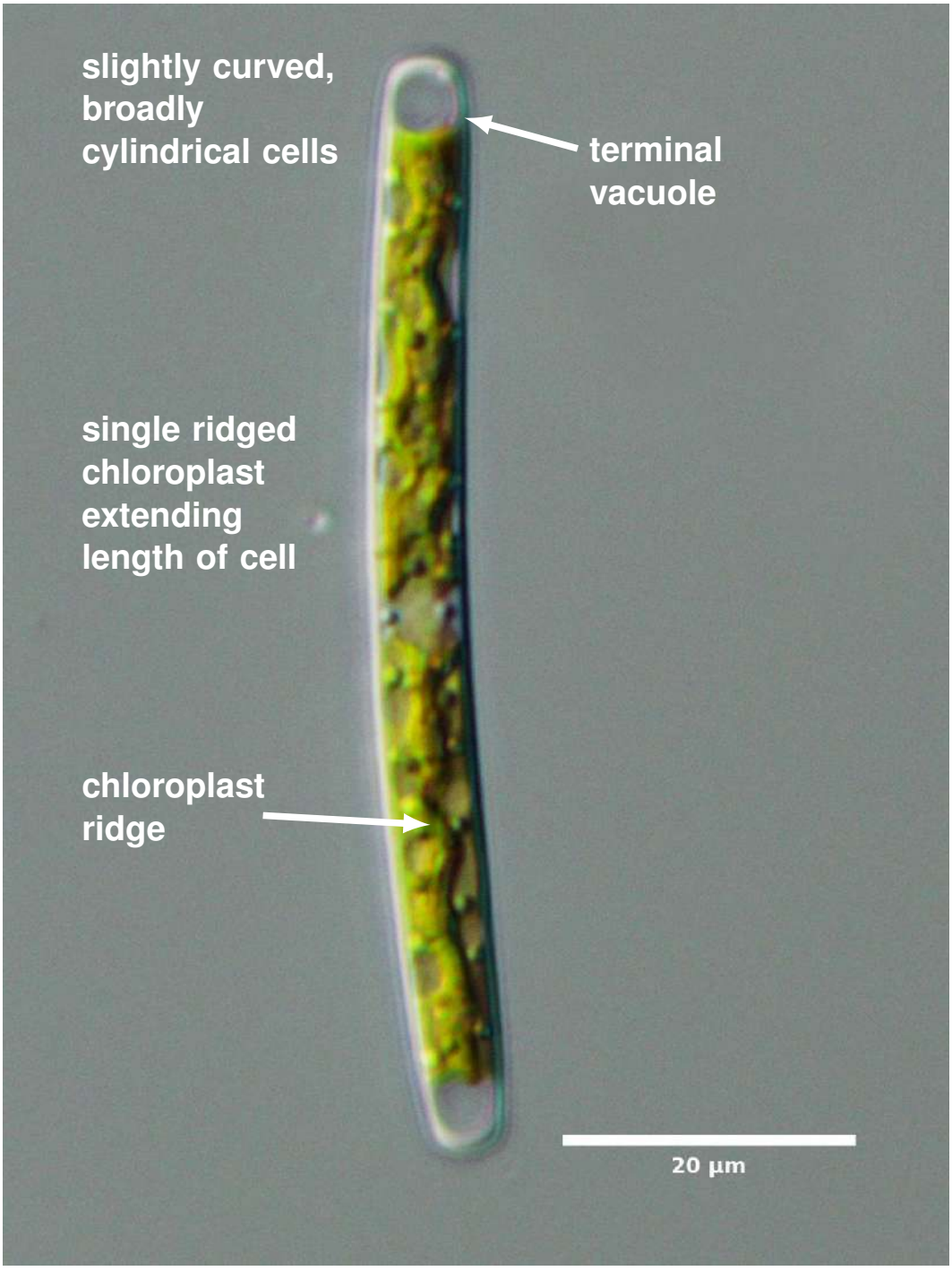


Figure 18.1: *Roya anglica* (DIC), small pond on trail to Big Four Ice Caves, Mountain Loop Highway, Snohomish County.

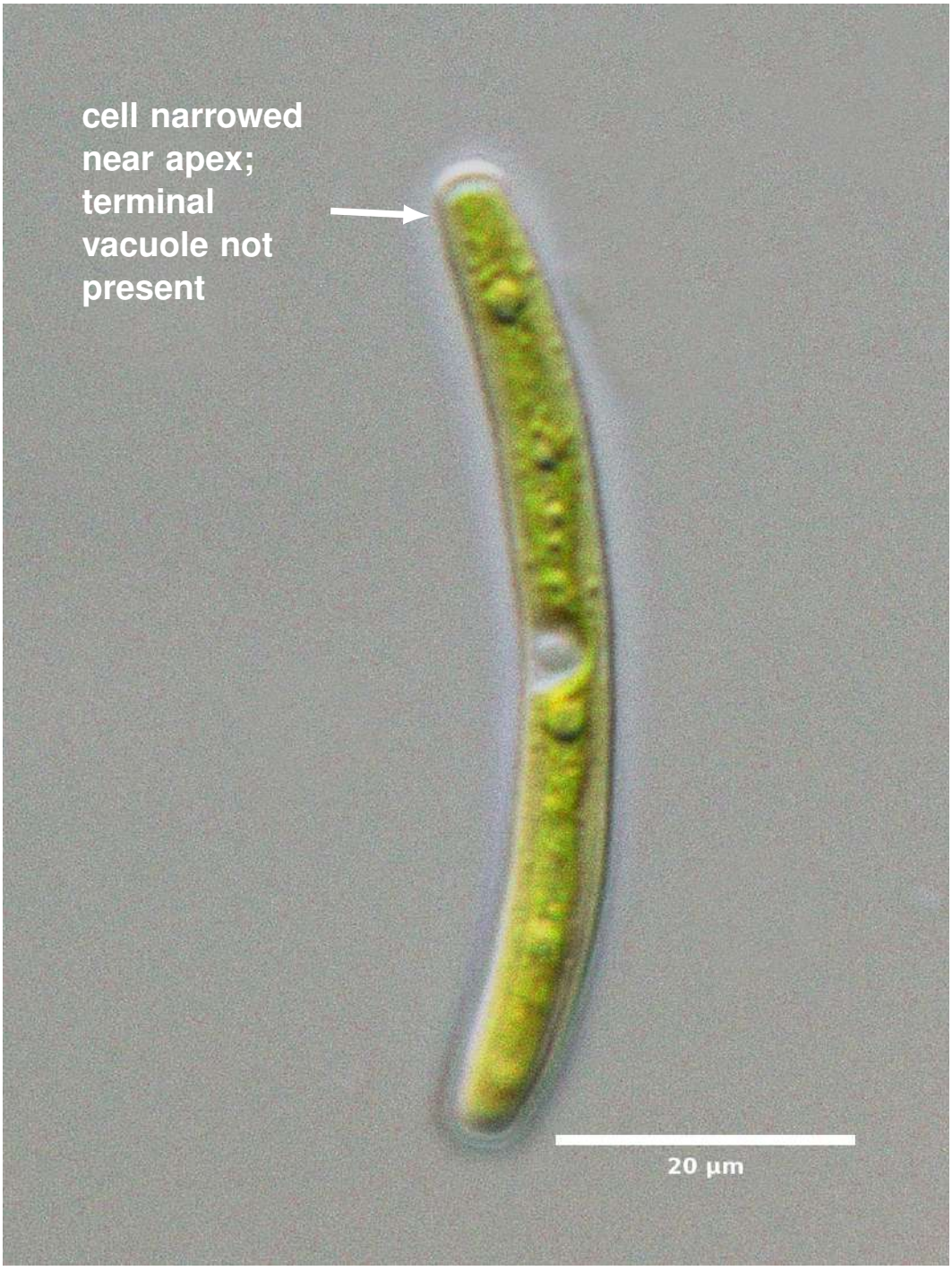


Figure 18.2: *Roya anglica* (DIC), small pond on trail to Big Four Ice Caves, Mountain Loop Highway, Snohomish County.



Figure 18.3: *Roya anglica* (DIC), Lake Twenty-two, Mountain Loop Highway, Snohomish County.

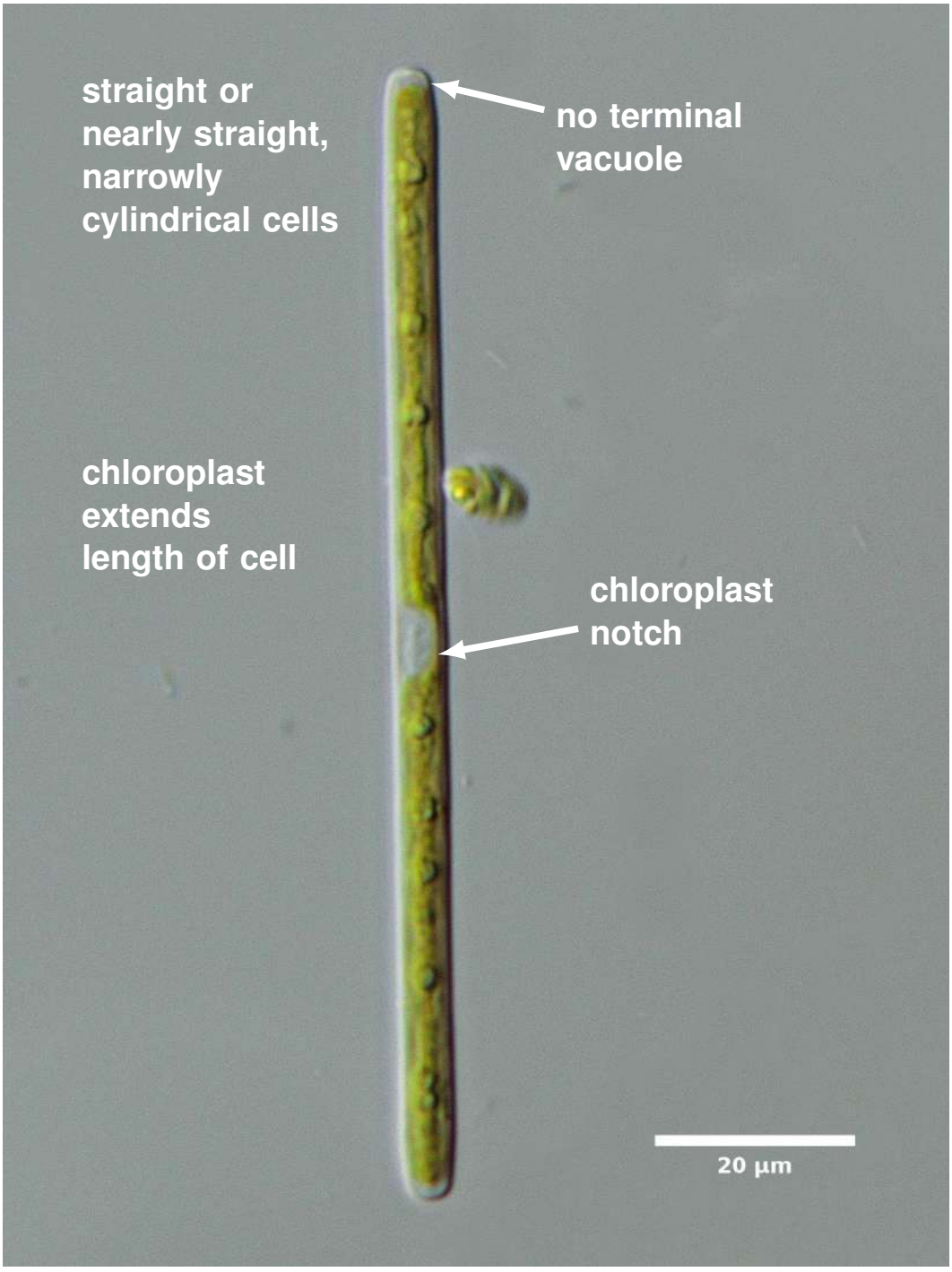


Figure 18.4: *Roya cambrica* (DIC), Myrtle Lake, Mountain Loop Highway, Snohomish County.



Figure 18.5: *Roya cambrica* (DIC), small pond on trail to Big Four Ice Caves, Mountain Loop Highway, Snohomish County.



Figure 18.6: *Roya cambrica* (DIC), small pond on trail to Big Four Ice Caves, Mountain Loop Highway, Snohomish County.

Chapter 19

Sphaerozosma Corda ex Ralfs

Northwest Washington taxa
Sphaerozosma vertebratum Brébisson ex Ralfs
Sphaerozosma vertebratum var. *latius* West & G. S. West

Table 19.1: Key to *Sphaerozosma* Species

A	Cell relatively large (width $\geq$ 30 μm), strongly compressed (L/W<0.7); with 2 horizontal rows of mucilage pores	*Sphaerozosma vertebratum* var. *latius* (Figures 19.4–19.6)
B	Cells relatively small (width <25 μm), uncompressed (L/W$\sim$1); without visible horizontal rows of pores	*Sphaerozosma vertebratum* (Figures 19.2–19.3)

Table 19.2: *Sphaerozosma* Cell Measurements

		Cell Width	Cell Length	Isthmus Width	L/W Ratio
Sphaerozosma	min	15.5 μm	17.3 μm	5.9 μm	0.9
vertebratum	med	19.6 μm	19.5 μm	7.2 μm	1.0
	max	22.7 μm	20.4 μm	7.8 μm	1.3
Sphaerozosma	min	30.5 μm	18.6 μm	7.5 μm	0.5
vertebratum	med	33.9 μm	19.7 μm	8.6 μm	0.6
var. *latius*	max	35.8 μm	21.1 μm	9.1 μm	0.6

Description

Sphaerozosma cells are medium sized, rectangular or elliptical in outline, with elliptical semi-cells and a deep, narrow sinus (Figures 19.1–19.6). The cells are joined by closely spaced, twisted, rod-like apical projections.

Sphaerozosma can be difficult to distinguish from *Onychonema* (Section 15, page 625), *Spondylosium* (Section 21, page 735), and *Teilingia* (Section 24, page 1207). Not surprisingly, many of the species in each genus have synonyms from one or more of the other genera in this group. The distinction between *Onychonema*, *Sphaerozosma*, *Spondylosium*, and *Teilingia* is based primarily on the way in which the cells are separated in the filament (Figure 19.1). *Sphaerozosma* cells are joined by narrowly spaced apical rods while *Onychonema* cells are joined by widely spaced apical rods. *Spondylosium* and *Teilingia* cells lack the distinctive rod-like apical projections, and instead have a smooth or granular apical surface.

Sphaerozosma vertebratum cells are rectangular in outline, with broadly elliptical semi-cells and a deep, open sinus (Figures 19.2–19.3). The cells are joined by twisted, rod-like apical extensions positioned near the center of the semi-cell apex. These extensions overlap with the extensions from adjacent cells, forming flat, or very slightly twisted filaments.

Sphaerozosma vertebratum* var. *latius is distinguished by its wide, strongly compressed cells and linear sinus that is closed (or very narrowly open) for most of its length (Figures 19.4–19.6). All of the northwest Washington specimens of this variety had very prominent horizontal rows of mucilage pores that look like paired granules on the lateral margin and are clearly visible as

double rows of pores in SEM images (Figure 19.5). One or more horizontal rows of pores is a diagnostic feature for both *Sphaerozosma aubertianum* West (no image available) and *Sphaerozosma vertebratum* (Coesel and Van Westen, 2013), and several taxonomic experts suggest merging *Sphaerozosma aubertianum* under *Sphaerozosma vertebratum* (see discussion by Croasdale, et al., 1983). Coesel and Meesters (2007) merge several varieties of *Sphaerozosma vertebratum*, including *Sphaerozosma vertebratum* var. *latius*, under the species *Sphaerozosma vertebratum*. But the northwest Washington specimens of var. *latius* were collected on multiple occasions from several sites, and are significantly different in size and appearance, so they have included as a separate variety.

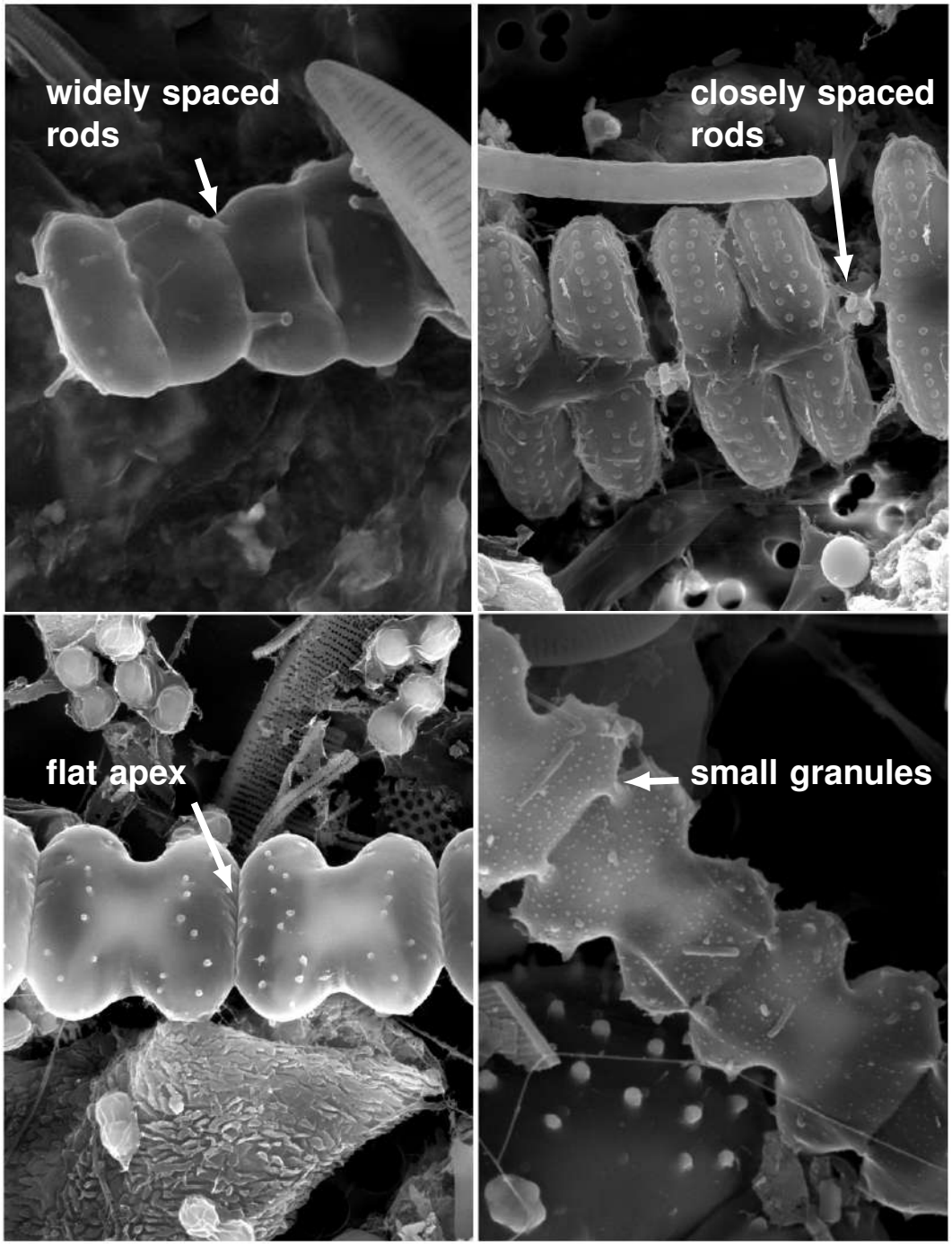


Figure 19.1: Comparison between cell linkages for *Onychonema* (upper left image), *Sphaerozosma* (upper right image), *Spondylosium* (lower left image), and *Teilingia* (lower right image).

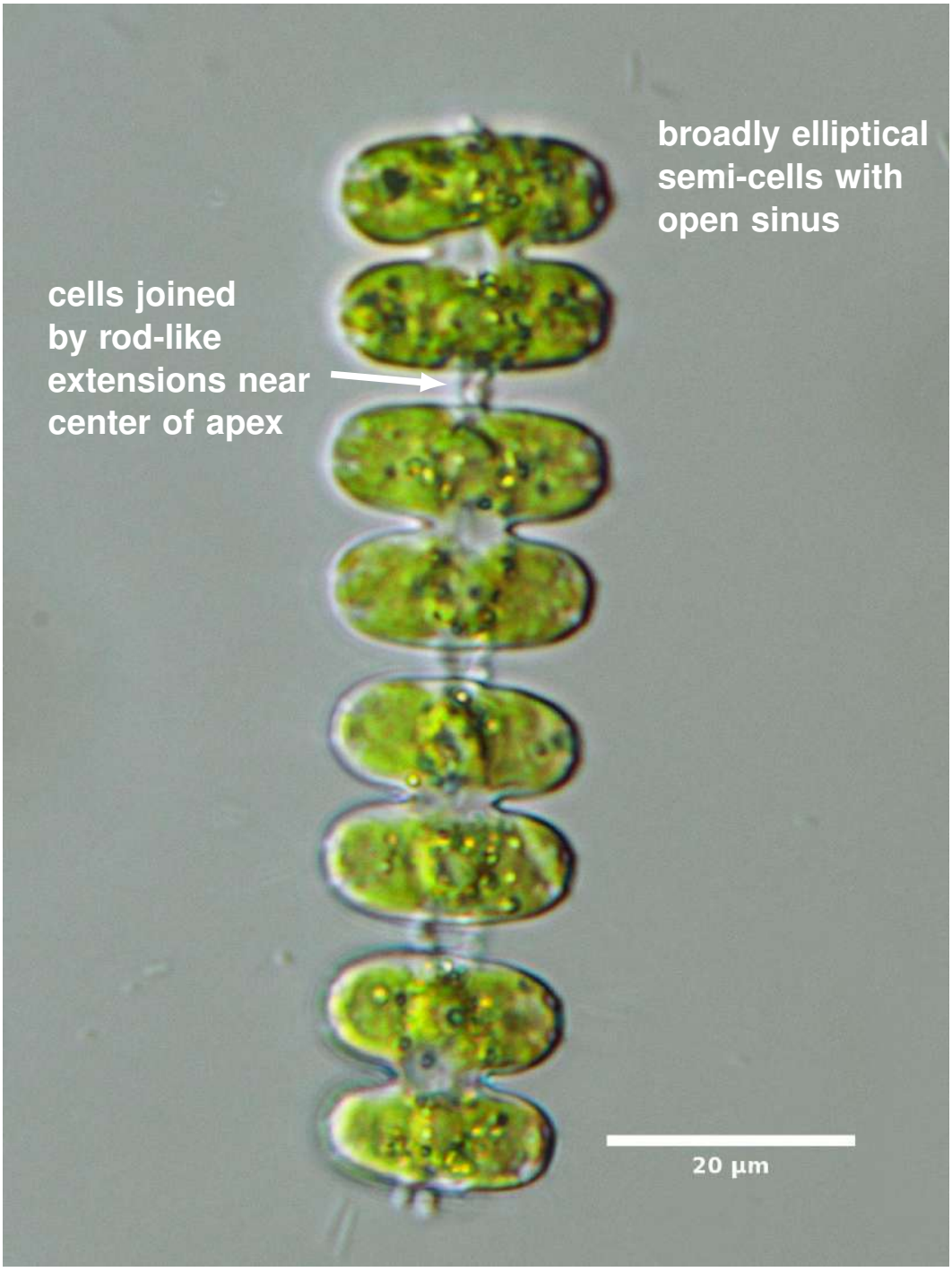


Figure 19.2: *Sphaerozosma vertebratum* (DIC), small residential pond on Valley Circle Drive, Snohomish County.

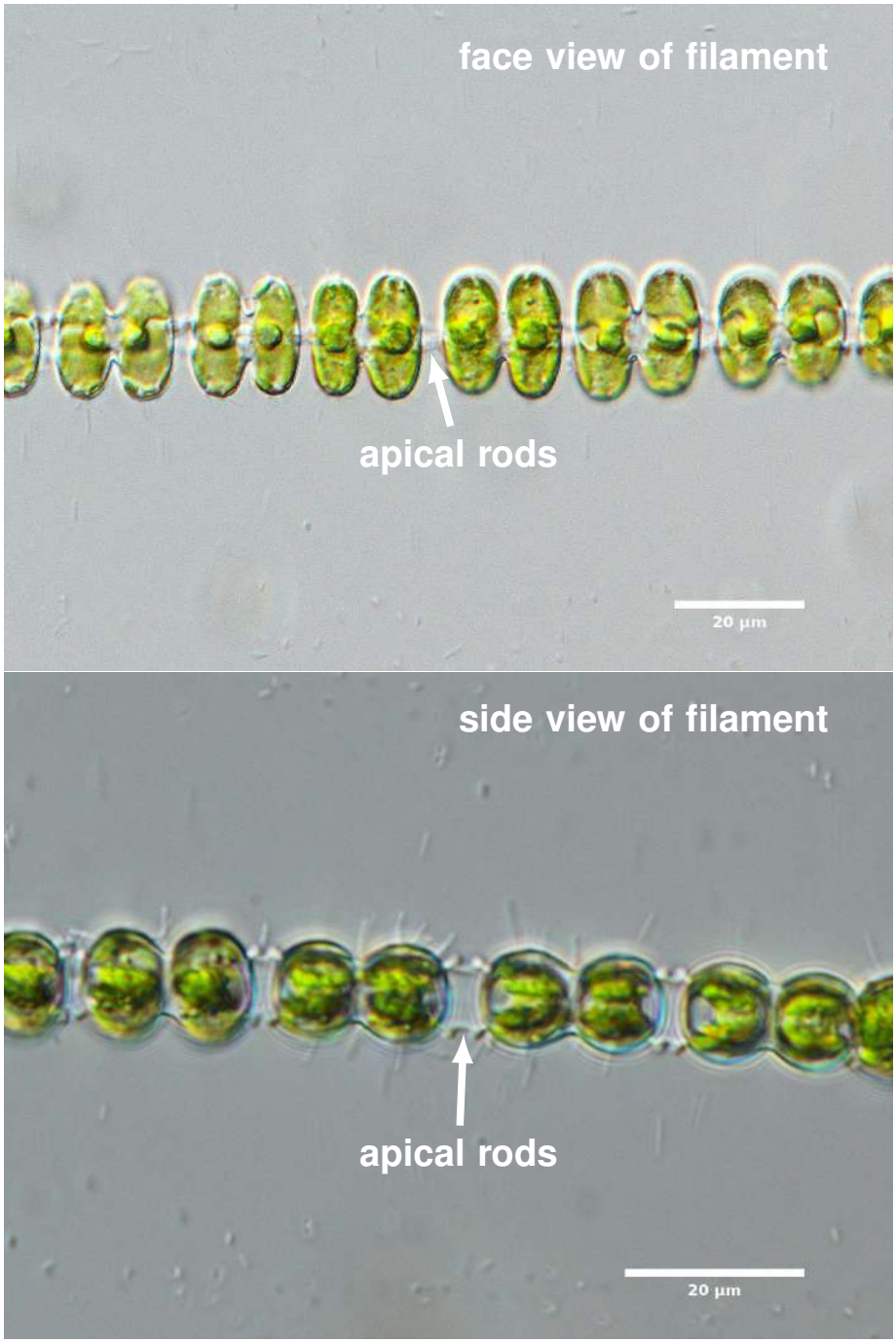


Figure 19.3: *Sphaerozosma vertebratum* (DIC/DIC), Vogler Lake, Skagit County (upper image); small residential pond on Valley Circle Drive, Snohomish County (lower image).

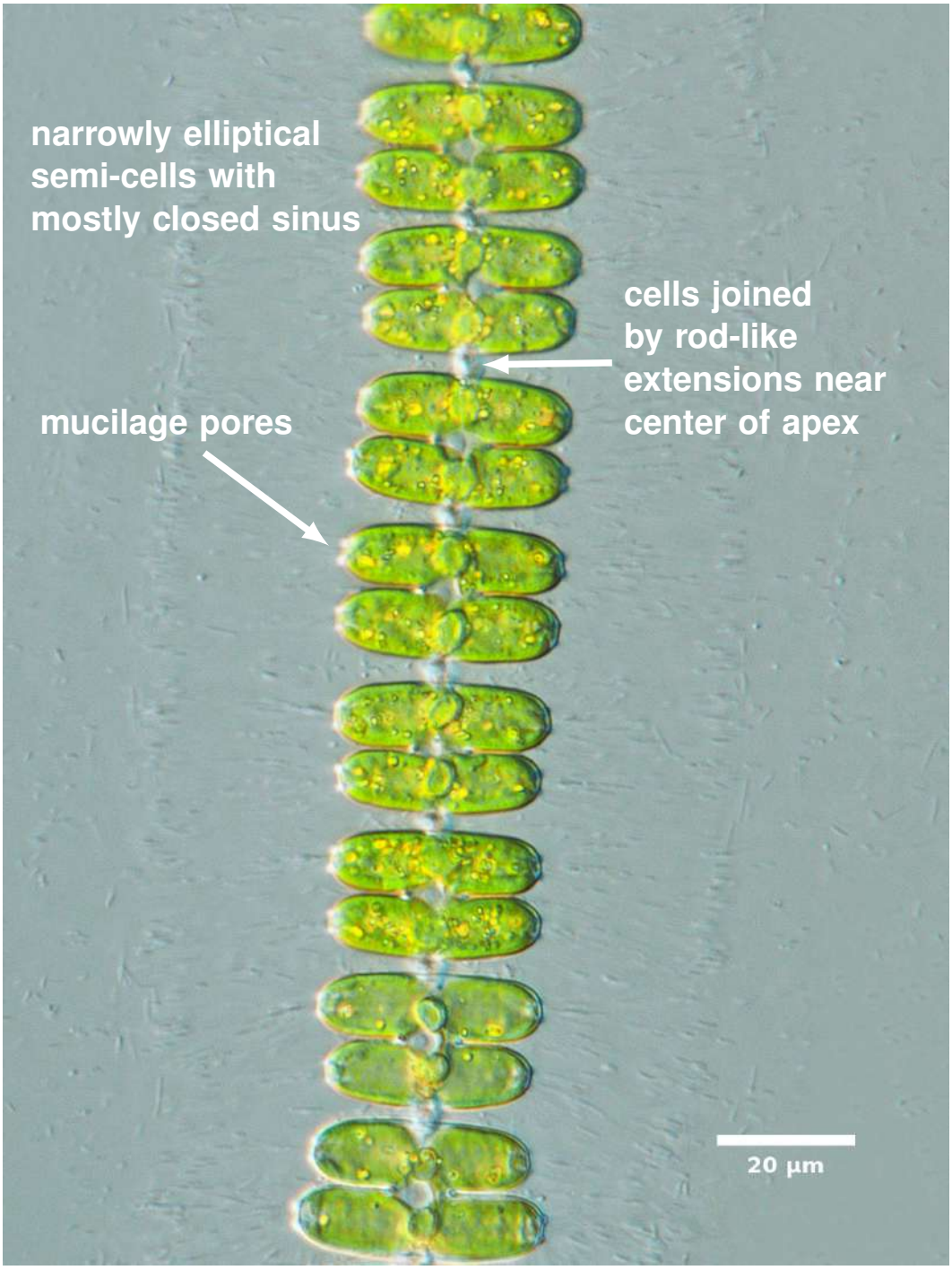
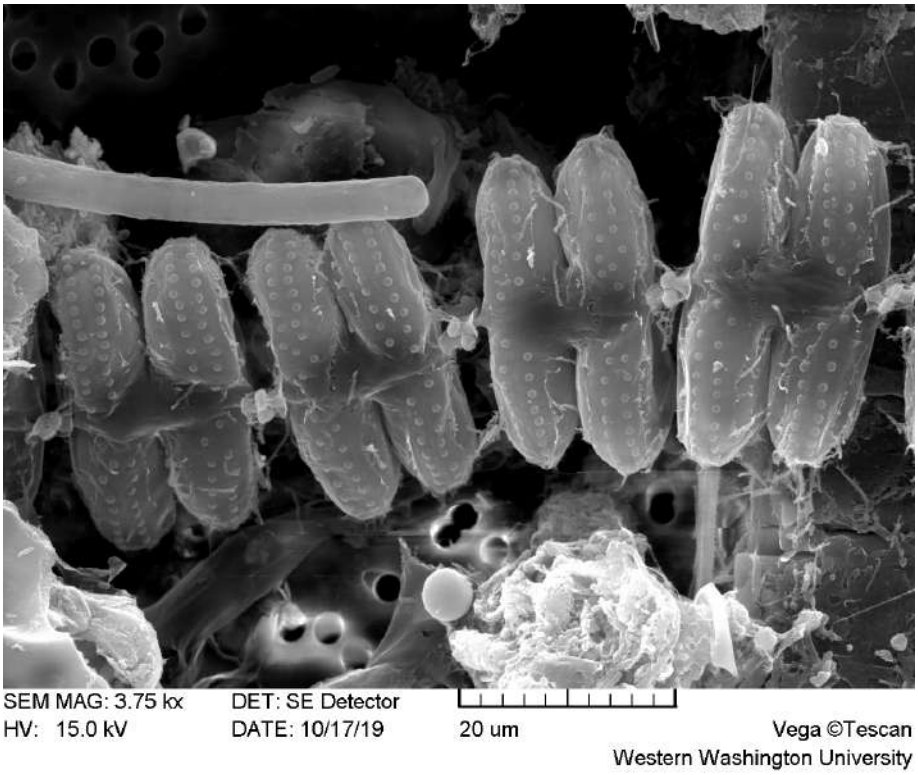


Figure 19.4: *Sphaerozosma vertebratum* var. *latius* (DIC), Pine Lake, Whatcom County.



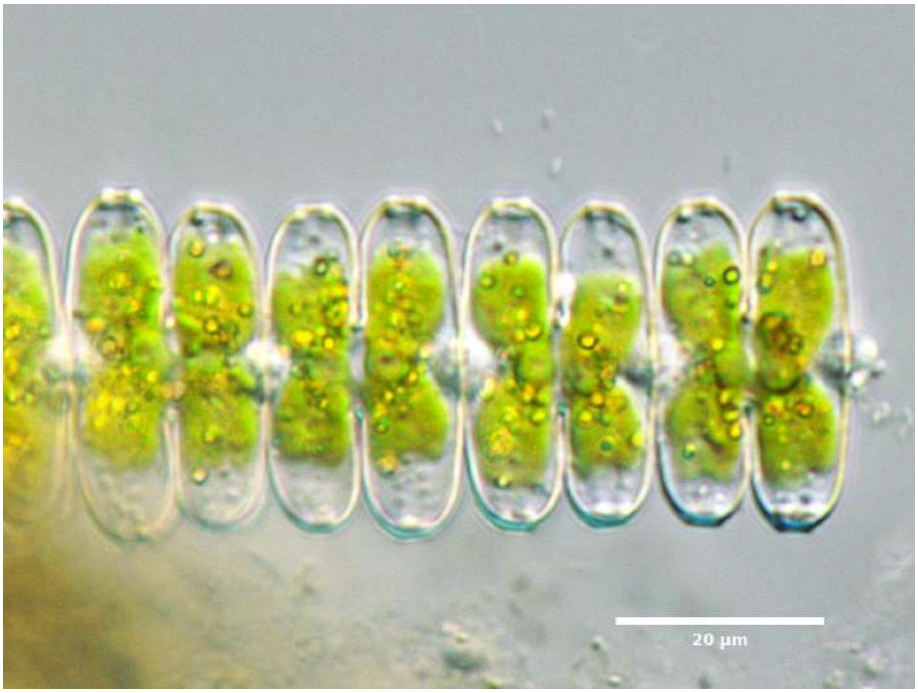


Figure 19.5: *Sphaerozosma vertebratum* var. *latius* (SEM/DIC), Pine Lake, Whatcom County (upper/lower images).



Figure 19.6: *Sphaerozosma vertebratum* var. *latius* (DIC), Fragrance Lake, Whatcom County.

Chapter 20

Spirotaenia Brébisson and *Tortitaenia* Brook

Northwest Washington taxa
Spirotaenia condensata Brébisson
Spirotaenia cf. *diplohelica* Coesel
Spirotaenia erythrocephala Itzigsohn
Tortitaenia alpina (Schmidle) A. J. Brook
Tortitaenia obscura (Ralfs) A. J. Brook

Table 20.1: Key to *Spirotaenia* and *Tortitaenia* Species

A	Chloroplast(s) ribbon-like, spiralling	
	A.1 Cell with a single spiralling chloroplast	
	A.1a Cell length $\geq$100 μm; chloroplasts without reddish orange end caps (usually)	*Spirotaenia condensata* (Figures 20.1–20.4)

continued on next page

Table 20.1: Key to *Spirotaenia* and *Tortitaenia* Species, continued

	A.1b Cell length $\leq$50 μm; conspicuous reddish orange end caps on one or both ends of chloroplast	*Spirotaenia erythrocephala* (Figures 20.6–20.8)
	A.2 Cells with two chloroplasts spiralling in opposite directions to form helix; conspicuous reddish orange end caps on one or both ends of chloroplast	*Spirotaenia* cf. *diplohelica* (Figure 20.5)
B	Chloroplast ridged (not ribbon-like), forming dense axial spiral; conspicuous reddish orange end caps on one or both ends of chloroplast	
	B.1 Cell length $\leq$50 μm	*Tortitaenia alpina* (Figures 20.9–20.10)
	B.2 Cell length $\geq$70 μm	*Tortitaenia obscura* (Figures 20.11–20.13)

Table 20.2: *Spirotaenia* and *Tortitaenia* Cell Measurements

		Cell Width	Cell Length	Isthmus Width	L/W Ratio
Spirotaenia condensata	min	16.4 μm	119.6 μm	–	5.5
	med	21.7 μm	134.7 μm	–	6.4
	max	29.3 μm	228.8μm	–	8.4
Spirotaenia	min	–	–	–	–
cf. *diplohelica*[†]	med	6.6 μm	40.9 μm	–	6.2
	max	–	–	–	–

[†]*summary statistics based on <5 cells*

continued on next page

Table 20.2: *Spirotaenia*/*Tortitaenia* Cell Measurements, continued

		Cell Width	Cell Length	Isthmus Width	L/W Ratio
Spirotaenia	min	4.4 μm	25.8 μm	–	4.4
erythrocephala	med	5.7 μm	33.2 μm	–	5.6
	max	8.5 μm	44.9 μm	–	8.6
Tortitaenia alpina	min	10.3 μm	44.2 μm	–	4.3
	med	10.6 μm	50.1 μm	–	4.7
	max	10.8 μm	58.4 μm	–	5.5
Tortitaenia obscura	min	15.5 μm	90.2 μm	–	5.7
	med	16.3 μm	97.0 μm	–	5.8
	max	17.4 μm	125.8 μm	–	8.1

[†]Summary statistics based on <5 cells

Description

Spirotaenia and *Tortitaenia* cells are cylindrical or fusiform and lack a discernible sinus, appearing morphologically similar to saccoderm desmids.[37] Both genera divide transversely, resulting in asymmetric daughter cells following cell division. *Spirotaenia* cells contain one or two flat, ribbon-like chloroplast that spirals around the inside of the cell wall (Figures 20.1–20.8). *Tortitaenia* cells contain one ridged chloroplast, with the ridges forming a spiral up the inside of the cell (Figures 20.9–20.13). Although the *Spirotaenia* chloroplast structure is usually obvious, the shape of the *Tortitaenia* chloroplast is frequently obscured by accumulated starch granules. Both genera may occur as solitary cells or form small groups of 2–4 cells enclosed in a diffuse mucilage and lined up parallel to the long axis of the cell.

Spirotaenia condensata is very common in northwest Washington lakes, ponds, and wetlands. The cells are large and cylindrical (cigar-shaped), with a single, flat, densely spiralling, chloroplast (Figures 20.1–20.4). The cell wall is smooth, but may exudes strands of mucilage or have surface epiphytes that resemble small hairs or cilia (Figure 20.4). Although this species is not described as having reddish

[37] Gontcharov and Melkonian (2004) suggest that *Spirotaenia* and some species of *Tortitaenia* should not be classified as desmids, but both genera will be included in this guide because of their superficial resemblance to saccoderm desmids.

orange end caps on the chloroplasts, it is a feature common in other members of this genus, and the cell in Figure 20.2 appears to have a faint reddish region on the apex of the chloroplast.

Spirotaenia diplohelica is an uncommon species of *Spirotaenia* characterized by small, fusiform cells and double spiralling chloroplasts that form a helix (Figure 20.5). The chloroplasts come together at the apex, appearing to originate at the bright reddish orange end caps. *Spirotaenia diplohelica* closely resembles *Spirotaenia erythrocephala* in size, appearance, and habitat. Only one specimen of this taxon was present in the northwest Washington samples, so the species identification is uncertain.

Spirotaenia erythrocephala can be distinguished by its small, fusiform cells (Figures 20.6–20.8). The cells contain a single, ribbon-like, spiralling chloroplast. *Spirotaenia erythrocephala* also has bright reddish orange end caps at one or both ends of the cell. The species name (*erythrocephala*) is derived from ancient Greek, and means red-head.

Tortitaenia alpina cells are small and fusiform, with nearly parallel sides along the center of the cell, then abruptly tapered and rounded near the apex (Figures 20.9–20.10). The single chloroplast is so dense that the features are difficult to see, but it does not form flat, ribbon-like spirals that characterize *Spirotaenia*. Reddish orange end caps are often present on one or both ends of the chloroplast. *Tortitaenia alpina* resembles *Tortitaenia obscura*, which is much larger.

Tortitaenia obscura cells are also fusiform, with nearly parallel sides, an abruptly tapered, rounded apex, and reddish orange end caps on one or both ends of the dense chloroplast (Figures 20.11–20.13). The cells are much larger than *Tortitaenia alpina* and are longer relative to width, resulting in a higher L/W ratio.



Figure 20.1: *Spirotaenia condensata* (DIC), Canyon Lake, Whatcom County.



Figure 20.2: *Spirotaenia condensata* (DIC), Vogler Lake, Skagit County.



Figure 20.3: *Spirotaenia condensata* (DIC), small residential pond on Valley Circle Drive, Snohomish County.

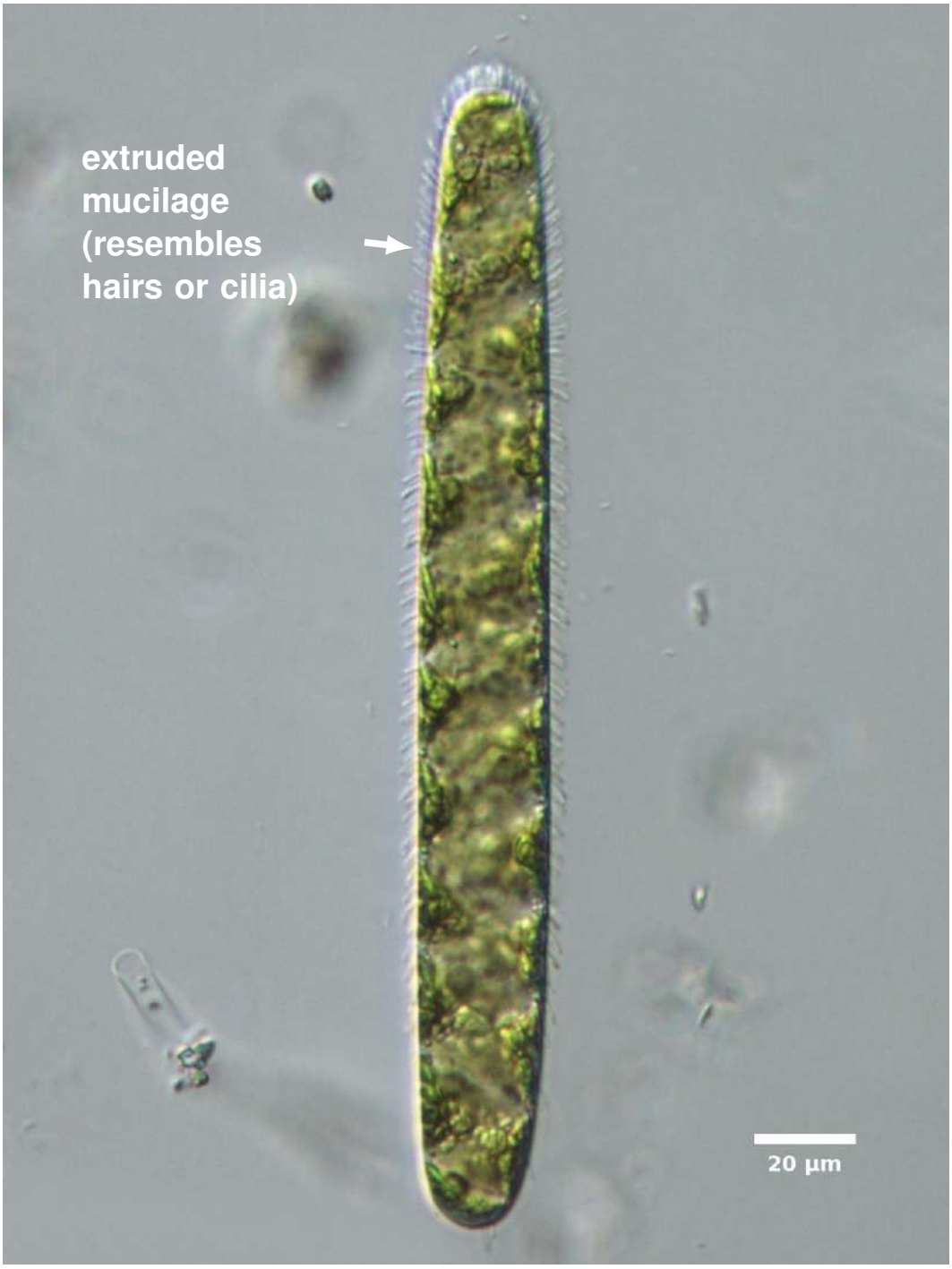


Figure 20.4: *Spirotaenia condensata* (DIC), Vogler Lake, Skagit County.

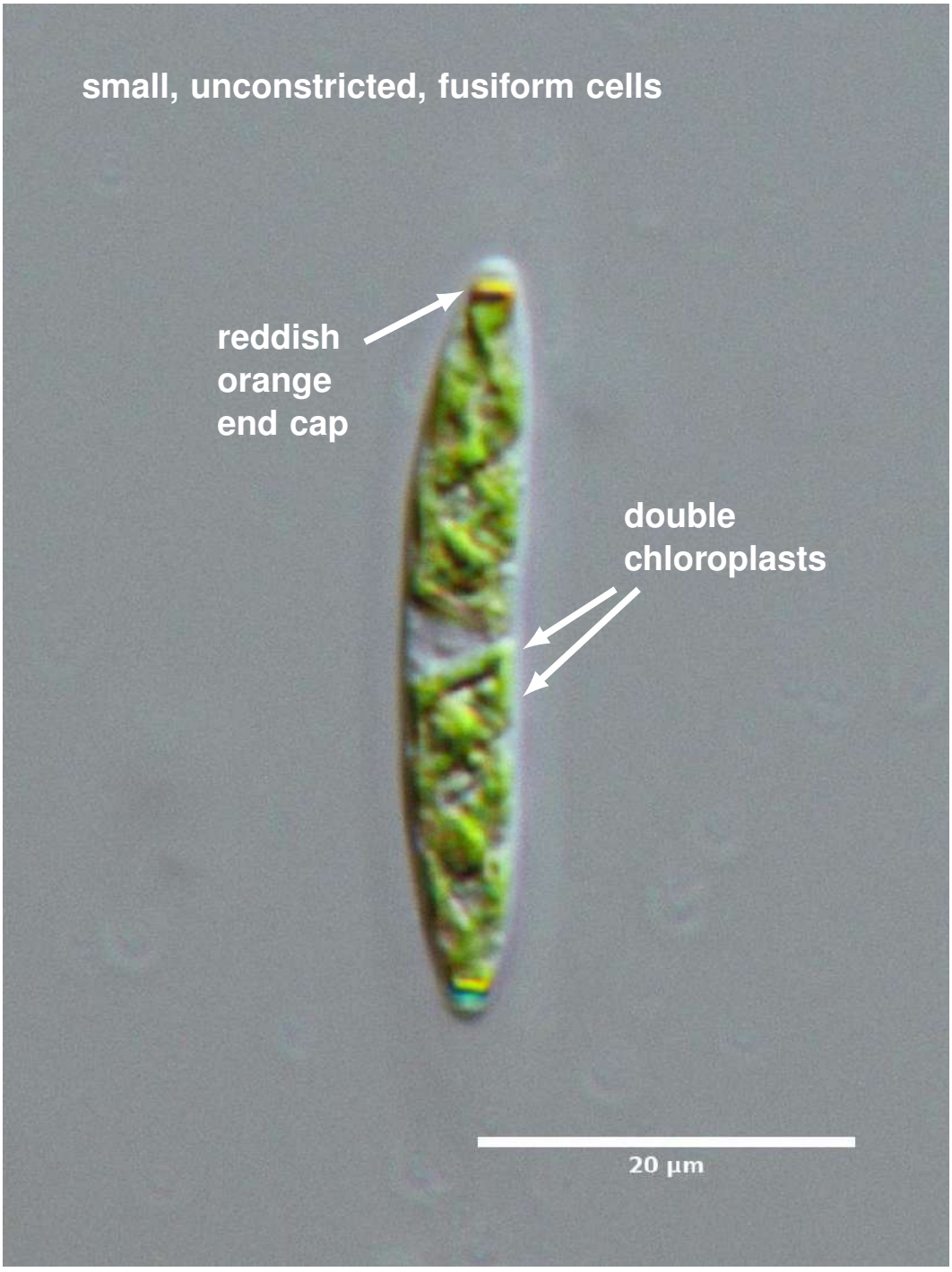


Figure 20.5: *Spirotaenia* cf. *diplohelica* (DIC), small pond near Canyon Lake, Whatcom County.



Figure 20.6: *Spirotaenia erythrocephala* (DIC), side channel of Chain Lake, Gifford Pinchot National Forest, Skamania County.



Figure 20.7: *Spirotaenia erythrocephala* (DIC), Sunrise Lake, Mt. Baker area, Whatcom County.



Figure 20.8: *Spirotaenia erythrocephala* (DIC), Gold Basin Mill Pond, Mountain Loop Highway, Snohomish County.

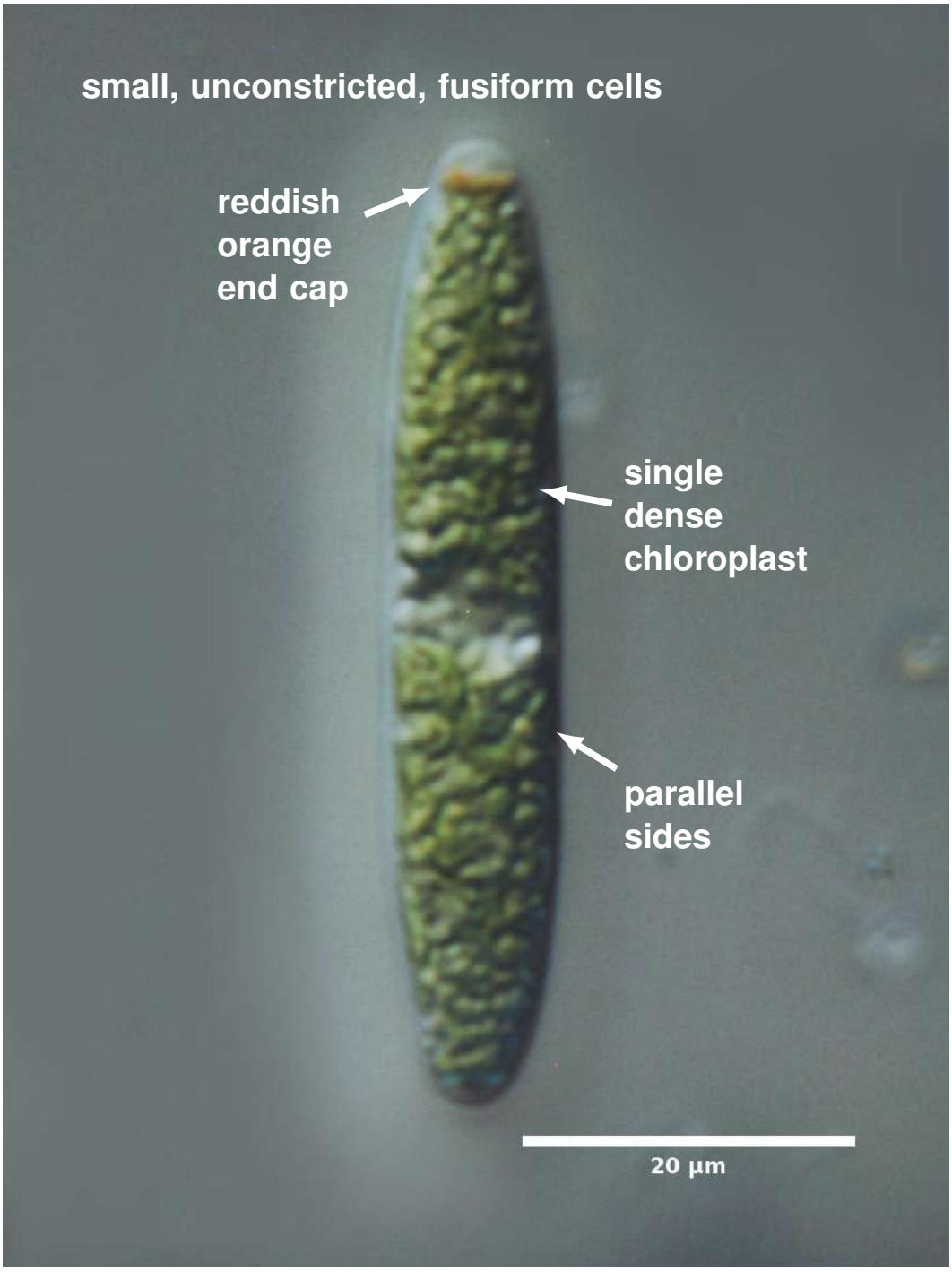


Figure 20.9: *Tortitaenia alpina* (DIC), small pond near Laurel Washington, Whatcom County.

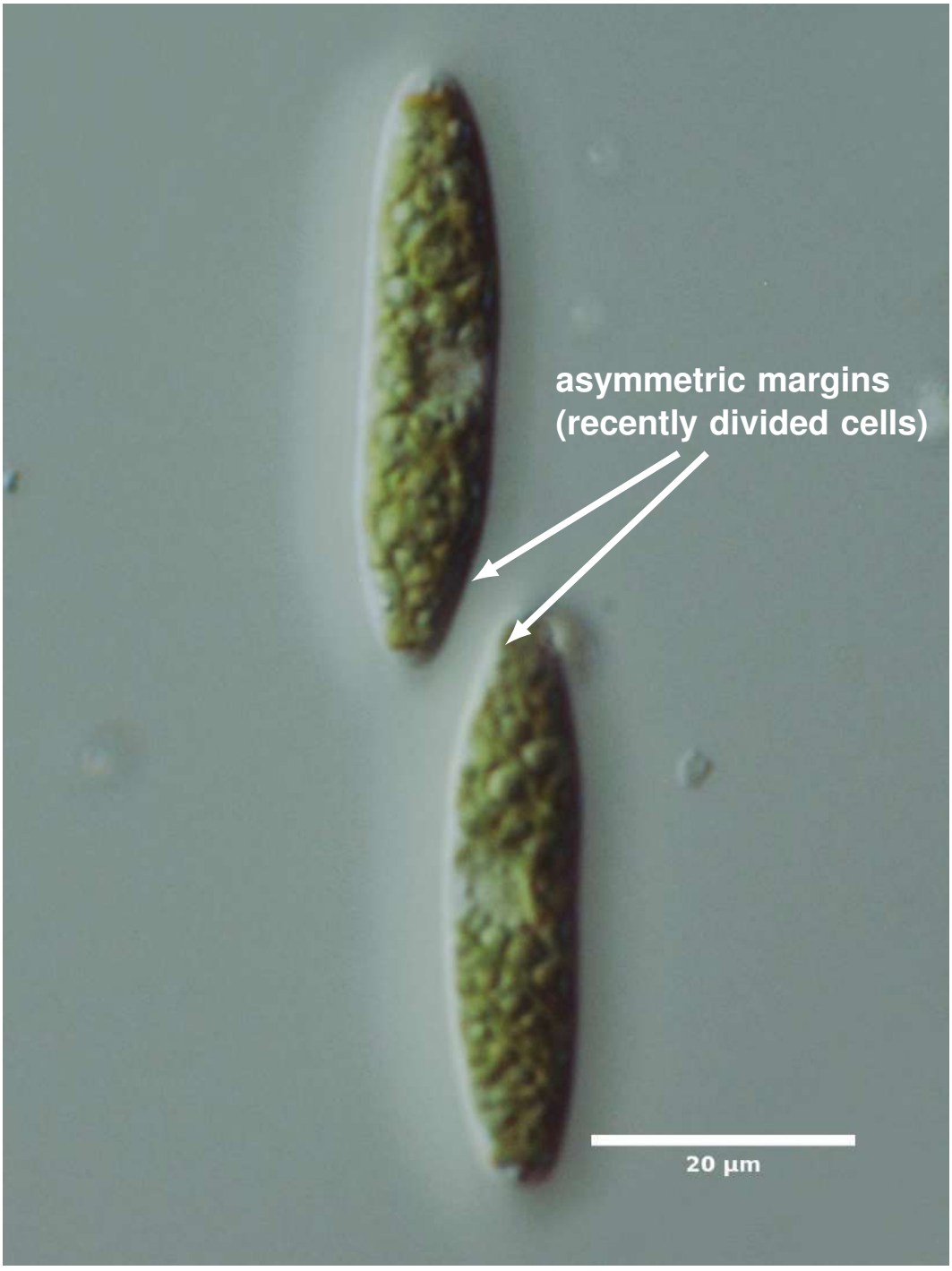


Figure 20.10: *Tortitaenia alpina* (DIC), small pond near Laurel Washington, Whatcom County.

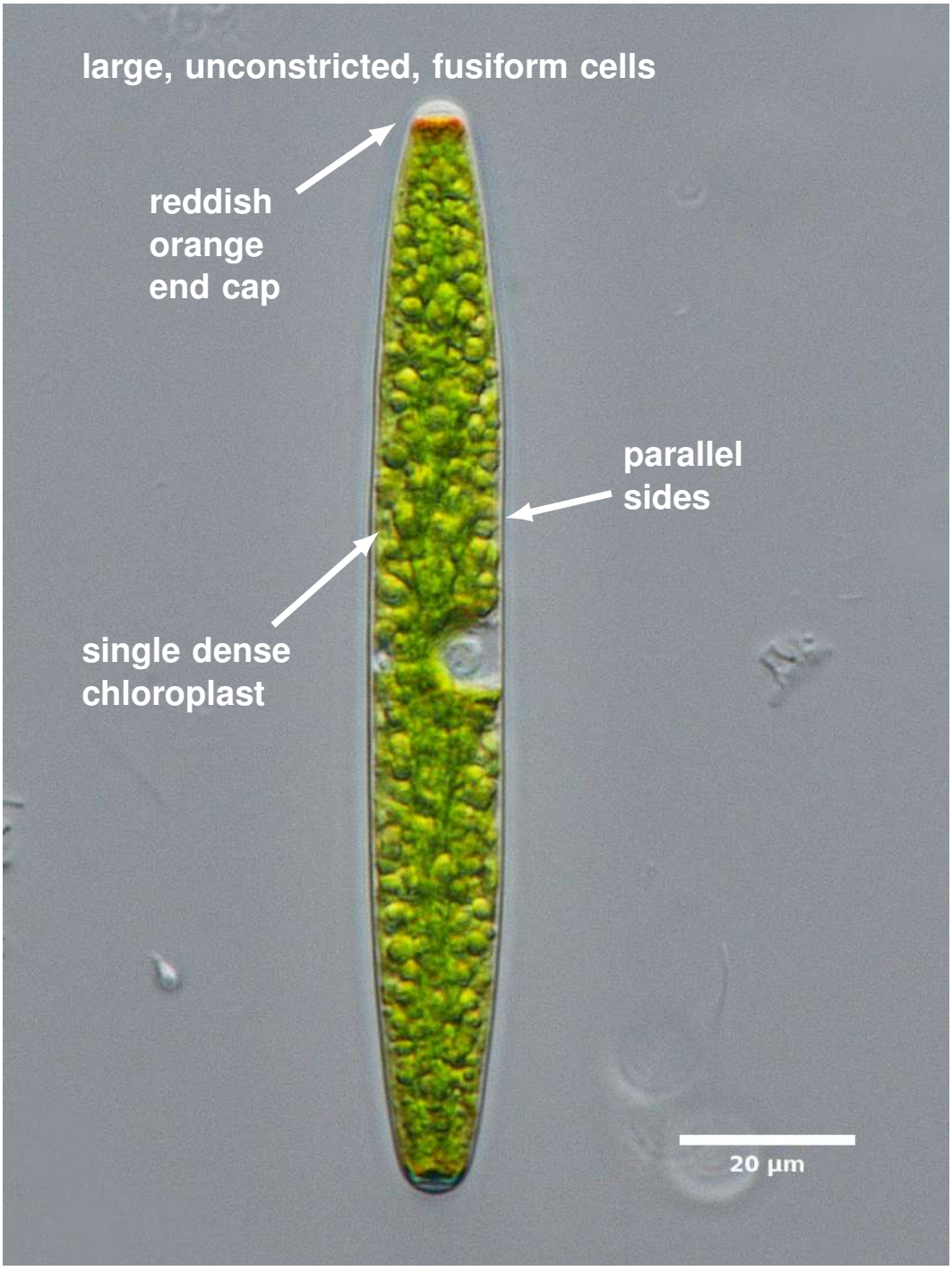


Figure 20.11: *Tortitaenia obscura* (DIC), side channel of Chain Lake, Gifford Pinchot National Forest, Skamania County.



Figure 20.12: *Tortitaenia obscura* (DIC), Chain Lake, Gifford Pinchot National Forest, Skamania County.



Figure 20.13: *Tortitaenia obscura* (DIC), side channel of Chain Lake, Gifford Pinchot National Forest, Skamania County.

Chapter 21

Spondylosium Brébisson ex Kützing

Northwest Washington taxa
Spondylosium cf. *javanicum* (Gutwinski) Gröblad
Spondylosium moniliforme Lundell
Spondylosium planum (Wolle) West & G. S. West
Spondylosium pulchrum (Bailey) W. Archer

Table 21.1: Key to *Spondylosium* Species

A	Cells triangular in cross-section; apex dome-shaped; sinus broad and open	
A.1	Semi-cells oval or broadly elliptical, not extended into distinct lateral lobes	*Spondylosium moniliforme* (Figures 21.5–21.7)
A.2	Semi-cells elliptical and compressed, forming distinct lateral lobes	*Spondylosium* cf. *javanicum* (Figures 21.2–21.3)

continued on next page

Table 21.1: Key to *Spondylosium* Species, continued

B	Cells flattened in cross-section; apex flat or slightly elevated but not dome-shaped	
B.1	Cells small (width <20 μm); length and width approximately equal (L/W $\approx$1); apex flat	*Spondylosium planum* (Figures 21.8–21.12)
B.2	Cells large (width >70 μm); compressed (L/W < 0.7); cells joined by apical extension	*Spondylosium pulchrum* (Figures 21.13–21.16)

Table 21.2: *Spondylosium* Cell Measurements

		Cell Width	Cell Length	Isthmus Width	L/W Ratio
Spondylosium	min	21.8 μm	23.4 μm	7.7 μm	1.0
cf. *javanicum*	med	22.7 μm	24.1 μm	8.2 μm	1.0
	max	24.1 μm	25.1 μm	8.4 μm	1.1
Spondylosium moniliforme	min	22.8 μm	31.4 μm	8.8 μm	1.1
	med	26.5 μm	32.9 μm	10.3 μm	1.2
	max	28.7 μm	34.9 μm	11.4 μm	1.5
Spondylosium planum	min	11.9 μm	11.1 μm	5.1 μm	0.7
	med	13.9 μm	12.1 μm	6.7 μm	0.9
	max	17.2 μm	13.2 μm	7.7 μm	1.1
Spondylosium pulchrum	min	71.7 μm	33.8 μm	19.1 μm	0.5
	med	74.8 μm	43.5 μm	21.0 μm	0.6
	max	81.6 μm	51.9 μm	22.8 μm	0.7

Description

Spondylosium semi-cells are oval or elliptical, with a deep, open sinus and smooth cell walls (Figures 21.1–21.16). The cells are joined by a smooth apical surface that lacks granules or rod-like extensions. *Spondylosium* can be difficult to distinguish from *Onychonema* (Section 15, page 625), *Sphaerozosma* (Section 19, page 707), and *Teilingia* (Section 24, page 1207). Not surprisingly, many of the species in each genus have synonyms from one or more of the other genera in this group. The distinction between *Onychonema*, *Sphaerozosma*, *Spondylosium*, and *Teilingia* is based primarily on the way in which the cells are separated in the filament (Figure 21.1). *Onychonema* and *Sphaerozosma* cells are joined by rod-like structures and the cells are clearly separated from each other in the filament. *Teilingia*, which looks very similar to some species of *Spondylosium*, has tiny, inconspicuous apical granules, a flat apex, and very closely spaced cells. These types of specimens will be particularly challenging to separate.

The specimens in Figures 21.2–21.3 are tentatively identified as ***Spondylosium* cf. *javanicum***, which is characterized by small, oval cells with slightly compressed, elliptical semi-cells and a widely open sinus. The apex is slightly convex (domed); the lateral margin is extended into broadly rounded, lateral lobes. This species is generally considered to be associated with warm, tropical lakes; Croasdale, et al. (1983) stated that this species was not reported from North America. But Williams (2001) found *Spondylosium javanicum* in a lake in western Ireland, which shares many environmental similarities to northwest Washington. Williams acknowledged that it seemed unusual to find a "tropical desmid" in western Ireland. The northwest Washington specimens were collected from Lake Terrell during the summer of 2013. *Spondylosium moniliforme*, a similar appearing species, was present in Lake Terrell in 2012 (Figure 21.4). The primary difference between these two species is the appearance of the lateral margin, which is rounded in *Spondylosium moniliforme* and extended into lateral lobes in *Spondylosium javanicum*. It is possible that extended lateral lobes are a morphological variation in *Spondylosium moniliforme*.

Spondylosium moniliforme cells are oval in outline, slightly elongated (L/W>1), with broadly elliptical or oval semi-cells and a widely open sinus (Figures 21.5–21.7). The apex is slightly convex (domed). The lateral margin merges smoothly with the apex, so the semi-cells are triangular in outline, unlike *Spondylosium* cf. *javanicum*, which has distinctly extended lateral lobes (Figure 21.4). The cells are joined along the domed apex, forming slightly twisted filaments.

Spondylosium planum is by far the most common species in northwest Washington lakes and ponds. The cells are small, flattened, and rectangular, with broadly rounded, elliptical semi-cells (Figures 21.8–21.12). The cells are joined across most of the flat apex, forming long, untwisted filaments. The semi-cells are deeply constricted, with an open, V-shaped sinus. *Spondylosium planum* is common in both planktonic and shoreline samples. Solitary cells are occasionally present, especially in planktonic samples, and can be confused with small species of *Cosmarium*.[38]

Spondylosium pulchrum cells are relatively large, rectangular, and flattened in cross-section (Figures 21.13–21.16). The semi-cells are narrowly elliptical, with a deep, open, V-shaped sinus. The cells are joined by a short, smooth extension of the apical margin, forming long, twisted filaments. *Spondylosium pulchrum* resembles *Sphaerozosma vertebratum* var. *latius* (Figure 19.4), which has cells joined by rod-like apical extensions.

[38] See **Freshwater Algae in Northwest Washington, Volume III. Part B.**

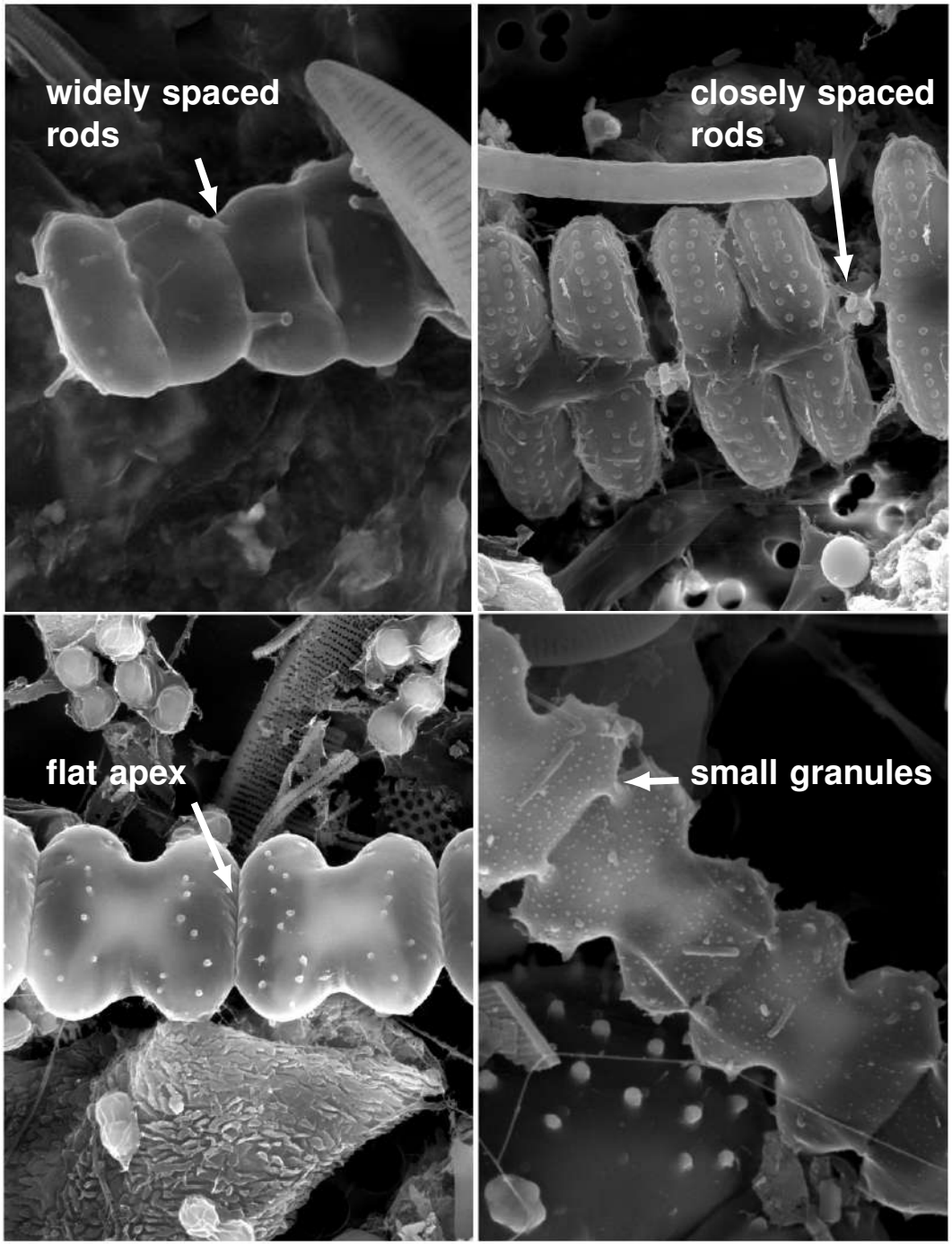


Figure 21.1: Comparison between cell linkages for *Onychonema* (upper left image), *Sphaerozosma* (upper right image), *Spondylosium* (lower left image), and *Teilingia* (lower right image).

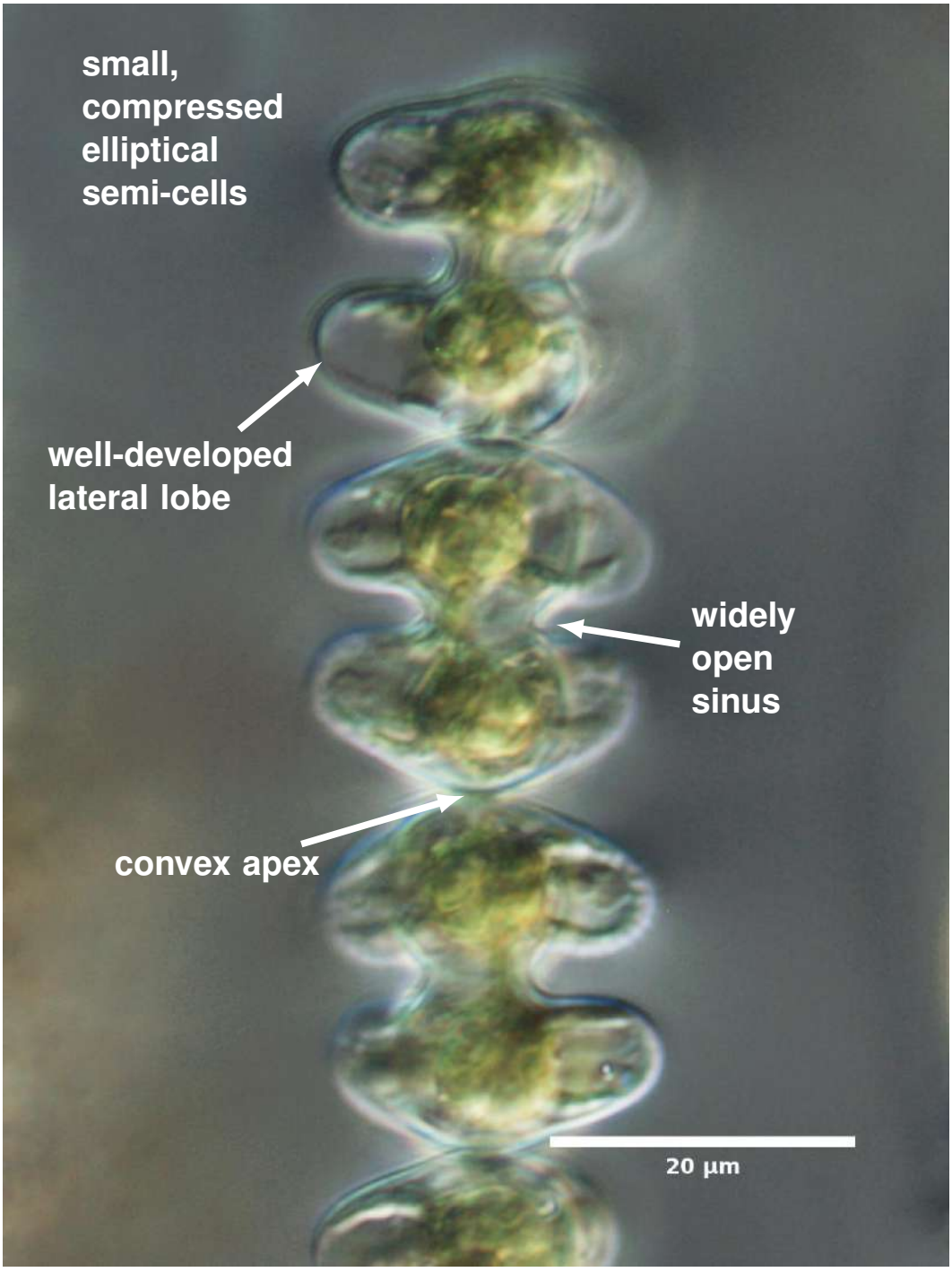


Figure 21.2: *Spondylosium* cf. *javanicum* (DIC), Lake Terrell, Whatcom County.

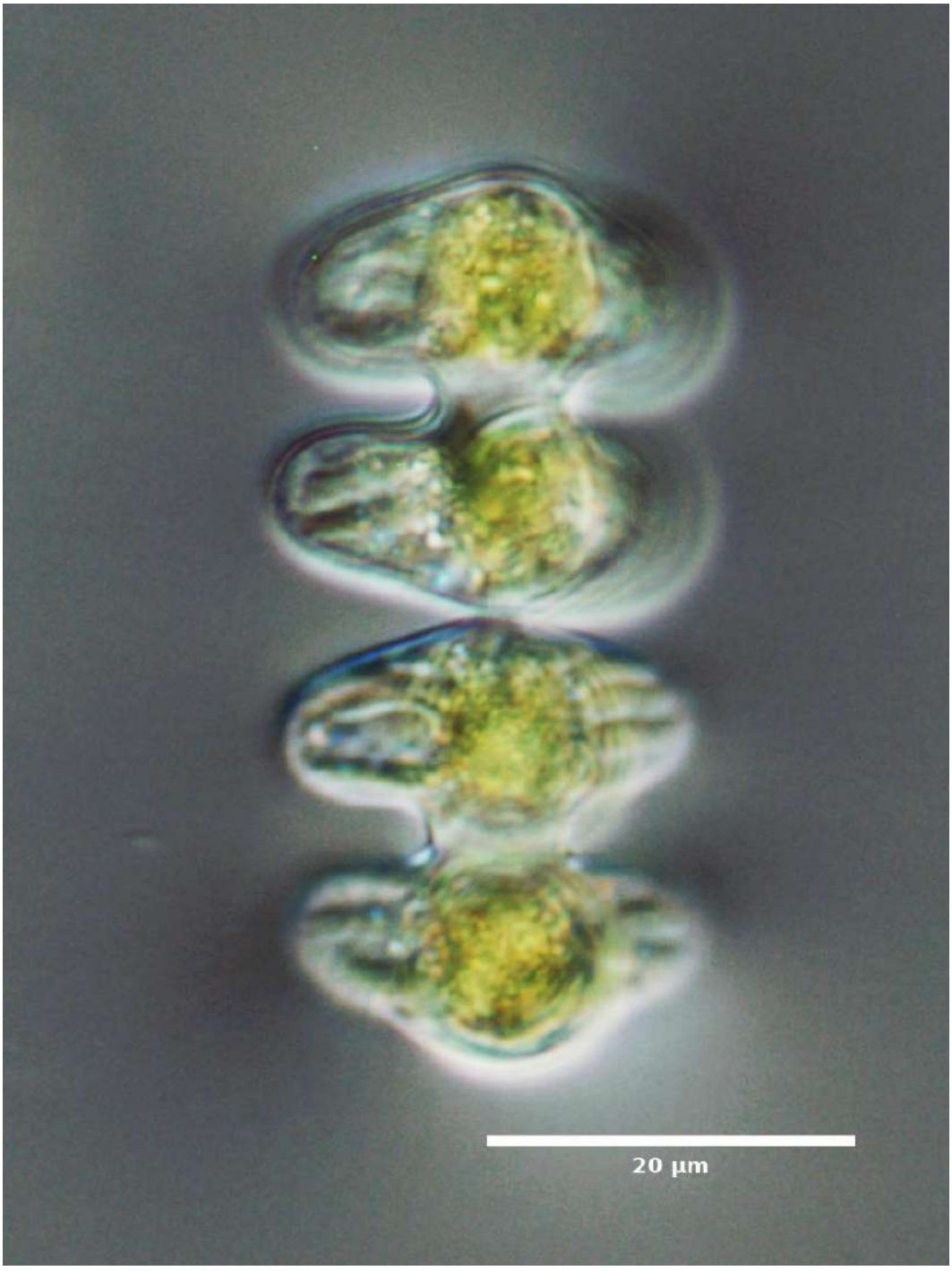


Figure 21.3: *Spondylosium* cf. *javanicum* (DIC), Lake Terrell, Whatcom County.

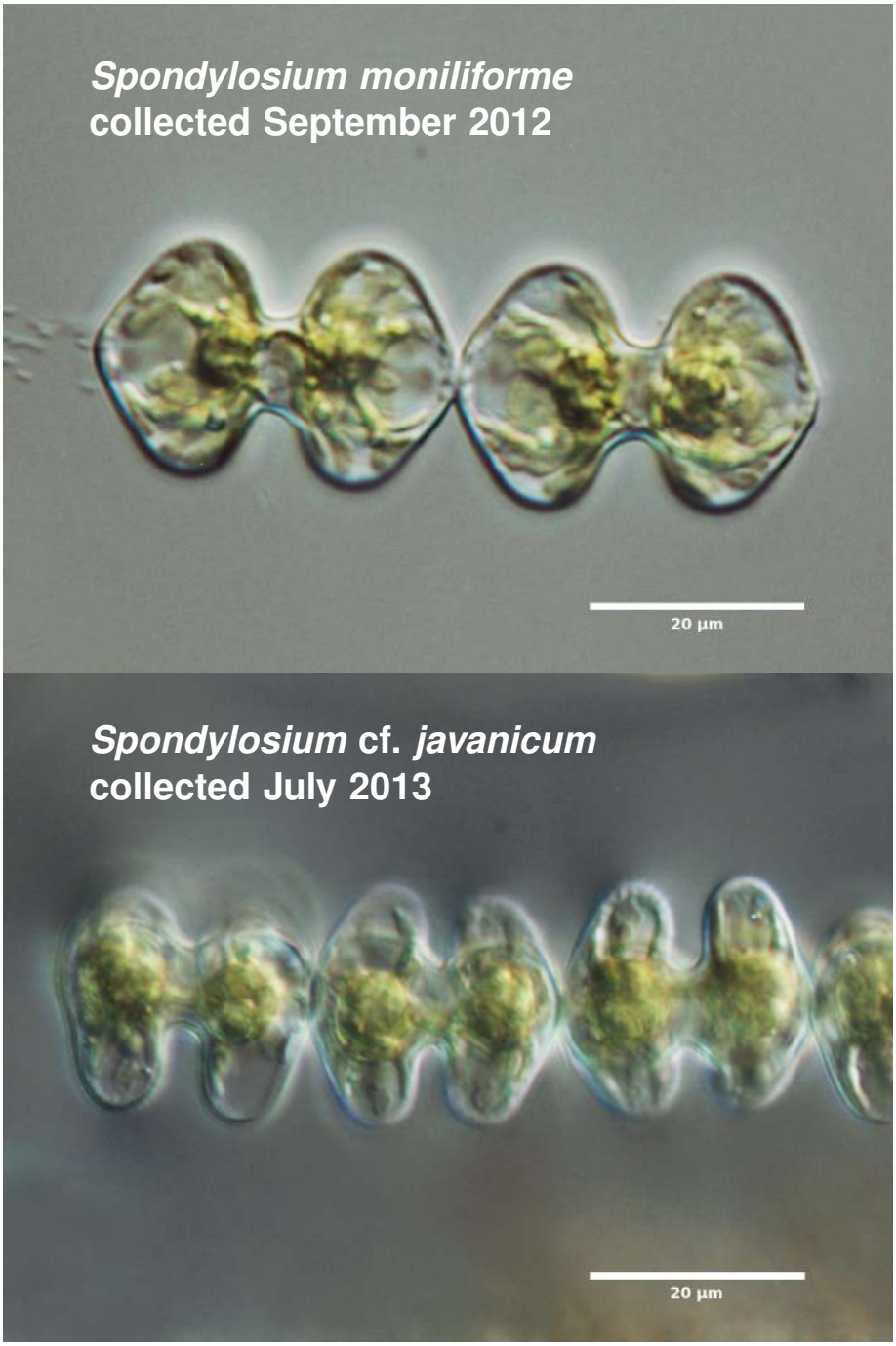


Figure 21.4: *Spondylosium moniliforme* and *Spondylosium* cf. *javanicum* (DIC/DIC), Lake Terrell, Whatcom County (upper/lower images).



Figure 21.5: *Spondylosium moniliforme* (DIC), Squires Lake, Whatcom County.

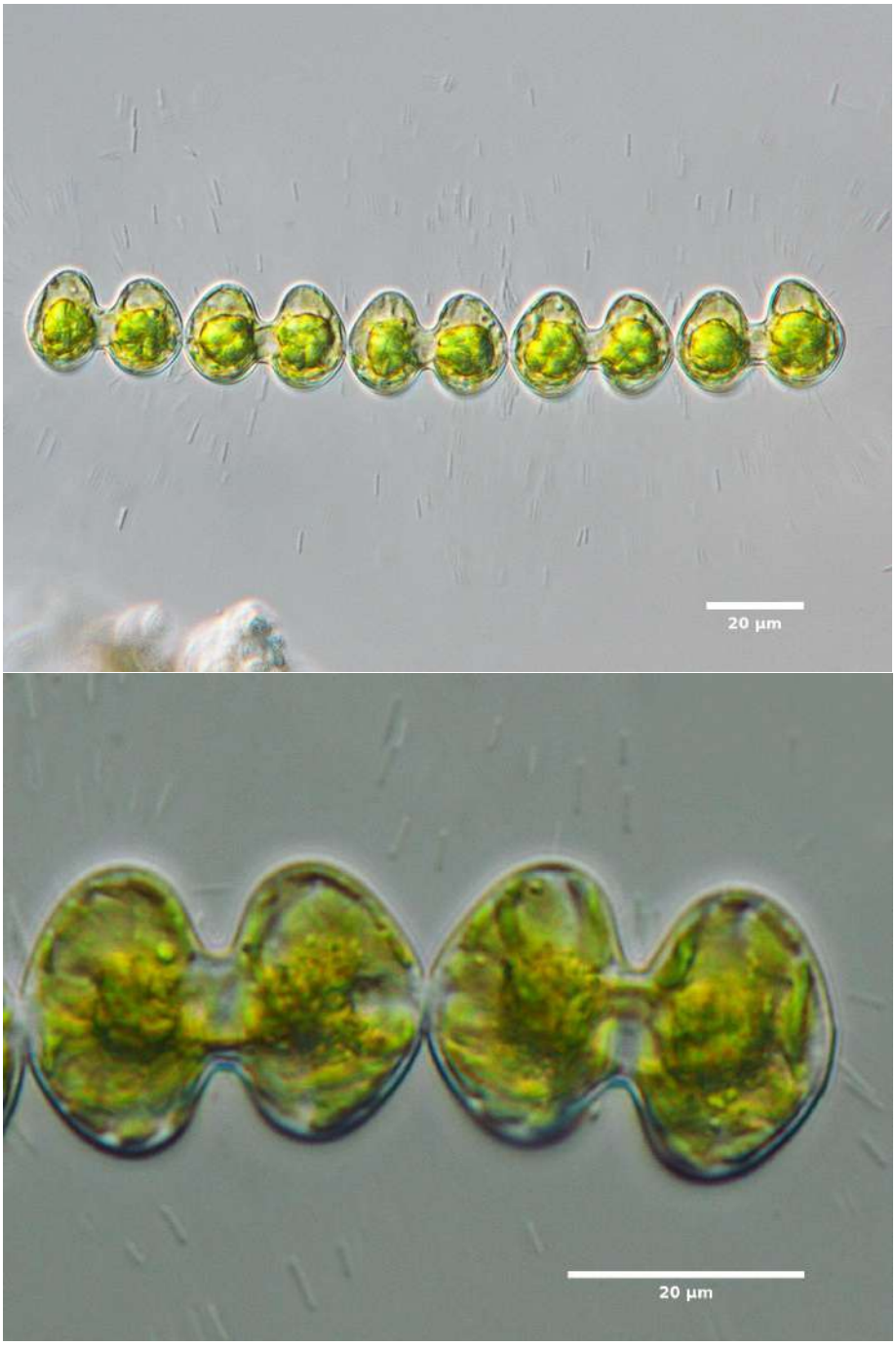


Figure 21.6: *Spondylosium moniliforme* (DIC/DIC), Squires Lake, Whatcom County (upper/lower images).

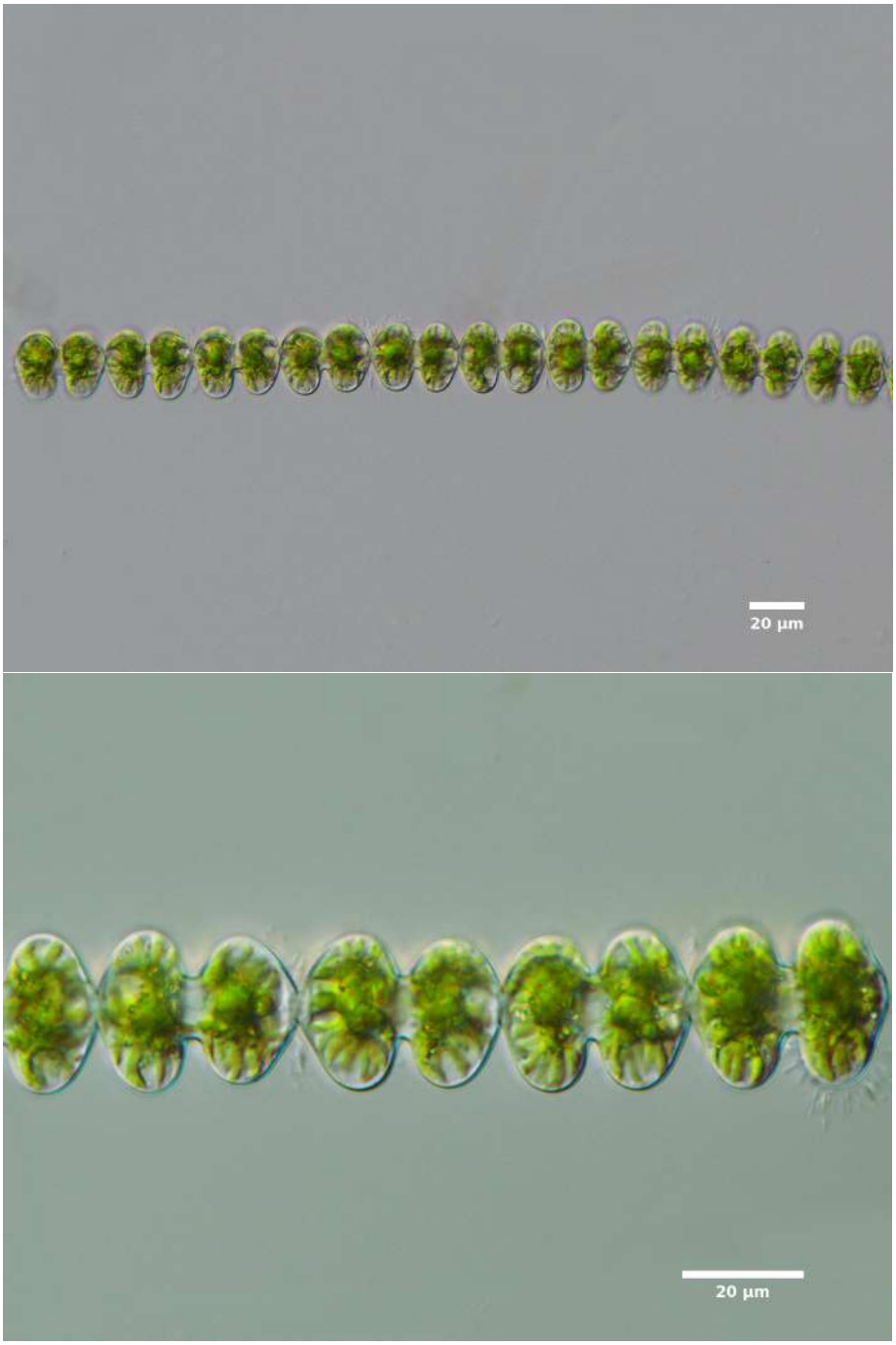


Figure 21.7: *Spondylosium moniliforme* (DIC/DIC), Lake Louise, Whatcom County (upper/lower images).

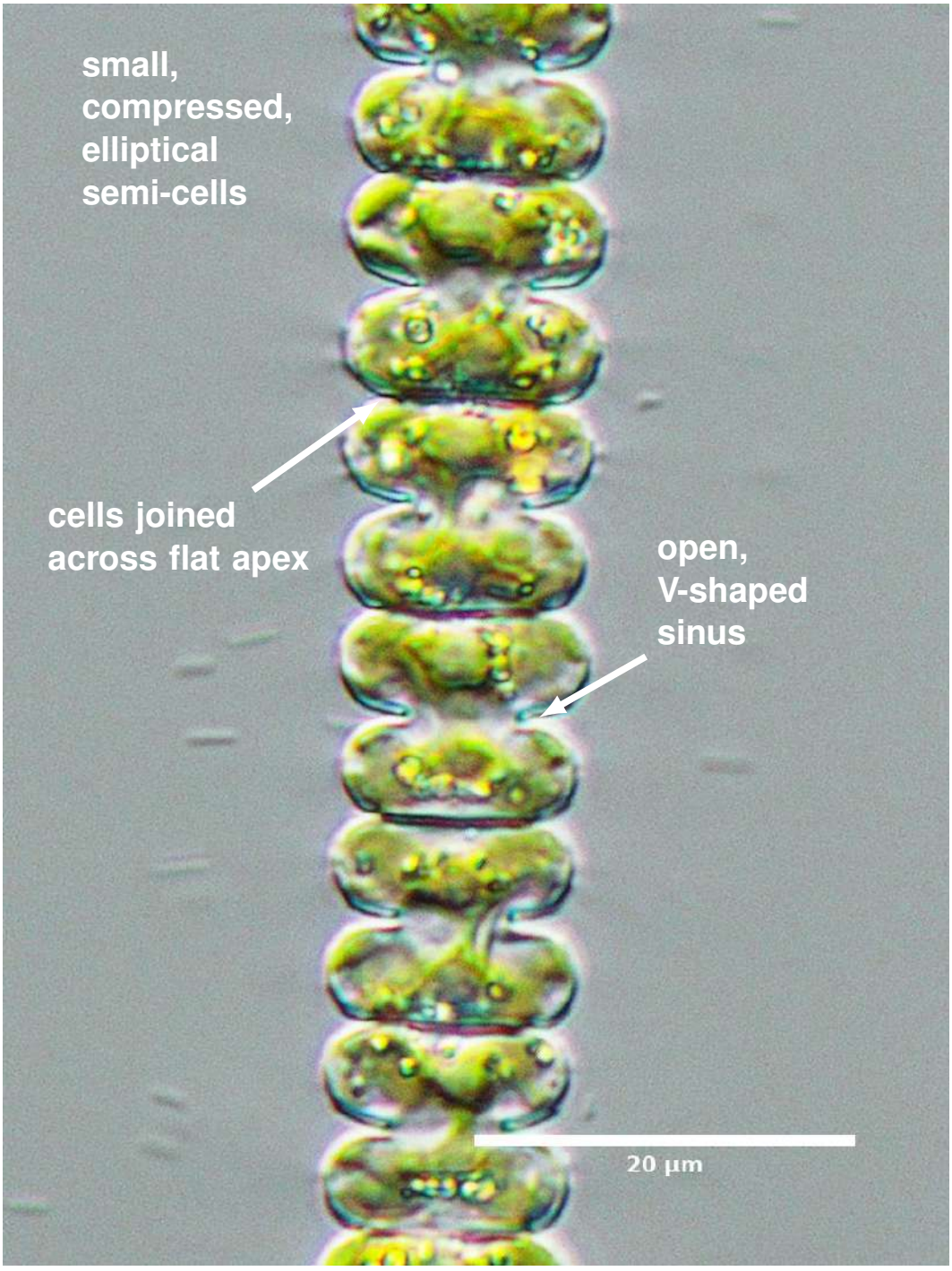
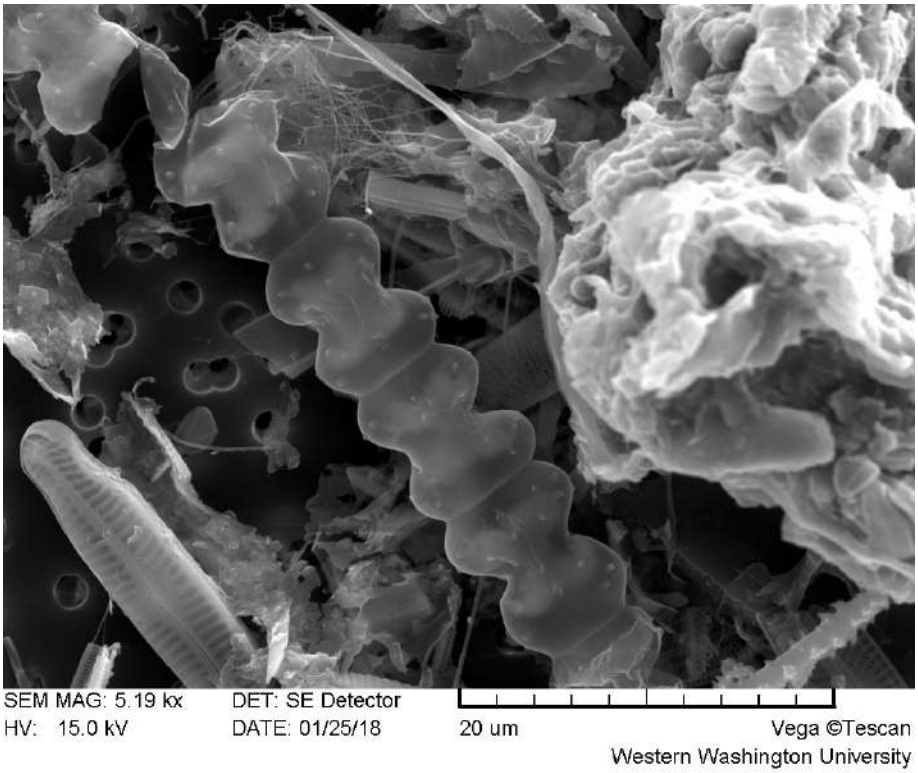


Figure 21.8: *Spondylosium planum* (DIC), Lake Terrell, Whatcom County.



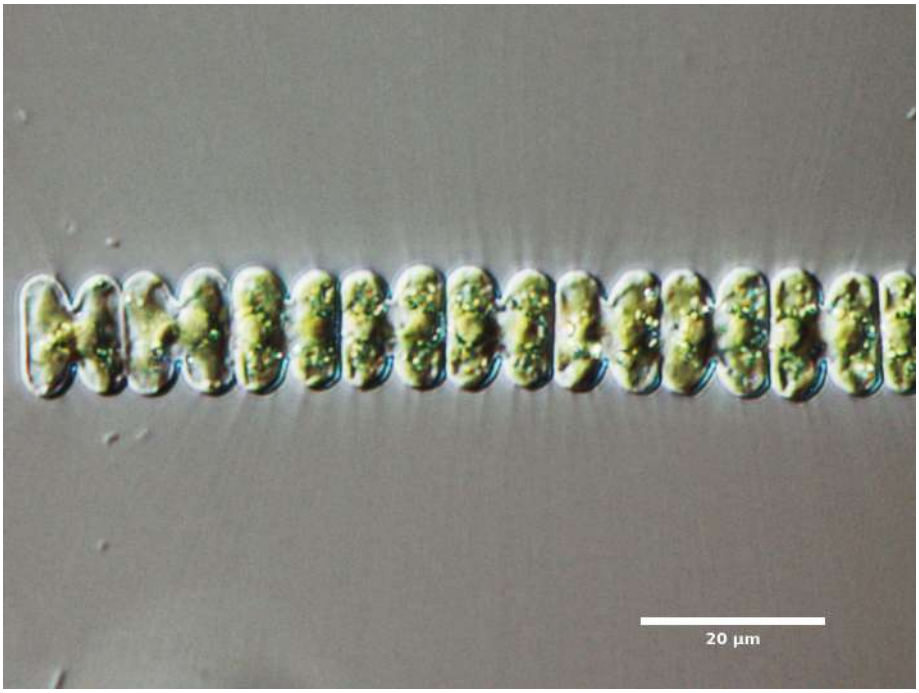


Figure 21.9: *Spondylosium planum* (SEM/DIC), Lake Evan, Mountain Loop Highway, Snohomish County (upper image); Lake Whatcom, Whatcom County (lower image).

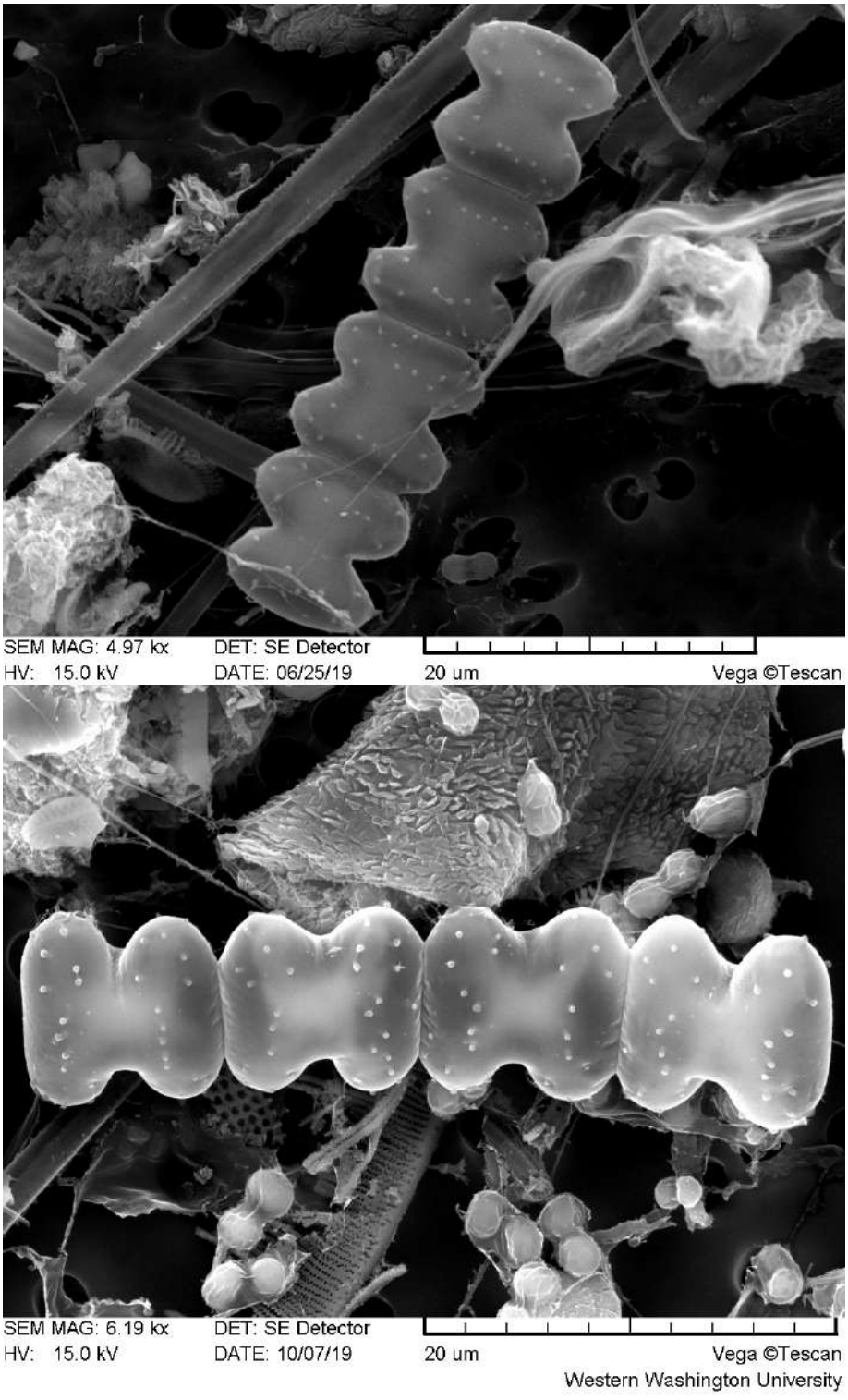


Figure 21.10: *Spondylosium planum* (SEM/SEM), Lake Whatcom, Whatcom County (upper/lower images).

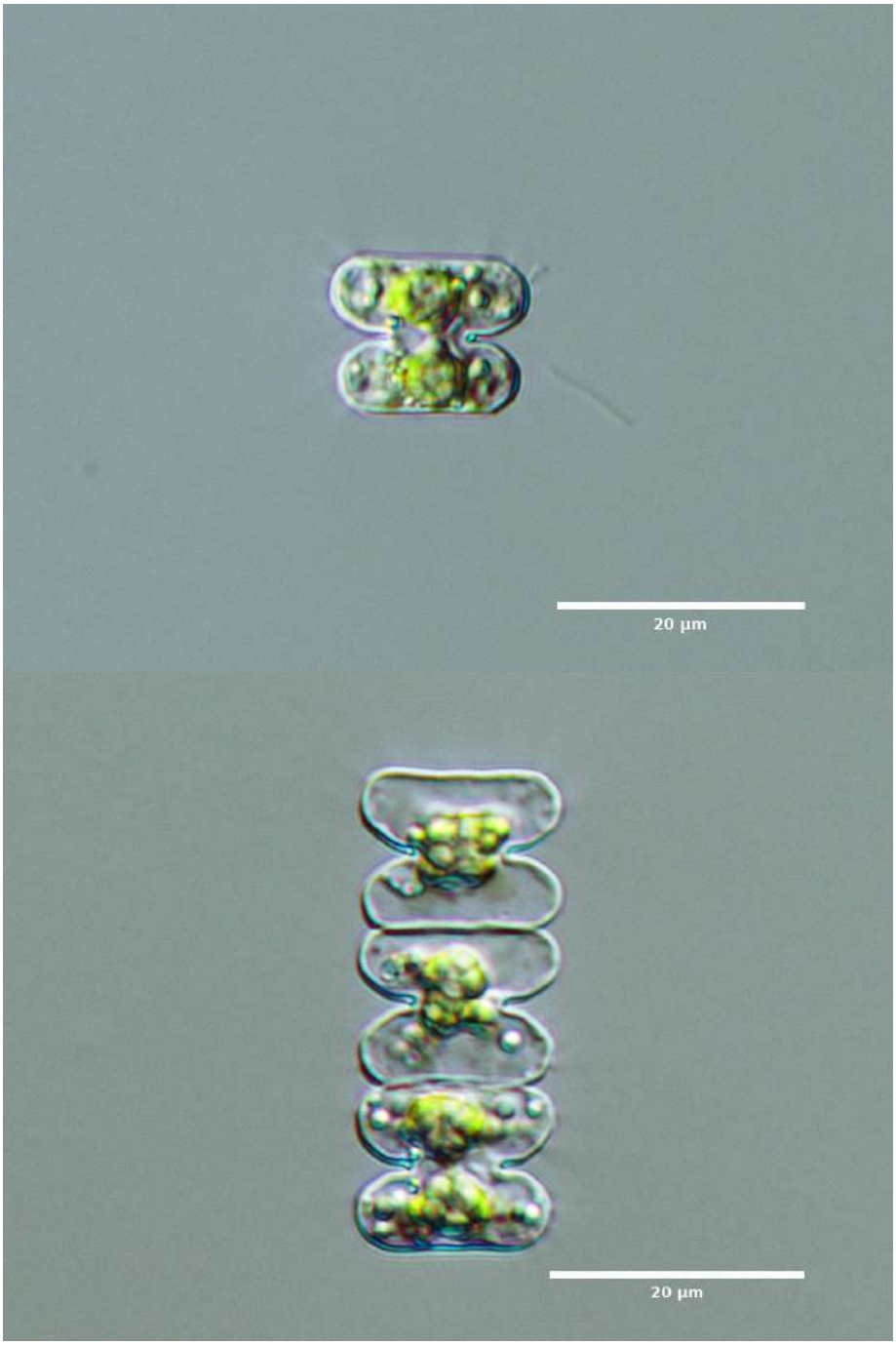


Figure 21.11: *Spondylosium planum* (DIC/DIC), Lake Whatcom, Whatcom County (upper/lower images).

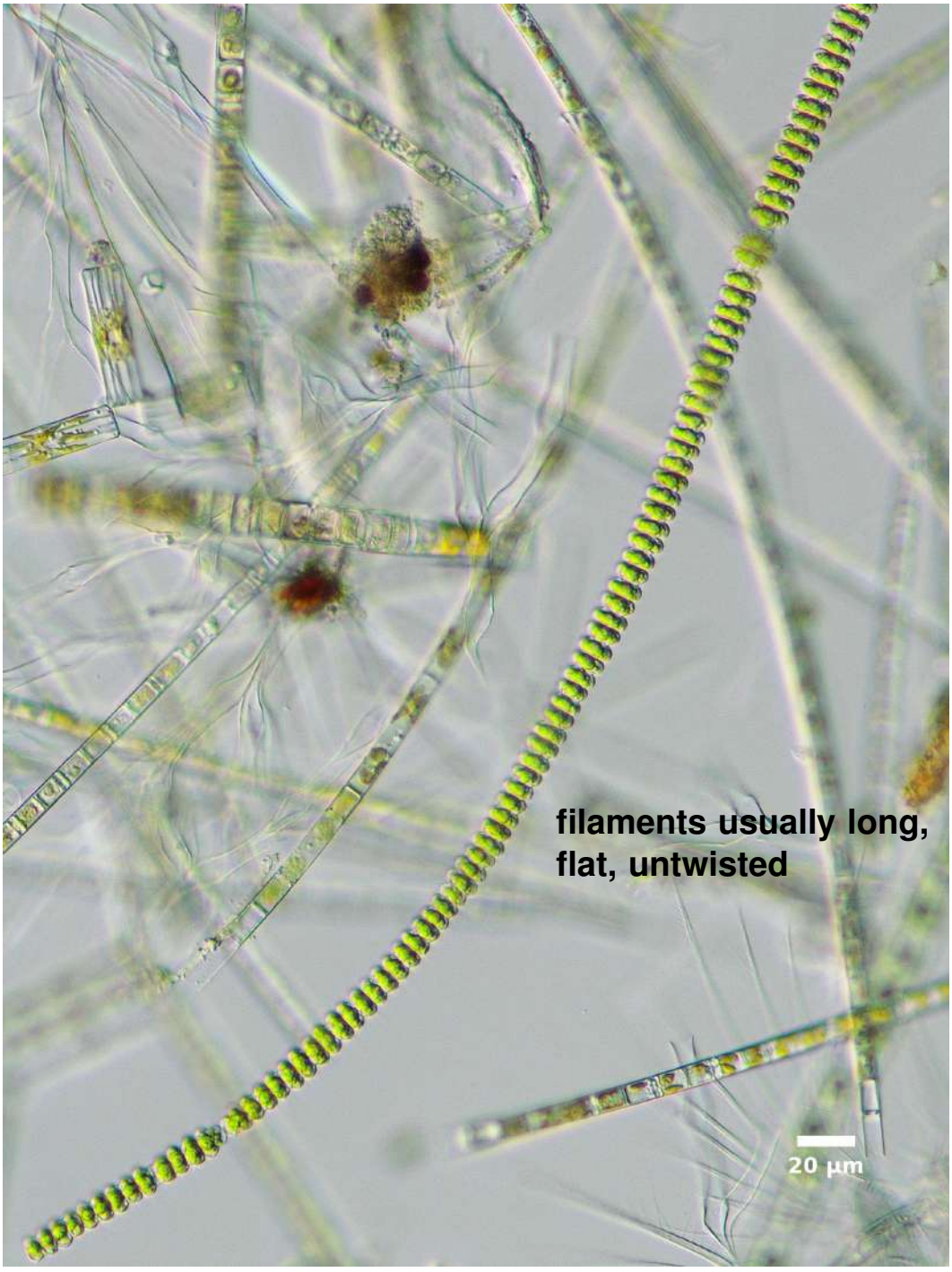


Figure 21.12: *Spondylosium planum* (DIC), Lake Whatcom, Whatcom County.

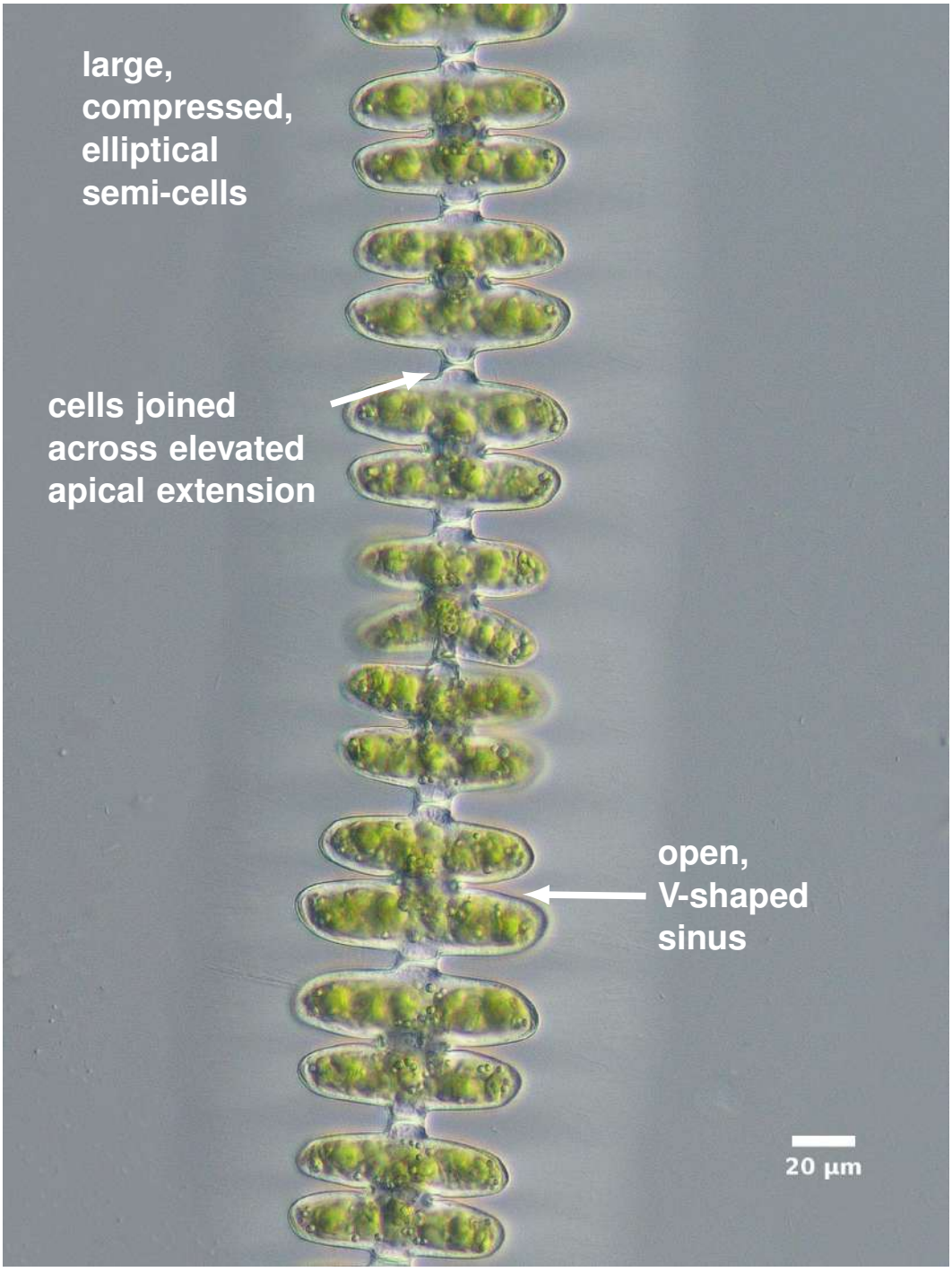


Figure 21.13: *Spondylosium pulchrum* (DIC), small floating bog along Morris Valley Road near Harrison, BC.

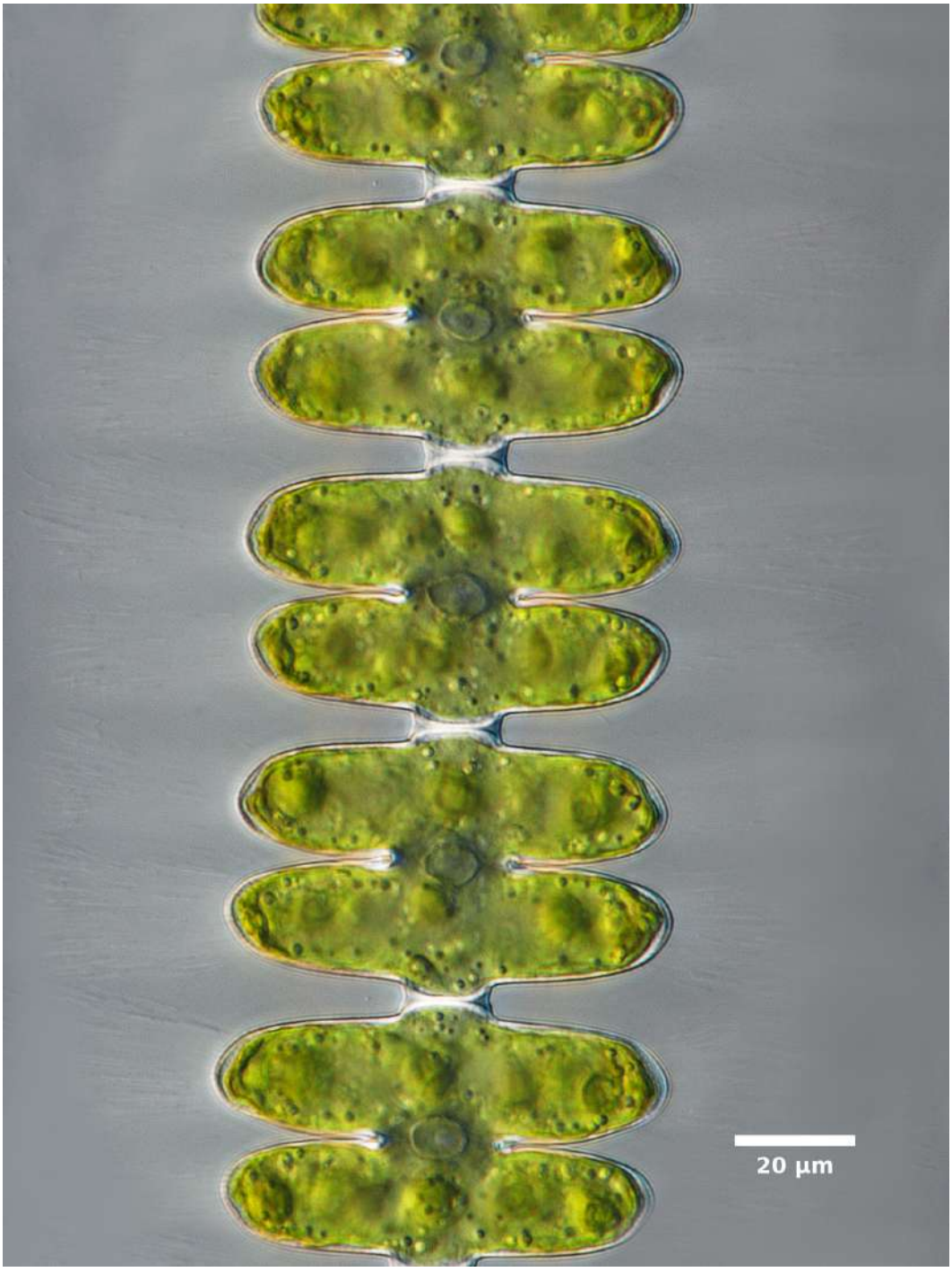


Figure 21.14: *Spondylosium pulchrum* (DIC), small floating bog along Morris Valley Road near Harrison, BC.

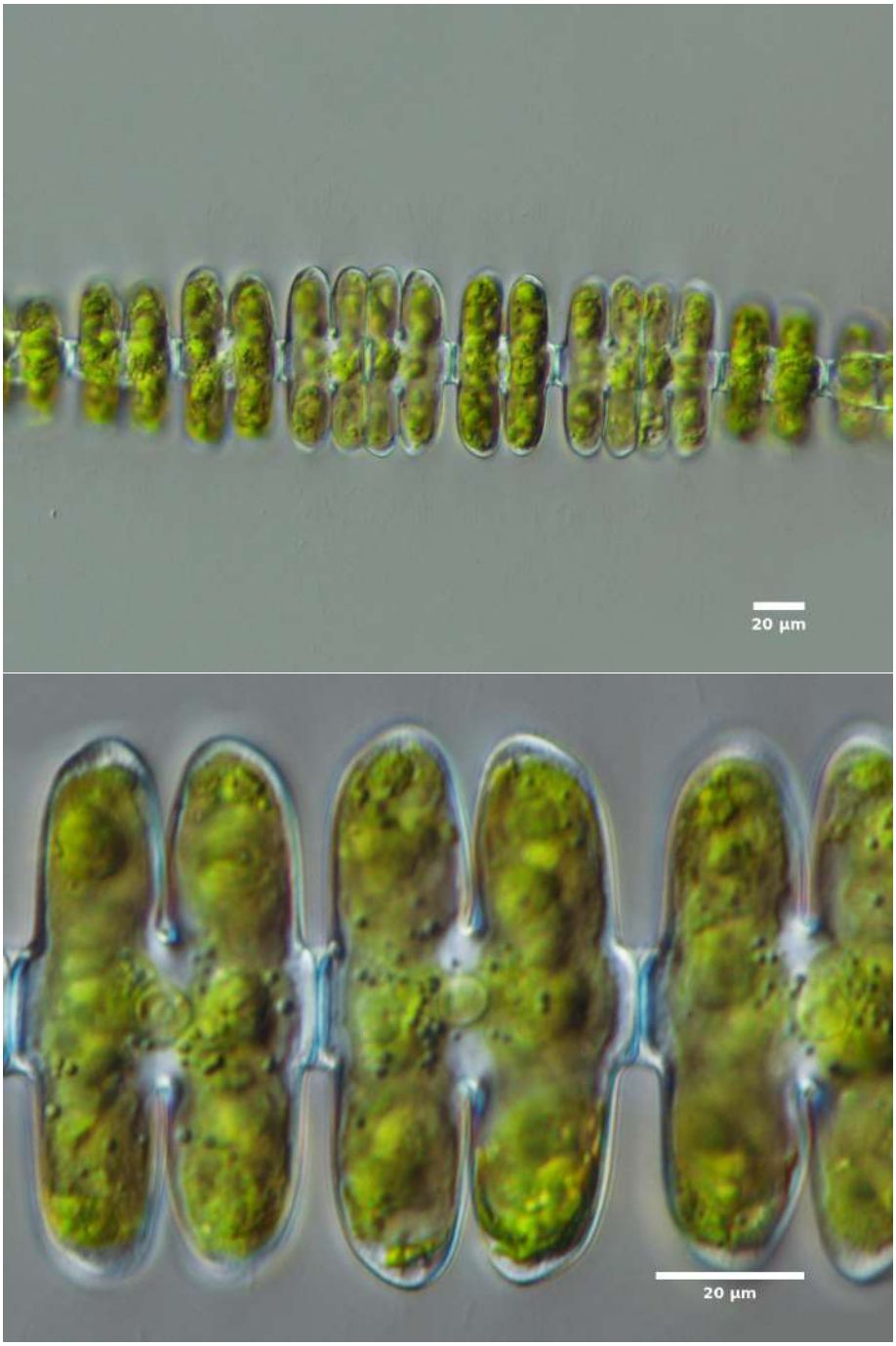


Figure 21.15: *Spondylosium pulchrum* (DIC/DIC), Summer Lake, Skagit County (upper/lower images).

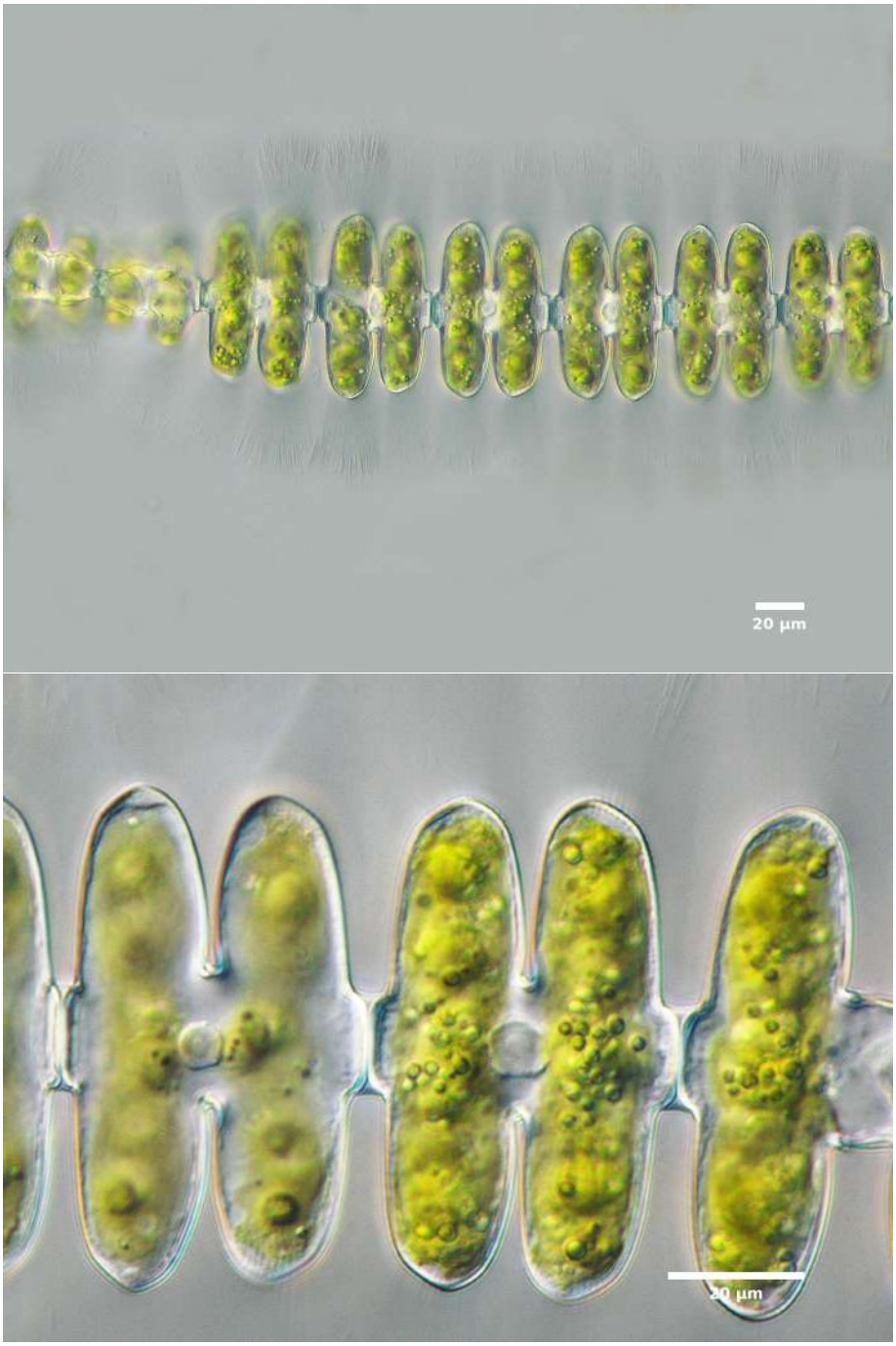


Figure 21.16: *Spondylosium pulchrum* (DIC/DIC), small floating bog along Morris Valley Road near Harrison, BC (upper/lower images).

Chapter 22

Staurastrum Meyen ex Ralfs

Northwest Washington taxa
Staurastrum acarides Nordstedt
Staurastrum alternans Brébisson
Staurastrum anatinum Cooke& Wills
Staurastrum anatinum var. *longibrachiatum* West & G. S. West
Staurastrum arctiscon (Ehrenberg ex Ralfs) P. Lundell
Staurastrum arctiscon f. *glabrum* West & G. S. West
Staurastrum arctiscon var. *truncatum* Irénée-Marie
Staurastrum arcuatum Nordstedt
Staurastrum asteroideum West & G. S. West
Staurastrum aversum P. Lundell
Staurastrum avicula Brébisson
Staurastrum avicula var. *lunatum* (Ralfs) Coesel & Meesters
Staurastrum avicula cf. var. *subarcuatum* (Wolle) West & G. S. West
Staurastrum bicorne Hauptfleisch
Staurastrum bieneanum Rabenhorst
Staurastrum boreale West & G. S. West
Staurastrum borgeanum Schmidle
Staurastrum brachiatum Ralfs ex Ralfs
Staurastrum brasiliense Nordstedt
Staurastrum brebissonii W. Archer
Staurastrum brevispina Brébisson
Staurastrum chaetoceras (Schröder) G. M. Smith
Staurastrum cingulum (West & G. S. West) G. M. Smith

Staurastrum cingulum cf. var. *obesum* G. M. Smith
Staurastrum clevei (Wittrock) J. Roy
Staurastrum crassangulatum Coesel
Staurastrum crenulatum (Nägeli) Delponte
Staurastrum cyrtocerum var. *inflexum* (Brébisson) Coesel & Meesters
Staurastrum dilatatum Ehrenberg ex Ralfs
Staurastrum cf. *dybowskii* Wołoszyńska
Staurastrum forficulatum P. Lundell
Staurastrum furcigerum (Brébisson) W. Archer
Staurastrum gemelliparum Nordstedt
Staurastrum geminatum Nordstedt
Staurastrum gracile Ralfs ex Ralfs
Staurastrum grande Bulnheim
Staurastrum grande var. *rotundatum* West & G. S. West
Staurastrum haaboeliense Wille
Staurastrum hexacerum Wittrock
Staurastrum hirsutum var. *pseudarnellii* Coesel & Meesters
Staurastrum hystrix Ralfs
Staurastrum inconspicuum Nordstedt
Staurastrum insigne P. Lundell
Staurastrum johnsonii West & G. S. West
Staurastrum kurilense Okada
Staurastrum laeve Ralfs
Staurastrum lanceolatum var. *compressum* West & G. S. West
Staurastrum lapponicum (Schmidle) Grönblae
Staurastrum lenzenwegeri Coesel & Meesters
Staurastrum longipes (Nordstedt) Teiling
Staurastrum longispinum (Baily) W. Archer
Staurastrum manfeldtii Delponte
Staurastrum margaritaceum Meneghini ex Ralfs
Staurastrum margaritaceum var. *alpinum* Schmidle
Staurastrum meriani Reinsch
Staurastrum micron West & G. S. West
Staurastrum minnesotense Wolle
Staurastrum monticulosum Brébisson
Staurastrum muticum Brébisson ex Ralfs
Staurastrum natator West
Staurastrum novae-terrae W. R. Taylor

Staurastrum ophiura P. Lundell
Staurastrum orbiculare Meneghini ex Ralfs
Staurastrum orbiculare var. *protractum* Playfair
Staurastrum cf. *pachyrhynchum* Nordstedt
Staurastrum paradoxum Meyen ex Ralfs
Staurastrum pingue Teiling
Staurastrum pingue var. *planctonicum* (Teiling) Coesel & Meesters
Staurastrum polytrichum (Perty) Rabenhorst
Staurastrum pseudotetracerum (Nordstedt) West & G. S. West
Staurastrum punctulatum Brébisson
Staurastrum ralfsii (West & G. S. West) Coesel & Meesters
Staurastrum ralfsii var. *depressum* (J. Roy & Bisset) Coesel & Meesters
Staurastrum reductum (Messikommer) Coesel
Staurastrum setigerum Cleve
Staurastrum setigerum cf. var. *occidentale* West & G. S. West
Staurastrum simonyi Heimerl
Staurastrum smithii Teiling
Staurastrum spongiosum Brébisson ex Ralfs
Staurastrum striatum (West & G. S. West) Růžička
Staurastrum striolatum (Nägeli) W. Archer
Staurastrum subcomptum Van Western & Coesel
Staurastrum subcruciatum Cooke & Wills
Staurastrum subnudibrachiatum var. *incisum* G. M. Smith
Staurastrum teliferum var. *gladiosum* [W. B. Turner] Coesel & Meesters
Staurastrum tetracerum Ralfs ex Ralfs
Staurastrum tetracerum var. *trigonum* P. Lundell
Staurastrum tohopekaligense Wolle
Staurastrum trapezioides Coesel & Meester
Staurastrum trifidum var. *inflexum* West & G. S. West
Staurastrum tumidum Brébisson ex Ralfs
(=*Xanthidium tumidum* [Ralfs] Šťastný, Škaloud & Neustupa)
Staurastrum vestitum Ralfs

Table 22.1: Key to *Staurastrum* Species

I. Semi-cells lobed or rounded (lacking processes); walls smooth except for mucilage pores or minute granulation (Figure 22.1)	See below
II. Semi-cells lobed or rounded (lacking processes); walls rough due to presence of granules, verrucae, teeth, spines (Figure 22.2)	Go to to page 761
III. Semi-cells with arm-like extensions (processes); walls smooth except for mucilage pores or minute granulation (Figure 22.3)	Go to to page 767
IV. Semi-cells with arm-like extensions (processes); walls rough due to presence of granules, verrucae, teeth, spines (Figure 22.4)	Go to to page 768
I. Semi-cells lobed or rounded (lacking processes); walls smooth except for mucilage pores or minute granulation	
A Semi-cells fusiform, lens-shaped, pentagonal, elliptical, or rhombic in outline	
A.1 Semi-cells rhombic with elevated apex; 5-radiate	*Staurastrum insigne* (Figures 22.134–22.135)
A.2 Semi-cells lens-shaped, fusiform, or pentagonal, with bluntly pointed, slightly thickened angles; usually triradiate	
A.2a Cell length >100 μm; semi-cells lens-shaped	*Staurastrum tumidum* =*Xanthidium tumidum* (Chapter 27, page 1245)

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Table 22.1: Key to *Staurastrum* Species, continued

	A.2b Cell length 70–100 μm; semi-cells lens-shaped or elliptical	*Staurastrum grande* (Figures 22.114–22.119)
	A.2c Cell length $<$40 μm; semi-cells fusiform or narrowly elliptical (L/W$<$1)	*Staurastrum lanceolatum* var. *compressum* (Figures 22.146–22.148)
	A.2d Cell length $<$40 μm; semi-cells lens-shaped or pentagonal	*Staurastrum crassangulatum* (Figures 22.81–22.82)
B	Semi-cells semi-circular, pyramidal, or kidney-shaped in outline; usually triradiate	
	B.1 Cell length $\geq$40 μm; semi-cells semi-circular	*Staurastrum orbiculare* (Figures 22.198–22.199)
	B.2 Cell length $\leq$45 μm; semi-cells mostly pyramidal or kidney-shaped	
	B.2a Semi-cells kidney-shaped; sinus open near margin	*Staurastrum muticum* (Figures 22.185–22.186)
	B.2b Semi-cells semi-circular or pyramidal (L/W$\geq$1); sinus closed and linear to margin, then flared	*Staurastrum ralfsii* (Figures 22.225–22.230)
C	Semi-cells cup-shaped, bowl-shaped, or wedge-shaped; usually triradiate	
	C.1 Semi-cells cup-shaped or wedge-shaped; small papilla on marginal angles	*Staurastrum aversum* (Figures 22.34–22.37)

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Table 22.1: Key to *Staurastrum* Species, continued

	C.2 Semi-cells flattened bowl-shaped; marginal angles thickened, but lacking papilla	*Staurastrum* cf. *pachyrhynchum* (Figures 22.203–22.205)
D	Semi-cells elliptical or pentagonal with broadly rounded margins; usually triradiate	
	D.1 Cell length >65 μm; semi-cells broadly elliptical	*Staurastrum grande* var. *rotundatum* (Figures 22.117–22.119)
	D.2 Cell length ≤55 μm; sinus closed to margin; small papilla on marginal angles	*Staurastrum brevispina* (Figures 22.69–22.71)
	D.3 Cell length ≤55 μm; sinus open near margin; no marginal papilla	
	D.3a Semi-cells pentagonal, with slightly flattened apex; marginal angles slightly thickened	*Staurastrum orbiculare* var. *protractum* (Figures 22.200–22.202)
	D.3b Semi-cells elliptical; cell length usually >30 μm	*Staurastrum bieneanum* (Figures 22.50–22.51)
	D.3c Semi-cells elliptical; cell length usually ≤30 μm	*Staurastrum muticum* (Figures 22.183–22.184)

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Table 22.1: Key to *Staurastrum* Species, continued

II. Semi-cells lobed or rounded (lacking processes); walls rough due to presence of granules, verrucae, teeth, spines	
A Semi-cells spiny but without granules or verrucae	
A.1 Cells very large (length >85 μm)	
A.1a Semi-cells trapezoidal or bowl-shaped; 5-radiate; 2–3 long spines at each angle; cell face otherwise smooth	*Staurastrum brasiliense* (Figures 22.61–22.64)
A.1b Semi-cells bowl-shaped or elliptical; triradiate; 2–3 short, stout spines at each angle; cell face otherwise smooth	*Staurastrum longispinum* (Figures 22.157–22.160)
A.1c Semi-cells elliptical; slightly compresses (L/W<1); triradiate; long, thin, paired spines at each angle; sparsely scattered spines on cell face	*Staurastrum minnesotense* (Figures 22.179–22.181)
A.2 Cell length ≤85 μm; face and angles of semi-cells spiny; spines similar in appearance; usually triradiate	
A.2a Spines short, tooth-like; semi-cells elliptical, fusiform, or rhombic	*Staurastrum brebissonii* (Figures 22.65–22.68)
A.2b Spines short, tooth-like; semi-cells trapezoidal	*Staurastrum trapezioides* (Figures 22.280–22.282)
A.2c Spines long, thin; semi-cells elliptical	*Staurastrum polytrichum* (Figures 22.216–22.217)

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Table 22.1: Key to *Staurastrum* Species, continued

A.3	Cell length $\leq$85 μm; face and angles of semi-cells spiny; spines on angles stouter; usually triradiate	
	A.3a Large, stout, paired spines on each angle; semi-cells broadly triangular (hourglass shape)	*Staurastrum setigerum* (Figures 22.233–22.235)
	A.3b Large, stout, paired spines on each angle; semi-cells elliptical	*Staurastrum setigerum* var. *occidentale* (Figures 22.236–22.238)
	A.3c Spines short, tooth-like, slightly larger on angles; semi-cells elliptical or compressed oval	*Staurastrum teliferum* var. *gladiosum* (Figures 22.267–22.271)
A.4	Cell length <50 μm; spines confined to angles; face of semi-cells smooth; usually triradiate	
	A.4a Semi-cells elliptical or lens-shaped; 3 short, stout, downwardly directed spines at each angle	*Staurastrum trifidum* var. *inflexum* (Figures 22.283–22.285)
	A.4b Semi-cells triangular; long bifurcate or intact spines at each angle	*Staurastrum novae-terrae* (Figures 22.189–22.191)
	A.4c Semi-cells oblong; 7–10 stout spines at each angle	*Staurastrum hystrix* (Figures 22.127–22.129)
	A.4d Semi-cells elliptical or oval; 6 long spines at each angle	*Staurastrum geminatum* (Figures 22.106–22.107)

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Table 22.1: Key to *Staurastrum* Species, continued

B	Semi-cells with simple granules or small teeth (no spines or verrucae)	
	B.1 Semi-cells semi-circular, broadly trapezoidal, or rectangular	
	B.1a Semi-cells semi-circular or trapezoidal; triradiate; faintly granulated; inconspicuous teeth on angles	*Staurastrum hirsutum* var. *pseudarnellii* (Figures 22.123–22.126)
	B.1b Semi-cells rectangular; triradiate; granules tooth-like; shallow, U-shaped incision half way up lateral margin	*Staurastrum acarides* (Figures 22.7–22.8)
	B.1c Semi-cells trapezoidal, with L/W>1.5; 6-radiate; granules rounded	*Staurastrum meriani* (Figures 22.176–22.177)
	B.2 Semi-cells broadly fusiform, elliptical, triangular, or rhombic; usually with visible rings of granules on lobes	
	B.2a Semi-cells broadly fusiform, elliptical, or triangular; triradiate; cells usually twisted	*Staurastrum alternans* (Figures 22.9–22.11)
	B.2b Semi-cells broadly fusiform with nearly equal upper and lower margins; triradiate; cells often twisted	*Staurastrum hexacerum* (Figures 22.121–22.122)
	B.2c Semi-cells broadly fusiform or elliptical; triradiate; cells not twisted	*Staurastrum lapponicum* (Figures 22.149–22.151)
	B.2d Semi-cells broadly fusiform or rhombic; triradiate or 4-radiate; cells not twisted or very slightly twisted	*Staurastrum striatum* (Figures 22.248–22.252)

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Table 22.1: Key to *Staurastrum* Species, continued

	B.2e Semi-cells rhombic with elongated base and elevated apex; 4-radiate; cells often twisted	*Staurastrum dilatatum* (Figures 22.92–22.93)
	B.2f Semi-cells rhombic, with very short lobes; 4-radiate; cells not twisted or very slightly twisted	*Staurastrum punctulatum* (Figures 22.221–22.224)
B.3	Semi-cells narrowly fusiform or narrowly elliptical; usually with visible rings of granules on lobes	
	B.3a Semi-cells narrowly elliptical, triangular, or rectangular; flat apex and rounded angles; triradiate or 4-radiate; cells twisted	*Staurastrum striolatum* (Figures 22.253–22.256)
	B.3b Semi-cells narrowly elliptical with rounded angles; lobes horizontal, ending in tooth-like spines; triradiate; cells not twisted	*Staurastrum simonyi* (Figures 22.239–22.240)
	B.3c Semi-cells narrowly fusiform with bluntly pointed angles; lobes directed upward, ending in tooth-like spines; triradiate; cells not twisted	*Staurastrum* cf. *dybowskii* (Figures 22.94–22.96)
	B.3d Semi-cells narrowly fusiform with bluntly pointed angles; lobes horizontal, ending in thin spines; triradiate; cells often twisted	*Staurastrum haaboeliense* (Figure 22.120)

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Table 22.1: Key to *Staurastrum* Species, continued

C	Semi-cells with combinations of granules, spines, verrucae, and teeth	
	C.1 Semi-cells semi-circular, oval, or trapezoidal; usually triradiate	
	C.1a Semi-cells faintly granulated; inconspicuous teeth on angles	*Staurastrum hirsutum* var. *pseudarnellii* (Figures 22.123–22.126)
	C.1b Semi-cells with horn-like apical extensions; bifurcate lateral spines; verrucae on cell face	*Staurastrum spongiosum* (Figures 22.243–22.247)
	C.2 Semi-cells bowl-shaped, with flat or nearly flat apex; triradiate; usually with visible rings of granules on lobes; usually triradiate	
	C.2a Angles ending in paired, asymmetric, tooth-like spines	*Staurastrum subcruciatum* (Figures 22.261–22.263)
	C.2b Angles ending in single tooth-like spine; may have very short processes	*Staurastrum avicula* var. *lunatum* (Figures 22.40–22.41)
	C.2c Angles ending in 1–2 tooth-like spines; apex with ring of 6 tooth-like spines	*Staurastrum arcuatum* (Figures 22.29–22.30)
	C.2d Semi-cell lobes with faint granules; angles with tooth-like spine; additional spine on lateral margin; horn-like spiny projections on apex	*Staurastrum monticulosum* (Figure 22.182)

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Table 22.1: Key to *Staurastrum* Species, continued

C.3	Semi-cells broadly fusiform, bowl-shaped, hexagonal, or elliptical; usually triradiate	
	C.3a Semi-cells broadly fusiform or bowl-shaped; forked spines on angles; horn-like apical extensions; granules on cell face	*Staurastrum arcuatum* (Figures 22.25–22.28)
	C.3b Semi-cells hexagonal or elliptical; forked spines on angles; horn-like apical extensions; spines/verrucae on cell face	*Staurastrum forficulatum* (Figures 22.97–22.99)
	C.3c Semi-cells broadly fusiform or bowl-shaped; paired or single spines on angles; no apical extensions	*Staurastrum avicula* (Figures 22.38–22.45)
C.4	Semi-cells narrowly fusiform or narrowly elliptical; usually with visible rings of granules on lobes; usually triradiate	
	C.4a Semi-cells narrowly elliptical with rounded angles; lobes horizontal, ending in tooth-like spines; cells not twisted	*Staurastrum simonyi* (Figures 22.239–22.240)
	C.4b Semi-cells narrowly fusiform with bluntly pointed angles; lobes directed upward, ending in tooth-like spines; cells not twisted	*Staurastrum* cf. *dybowskii* (Figures 22.94–22.96)
	C.4c Semi-cells narrowly fusiform with bluntly pointed angles; lobes horizontal, ending in thin spines; cells often twisted	*Staurastrum haaboeliense* (Figure 22.120)

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Table 22.1: Key to *Staurastrum* Species, continued

III. Semi-cells with arm-like extensions (processes); walls smooth except for mucilage pores or minute granulation	
A Semi-cell X-shaped	
A.1 Cell length >50 μm; 4-radiate; cells constricted at isthmus	*Staurastrum subnudibrachiatum* (Figures 22.264–22.266)
A.2 Cell length 15–45 μm; triradiate or 4-radiate; cells not constricted at isthmus	*Staurastrum brachiatum* (Figures 22.58–22.60)
B Semi-cells bowl-shaped or elliptical; triradiate; 6–9 processes	
B.1 Semi-cells oval or broadly elliptical; 9 processes	*Staurastrum tohopekaligense* (Figures 22.276–22.279)
B.2 Semi-cells bowl-shaped or broadly elliptical; 6 processes; cell length >45 μm	*Staurastrum clevei* (Figures 22.79–22.80)
B.3 Semi-cells bowl-shaped with flat apex; 6 processes; cell length <30 μm	*Staurastrum laeve* (Figures 22.144–22.145)
C Semi-cells oval, hexagonal, or elliptical; 12–15 processes forming whorls	
C.1 Semi-cells with 15 processes (6 apical, 9 medial); cell length >100 μm	*Staurastrum arctiscon* f. *glabrum* (Figures 22.21–22.22)
C.2 Semi-cells with 12 processes (6 apical, 6 medial); cell length 45–55 μm	*Staurastrum gemelliparum* (Figures 22.103–22.105)

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Table 22.1: Key to *Staurastrum* Species, continued

IV. Semi-cells with arm-like extensions (processes); walls rough due to presence of granules, verrucae, teeth, spines	
A Semi-cells biradiate	
A.1 Semi-cells cup-shaped, bowl-shaped, or rectangular; apex flat or slightly concave	
A.1a Cells not twisted; sinus U-shaped with acute, thickened angles	*Staurastrum lenzenwegeri* (Figures 22.152–22.153)
A.1b Cells slightly twisted; sinus V-shaped	*Staurastrum tetracerum* (Figures 22.272–22.275)
A.1c Cells strongly twisted (up to 90°)	*Staurastrum smithii* (Figures 22.241–22.242)
A.2 Semi-cells vase-shaped with inflated region above isthmus	
A.2a Processes robust, horizontally directed; horizontal subapical rows of verrucae; ring of granules above isthmus	*Staurastrum bicorne* (Figures 22.47–22.49)
A.2b Processes slender, horizontal or upwardly directed; horizontal subapical row of verrucae; rings of tooth-like granules above isthmus	*Staurastrum johnsonii* (Figures 22.136–22.139)
A.2c Processes slender, upwardly directed; cell body smooth	*Staurastrum reductum* (Figures 22.231–22.232)
A.3 Semi-cells triangular, fusiform, or rhombic	

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Table 22.1: Key to *Staurastrum* Species, continued

	A.3a Semi-cells triangular; apex flat; lateral margin straight; processes long, slender; cell body and processes faintly granulated	*Staurastrum chaetoceras* (Figures 22.72–22.74)
	A.3b Semi-cells triangular or rhombic; apex convex; lateral margin inflated above sinus; cell body and processes with coarse granules, verrucae, and teeth	*Staurastrum natator* (Figures 22.187–22.188)
	A.3c Semi-cells broadly fusiform; processes short, blunt; lateral margin not inflated above sinus; cell body and processes with coarse granules, verrucae, and teeth; may also be triradiate	*Staurastrum kurilense* (Figures 22.140–22.143)
B	Semi-cells triradiate (large, difficult group)	
	B.1 Semi-cells elliptical; triradiate; appear to have 6 processes: 3 apical, upwardly directed; 3 mid-cell, horizontally directed	*Staurastrum furcigerum* (Figures 22.100–22.102)
	B.2 Processes reduced to inconspicuous hollow extensions on angles; usually triradiate (cross-listed with Section II)	
	B.2a Semi-cells narrowly fusiform with bluntly pointed angles; lobes horizontal, ending in thin spines; cells often twisted;	*Staurastrum haaboeliense* (Figure 22.120)
	B.2b Semi-cells narrowly fusiform with bluntly pointed angles; lobes directed upward, ending in tooth-like spines; cells not twisted	*Staurastrum* cf. *dybowskii* (Figures 22.94–22.96)

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Table 22.1: Key to *Staurastrum* Species, continued

	B.2c Semi-cells broadly fusiform with nearly equal upper and lower margins; cells often twisted	*Staurastrum hexacerum* (Figures 22.121–22.122)
	B.2d Semi-cells broadly fusiform, bowl-shaped, or elliptical; paired, symmetric spines on angles; apical ring of horn-like extensions or tooth-like spines	*Staurastrum arcuatum* (Figures 22.25–22.30)
	B.2e Semi-cells broadly fusiform, bowl-shaped, or elliptical; paired, symmetric spines on angles; no apical ring of spines or extensions	*Staurastrum avicula* (Figures 22.38–22.45)
	B.2f Semi-cells broadly fusiform, bowl-shaped, or elliptical; paired, asymmetric spines on angles; no apical ring of spines or extensions	*Staurastrum subcruciatum* (Figures 22.261–22.263)
B.3	Processes short, blunt, but with distinct arm-like extensions	
	B.3a Cells strongly twisted; semi-cells cup-shaped or triangular, with small granules; processes slightly recurved	*Staurastrum cytocerum* var. *inflexum* (Figures 22.88–22.91)
	B.3b Cells not twisted; cell length <15 μm; semi-cells bowl-shaped, sparsely granulated; processes upwardly directed	*Staurastrum micron* (Figure 22.178)
	B.3c Cells not twisted; semi-cells cup-shaped or wedge-shaped with coarse granule/verrucae; processes recurved	*Staurastrum borgeanum* (Figures 22.55–22.57)

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Table 22.1: Key to *Staurastrum* Species, continued

	B.3d Cells not twisted; semi-cells triangular; processes upwardly directed, with rings of rounded granules	*Staurastrum pseudotetracerum* (Figures 22.218–22.220)
	B.3e Cells not twisted; semi-cells cup-shaped or triangular; processes upwardly directed, with rings of teeth	*Staurastrum boreale* (Figures 22.52–22.54)
B.4	Processes long, arm-like, upwardly directed; cell length <25 μm; semi-cells bowl-shaped or rectangular	*Staurastrum tetracerum* var. *trigonum* (Figure 22.275)
B.5	Processes long, arm-like; cell length usually 25–50 μm	
	B.5a Semi-cells triangular; processes upwardly directed, extending into long bifurcate or intact spines	*Staurastrum novae-terrae* (Figures 22.189–22.191)
	B.5b Semi-cells cup-shaped; processes slightly upwardly directed, ending in stout teeth; semi-cell with delicate granules	*Staurastrum paradoxum* (Figures 22.206–22.207)
	B.5c Semi-cells cup-shaped or wedge-shaped; processes horizontal, ending in delicate teeth; semi-cell with delicate granules	*Staurastrum gracile* (Figures 22.108–22.113)
	B.5d Semi-cells cup-shaped, vase-shaped, or cylindrical; processes horizontal, with large spiralling teeth	*Staurastrum manfeldtii* (Figures 22.161–22.167)

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Table 22.1: Key to *Staurastrum* Species, continued

	B.5e Semi-cells cup-shaped, vase-shaped, or cylindrical; processes upwardly directed, with tiny spiralling teeth; cell body nearly smooth	*Staurastrum pingue* (Figures 22.208–22.210)
	B.5f Semi-cells lens-shaped; processes horizontal or downwardly directed; cell with horizontal rows of bifurcate verrucae	*Staurastrum vestitum* (Figures 22.286–22.290)
B.6	Processes long, arm-like, upwardly directed; cell length >50 μm	
	B.6a Semi-cells elliptical; transverse rows of coarse verrucae; processes with rings of granules	*Staurastrum anatinum* (Figures 22.12–22.16)
	B.6b Semi-cells cup-shaped or triangular; processes with rings of granules; ring of granules above isthmus	*Staurastrum cingulum* (Figures 22.75–22.78)
	B.6c Semi-cells vase-shaped with inflated base; transverse row of verrucae; processes with spiralling teeth	*Staurastrum johnsonii* (Figures 22.136–22.139)
	B.6d Semi-cell cup-shaped; processes very long and thin, with spiralling teeth; semi-cell body nearly smooth	*Staurastrum longipes* (Figures 22.154–22.156)
	B.6e Semi-cells cup-shaped, vase-shaped, or cylindrical; processes upwardly directed, with tiny spiralling teeth; cell body nearly smooth	*Staurastrum pingue* (Figures 22.208–22.210)

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Table 22.1: Key to *Staurastrum* Species, continued

	B.6f Semi-cell cup-shaped, vase-shaped, or cylindrical; processes upwardly directed, with tiny spiralling teeth; rings of granules above isthmus	*Staurastrum pingue* var. *planctonicum* (Figures 22.211–22.215)
C	Semi-cells 4-radiate	
	C.1 Cell length <20 μm; semi-cells rectangular; processes short, bent	*Staurastrum inconspicuum* (Figures 22.130–22.133)
	C.2 Cell length ≥20 μm; semi-cells lens-shaped, or fusiform; cells with large granules and coarse verrucae	
	C.2a Semi-cell with slightly recurved processes ending in minute teeth	*Staurastrum crenulatum* (Figures 22.83–22.87)
	C.2b Semi-cells with horizontal processes ending in tooth-like spines	*Staurastrum vestitum* (Figures 22.286–22.290)
	C.3 Cell length ≥20 μm; semi-cells cup-shaped, vase-shaped, wedge-shaped, triangular, or campanulate	
	C.3a Cell length <30 μm; semi-cells with elongated base; processes very short, blunt, horizontal; semi-cell with delicate granules, teeth, and verrucae	*Staurastrum margaritaceum* (Figures 22.168–22.172)
	C.3b Cell length <30 μm; semi-cells without elongated base; processes moderately long, slightly upwardly directed; semi-cell with delicate granules	*Staurastrum boreale* (Figures 22.52–22.54)

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Table 22.1: Key to *Staurastrum* Species, continued

	C.3c Cell length 25-40 μm; semi-cells without elongated base; processes moderately long, horizontal; semi-cell with delicate granules	*Staurastrum gracile* (Figures 22.108–22.113)
	C.3d Cell length 35–50 μm; semi-cells with slightly elongated base; processes short, slightly recurved; semi-cell with coarse granules, teeth, and verrucae	*Staurastrum borgeanum* (Figures 22.55–22.57)
D	Semi-cells $\geq$5-radiate	
	D.1 Semi-cells with whorls of 6 apical and 9 medial processes	
	D.1a Processes ending in long, sharply pointed spines or teeth	*Staurastrum arctiscon* (Figures 22.17–22.20)
	D.1b Ends of processes truncated	*Staurastrum arctiscon* var. *truncatum* (Figures 22.23–22.24)
	D.2 Semi-cells with whorls of 3 apical and 3 medial processes	*Staurastrum furcigerum* (Figures 22.100–22.102)
	D.3 Semi-cells 5–7-radiate; processes not in apical/medial whorls	
	D.3a Cell length >100 μm; processes long, strongly recurved; apex with ring of horn-like extensions	*Staurastrum ophiura* (Figures 22.192–22.197)

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Table 22.1: Key to *Staurastrum* Species, continued

D.3b Cell length <40 μm; processes long, slightly recurved; large apical verrucae	*Staurastrum crenulatum* (Figures 22.83–22.87)
D.3c Cell length <40 μm; processes short, upwardly directed	*Staurastrum asteroideum* (Figures 22.31–22.33)
D.3d Cell length <40 μm; processes short, horizontal; semi-cell vase-shaped	*Staurastrum subcomptum* (Figures 22.257–22.260)
D.3e Cell length <40 μm; processes short, horizontal; semi-cell cup-shaped	*Staurastrum margaritaceum* (Figures 22.168–22.172)

Table 22.2: *Staurastrum* Cell Measurements. Unless otherwise indicated, cell measurements include extensions, processes, and teeth; where appropriate, separate measurements were included for spines

		Cell Width	Cell Length	Isthmus Width	L/W Ratio
Staurastrum acarides	min	29.9 μm	41.1 μm	14.6 μm	1.3
	med	31.1 μm	43.6 μm	18.5 μm	1.4
	max	33.8 μm	48.0 μm	20.6 μm	1.5
Staurastrum alternans	min	21.4 μm	22.3 μm	8.0 μm	0.9
	med	27.0 μm	28.5 μm	9.5 μm	1.1
	max	30.0 μm	30.2 μm	11.4 μm	1.2
Staurastrum anatinum	min	95.8 μm	60.8 μm	19.1 μm	0.6
	med	101.8 μm	71.6 μm	20.6 μm	0.7
	max	111.9 μm	79.1 μm	22.5 μm	0.7

[†]*summary statistics based on <5 cells*

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Table 22.2: *Staurastrum* Cell Measurements, continued

		Cell Width	Cell Length	Isthmus Width	L/W Ratio
Staurastrum anatinum f.	min	65.2 μm	29.0 μm	10.3 μm	0.4
	med	93.8 μm	63.2 μm	17.8 μm	0.7
	max	124.6 μm	74.1 μm	20.8 μm	0.8
Staurastrum anatinum	min	70.9 μm	56.0 μm	11.5 μm	0.7
var. *longibrachiatum*	med	75.2 μm	60.8 μm	12.5 μm	0.8
	max	82.8 μm	72.6 μm	14.6 μm	1.0
Staurastrum arctiscon	min	100.9 μm	106.4 μm	22.6 μm	0.9
	med	108.4 μm	112.4 μm	28.0 μm	1.0
	max	129.9 μm	131.3 μm	31.7 μm	1.1
Staurastrum arctiscon	min	108.0 μm	103.3 μm	26.4 μm	0.9
f. *glabrum*	med	117.0 μm	116.9 μm	29.5 μm	1.0
	max	131.0 μm	123.6 μm	30.9 μm	1.1
Staurastrum arctiscon	min	119.7 μm	120.0 μm	27.2 μm	0.9
var. *truncatum*	med	128.6 μm	133.9 μm	30.5 μm	1.0
	max	147.1 μm	149.6 μm	33.2 μm	1.1
Staurastrum arcuatum	min	36.3 μm	27.3 μm	7.2 μm	0.6
	med	44.8 μm	34.6 μm	9.2 μm	0.8
	max	54.0 μm	42.8 μm	12.9 μm	0.9
Staurastrum arcuatum	min	32.7 μm	29.3 μm	9.5 μm	0.7
var. A	med	38.2 μm	31.4 μm	11.2 μm	0.8
	max	45.4 μm	36.1 μm	11.9 μm	1.0
Staurastrum	min	25.3 μm	20.6 μm	6.8 μm	0.7
asteroideum	med	27.3 μm	23.3 μm	7.3 μm	0.9
	max	31.2 μm	24.3 μm	7.9 μm	0.9

[†]*summary statistics based on <5 cells*

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Table 22.2: *Staurastrum* Cell Measurements, continued

		Cell Width	Cell Length	Isthmus Width	L/W Ratio
Staurastrum aversum	min	26.6 μm	29.6 μm	5.6 μm	1.0
	med	34.2 μm	38.2 μm	10.1 μm	1.1
	max	44.0 μm	51.5 μm	13.5 μm	1.4
Staurastrum avicula	min	31.0 μm	24.5 μm	9.4 μm	0.6
	med	36.1 μm	28.9 μm	11.3 μm	0.8
	max	40.4 μm	32.0 μm	14.1 μm	1.0
Staurastrum avicula	min	30.0 μm	26.5 μm	10.4 μm	0.7
var. *lunatum*	med	37.0 μm	27.8 μm	11.4 μm	0.8
	max	39.0 μm	31.0 μm	12.1 μm	0.9
Staurastrum avicula	min	21.8 μm	17.5 μm	4.5 μm	0.8
cf. var. *subarcuatum*	med	23.2 μm	19.8 μm	7.2 μm	0.8
(estimate from SEM)	max	25.7 μm	20.8 μm	8.4 μm	0.9
Staurastrum avicula	min	33.9 μm	31.8 μm	9.1 μm	0.7
var. A	med	40.8 μm	34.5 μm	11.1 μm	0.9
	max	54.2 μm	38.5 μm	15.3 μm	1.0
Staurastrum avicula	min	26.6 μm	27.9 μm	8.5 μm	0.9
var. B	med	29.8 μm	29.5 μm	10.1 μm	1.0
	max	33.8 μm	32.0 μm	12.5 μm	1.1
Staurastrum bicorne	min	78.5 μm	45.1 μm	10.1 μm	0.5
	med	87.3 μm	54.1 μm	11.2 μm	0.7
	max	99.4 μm	64.7 μm	14.2 μm	0.7
Staurastrum bieneanum	min	29.4 μm	32.6 μm	8.8 μm	0.9
	med	33.7 μm	34.3 μm	10.5 μm	1.0
	max	39.3 μm	39.0 μm	11.1 μm	1.1

†*summary statistics based on <5 cells*

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Table 22.2: *Staurastrum* Cell Measurements, continued

		Cell Width	Cell Length	Isthmus Width	L/W Ratio
Staurastrum boreale	min	26.0 μm	21.7 μm	6.8 μm	0.8
	med	27.1 μm	22.5 μm	7.5 μm	0.8
	max	28.4 μm	23.8 μm	7.6 μm	0.9
Staurastrum borgeanum	min	40.1 μm	35.0 μm	11.3 μm	0.8
	med	43.3 μm	35.6 μm	11.5 μm	0.8
	max	49.6 μm	38.7 μm	13.3 μm	0.9
Staurastrum brachiatum	min	15.8 μm	14.8 μm	6.9 μm	0.8
	med	28.6 μm	26.5 μm	8.7 μm	1.0
	max	48.8 μm	43.5 μm	10.9 μm	1.2
Staurastrum brasiliense	min	57.9 μm	64.1 μm	26.1 μm	1.0
(without spines)	med	73.7 μm	78.8 μm	33.0 μm	1.1
	max	82.8 μm	94.2 μm	35.2 μm	1.3
Staurastrum brasiliense	min	88.2 μm	88.2 μm	26.1 μm	0.9
(with spines)	med	131.1 μm	123.8 μm	33.0 μm	1.0
	max	143.6 μm	147.1 μm	35.2 μm	1.1
Staurastrum brebissonii	min	33.7 μm	32.1 μm	10.6 μm	0.9
(without spines)	med	39.0 μm	41.1 μm	13.8 μm	1.0
	max	46.7 μm	53.7 μm	16.6 μm	1.2
Staurastrum brebissonii	min	36.2 μm	35.4 μm	10.6 μm	0.8
(with spines)	med	43.3 μm	40.5 μm	13.8 μm	1.0
	max	53.5 μm	57.1 μm	16.6 μm	1.2
Staurastrum brevispina	min	32.8 μm	30.3 μm	10.2 μm	0.9
	med	40.1 μm	43.8 μm	12.6 μm	1.1
	max	51.7 μm	55.4 μm	18.3 μm	1.2

[†]*summary statistics based on <5 cells*

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Table 22.2: *Staurastrum* Cell Measurements, continued

		Cell Width	Cell Length	Isthmus Width	L/W Ratio
Staurastrum chaetoceras	min	52.7 μm	42.4 μm	5.1 μm	0.8
	med	73.9 μm	73.2 μm	6.3 μm	1.0
	max	91.3 μm	86.7 μm	7.2 μm	1.2
Staurastrum cingulum	min	88.2 μm	78.3 μm	10.4 μm	0.9
	med	92.6 μm	89.3 μm	11.9 μm	1.0
	max	103.4 μm	100.8 μm	12.9 μm	1.1
Staurastrum cingulum	min	–	–	–	–
cf. var. *obesum*	med	36.4 μm	22.0 μm	7.2 μm	0.6
(estimate from SEM)†	max	–	–	–	–
Staurastrum clevei	min	42.6 μm	44.4 μm	12.2 μm	0.9
	med	51.6 μm	47.5 μm	13.1 μm	0.9
	max	54.2 μm	57.2 μm	13.6 μm	1.3
Staurastrum	min	35.2 μm	28.6 μm	7.6 μm	0.8
crassangulatum†	med	36.1 μm	30.0 μm	8.4 μm	0.8
	max	38.2 μm	35.6 μm	11.1 μm	0.9
Staurastrum	min	37.2 μm	21.7 μm	5.3 μm	0.5
crenulatum	med	40.7 μm	24.1 μm	6.3 μm	0.6
	max	47.3 μm	27.2 μm	6.9 μm	0.6
Staurastrum	min	34.0 μm	27.0 μm	8.1 μm	0.7
crenulatum var. A	med	38.0 μm	29.6 μm	9.2 μm	0.8
	max	39.7 μm	31.4 μm	9.8 μm	0.8
Staurastrum cytocerum	min	24.6 μm	19.8 μm	6.0 μm	0.6
var. *inflexum*	med	31.4 μm	21.9 μm	7.6 μm	0.7
	max	37.2 μm	25.2 μm	8.5 μm	0.9

†*summary statistics based on <5 cells*

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Table 22.2: *Staurastrum* Cell Measurements, continued

		Cell Width	Cell Length	Isthmus Width	L/W Ratio
Staurastrum dilatatum†	min	43.1 μm	40.7 μm	16.9 μm	0.9
	med	43.6 μm	42.0 μm	17.0 μm	1.0
	max	44.1 μm	43.4 μm	17.2 μm	1.0
Staurastrum cf. *dybowskii*†	min	24.8 μm	17.9 μm	5.6 μm	0.7
	med	26.6 μm	19.2 μm	6.7 μm	0.7
	max	31.7 μm	20.8 μm	7.3 μm	0.8
Staurastrum forficulatum	min	30.8 μm	34.2 μm	10.9 μm	0.8
(without spines)	med	32.8 μm	35.5 μm	12.7 μm	1.1
	max	44.8 μm	38.0 μm	15.3 μm	1.1
Staurastrum forficulatum	min	45.8 μm	42.6 μm	10.9 μm	0.8
(with spines)	med	53.8 μm	46.5 μm	12.7 μm	0.9
	max	55.0 μm	52.6 μm	15.3 μm	1.0
Staurastrum furcigerum	min	48.5 μm	53.9 μm	12.6 μm	0.9
	med	62.0 μm	62.8 μm	15.4 μm	1.0
	max	96.4 μm	88.4 μm	23.4 μm	1.1
Staurastrum gemelliparum	min	23.3 μm	23.2 μm	7.8 μm	1.0
	med	26.5 μm	26.3 μm	8.7 μm	1.0
	max	27.1 μm	28.8 μm	9.4 μm	1.1
Staurastrum geminatum	min	23.1 μm	29.9 μm	9.6 μm	1.1
(without spines)	med	24.2 μm	30.6 μm	10.3 μm	1.3
	max	26.8 μm	31.6 μm	11.0 μm	1.3
Staurastrum geminatum	min	38.6 μm	40.3 μm	9.6 μm	1.0
(with spines)	med	40.6 μm	44.0 μm	10.3 μm	1.1
	max	45.8 μm	51.3 μm	11.0 μm	1.1

†*summary statistics based on <5 cells*

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Table 22.2: *Staurastrum* Cell Measurements, continued

		Cell Width	Cell Length	Isthmus Width	L/W Ratio
Staurastrum gracile	min	37.4 μm	24.5 μm	8.2 μm	0.5
	med	46.4 μm	31.1 μm	9.5 μm	0.7
	max	59.5 μm	37.2 μm	11.2 μm	0.8
Staurastrum cf. *gracile*[†]	min	35.2 μm	25.5 μm	7.4 μm	0.7
	med	37.3 μm	28.8 μm	8.8 μm	0.8
	max	39.8 μm	31.5 μm	8.9 μm	0.8
Staurastrum grande	min	68.5 μm	70.1 μm	16.5 μm	0.9
	med	87.0 μm	88.1 μm	20.7 μm	1.0
	max	104.0 μm	95.3 μm	24.4 μm	1.1
Staurastrum grande	min	68.1 μm	77.4 μm	19.5 μm	1.0
var. *rotundatum*	med	70.6 μm	82.2 μm	21.6 μm	1.2
	max	78.8 μm	87.3 μm	24.4 μm	1.2
Staurastrum haaboeliense[†]	min	–	–	–	–
	med	36.5 μm	25.9 μm	8.1 μm	0.7
	max	–	–	–	–
Staurastrum hexacerum	min	29.0 μm	25.0 μm	7.3 μm	0.7
	med	32.3 μm	27.0 μm	9.1 μm	0.8
	max	40.0 μm	29.8 μm	10.9 μm	0.9
Staurastrum hirsutum	min	26.1 μm	34.1 μm	10.5 μm	1.1
var. *pseudarnellii*	med	29.6 μm	36.1 μm	12.6 μm	1.2
	max	32.0 μm	38.5 μm	14.2 μm	1.3
Staurastrum hystrix	min	23.7 μm	27.1 μm	10.0 μm	1.1
(without spines)	med	24.1 μm	28.1 μm	11.7 μm	1.2
	max	25.6 μm	29.5 μm	12.2 μm	1.2

[†]*summary statistics based on <5 cells*

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Table 22.2: *Staurastrum* Cell Measurements, continued

		Cell Width	Cell Length	Isthmus Width	L/W Ratio
Staurastrum hystrix	min	33.3 μm	37.0 μm	10.0 μm	1.1
(with spines)	med	35.4 μm	41.2 μm	11.7 μm	1.2
	max	36.4 μm	44.0 μm	12.2 μm	1.2
Staurastrum inconspicuum	min	12.0 μm	12.4 μm	6.0 μm	0.9
	med	13.4 μm	14.2 μm	6.8 μm	1.0
	max	18.1 μm	18.4 μm	7.8 μm	1.2
Staurastrum insigne[†]	min	–	–	–	
(estimate from SEM)	med	21.0 μm	31.2 μm	9.7 μm	1.5
	max	–	–	–	
Staurastrum johnsonii	min	75.3 μm	60.2 μm	10.1 μm	0.6
	med	95.1 μm	74.7 μm	11.6 μm	0.8
	max	105.1 μm	100.8 μm	12.9 μm	1.0
Staurastrum kurilense	min	40.1 μm	33.2 μm	10.6 μm	0.6
	med	53.0 μm	38.7 μm	13.3 μm	0.7
	max	61.9 μm	41.8 μm	14.2 μm	0.9
Staurastrum laeve	min	24.9 μm	24.8 μm	7.1 μm	0.9
	med	26.6 μm	25.4 μm	8.1 μm	1.0
	max	28.1 μm	25.6 μm	9.2 μm	1.0
Staurastrum lanceolatum	min	27.0 μm	22.1 μm	7.2 μm	0.7
var. *compressum*	med	28.5 μm	24.3 μm	8.1 μm	0.9
	max	31.2 μm	29.6 μm	8.9 μm	0.9
Staurastrum lapponicum	min	31.2 μm	28.0 μm	9.5 μm	0.8
	med	35.8 μm	33.9 μm	11.8 μm	1.0
	max	42.2 μm	40.4 μm	13.3 μm	1.1

[†]*summary statistics based on <5 cells*

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Table 22.2: *Staurastrum* Cell Measurements, continued

		Cell Width	Cell Length	Isthmus Width	L/W Ratio
Staurastrum lenzenwegeri	min	27.0 μm	26.5 μm	4.0 μm	0.7
	med	34.2 μm	28.4 μm	5.7 μm	0.9
	max	41.5 μm	34.3 μm	5.8 μm	1.0
Staurastrum longipes	min	61.9 μm	54.6 μm	7.3 μm	0.7
	med	83.3 μm	67.5 μm	8.4 μm	0.8
	max	105.4 μm	92.6 μm	10.9 μm	1.0
Staurastrum longispinum	min	91.1 μm	98.2 μm	31.0 μm	0.9
(without spines)	med	101.1 μm	109.2 μm	39.4 μm	1.0
	max	118.0 μm	112.6 μm	43.2 μm	1.2
Staurastrum longispinum	min	132.4 μm	98.2 μm	31.0 μm	0.6
(with spines)	med	148.3 μm	109.2 μm	39.4 μm	0.7
	max	174.8 μm	112.6 μm	43.2 μm	0.8
Staurastrum manfeldtii	min	59.4 μm	39.0 μm	9.4 μm	0.5
	med	65.6 μm	39.9 μm	10.7 μm	0.6
	max	79.4 μm	41.7 μm	13.4 μm	0.7
Staurastrum manfeldtii	min	53.1 μm	37.5 μm	10.1 μm	0.5
var. A	med	62.3 μm	39.9 μm	11.2 μm	0.7
	max	88.7 μm	46.1 μm	12.8 μm	0.7
Staurastrum	min	24.1 μm	24.8 μm	8.2 μm	0.9
margaritaceum	med	26.0 μm	26.2 μm	8.5 μm	1.0
	max	29.0 μm	28.7 μm	9.6 μm	1.1
Staurastrum	min	25.5 μm	29.3 μm	9.7 μm	1.0
margaritaceum	med	28.6 μm	31.1 μm	10.9 μm	1.1
var. *alpinum*	max	29.8 μm	37.0 μm	12.0 μm	1.3

[†]*summary statistics based on <5 cells*

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Table 22.2: *Staurastrum* Cell Measurements, continued

		Cell Width	Cell Length	Isthmus Width	L/W Ratio
Staurastrum meriani	min	26.3 μm	45.8 μm	17.1 μm	1.7
	med	27.5 μm	49.4 μm	18.4 μm	1.8
	max	29.0 μm	50.4 μm	19.6 μm	1.9
Staurastrum micron	min	10.9 μm	10.4 μm	3.3 μm	0.7
(estimate from SEM)	med	12.2 μm	10.6 μm	3.5 μm	1.0
	max	14.3 μm	14.1 μm	3.6 μm	1.2
Staurastrum	min	83.3 μm	98.3 μm	25.1 μm	1.0
minnesotense	med	112.7 μm	125.5 μm	31.7 μm	1.1
(without spines)	max	136.2 μm	133.0 μm	37.6 μm	1.2
Staurastrum	min	126.1 μm	105.5 μm	25.1 μm	0.8
minnesotense	med	152.4 μm	132.7 μm	31.7 μm	0.8
(with spines)	max	192.5 μm	179.9 μm	37.6 μm	0.9
Staurastrum	min	–	–	–	–
monticulosum[†]	med	26.2 μm	24.3 μm	9.4 μm	0.9
	max	–	–	–	–
Staurastrum muticum	min	22.0 μm	21.9 μm	6.4 μm	0.9
var. A	med	27.1 μm	27.8 μm	8.5 μm	1.0
	max	28.6 μm	29.6 μm	9.2 μm	1.1
Staurastrum muticum	min	17.4 μm	19.6 μm	7.3 μm	0.9
var. B[†]	med	19.1 μm	20.6 μm	7.5 μm	1.1
	max	23.8 μm	21.3 μm	8.1 μm	1.2
Staurastrum natator	min	60.6 μm	45.3 μm	9.7 μm	0.7
	med	62.5 μm	51.2 μm	10.4 μm	0.8
	max	70.9 μm	56.2 μm	11.5 μm	0.9

[†]*summary statistics based on <5 cells*

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Table 22.2: *Staurastrum* Cell Measurements, continued

		Cell Width	Cell Length	Isthmus Width	L/W Ratio
Staurastrum novae-terrae	min	17.5 μm	23.4 μm	6.6 μm	1.1
(without spines)	med	22.0 μm	25.1 μm	7.9 μm	1.1
	max	24.1 μm	26.7 μm	8.9 μm	1.4
Staurastrum novae-terrae	min	40.0 μm	26.8 μm	6.6 μm	0.6
(with spines)	med	43.8 μm	32.6 μm	7.9 μm	0.7
	max	48.4 μm	38.6 μm	8.9 μm	0.9
Staurastrum ophiura	min	70.1 μm	43.8 μm	11.9 μm	0.5
	med	106.9 μm	67.0 μm	19.6 μm	0.6
	max	142.8 μm	82.5 μm	22.8 μm	0.7
Staurastrum ophiura†	min	50.1 μm	24.3 μm	8.9 μm	0.4
var. A	med	55.8 μm	25.2 μm	9.1 μm	0.5
	max	61.2 μm	28.0 μm	10.4 μm	0.6
Staurastrum orbiculare	min	42.6 μm	40.2 μm	9.9 μm	0.9
	med	50.0 μm	52.1 μm	13.5 μm	1.0
	max	57.8 μm	60.2 μm	18.8 μm	1.2
Staurastrum orbiculare	min	38.0 μm	40.5 μm	8.7 μm	0.9
var. *protractum*	med	40.6 μm	43.9 μm	11.0 μm	1.1
	max	50.6 μm	46.5 μm	12.2 μm	1.1
Staurastrum orbiculare	min	41.8 μm	42.5 μm	11.3 μm	0.8
var. A†	med	42.6 μm	42.7 μm	11.6 μm	1.0
	max	51.0 μm	43.2 μm	12.5 μm	1.0
Staurastrum	min	34.2 μm	32.3 μm	8.2 μm	0.8
cf. *pachyrhynchum*	med	36.6 μm	34.0 μm	10.0 μm	0.9
	max	43.6 μm	36.2 μm	10.9 μm	1.0

†*summary statistics based on <5 cells*

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Table 22.2: *Staurastrum* Cell Measurements, continued

		Cell Width	Cell Length	Isthmus Width	L/W Ratio
Staurastrum	min	–	–	–	–
cf. *pachyrhynchum*	med	23.3 μm	22.9 μm	7.8 μm	1.0
var. A[†]	max	–	–	–	–
Staurastrum paradoxum	min	47.8 μm	27.9 μm	10.1 μm	0.5
	med	53.6 μm	30.8 μm	11.4 μm	0.6
	max	57.6 μm	34.1 μm	13.2 μm	0.6
Staurastrum pingue	min	49.0 μm	38.0 μm	5.8 μm	0.7
	med	60.6 μm	52.3 μm	6.6 μm	0.8
	max	77.1 μm	61.6 μm	7.9 μm	1.0
Staurastrum pingue	min	90.5 μm	62.2 μm	8.6 μm	0.6
var. *planctonicum*	med	102.0 μm	77.3 μm	11.3 μm	0.7
	max	118.9 μm	102.2 μm	13.2 μm	1.1
Staurastrum polytrichum	min	49.2 μm	50.3 μm	16.1 μm	0.9
(without spines)	med	54.7 μm	60.2 μm	18.9 μm	1.1
	max	75.8 μm	77.4 μm	25.4 μm	1.1
Staurastrum polytrichum	min	62.3 μm	55.4 μm	16.1 μm	0.8
(with spines)	med	72.1 μm	68.7 μm	18.9 μm	1.0
	max	85.8 μm	84.7 μm	25.4 μm	1.1
Staurastrum	min	24.5 μm	17.1 μm	6.0 μm	0.6
pseudotetracerum	med	27.1 μm	20.5 μm	6.3 μm	0.8
	max	32.8 μm	26.6 μm	7.2 μm	1.0
Staurastrum punctulatum	min	28.6 μm	38.1 μm	13.6 μm	1.1
	med	32.2 μm	39.6 μm	14.4 μm	1.3
	max	33.9 μm	41.2 μm	15.3 μm	1.4

[†]*summary statistics based on <5 cells*

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Table 22.2: *Staurastrum* Cell Measurements, continued

		Cell Width	Cell Length	Isthmus Width	L/W Ratio
Staurastrum ralfsii	min	24.5 μm	27.1 μm	8.6 μm	1.1
	med	33.0 μm	40.9 μm	12.0 μm	1.2
	max	36.3 μm	42.1 μm	12.7 μm	1.3
Staurastrum ralfsii	min	22.5 μm	25.8 μm	6.7 μm	1.0
var. *depressum*	med	27.5 μm	28.4 μm	8.3 μm	1.1
	max	33.8 μm	34.3 μm	9.5 μm	1.2
Staurastrum reductum	min	45.7 μm	33.6 μm	4.6 μm	0.6
	med	60.4 μm	43.3 μm	5.2 μm	0.7
	max	68.7 μm	48.8 μm	5.6 μm	0.8
Staurastrum setigerum	min	40.9 μm	47.5 μm	13.5 μm	1.0
(without spines)	med	44.6 μm	51.9 μm	15.5 μm	1.2
	max	54.8 μm	55.7 μm	17.8 μm	1.2
Staurastrum setigerum	min	67.0 μm	56.3 μm	13.5 μm	0.8
(with spines)	med	74.7 μm	65.7 μm	15.5 μm	0.9
	max	88.4 μm	76.9 μm	17.8 μm	1.1
Staurastrum setigerum	min	39.0 μm	37.2 μm	12.0 μm	0.9
cf. var. *occidentale*	med	44.8 μm	40.9 μm	14.2 μm	0.9
(without spines)	max	49.5 μm	42.5 μm	15.9 μm	1.0
Staurastrum setigerum	min	52.5 μm	45.0 μm	12.0 μm	0.7
cf. var. *occidentale*	med	64.5 μm	51.7 μm	14.2 μm	0.8
(with spines)	max	72.2 μm	54.8 μm	15.9 μm	1.0
Staurastrum simonyi	min	21.0 μm	19.8 μm	7.3 μm	0.8
	med	23.5 μm	23.7 μm	8.6 μm	1.0
	max	26.2 μm	27.0 μm	10.6 μm	1.1

†*summary statistics based on <5 cells*

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Table 22.2: *Staurastrum* Cell Measurements, continued

		Cell Width	Cell Length	Isthmus Width	L/W Ratio
Staurastrum smithii	min	36.0 μm	36.2 μm	4.9 μm	0.8
	med	44.6 μm	41.1 μm	6.8 μm	1.0
	max	45.2 μm	46.1 μm	7.6 μm	1.1
Staurastrum spongiosum	min	34.3 μm	42.2 μm	11.3 μm	1.0
	med	39.1 μm	45.6 μm	12.8 μm	1.2
	max	47.3 μm	53.6 μm	18.8 μm	1.3
Staurastrum striatum	min	26.0 μm	28.6 μm	9.3 μm	0.9
	med	32.6 μm	37.1 μm	12.1 μm	1.1
	max	44.2 μm	46.7 μm	19.3 μm	1.2
Staurastrum cf. *striatum*	min	30.0 μm	27.8 μm	9.6 μm	0.9
	med	31.8 μm	29.8 μm	10.7 μm	0.9
	max	33.4 μm	32.5 μm	11.9 μm	1.0
Staurastrum striolatum	min	23.5 μm	19.7 μm	6.0 μm	0.7
	med	26.7 μm	21.8 μm	8.0 μm	0.8
	max	33.6 μm	27.9 μm	9.5 μm	1.1
Staurastrum subcomptum	min	26.5 μm	30.4 μm	7.5 μm	1.0
	med	30.9 μm	33.8 μm	8.6 μm	1.1
	max	34.8 μm	36.6 μm	9.0 μm	1.2
Staurastrum subcruciatum	min	29.3 μm	25.6 μm	7.3 μm	0.7
	med	34.7 μm	28.7 μm	9.5 μm	0.8
	max	41.0 μm	34.8 μm	10.0 μm	1.0
Staurastrum subnudibrachiatum var. *incisum*	min	63.2 μm	51.3 μm	14.5 μm	0.8
	med	67.2 μm	57.8 μm	15.1 μm	0.8
	max	74.7 μm	65.7 μm	16.2 μm	0.9

†*summary statistics based on <5 cells*

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Table 22.2: *Staurastrum* Cell Measurements, continued

		Cell Width	Cell Length	Isthmus Width	L/W Ratio
Staurastrum teliferum	min	34.5 μm	35.0 μm	9.9 μm	0.9
var. *gladiosum*	med	37.7 μm	37.3 μm	13.3 μm	1.0
(without spines)	max	46.6 μm	41.3 μm	15.1 μm	1.1
Staurastrum teliferum	min	43.5 μm	38.1 μm	9.9 μm	0.8
var. *gladiosum*	med	45.7 μm	41.9 μm	13.3 μm	0.9
(with spines)	max	54.4 μm	45.5 μm	15.1 μm	1.0
Staurastrum tetracerum	min	20.6 μm	24.2 μm	5.3 μm	0.9
	med	28.0 μm	30.4 μm	6.1 μm	1.1
	max	39.1 μm	36.7 μm	7.7 μm	1.2
Staurastrum tetracerum	min	17.8 μm	18.1 μm	5.5 μm	0.9
var. *trigonum*	med	20.6 μm	20.3 μm	6.2 μm	1.0
	max	22.6 μm	23.8 μm	7.1 μm	1.2
Staurastrum	min	38.5 μm	45.5 μm	12.1 μm	0.9
tohopekaligense	med	46.8 μm	50.4 μm	13.2 μm	1.1
	max	57.6 μm	55.3 μm	14.8 μm	1.3
Staurastrum trapezioides[†]	min	46.9 μm	48.9 μm	15.2 μm	0.9
	med	57.0 μm	49.5 μm	15.5 μm	1.1
	max	58.3 μm	61.4 μm	19.4 μm	1.1
Staurastrum trifidum	min	42.9 μm	33.5 μm	10.3 μm	0.7
var. *inflexum*	med	45.7 μm	34.5 μm	12.4 μm	0.8
	max	48.4 μm	37.5 μm	13.8 μm	0.8
Staurastrum vestitum	min	45.1 μm	31.3 μm	10.3 μm	0.5
	med	58.4 μm	37.6 μm	12.5 μm	0.6
	max	69.7 μm	44.3 μm	14.3 μm	0.7

[†]*summary statistics based on <5 cells*

Description

Staurastrum cells are solitary, except for brief periods of entanglement during cell division, and radially symmetric with rounded, lobed, or extended apical margins (Figures 22.1–22.5). The cells may have two sides (biradiate), three sides (triradiate), or more (pluriradiate), and there can be different numbers of sides on adjacent cells (Janus-form cells) or in different specimens within the same population. When viewed from the side the semi-cells may have a simple, rounded appearance; may form broadly rounded lobes; or may have short or long, hollow, arm-like "processes" that extend from the cell wall at the apical margin (Figures 22.1–22.4). The cell wall may be ornamented with teeth, spines, and granules, or may appear smooth under conventional light microscopy.[39] Spines and teeth are often present on the apical lobes or processes (e.g., rows 2 and 4 in Figure 22.5).

The genus *Staurastrum* contains thousands of species and varieties, many of which are polymorphic or resemble other desmid species. While this chapter includes nearly 100 species and varieties of *Staurastrum*, there are undoubtedly taxa present in the northwest Washington lakes that were not included in this guide. When selecting key features like radial symmetry, we listed the most common forms found in northwest Washington specimens rather than the full range of possibilities for the species. Because of the likelihood of polymorphy, it is essential to look at more than one specimen before attempting any identifications.

In addition to the issue of polymorphy, *Staurastrum* can be difficult to separate from *Cosmarium*,[40] *Staurodesmus* (see Section 23, page 1107), and *Xanthidium* (see Section 27, page 1245). *Cosmarium* cells will usually be circular or elliptical in cross-section and lack long marginal spines; *Staurodesmus* cells will usually be biradiate or triradiate, smooth-walled, with single spines (monospinous); and *Xanthidium* cells will usually be biradiate, slightly compressed in cross-section, with at least four spines on each semi-cell. Unfortunately, these distinctions are not absolute, and there are some species in each genus that will be difficult to separate correctly. For example, *Staurastrum brevispina*, *Staurodesmus patens*, and *Xanthidium tumidum*[41] are all triradiate, smooth-walled desmids with minute, tooth-like spines or knobs on the apical angles (Figure 22.6). The only reliable feature for separating these three taxa is the size difference (note scale in Figure 22.6).

[39] Cells that appear smooth under conventional light microscopy often show faint pits, scrobulations, or other ornamentation when viewed using SEM.

[40] See **Freshwater Algae in Northwest Washington, Volume III. Part B.**

[41] *Xanthidium tumidum* is often listed as *Staurastrum tumidum* or *Staurodesmus tumidus* in taxonomic references.

Staurastrum acarides semi-cells are triradiate, lobed, and trapezoidal in outline, with shallow, U-shaped incisions approximately half way up the lateral margins (Figures 22.7–22.8). The apex is flat or slightly convex, with rounded margins. The cell is covered with short, tooth-like granules that form irregular concentric rings on the short lobes and are also scattered on the face of the cell. Coesel and Meesters (2013) state that this is an arctic-alpine species that can found on moist rocks and other wet surfaces; the northwest Washington specimens were collected from a rocky cliff in the spray zone of a waterfall near Rainy Pass in the North Cascades (elevation >1500 m).

Staurastrum alternans semi-cells are triradiate, and broadly fusiform, elliptical, or triangular in outline, with short, broadly rounded lobes (Figures 22.9–22.11). The cells are usually twisted so that the semi-cells are in different planes. The semi-cell lobes are covered with widely spaced concentric rings of small granules, with additional granules forming vertical rows on the cell face between the lobes. There may be a ring of tiny granules above the isthmus, but this is often only visible using SEM (Figure 22.10). *Staurastrum alternans* resembles *Staurastrum dilatatum* (Figure 22.92) and *Staurastrum lapponicum* (Figure 22.149), both of which are larger; *Staurastrum striatum* (Figure 22.248), which is rarely twisted; and *Staurastrum striolatum* (Figure 22.253), which is twisted and rectangular.

Staurastrum anatinum is polymorphic with regards to semi-cell shape and length of the processes. The semi-cells are usually triradiate and lens-shaped, broadly elliptical, oval, or cup-shaped in outline (Figures 22.12–22.16). The apical margins are extended into long, upwardly directed processes that end in 2–4 sharp, tooth-like spines. The processes have indistinct concentric rings of granules; the cell face has transverse rows of verrucae[42] or tooth-like spines that are often visible slightly below the apex. ***Staurastrum anatinum* var. *longibrachiatum*** (Figure 22.15) can be distinguished by its long, straight processes that are wider than the cell body. The specimens collected from Boardman Lake have distinctively fused, sharply pointed verrucae, so they are listed as a form of *Staurastrum anatinum* (Figure 22.16). *Staurastrum anatinum* closely resembles *Staurastrum vestitum* (Figure 22.286), which also has transverse rows of coarse granules; Coesel and Meesters (2013) suggest that there is considerable overlap between these species.

Staurastrum arctiscon semi-cells are pluriradiate, with 15 long, radiating processes; moderately constricted, and broadly elliptical or oval in outline (Figures 22.17–22.24). The processes are arranged into an apical whorl with six upwardly

[42] Verrucae are clusters of fused granules that have a rough, wart-like appearance.

directed processes and a median whorl with nine nearly horizontal processes (total=15); the whorls can be difficult to see unless you are using SEM (Figure 22.18). The semi-cell wall is mostly smooth except for mucilage pores, but the nominate variety[43] has concentric rings of small granules on each process and 2–3 stout spines or teeth on the end of each process.

In addition to the nominate variety, two visibly different morphological forms of *Staurastrum arctiscon* were present in the northwest Washington samples: ***Staurastrum arctiscon* f. *glabrum*** (Figures 22.21–22.22), and ***Staurastrum arctiscon* var. *truncatum*** (Figures 22.23–22.24). *Staurastrum arctiscon* f. *glabrum* is nearly identical to the nominate variety, but has smooth, ungranulated processes. The variety is currently listed as a synonym for *Staurastrum arctiscon*, but smooth-walled specimens were present in multiple locations, so we have retained it as a distinguishable form. The smooth-walled form is extremely difficult to distinguish from *Staurastrum leptacanthum* var. *borgei* Kurt Förster (no image available), which has smooth walls and the same 6/9 configuration of processes. Ling and Tyler (1995) state that the only consistent difference between these two taxa is size: *Staurastrum arctiscon* f. *glabrum* is larger (length = 105–127 μm; width = 101–115 μm) compared to *Staurastrum leptacanthum* var. *borgei* (length = 78–112 μm; width = μm 77–120). Based on these size ranges, the northwest Washington specimens are likely to be *Staurastrum arctiscon* f. *glabrum*. *Staurastrum arctiscon* f. *glabrum* also resembles *Staurastrum clevei*, *Staurastrum gemelliparum*, *Staurastrum laeve*, and *Staurastrum tohopekaligense* (Figures 22.79, 22.103, 22.144, and 22.276), but none of these species have the same configuration of processes.

The second variety, *Staurastrum arctiscon* var. *truncatum*, is virtually identical to the nominate variety but has truncated bifurcations on the each of each process rather than sharp spines (Figures 22.23–22.24). *Staurastrum arctiscon* var. *truncatum* was collected at the same location on the same date as specimens of the nominate variety (Figure 22.24), which raises the question of whether the cells with truncated processes are a truly distinct variety.

Staurastrum arcuatum semi-cells are usually triradiate and broadly fusiform, bowl-shaped or elliptical in outline (Figures 22.25–22.30). The apex is flattened or slightly convex; the primary shape of the semi-cell is lobed, but the apical margin is extended into very short, inconspicuous processes that end in long, stout, paired spines. The semi-cell also has a subapical ring of six short, horn-like extensions,

[43] *Staurastrum arctiscon* var. *arctiscon*

each ending in bifurcate teeth or spines; these extensions may be absent or greatly reduced on immature semi-cells. The semi-cell lobes have widely spaced concentric rings of granules, best viewed using SEM (Figures 22.26–22.28).

Staurastrum arcuatum var. A appears to be a simplified form with bowl-shaped cells, short, stout spines on the angles of each lobe, and a subapical ring of six tooth-like spines (Figures 22.29–22.30). The lobes have concentric rings of granules, similar to the nominate variety.[44] *Staurastrum arcuatum* var. A resembles *Staurastrum avicula* (Figure 22.38) except for the ring of subapical teeth.

Staurastrum arcuatum belongs to a group of highly polymorphic taxa that includes *Staurastrum avicula* (Figure 22.38), *Staurastrum forficulatum* (Figure 22.97), and *Staurastrum subcruciatum* (Figure 22.261). These species are difficult to separate because immature semi-cells may not have fully developed morphological features, and it is not unusual to find cells that display atypical features.

Staurastrum asteroideum semi-cells are 5-radiate; slightly constricted; cup-shaped in outline, with a convex apex and slightly expanded base (Figures 22.31–22.33). The apical margins are extended into short, blunt, upwardly directed processes tipped with minute teeth. The processes have widely spaced concentric rings of small granules and there is a ring of small granules above the isthmus; these features are best seen in SEM images (Figure 22.33). *Staurastrum asteroideum* resembles *Staurastrum subcomptum* (Figure 22.257) and *Staurastrum margaritaceum* (Figure 22.168), both of which have horizontal processes.

Staurastrum aversum semi-cells are triradiate, lobed, and cup-shaped or wedge-shaped in outline, with a flat apex and broadly rounded lobe margins (Figures 22.34–22.37). The cell wall is smooth except for an indistinct papilla on each lobe. This species resembles *Staurastrum brevispina* (Figure 22.69), which also has a short papilla on the angles of each lobe, but *Staurastrum brevispina* semi-cells are elliptical or oval, with a rounded apex and closed sinus.

Staurastrum avicula semi-cells are usually triradiate, lobed, and broadly fusiform, bowl-shaped, or elliptical in outline, with a flat or slightly convex apex (Figures 22.38–22.45). The semi-cell lobes have closely spaced concentric rings of granules and end in paired (or solitary) spines. Several varieties of *Staurastrum avicula* were present in the northwest Washington samples. ***Staurastrum avicula* var. *lunatum*** is characterized by relatively small, bowl-shaped cells with single, upwardly directed spines on the apical angles (Figures 22.40–22.41). ***Staurastrum avicula***

[44] *Staurastrum arcuatum* var. *arcuatum*

var. *subarcuatum* was tentatively identified from SEM images (Figure 22.42). This variety has bowl-shaped semi-cells with very short, horn-like extensions on the apical margins that end in long, equal-length, paired spines, similar to *Staurastrum arcuatum* (Figure 22.25), but without the subapical ornamentation; and similar to *Staurastrum subcruciatum* (Figure 22.261), but without the asymmetric marginal spines. The remaining varieties, labeled *Staurastrum avicula* var. A, and var. B, were common in plankton samples from several large, low elevation lakes (Figures 22.43–22.45). Both varieties resembled *Staurastrum avicula* var. *lunatum*, but often had more than one tooth-like spine on the apical margins.

Staurastrum avicula belongs to a group of highly polymorphic taxa that includes *Staurastrum arcuatum* (Figure 22.25), *Staurastrum forficulatum* (Figure 22.97), and *Staurastrum subcruciatum* (Figure 22.261). These species are difficult to separate because immature semi-cells may not have fully developed morphological features, and it is not unusual to find cells that display atypical features. For example, the specimen in Figure 22.46 was collected in the same sample with specimens of "typical" *Staurastrum avicula*. Note how the cell in Figure 22.46 displays features of both *Staurastrum avicula* and *Staurastrum arcuatum* on different semi-cells.

Staurastrum bicorne semi-cells are biradiate and vase-shaped in outline, with an inflated region above the sinus and a slightly convex apex (Figures 22.47–22.49). The apical margins are extended into long, horizontal processes that have concentric rings of tiny granules and end in 2–3 short, tooth-like spines. There are 1–2 rings of tiny granules above the isthmus, and two horizontal rows of coarse, verrucae across the apex of the semi-cell.

Staurastrum bieneanum semi-cells are usually triradiate, lobed, and elliptical in outline (Figures 22.50–22.51). The semi-cells are smooth-walled, with no distinctive ornamentation other than slightly thickened lateral margins. *Staurastrum bieneanum* resembles *Staurastrum crassangulatum* (Figure 22.81), *Staurastrum grande* (Figure 22.114), *Staurastrum muticum* (Figure 22.183), and *Staurastrum orbiculare* var. *protractum* (Figures 22.200). Collectively, these species are a catch-all for smooth-walled forms with oval, elliptical, or broadly fusiform semi-cells. The best feature for separating some of these species is size: *Staurastrum muticum* has small cells (width and length <30 μm) and *Staurastrum grande* has very large cells (width and length >65 μm). *Staurastrum orbiculare* var. *protractum* semi-cells are usually more pentagonal than elliptical. *Staurastrum bieneanum* and *Staurastrum crassangulatum* have cells with similar lengths and widths, but *Staurastrum crassangulatum* semi-cells have more acute lobe angles.

Staurastrum boreale semi-cell are usually triradiate or 4-radiate, often with both forms present in the same sample, and cup-shaped or triangular in outline, with a flat or slightly convex apex (Figures 22.52–22.54). The apical margin is extended into short, horizontal or slightly upwardly directed processes ending in short tooth-like spines. The processes have regularly spaced, concentric rings of small, tooth-like spines. The spines or granules extend onto the cell face and apex, and there is a ring of small teeth above the isthmus (Figure 22.54). *Staurastrum boreale* is difficult to separate from some varieties of *Staurastrum crenulatum* (Figure 22.83), which usually has a crenulated apex due to the presence of large apical verrucae. *Staurastrum boreale* is especially difficult to separate from *Staurastrum gracile* (Figure 22.108), which has a very similar cell morphology but is about 50% larger than *Staurastrum boreale*.

Staurastrum borgeanum semi-cells are triradiate or 4-radiate and cup-shaped or wedge-shaped in outline (Figures 22.55–22.57). The cells may be slightly twisted so that the semi-cells are in different planes. The apical margin is extended to form short, blunt, horizontal or slightly recurved processes tipped with small tooth-like spines. The processes and apex have concentric rings of coarse granules or short teeth, many of which are double or fused into verrucae. The cell face has short, vertical rows of coarse granules or verrucae between the processes, and there is a ring of granules above the isthmus. *Staurastrum borgeanum* resembles *Staurastrum hexacerum* (Figure 22.121) and *Staurastrum cytocerum* var. *inflexum* (Figure 22.88), both of which are slightly smaller and more delicately ornamented.

Staurastrum brachiatum semi-cells are usually triradiate or 4-radiate and distinctively X-shaped in outline, with long, thick processes extending in a line from the isthmus and ending in 2–5 thick, rounded, teeth (Figures 22.58–22.60). The cells are smooth-wall, soft bodied, and highly polymorphic, especially with respect to the length of the processes and configuration of teeth. *Staurastrum brachiatum* resembles *Staurastrum subnudibrachiatum* var. *incisum*, which is characterized by large, oval semi-cells with an "incised" sinus (compare both species in Figure 22.60). According to Coesel and Meesters (2013), there are intermediate forms that resemble both of these species, and both species were present in Bear Lake on the same date (Figure 22.60), so the species separation is questionable.

Staurastrum brasiliense is a large, easily recognized species characterized by 5-radiate, lobed semi-cells that are bowl-shaped or trapezoidal in outline, with nearly straight lateral margins (Figures 22.61–22.64). The cell wall is smooth except for 2–3 long, straight spines at each of the five apical angles.

Staurastrum brebissonii semi-cells are triradiate, lobed, and elliptical, broadly fusiform, or rhombic in outline (Figures 22.65–22.68). The semi-cells are densely and evenly covered with short spines that form transverse rows across the face of the cell and concentric circles around the angles. Although the spines may be slightly longer on the angles, they are mostly short (2–3 μm length) and very uniform. *Staurastrum brebissonii* is very similar to *Staurastrum trapezioides* (Figure 22.280), which was formerly described as *Staurastrum brebissonii* var. *truncatum*; *Staurastrum trapezioides* can be distinguished by its larger size and more angular semi-cells. *Staurastrum brebissonii* also resembles *Staurastrum teliferum* var. *gladiosum* (Figure 22.267) and *Staurastrum polytrichum* (Figure 22.216), both of which have longer spines.

Staurastrum brevispina semi-cells are triradiate, lobed, and elliptical, oval, or semi-circular in outline (Figures 22.69–22.71). The apical margins are smoothly rounded, and the apex is mostly convex, but may have flattened or slightly concave central region. The cells have a closed, nearly linear sinus. The cell walls smooth except for a very short papilla on the lobe angles. *Staurastrum brevispina* is large and distinctive, but could be confused with *Staurastrum aversum*, which also has a short papilla on the lobe angles, but is cup-shaped or wedge-shaped with a widely open sinus.

Staurastrum chaetoceras semi-cells are usually biradiate and triangular in outline, with a flat apex and long, narrow, upwardly directed processes (Figures 22.72–22.74). The processes have widely spaced concentric rings of minute, tooth-like granules. Additional granules form vertical rows that extend from the apex about half way down the cell face. There is often a faint ring of tiny granules above isthmus, but these are hard to see, even in SEM images (Figure 22.73). *Staurastrum chaetoceras* resembles *Staurastrum longipes* (Figure 22.154), and may be present in the same sample. But *Staurastrum longipes* is triradiate and mostly smooth-walled, with spiralling teeth on the processes rather than concentric rings of granules.

Staurastrum cingulum semi-cells are triradiate and cup-shaped or triangular in outline (Figures 22.75–22.78). The apical margins are extended into three long, narrow, upwardly directed processes that are tipped with tooth-like spines. The processes are covered with widely spaced concentric rings of sharp granules, with additional granules extending in a vertical line from the apex to about the middle of the cell face, and forming a prominent ring above the isthmus. ***Staurastrum cingulum* var. *obesum*** (Figure 22.78, lower image) is a more robust variety, with the same granular pattern, but with the apical granules fused into coarse

verrucae. The variety identification is uncertain because there is only one specimen to examine. *Staurastrum cingulum* is often collected in planktonic samples and can be found in a wide variety of habitats. It belongs to a difficult group of *Staurastrum* species that include *Staurastrum johnsonii* (Figure 22.136), *Staurastrum manfeldtii* (Figure 22.161), *Staurastrum pingue* var. *pingue* and var. *planctonicum* (Figures 22.208 and 22.211). Most of the diagnostic features in this group are subtle, and it is not unusual to find several of these species in the same plankton sample. *Staurastrum cingulum* can be sometimes be distinguished by the very regularly spaced rings of granules on the processes and above the isthmus.

Staurastrum clevei semi-cells are usually triradiate, smooth-walled, and bowl-shaped or broadly elliptical in outline (Figures 22.79–22.80). The apical margins are extended into three long, bifurcate processes, with additional arm-like extensions located between and slightly above the lower processes (total=6). *Staurastrum clevei* resembles *Staurastrum arctiscon* f. *glabrum*, *Staurastrum gemelliparum*, *Staurastrum laeve*, and *Staurastrum tohopekaligense* (Figures 22.21, 22.103, 22.144, and 22.276), but none of these have the same configuration of processes.

Staurastrum crassangulatum semi-cells are triradiate, lobed, and broadly lens-shaped or pentagonal in outline (Figures 22.81–22.82). The semi-cells are smooth-walled, with slightly pointed and thickened lobe angles, giving the cell an slightly angular appearance. *Staurastrum crassangulatum* resembles *Staurastrum bieneanum* (Figure 22.50), *Staurastrum grande* (Figure 22.114), *Staurastrum muticum* (Figure 22.183), and *Staurastrum orbiculare* var. *protractum* (Figures 22.200). Collectively, these species are a catch-all for smooth-walled forms with oval, elliptical, or broadly fusiform semi-cells. The best feature for separating some of these species is size: *Staurastrum muticum* has small cells (width and length <30 μm) and *Staurastrum grande* has very large cells (width and length >65 μm). *Staurastrum orbiculare* var. *protractum* semi-cells are usually larger than *Staurastrum crassangulatum*. *Staurastrum bieneanum* and *Staurastrum crassangulatum* have cells with similar lengths and widths, but *Staurastrum crassangulatum* semi-cells are often pentagonal, with more acute lobe angles.

Staurastrum crenulatum semi-cells are 3–5-radiate (4–5 radiate in northwest Washington samples) and broadly fusiform, bowl-shaped, or vase-shaped in outline, with a slightly inflated base and convex apex (Figures 22.83–22.87). The apical margins are extended into moderately long, horizontal or slightly upwardly directed processes. The processes are covered with irregular rings of granules that are often

larger on the upper (dorsal) and lower (ventral) margins of the process. The apex has horizontal rows of large, coarse verrucae that give the cell a crenulated appearance. This species is extremely polymorphic and poorly described in the literature (Coesel and Meester, 2013).

Two morphological forms were present in the samples. *Staurastrum crenulatum* var. A is characterized by vase-shaped semi-cells with a slightly inflated base (Figures 22.83–22.84). This form resembles *Staurastrum boreale* (Figure 22.52) and *Staurastrum gracile* (Figure 22.108), which lack the distinctive apical crenulations, and *Staurastrum manfeldtii* (Figure 22.161), which is much larger. The second form, *Staurastrum crenulatum* var. B, is characterized by robust, fusiform cells with nearly horizontal but slightly recurved processes (Figures 22.85–22.87). Both of these forms can be found in the illustrations of *Staurastrum crenulatum* provided by Coesel and Meesters (2013; see Plate 74, #14 and #16).

Staurastrum cytocerum* var. *inflexum semi-cells are usually triradiate and cup-shaped or triangular in outline, with a convex apex (Figures 22.88–22.91). Cells are usually twisted so that the semi-cells are in different planes. The apical margin is extended to form long, abruptly narrowed, slightly recurved processes. The processes are covered with concentric rings of small granules, the cell face has vertical rows of fine granules, and there is a ring of granules above the isthmus. *Staurastrum cytocerum* var. *inflexum* is very similar to *Staurastrum hexacerum* (Figure 22.121), which has shorter, more evenly curved processes and is usually less strongly twisted. It is also similar to *Staurastrum borgeanum* (Figure 22.55), which is larger and has very coarse granulation.

Staurastrum dilatatum semi-cells are usually 4–5-radiate (occasionally triradiate), and rhombic in outline, with short, broadly rounded lobes, a convex apex, and nearly straight or slightly concave lower lateral margins (Figures 22.92–22.93). The base of the semi-cell may form a short column with parallel sides from the isthmus to the base of the processes, The cells are often twisted so that the semi-cells are in different planes. The processes are covered with concentric rings of coarse granules, with additional granules forming vertical rows on the cell face between the lobes. There is a ring of smaller granules above the isthmus, but this feature is difficult to see without SEM. *Staurastrum dilatatum* resembles *Staurastrum alternans* (Figure 22.9), *Staurastrum lapponicum* (Figure 22.149), *Staurastrum striatum* (Figure 22.248), and *Staurastrum striolatum* (Figure 22.253), all of which are smaller.

Staurastrum dybowskii semi-cells are triradiate and narrowly fusiform in outline. The northwest Washington specimens have a slightly concave apex and narrow, upwardly directed lobes (Figures 22.94–22.96). The semi-cell lobes end in 2–3 blunt, tooth-like spines and are covered with concentric rings of coarse granules. There are additional vertical rows of granules on the cell face between the lobes, a faint ring above the isthmus, and a ring of paired granules on the apex. The species identification is uncertain because the specimens did not match all of the diagnostic features provided by Coesel and Meesters (2013) or Prescott, et al. (1982). *Staurastrum dybowskii* resembles *Staurastrum haaboeliense* (Figure 22.120) and *Staurastrum simonyi* (Figure 22.239), both of which have horizontally directed semi-cell lobes.

Staurastrum forficulatum semi-cells are usually triradiate, and hexagonal, trapezoidal, or elliptical in outline (Figures 22.97–22.99). The semi-cell has very distinctive, long, paired, spines on the lateral margin, usually joined to the semi-cell by very short processes. There is a subapical ring of six short, horn-like extensions (two per semi-cell lobe), each ending in bifurcate teeth or spines. The cells also have spiny projections and large verrucae on the face and lobes of the semi-cell.

Staurastrum forficulatum belongs to a group of highly polymorphic taxa that includes *Staurastrum arcuatum* (Figure 22.25), *Staurastrum avicula* (Figure 22.38), and *Staurastrum subcruciatum* (Figure 22.261). These species are difficult to separate because immature semi-cells may not have fully developed morphological features, and it is not unusual to find cells that display atypical features. *Staurastrum forficulatum* closely resembles *Staurastrum arcuatum* (Figure 22.25), which is smaller and has fusiform or bowl-shaped cells with a flattened apex and narrowed lateral margins; *Staurastrum forficulatum* has a rounded apex and rounded lateral margins.

Staurastrum furcigerum semi-cells are usually triradiate and elliptical in outline (Figures 22.100–22.102). The apical margins are extended to form three short, horizontal processes. The apex of the semi-cell is further extended into three upwardly directed processes that are positioned midway between the horizontal processes. All of the processes end in 2–3 stout spines and are covered with concentric rings of small granules. *Staurastrum furcigerum* is found in a very wide range of habitats and is polymorphic, especially with respect to the process length (Figure 22.102).

Staurastrum gemelliparum semi-cells are triradiate, smooth-walled, and oval or hexagonal in outline (Figures 22.103–22.105). The semi-cell margins are extended

into 12 short processes, each of which are tipped with 2–3 stout spines. The SEM image (Figure 22.104) shows that the processes form groups of four on each of the semi-cells angles, resulting in six upwardly directed processes and six horizontal processes (total=12). *Staurastrum gemelliparum* resembles *Staurastrum arctiscon* f. *glabrum*, *Staurastrum clevei*, *Staurastrum laeve* and *Staurastrum tohopekaligense* (Figures 22.21, 22.79, 22.144, and 22.276), but none of these species have the same configuration of processes.

Staurastrum geminatum semi-cells are triradiate, lobed, and elliptical or broadly oval in outline (Figures 22.106–22.107). The semi-cells are smooth except for six long spines on each lobe. The spines are arranged in pairs, with one spine directed upward and the other directed horizontally or downward; one spine pair is positioned at each apical angle; two more pairs are positioned on either side of the first pair. The spines are long, stout, and often slightly curved. *Staurastrum geminatum* closely resembles *Staurastrum setigerum* (Figure 22.233), which has a very similar arrangement of upper and lower spines. But the *Staurastrum setigerum* spines are not uniform (see description below), and the semi-cells are much larger. *Staurastrum geminatum* also resembles *Staurastrum hystrix* (Figure 22.127), which has angular, oblong semi-cells with a ring of 7–10 spines around each lobes.

Staurastrum gracile semi-cells are triradiate or 4-radiate and wedge-shaped or cup-shaped in outline, with a flat or slightly convex apex (Figures 22.108–22.113). The apical margin is extended into short or long, horizontal or slightly upwardly directed processes than end in short tooth-like spines. The processes are covered with regularly spaced concentric rings of small, tooth-like granules. Additional rows of fused or paired granules extend from the apex onto the cell face, and there is a ring of small granules above the isthmus. *Staurastrum gracile* looks nearly identical to *Staurastrum boreale*, but is about 50% larger. According to Coesel and Meesters (2013), *Staurastrum gracile* "is known as one of the most notorious catch-all species." Although there are many varieties listed in the taxonomic literature, separating the varieties is beyond the scope of this guide.

Staurastrum grande *Staurastrum grande* semi-cells are triradiate, lobed, and broadly elliptical to broadly lens-shaped (Figures 22.114–22.119). The semi-cells are smooth-walled except for rather prominent mucilage pores, and have a flat or slightly concave apex. The nominate variety[45] has thickened, bluntly pointed lobe angles, giving the semi-cells a distinctive lens-shaped appearance (Figures 22.114–22.116). ***Staurastrum grande*** **var.** ***rotundatum*** semi-cells are distinguished by

[45] *Staurastrum grande* var. *grande*

rounded lobe angles and a more closed sinus (Figures 22.117–22.119). *Staurastrum grande* can be distinguished from other smooth-walled species of *Staurastrum* by its large size (width and length >65 μm).

Staurastrum haaboeliense semi-cells are usually triradiate, lobed, and fusiform in outline with a slightly concave apex and narrow, horizontal lateral lobes (Figure 22.120). The semi-cell lobes are tipped with several thin, sharp spines. The cell wall is covered with concentric series of granules, but the ornamentation is difficult to see without SEM imagery. *Staurastrum haaboeliense* resembles *Staurastrum simonyi* (Figure 22.239), which has more elliptical semi-cells, apical spines, and tooth-like spines on the lobe margins; and *Staurastrum dybowskii* (Figure 22.94), which has upwardly directed semi-cell lobes.

Staurastrum hexacerum semi-cells are usually triradiate, and broadly fusiform in outline, with nearly equal curvature on the upper and lower semi-cell margins (Figures 22.121–22.122). The cells are often twisted so that the semi-cells are in different planes. The apical margin is extended to form short, triangular processes that merge smoothly with the apex and lower lateral margin. The processes are covered with concentric rings of granules but the pattern is difficult to see without SEM imagery. *Staurastrum hexacerum* is very similar to *Staurastrum cytocerum* var. *inflexum* (Figure 22.88), which is more strongly twisted and has longer processes. It is also similar to *Staurastrum borgeanum* (Figure 22.55), which is larger and has very coarse granulation.

Staurastrum hirsutum var. ***pseudarnellii*** semi-cells are triradiate, lobed, and semi-circular or trapezoidal in outline (Figures 22.123–22.126). The nominate variety[46] is covered with fine spines, but the northwest Washington variety is covered with small, bluntly pointed granules. The granules form widely-spaced concentric rings on the semi-cell lobes; slightly larger, tooth-like granules are present along the lobe angles. The semi-circular outline and bluntly rounded lobes makes this species difficult to distinguish from *Cosmarium*.[47]

Staurastrum hystrix semi-cells are triradiate, lobed, and oblong in outline, with a flat or concave apex and distinctly angular lateral margins (Figures 22.127–22.129). The semi-cells are smooth except for rings of 7–10 long, stout, straight or recurved spines on each lobe. *Staurastrum hystrix* resembles *Staurastrum geminatum* (Figure 22.106), which has six spines (three pairs) on each lobe.

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[46] *Staurastrum hirsutum* var. *hirsutum*; no image available

[47] See **Freshwater Algae in Northwest Washington, Volume III. Part B.**

Staurastrum inconspicuum semi-cells are very small, usually 4-radiate, and rectangular in outline, with four short, arm-like processes extending from the apical margin (Figures 22.130–22.133). The processes extend at a slight angle from the semi-cell body, then bend upward, ending in short teeth or granules. The cell body is mostly smooth, but there are often granules or spines at the base and at the bend in each process. The length of the processes is quite variable, and has at times been used to distinguish a variety, *Staurastrum inconspicuum* var. *crassum*, characterized by very short processes (e.g., Figure 22.133). This feature is now considered by most taxonomists to be a morphological variation found in the nominate variety.[48]

Staurastrum insigne semi-cells are usually 5-radiate, rhombic in outline, with an elevated apex (Figures 22.134–22.135). The apical angles are extended to form short, blunt lobes. The cell wall is smooth except for mucilage pores visible in SEM images. (Only SEM images are available for this species.)

Staurastrum johnsonii semi-cells are mostly biradiate or triradiate and vase-shaped with an inflated area above the isthmus (Figures 22.136–22.139). The apical margin is extended into long, horizontal or upwardly directed processes that end in short, tooth-like spines. The processes are covered with spiralling teeth (not concentric rings of granules); the teeth on the upper and lower portions of the process are larger than the lateral ones, giving the processes a rectangular appearance. There are two subapical horizontal rows of verrucae and two rings of small teeth above the isthmus; the uppermost ring may be incomplete. *Staurastrum johnsonii* is found in a wide variety of habitats. It belongs to a difficult group of *Staurastrum* species that include *Staurastrum cingulum* (Figure 22.75), *Staurastrum manfeldtii* (Figure 22.161), *Staurastrum pingue* var. *pingue* and var. *planctonicum* (Figures 22.208 and 22.211). Most of the diagnostic features in this group are subtle, and it is not unusual to find several of these species in the same plankton sample. *Staurastrum johnsonii* can be distinguished by its rather smooth, graceful, vase-shaped semi-cells and double ring of granules or small teeth above the isthmus.

Staurastrum kurilense semi-cells are usually biradiate,[49] bluntly fusiform in outline, with a prominent central protrusion (Figures 22.140–22.143). The SEM images of show six horizontal apical verrucae and a double circle of granules on the central protuberance, along with concentric rings of granules on the processes and a ring of teeth above the isthmus. The specimen in Figure 22.143 shows a side view of *Staurastrum kurilense*.

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[48] *Staurastrum inconspicuum* var. *inconspicuum*

[49] Triradiate semi-cells were found at the same location, but images are not available for this guide

Staurastrum laeve semi-cells are triradiate and bowl-shaped in outline, with a flat apex (Figures 22.144–22.145). Each of the three apical angles is extended into two bifurcate processes. As a result, there are a total of six processes, all in approximately the same plane. *Staurastrum laeve* resembles *Staurastrum arctiscon* f. *glabrum*, *Staurastrum clevei*, *Staurastrum gemelliparum* and *Staurastrum tohopekaligense* (Figures 22.21, 22.79, 22.103, and 22.276), but none of these species have the same configuration of processes.

Staurastrum lanceolatum* var. *compressum semi-cells are usually triradiate, lobed, and fusiform or narrowly elliptical in outline (Figures 22.146–22.148). The semi-cell lobes are distinctly thickened along the outer angles, but the cell wall is otherwise smooth. The absence of spines and other distinctive features makes this species difficult to distinguish from *Cosmarium*.[50]

Staurastrum lapponicum semi-cells are usually triradiate and broadly fusiform, elliptical, or somewhat rhombic in outline, with short, broadly rounded lobes, a convex apex, and nearly straight of slightly concave lower lobe margins (Figures 22.149–22.151). The entire cell is covered with rows of small granules that form concentric rings on the semi-cell lobes and vertical rows on the cell face. *Staurastrum lapponicum* closely resembles *Staurastrum dilatatum*, which is larger, more angular (rhombic), and often twisted. *Staurastrum lapponicum* also resembles *Staurastrum alternans* (Figure 22.9) and *Staurastrum striolatum* (Figure 22.253), both of which usually have twisted cells; *Staurastrum lapponicum* cells are not twisted. *Staurastrum lapponicum* closely resembles *Staurastrum striatum* (Figure 22.248), which has fusiform rather than elliptical cells and smaller granules.

Staurastrum lenzenwegeri semi-cells are small, biradiate, bowl-shaped or rectangular in outline, with a concave apex, and a distinctive, U-shaped sinus that extends to angular teeth at the base of each process (Figures 22.152–22.153). The apical margins are extended into long, upwardly directed processes that are covered with spiralling teeth and tipped with 3–4 small, tooth-like spines. This species is associated with eutrophic habitats and was collected in plankton samples from Moses Lake, a eutrophic lake in eastern Washington. *Staurastrum lenzenwegeri* resembles *Staurastrum smithii* (Figure 22.241), which has strongly twisted semi-cells; and *Staurastrum tetracerum* (Figure 22.272), which lacks the U-shaped sinus.

Staurastrum longipes semi-cells are usually triradiate and cup-shaped in outline, with a slightly concave apex, and shallow, open sinus (Figures 22.154–22.156). The

[50] See **Freshwater Algae in Northwest Washington, Volume III. Part B.**

apical margins are extended into long, very narrow, upwardly directed processes with minute, spiralling teeth, ending in 3–4 stout, tooth-like spines. The cell wall is smooth except for the spines and teeth on the processes. The isthmus is only slightly constricted relative to the cell body, giving the cell a rectangular appearance. *Staurastrum longipes* resembles *Staurastrum chaetoceras* (Figure 22.72), which can be present in the same sample, but *Staurastrum chaetoceras* is mostly biradiate and has granular ornamentation on the processes and cell face.

Staurastrum longispinum semi-cells are very large, triradiate, lobed, and bowl-shaped or elliptical in outline (Figures 22.157–22.160). The apical angles extend into 2–3 long, stout spines that are positioned in the same plane, one below the other. The uppermost spines are usually curved slightly upward and the lower spines are more horizontal. The cell wall is smooth, except for the spines. This species is easily misidentified as a type of *Staurodesmus* (see Chapter 23)

Staurastrum manfeldtii semi-cells are mostly triradiate and cup-shaped in outline, with a inflated region above the isthmus. (Figures 22.161–22.167). The apical margin is extended into three long, horizontal or downwardly directed processes that are tipped with short, tooth-like spines. The processes are covered with spiralling teeth (not concentric rings of granules); the teeth on the upper and lower portions of the processes are much larger than the lateral ones, which gives the processes a rectangular appearance in cross-section. There are also two subapical, horizontal rows of teeth (not verrucae) and a cluster of granules above the isthmus in line with the base of each process (Figures 22.161–22.163). A morphologically distinct variety, *Staurastrum manfeldtii* var. A, can be distinguished by its long, cylindrical cells that are only slightly inflated above the isthmus (Figures 22.164–22.167). The processes and subapical teeth/verrucae are similar to the specimens in Figure 22.161–22.163, but the isthmus ornamentation includes a ring of sharp teeth in addition to clusters of granules in line with the base of each process.

Staurastrum manfeldtii is extremely polymorphic, and can be found in a wide variety of habitats. It belongs to a difficult group of *Staurastrum* species that include *Staurastrum cingulum* (Figure 22.75), *Staurastrum johnsonii* (Figure 22.136), *Staurastrum pingue* var. *pingue* and var. *planctonicum* (Figures 22.208 and 22.211). Most of the diagnostic features in this group are subtle, and it is not unusual to find several of these species in the same plankton sample. *Staurastrum manfeldtii* can be distinguished by its rough appearance that is caused by the large spiralling teeth on the processes and the coarse, subapical verrucae.

Staurastrum margaritaceum semi-cells are 4–6-radiate and cup-shaped or campanulate in outline (Figures 22.168–22.172). The apical angles are extended to form short, blunt, horizontal processes that are tipped with tiny, blunt, tooth-like spines. The processes have concentric rings of large granules or teeth, and there is usually a ring of granules or teeth above the isthmus. The apex also has large granules that are sometimes fused into verrucae. *Staurastrum margaritaceum* is quite common in mountain lakes and ponds in northwest Washington, with different locations often containing varieties with different radial symmetry. *Staurastrum margaritaceum* resembles *Staurastrum asteroideum* (Figure 22.31), which is 5-radiate with upwardly directed processes; and *Staurastrum subcomptum* (Figure 22.257), which has vase-shaped semi-cells with a columnar base.

Staurastrum margaritaceum **var.** ***alpinum*** is an unusual variety that can be distinguished by the replacement of arm-like processes with broadly expanded lobes (Figures 22.173–22.175). This variety is also characterized by concentric rings of small granules on the lobes, a ring of granules above the isthmus, and horizontal rows of granules extending from the apex onto the face of the semi-cell. This is an alpine variety, and all the northwest Washington specimens were collected from a shallow, mossy pond in the North Cascades.

Staurastrum meriani semi-cells are 3–6-radiate (the northwest Washington specimens are 6-radiate), lobed, and broadly rectangular or trapezoidal in outline, with straight lateral margin and a convex apex (Figures 22.176–22.177). The cell wall is densely covered with large, regularly spaced granules. The northwest Washington specimens also appear to have a ring of large granules above the isthmus. Coesel and Meesters (2013) state that this is an arctic and subalpine species that can be found on moist rocks and other wet surfaces; the northwest Washington specimens were collected from a rocky cliff in the spray zone of a waterfall near Rainy Pass in the North Cascades.

Staurastrum micron semi-cells are usually triradiate and bowl-shaped in outline (Figure 22.178). The apical margin is extended into short, blunt, upwardly directed processes that are slightly enlarged at the end and tipped with 3–4 tooth-like spines. The processes also have irregular rings of granules or tiny tooth-like spines, which appear clustered into small groups rather than forming regularly spaced concentric rings. The cell body is mostly smooth, with a few widely scattered granules that are mostly associated with the processes. The northwest Washington specimens are very tiny (length and width 10–14 μm) and were only found in SEM images.

Staurastrum minnesotense semi-cells are triradiate, lobed, and broadly elliptical (Figures 22.179–22.181). The cells are exceptionally large and mostly smooth except for minute "punctae" (tiny pits or depressions) and sparsely distributed spines. The lateral margins have a pair of relatively long, stout spines, which are somewhat similar to *Staurastrum setigerum* (Figure 22.233), but are positioned one above the other rather than divergently forked. There is also an apical ring of nine long, thin spines and a few sparsely scattered spines on the rest of the semi-cell. The unusually large size and sparsely scattered spines makes this species relatively easy to identify. It should be noted, however, that the northwest Washington specimens are larger than the size ranges listed by Prescott, et al. (1982) for this species.

Staurastrum monticulosum semi-cells are triradiate, lobed, and bowl-shaped or trapezoidal in outline (Figure 22.182). Each apical angle ends in a short, upwardly directed, tooth-like spine; a second, downwardly directed spine is located below the marginal spine. The apex has a ring of six tooth-like spines. The lobes should have concentric rings of granules, but this feature is not visible in Figure 22.182.

Staurastrum muticum semi-cells are usually triradiate and broadly elliptical, kidney-shaped, pyramidal, or semi-circular in outline, with a smooth cell wall (Figures 22.183–22.186). Two morphological variations were present in the northwest Washington samples. *Staurastrum muticum* var. A specimens were collected in a small, low elevation artificial pond, and are characterized by elliptical cells with a widely open sinus (Figures 22.183–22.184). *Staurastrum muticum* var. B specimens were collected in a high elevation mountain lake, and are characterized by small, kidney-shaped cells that have a partly open sinus (Figures 22.185–22.186).

Staurastrum muticum resembles *Staurastrum bieneanum* (Figure 22.50), *Staurastrum crassangulatum* (Figure 22.81), and *Staurastrum grande* (Figure 22.114). Collectively, these species are a catch-all for smooth-walled forms with oval, elliptical, or broadly fusiform semi-cells. The best feature for separating these species is size; *Staurastrum muticum* is the smallest in the group (Table 22.2).

Staurastrum natator semi-cells are mostly biradiate, triangular, or rhombic in outline, and slightly inflated above the isthmus (Figures 22.187–22.188). The apical margin is extended to form two long, upwardly directed processes ending in blunt, tooth-like spines. There are concentric rings of fairly large granules on the processes and large verrucae positioned horizontally across the apex. The semi-cell has a large central protuberance containing one or more rings of coarse granules (Figure 22.188).

Staurastrum novae-terrae semi-cells are triradiate and triangular in outline, with nearly straight lateral margins and a flat or slightly convex apex (Figures 22.189–22.191). The semi-cells are lobed, but have very long, spiny extensions on the apical margins that could be interpreted as arm-like processes. The extensions appear hollow near the point of attachment to the semi-cell body, but are solid throughout most of their length. The extensions are sharply pointed and either bifurcate or intact. Six additional short, horn-like, bifurcate extensions are located on the apex, and there are several short, robust, downwardly directed spines near the base of each process. These downwardly directed spines are present on numerous specimens from multiple sites in the North Cascades, and are not described by Prescott, et at. (1982) for triradiate semi-cells, so they may represent an undescribed variety.

Staurastrum ophiura semi-cells are 5–7-radiate, cup-shaped or vase-shaped in outline, with a convex apex (Figures 22.192–22.197). The apical margins are extended into 5–7 long, recurved processes that end in stout, tooth-like spines. The processes are covered with rings of granules or short teeth, and the apex also has a ring of granules, verrucae, or horn-like projections. The cells are polymorphic with respect to radial symmetry, process length, and overall cell size. This species is very common in northwest Washington lakes, and often displays different radial symmetry at different sites.

Staurastrum orbiculare semi-cells are triradiate, lobed, and semi-circular, pentagonal, or broadly elliptical in outline, with a narrow, linear sinus that opens near the lateral margin (Figures 22.198–22.202). The semi-cell lobes are rounded, resulting in an oval or circular cell outline. The cell wall is smooth, but may show slight pitting or sculpting in SEM images (Figure 22.201). *Staurastrum orbiculare* resembles *Staurastrum ralfsii* (Figure 22.225), which is smaller and more pyramidal in outline.[51] ***Staurastrum orbiculare* var. *protractum*** is characterized by broadly pentagonal semi-cells with a flattened apex and partially open sinus (Figure 22.200–22.201). The specimens in Figure 22.202 have compressed semi-circular or kidney-shaped semi-cells with a closed, linear sinus, so they may be *Staurastrum orbiculare* var. *protractum*, or a different variety. *Staurastrum orbiculare* var. *protractum* resembles *Staurastrum bieneanum* (Figure 22.50), *Staurastrum crassangulatum* (Figure 22.81), *Staurastrum grande* (Figure 22.114), and *Staurastrum muticum* (Figure 22.183). Collectively, these species are a catch-all for smooth-walled forms with oval, elliptical, or broadly fusiform semi-cells. The best feature for separating some of these species is size: *Staurastrum muticum* has small cells (width and length <30 μm) and *Staurastrum grande* has very large cells (width and length

[51] *Staurastrum ralfsii* was formerly named *Staurastrum orbiculare* var. *ralfsii*.

>65 μm). *Staurastrum orbiculare* var. *protractum* semi-cells are usually more pentagonal than *Staurastrum bieneanum* and *Staurastrum crassangulatum*, which are elliptical.

Staurastrum pachyrhynchum semi-cells are 3–5-radiate, lobed; smooth walled; inversely triangular, semi-circular, or elliptical in outline; with thickened apical angles. The specimens in Figures 22.203–22.205 are triradiate, with broad, smooth, bowl-shaped semi-cells that are thickened at the lobe angles. The specimen in Figure 22.205 is considerably smaller than the other specimens, so it may be a different species or variety. All of the northwest Washington specimens are somewhat different than the descriptions provided by Coesel and Meesters (2013) and Prescott, et al. (1982), so the species identification is uncertain.

Staurastrum paradoxum semi-cells are 3–4-radiate, cup-shaped, with moderately long, slightly divergent processes that end in 3–4 sharp, tooth-like spines (Figures 22.206–22.207). The processes have concentric rings of small, uniformly sized granules. Concentric rings of small, uniformly sized granules may continue onto the cell body, especially in the upper portion of the cell. *Staurastrum paradoxum* is a difficult and confusing species to identify. Many of the forms previously listed as varieties have been renamed as separate species (e.g., *Staurastrum paradoxum* var. *cingulum* = *Staurastrum cingulum*, Figure 22.75). Prescott, et al. (1982) did not include *Staurastrum paradoxum* as a distinct species; we are following the description provided by Coesel and Meesters (2013), who noted the distinctive uniformity of granules on the cell surface. *Staurastrum paradoxum* closely resembles *Staurastrum anatinum* (Figure 22.12), which should be distinguishable by its coarse, less regular pattern of granulation on the cell wall.

Staurastrum pingue semi-cells are triradiate; cylindrical, cup-shaped, or vase-shaped in outline; and may have a slightly inflated region above the isthmus (Figures 22.208–22.215). The apical margin is extended into three long processes that end in short, tooth-like spines. The processes are covered with small, spiralling teeth (not concentric rings of granules). The cell body usually appears to be smooth, but SEM images reveal faint granulation, small teeth, and small verrucae.

Staurastrum pingue is represented by the nominate variety, *Staurastrum pingue* var. *pingue* (Figures 22.208–22.210) and a larger, more common variety, *Staurastrum pingue* var. *planctonicum* (Figures 22.211–22.215). Other than size, it is difficult to separate these two varieties, even using SEM. The best diagnostic features, according to Coesel and Meesters (2013), are isthmus size ($\geq$10 μm for var. *planctonicum*) and the number of teeth on the end of each process

(three for var. *planctonicum*; four for var. *pingue*). In the northwest Washington samples, process teeth were not a good diagnostic feature, but the isthmus size for *Staurastrum pingue* var. *pingue* was 5.8–7.9 μm compared to 8.6–13.2 μm for *Staurastrum pingue* var. *planctonicum*.

Staurastrum pingue and *Staurastrum pingue* var. *planctonicum* are very common in planktonic samples and can be found in a wide variety of habitats. They belong to a difficult group of *Staurastrum* species that include *Staurastrum cingulum* (Figure 22.75), *Staurastrum johnsonii* (Figure 22.136), and *Staurastrum manfeldtii* (Figure 22.161). Most of the diagnostic features in this group are subtle, and it is not unusual to find several of these species in the same plankton sample. Both varieties of *Staurastrum pingue* can usually be distinguished by the relatively smooth appearance of the vase-like semi-cells.

Staurastrum polytrichum semi-cells are triradiate, lobed, and elliptical in outline, with an open sinus that gives the cells an hourglass appearance (Figures 22.216–22.217). The semi-cells are covered with moderately long, stout spines arranged in 2–3 horizontal rows across the face of the cell, with irregular circles around the lobes. The spines on the angles are usually longer than the spines on the cell face and apex. *Staurastrum polytrichum* resembles *Staurastrum teliferum* var. *gladiosum* (Figure 22.267), which is much smaller, more compact, and usually has shorter, less densely arranged spines.

Staurastrum pseudotetracerum semi-cells are triradiate and almost perfectly triangular in outline, with linear lateral margins and a flat apex (Figures 22.218–22.220). The apical margins are extended into short, narrow processes that end in 4–5 very small, tooth-like spines. The processes are covered with widely spaced concentric rings of tiny granules. Additional granules form a vertical row extending downward from the apex to about the middle of the cell face, and there is a faint ring of small granules above the isthmus. *Staurastrum pseudotetracerum* resembles *Staurastrum boreale* (Figure 22.52), which has a cup-shaped semi-cell, much coarser granulation, and was collected in an oligo-mesotrophic mountain pond; the *Staurastrum pseudotetracerum* specimens were collected in a low elevation sphagnum bog.

Staurastrum punctulatum is a poorly describes species that is characterized by lobed, rhombic semi-cells covered with concentric rings of small granules. The northwest Washington specimens of *Staurastrum punctulatum* are 4-radiate with rhombic semi-cells that have very short, broadly rounded semi-cell lobes (Figures 22.221–22.224). The majority of the cell is covered with widely spaced rows of

small granules that form concentric rings on the semi-cell lobes and vertical rows on the cell face. The cells are either untwisted, or at most very slightly twisted, and longer than wide, which helps separate this species from other lobed, granulated *Staurastrum* species (e.g., *Staurastrum lapponicum*; Figure 22.149). Immature semi-cells are nearly spherical (Figure 22.224), making this species difficult to distinguish from *Cosmarium*.[52] The northwest Washington specimens are likely to be an alpine variety; all the specimens were collected from a shallow, mossy tributary to Upper Anderson Lake in the North Cascades. The semi-cell features fit the description provided by Prescott, et al., (1982) for *Staurastrum punctulatum* var. *pygmaeum*, which has been merged with the nominate variety.[53] Given the remote alpine habitat, it is possibly that the Upper Anderson Lake samples are an undescribed variety.

Staurastrum ralfsii semi-cells are triradiate, lobed, and semi-circular or pyramidal in outline, with a strongly convex apical margin and deeply constricted, nearly linear sinus that is closed except at the margin (Figures 22.225–22.230). The semi-cell lobes are rounded, resulting in an oval or circular cell outline. The cell wall is smooth except for regularly spaced pits and mucilage pores that are visible in SEM images. *Staurastrum ralfsii* was formerly listed as a variety of *Staurastrum orbiculare*, but the cells are smaller than most *Staurastrum orbiculare* varieties. ***Staurastrum ralfsii* var. *depressum*** resembles the nominate variety,[54] but has slightly compressed pyramidal semi-cells (Figures 22.228–22.230).

Staurastrum reductum semi-cells are biradiate, vase-shaped, with an inflated region above the isthmus (Figures 22.231–22.232). The apical margins are expended to form long, slender, upwardly directed processes that end in 2–3 tooth-like spines. The processes are covered with spiralling teeth, but the cell body is otherwise smooth. Coesel (2007) describes *Staurastrum reductum* as being morphologically intermediate between *Staurastrum manfeldtii* (Figure 22.161) and *Staurastrum pingue* var. *planctonicum* (Figure 22.211), both of which are usually triradiate. *Staurastrum reductum* resembles *Staurastrum chaetoceras* (Figure 22.72), which is triangular in outline rather than vase-shaped.

Staurastrum setigerum semi-cells are triradiate, lobed, and broadly triangular in outline, with nearly straight lateral margins and a flat or slightly convex apex, giving the cell an hourglass shape (Figures 22.233–22.235). The semi-cells are covered

[52] See **Freshwater Algae in Northwest Washington, Volume III. Part B.**
[53] *Staurastrum punctulatum* var. *punctulatum*
[54] *Staurastrum ralfsii* var. *ralfsii*

with long spines that form horizontal rows across the cell face, with additional spines forming an apical ring. Spines on the angles are longer and stouter than spines on the cell face or apex. Two of the spines on each lateral angle are particularly large and divergently forked, which helps distinguish this species from other spiny *Staurastrum* species. ***Staurastrum setigerum* var. *occidentale*** lacks the hourglass shape found in the nominate variety[55] and instead has compact elliptical semi-cells with fewer spines (Figures 22.236–22.238). The spines are mostly confined to the angles and the apex. The specimens from eastern Washington do not entirely match the description for this variety in Prescott, et al. (1982), so the identification is tentative. *Staurastrum setigerum* resembles *Staurastrum geminatum* (Figure 22.106) and *Staurastrum hystrix* (Figure 22.127), both of which are much smaller. *Staurastrum setigerum* also resembles *Staurastrum teliferum* var. *gladiosum* (Figure 22.267), *Staurastrum minnesotense* (Figure 22.179), and *Staurastrum polytrichum* (Figure 22.216), but none of these species have the distinctive large, paired, divergently forked, marginal spines.

Staurastrum simonyi semi-cells are usually triradiate, lobed, and narrowly fusiform or elliptical in outline, with a convex, spiny apex and nearly straight lower lateral margin (Figures 22.239–22.240). The semi-cell lobes are tipped with short, stout, tooth-like spines. The cell is sparsely covered with granules that are arranged in concentric rings on the lobes, but the ornamentation is difficult to see without SEM imagery. *Staurastrum simonyi* resembles *Staurastrum haaboeliense* (Figure 22.120), which has narrow, fusiform semi-cells and fine, sharp spines on the semi-cell lobes; and *Staurastrum dybowskii* (Figure 22.94), which has upwardly directed semi-cell lobes.

Staurastrum smithii semi-cells are small, biradiate, and cup-shaped, with a concave apex (Figures 22.241–22.242). The apical margins are extended into long, upwardly directed processes that are covered with spiralling teeth and tipped with minute, tooth-like spines. The cells are strongly twisted at the isthmus, with up to a 90° angle between semi-cells. This species is associated with eutrophic habitats and was collected in plankton samples from Sunset Lake, a small, eutrophic residential pond in Bellingham, Washington. This species resembles *Staurastrum lenzenwegeri* (Figure 22.152) and *Staurastrum tetracerum* (Figure 22.272), neither of which are as strongly twisted.

Staurastrum spongiosum semi-cells are triradiate and oval, semi-circular, or trapezoidal in outline, with a flat or slightly convex apex (Figures 22.243–22.247).

[55] *Staurastrum setigerum* var. *setigerum*

The apex has approximately six horn-like extensions that end in short, bifurcate teeth. The face of the cell is covered with regularly arranged verrucae and the lateral margin has bifurcate spines at the angles. The cell details are difficult to see without using SEM and is easily misidentified as a species of *Cosmarium*.[56]

Staurastrum striatum semi-cells are triradiate and broadly fusiform or rhombic with short, rounded semi-cell lobes (Figures 22.248–22.252). The cell is covered with widely spaced rows of granules forming concentric rings on the semi-cell lobes and vertical rows on the cell face between the lobes. The cells are not strongly twisted, which distinguished this species from a few of the similar species of lobed, granulated *Staurastrum*. *Staurastrum striatum* is very similar to *Staurastrum punctulatum* except for radial symmetry, which is triradiate for *Staurastrum striatum* and 4-radiate for *Staurastrum punctulatum*.

Staurastrum striolatum semi-cells are triradiate or 4-radiate and narrowly elliptical, triangular, or rectangular in outline, with broadly rounded semi-cell lobes, a nearly flat or slightly convex apex, flat or concave lower lateral margins, and (often) an elongated region above isthmus (Figures 22.253–22.256). The cells are usually strongly twisted so that the semi-cells are in different planes. The entire cell is covered with regularly spaced rows of granules that form concentric rings on the semi-cell lobes and vertical rows on the cell face. Due to the relatively unique twisted, rectangular semi-cell shape, *Staurastrum striolatum* is slightly easier to recognize than most other lobed, granulated *Staurastrum* species. It resembles *Staurastrum alternans* (Figure 22.9), which is also usually twisted, but has elliptical or broadly fusiform semi-cells.

Staurastrum subcomptum semi-cells are 6-radiate and vase-shaped in outline, with a column-shaped base and expanded, convex apex (Figures 22.257–22.260). The marginal angles are extended into six short, horizontal processes that end in 5–6 short tooth-like spines. The processes have concentric rings of large granules. The apex has a ring of coarse verrucae, and there is a ring of short teeth above the isthmus. *Staurastrum subcomptum* resembles *Staurastrum asteroideum* (Figure 22.31), which is 5-radiate with upwardly directed processes; and *Staurastrum margaritaceum* (Figure 22.168), which has cup-shaped or campanulate semi-cells.

Staurastrum subcruciatum semi-cells are triradiate and bowl-shaped, elliptical, or broadly fusiform in outline (Figures 22.261–22.263). The apical margin is slightly extended into short processes that end in two stout spines. The spines

[56] See **Freshwater Algae in Northwest Washington, Volume III. Part B.**

are asymmetric: the upper spine is longer and more upwardly directed; the lower spine is short, often tooth-like, and positioned horizontally or directed downward. The semi-cell lobes are covered with concentric rings of relatively large granules that are often visible without using SEM. *Staurastrum subcruciatum* resembles *Staurastrum avicula* (Figure 22.38) but can be distinguished by the asymmetric spines. *Staurastrum subcruciatum* belongs to a group of highly polymorphic taxa that includes *Staurastrum arcuatum* (Figure 22.25), *Staurastrum avicula* (Figure 22.38), and *Staurastrum forficulatum* (Figure 22.97). These species are difficult to separate because immature semi-cells may not have fully developed morphological features, and it is not unusual to find cells that display atypical features.

Staurastrum subnudibrachiatum* var. *incisum semi-cells are mostly 4-radiate and roughly X-shaped in outline, with long, thick processes extending from a spherical or oval center, ending in 1-3 thick, rounded, teeth (Figures 22.264–22.266). The cells are smooth-walled, soft-bodied, and highly polymorphic, especially with respect to the length of the processes and configuration of teeth on the processes. *Staurastrum subnudibrachiatum* resembles *Staurastrum brachiatum* which is characterized by smaller semi-cells that lack the oval cell body and "incised" sinus. According to Coesel and Meesters (2013), there are intermediate forms that resemble both of these species, and both species were present in Bear Lake on the same date (Figure 22.60), so the species separation is questionable.

Staurastrum teliferum* var. *gladiosum semi-cells are triradiate, lobed, and elliptical or compressed oval in outline (Figures 22.267–22.271). The cell face is sparsely covered with stout, tooth-like spines that form horizontal rows across the face of the cell and irregular concentric rings on the lobes. The spines are often variable in length and thickness, with longer, stouter spines on the angles and semi-cell face, and shorter spines near the apex. *Staurastrum teliferum* var. *gladiosum* resembles *Staurastrum polytrichum* (Figure 22.216), which is much larger and more densely covered with spines.

Staurastrum tetracerum semi-cells are small, biradiate or triradiate, and bowl-shaped or rectangular in outline with a flat or slightly concave apex (Figures 22.272–22.275). The apical margins are extended into long, upwardly directed processes that are covered with spiralling teeth and tipped with minute, tooth-like spines. There are additional tooth-like spines or granules scattered sparsely across the face of the semi-cell. The cells are often slightly twisted, resulting in semi-cells that lie in different planes, but they are not as strongly twisted as *Staurastrum smithii* (Figure 22.241). The triradiate cells (Figure 22.275) are listed

as ***Staurastrum tetracerum* var *trigona*** in some taxonomic guides. This species is extremely polymorphic, especially with regards to the length of the processes. *Staurastrum tetracerum* is found in a wide range of habitats, and will occasionally form blooms in eutrophic lakes. In addition to *Staurastrum smithii*, *Staurastrum tetracerum* resembles *Staurastrum lenzenwegeri* (Figure 22.152), which can be distinguished by the U-shaped sinus.

Staurastrum tohopekaligense semi-cells appear pluriradiate, but are actually triradiate and oval or broadly elliptical in outline (Figures 22.276–22.279). The apical margins are extended into nine processes, with three processes produced on each of the three apical angles. The processes are usually bifurcate (occasionally trifurcate); the cell face is smooth except for mucilage pores visible in SEM images. *Staurastrum tohopekaligense* resembles *Staurastrum clevei* (Figure 22.79) and *Staurastrum laeve* (Figure 22.144), both of which have only six processes; *Staurastrum gemelliparum* (Figure 22.103), which has 12 processes (four on each of the three apical angles); and *Staurastrum arctiscon* f. *glabrum* (Figure 22.21), which is much larger and has 15 processes.

Staurastrum trapezioides semi-cells are triradiate, lobed, and trapezoidal in outline (Figures 22.280–22.282). The semi-cells are densely and evenly covered with short spines that form transverse rows across the face of the cell and concentric circles around the angles. *Staurastrum trapezioides* is very similar to *Staurastrum brebissonii* (Figure 22.65), and was formerly listed as *Staurastrum brebissonii* var. *truncatum*; *Staurastrum trapezioides* can be distinguished by its larger size and more angular semi-cells. *Staurastrum trapezioides* also resembles *Staurastrum teliferum* var. *gladiosum* (Figure 22.267) and *Staurastrum polytrichum* (Figure 22.216), both of which have much longer spines.

Staurastrum trifidum* var. *inflexum semi-cells are triradiate, lobed, and elliptical or broadly lens-shaped in outline (Figures 22.283–22.285). The apex is broadly convex, but may be flattened or even slightly concave at the center. The apical angles extend into three stout, unequal, downwardly directed spines that originate from different locations along the apical margin. This unusual desmid is relatively rare in northwest Washington lakes, but can almost always be found in shoreline samples from Myrtle Lake.

Staurastrum vestitum semi-cells are triradiate or 4-radiate and lens-shaped in outline (Figures 22.286–22.290). The apical margins are extended into short horizontal or downwardly directed processes ending in 3–4 sharp, tooth-like spines. The semi-cell face has two transverse rows of verrucae or bifurcate spines; one row

is located near the apex and the second row crosses the middle of the semi-cell. The verrucae or bifurcate spines located in the center of each transverse row are often notably larger than others in the row (Figures 22.287). *Staurastrum vestitum* closely resembles *Staurastrum anatinum* (Figure 22.12), which has one transverse row of coarse granules; Coesel and Meesters (2013) suggest that there is considerable overlap between these species.

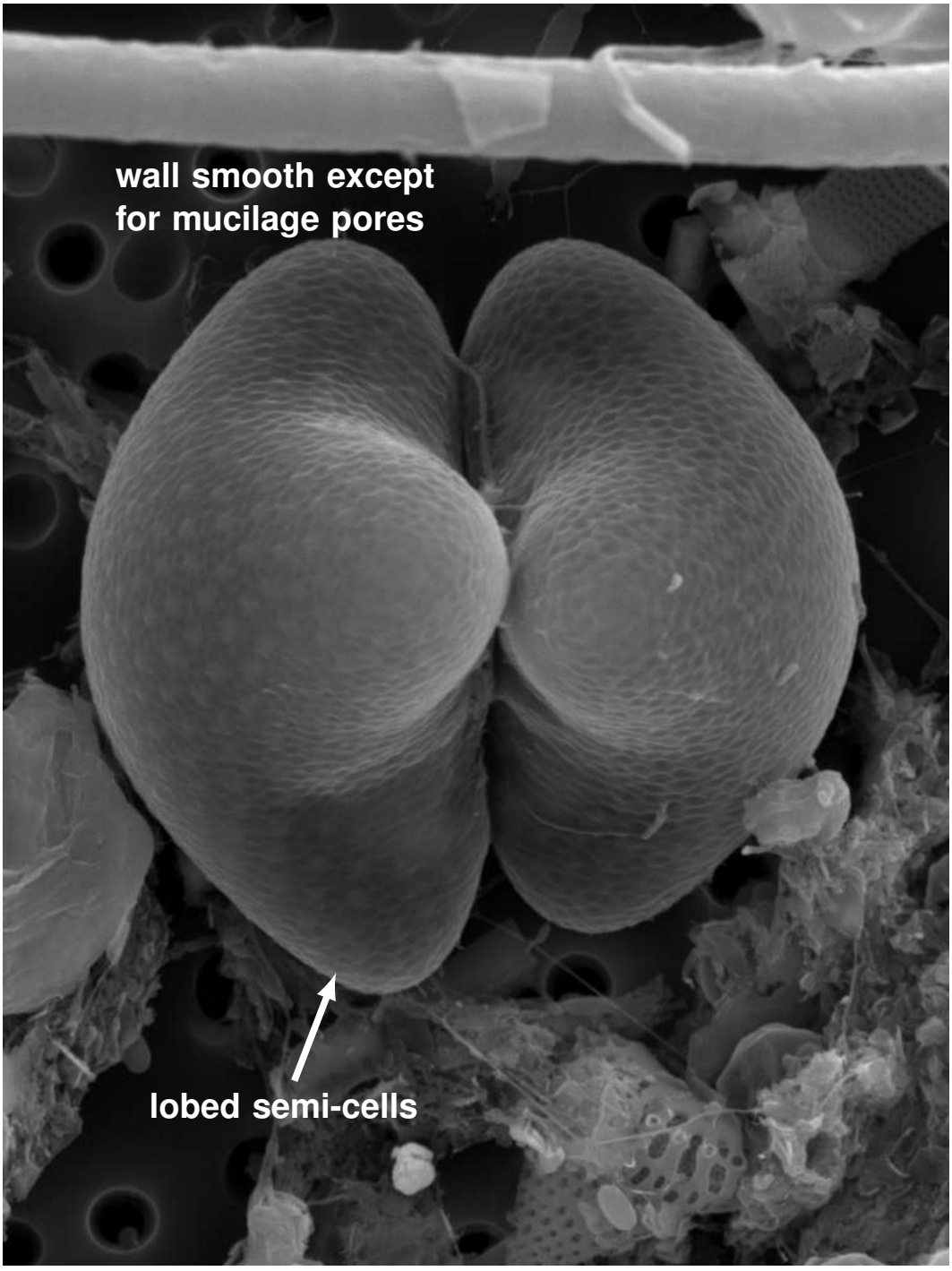


Figure 22.1: *Staurastrum ralfsii* var. *depressum*: example of semi-cell with bluntly rounded lobes (no arm-like processes) and smooth cell wall.

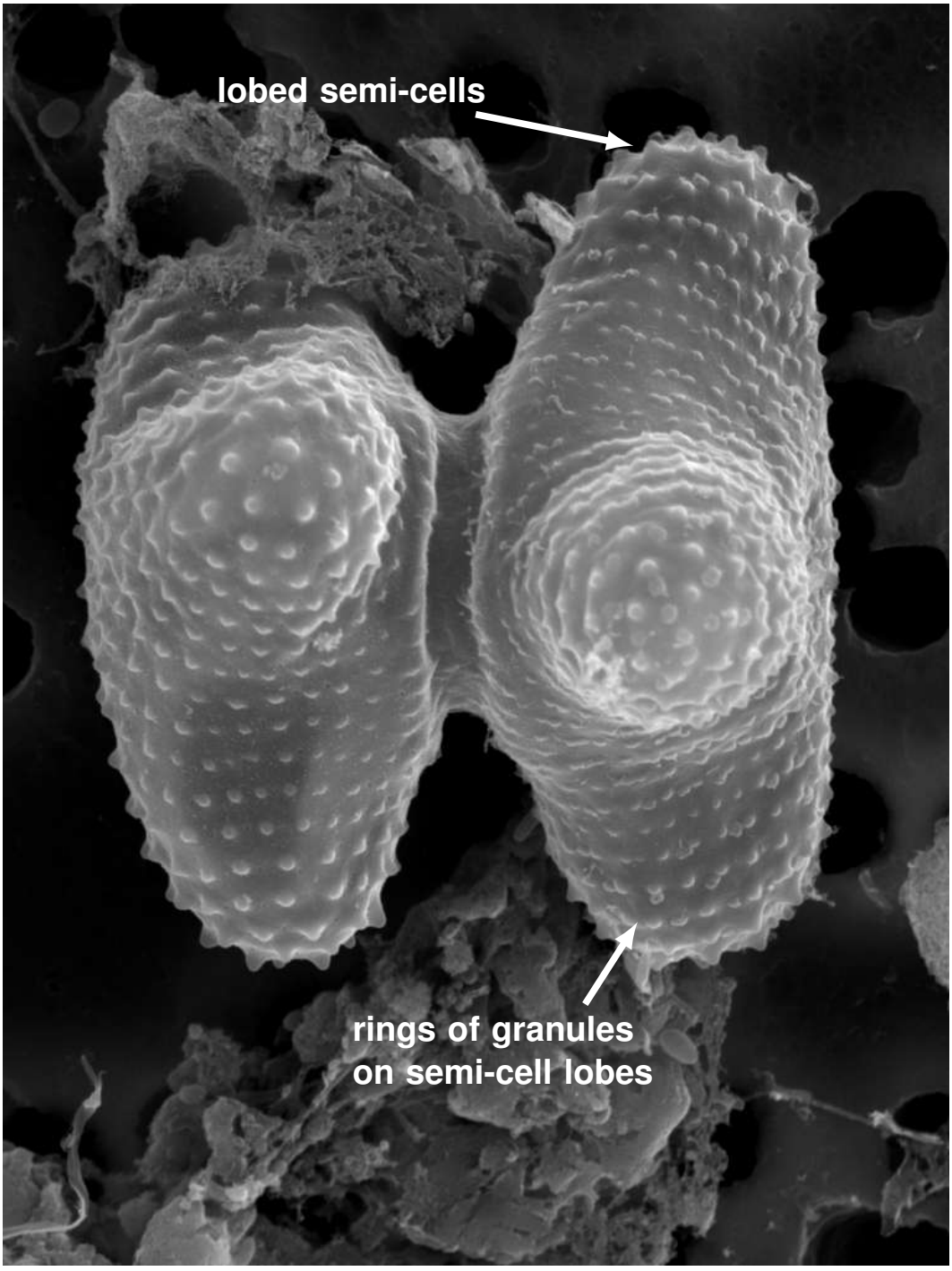


Figure 22.2: *Staurastrum striolatum*: example of semi-cell with bluntly rounded lobes (no arm-like processes) and walls covered with small granules.

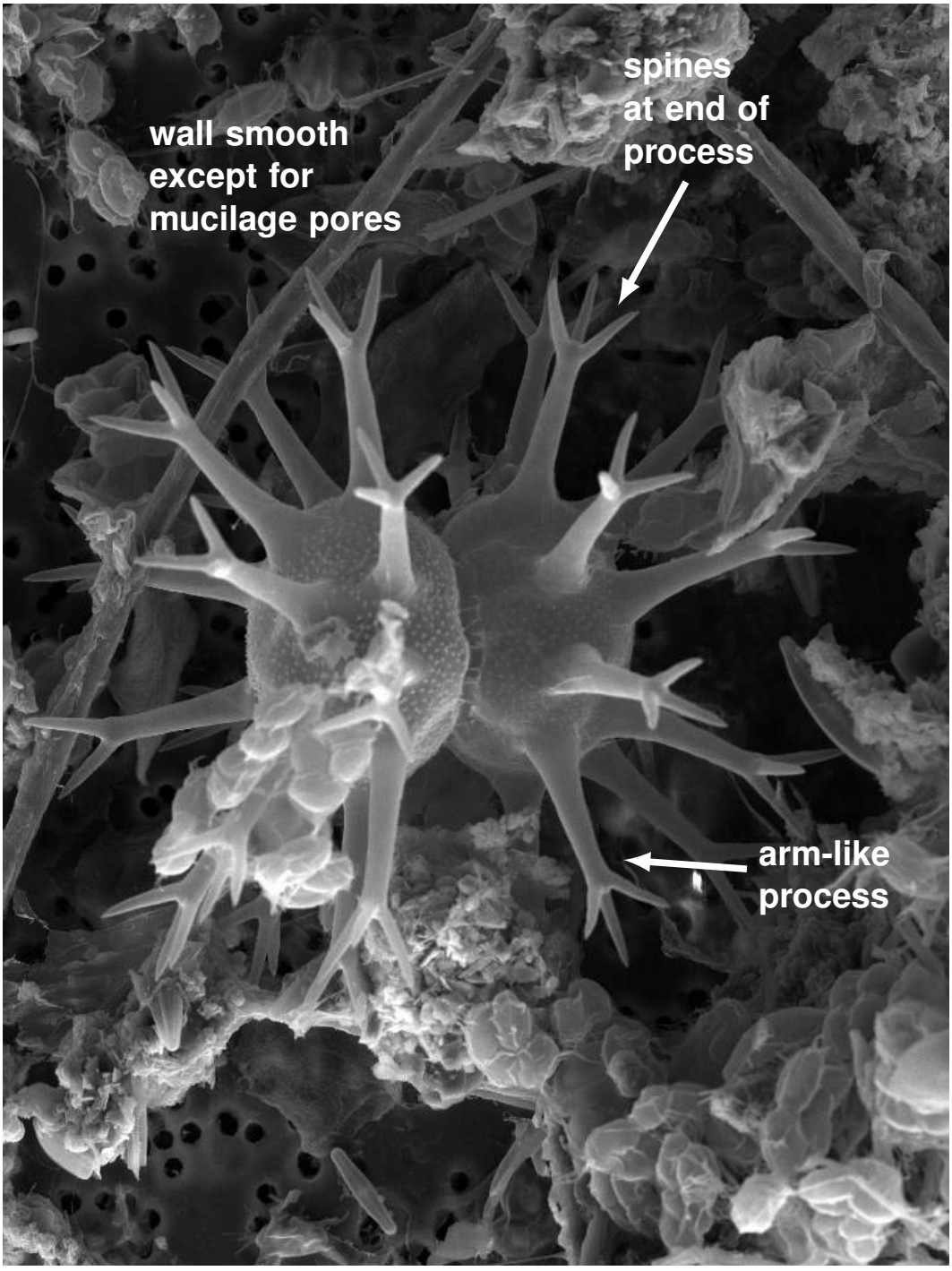


Figure 22.3: *Staurastrum arctiscon* f. *glabrum*: example of semi-cell with arm-like processes and smooth cell wall.

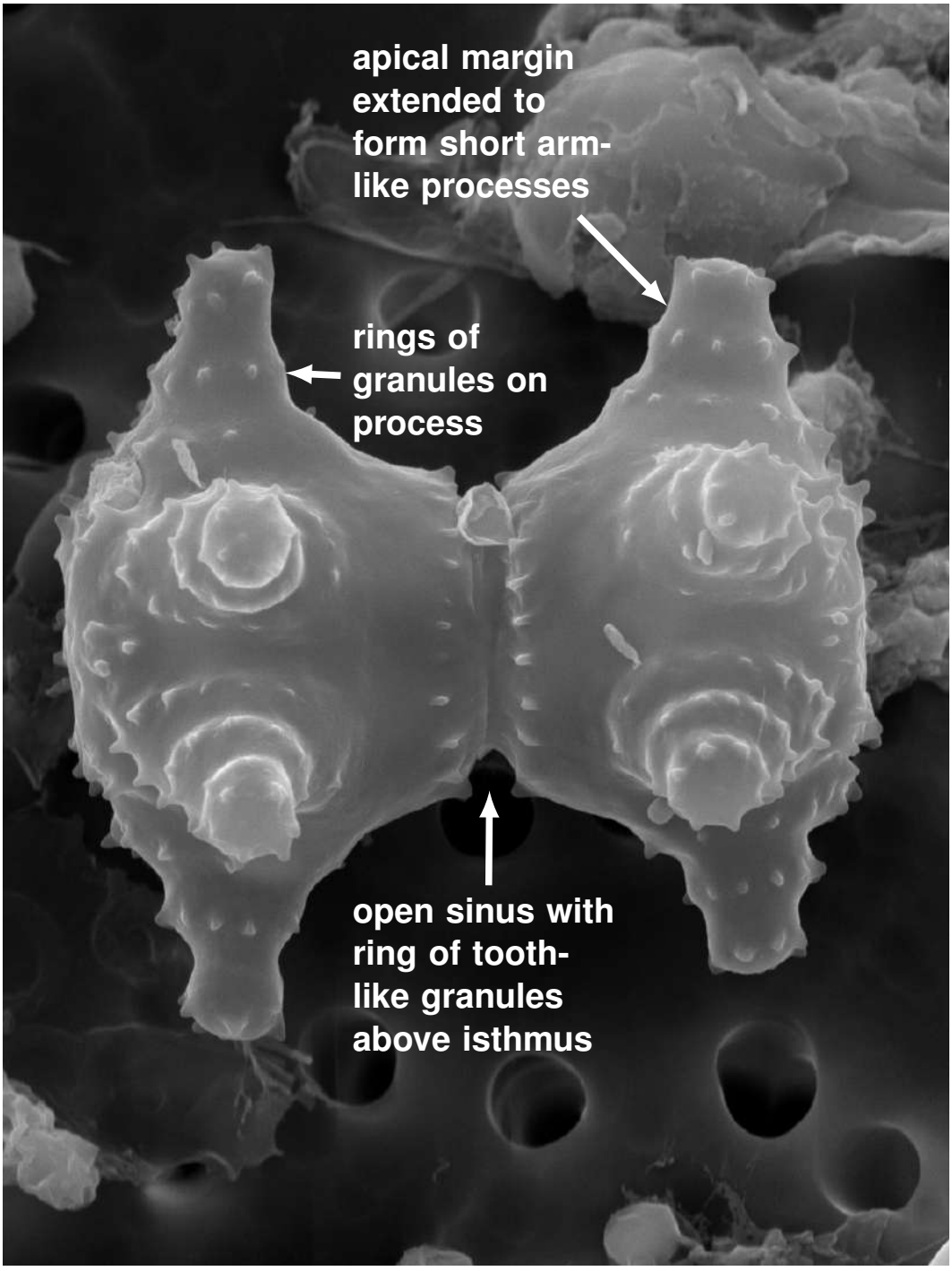


Figure 22.4: *Staurastrum margaritaceum*: example of semi-cell with arm-like processes and walls with granules and teeth.

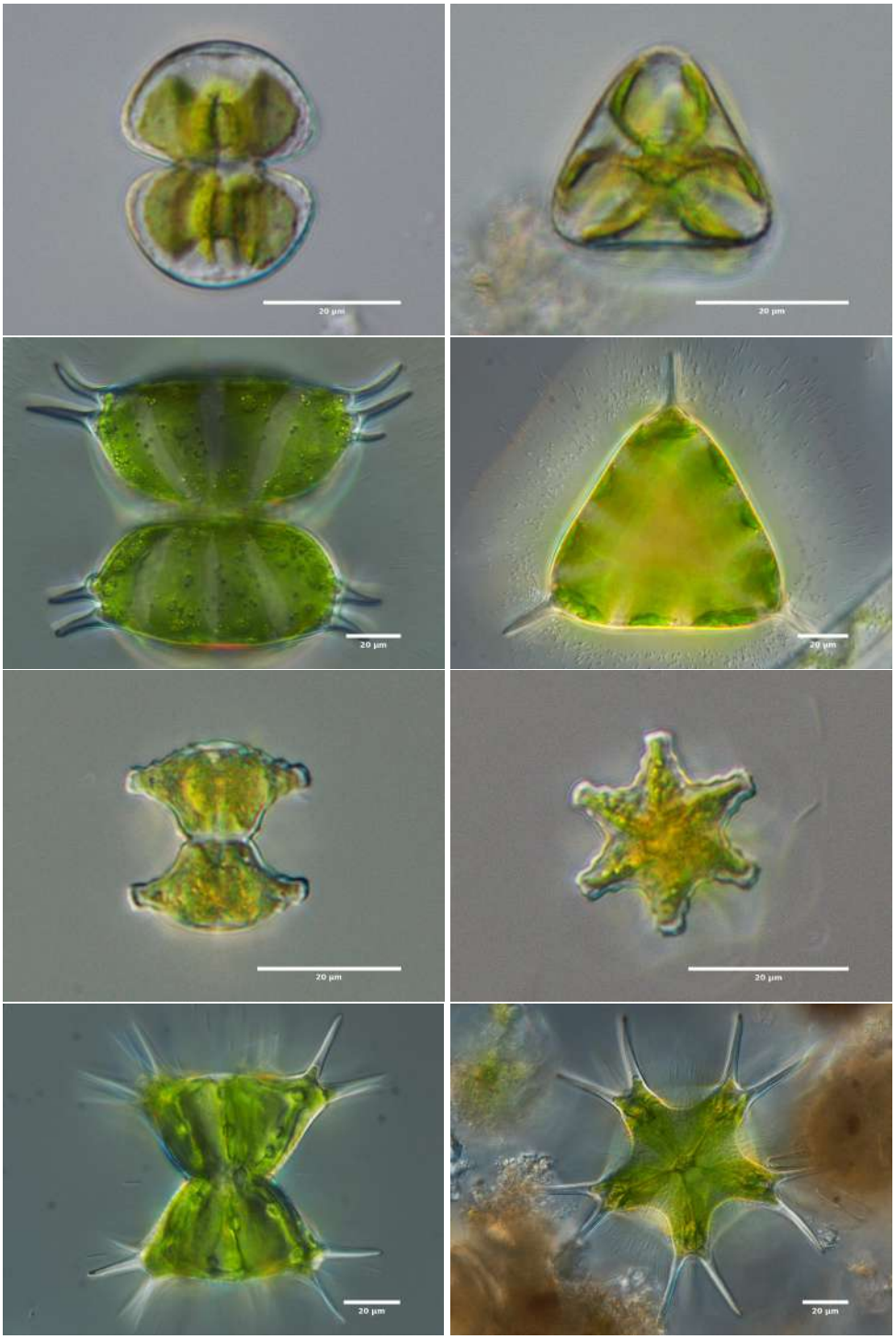


Figure 22.5: Radial symmetry in *Staurastrum*. First row: triradiate, semi-cell with smooth, rounded angles (*Staurastrum hirsutum* var. *pseudarnellii*); second row: triradiate semi-cell with spiny, rounded, angles (*Staurastrum longispinum*); third row: 6-radiate semi-cell with short arm-like processes (*Staurastrum margaritaceum*); fourth row: 5-radiate semi-cell with spiny, rounded angles but with apical view indicating short truncated processes (*Staurastrum brasiliense*).

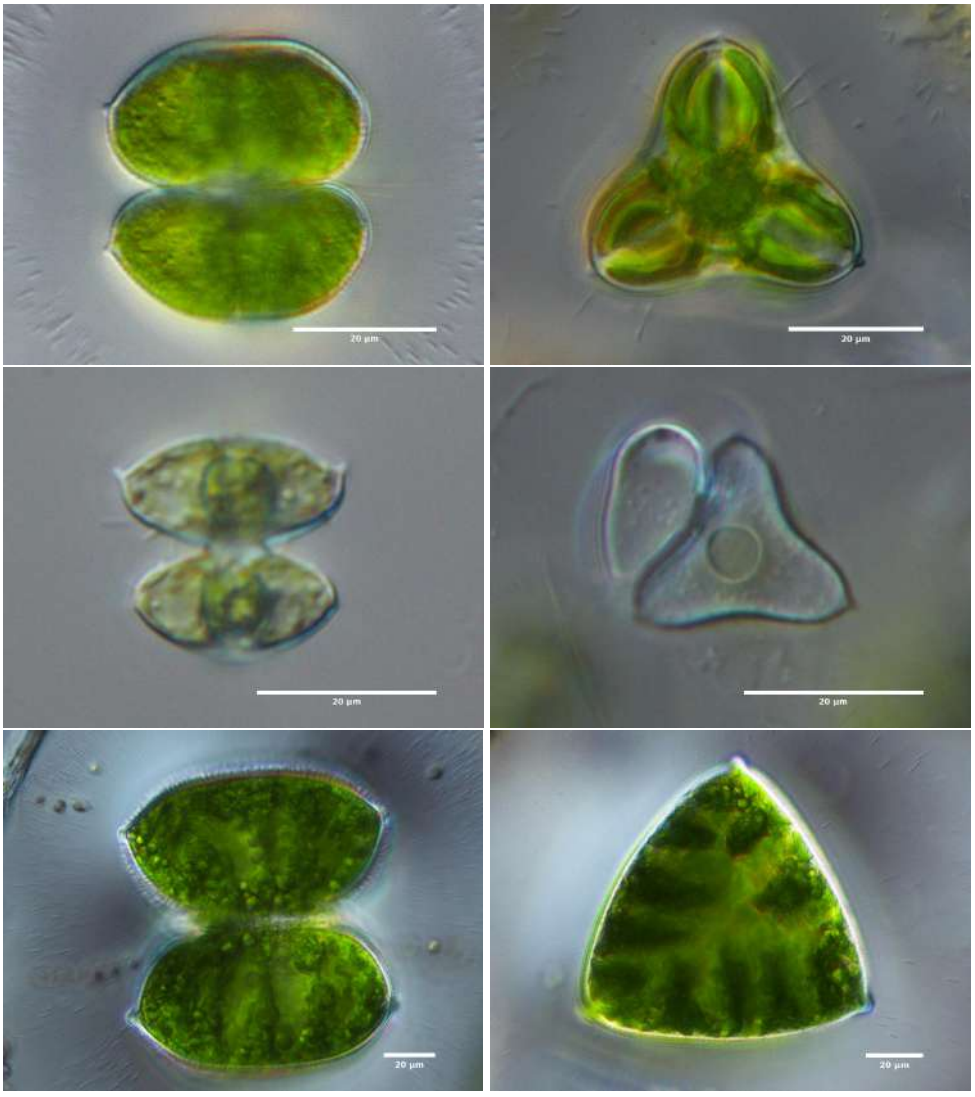


Figure 22.6: Apical and lateral views of three triradiate desmids assigned to different genera: *Staurastrum brevispina* (top row), *Staurodesmus patens* (middle row), and *Xanthidium tumidum* (bottom row).

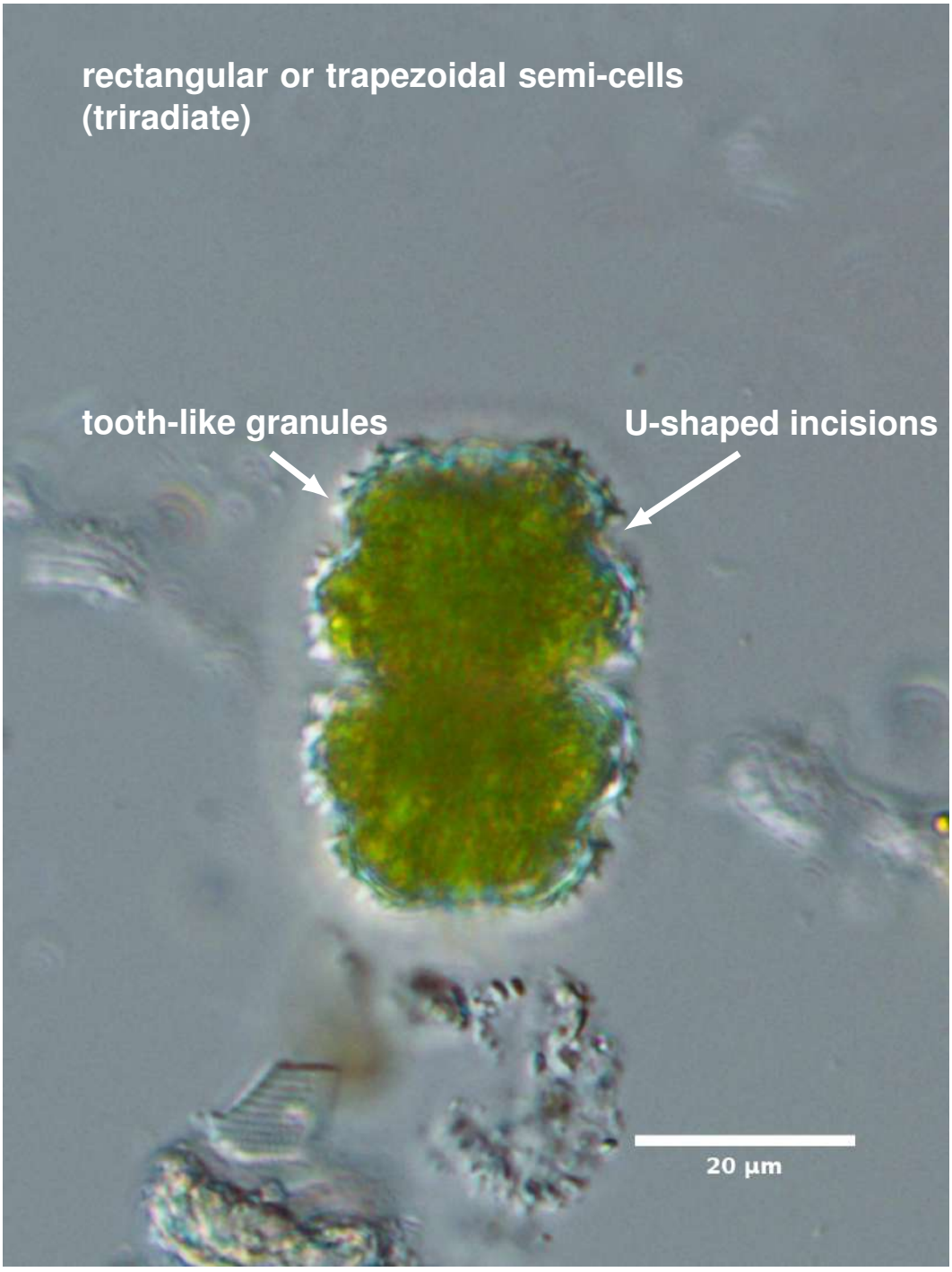


Figure 22.7: *Staurastrum acarides* (DIC), spray zone from waterfall near Rainy Pass, North Cascades Highway.



Figure 22.8: *Staurastrum acarides* (DIC), spray zone from waterfall near Rainy Pass, North Cascades Highway.



Figure 22.9: *Staurastrum alternans* (DIC), small pond on trail to Big Four Ice Caves, Mountain Loop Highway, Snohomish County.

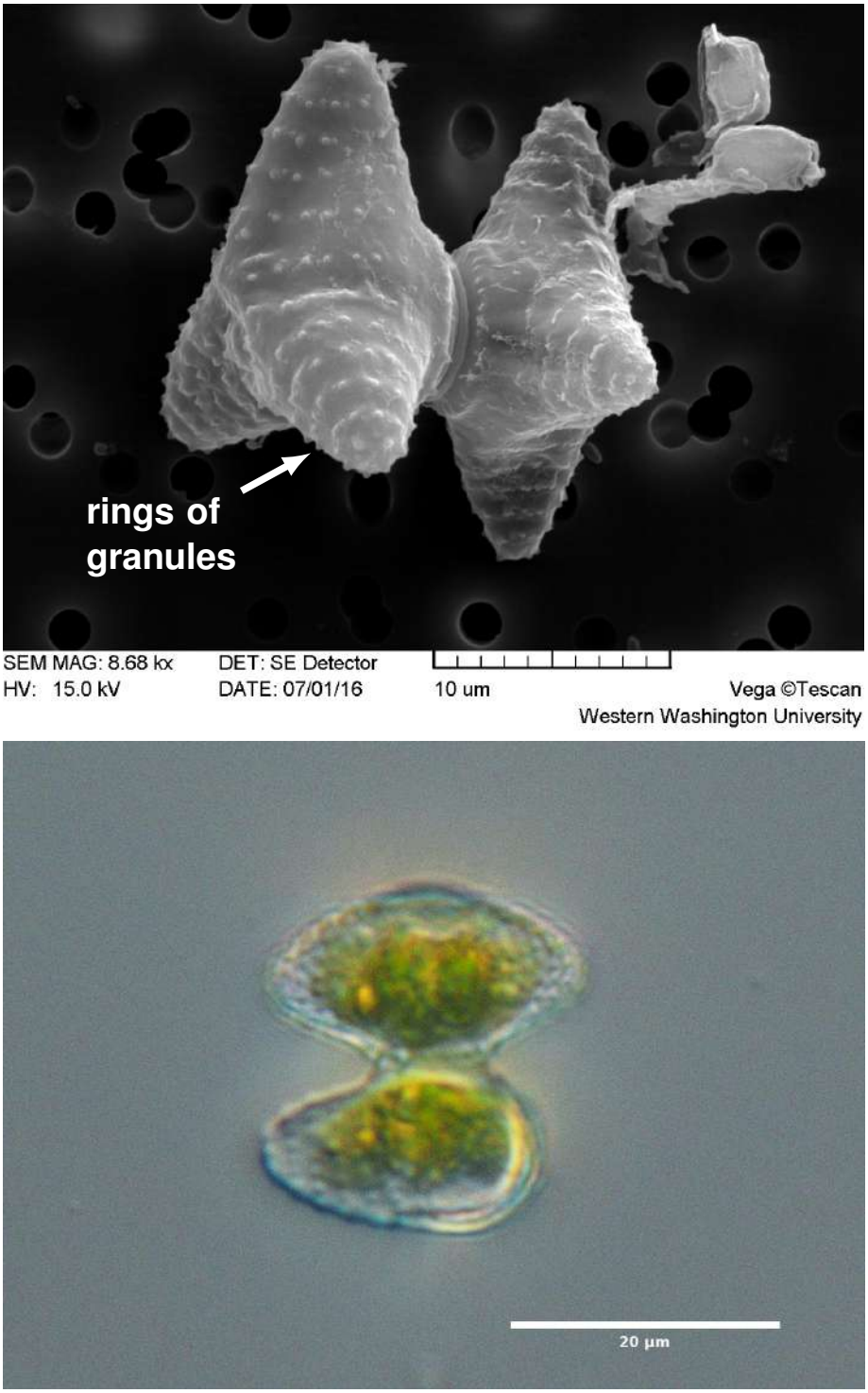


Figure 22.10: *Staurastrum alternans* (SEM/DIC), Lake Twenty-two, Mountain Loop Highway, Snohomish County (upper image); small pond on trail to Big Four Ice Caves, Mountain Loop Highway, Snohomish County (lower image).



Figure 22.11: *Staurastrum alternans* (DIC), Heather Lake, Mountain Loop Highway, Snohomish County.

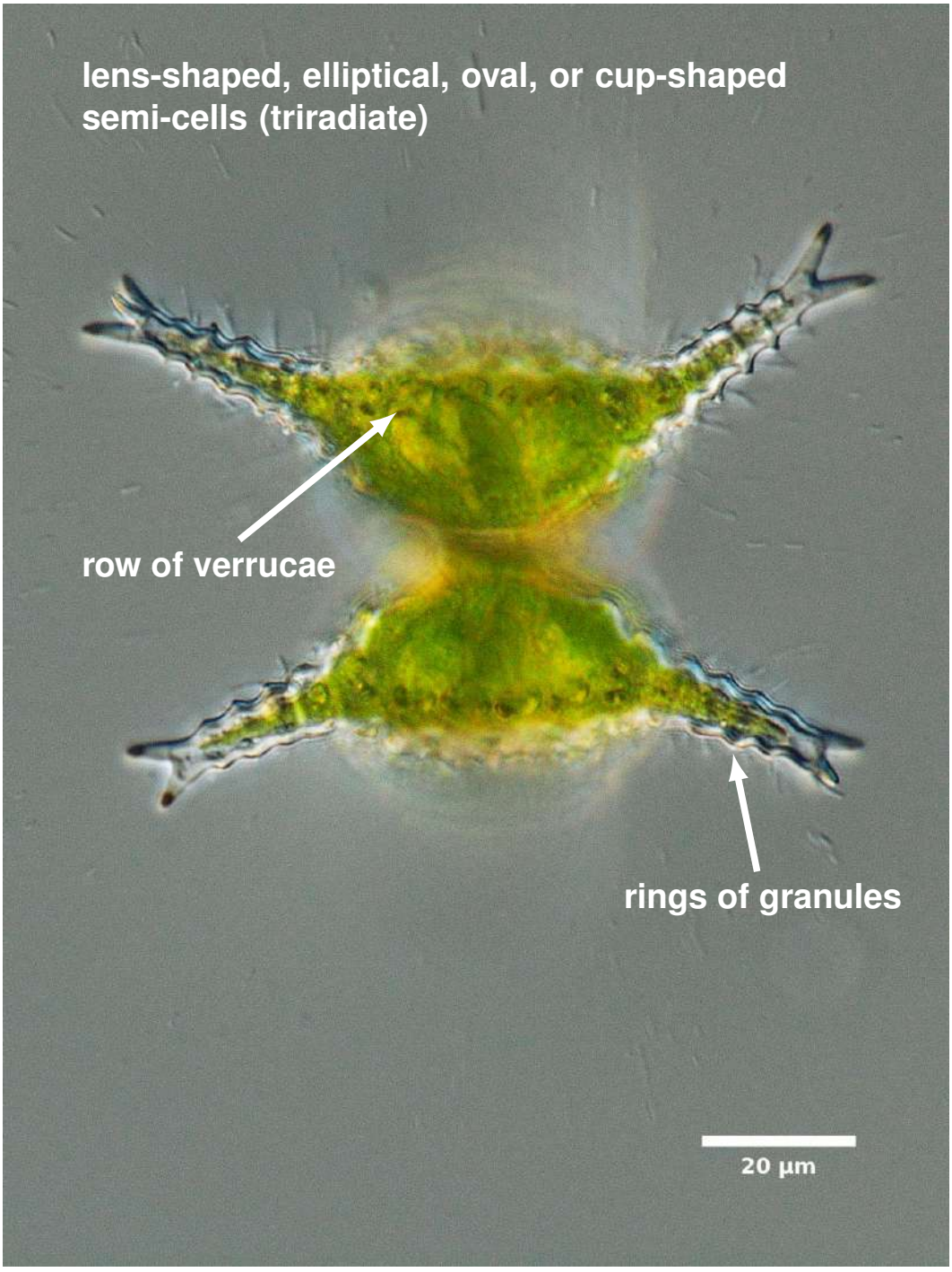
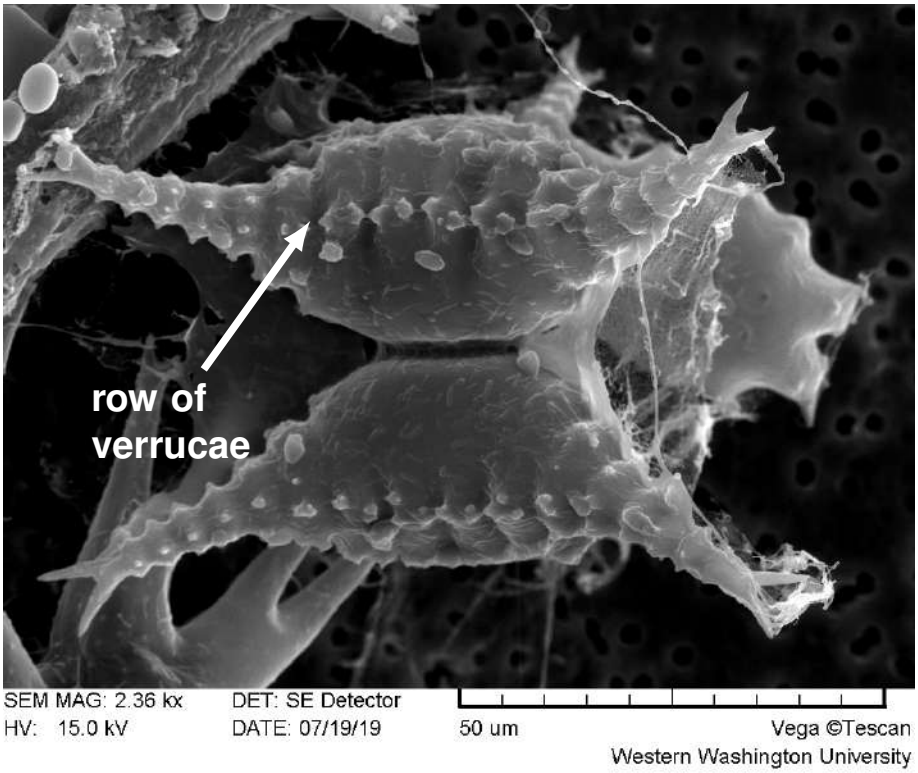


Figure 22.12: *Staurastrum anatinum* (DIC), Chain Lake, Gifford Pinchot National Forest, Skamania County.



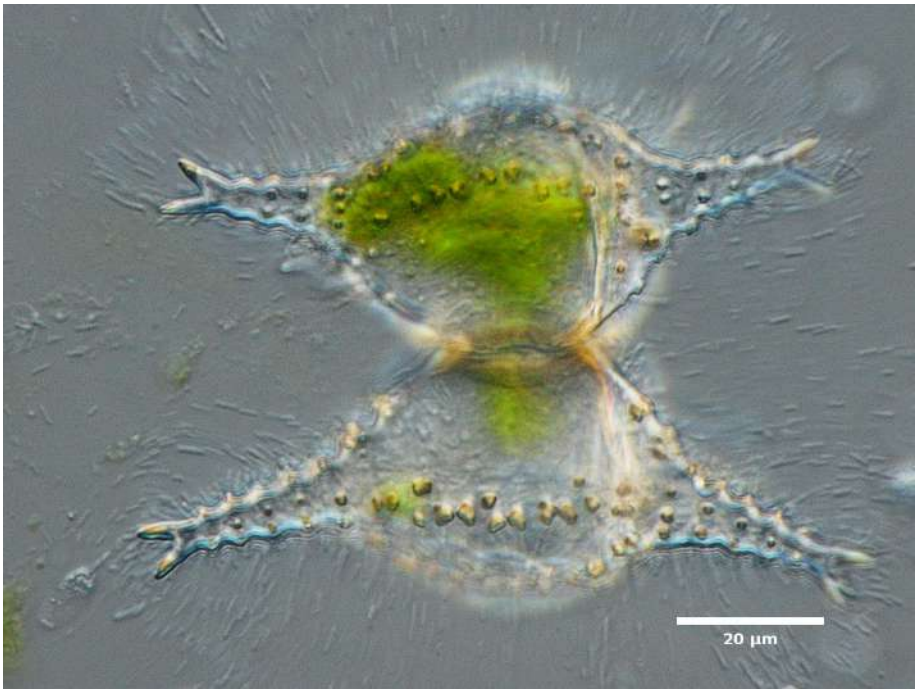


Figure 22.13: *Staurastrum anatinum* (SEM/DIC), Chain Lake, Gifford Pinchot National Forest, Skamania County (upper/lower images).

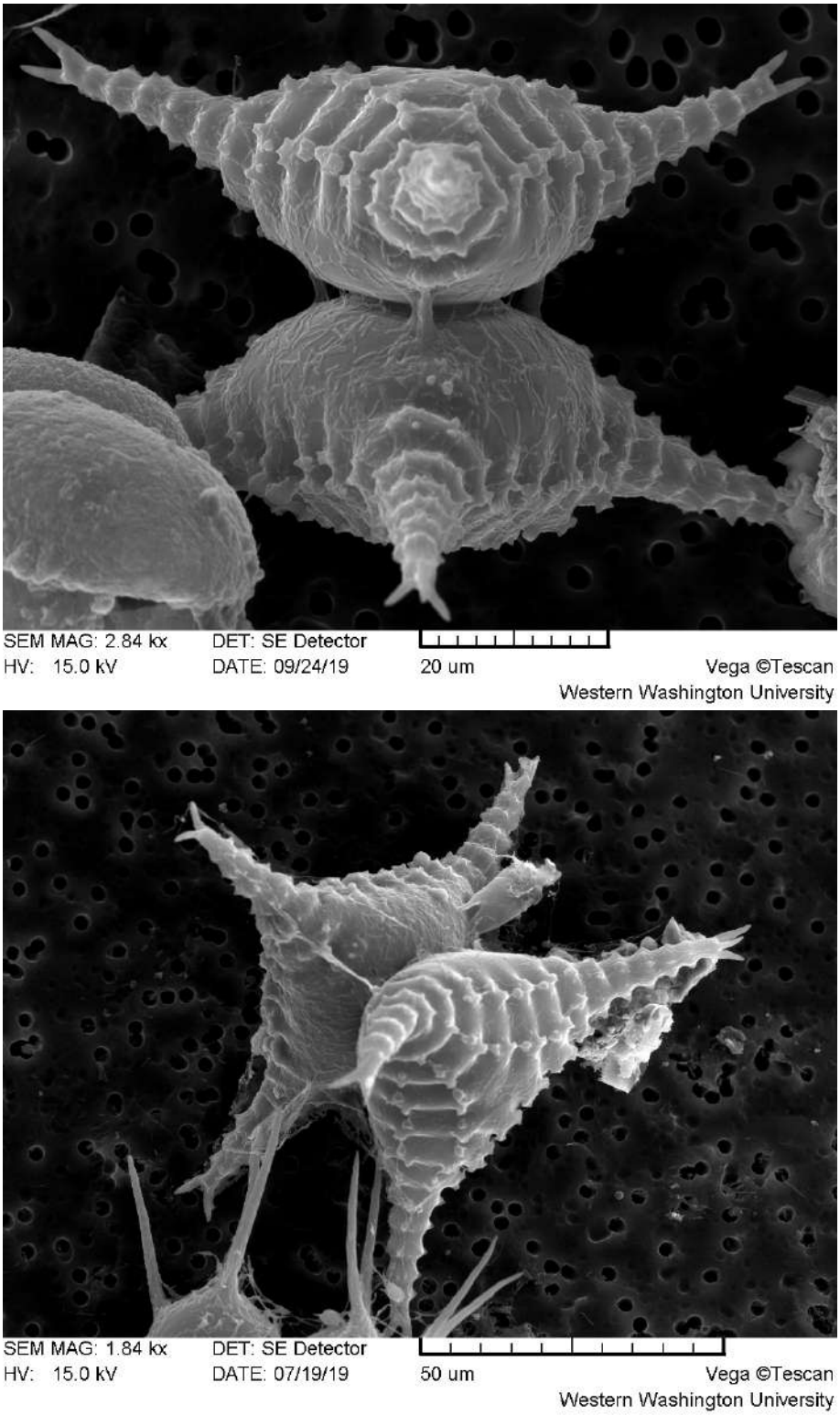


Figure 22.14: *Staurastrum anatinum* (SEM/SEM), Chain Lake, Gifford Pinchot National Forest, Skamania County (upper/lower images).



Figure 22.15: *Staurastrum anatinum* var. *longibrachiatum* (DIC/DIC), Clear Lake, Skagit County (upper/lower images).

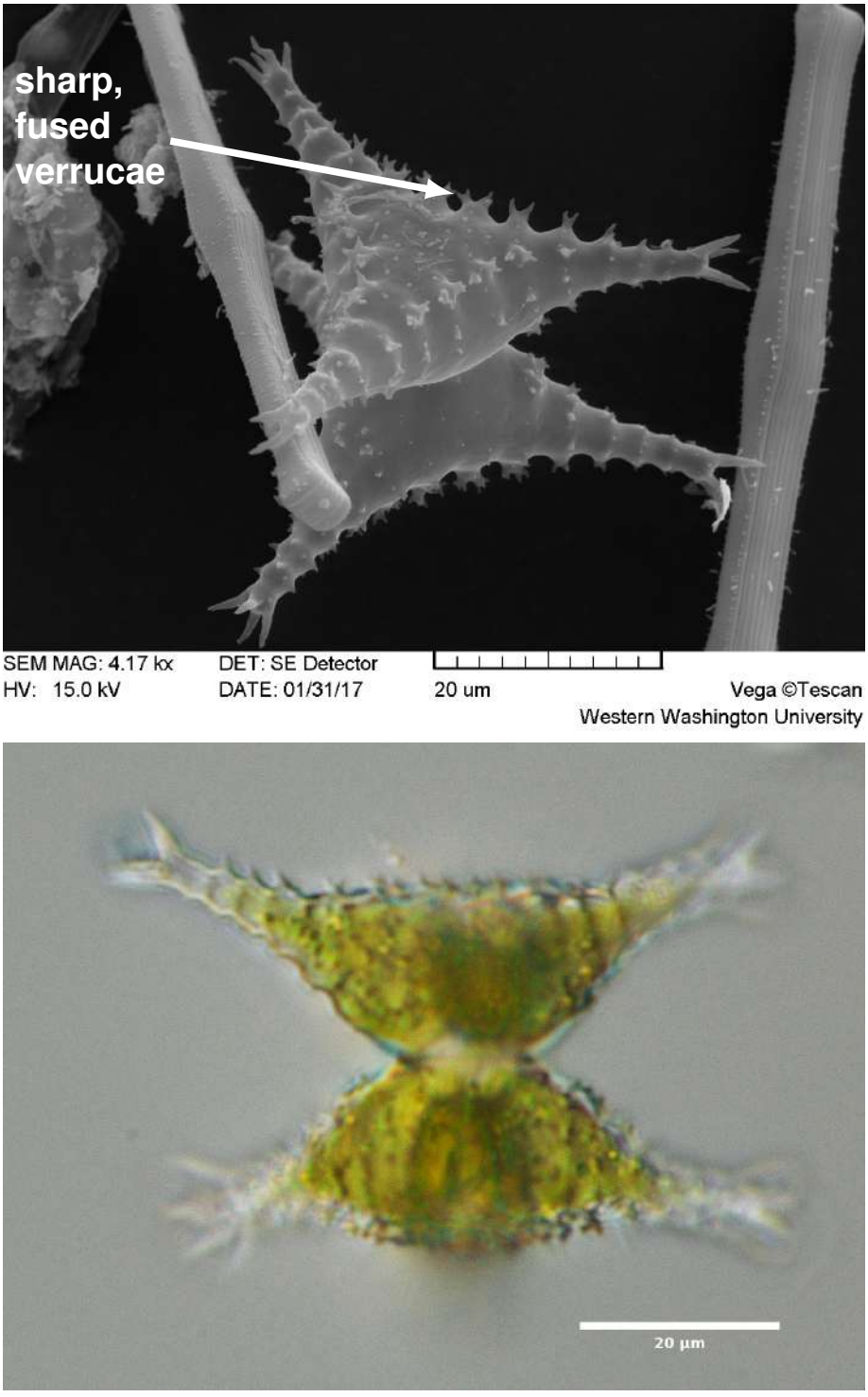


Figure 22.16: *Staurastrum anatinum* f. (SEM/DIC), Boardman Lake, Mountain Loop Highway, Snohomish County (upper/lower images).

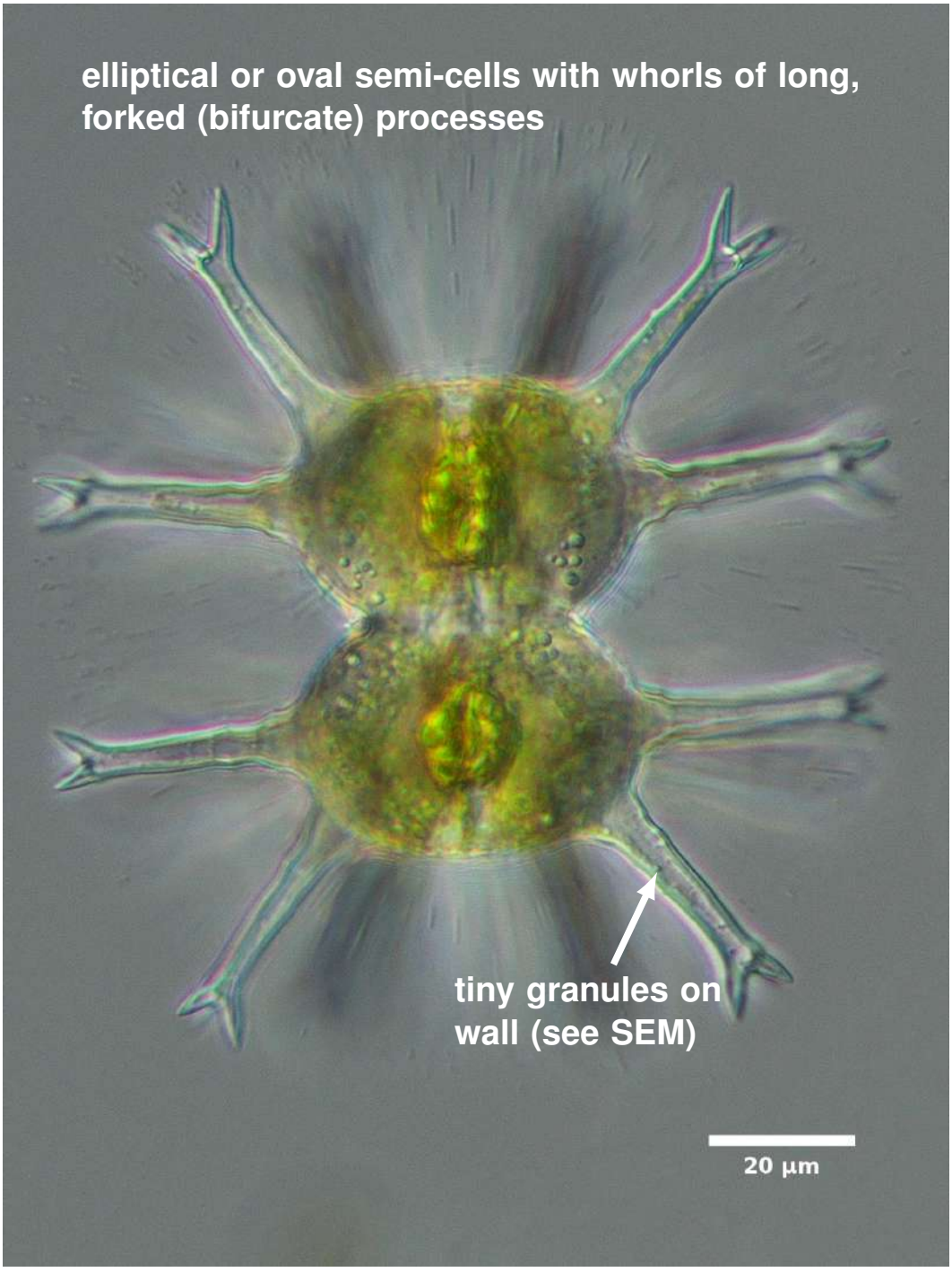


Figure 22.17: *Staurastrum arctiscon* (DIC), Lower Anderson Lake, Mt. Baker area, Whatcom County.

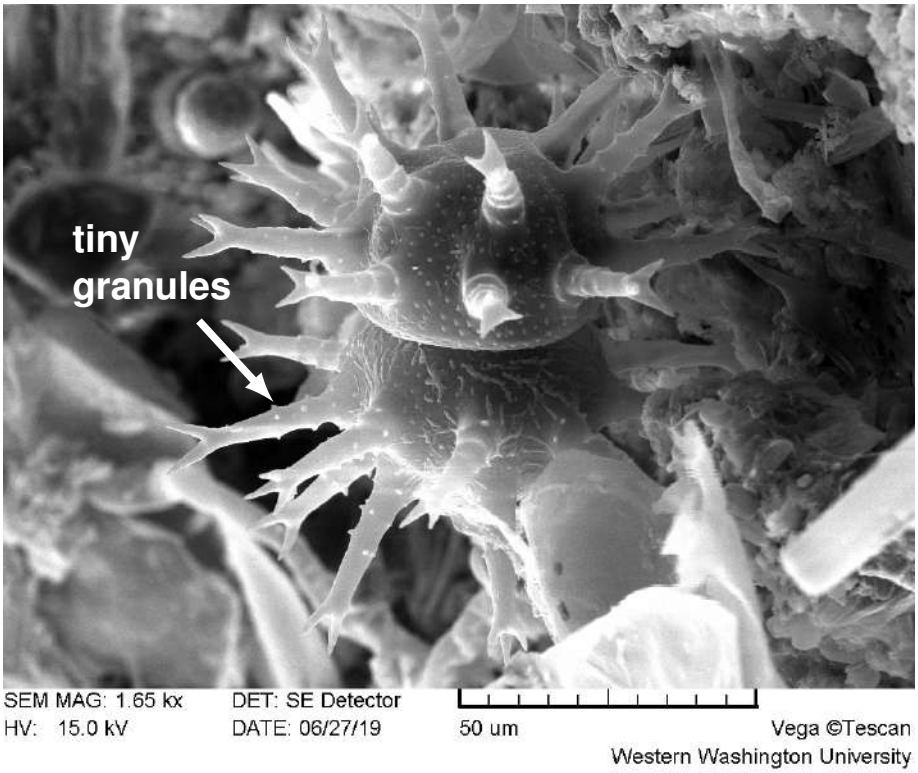




Figure 22.18: *Staurastrum arctiscon* (SEM/DIC), Mirror Lake, Whatcom County (upper/lower images).

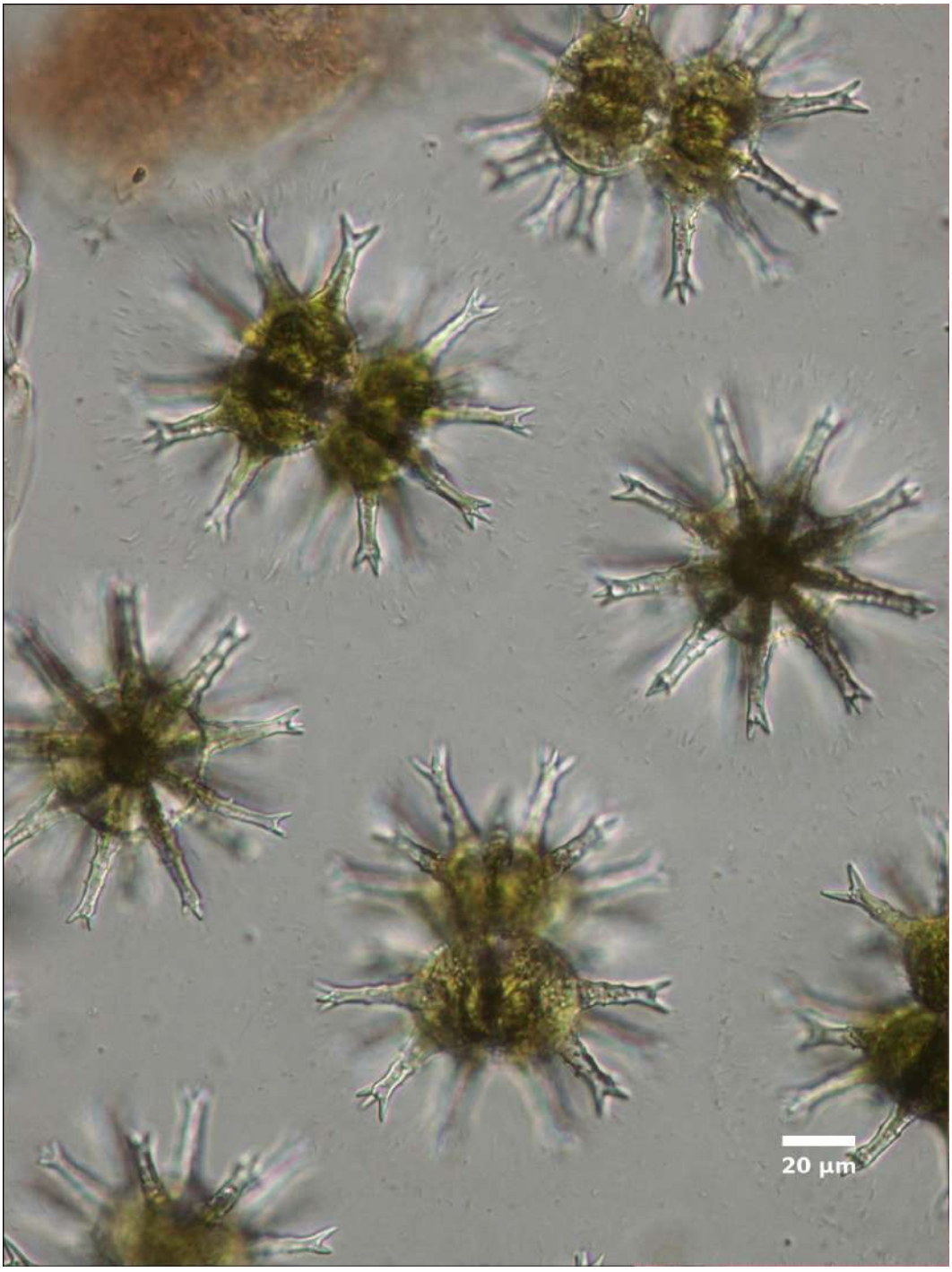


Figure 22.19: *Staurastrum arctiscon* bloom (DIC), Mirror Lake, Whatcom County.



Figure 22.20: *Staurastrum arctiscon* with short processes (DIC), Hoag Pond, Whatcom County.



Figure 22.21: *Staurastrum arctiscon* f. *glabrum* (DIC), Lake Ki, Snohomish County.

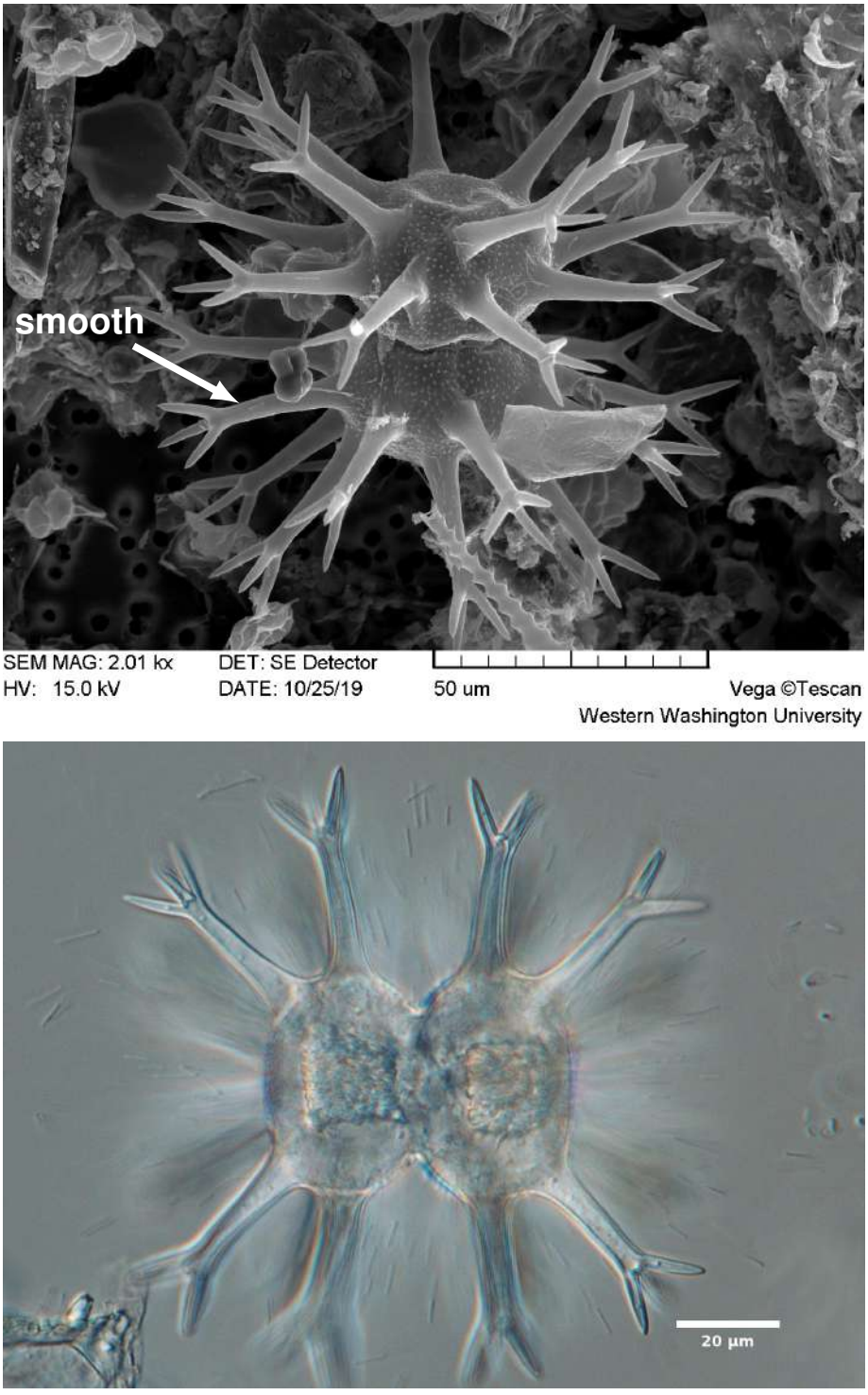


Figure 22.22: *Staurastrum arctiscon* f. *glabrum* (SEM/DIC), Lake Ki, Snohomish County (upper/lower images).

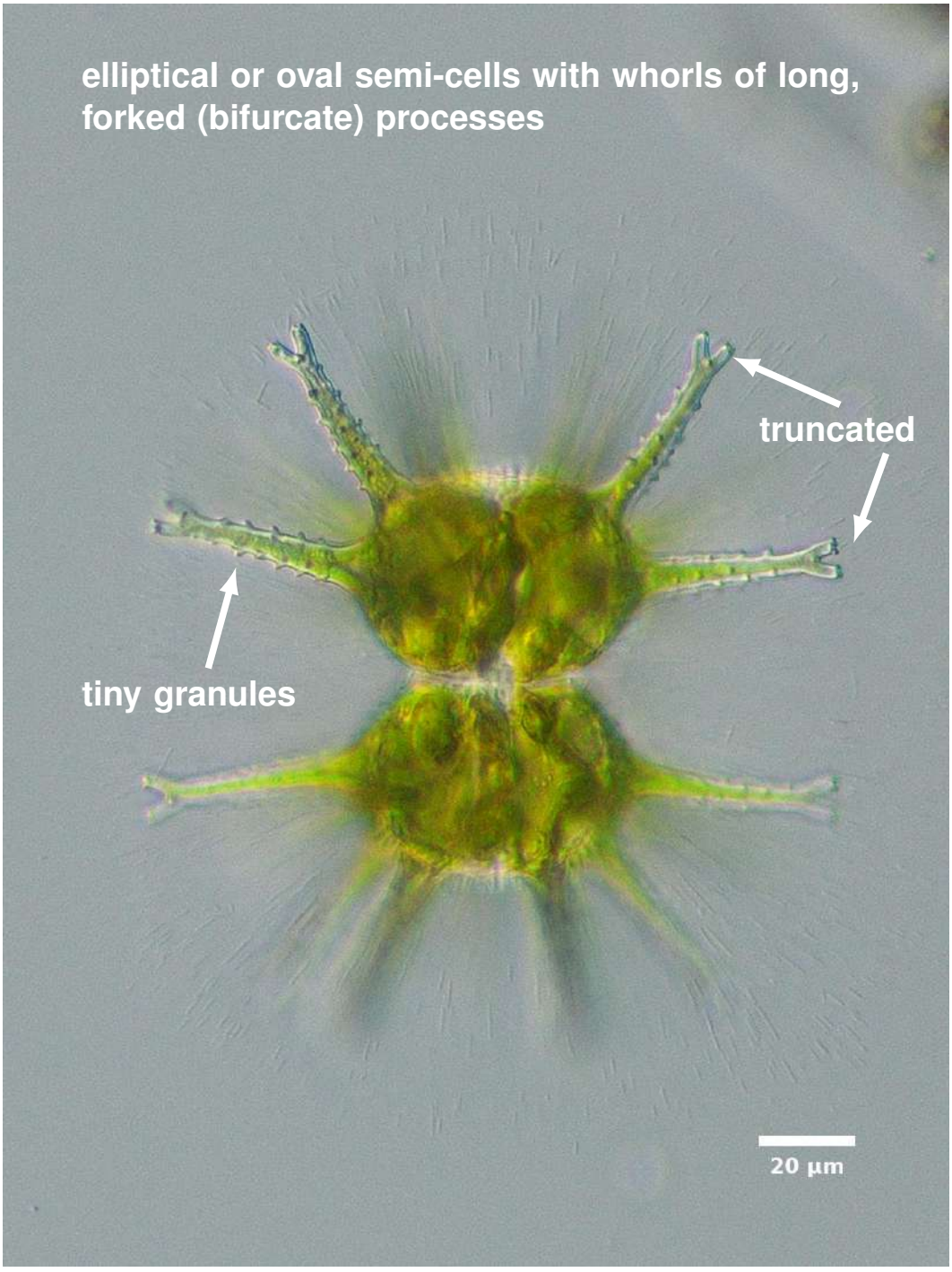


Figure 22.23: *Staurastrum arctiscon* var. *truncatum* (DIC), Wood Lake, Morris Valley Road near Harrison, BC.

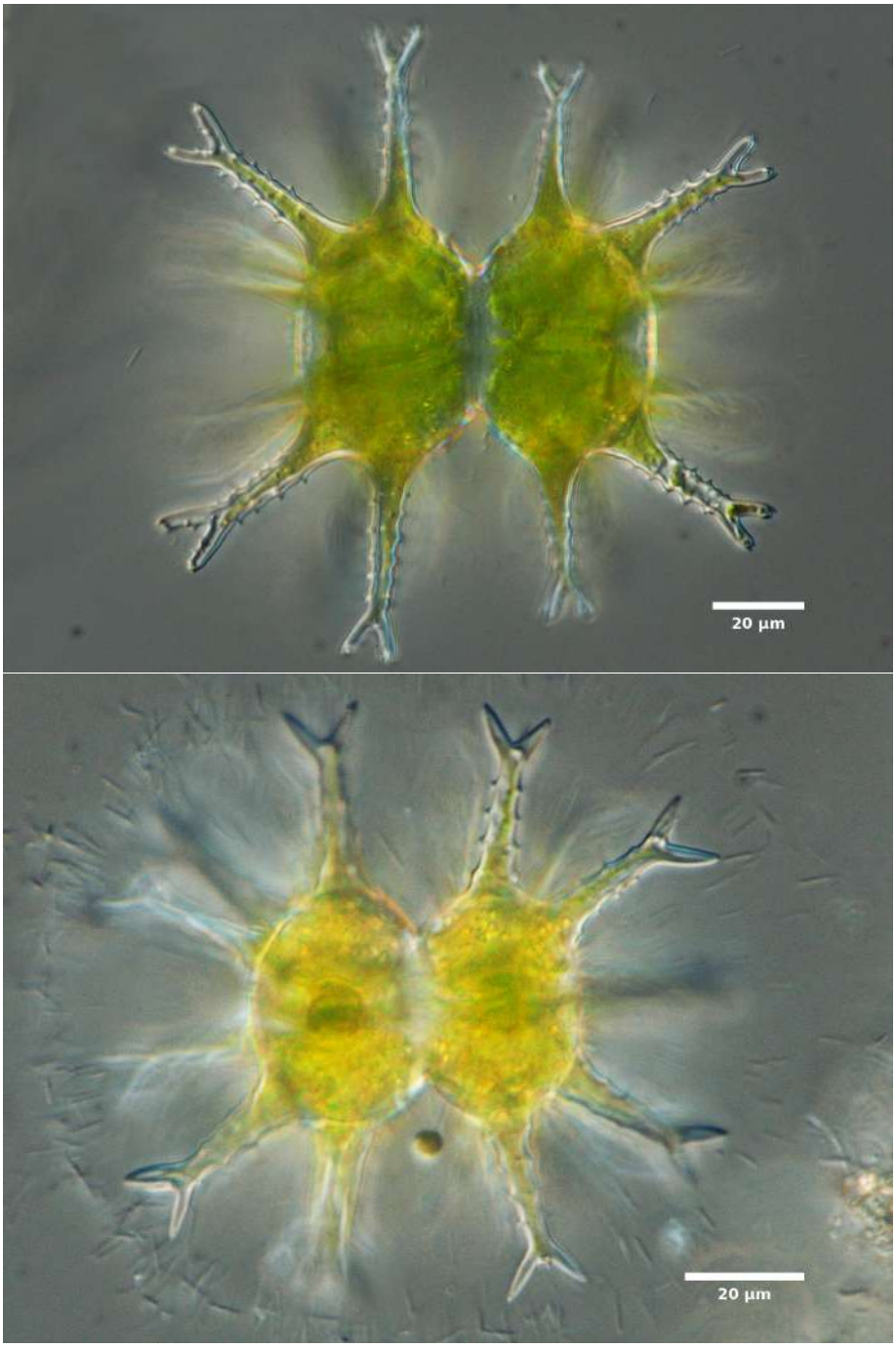


Figure 22.24: *Staurastrum arctiscon* and *Staurastrum arctiscon* var. *truncatum* (DIC/DIC), Boardman Lake, Mountain Loop Highway, Snohomish County (upper/lower images); specimens collected in the same sample.

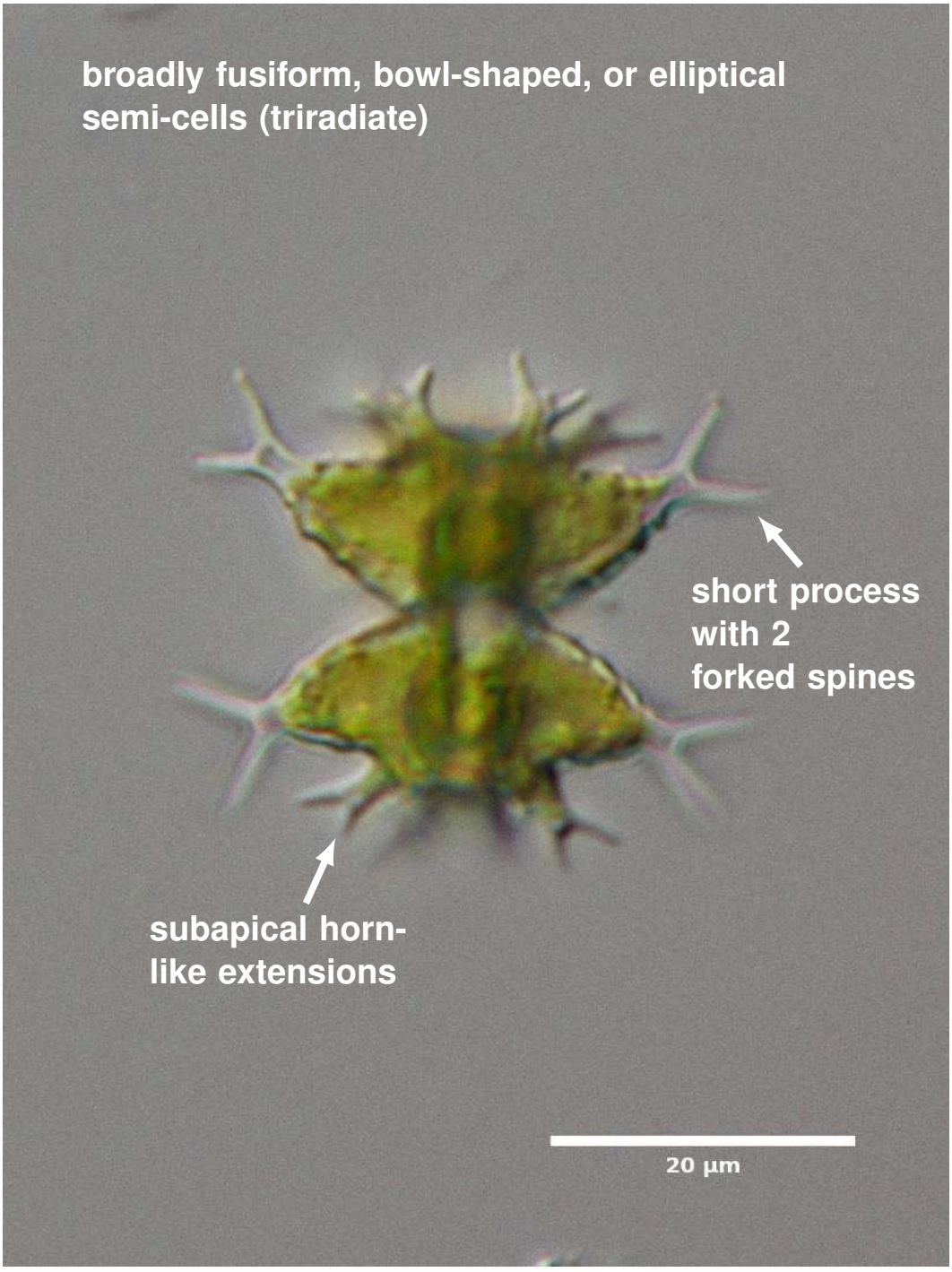


Figure 22.25: *Staurastrum arcuatum* (DIC), Myrtle Lake, Mountain Loop Highway, Snohomish County.

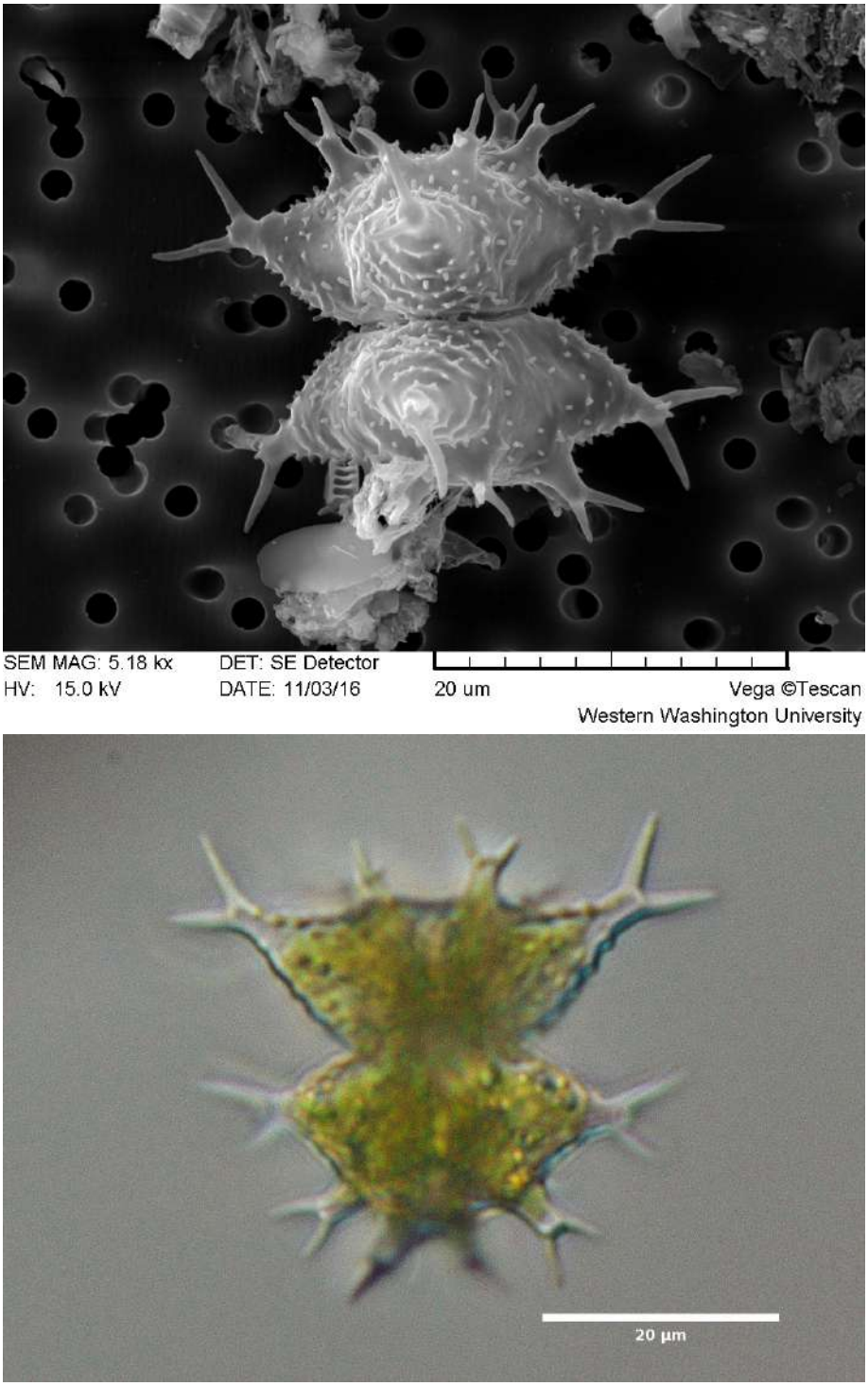


Figure 22.26: *Staurastrum arcuatum* (SEM/DIC), Heather Lake, Mountain Loop Highway, Snohomish County (upper/lower images).

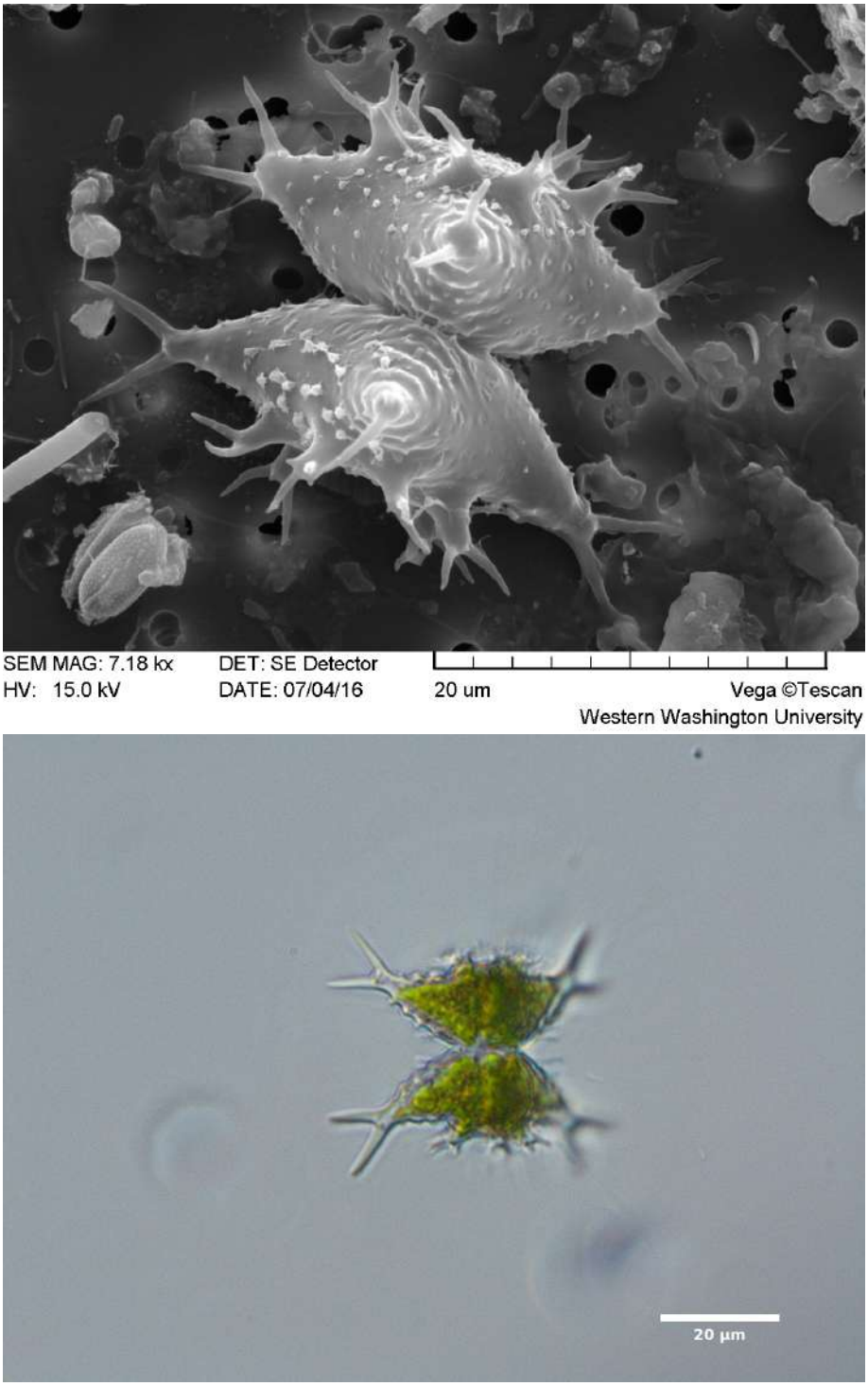


Figure 22.27: *Staurastrum arcuatum* (SEM/DIC), Boardman Lake, Mountain Loop Highway, Snohomish County (upper/lower images).

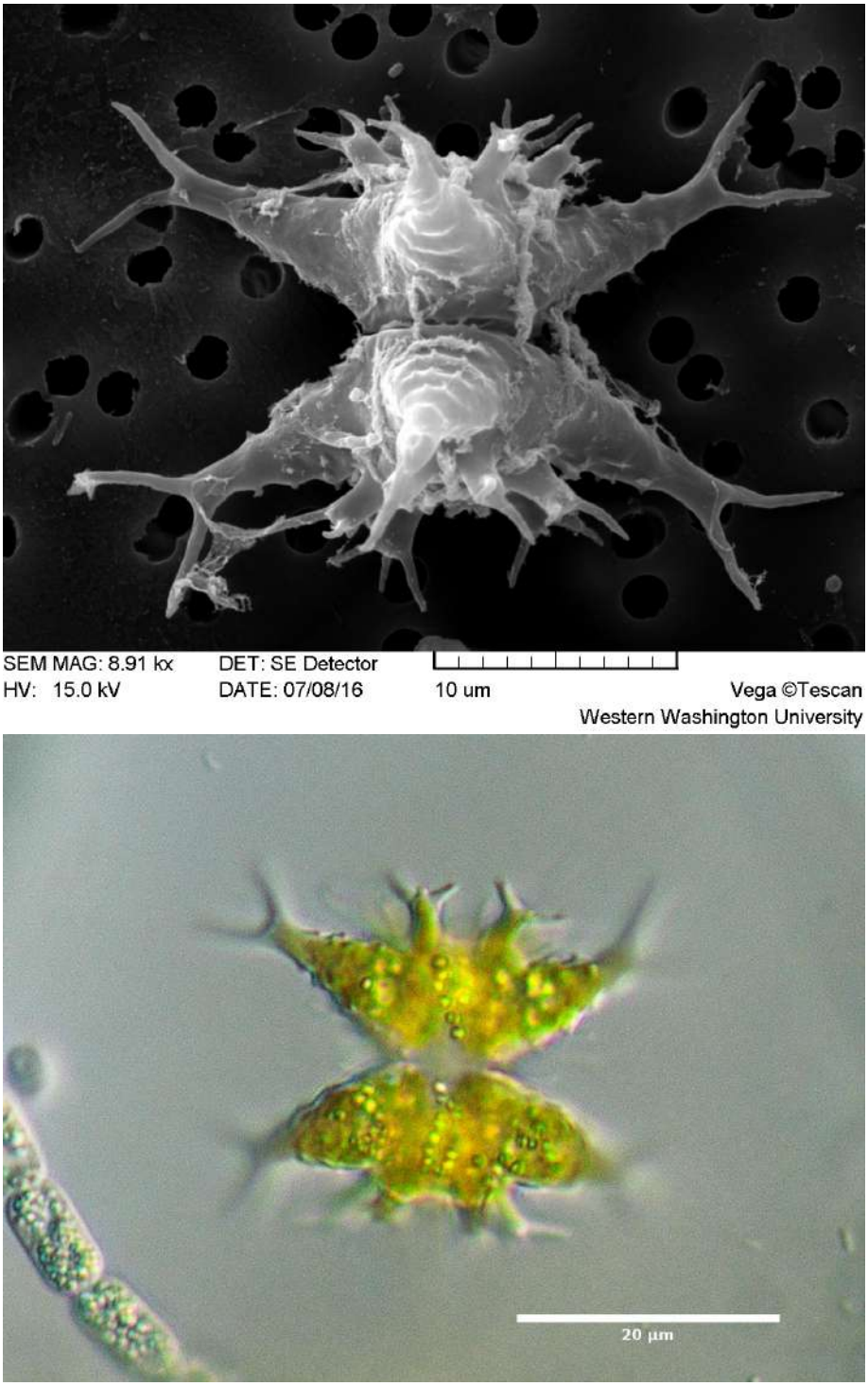


Figure 22.28: *Staurastrum arcuatum* (SEM/DIC), Myrtle Lake, Mountain Loop Highway, Snohomish County (upper/lower images).

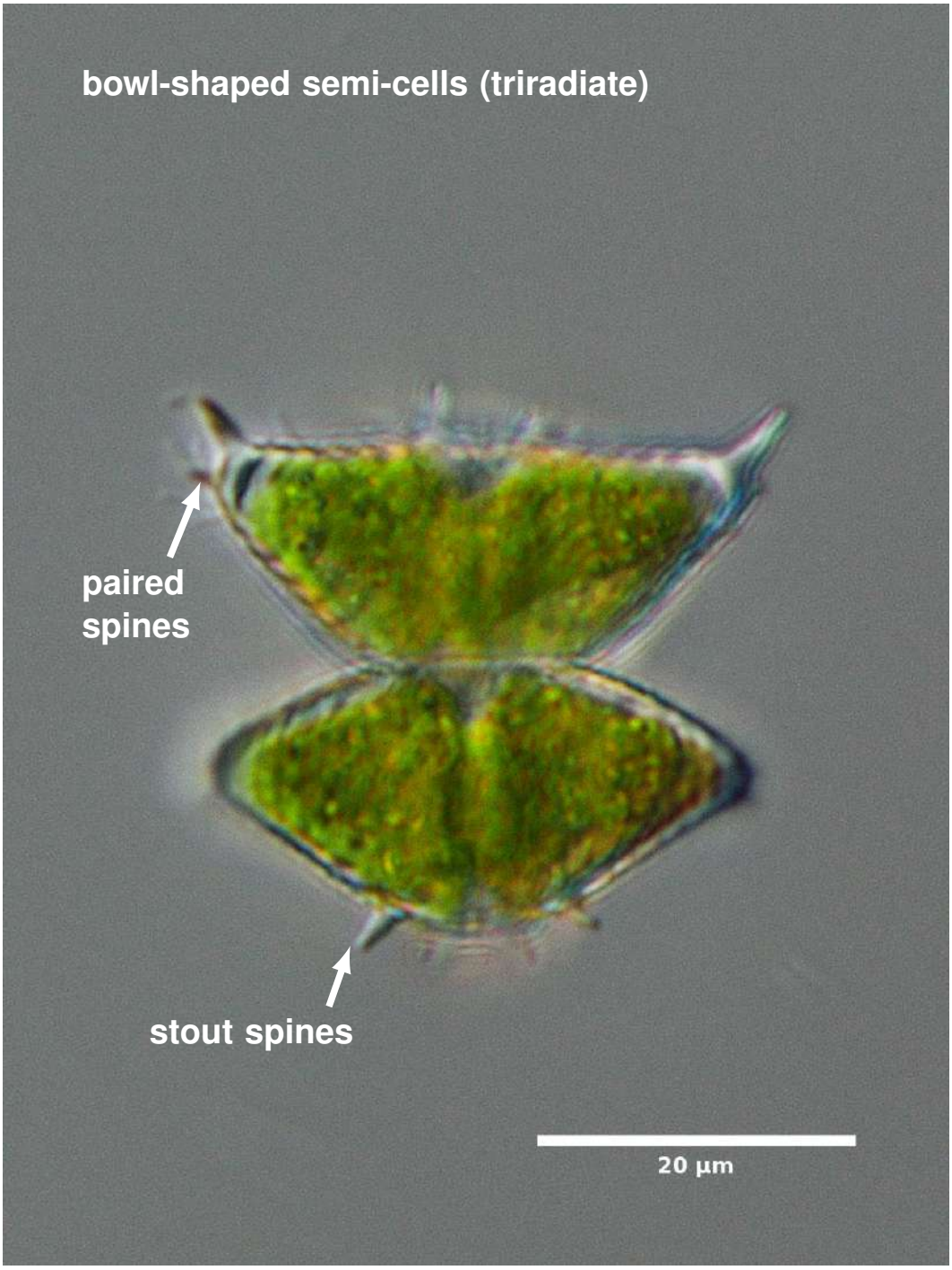


Figure 22.29: *Staurastrum arcuatum* var. A (DIC), Chain Lake, Gifford Pinchot National Forest, Skamania County.

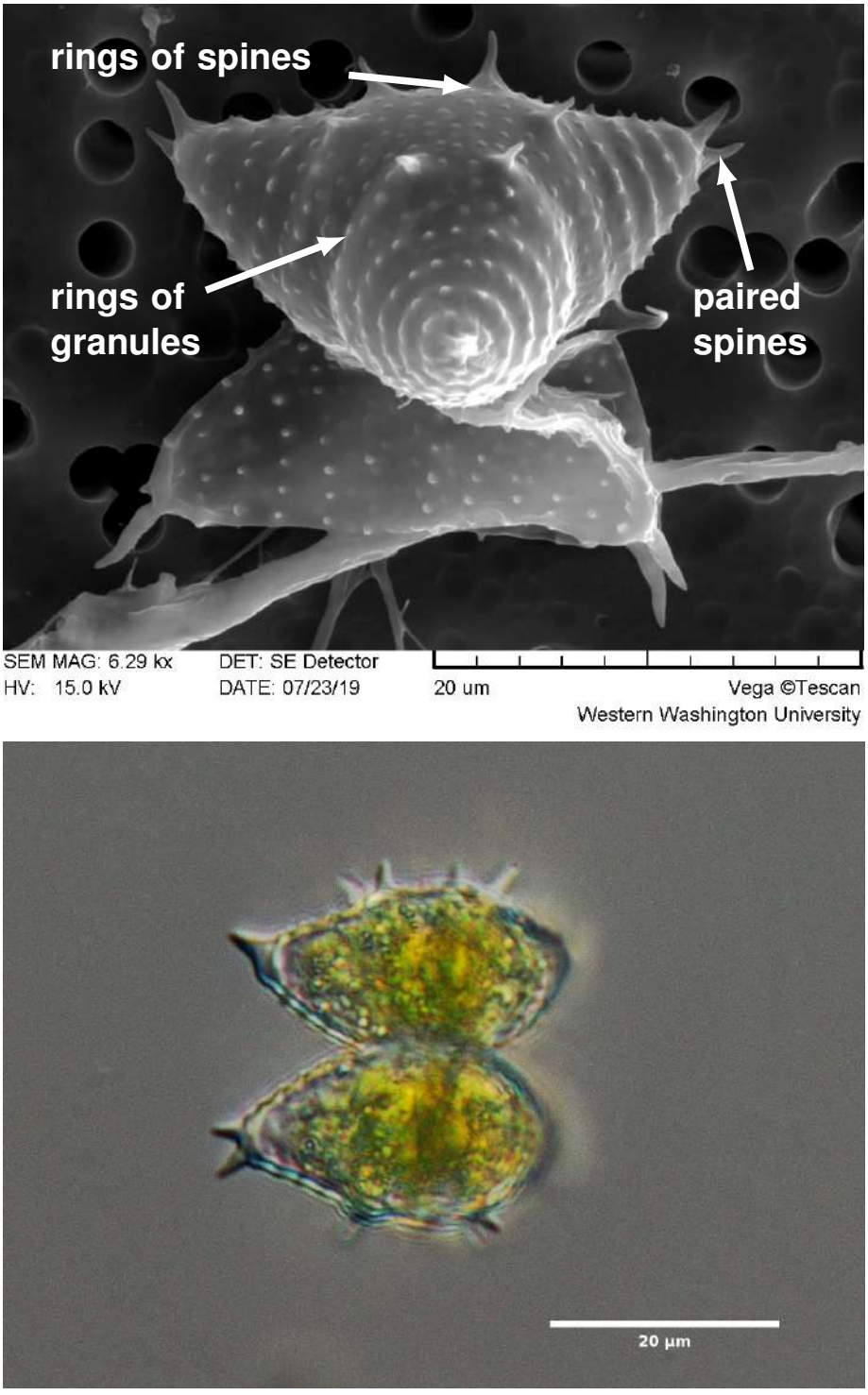


Figure 22.30: *Staurastrum arcuatum* var. A (SEM/DIC), Chain Lake, Gifford Pinchot National Forest, Skamania County (upper/lower images).



Figure 22.31: *Staurastrum asteroideum* (DIC), Boardman Lake, Mountain Loop Highway, Snohomish County.

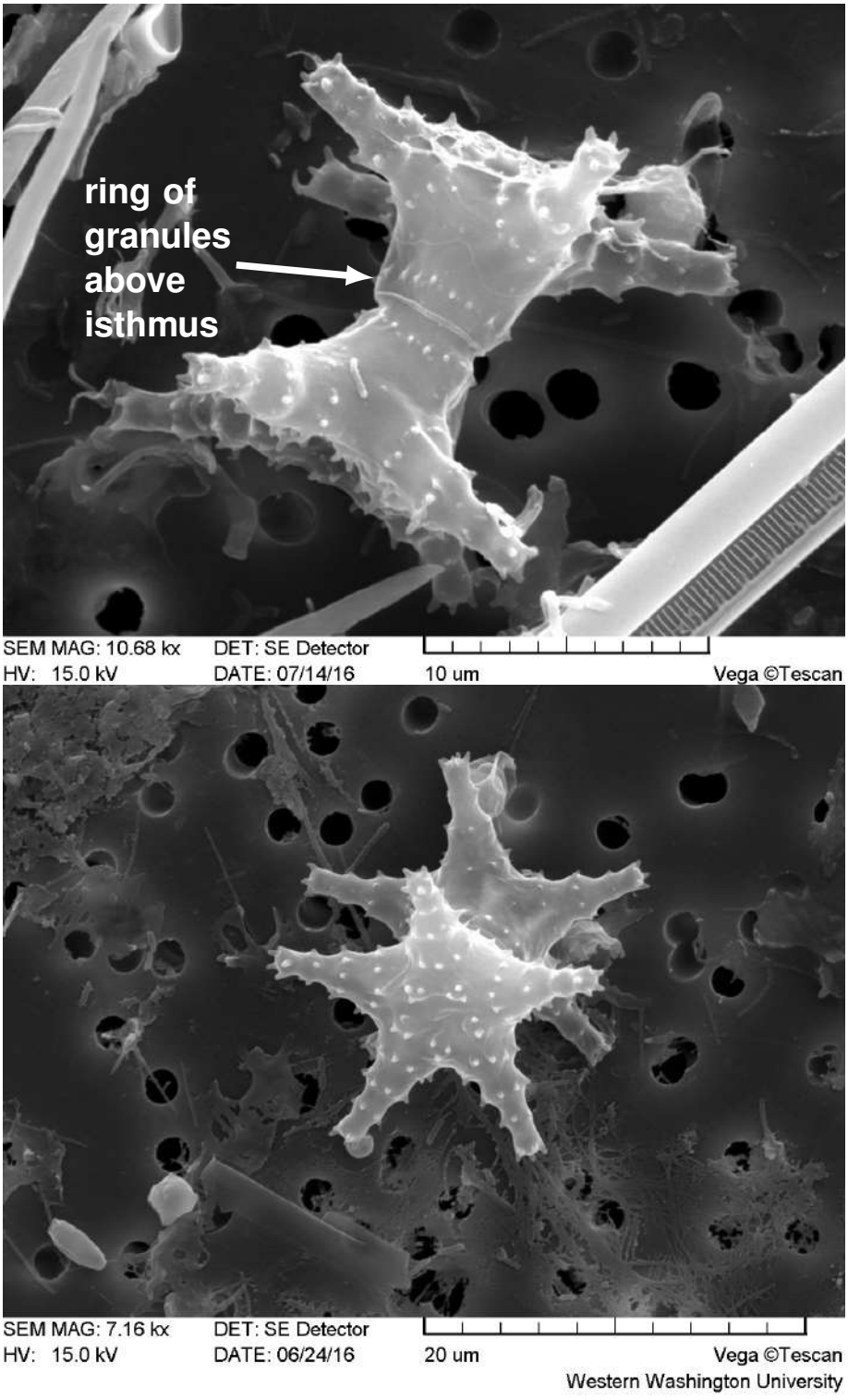


Figure 22.32: *Staurastrum asteroideum* (SEM/SEM), Boardman Lake, Mountain Loop Highway, Snohomish County (upper/lower images).

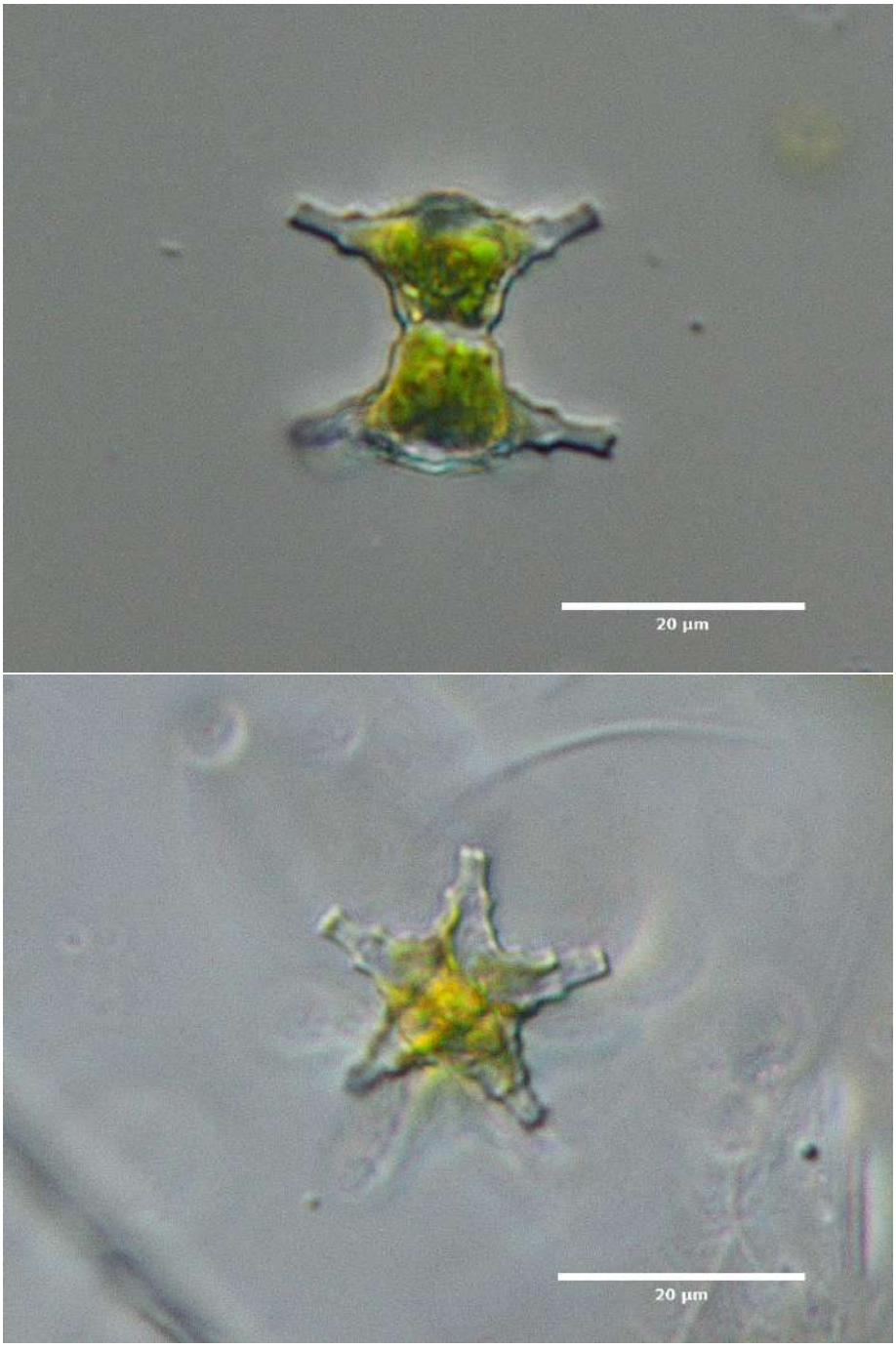


Figure 22.33: *Staurastrum asteroideum* (DIC/DIC), Boardman Lake, Mountain Loop Highway, Snohomish County (upper/lower images).

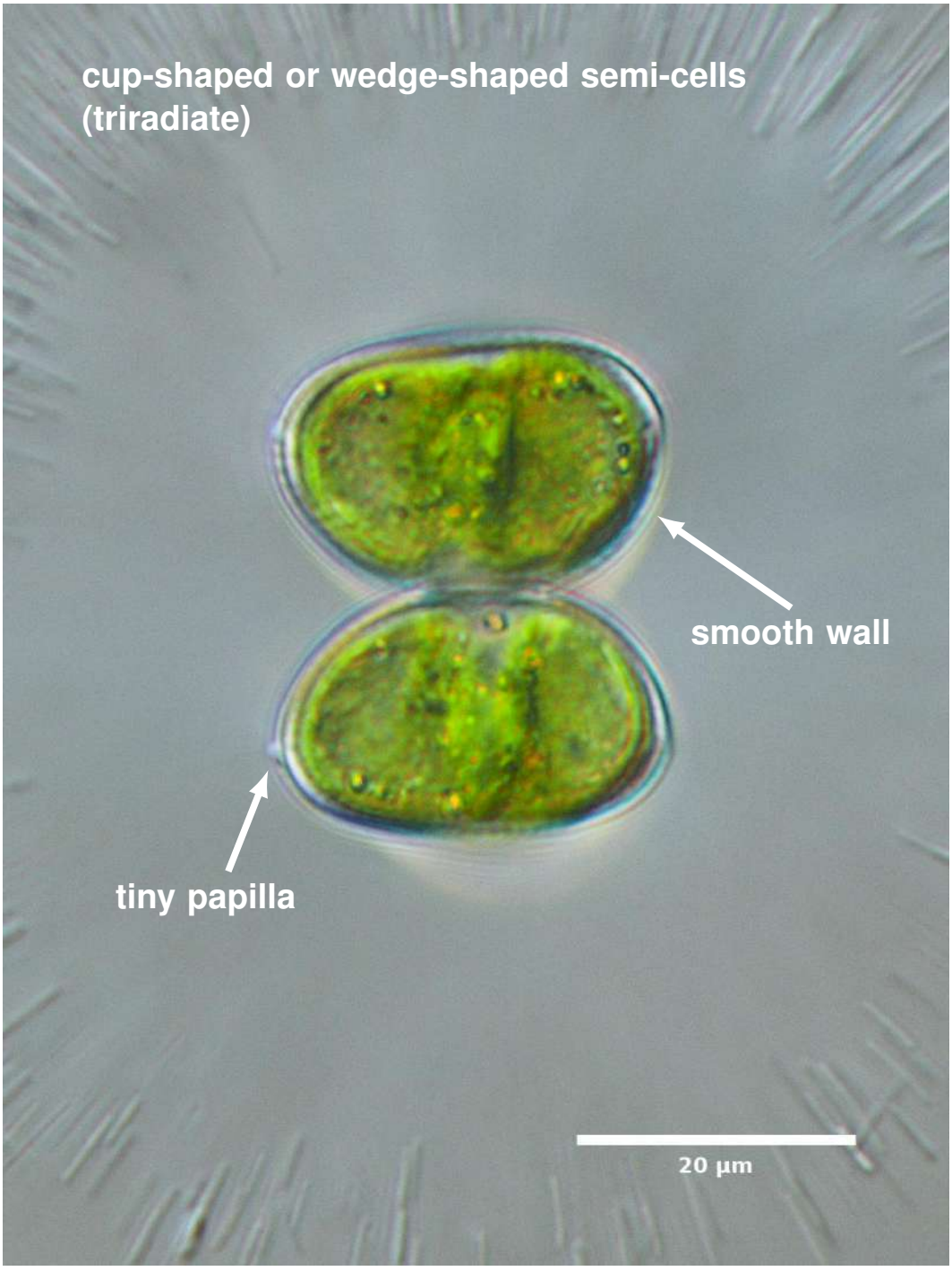


Figure 22.34: *Staurastrum aversum* (DIC), Bear Lake, Mountain Loop Highway, Snohomish County.

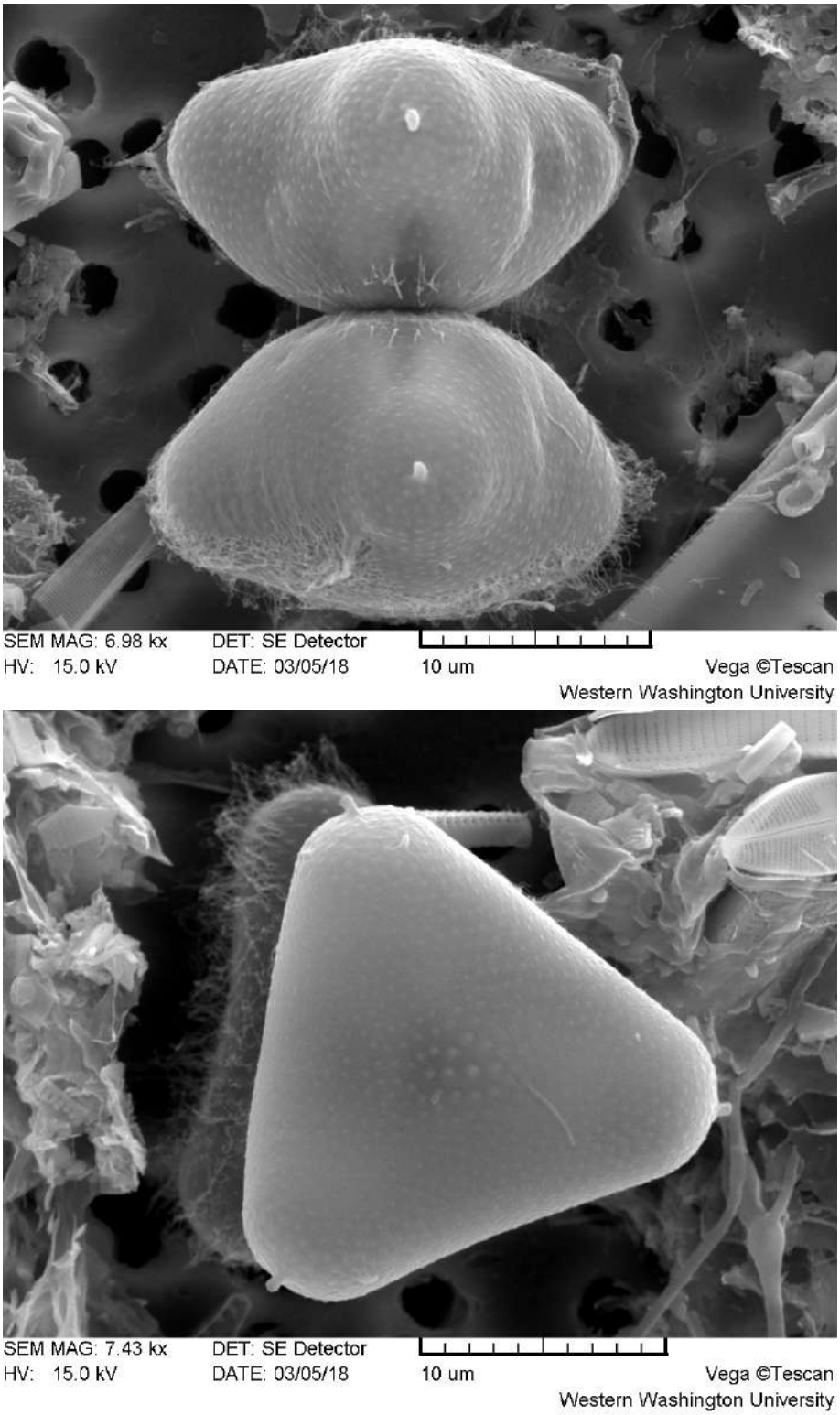


Figure 22.35: *Staurastrum aversum* (SEM/SEM), Lake Evan, Mountain Loop Highway, Snohomish County (upper/lower images)

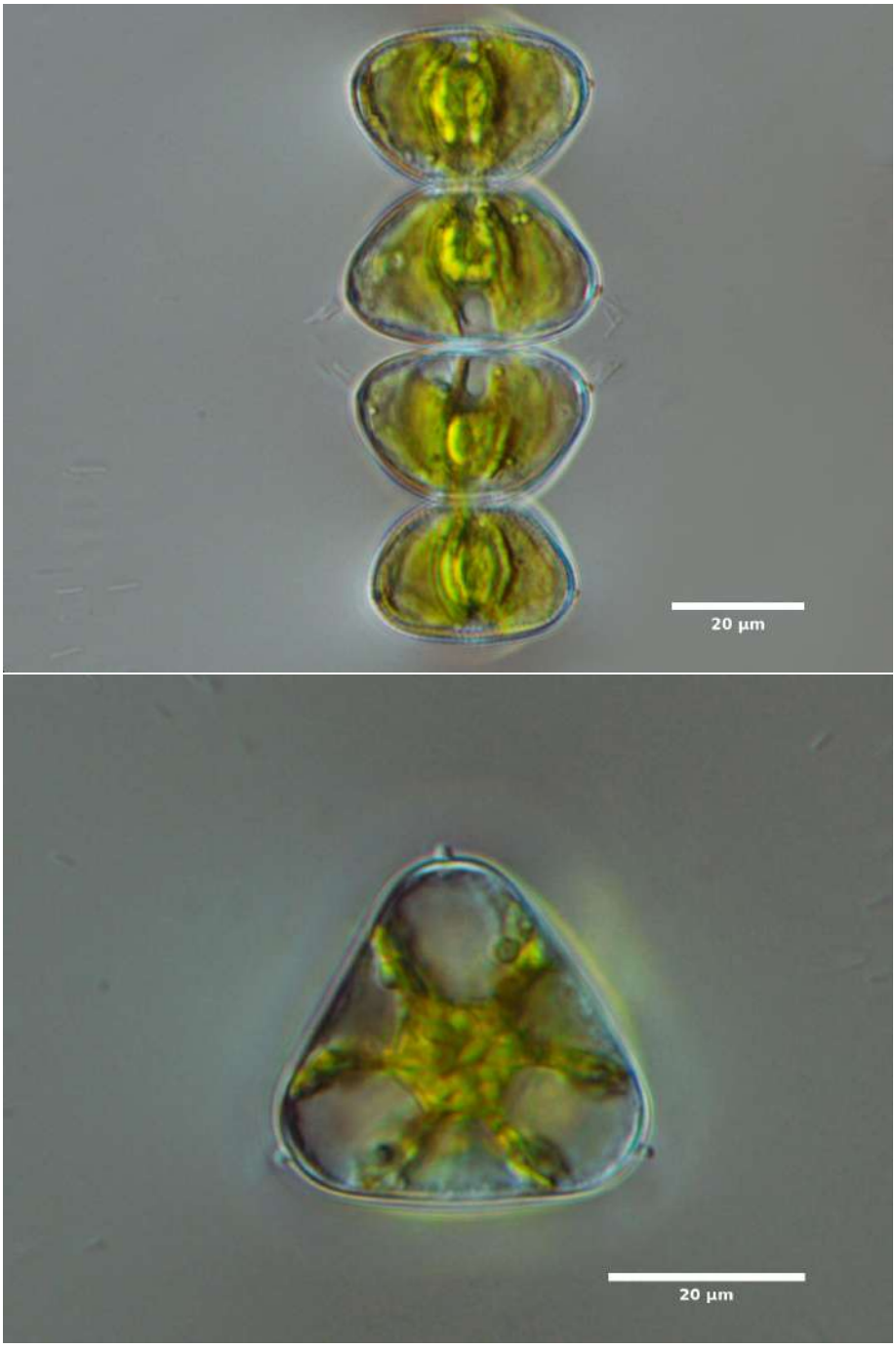


Figure 22.36: *Staurastrum aversum* (DIC/DIC), Bear Lake, Mountain Loop Highway, Snohomish County (upper/lower images)

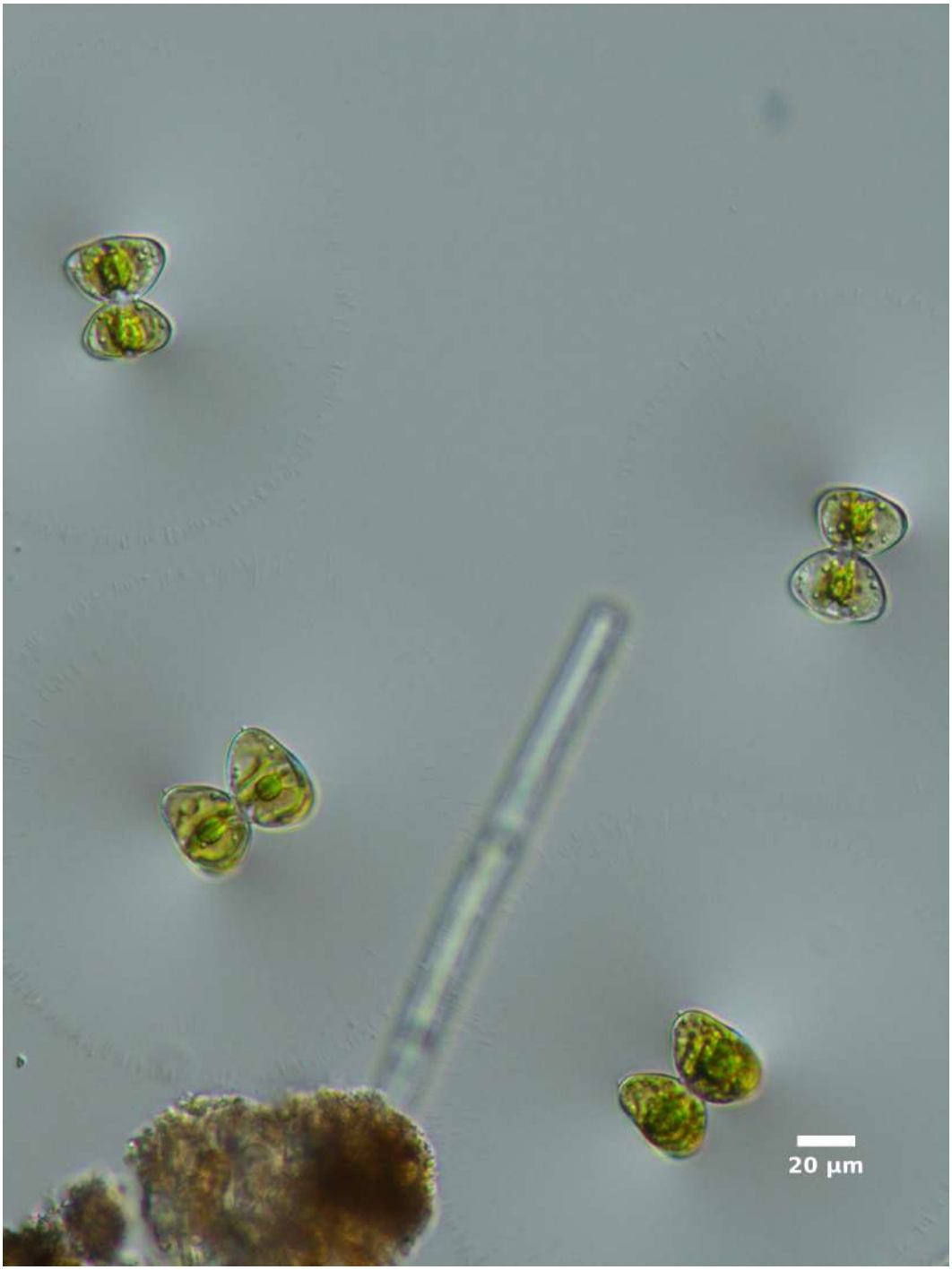


Figure 22.37: *Staurastrum aversum* bloom (DIC), Picture Lake, Mt. Baker area, Whatcom County.

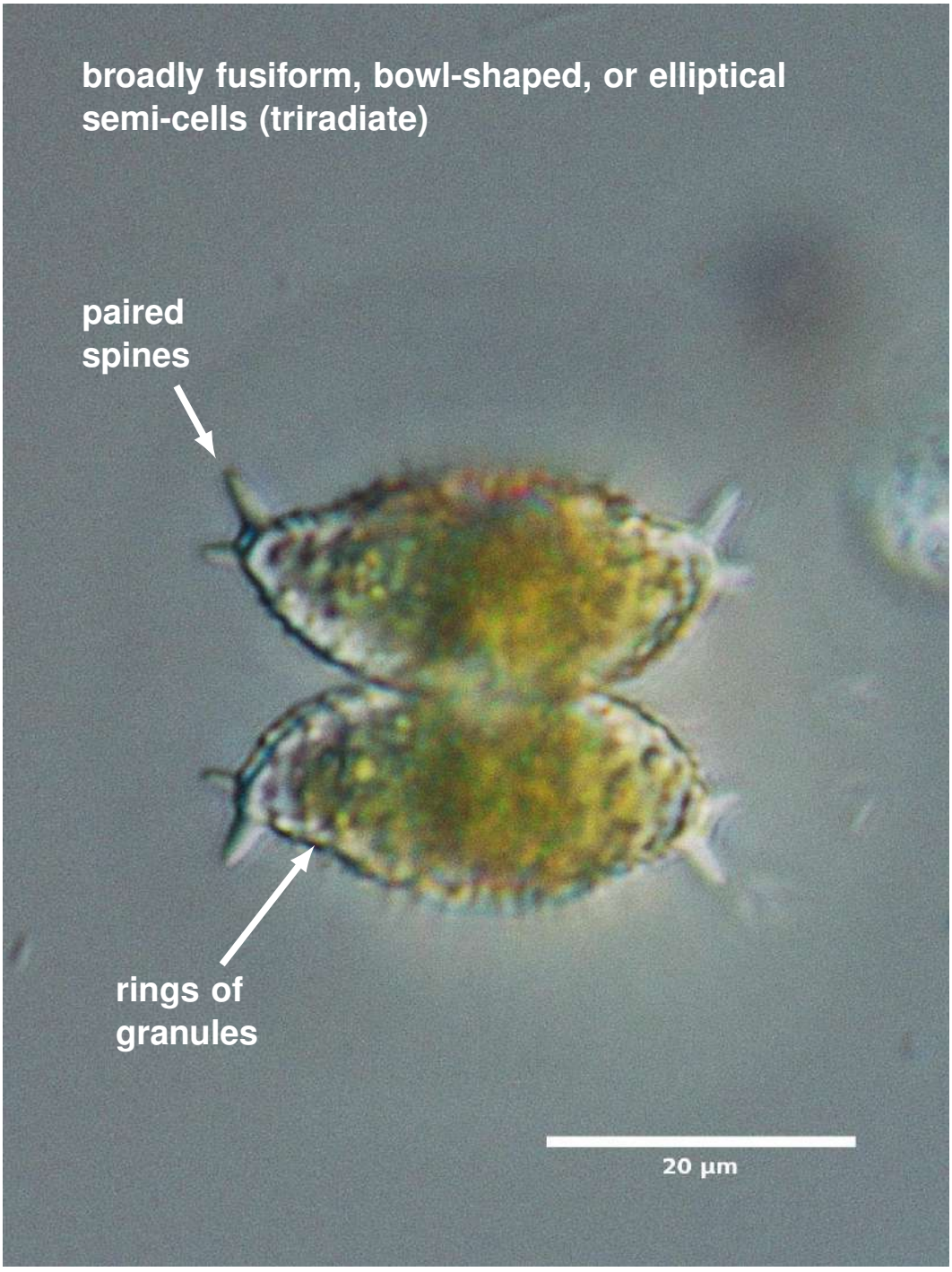


Figure 22.38: *Staurastrum avicula* (DIC), small boggy pond on Morris Valley Road near Harrison BC.

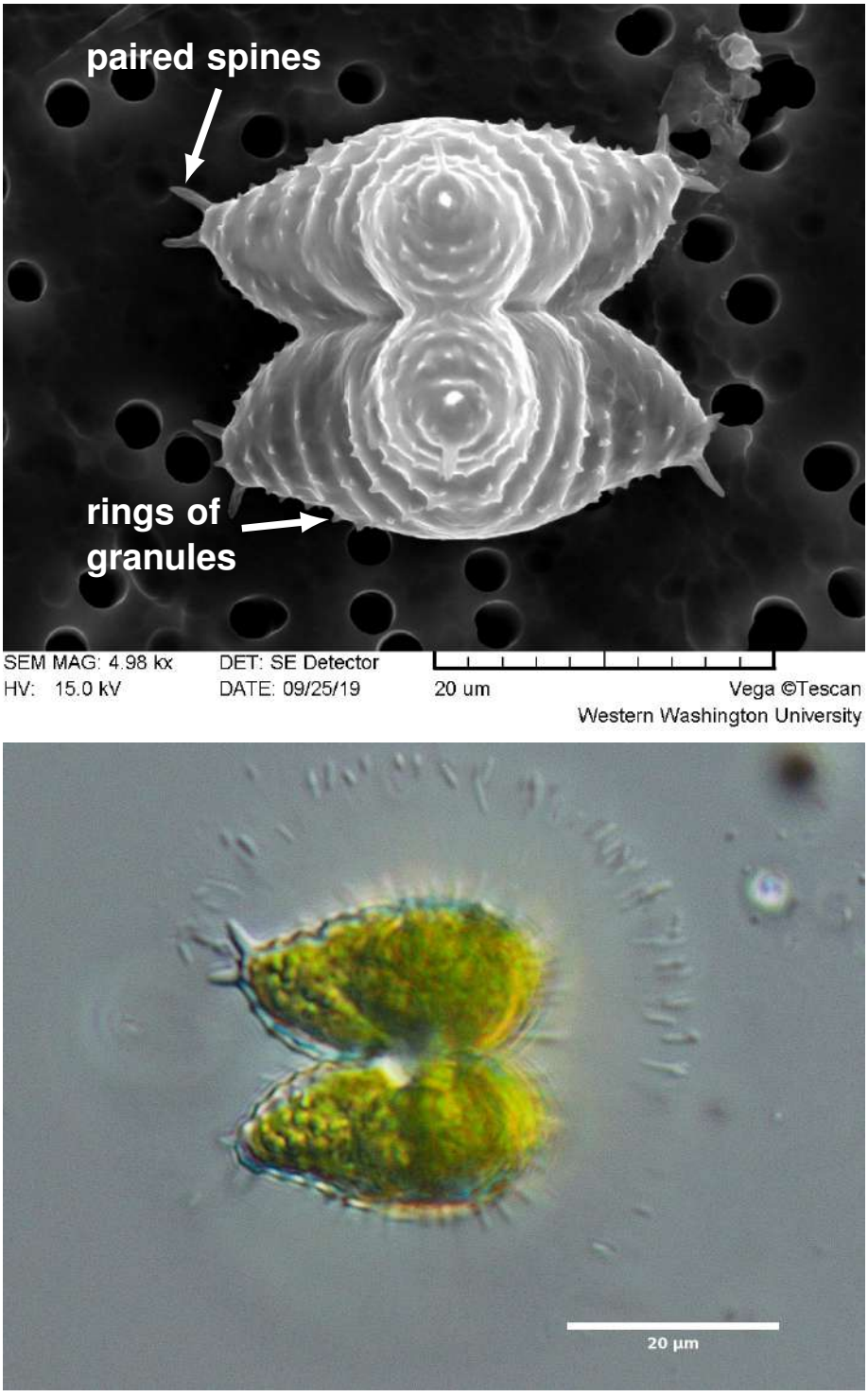


Figure 22.39: *Staurastrum avicula* (SEM/DIC), small boggy pond on Morris Valley Road near Harrison BC (upper/lower images).

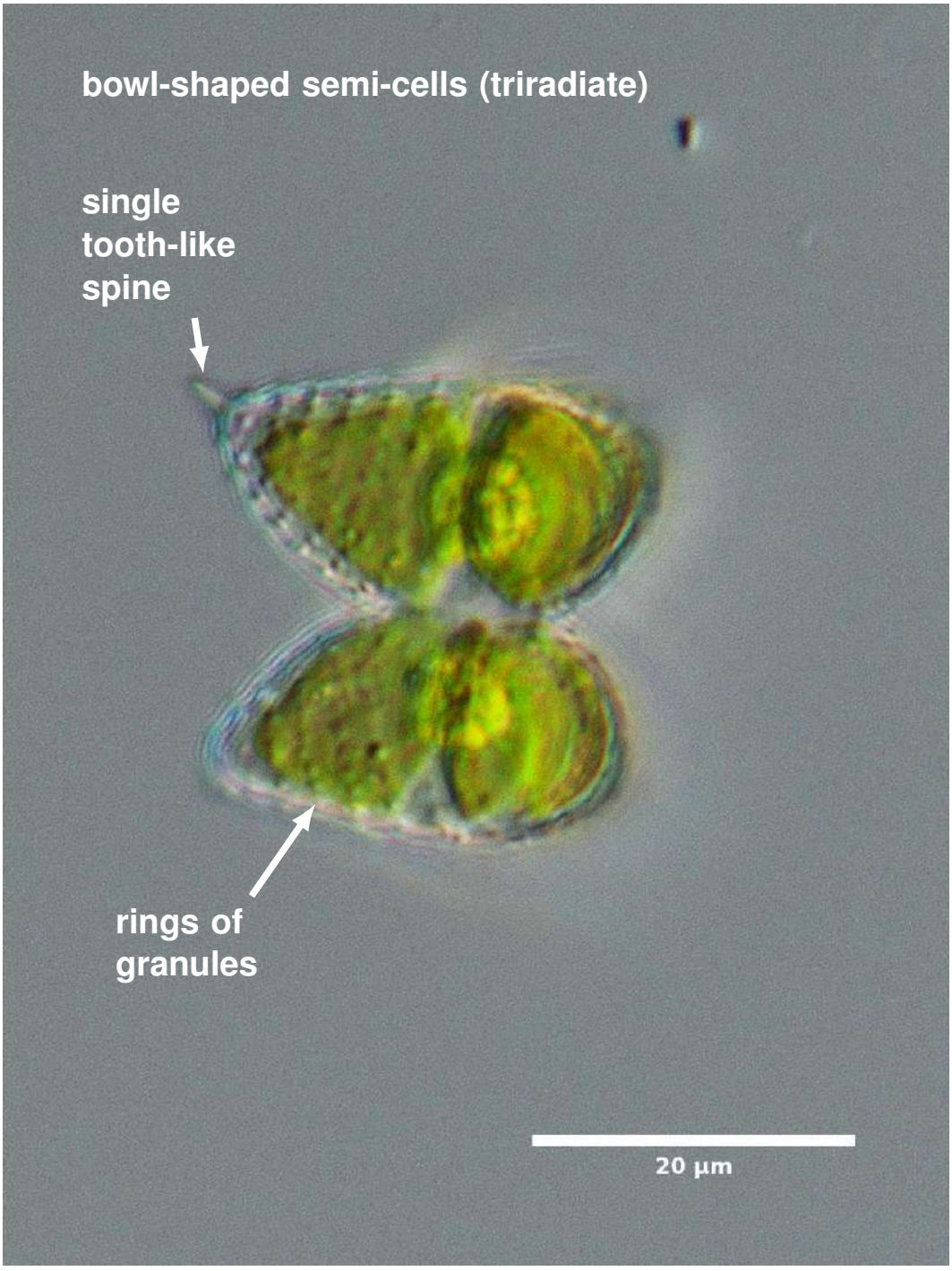


Figure 22.40: *Staurastrum avicula* var. *lunatum* (DIC), small residential pond, Skagit County.



Figure 22.41: *Staurastrum avicula* var. *lunatum* (DIC/DIC), small residential pond, Skagit County (upper/lower images).

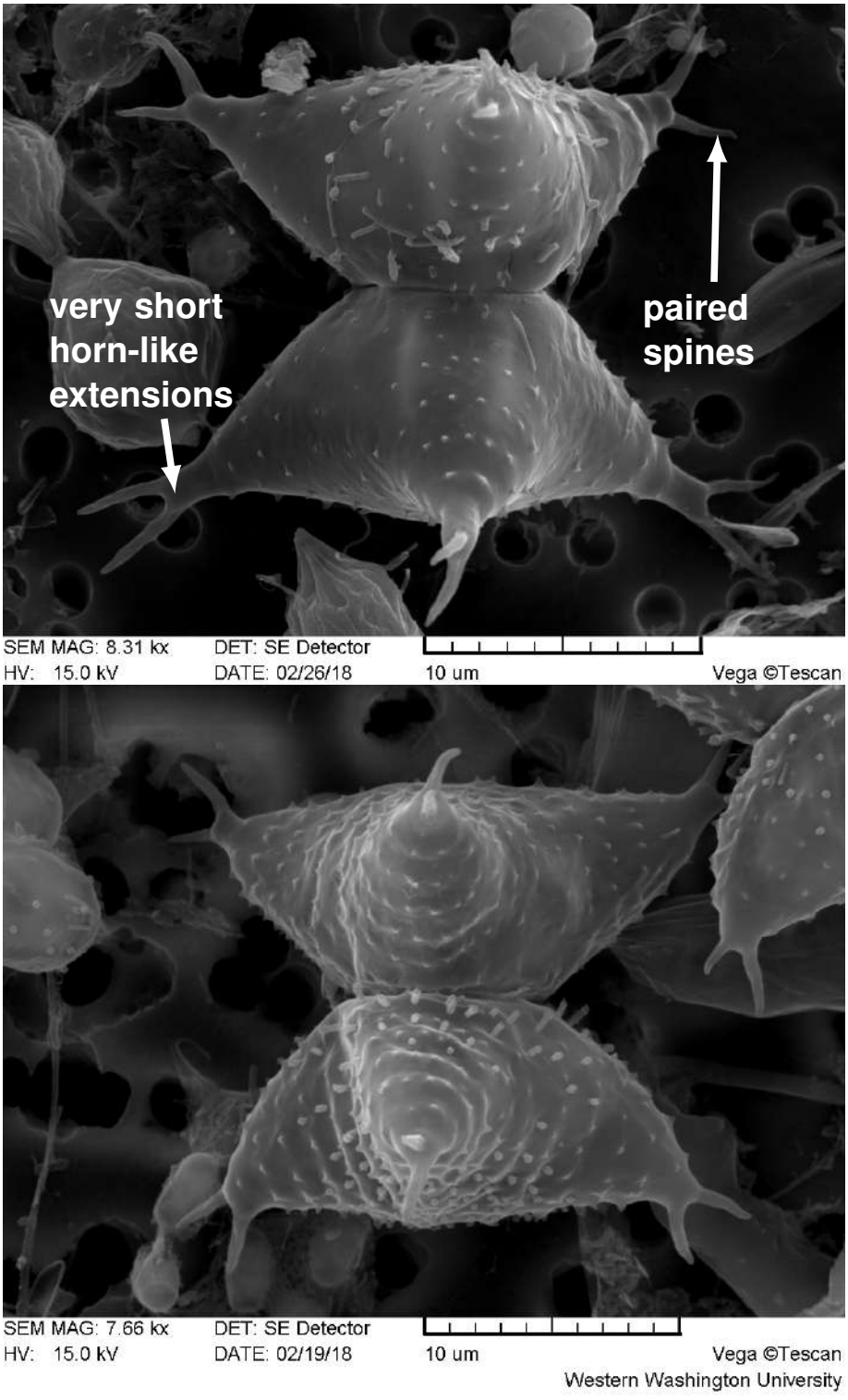


Figure 22.42: *Staurastrum avicula* cf. var. *subarcuatum* (SEM/SEM), Myrtle Lake, Mountain Loop Highway, Snohomish County (upper/lower images).



Figure 22.43: *Staurastrum avicula* var. A (DIC), Lake Whatcom, Whatcom County.

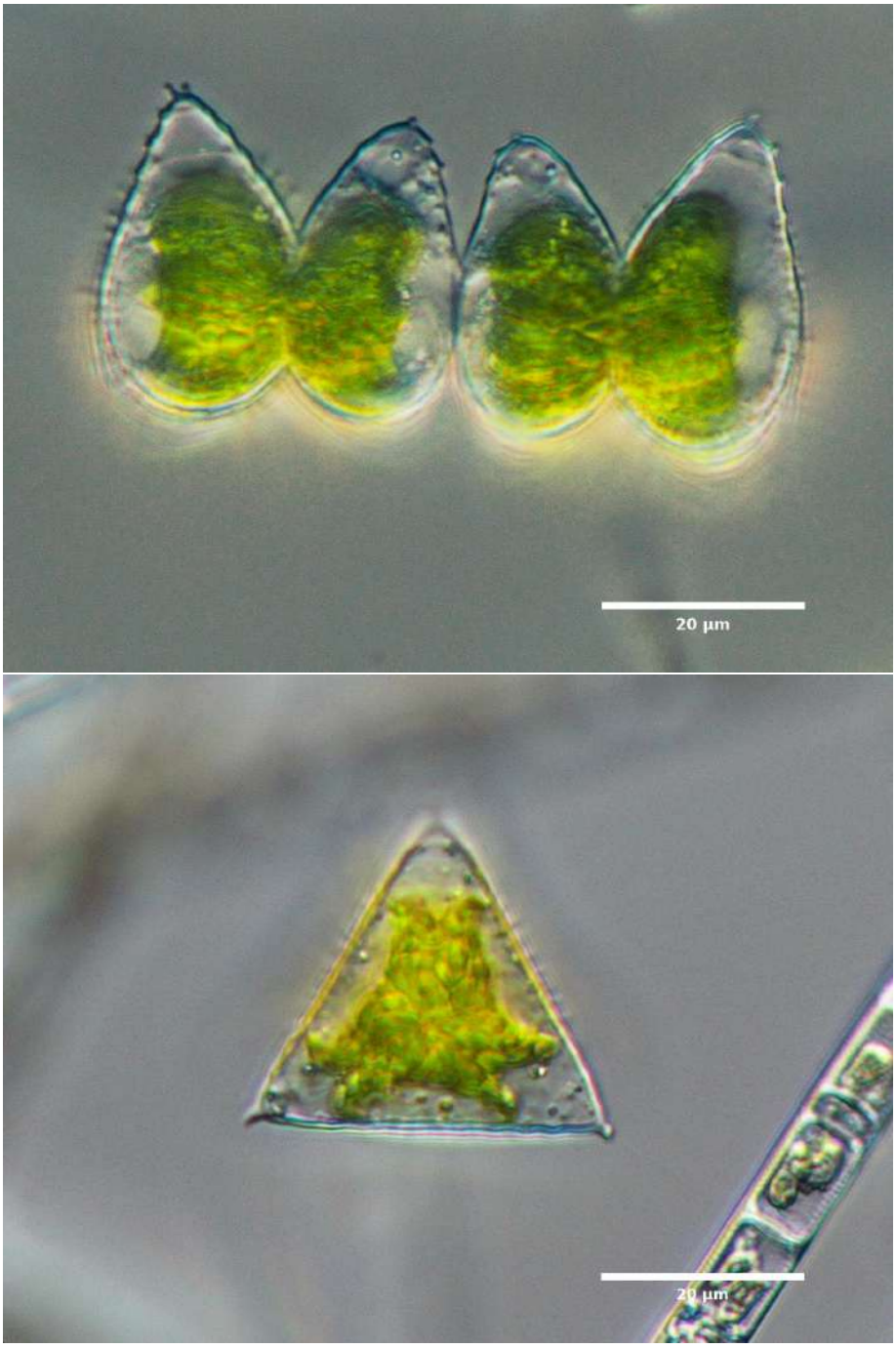


Figure 22.44: *Staurastrum avicula* var. A (DIC/DIC), Lake Whatcom, Whatcom County (upper/lower images).



Figure 22.45: *Staurastrum avicula* var. B (DIC), Lake Whatcom, Whatcom County (upper/lower images).



Figure 22.46: Atypical specimen resembling *Staurastrum avicula* (upper semi-cell) and *Staurastrum arcuatum* (lower semi-cell); small boggy pond on Morris Valley Road near Harrison, BC.

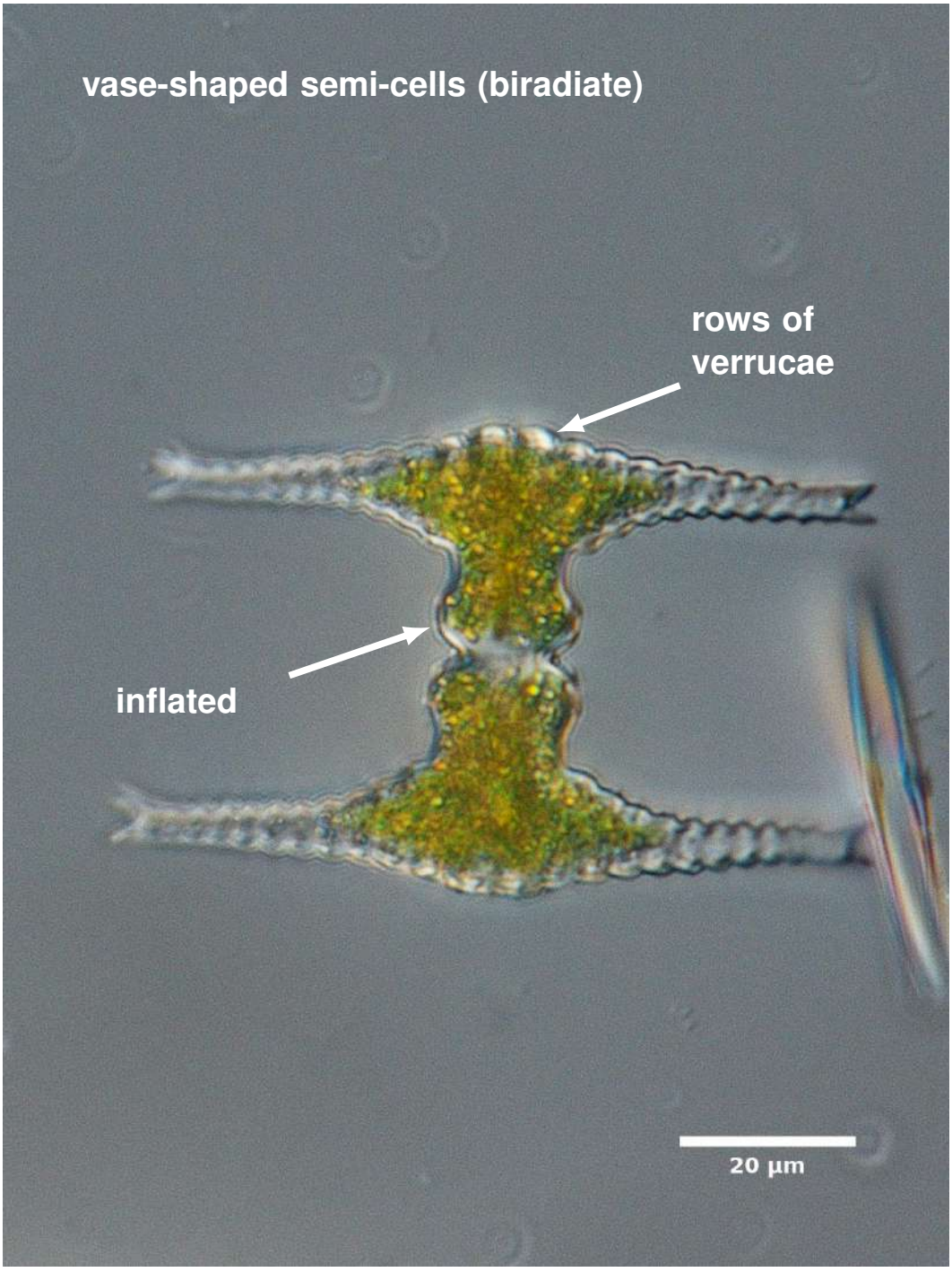
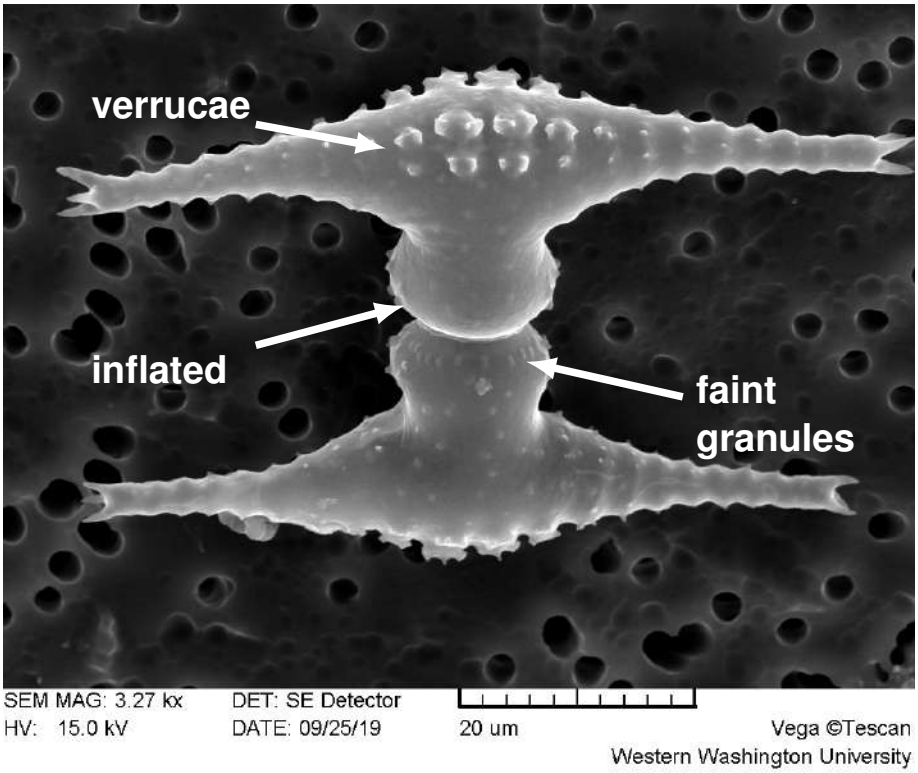


Figure 22.47: *Staurastrum bicorne* (DIC), small boggy pond on Morris Valley Road near Harrison, BC.



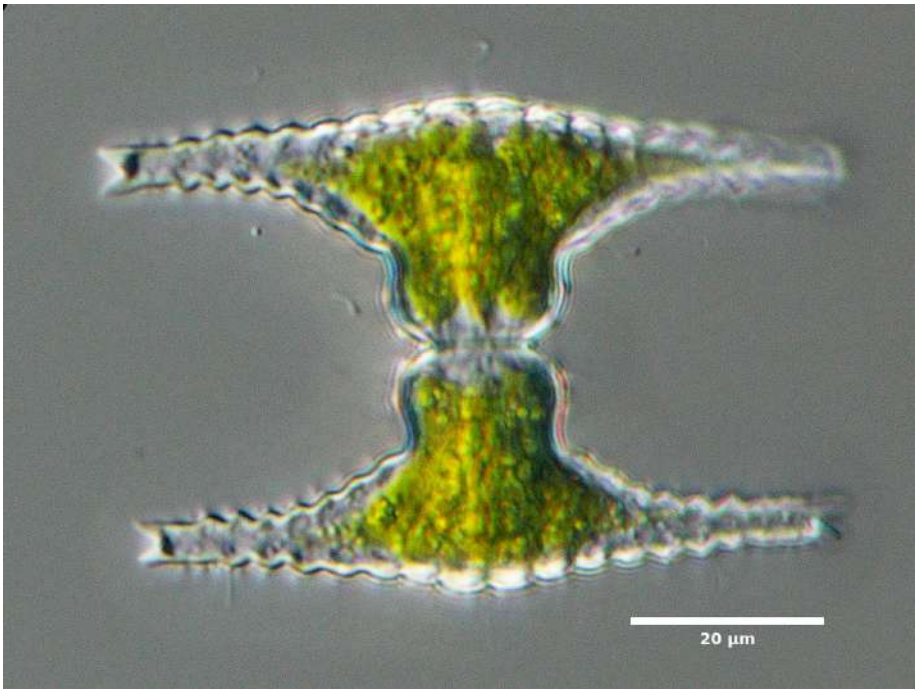


Figure 22.48: *Staurastrum bicorne* (SEM/DIC), small boggy pond on Morris Valley Road near Harrison, BC (upper/lower images).

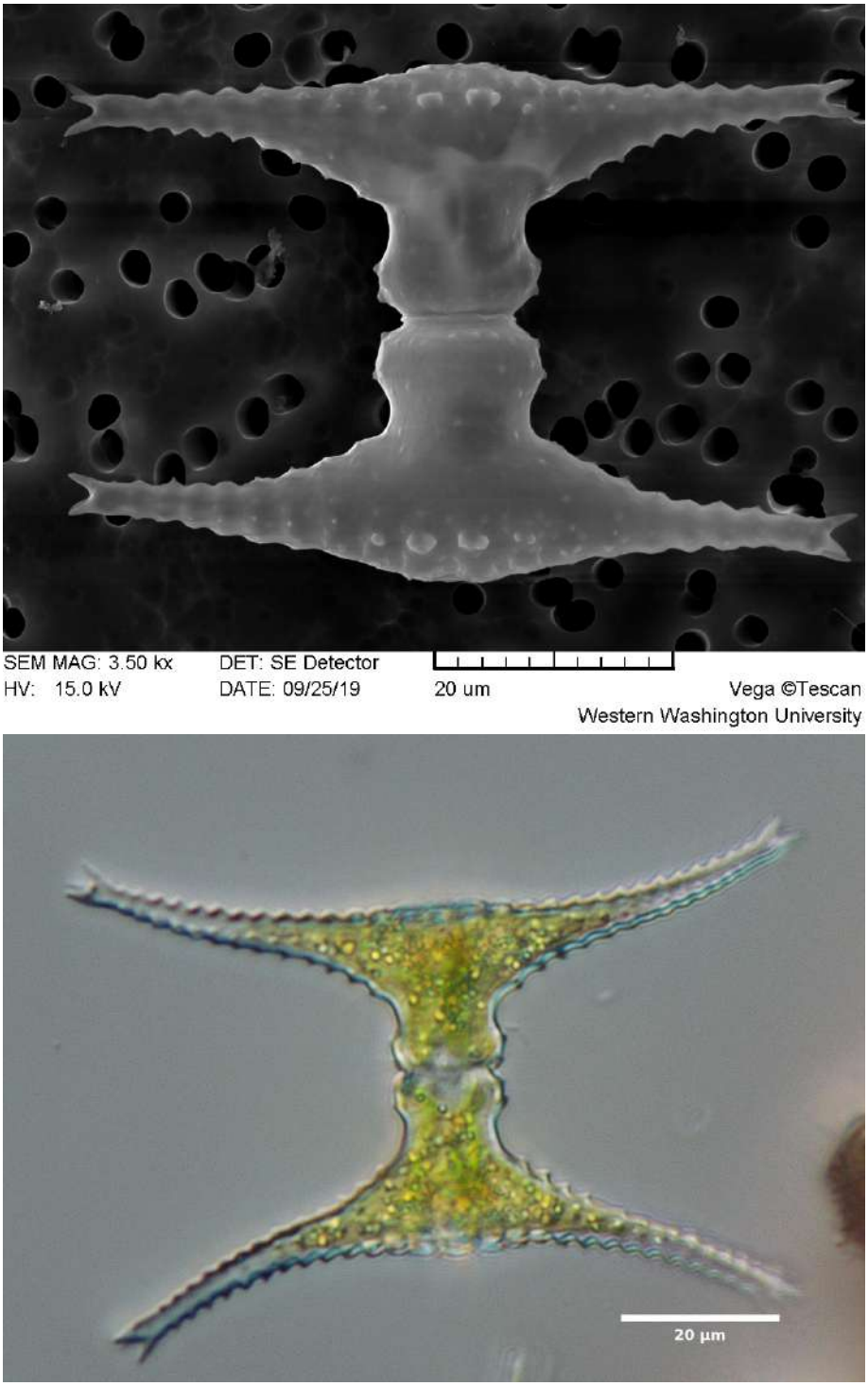


Figure 22.49: *Staurastrum bicorne* (SEM/DIC), small boggy pond on Morris Valley Road near Harrison, BC (upper image); Wood Lake, Morris Valley Road near Harrison, BC (lower image).

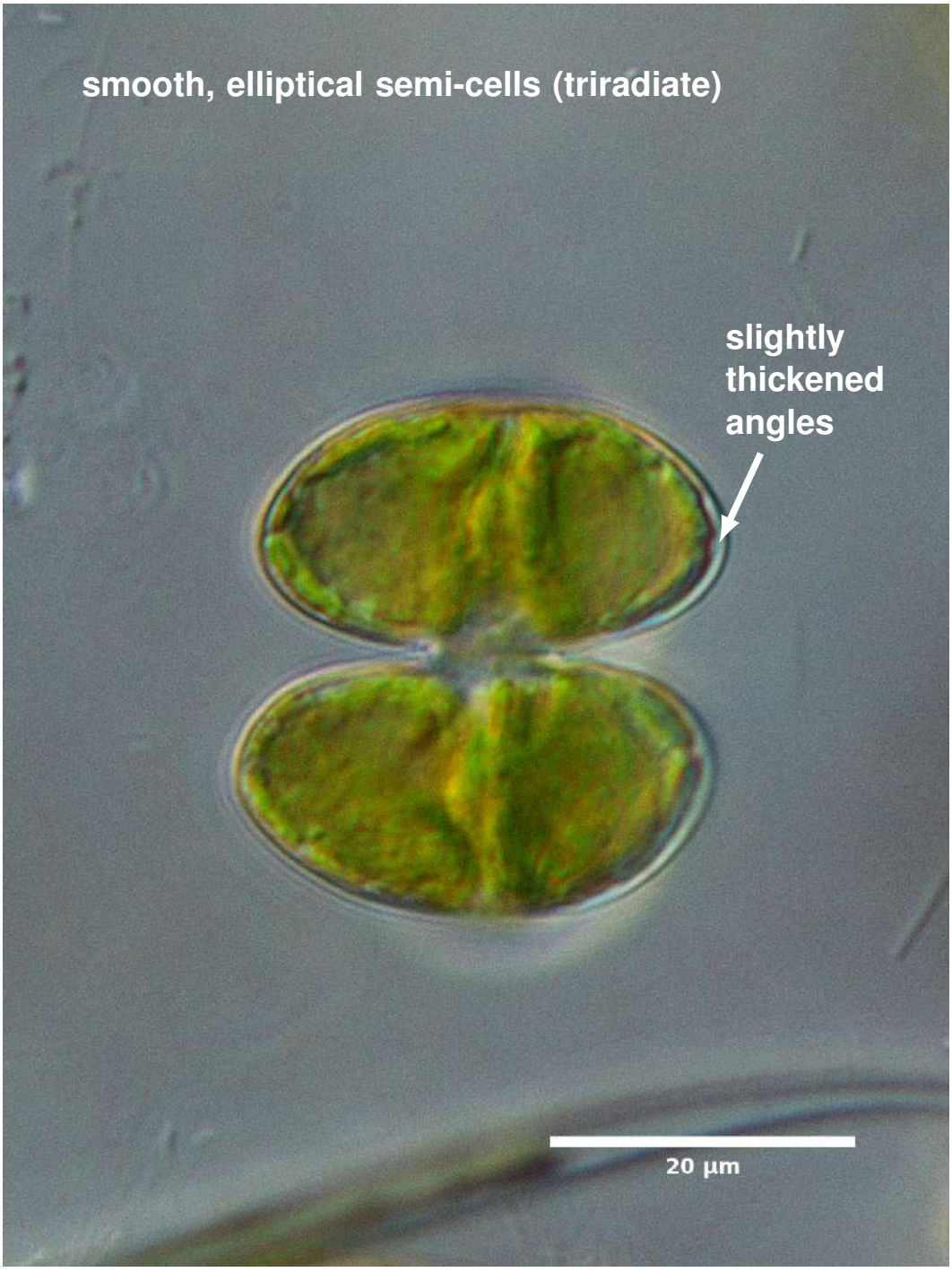


Figure 22.50: *Staurastrum bieneanum* (DIC), small floating bog along Morris Valley Road near Harrison, BC.

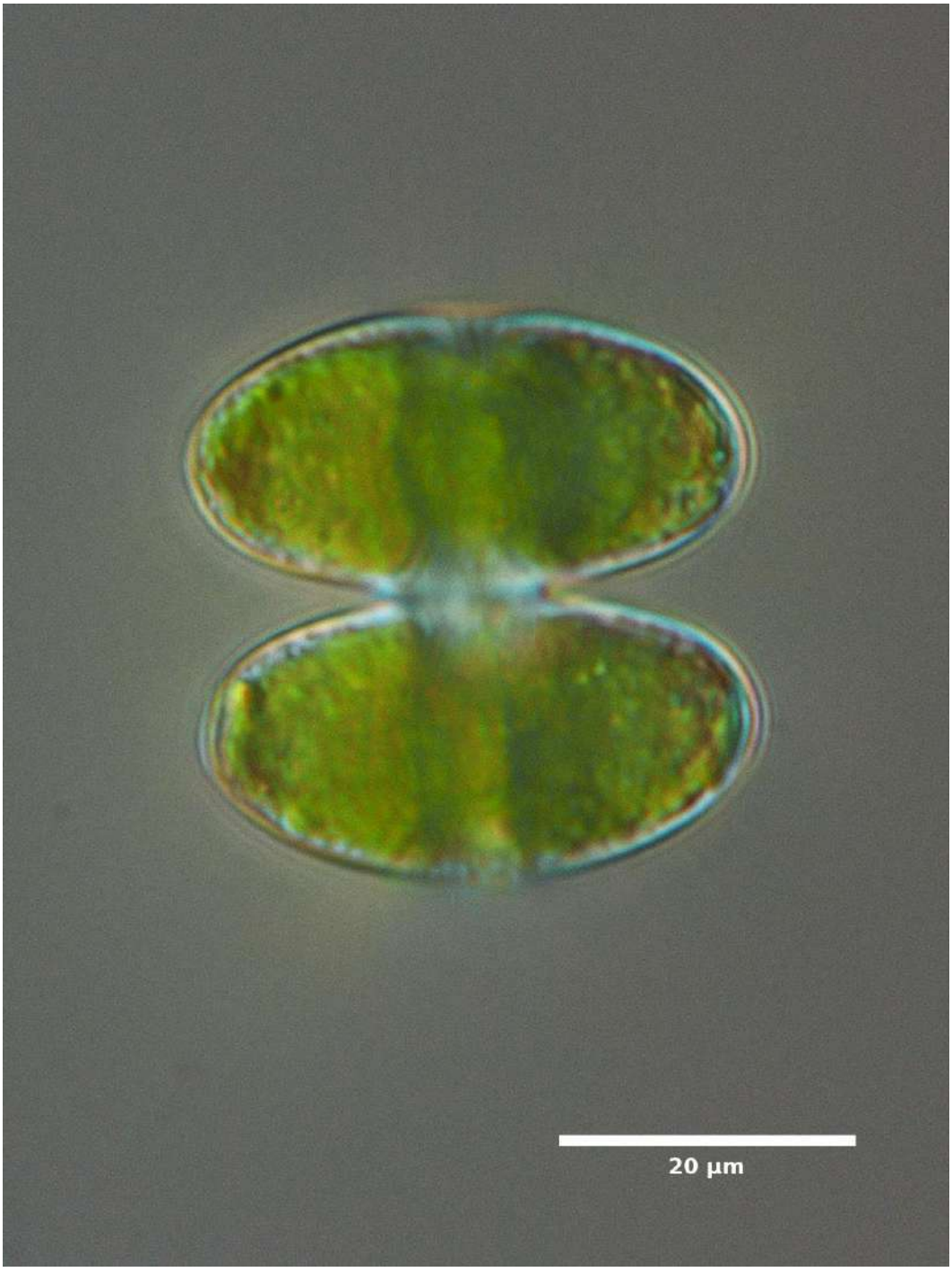


Figure 22.51: *Staurastrum bieneanum* (DIC), Myrtle Lake, Mountain Loop Highway, Snohomish County.



Figure 22.52: *Staurastrum boreale* (DIC), Gold Basin Mill Pond, Mountain Loop Highway, Snohomish County.

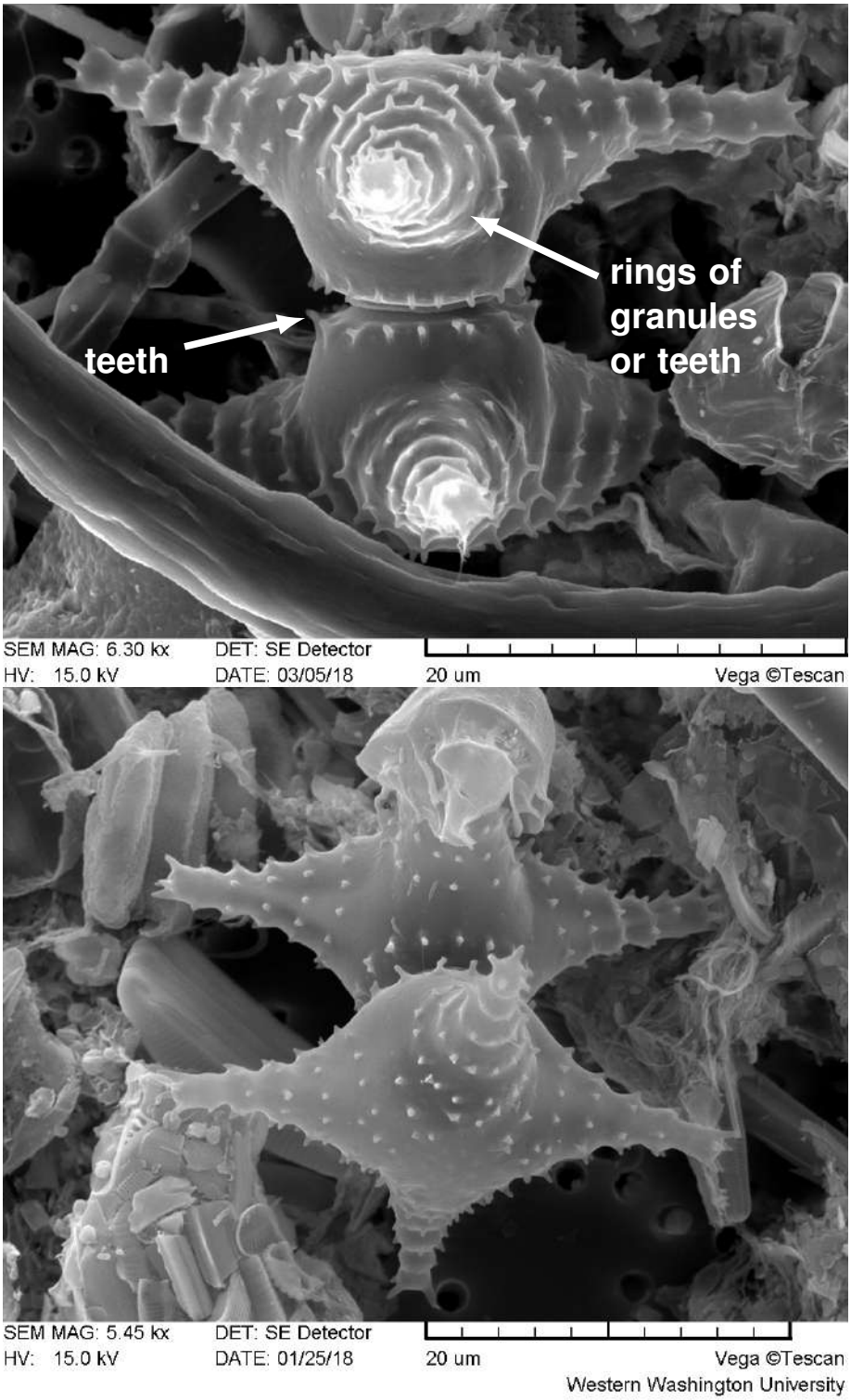


Figure 22.53: *Staurastrum boreale* (SEM/SEM), triradiate and 4-radiate semi-cells from Heather Lake, Mountain Loop Highway, Snohomish County (upper/lower images).

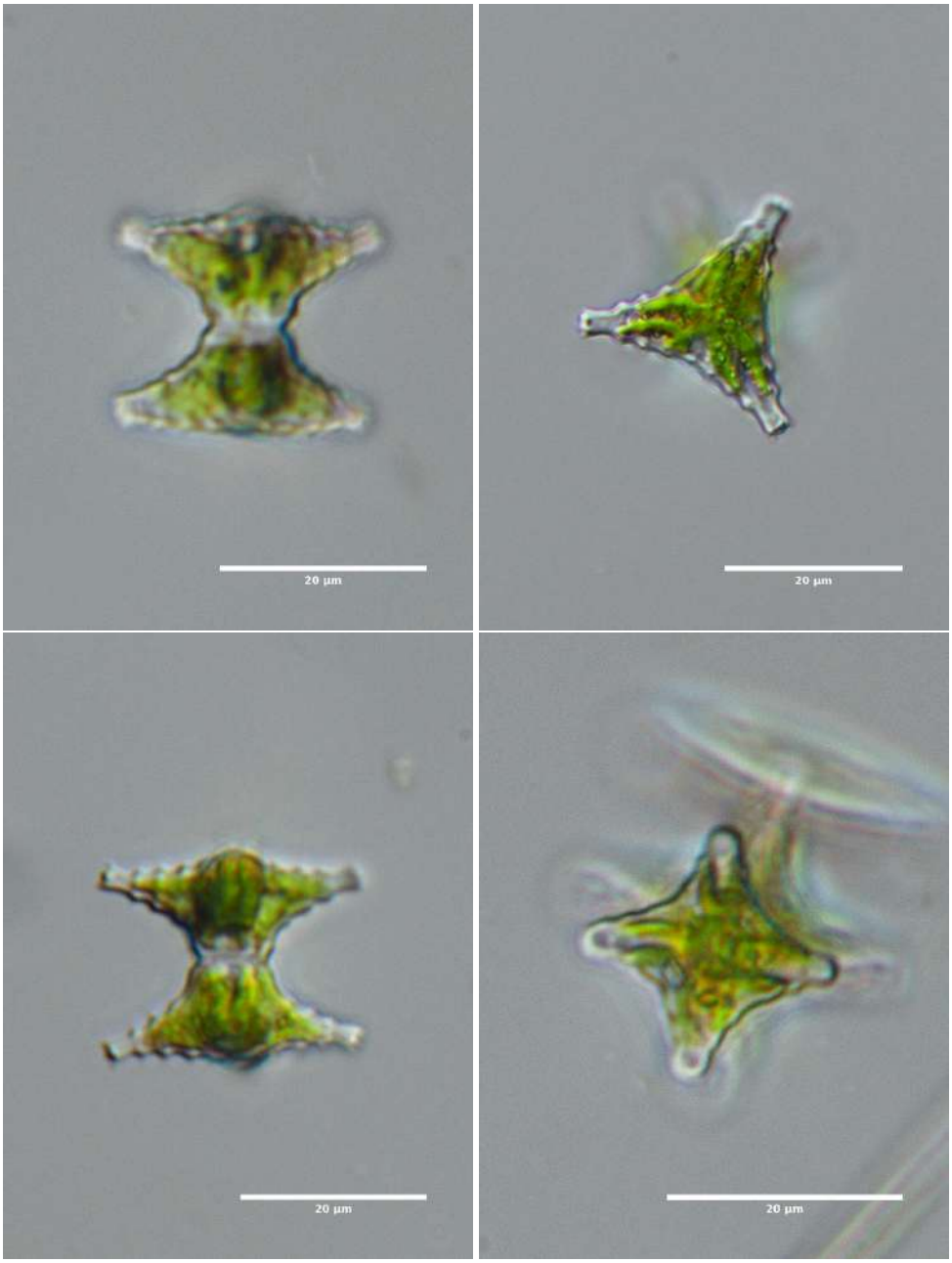


Figure 22.54: *Staurastrum boreale* triradiate semi-cells (upper images) and 4-radiate semi-cells (lower images) collected in same sample from Gold Basin Mill Pond, Mountain Loop Highway, Snohomish County (DIC).

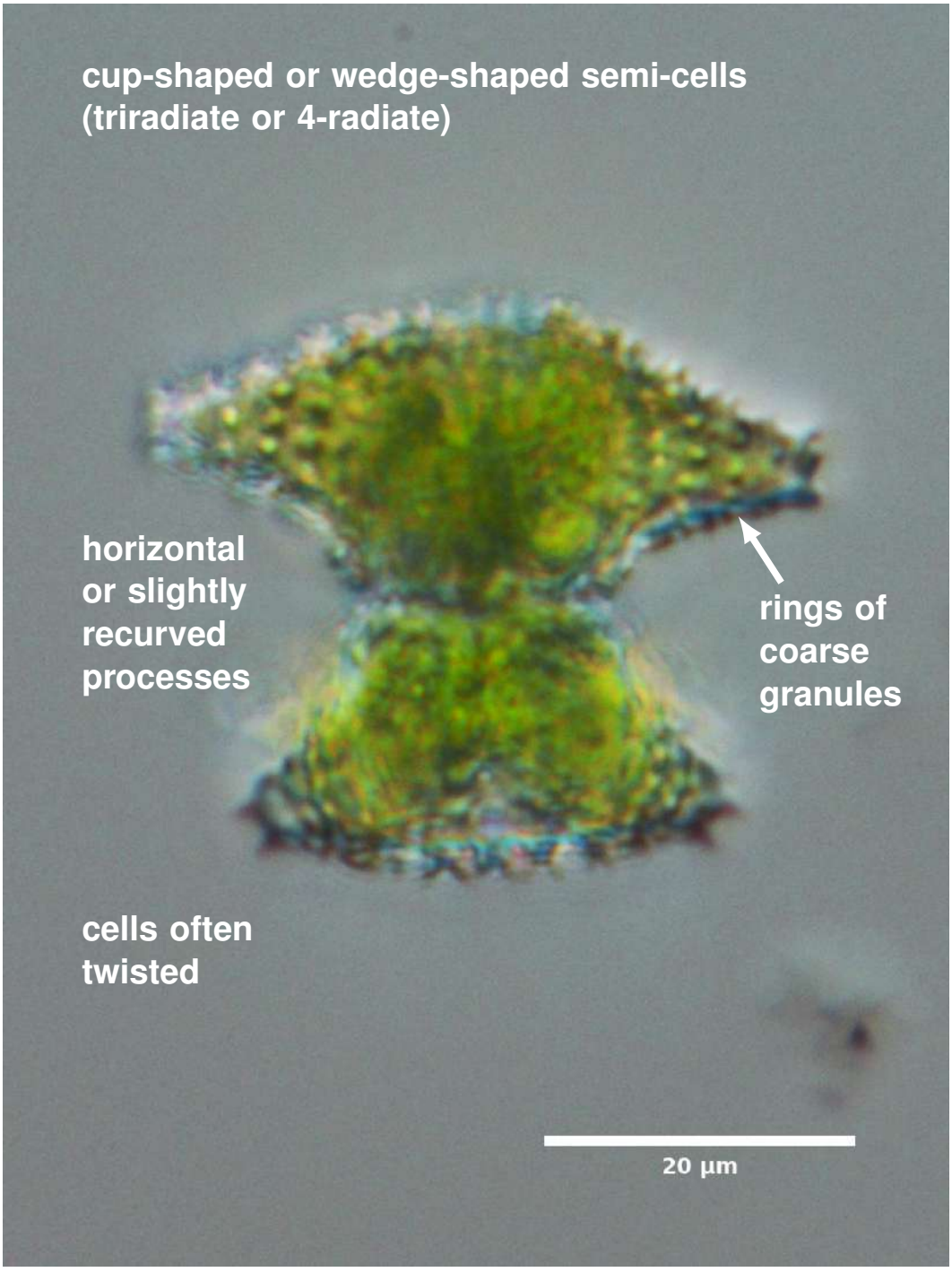


Figure 22.55: *Staurastrum borgeanum* 4-radiate semi-cells (DIC), Goat Lake, Mountain Loop Highway, Snohomish County.

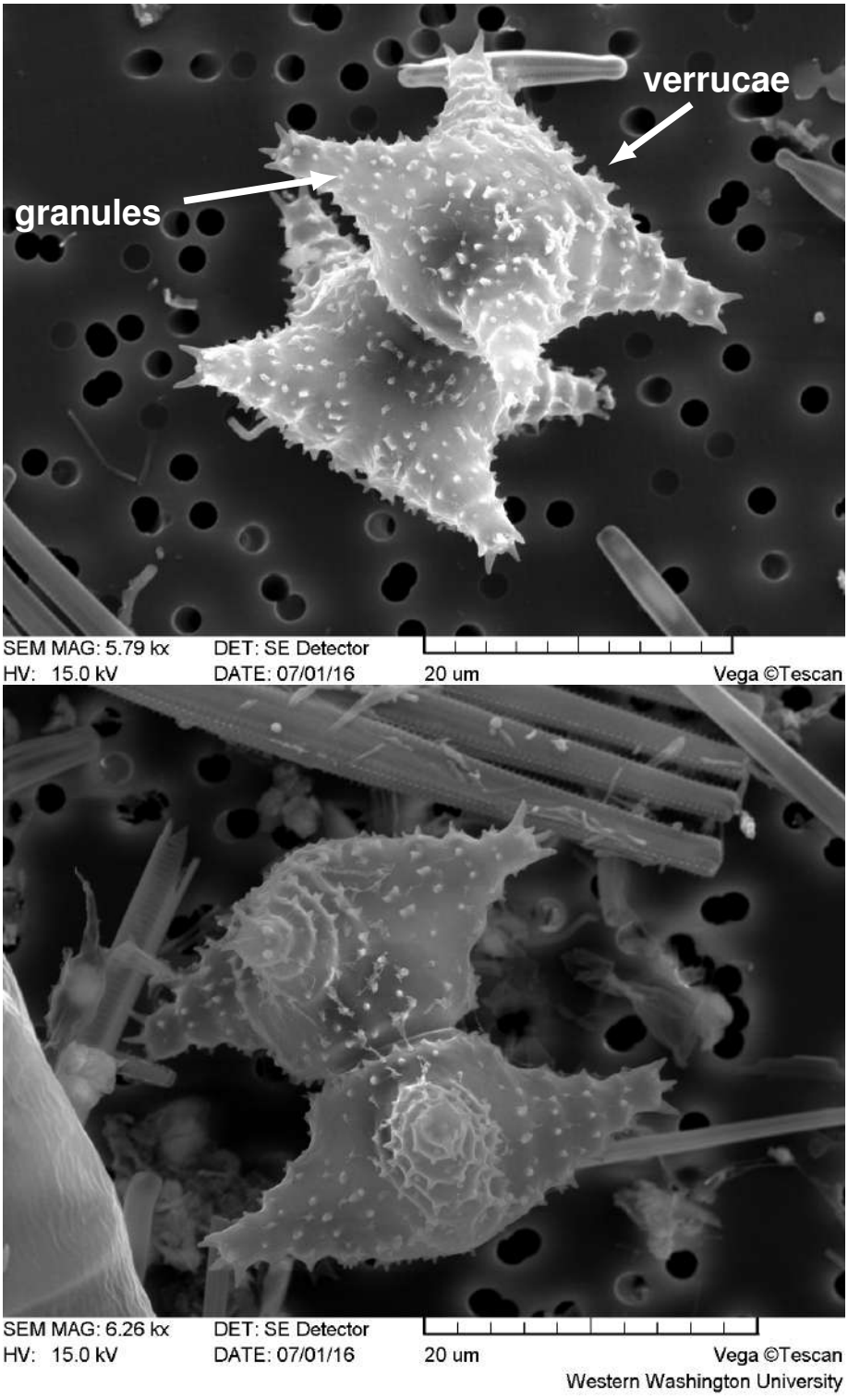


Figure 22.56: *Staurastrum borgeanum* 4-radiate semi-cells (SEM/SEM), Goat Lake, Mountain Loop Highway, Snohomish County (upper/lower images).



Figure 22.57: *Staurastrum borgeanum* triradiate semi-cells (DIC), Lake Twenty-two, Mountain Loop Highway, Snohomish County.

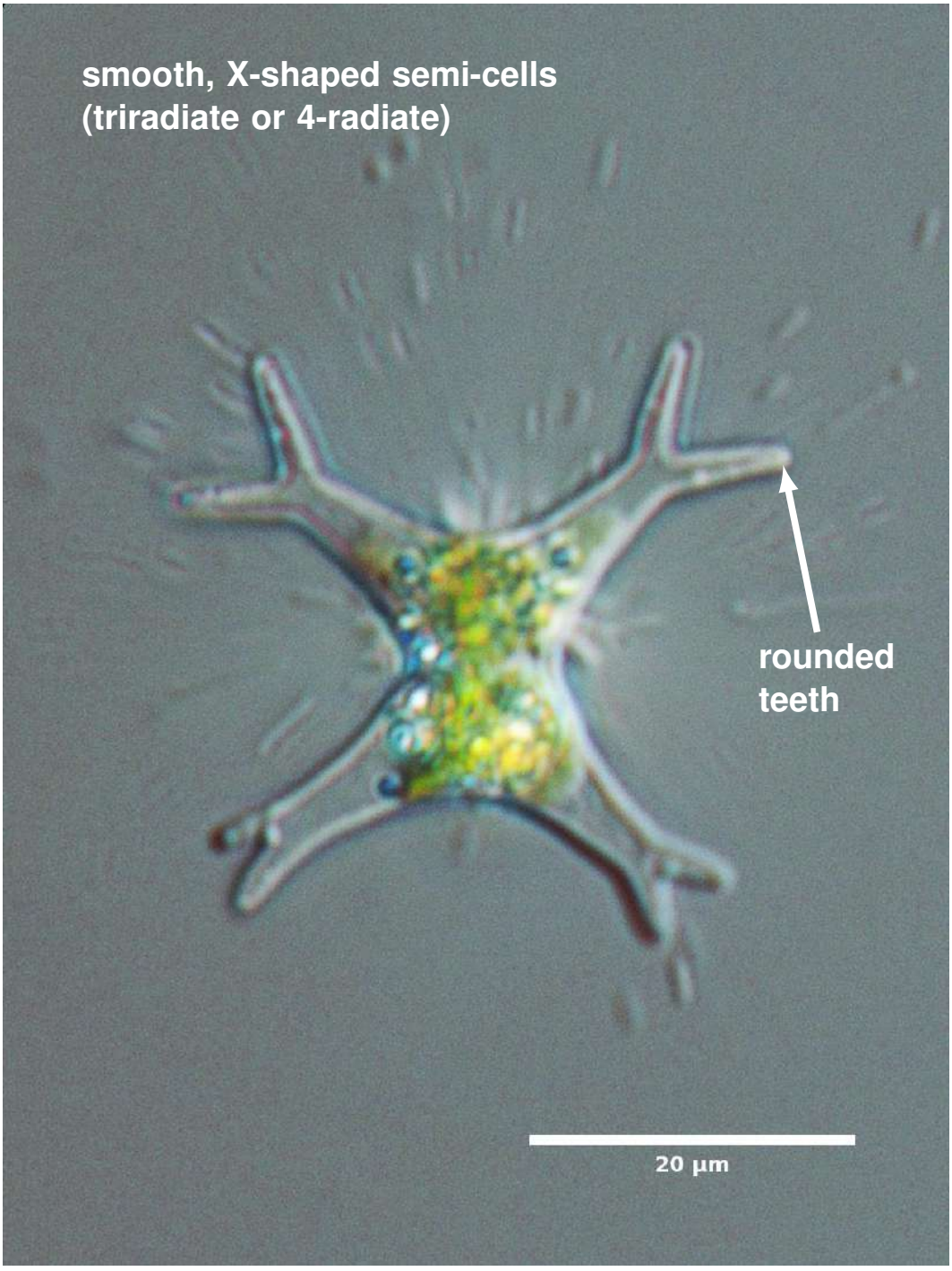


Figure 22.58: *Staurastrum brachiatum* (DIC), Heather Lake, Mountain Loop Highway, Snohomish County.

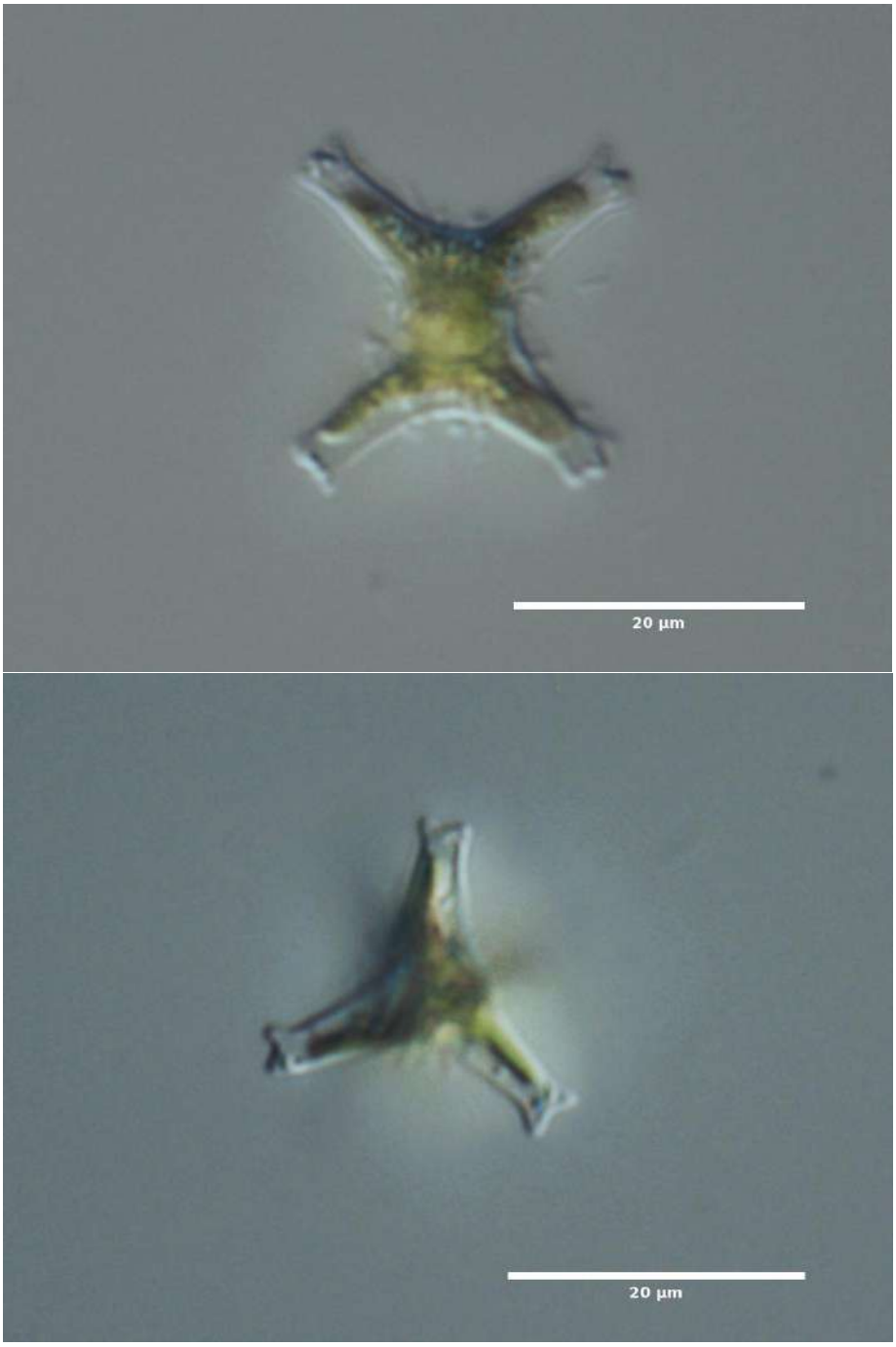


Figure 22.59: *Staurastrum brachiatum* (DIC/DIC), small pond on trail to Lower Anderson Lake, Mt. Baker area, Whatcom County (upper/lower images).

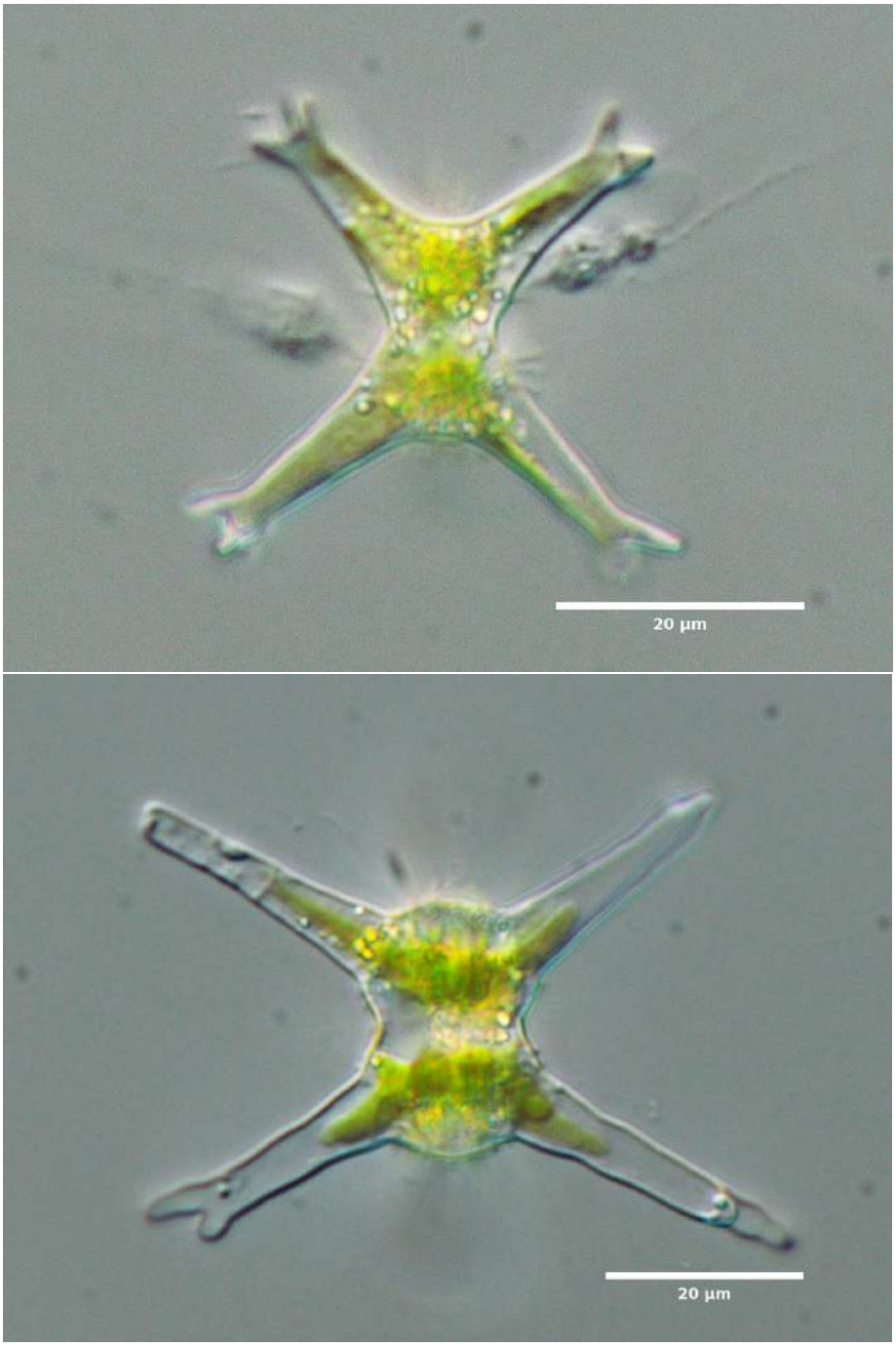


Figure 22.60: *Staurastrum brachiatum* (upper image) and *Staurastrum subnudibrachiatum* var. *incisum* (lower image); specimens collected on the same date from Bear Lake, Mountain Loop Highway, Snohomish County.



Figure 22.61: *Staurastrum brasiliense* (DIC), Canyon Lake, Whatcom County.



Figure 22.62: *Staurastrum brasiliense* (DIC/DIC), Chain Lake, Gifford Pinchot National Forest, Skamania County (upper/lower images).

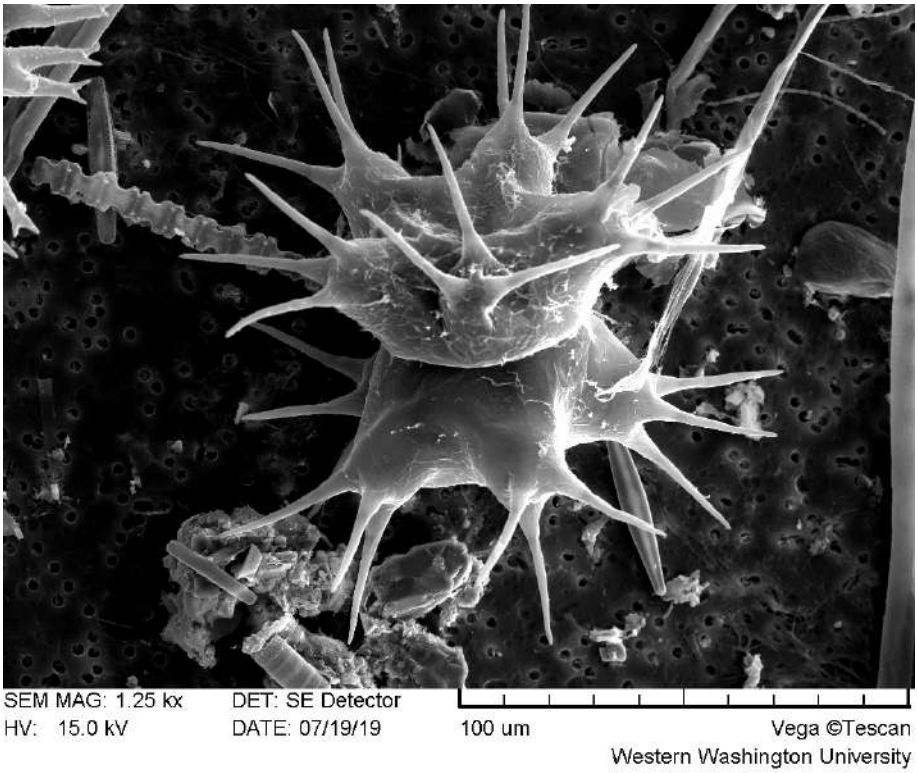




Figure 22.63: *Staurastrum brasiliense* (SEM/DIC), Chain Lake, Gifford Pinchot National Forest, Skamania County (upper/lower images).

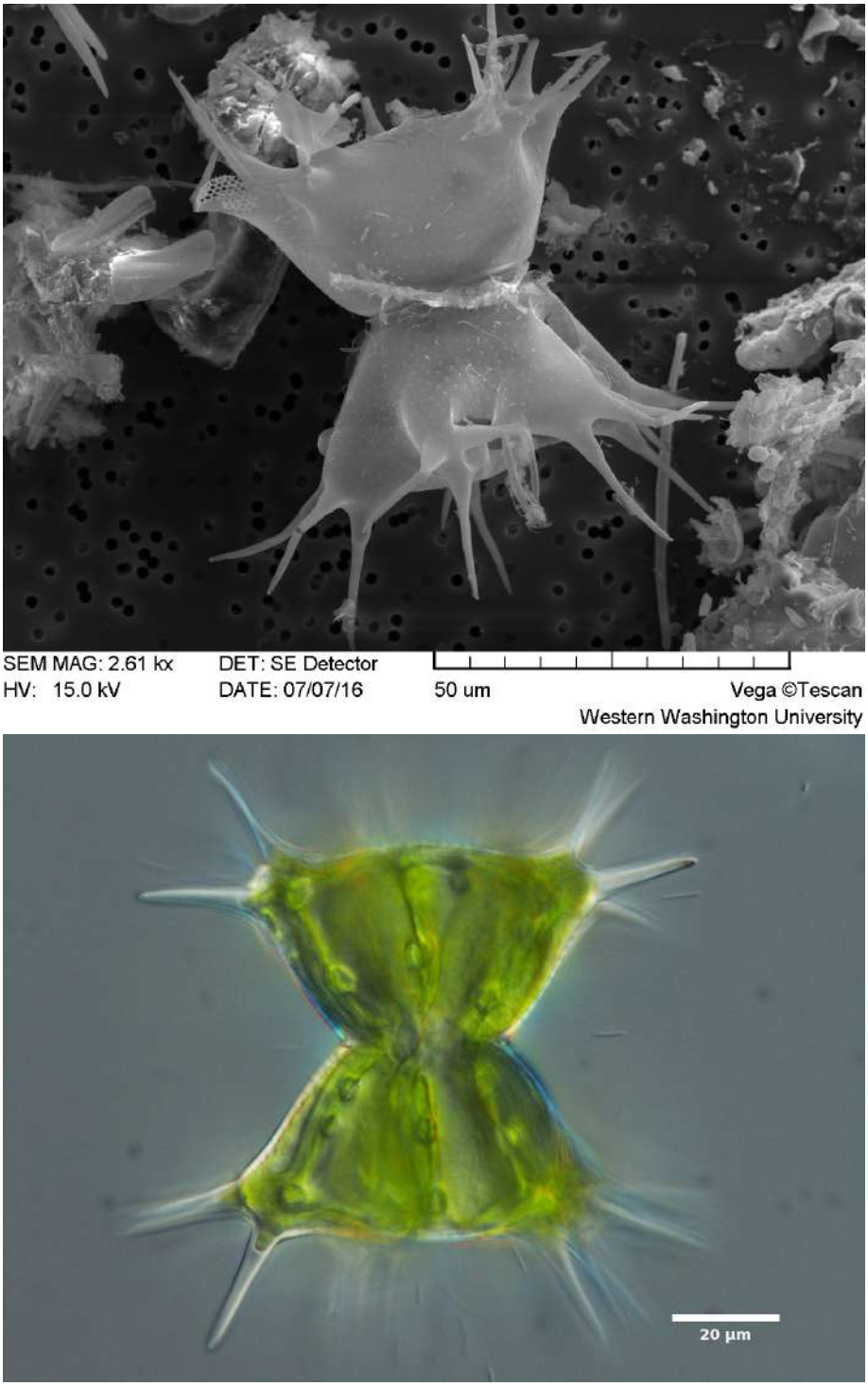


Figure 22.64: *Staurastrum brasiliense* (SEM/DIC), Boardman Lake, Mountain Loop Highway, Snohomish County (upper/lower images).



Figure 22.65: *Staurastrum brebissonii* (DIC), Heather Lake, Mountain Loop Highway, Snohomish County.



Figure 22.66: *Staurastrum brebissonii* (DIC/DIC), Heather Lake, Mountain Loop Highway, Snohomish County (upper/lower images).

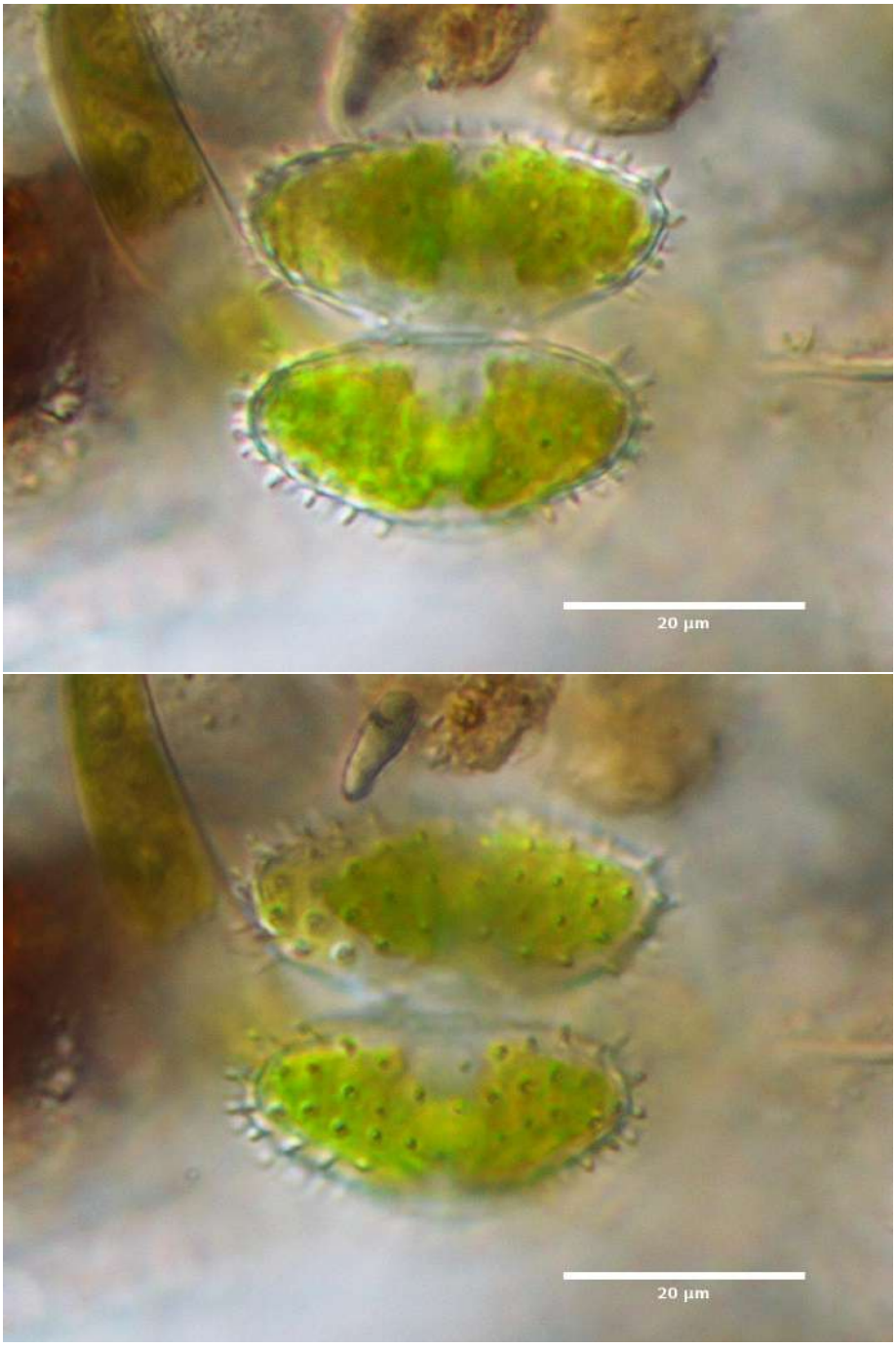


Figure 22.67: *Staurastrum brebissonii* (DIC/DIC), small residential pond on Valley Circle Drive, Snohomish County (upper/lower images).

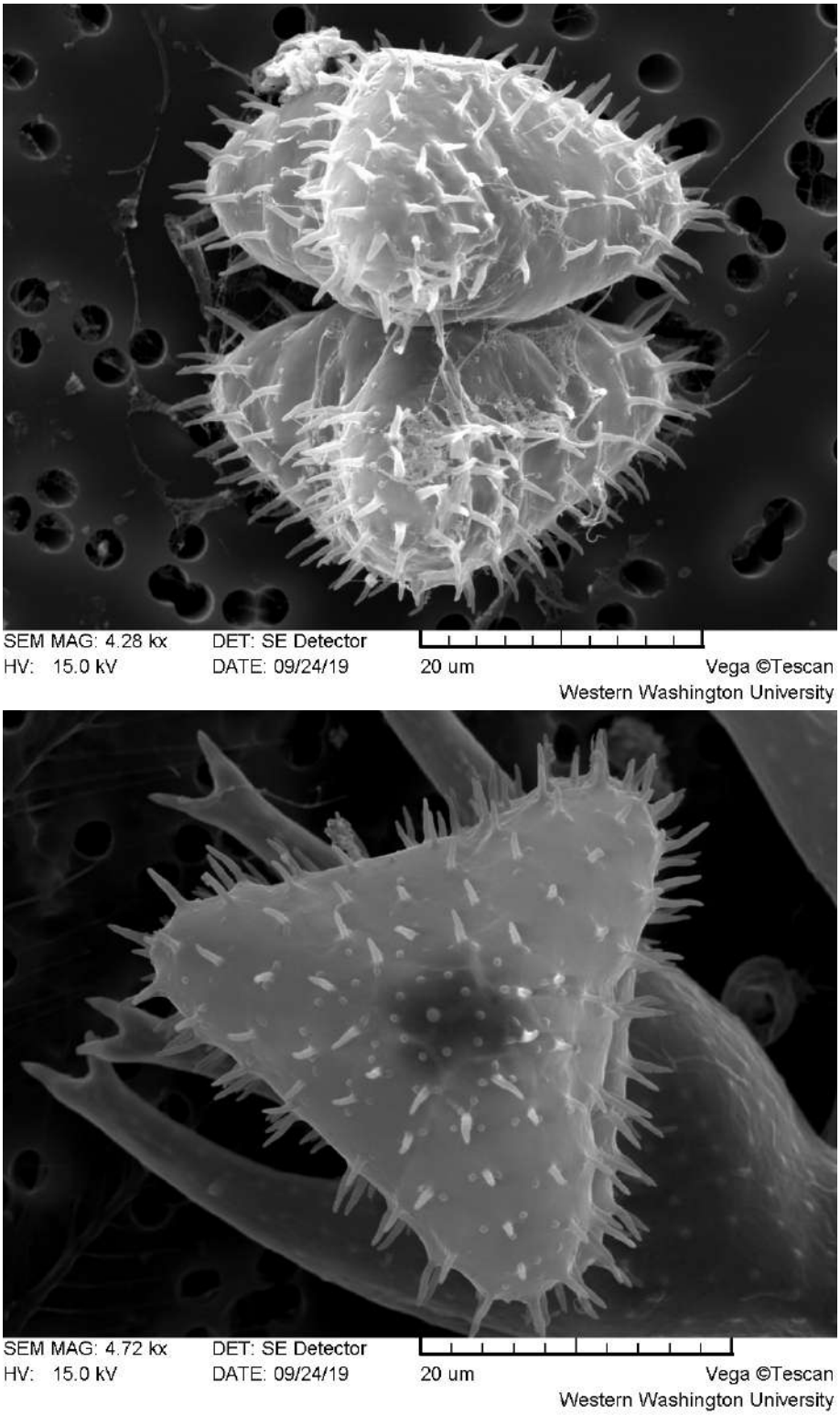


Figure 22.68: *Staurastrum brebissonii* (SEM/SEM), Chain Lake, Gifford Pinchot National Forest, Skamania County (upper/lower images).

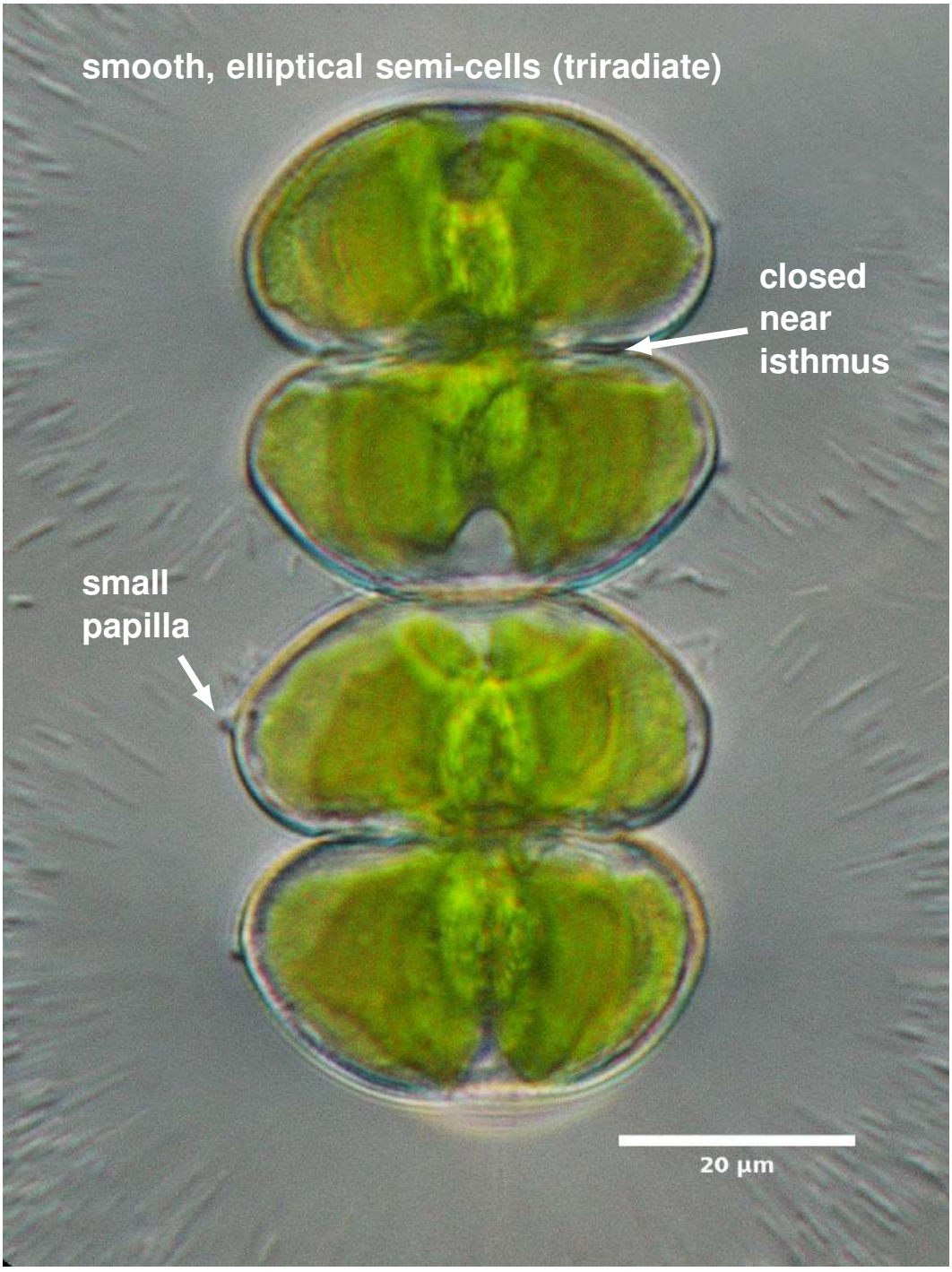


Figure 22.69: *Staurastrum brevispina* (DIC), Lake Terrell, Whatcom County.



Figure 22.70: *Staurastrum brevispina* (SEM/DIC), Myrtle Lake, Mountain Loop Highway, Snohomish County (upper/lower images).

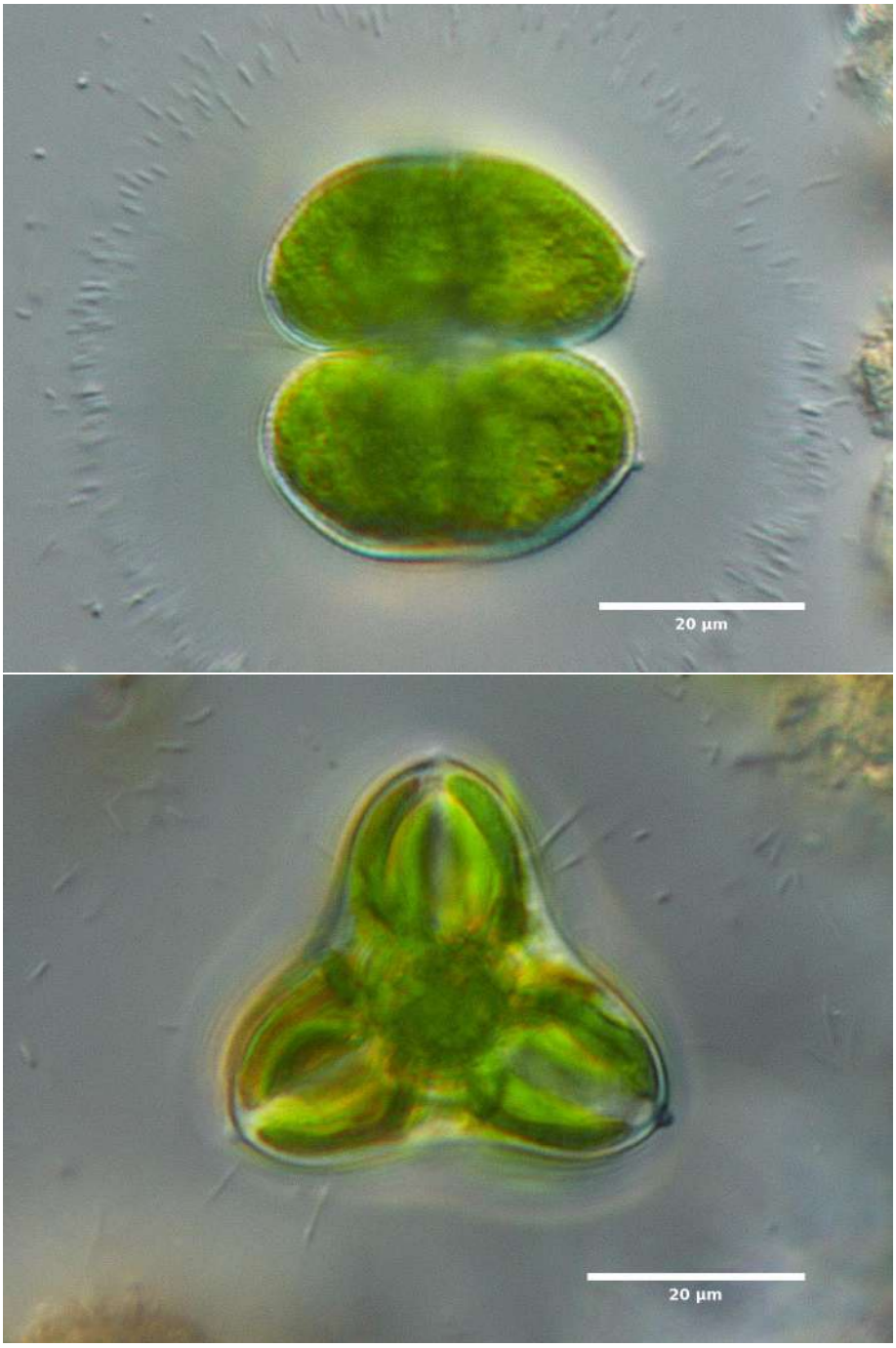


Figure 22.71: *Staurastrum brevispina* (DIC/DIC), Lake Geneva, Whatcom County (upper/lower images).

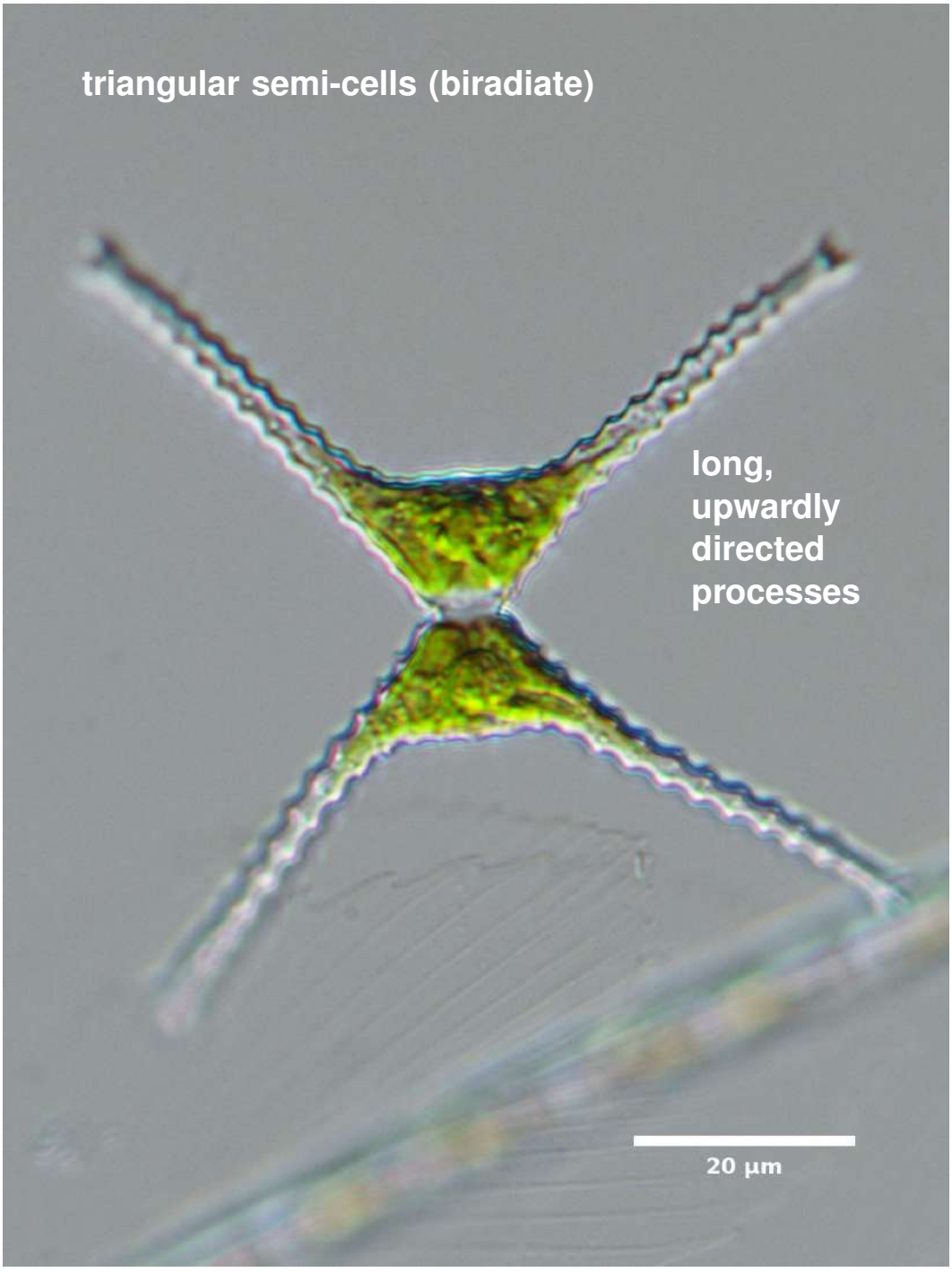
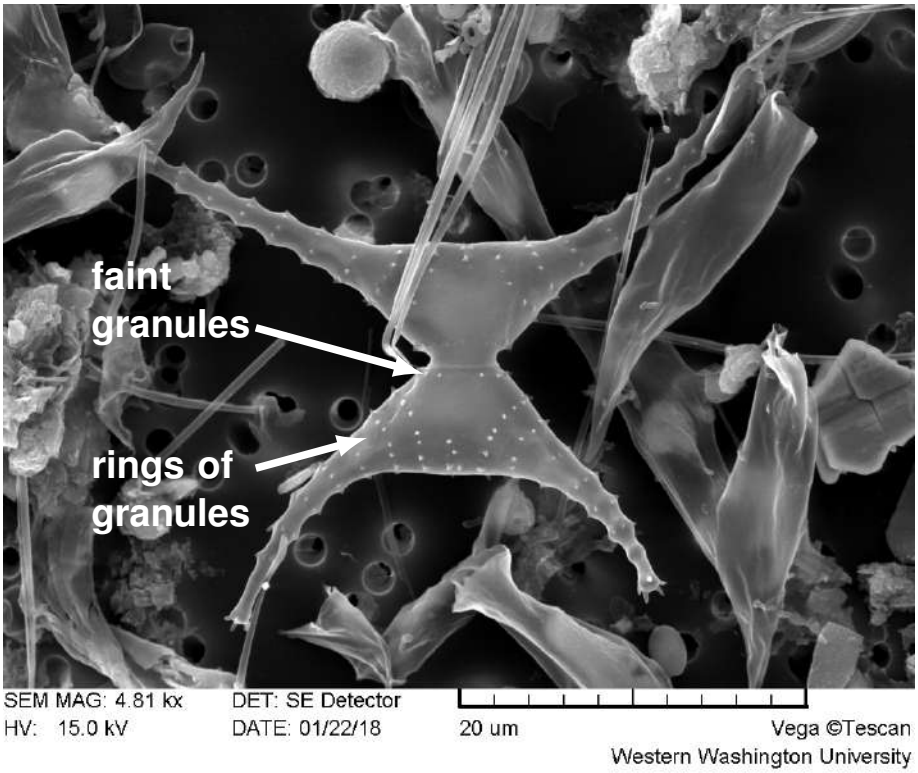


Figure 22.72: *Staurastrum chaetoceras* (DIC), Beaver Lake, Skagit County.



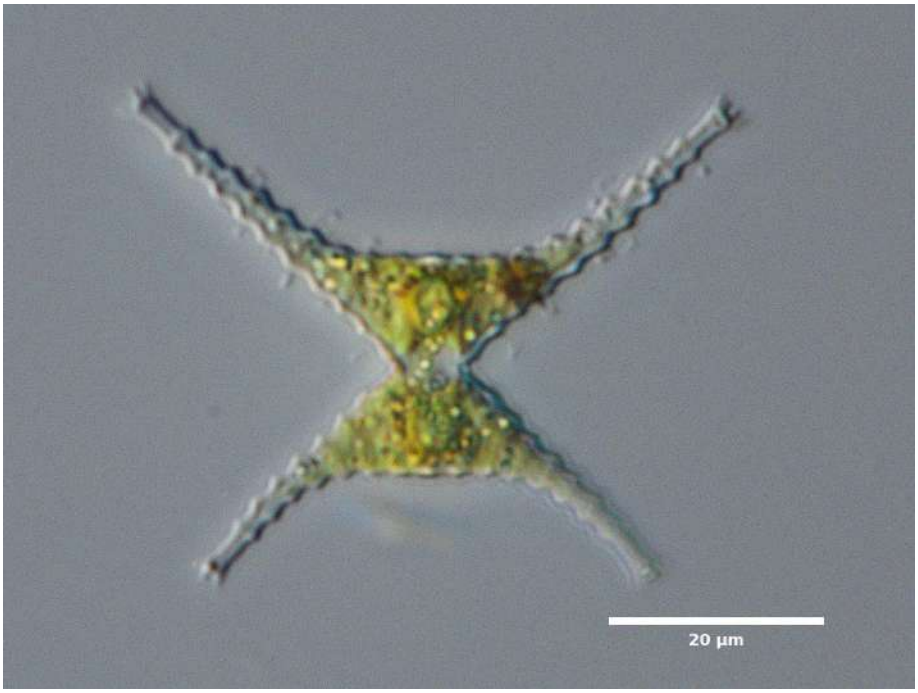


Figure 22.73: *Staurastrum chaetoceras* (SEM/DIC), Bug Lake, Whatcom County (upper/lower images).

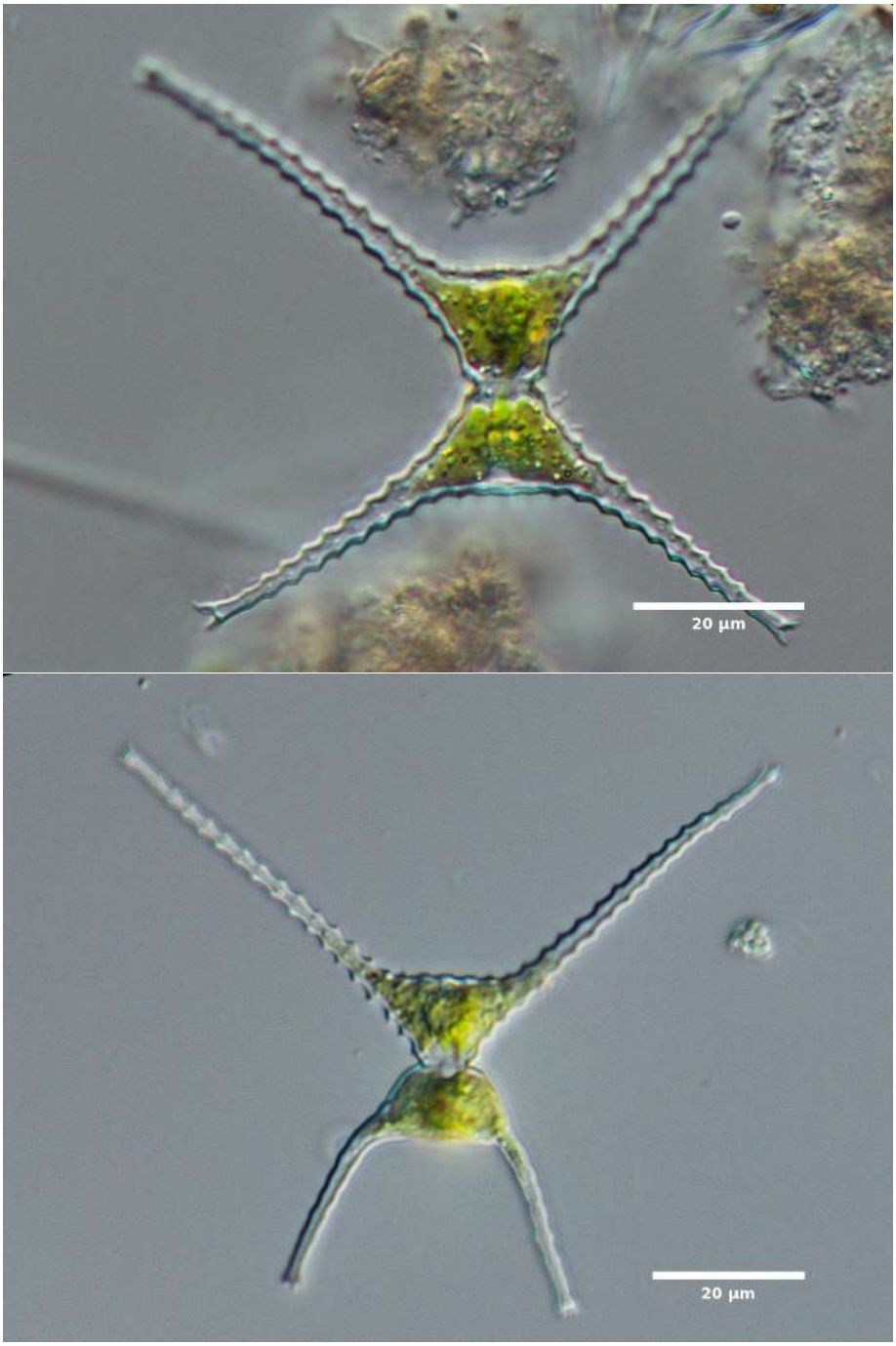


Figure 22.74: *Staurastrum chaetoceras* (DIC/DIC), Lake Terrell, Whatcom County (upper/lower images).

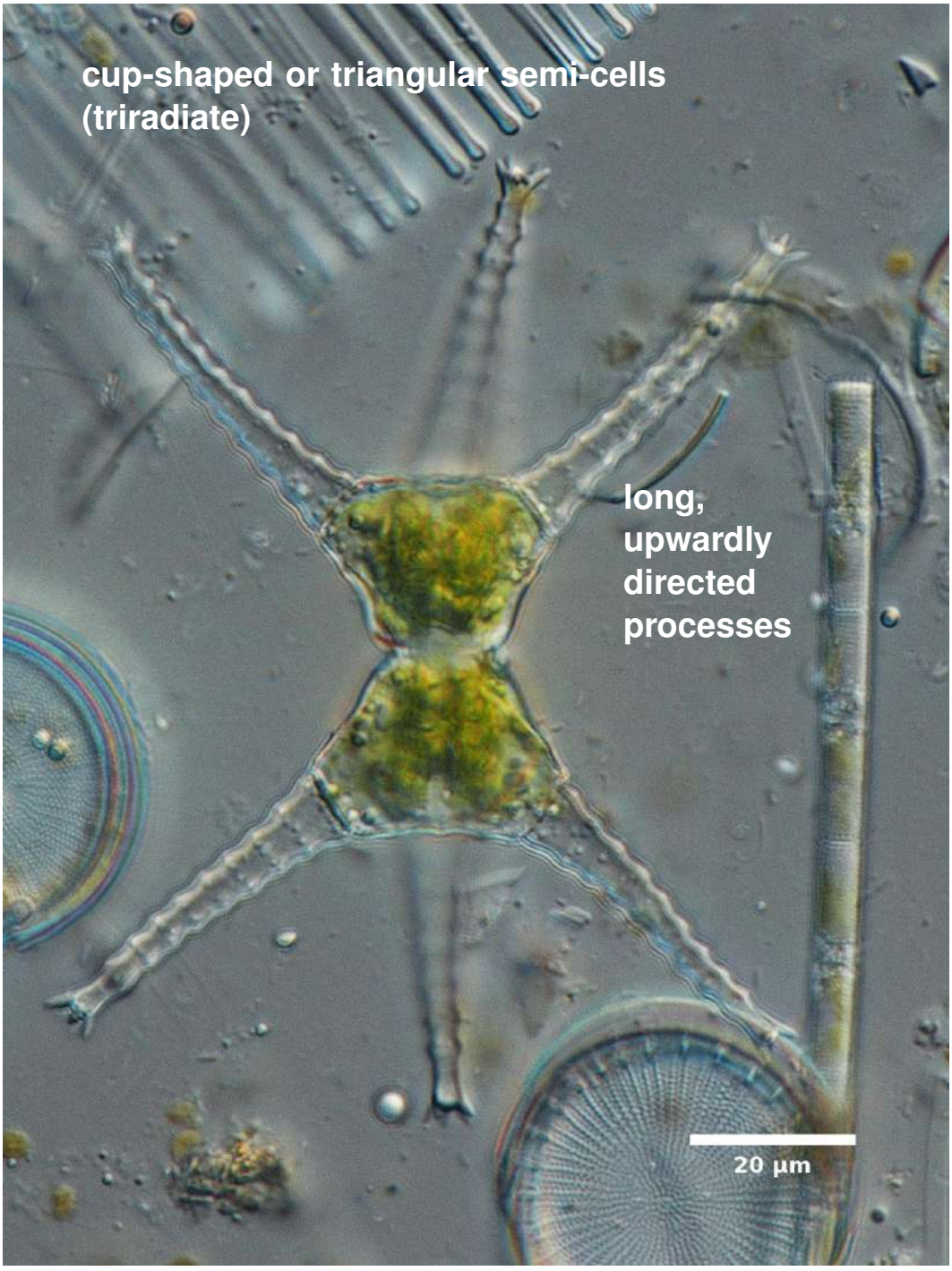


Figure 22.75: *Staurastrum cingulum* (DIC), Lone Lake, Island County.

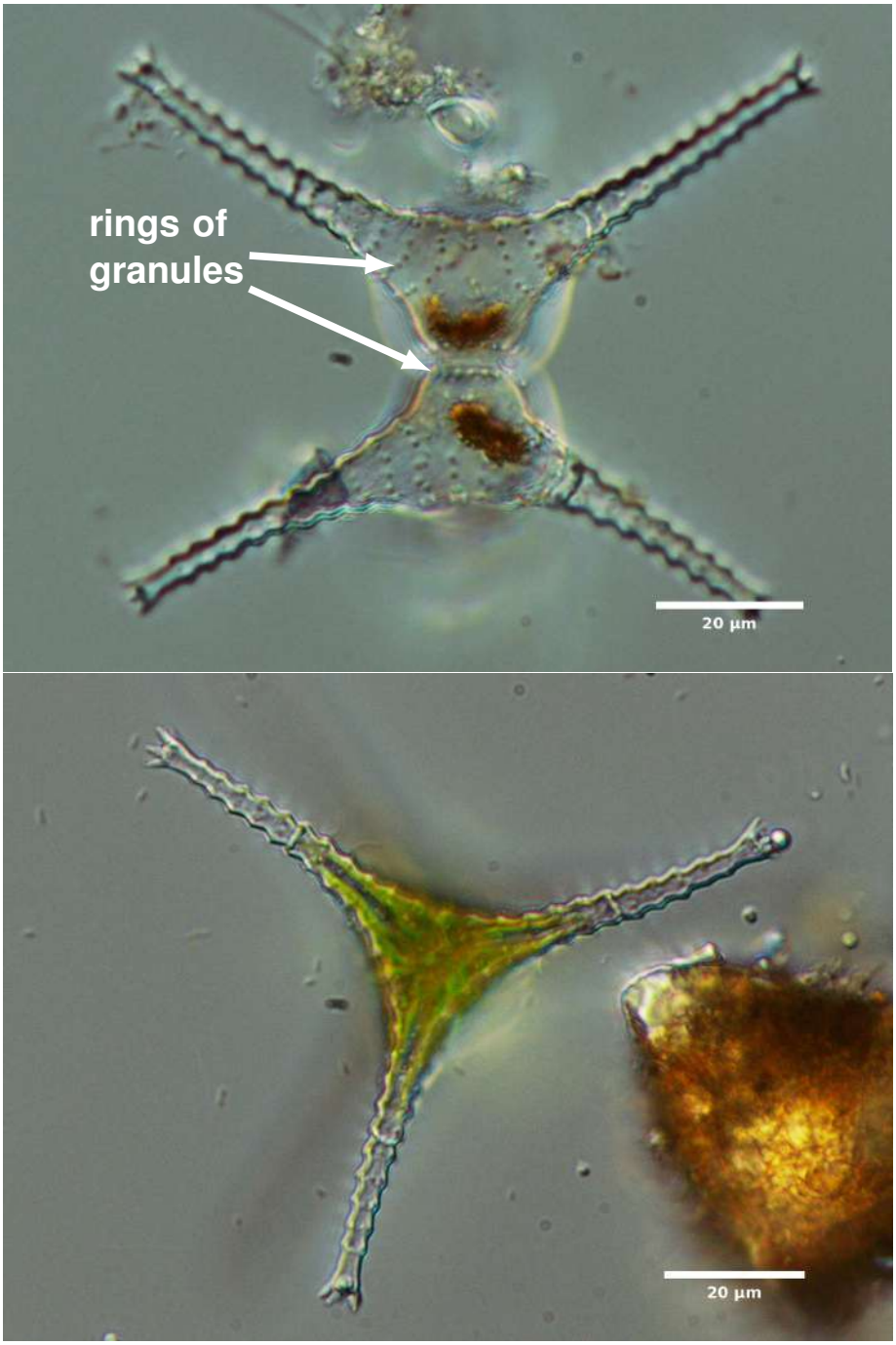


Figure 22.76: *Staurastrum cingulum* (DIC/DIC), Squalicum Lake, Whatcom County (upper/lower images).

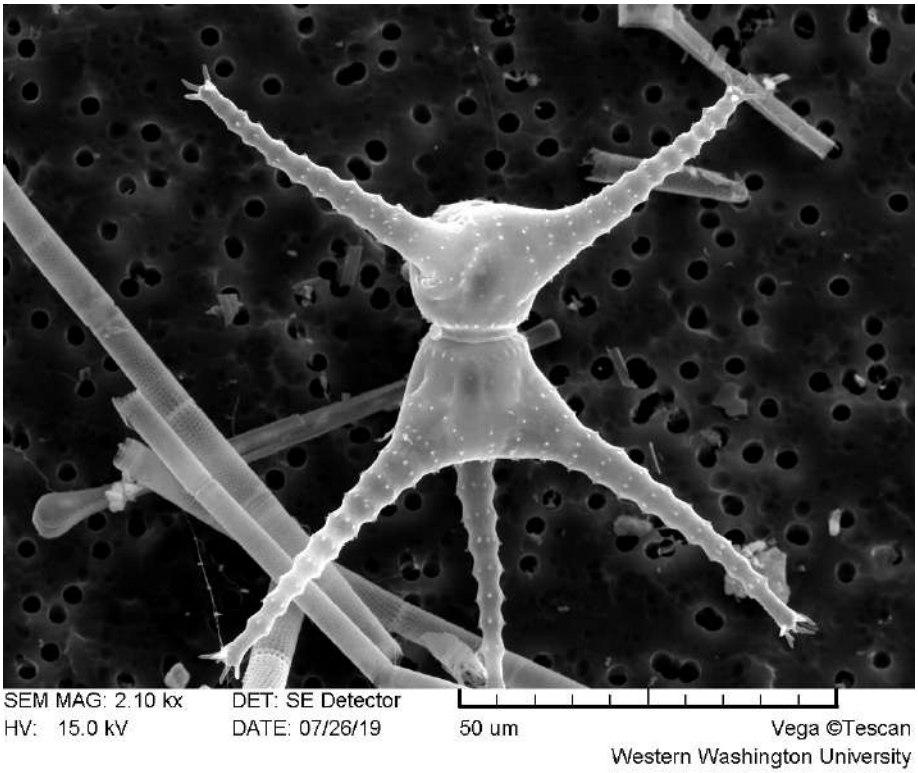




Figure 22.77: *Staurastrum cingulum* (SEM/DIC), Lone Lake, Island County (upper/lower images).

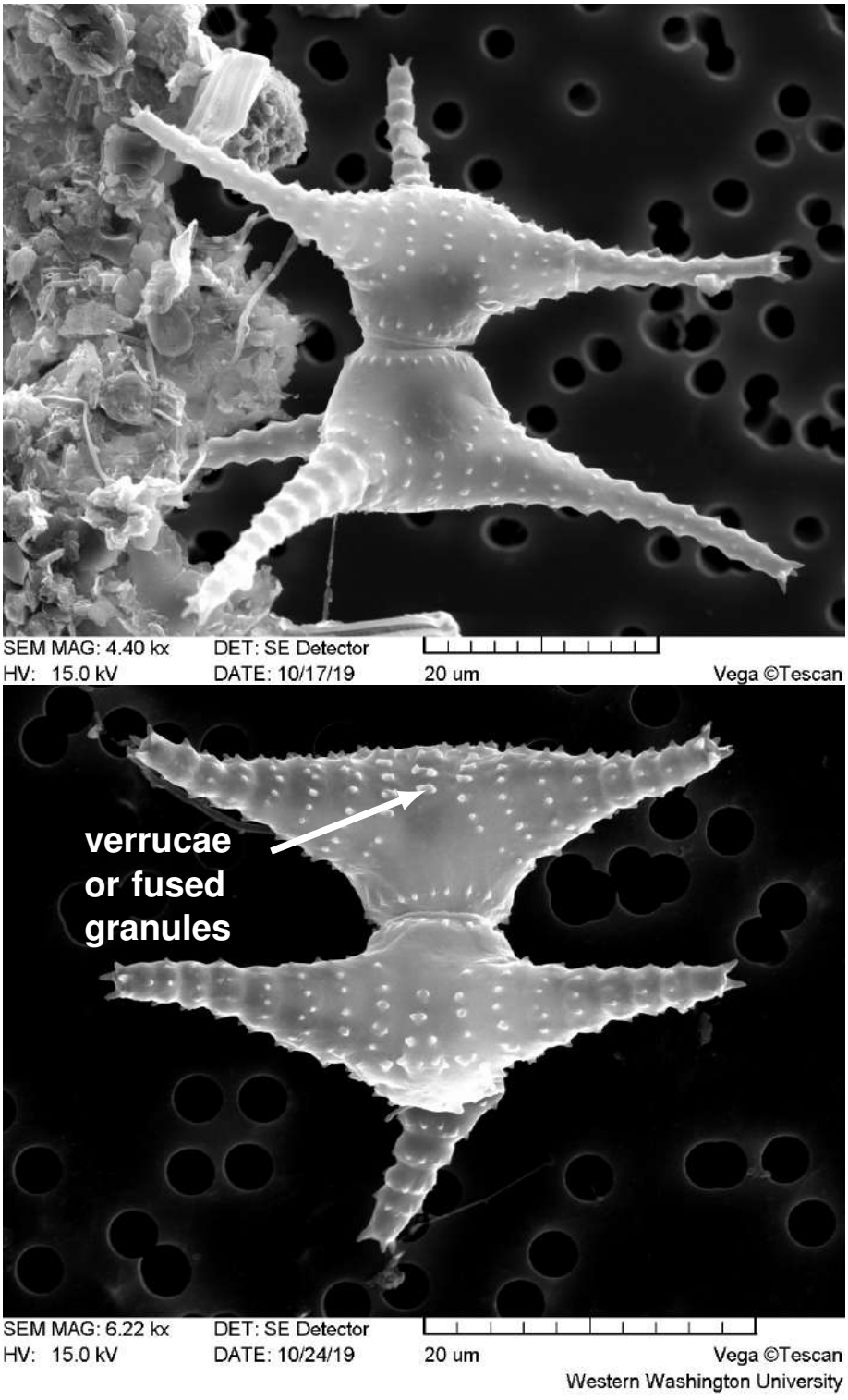


Figure 22.78: *Staurastrum cingulum* (SEM), Big Lake (upper image); *Staurastrum cingulum* cf. var. *obesum* (SEM), Clear Lake, Skagit County (lower image).

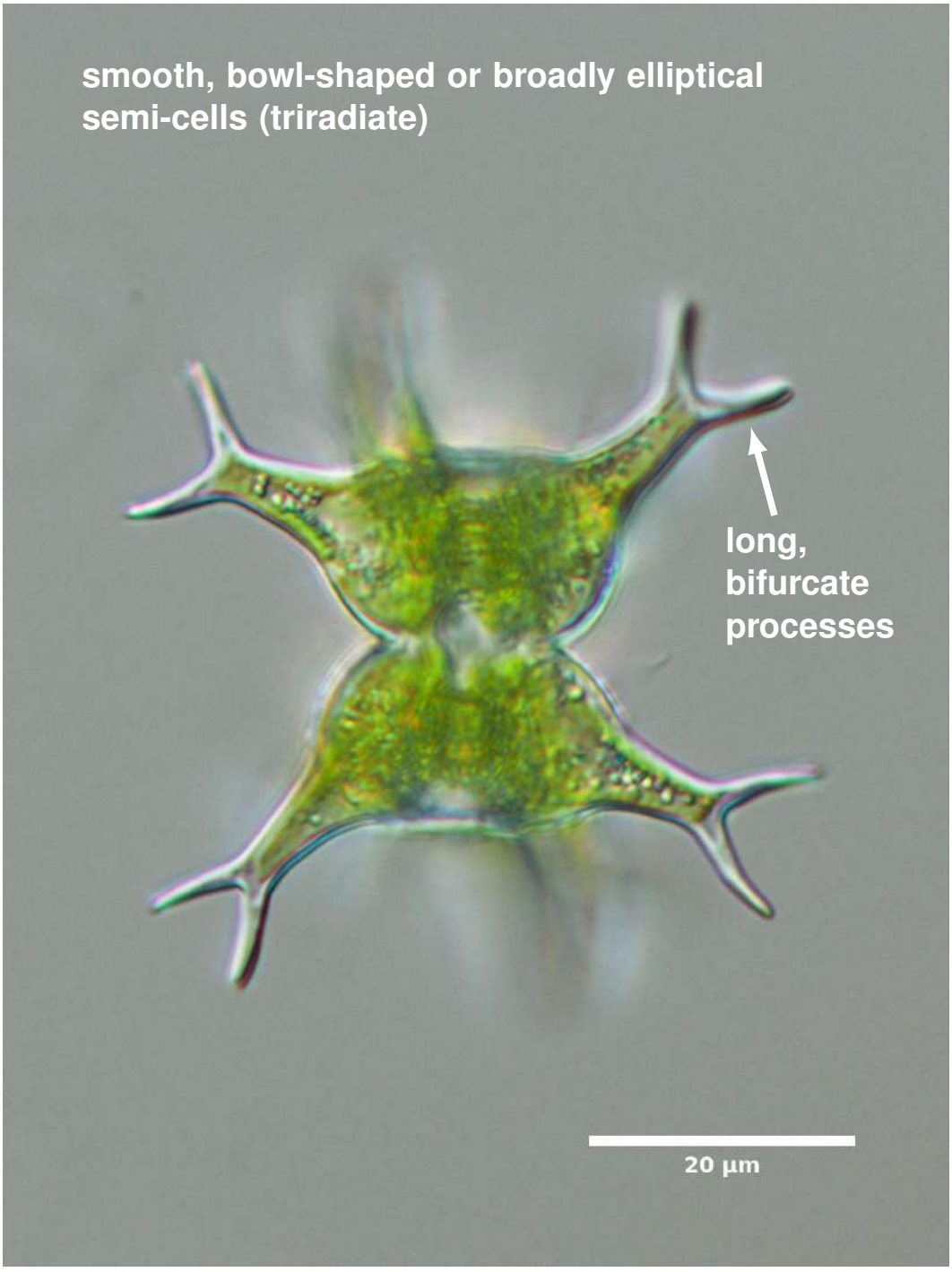


Figure 22.79: *Staurastrum clevei* (DIC), Lower Ashland Lake, Mountain Loop Highway, Snohomish County.

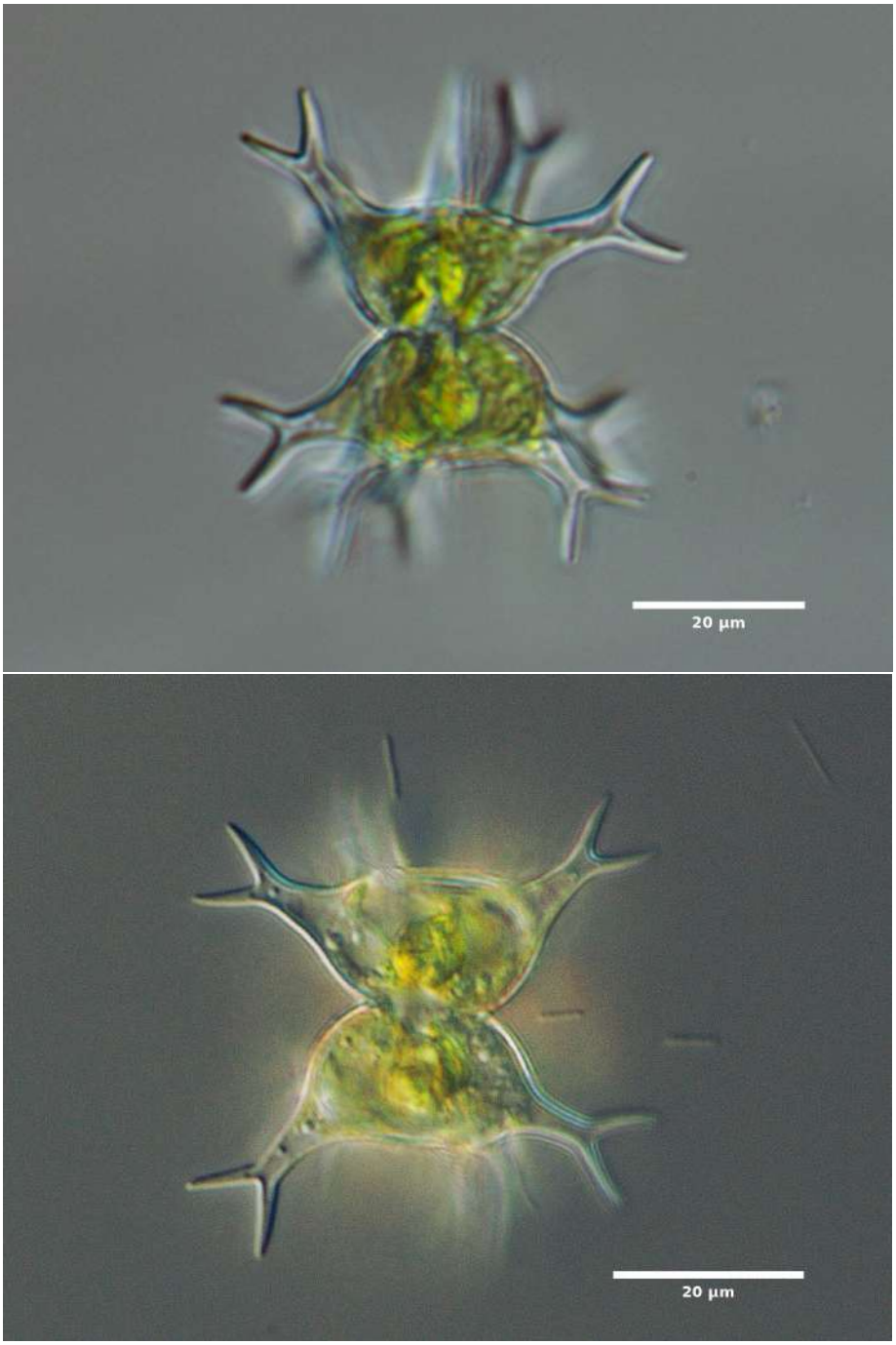


Figure 22.80: *Staurastrum clevei* (DIC/DIC), Goat Lake, Mountain Loop Highway, Snohomish County (upper image); Bear Lake, Mountain Loop Highway, Snohomish County (lower image).



Figure 22.81: *Staurastrum crassangulatum* (DIC), Myrtle Lake, Mountain Loop Highway, Snohomish County.

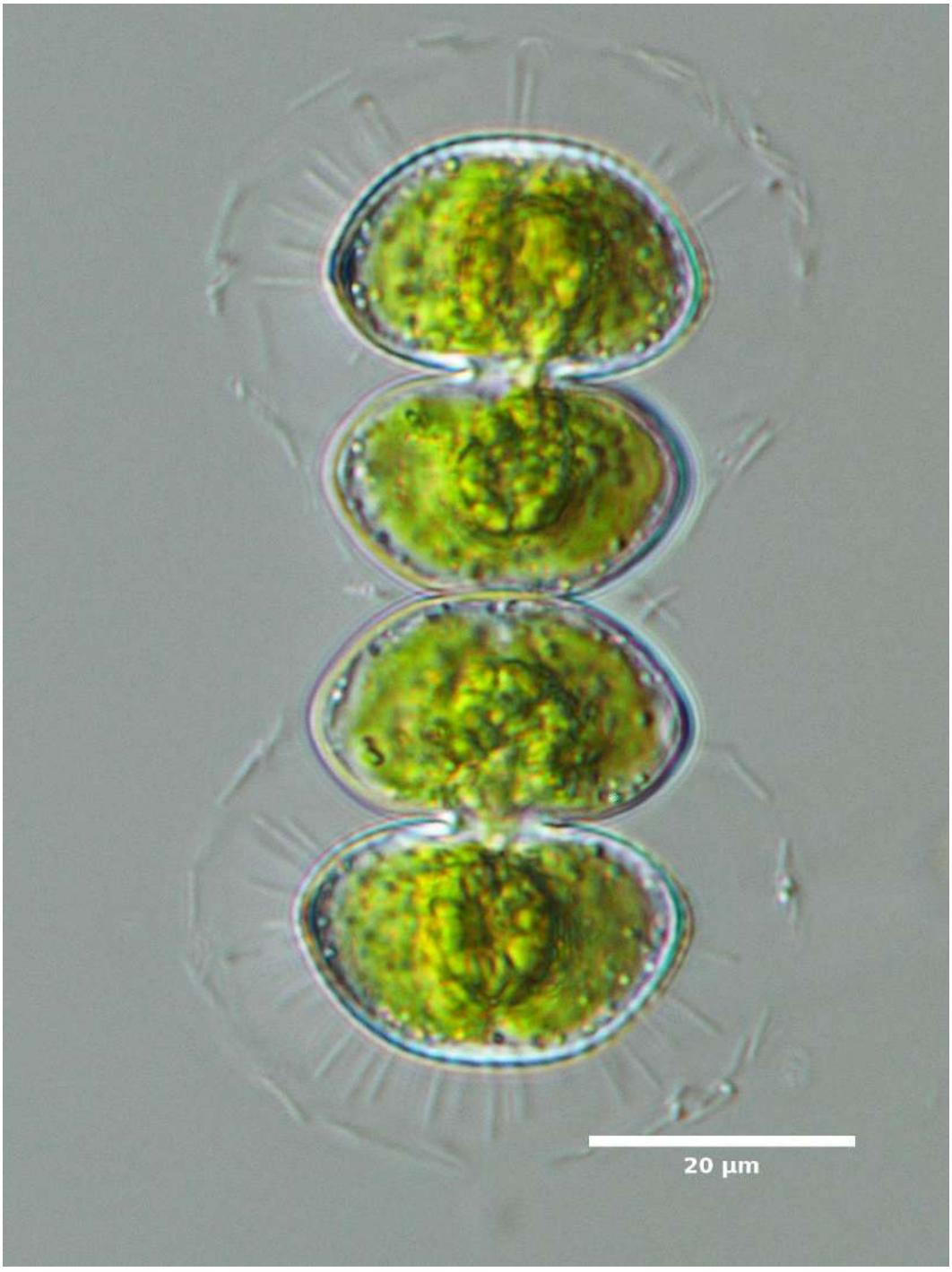


Figure 22.82: *Staurastrum crassangulatum* (DIC), Myrtle Lake, Mountain Loop Highway, Snohomish County.

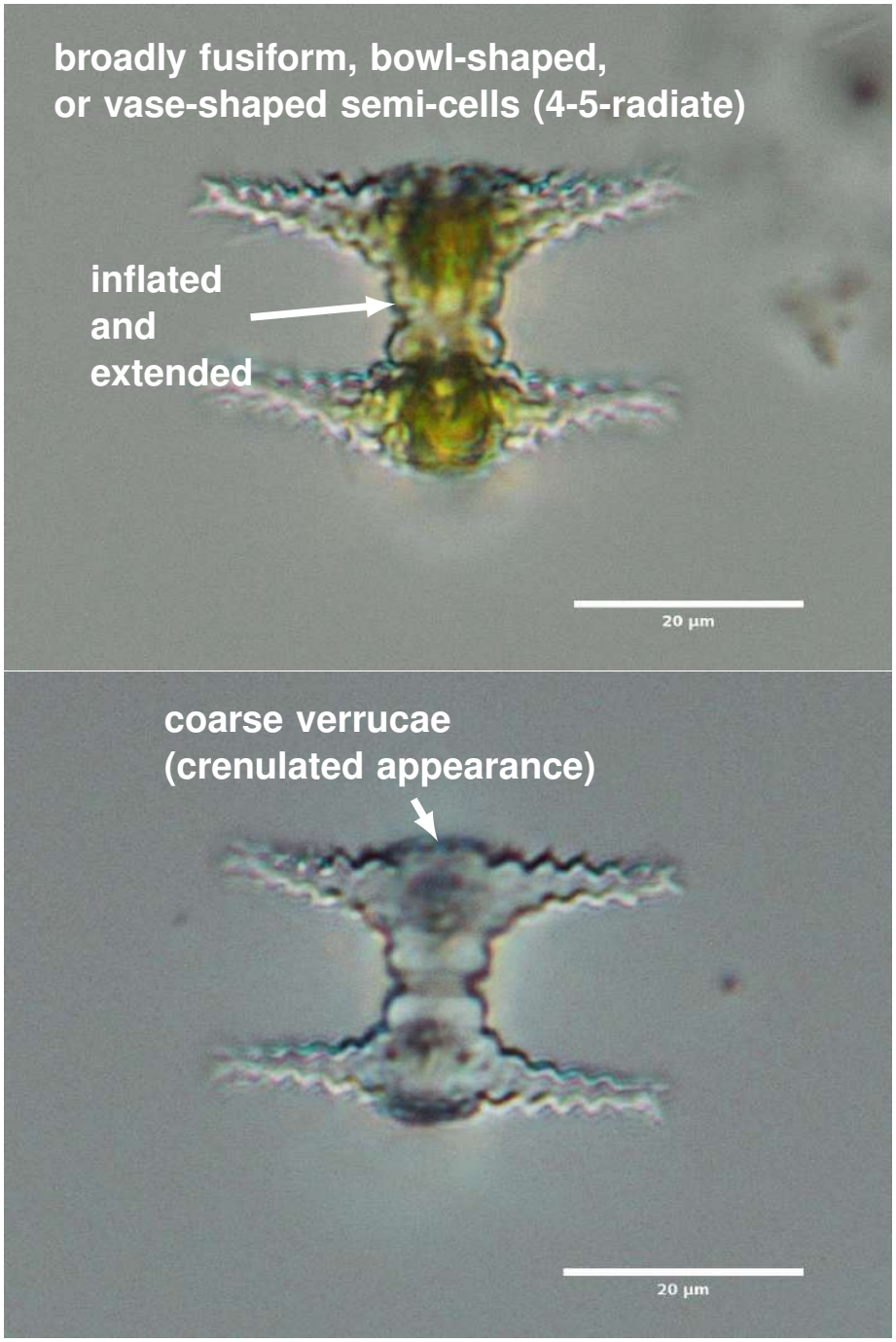


Figure 22.83: *Staurastrum crenulatum* var. A (DIC/DIC), Lake Ki, Snohomish County (upper/lower images).

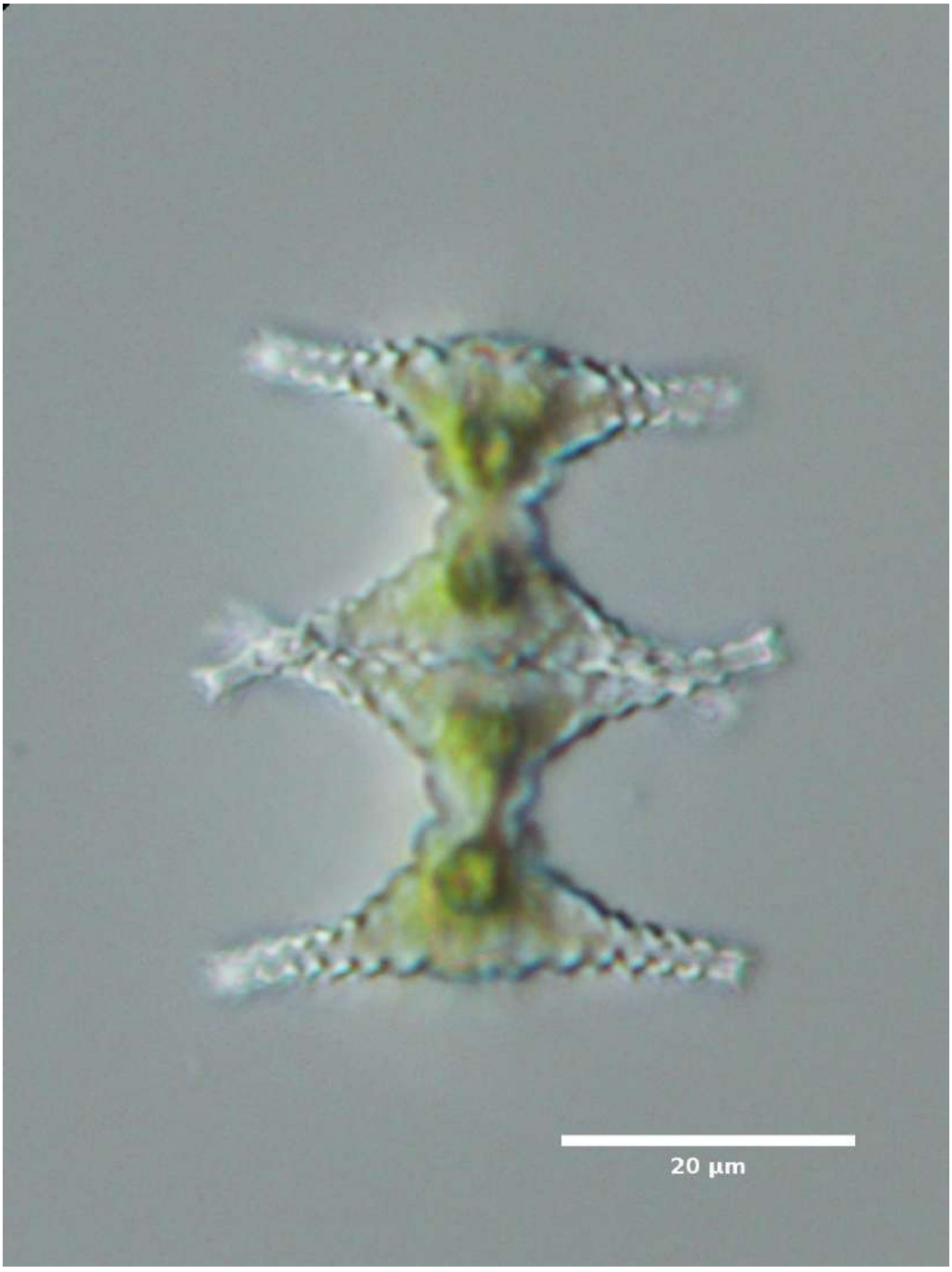


Figure 22.84: *Staurastrum crenulatum* var. A (DIC), Lake Erie, Skagit County.

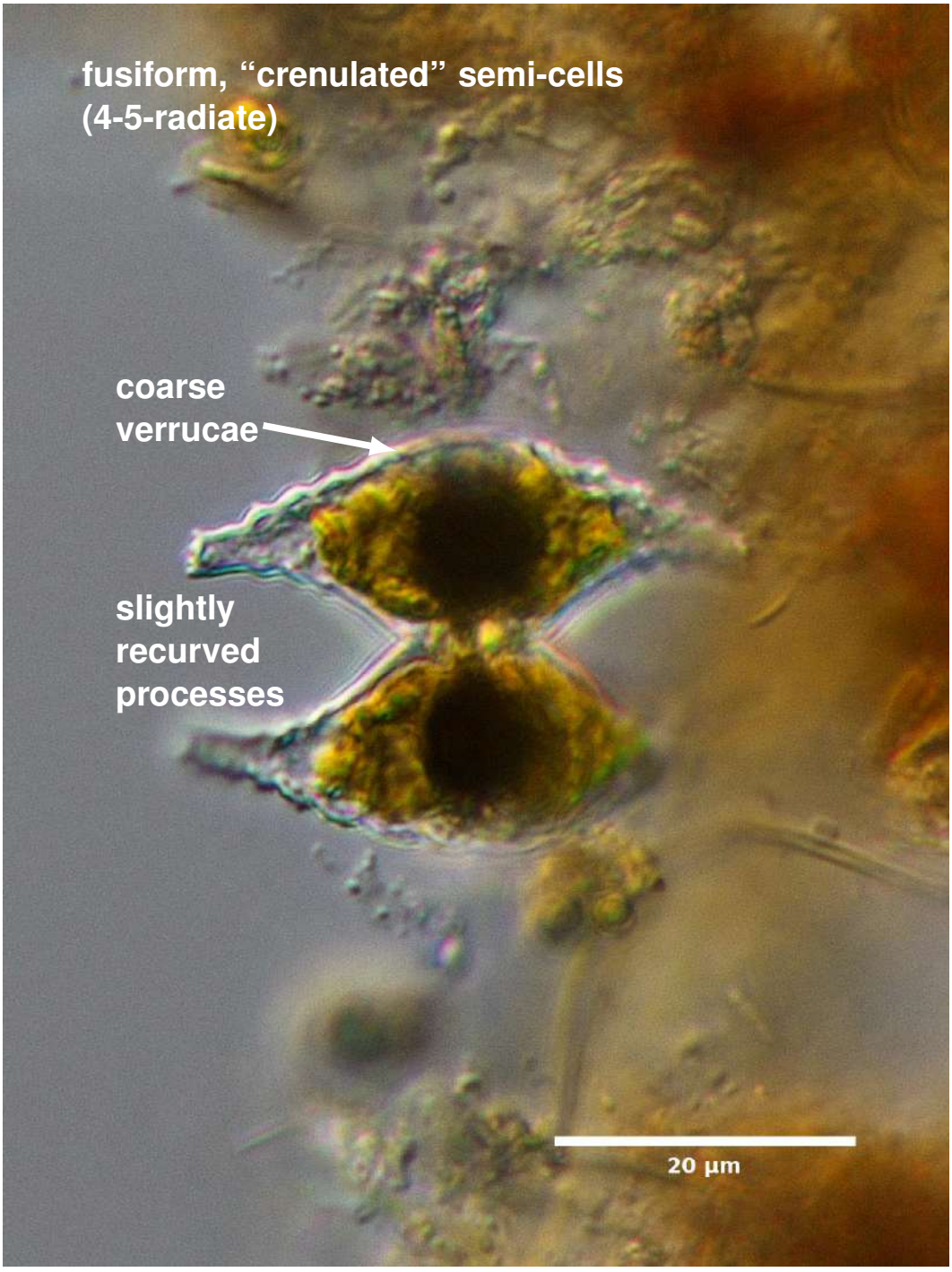


Figure 22.85: *Staurastrum crenulatum* var. B (DIC), Hoag Pond, Whatcom County.

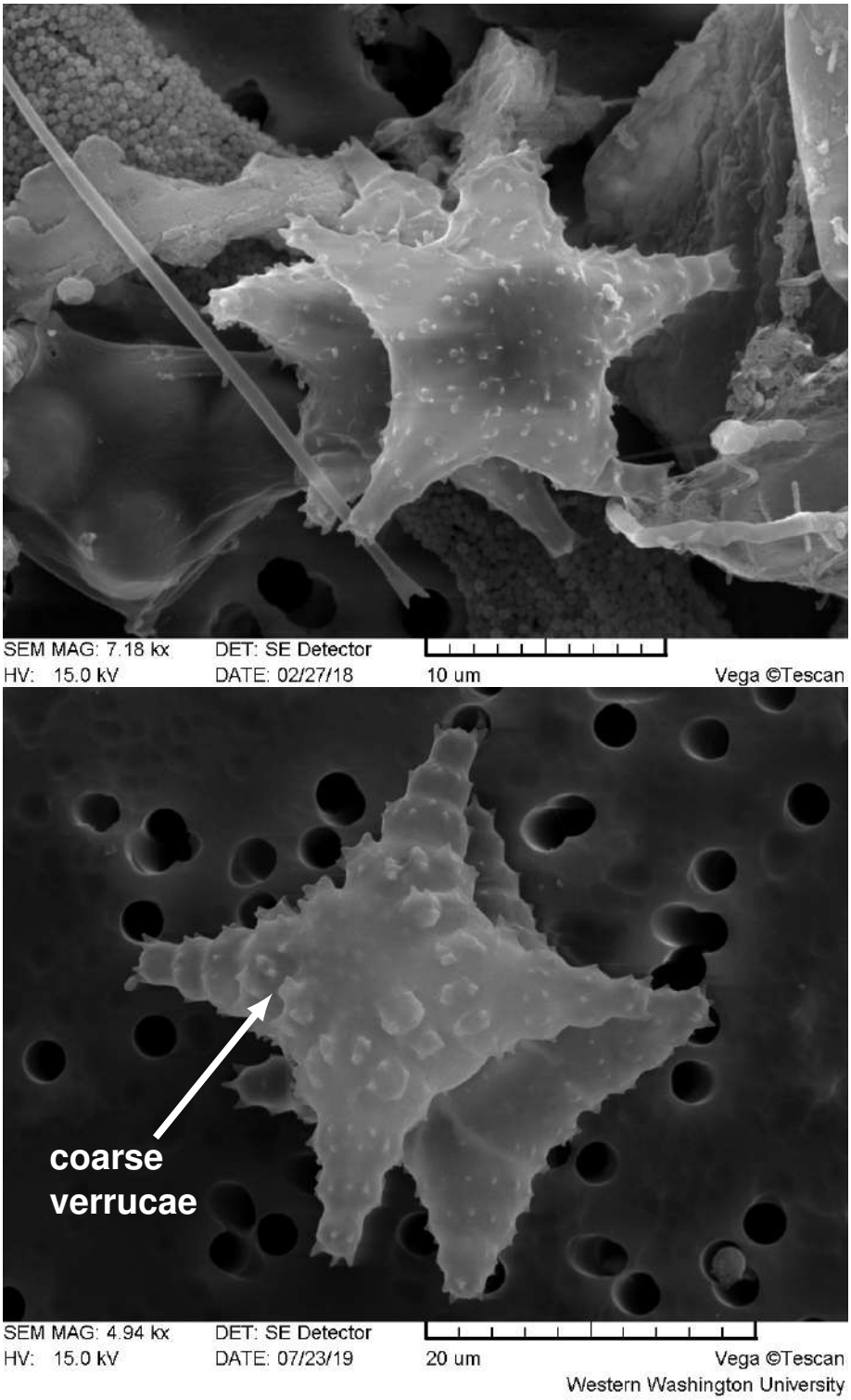


Figure 22.86: *Staurastrum crenulatum* var. B (SEM/SEM), Hoag Pond, Whatcom County (upper/lower images).



Figure 22.87: *Staurastrum crenulatum* var. B (DIC/DIC), Hoag Pond, Whatcom County (upper/lower images).

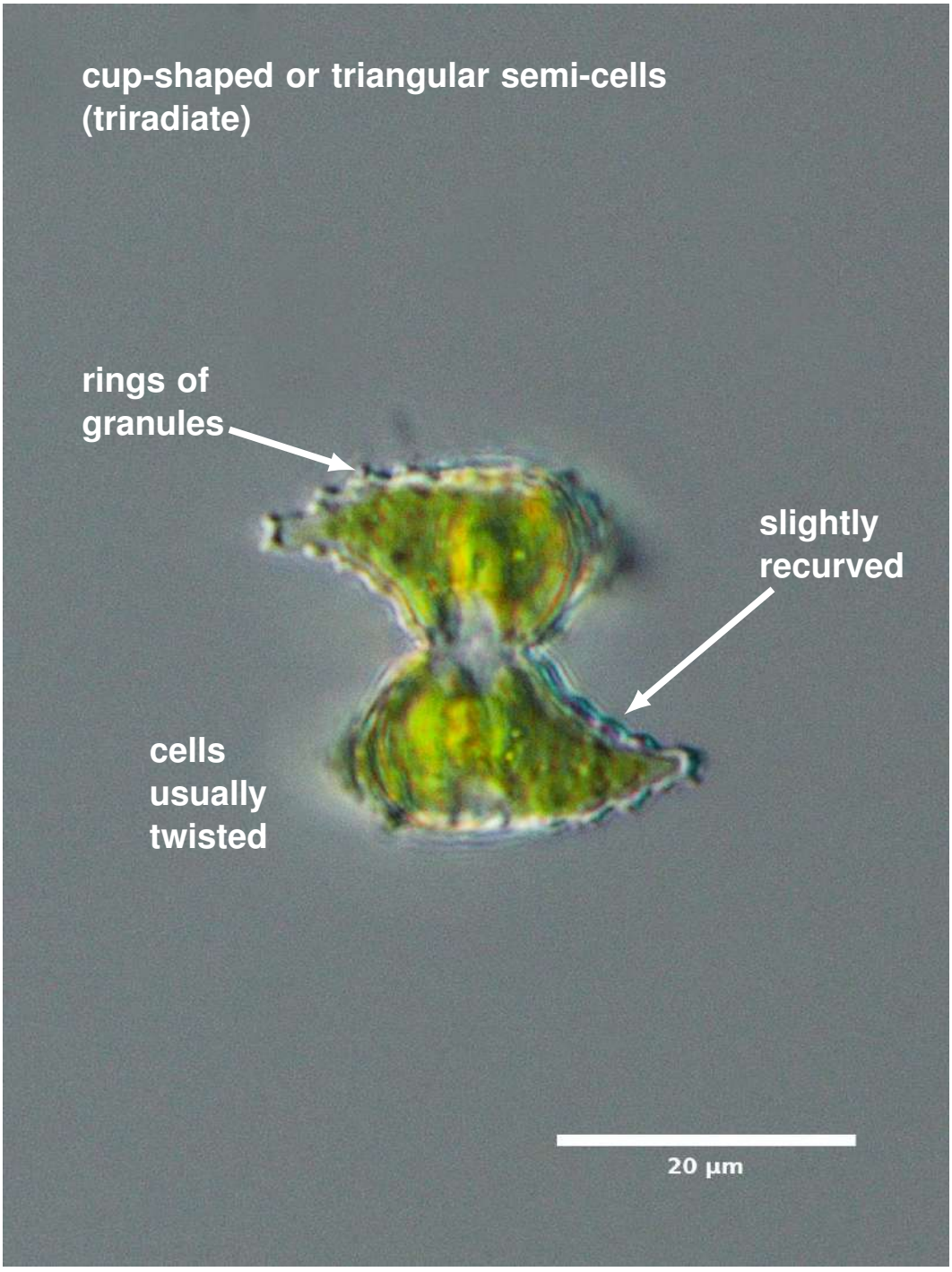


Figure 22.88: *Staurastrum cytocerum* var. *inflexum* (DIC) small pond on trail to Big Four Ice Caves, Mountain Loop Highway, Snohomish County.

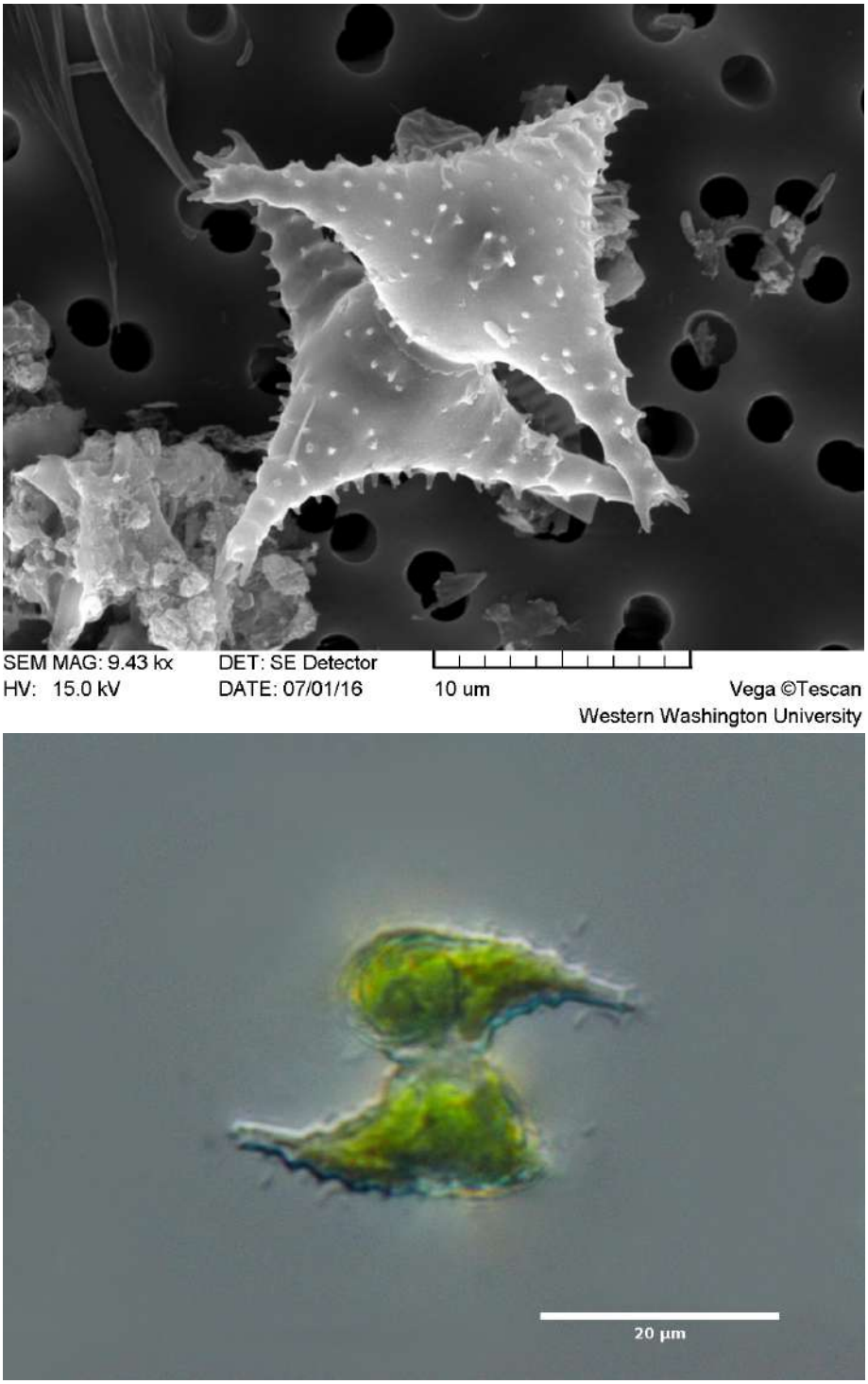


Figure 22.89: *Staurastrum cytocerum* var. *inflexum* (SEM/DIC) Goat Lake, Mountain Loop Highway, Snohomish County (upper image); Gold Basin Mill Pond, Mountain Loop Highway, Snohomish County (lower image).

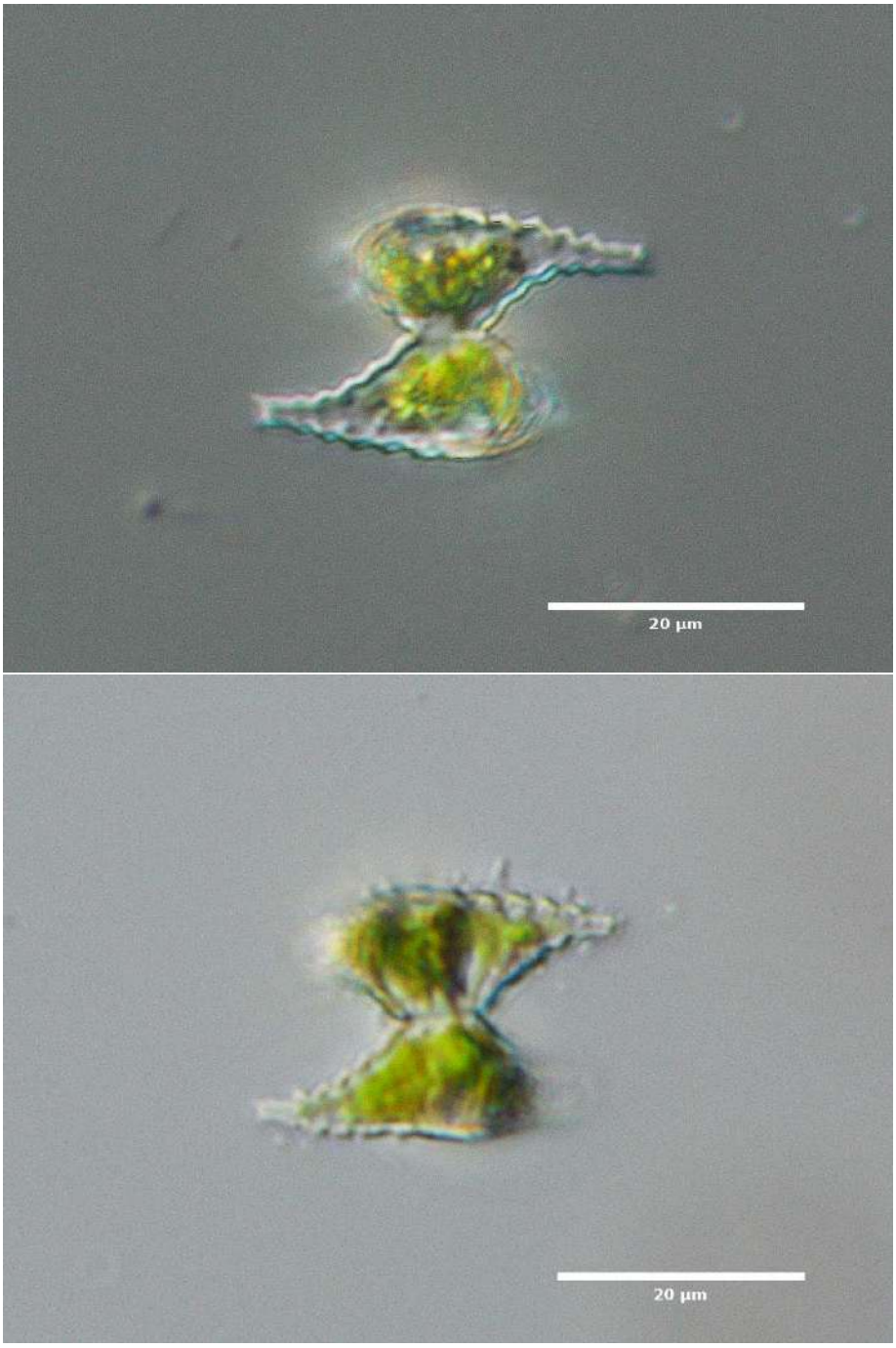


Figure 22.90: *Staurastrum cytocerum* var. *inflexum* (DIC/DIC) Hoag Pond, Whatcom County (upper/lower images).

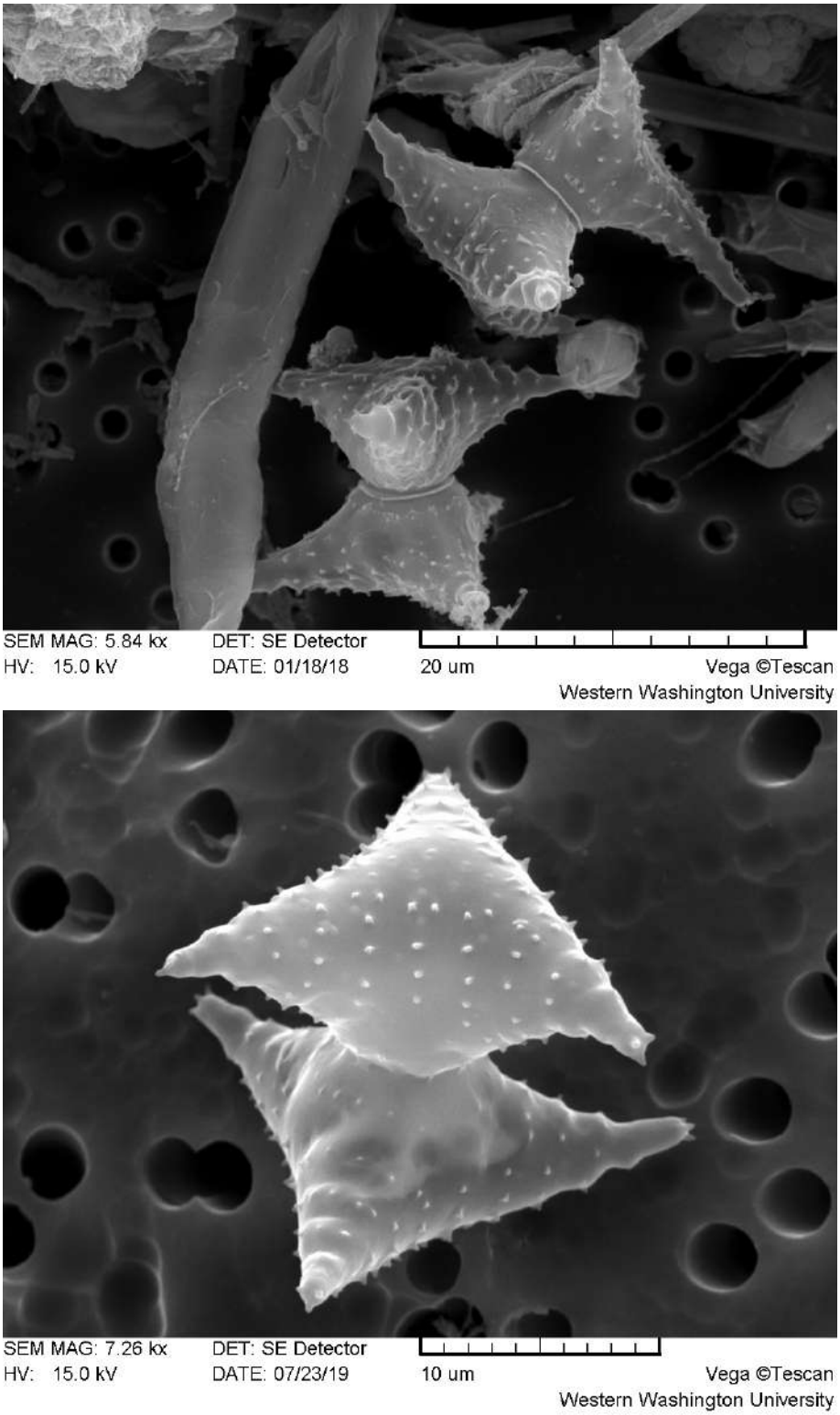


Figure 22.91: *Staurastrum cytocerum* var. *inflexum* (SEM/SEM) Hoag Pond, Whatcom County (upper/lower images).

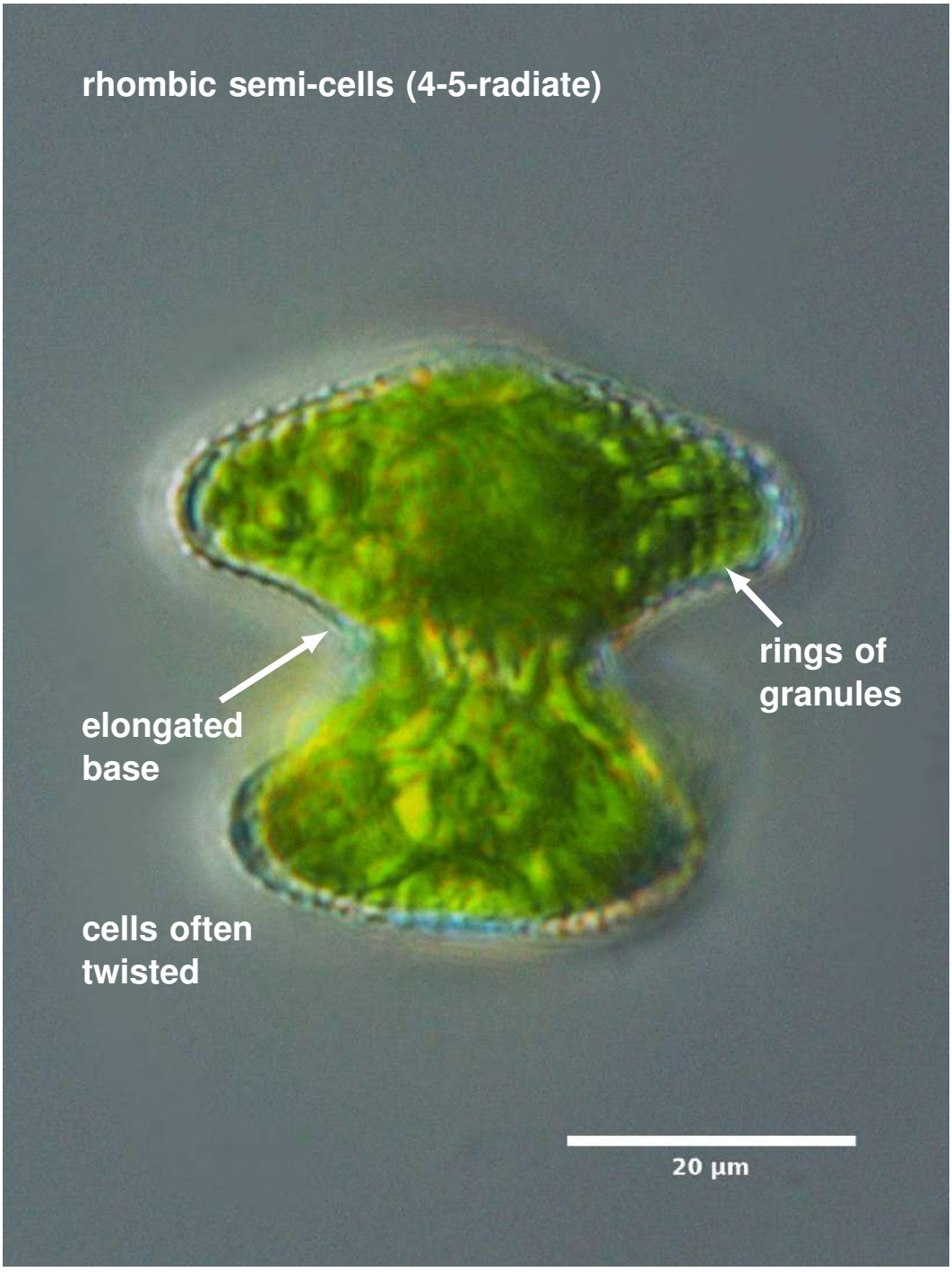


Figure 22.92: *Staurastrum dilatatum* (DIC), small pond on trail to Big Four Ice Caves, Mountain Loop Highway, Snohomish County.

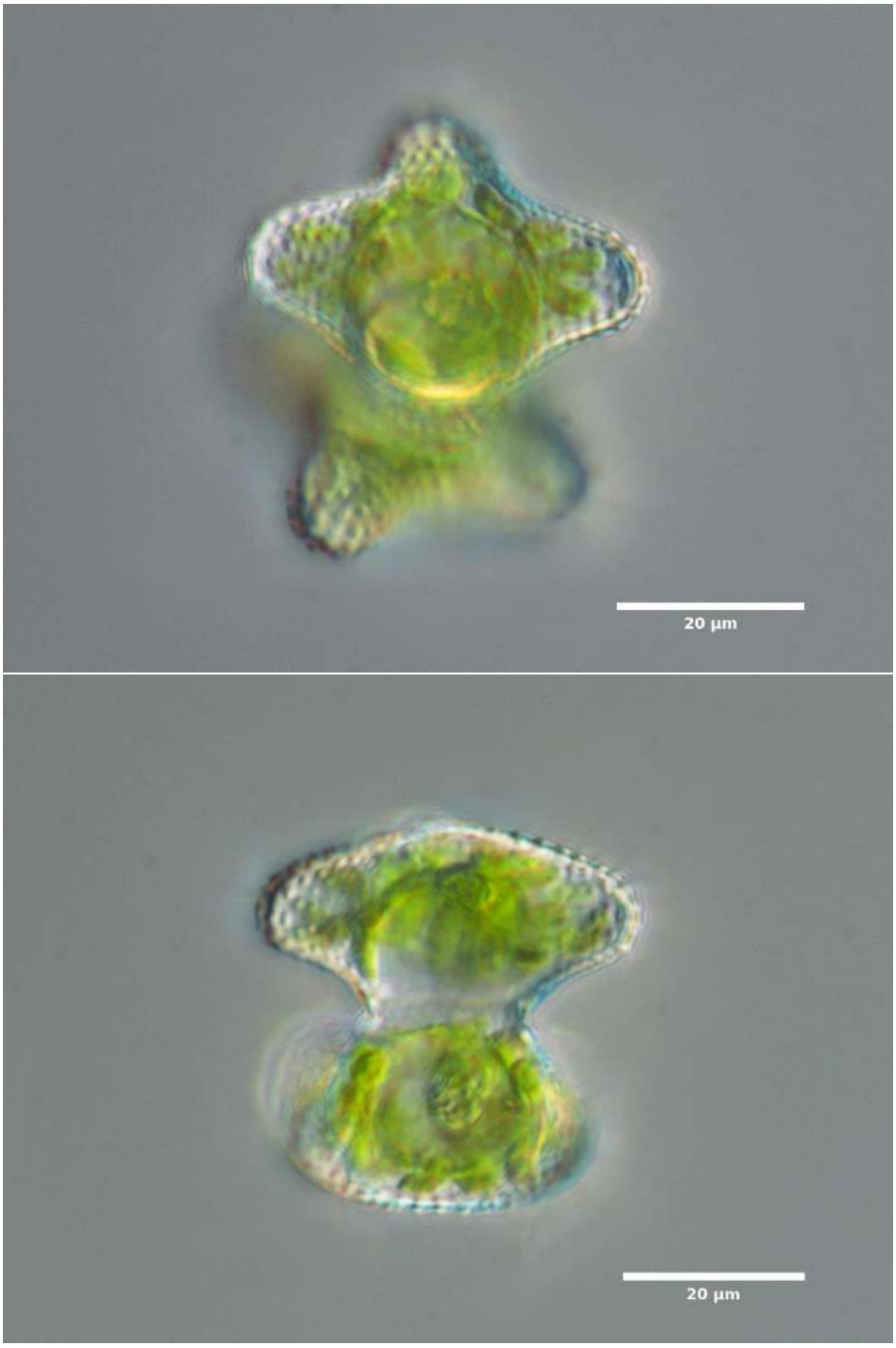
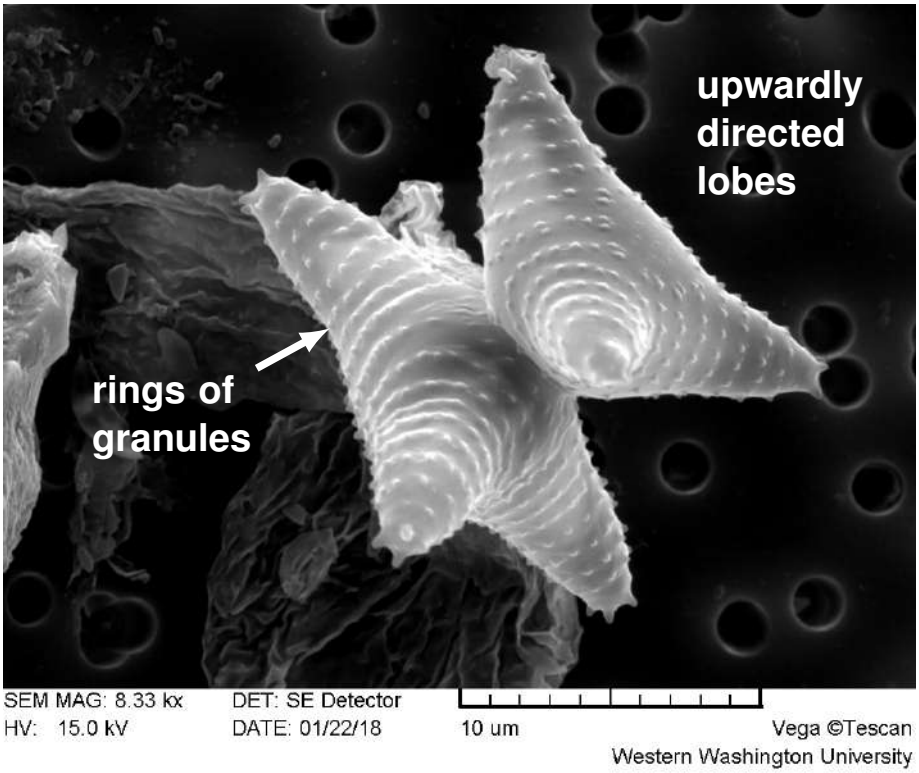


Figure 22.93: *Staurastrum dilatatum* (DIC/DIC), small pond on trail to Big Four Ice Caves, Mountain Loop Highway, Snohomish County (upper/lower images).



Figure 22.94: *Staurastrum* cf. *dybowskii* (DIC), Sunset Lake, Whatcom County.



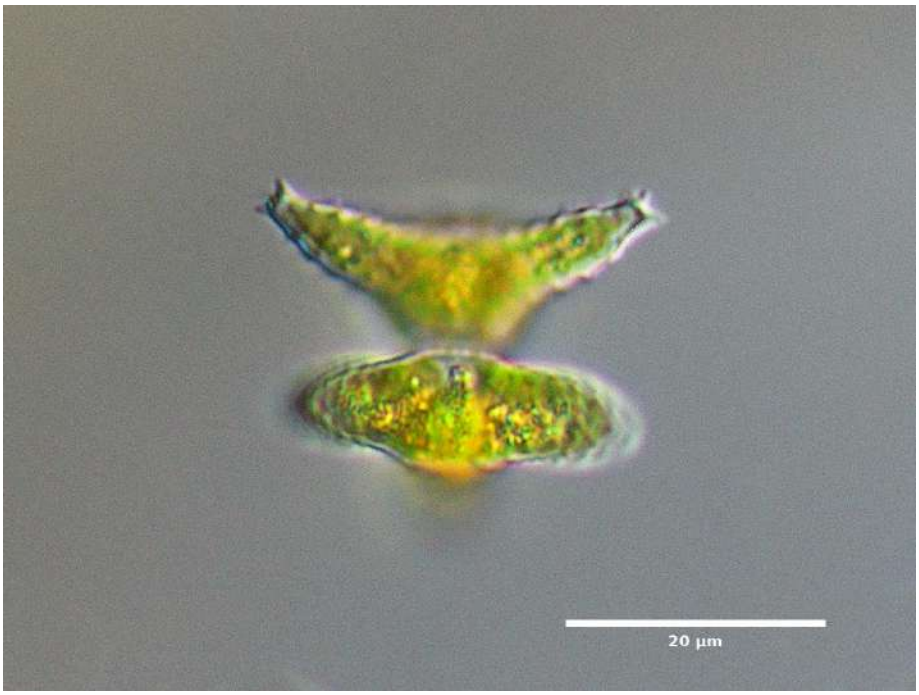


Figure 22.95: *Staurastrum* cf. *dybowskii* (SEM/DIC), Bug Lake, Whatcom County (upper/lower images).

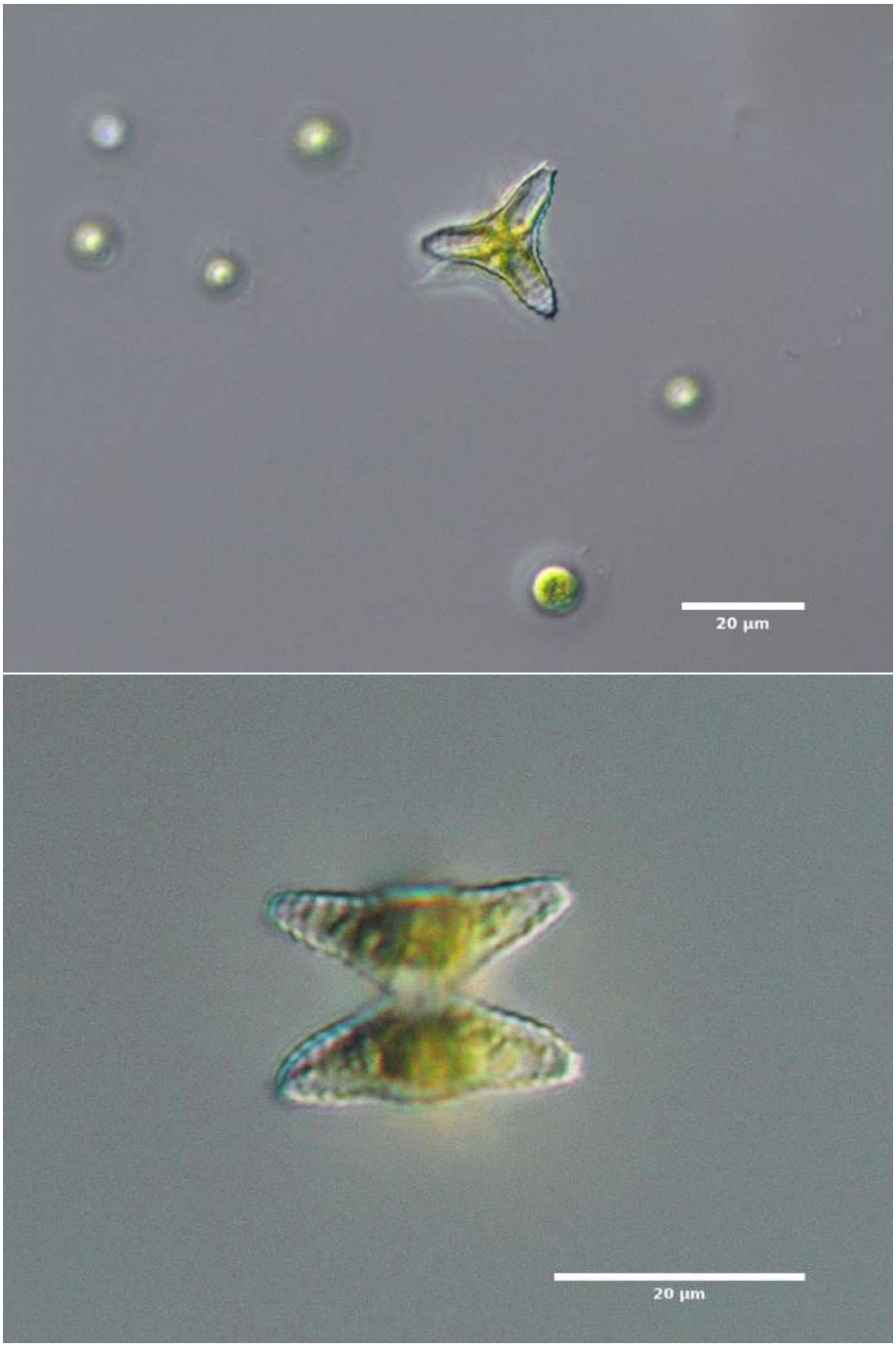


Figure 22.96: *Staurastrum* cf. *dybowskii* (DIC/DIC), Sunset Lake, Whatcom County (upper/lower images).

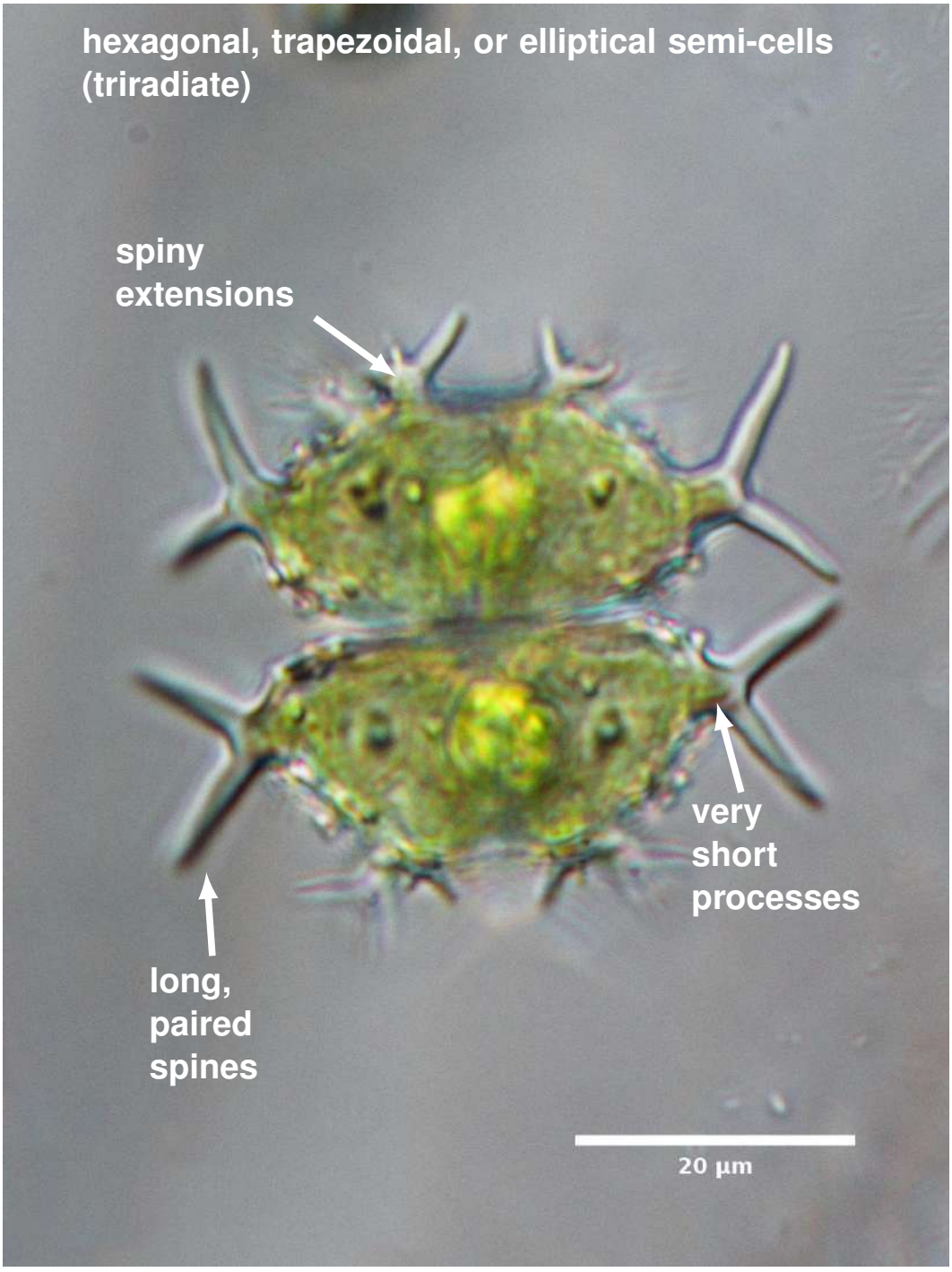


Figure 22.97: *Staurastrum forficulatum* (DIC), Picture Lake, Mt. Baker area, Whatcom County (upper/lower images).

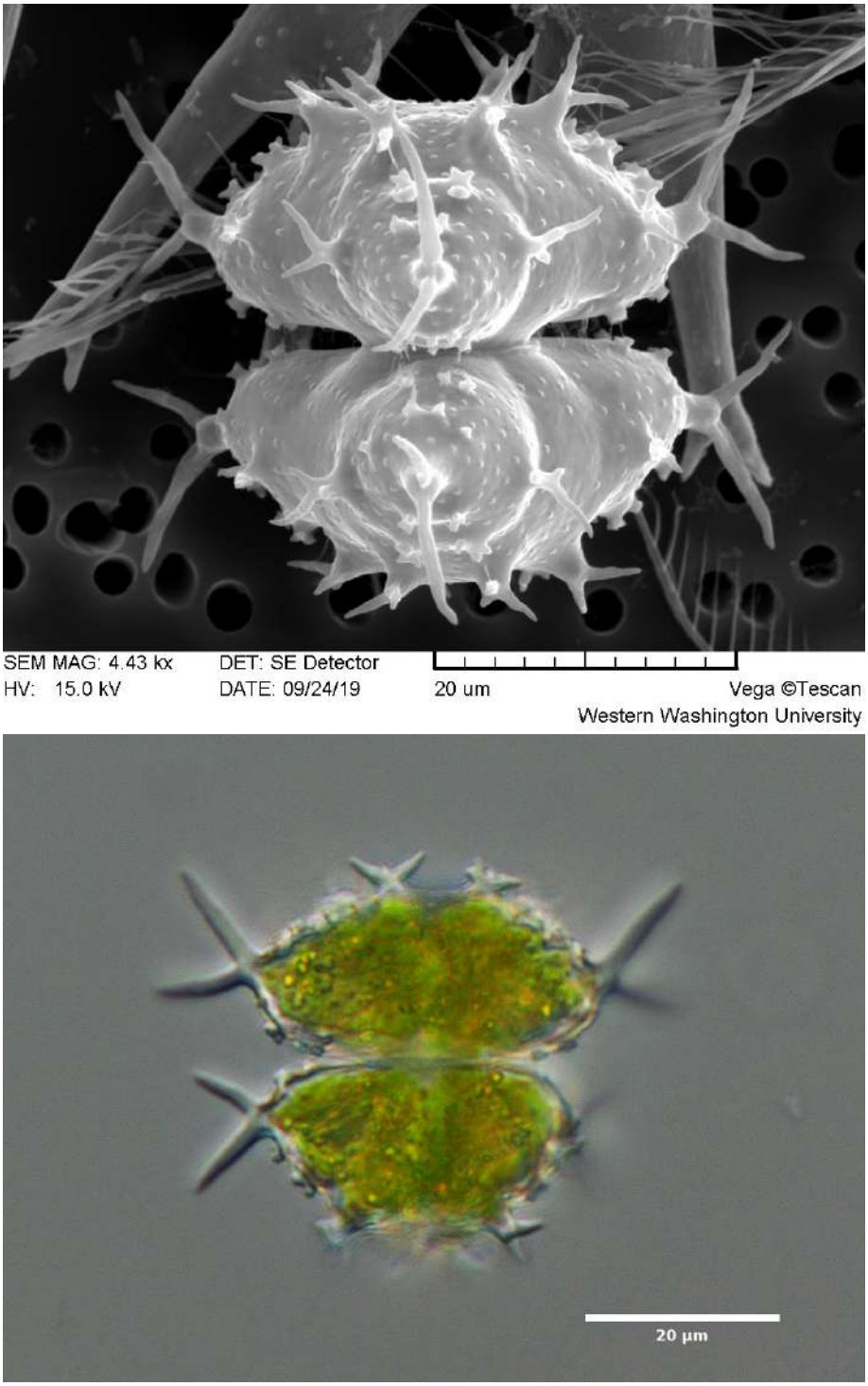


Figure 22.98: *Staurastrum forficulatum* (SEM/DIC), Chain Lake, Gifford Pinchot National Forest, Skamania County (upper/lower images).

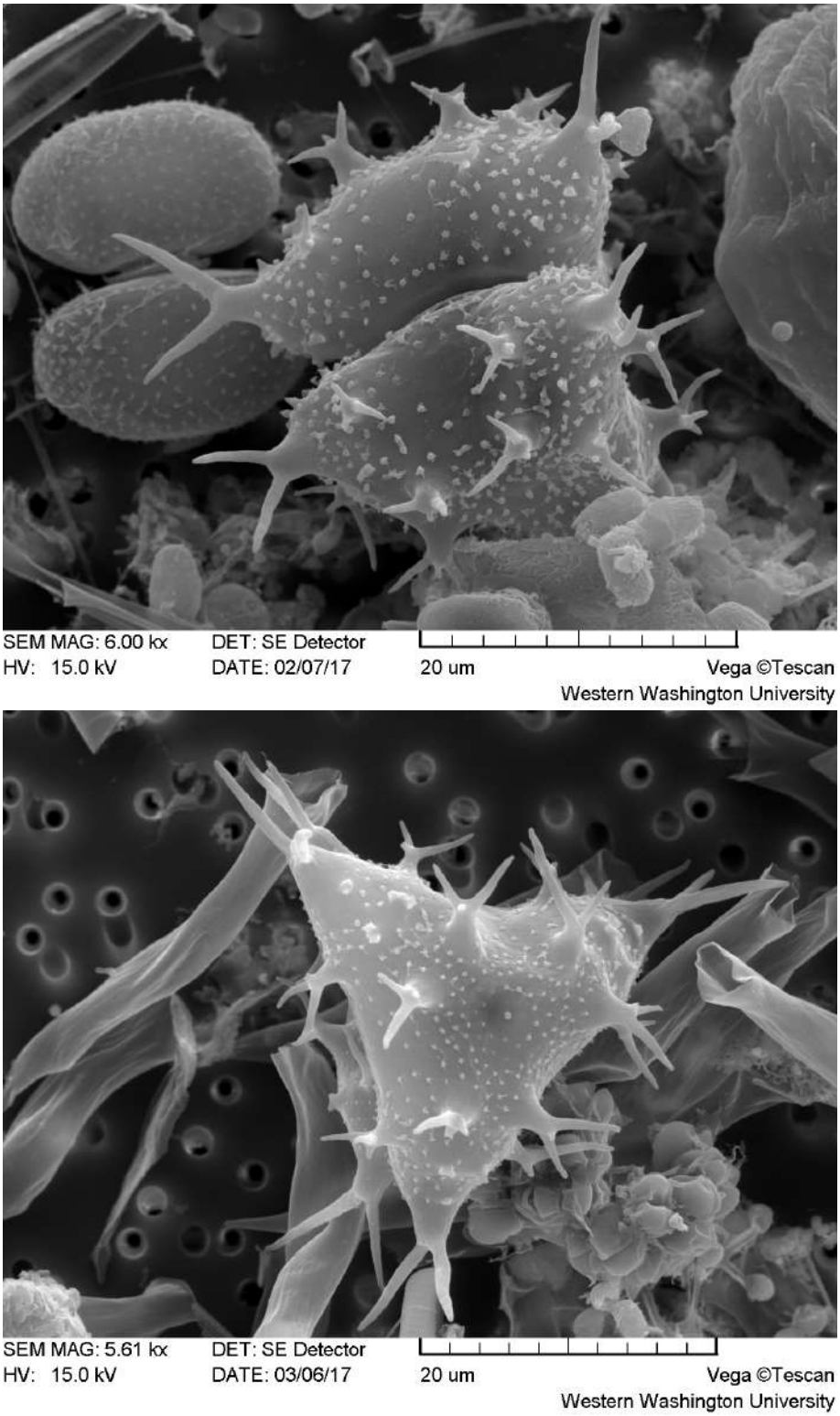


Figure 22.99: *Staurastrum forficulatum* (SEM/SEM), Picture Lake, Mt. Baker area, Whatcom County (upper image); Heather Meadows Pond, Mt. Baker area, Whatcom County (lower image).

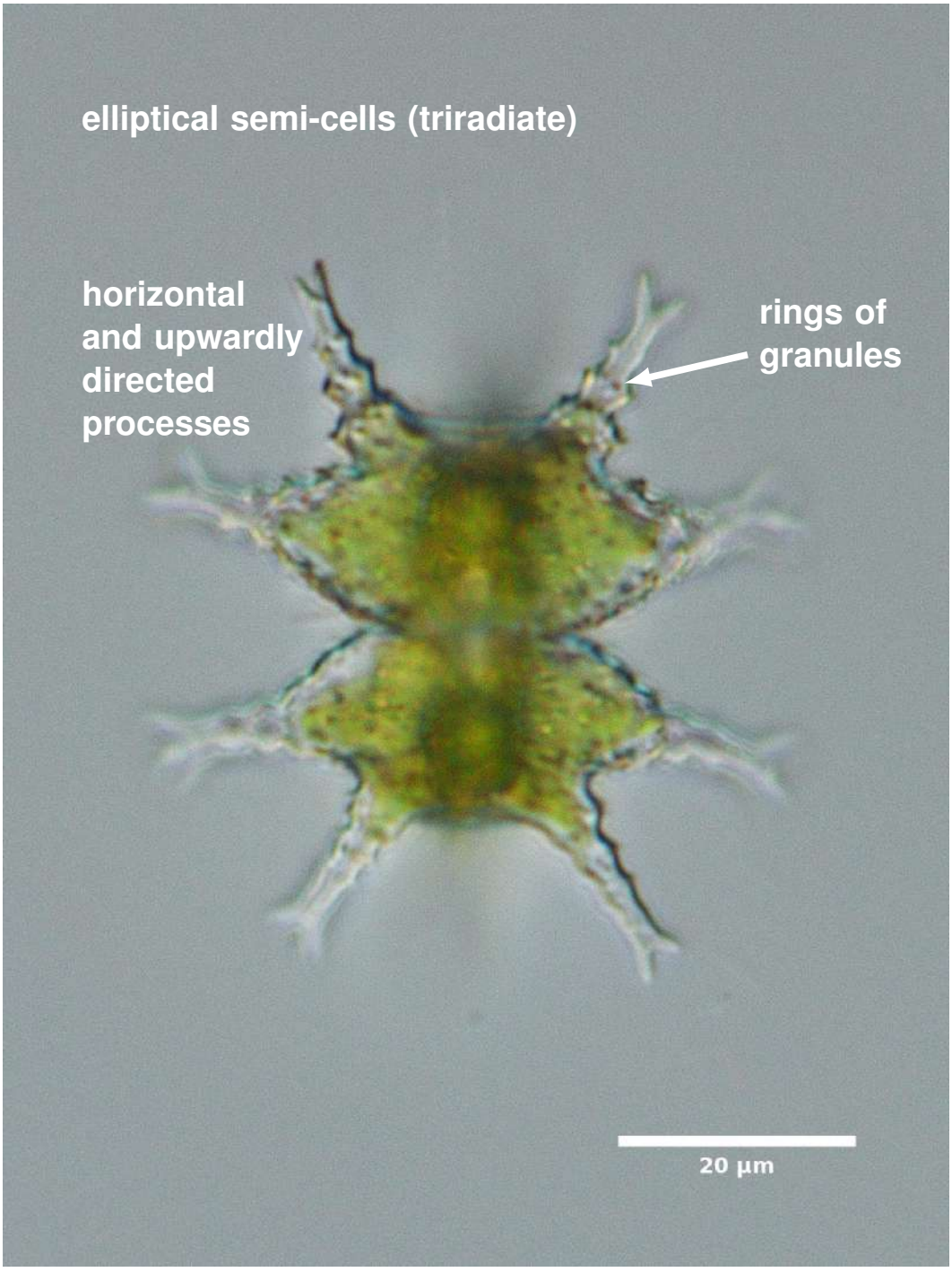


Figure 22.100: *Staurastrum furcigerum* (DIC), Lower Anderson Lake, Mt. Baker area, Whatcom County.

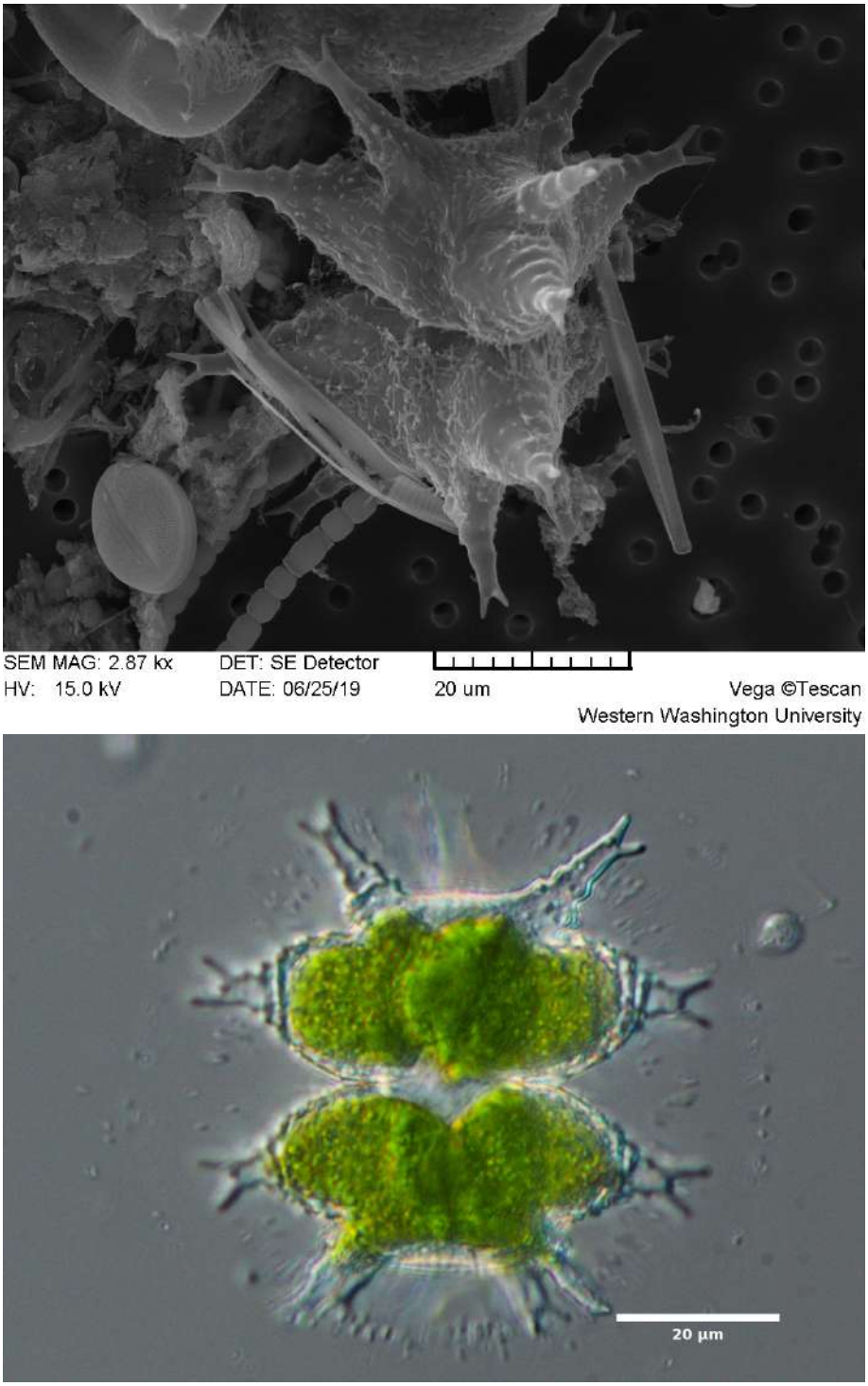


Figure 22.101: *Staurastrum furcigerum* (SEM/DIC), Lake Geneva, Whatcom County (upper/lower images).

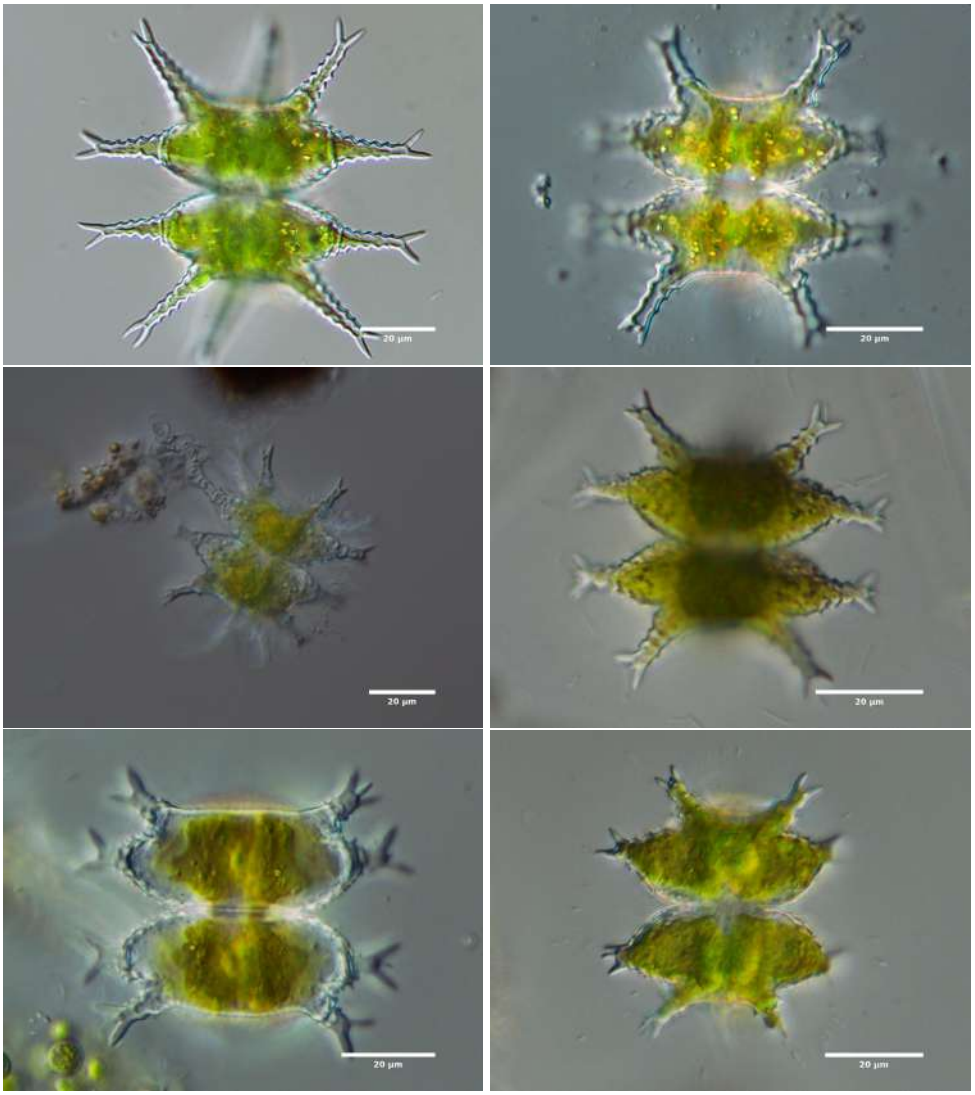


Figure 22.102: *Staurastrum furcigerum* semi-cell variations (DIC); all specimens collected from lakes or ponds in northwest Washington.

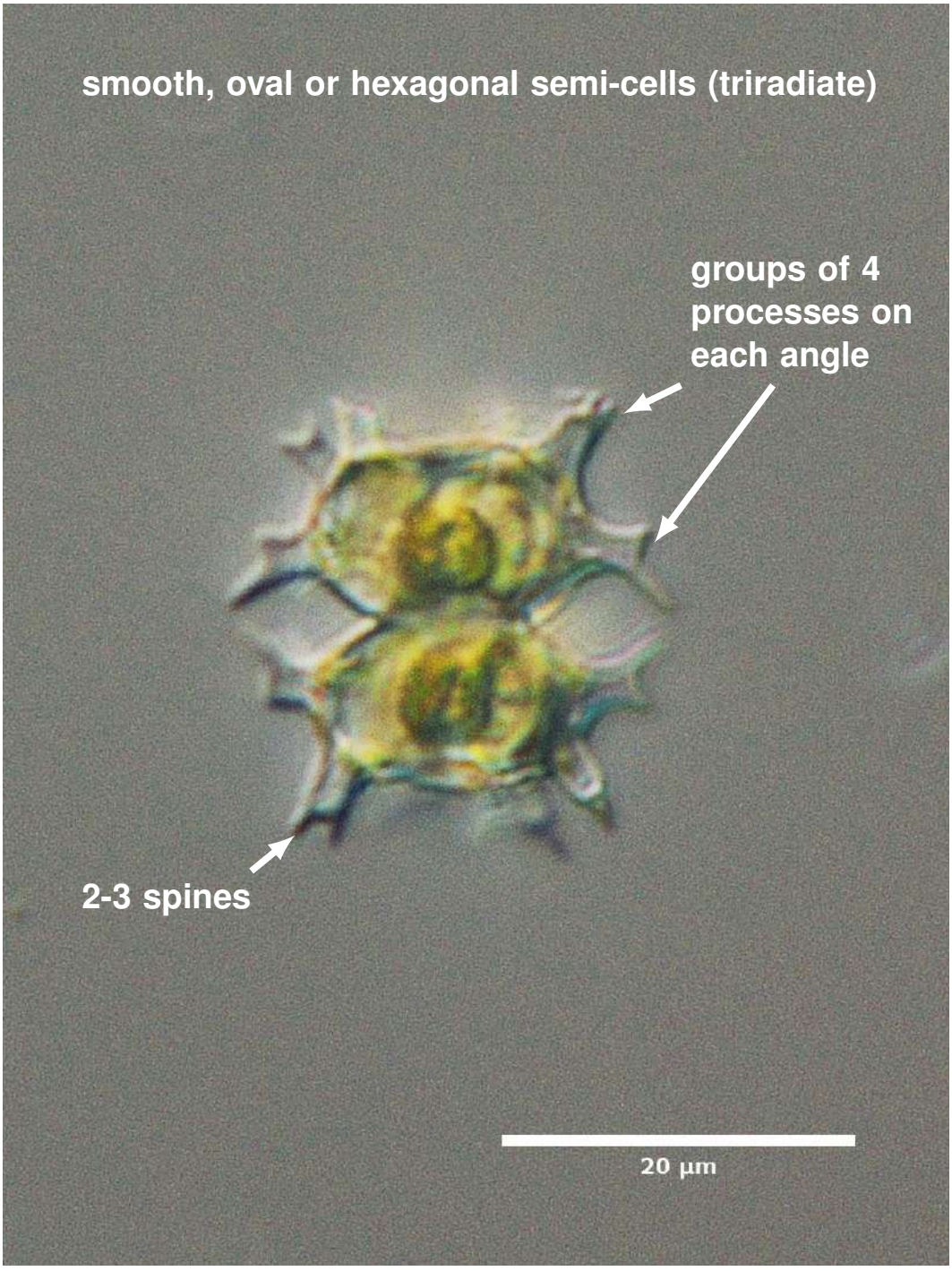


Figure 22.103: *Staurastrum gemelliparum* (DIC), Lake Olallie, Gifford Pinchot National Forest, Skamania County.

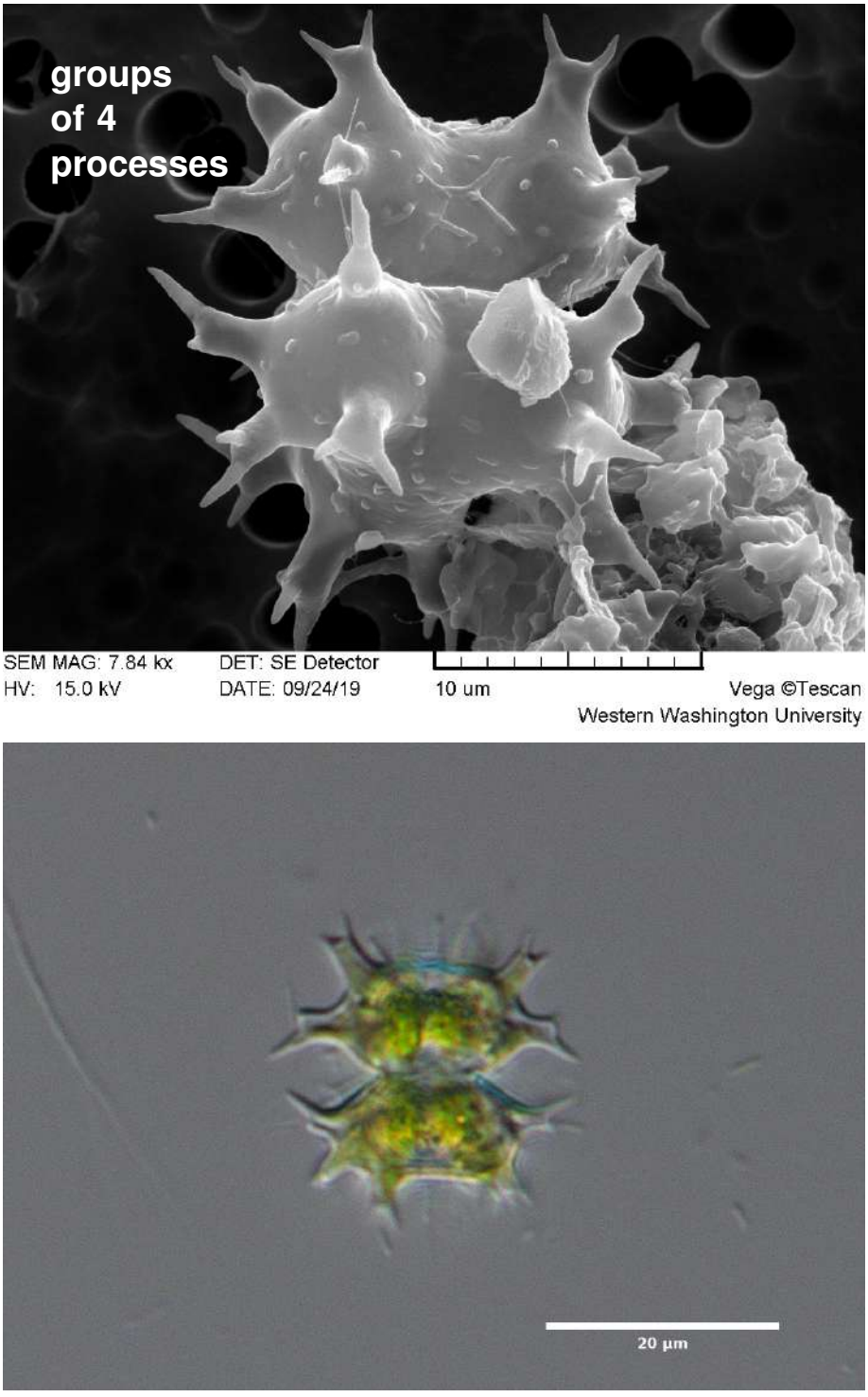


Figure 22.104: *Staurastrum gemelliparum* (SEM/DIC), Chain Lake, Gifford Pinchot National Forest, Skamania County (upper/lower images).

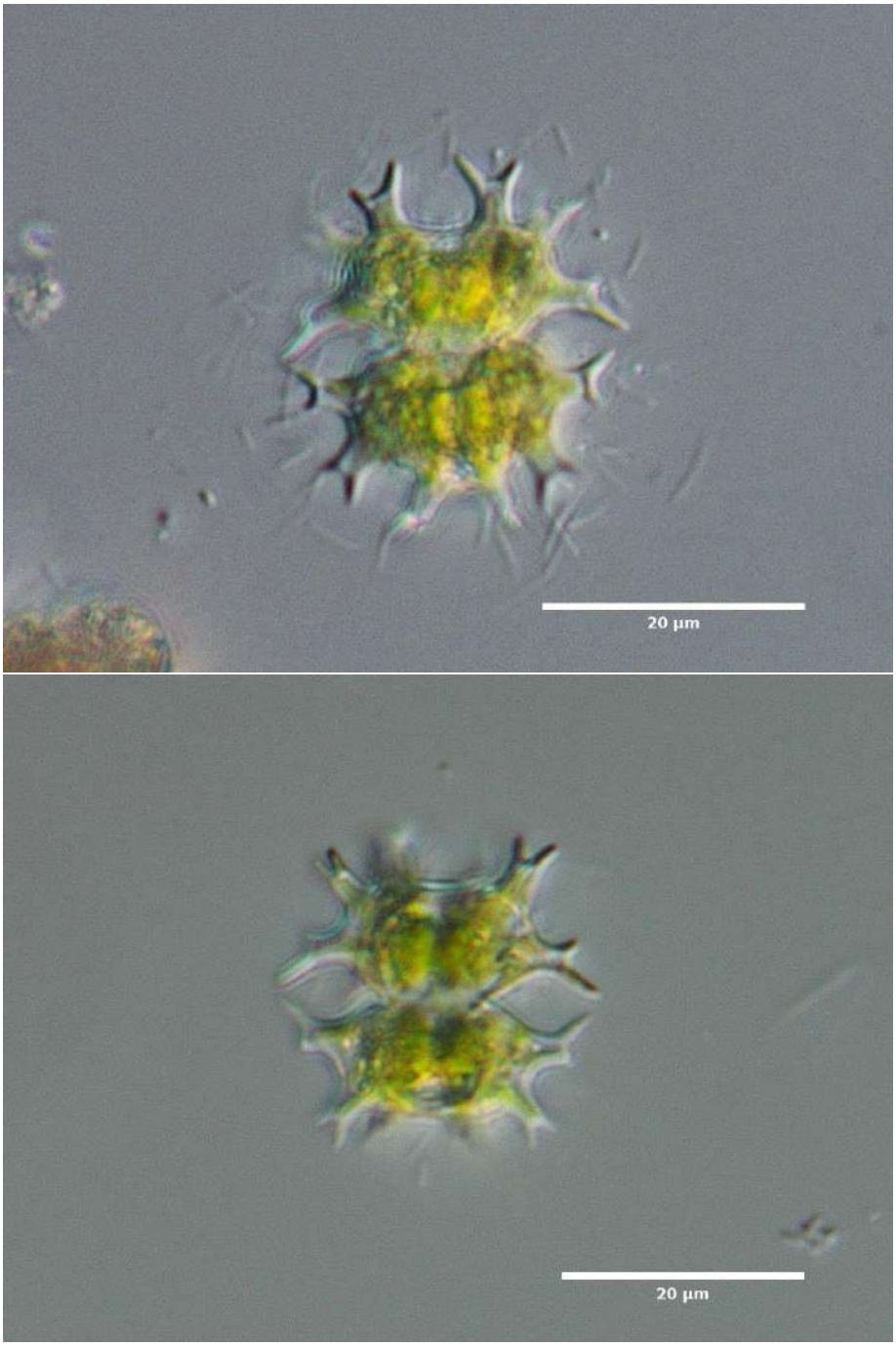


Figure 22.105: *Staurastrum gemelliparum* (DIC/DIC), Chain Lake, Gifford Pinchot National Forest, Skamania County (upper/lower images).

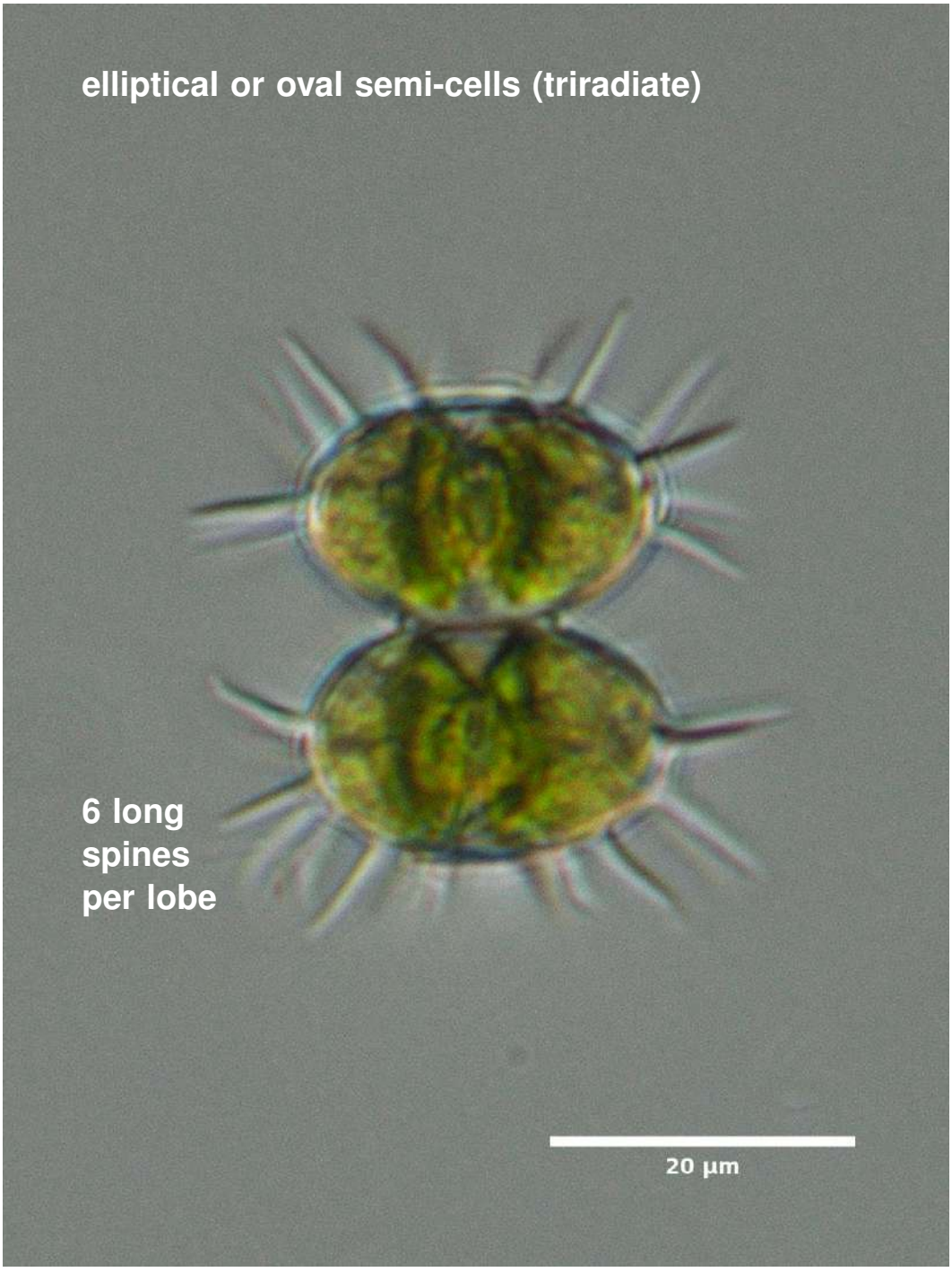


Figure 22.106: *Staurastrum geminatum* (DIC), Lake Evan, Mountain Loop Highway, Snohomish County.



Figure 22.107: *Staurastrum geminatum* (DIC), Lake Evan, Mountain Loop Highway, Snohomish County.

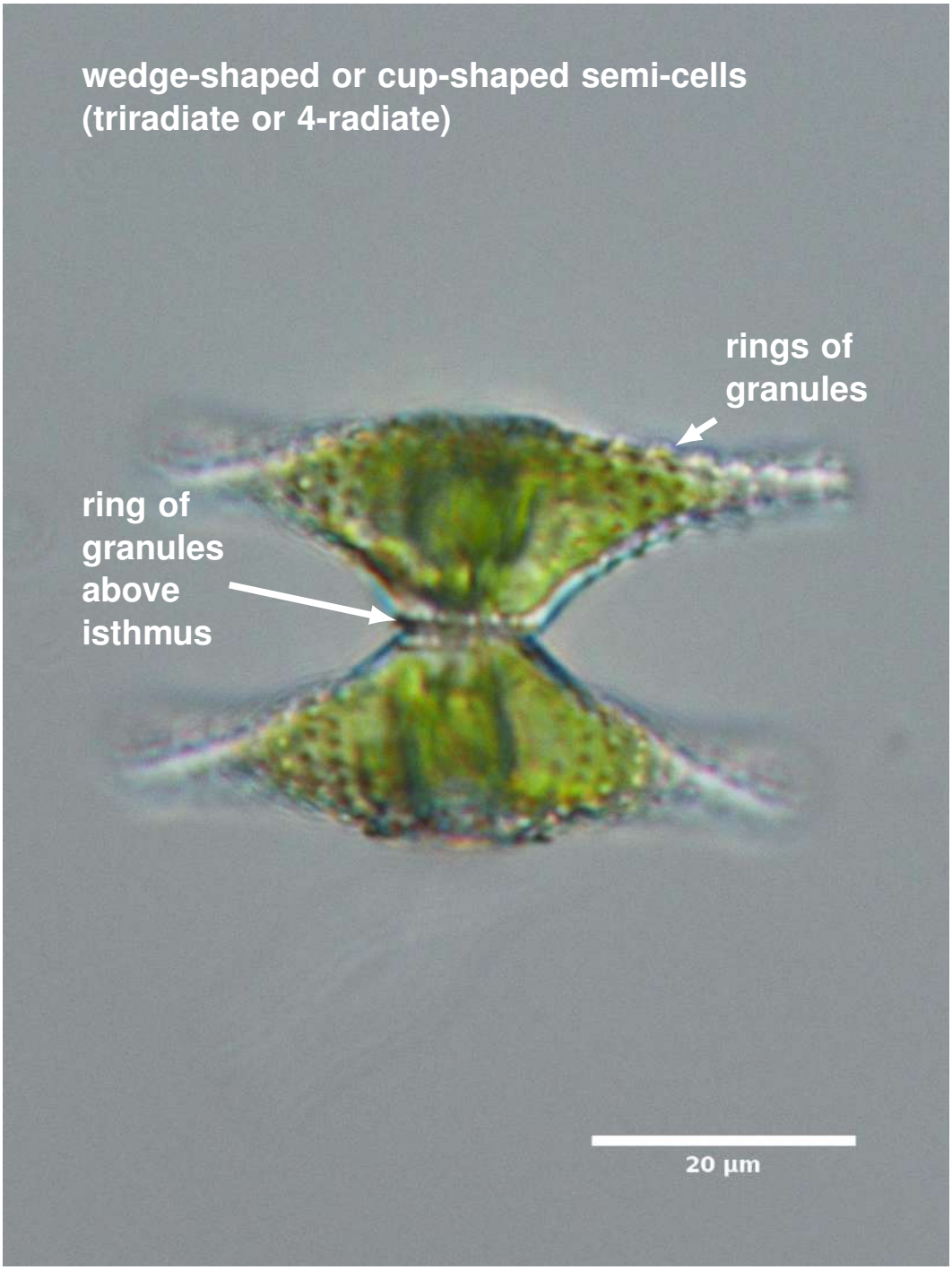


Figure 22.108: *Staurastrum gracile* (DIC), Myrtle Lake, Mountain Loop Highway, Snohomish County (upper/lower images).

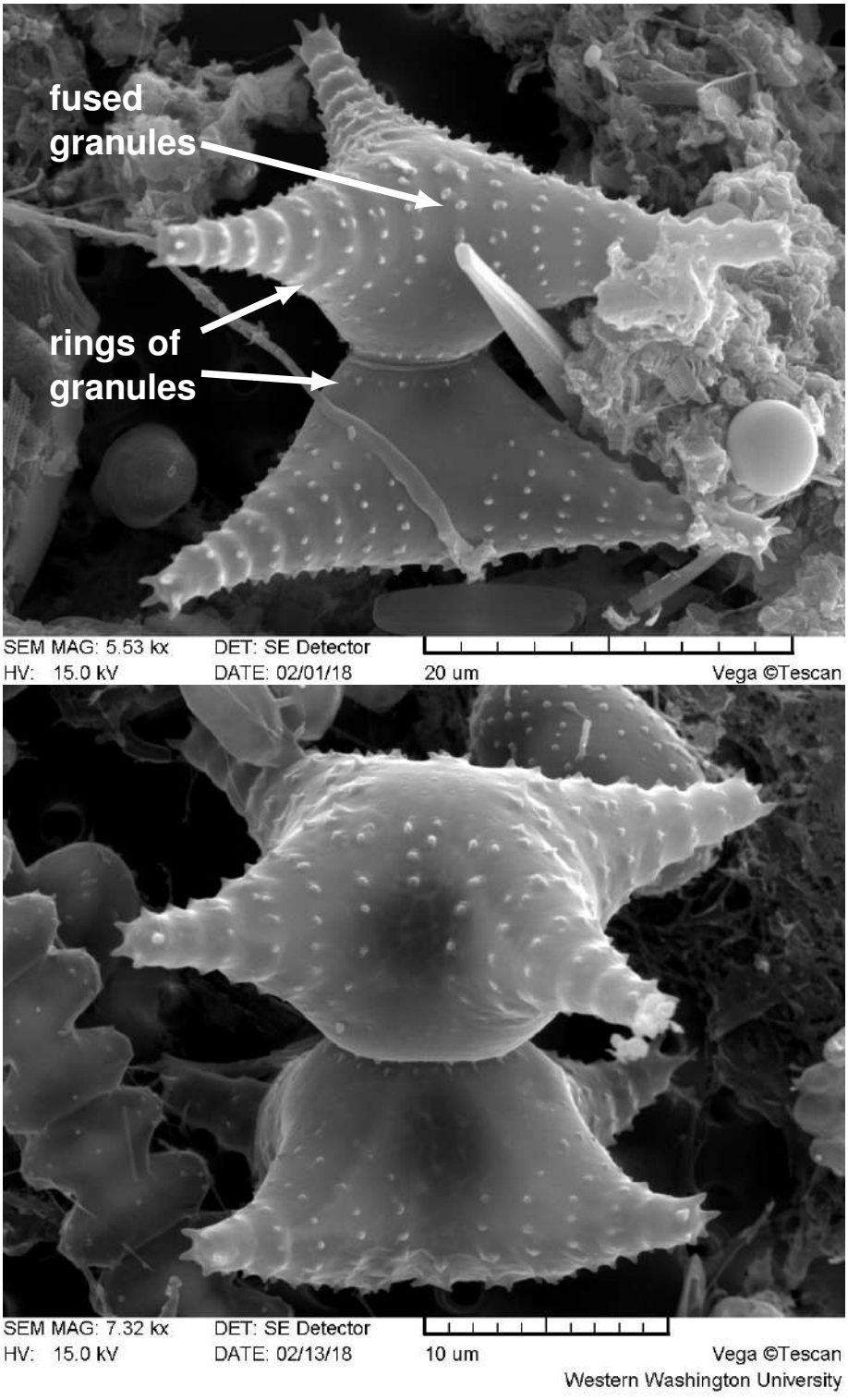


Figure 22.109: *Staurastrum gracile* (SEM/SEM), Myrtle Lake, Mountain Loop Highway, Snohomish County (upper/lower images).

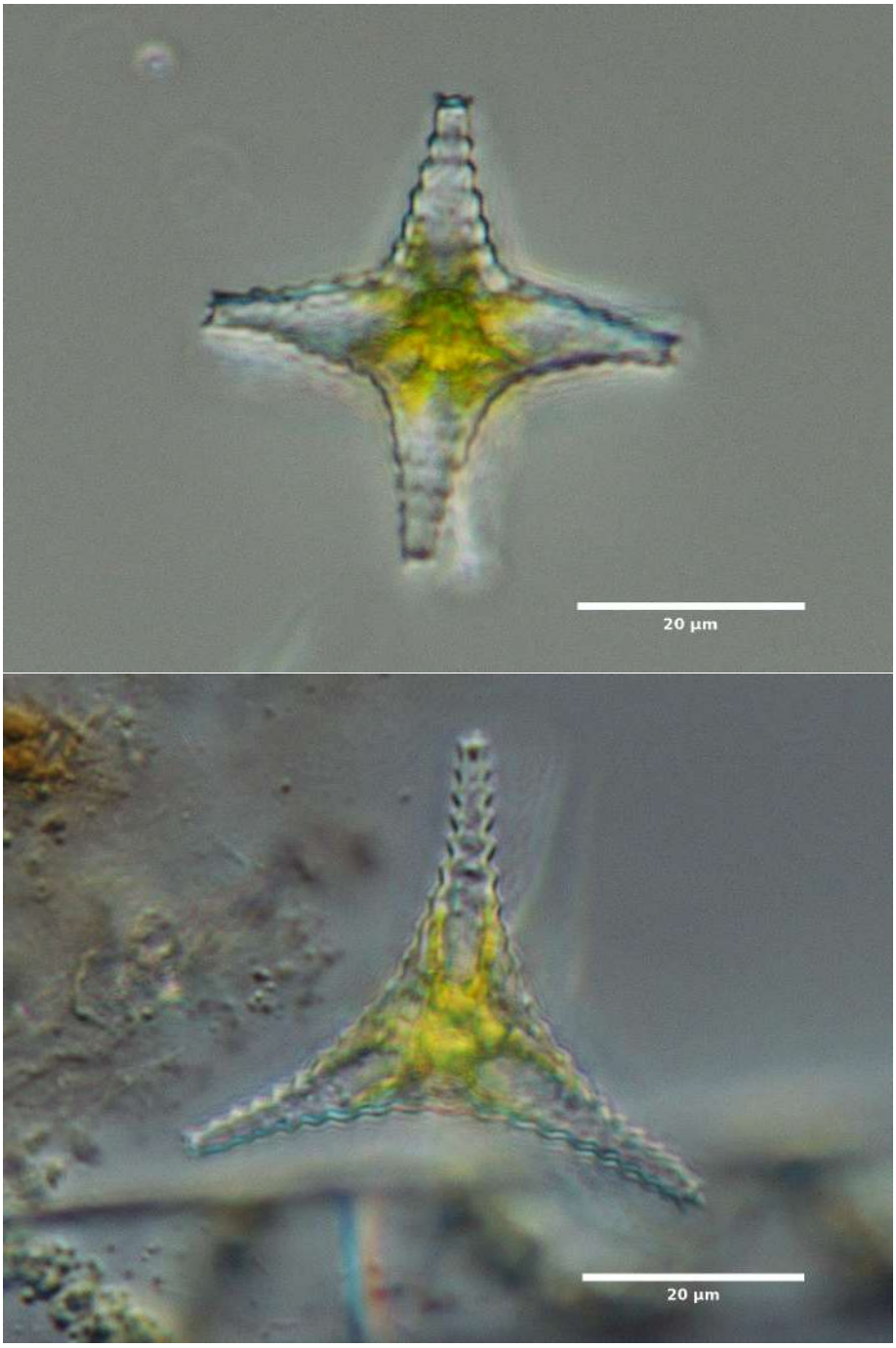


Figure 22.110: *Staurastrum gracile* (DIC/DIC), small boggy pond on Morris Valley Road near Harrison BC (upper/lower images).

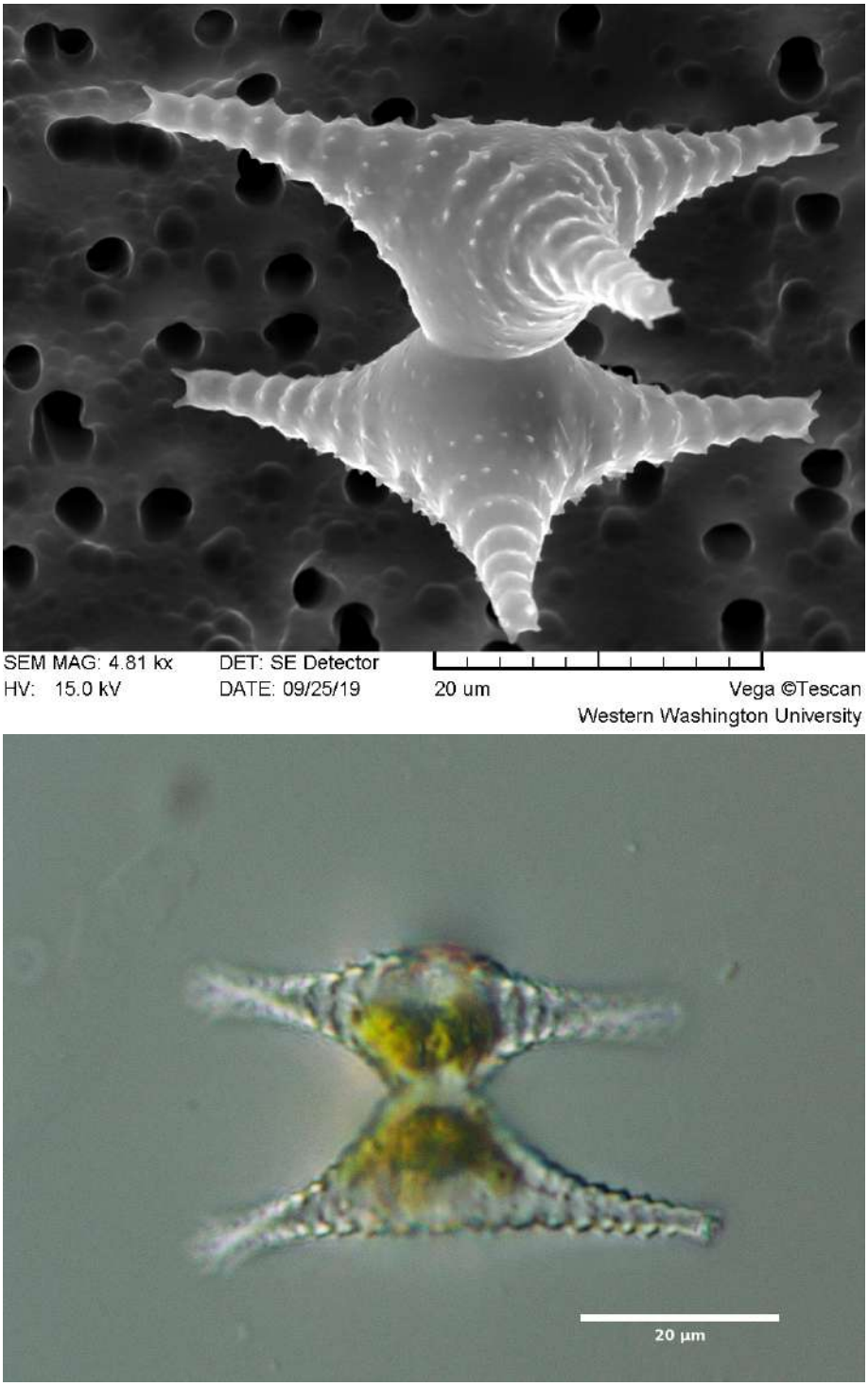


Figure 22.111: *Staurastrum gracile* (SEM//DIC), small boggy pond on Morris Valley Road near Harrison BC (upper/lower images).

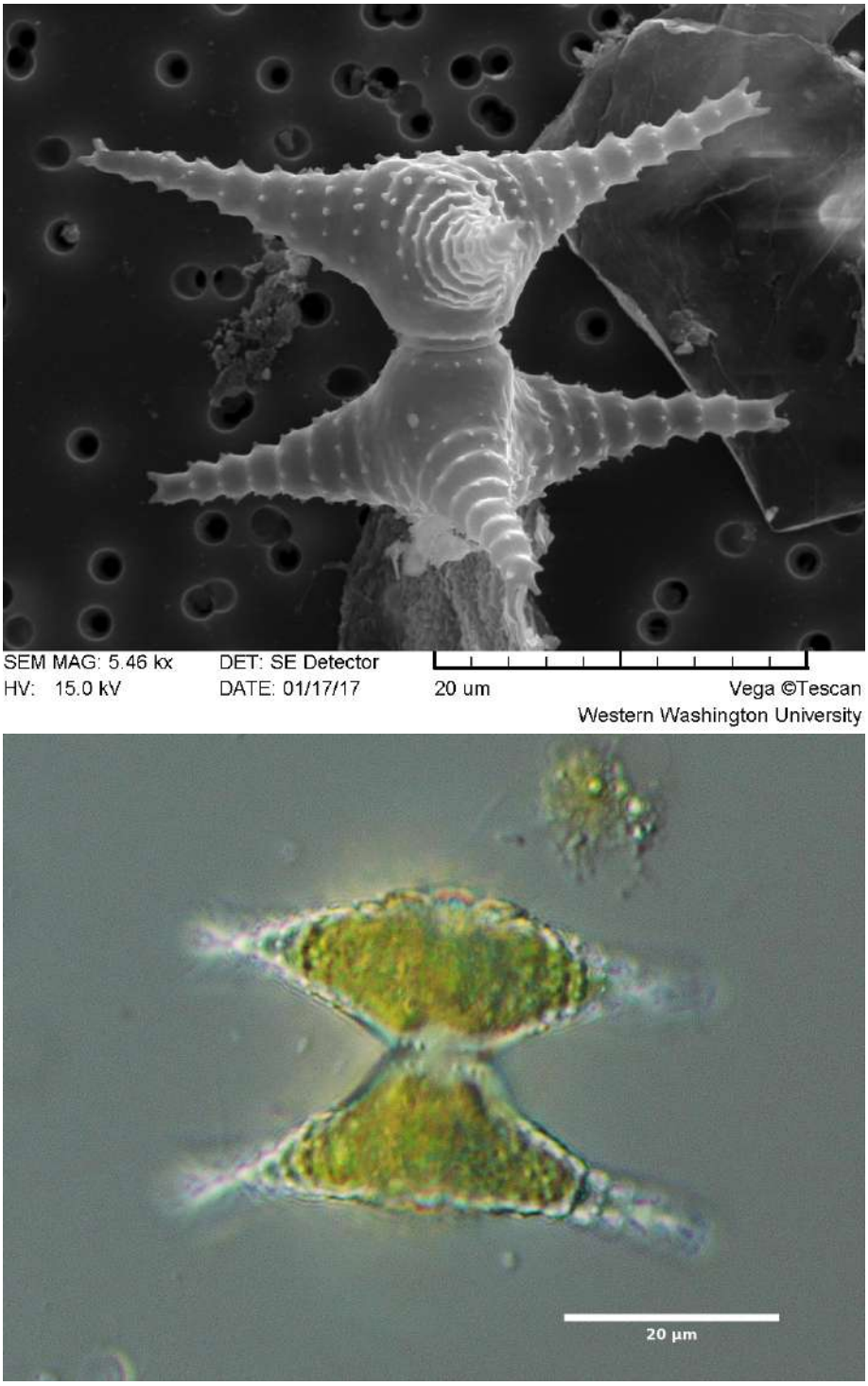


Figure 22.112: *Staurastrum gracile* (SEM/DIC), Myrtle Lake, Mountain Loop Highway, Snohomish County (upper/lower images).

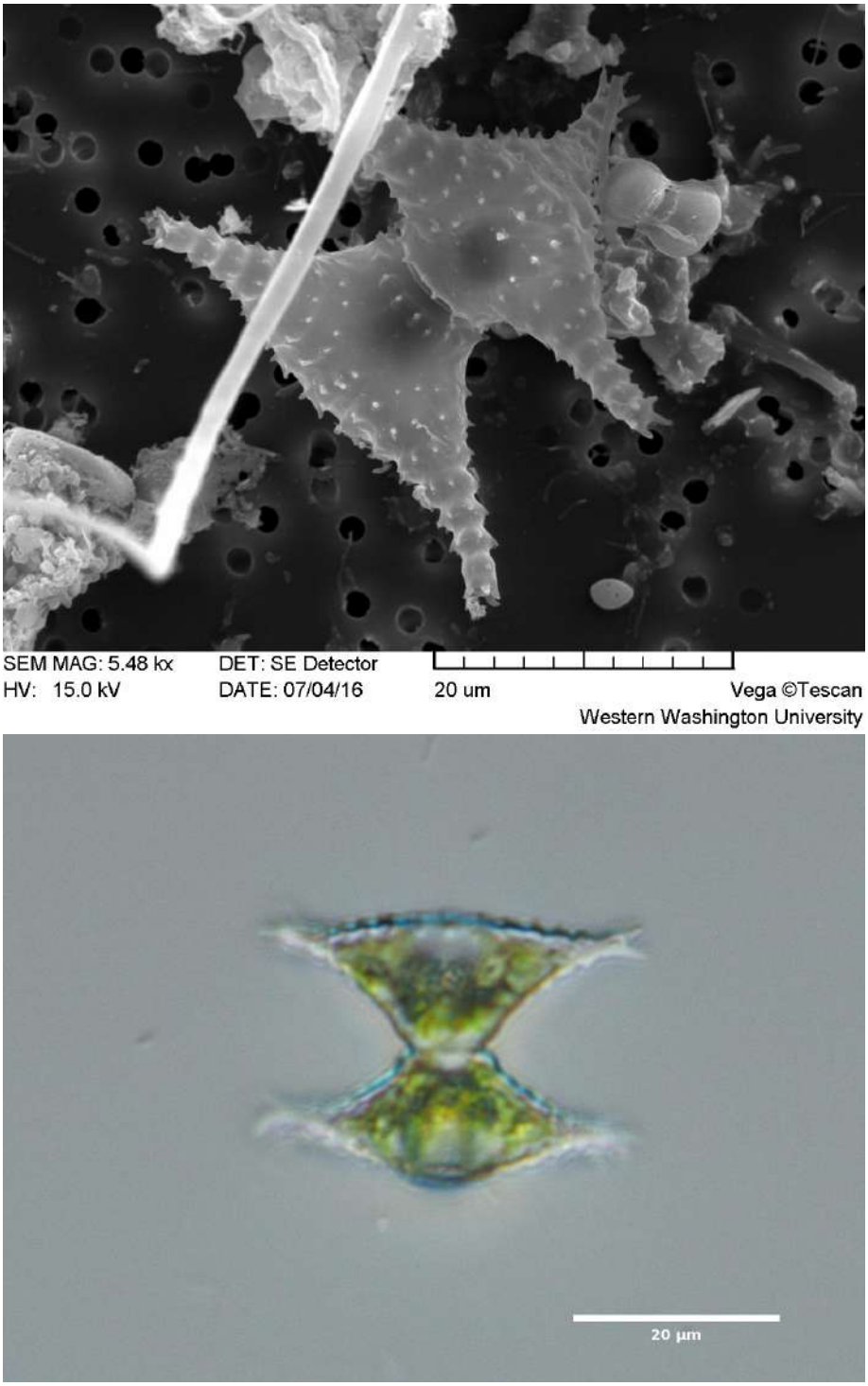


Figure 22.113: *Staurastrum* cf. *gracile* (SEM/DIC), Boardman Lake, Mountain Loop Highway, Snohomish County (upper/lower images).

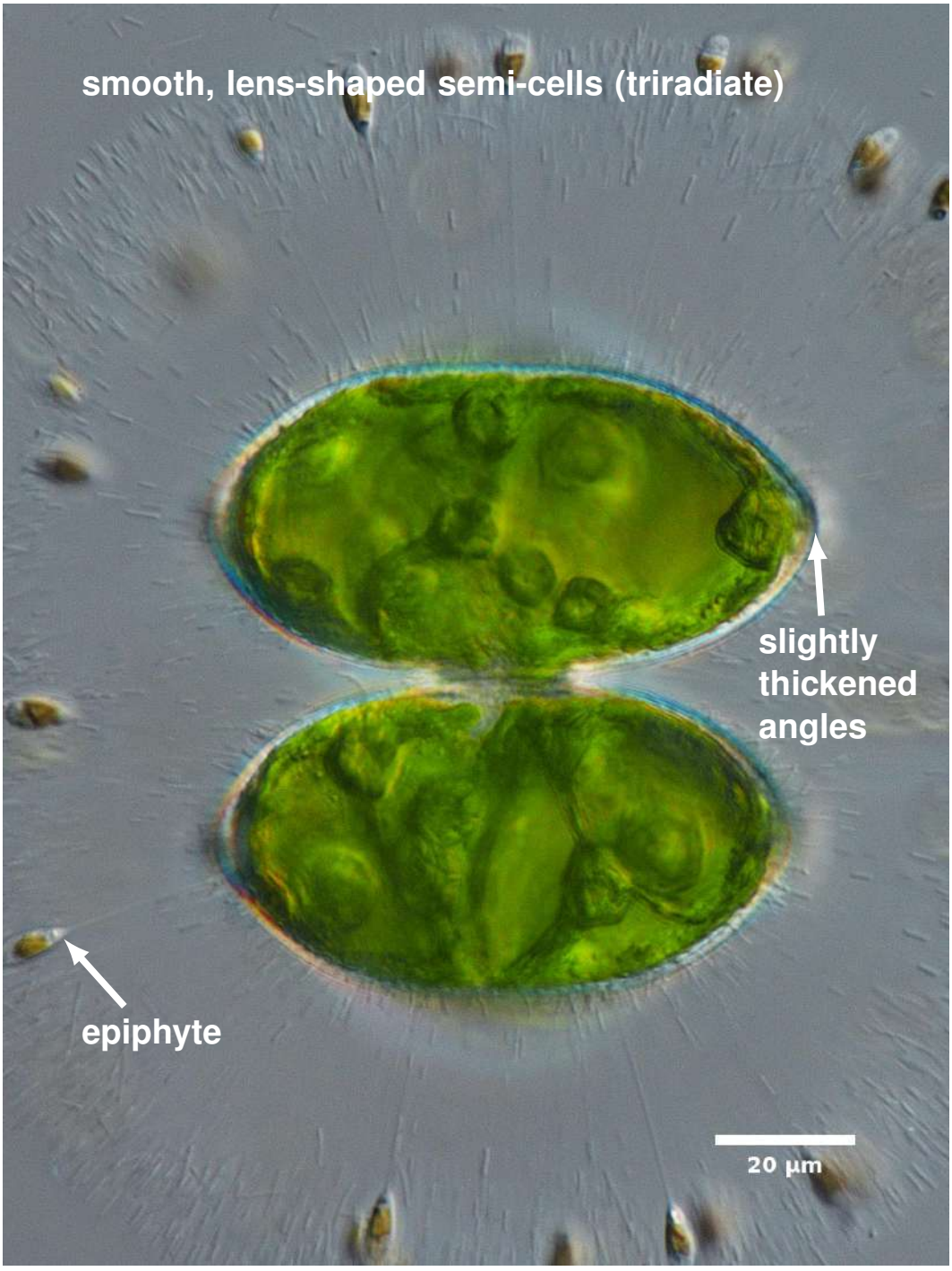


Figure 22.114: *Staurastrum grande* (DIC), small floating bog along Morris Valley Road near Harrison, BC.



Figure 22.115: *Staurastrum grande* (DIC/DIC), small floating bog along Morris Valley Road near Harrison, BC (upper/lower images).



Figure 22.116: *Staurastrum grande* (DIC/DIC), Wood Lake, Morris Valley Road near Harrison, BC (upper image); small floating bog along Morris Valley Road near Harrison, BC (lower image).

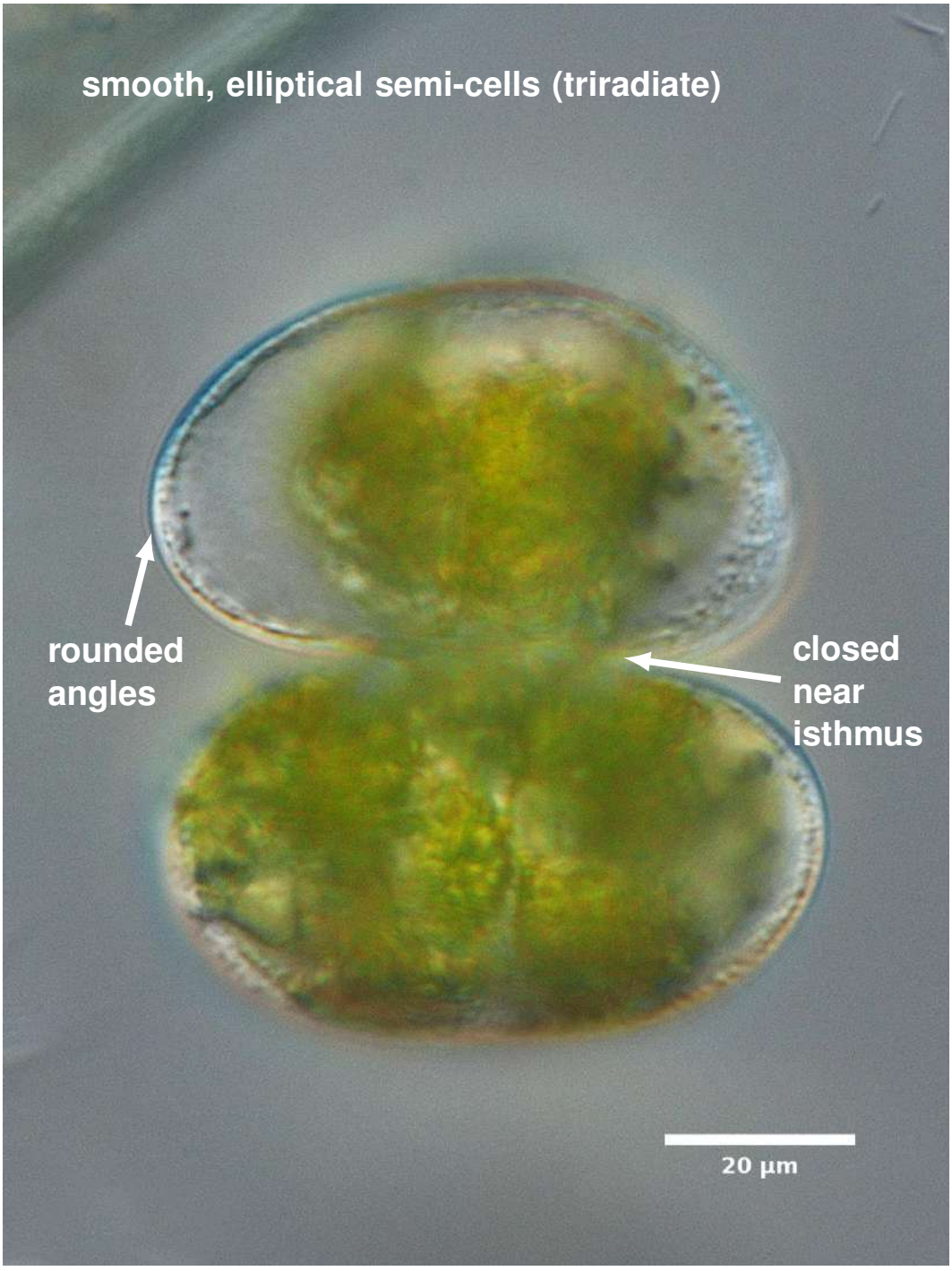


Figure 22.117: *Staurastrum grande* var. *rotundatum* (DIC), small floating bog along Morris Valley Road near Harrison, BC.

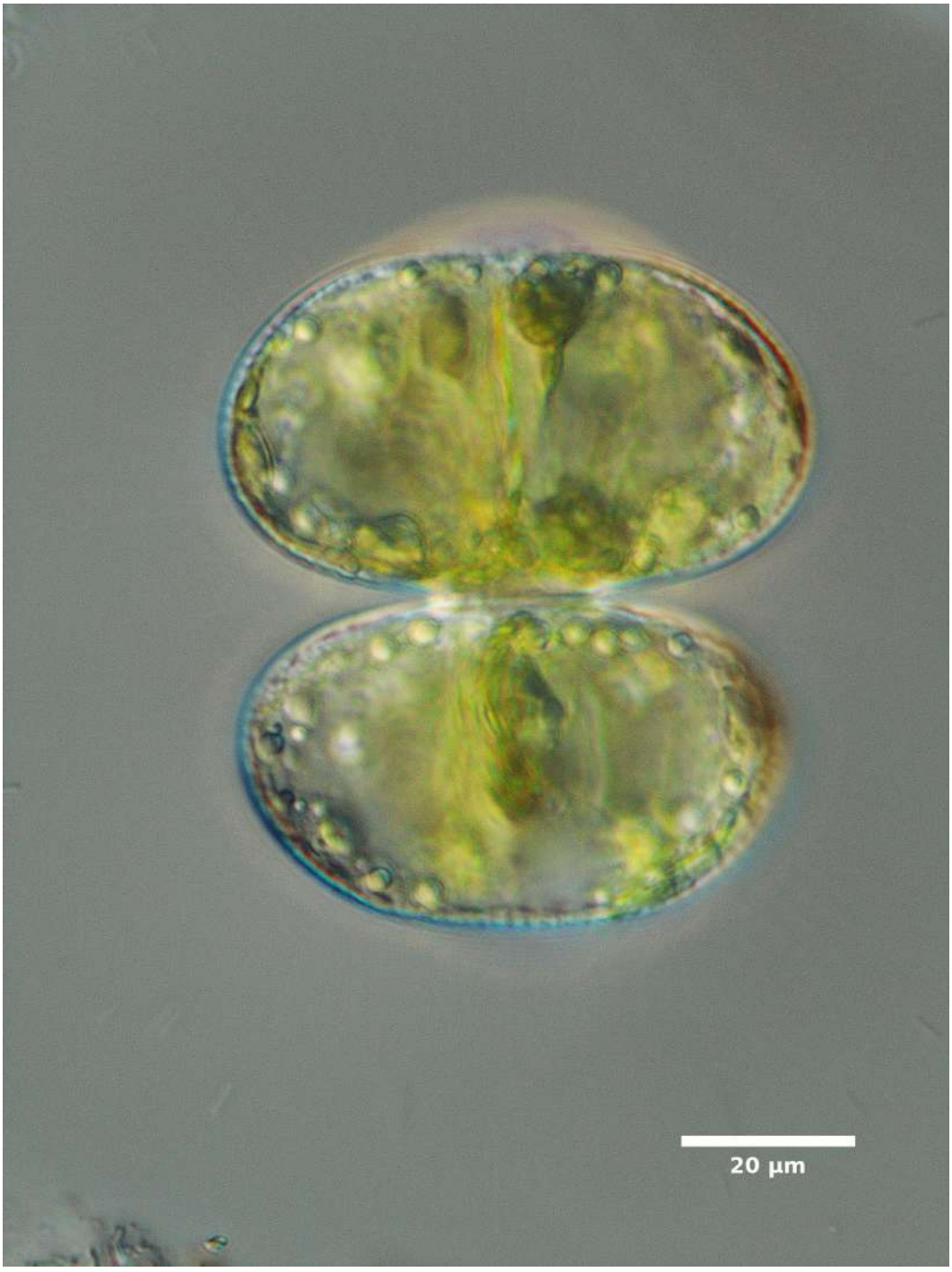


Figure 22.118: *Staurastrum grande* var. *rotundatum* (DIC), small floating bog along Morris Valley Road near Harrison, BC.

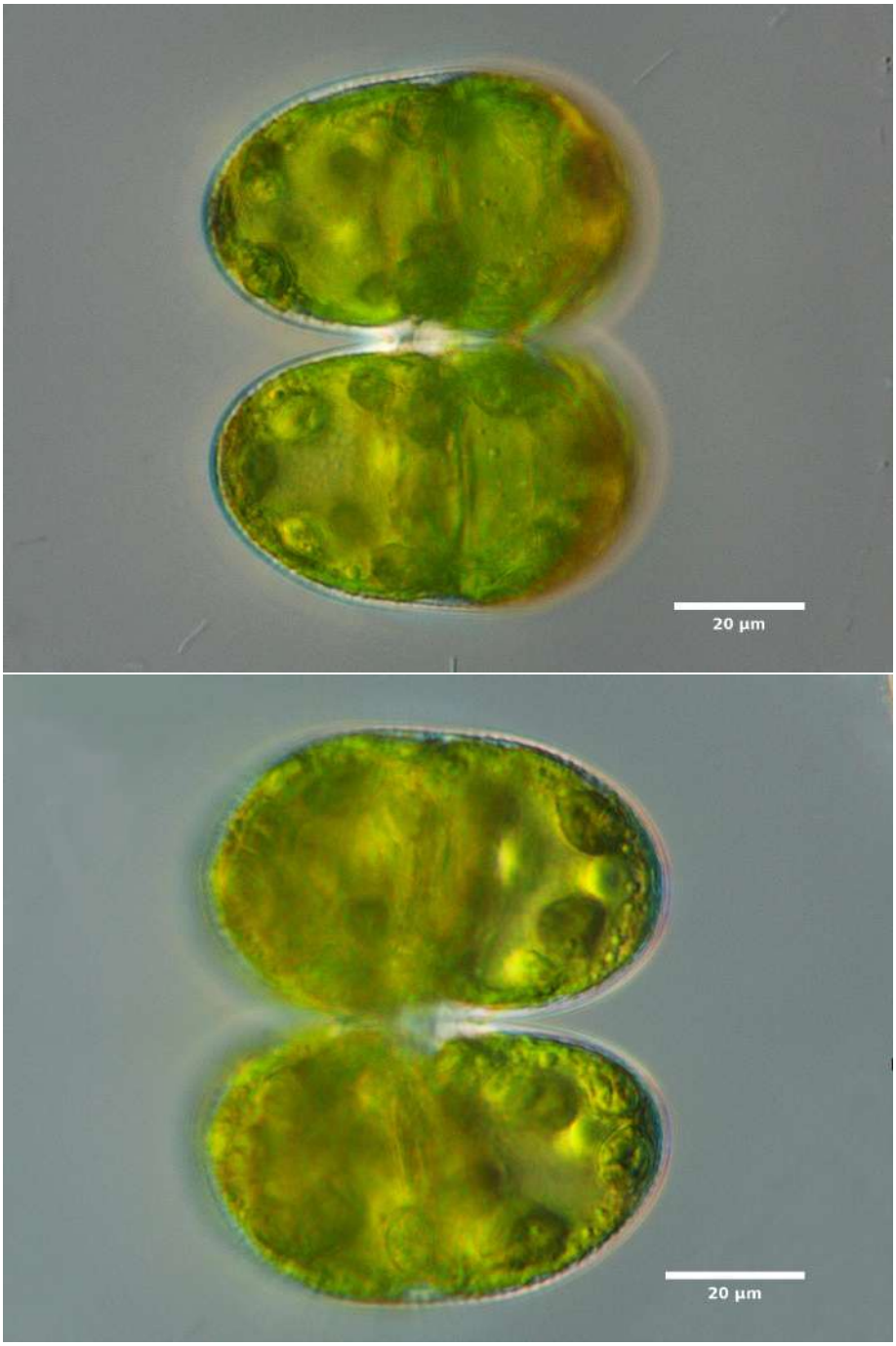


Figure 22.119: *Staurastrum grande* var. *rotundatum* (DIC/DIC), small floating bog along Morris Valley Road near Harrison, BC (upper/lower images)

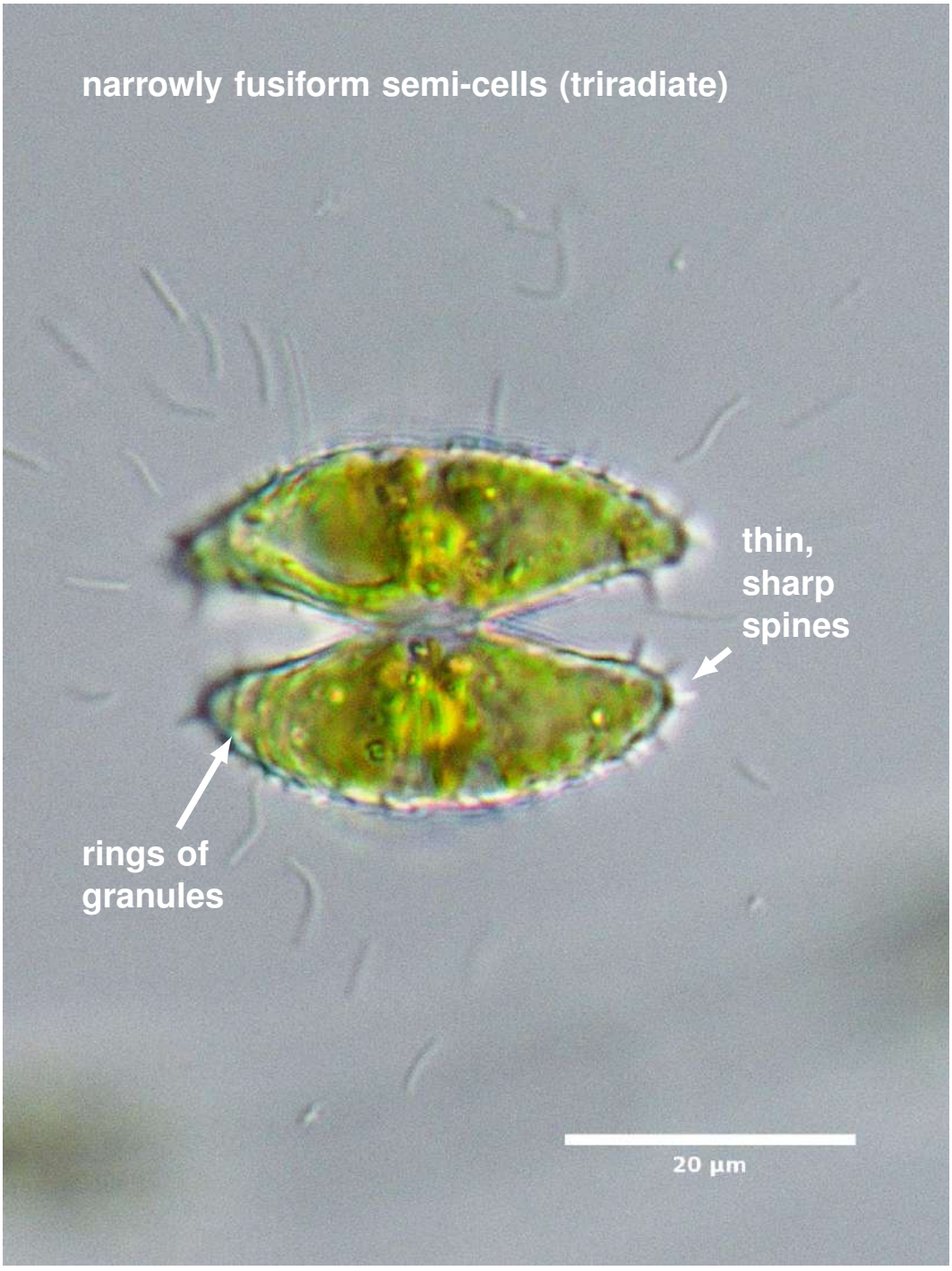


Figure 22.120: *Staurastrum haaboeliense* (DIC), Bear Lake, Mountain Loop Highway, Snohomish County.

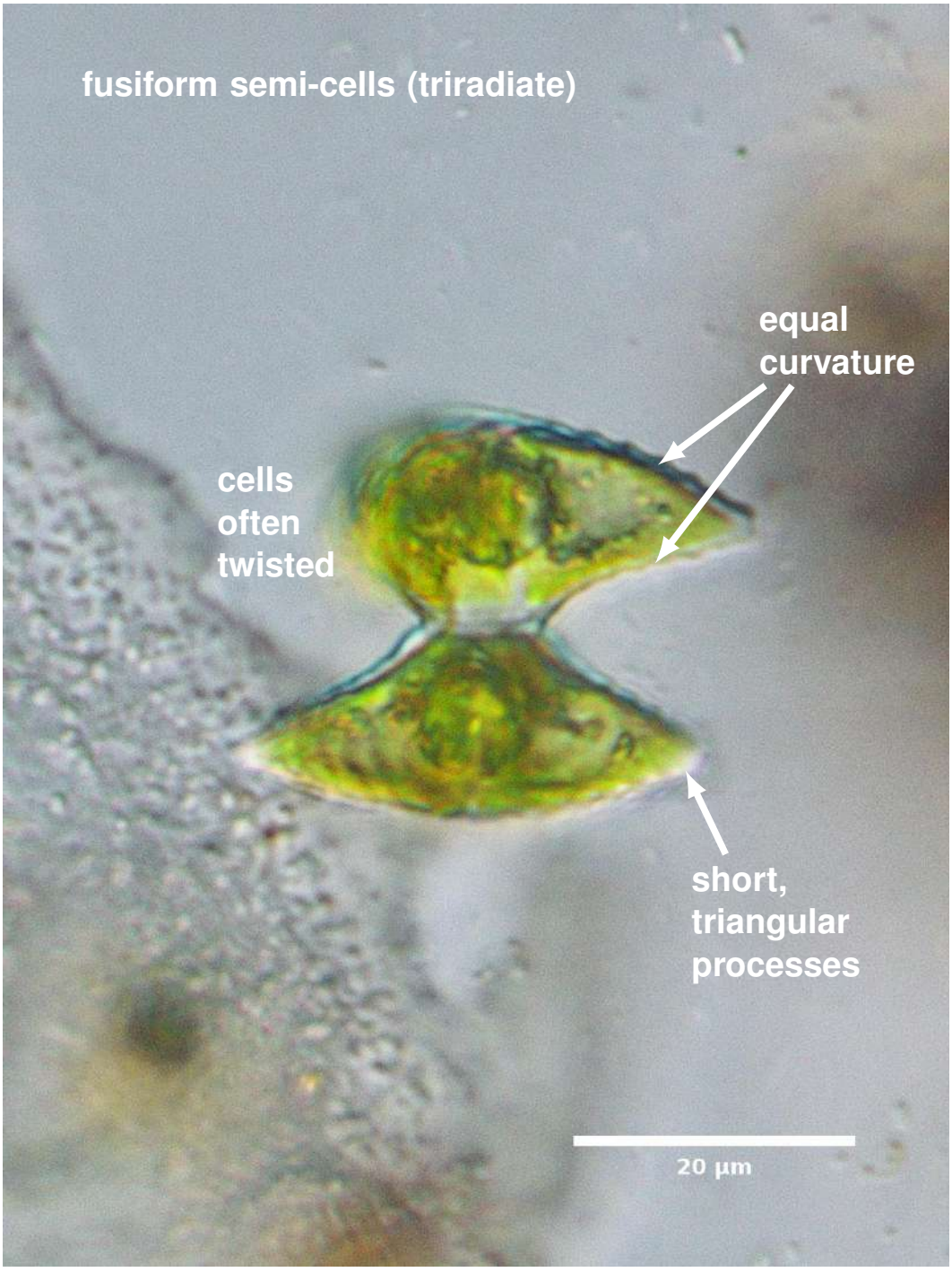


Figure 22.121: *Staurastrum hexacerum* (DIC), Vogler Lake, Skagit County.

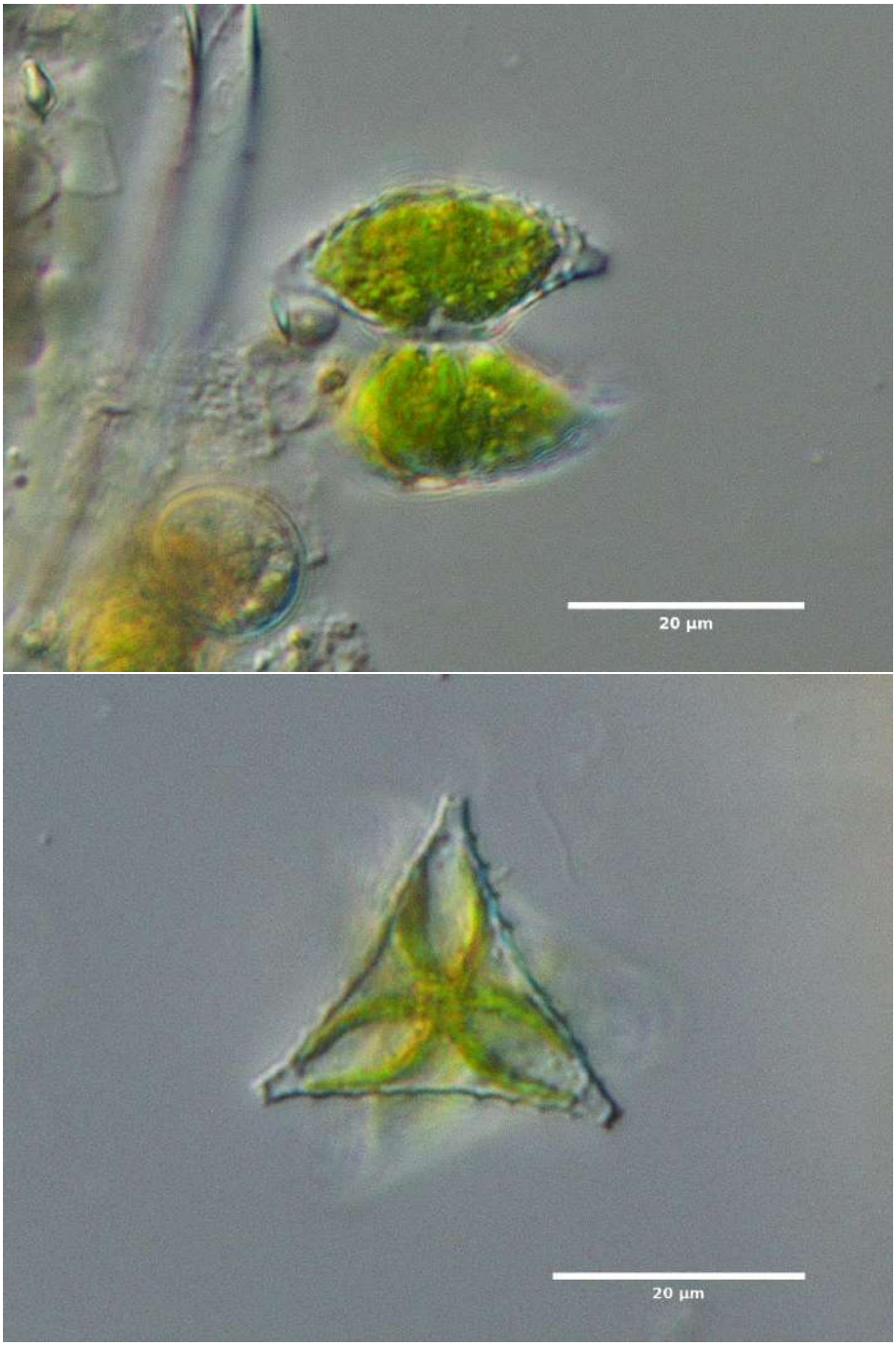


Figure 22.122: *Staurastrum hexacerum* (DIC/DIC), small residential pond, Skagit County (upper/lower images).

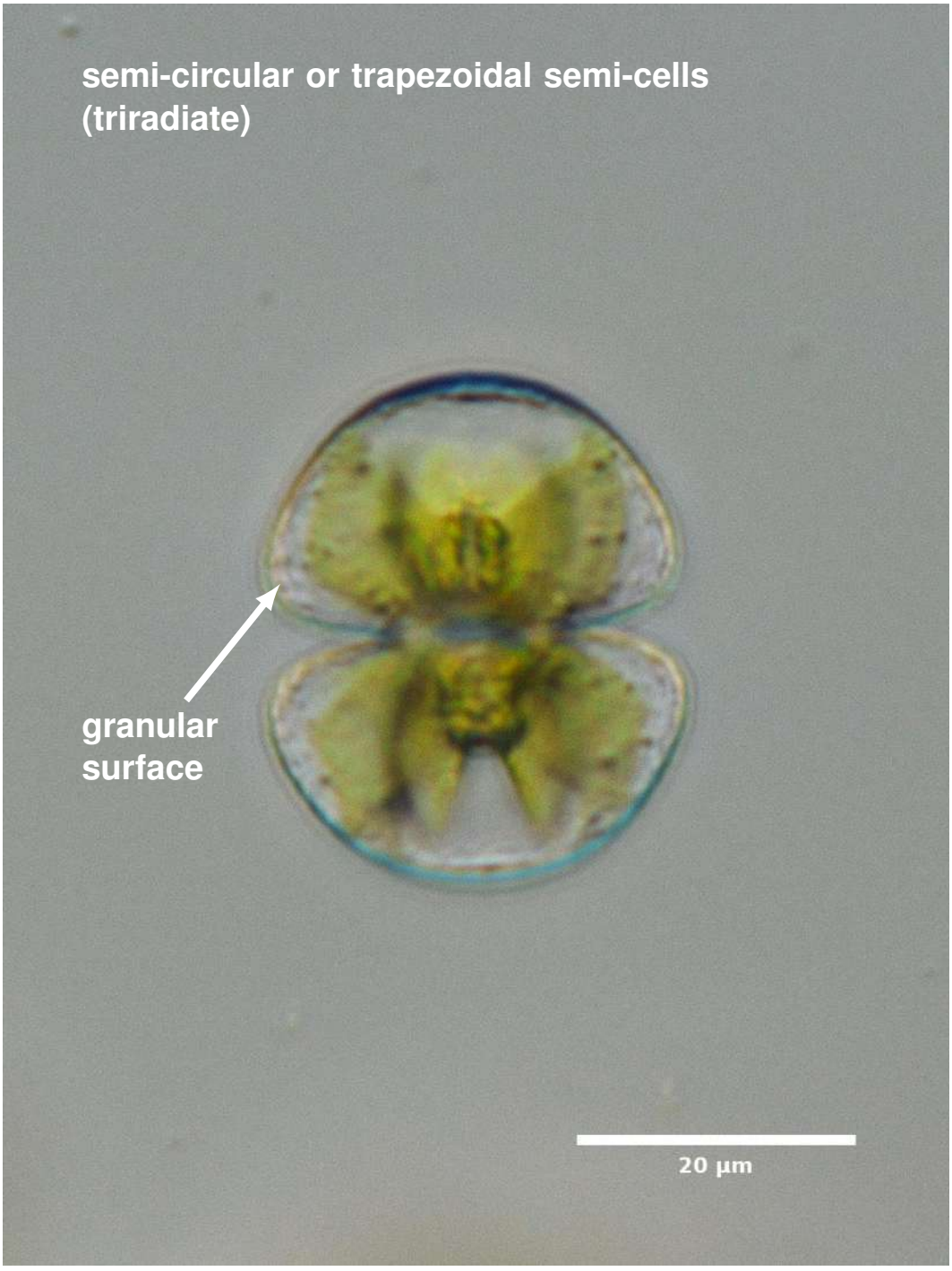


Figure 22.123: *Staurastrum hirsutum* var. *pseudarnellii* (DIC) tributary to Upper Anderson Lake, Mt. Baker area, Whatcom County.

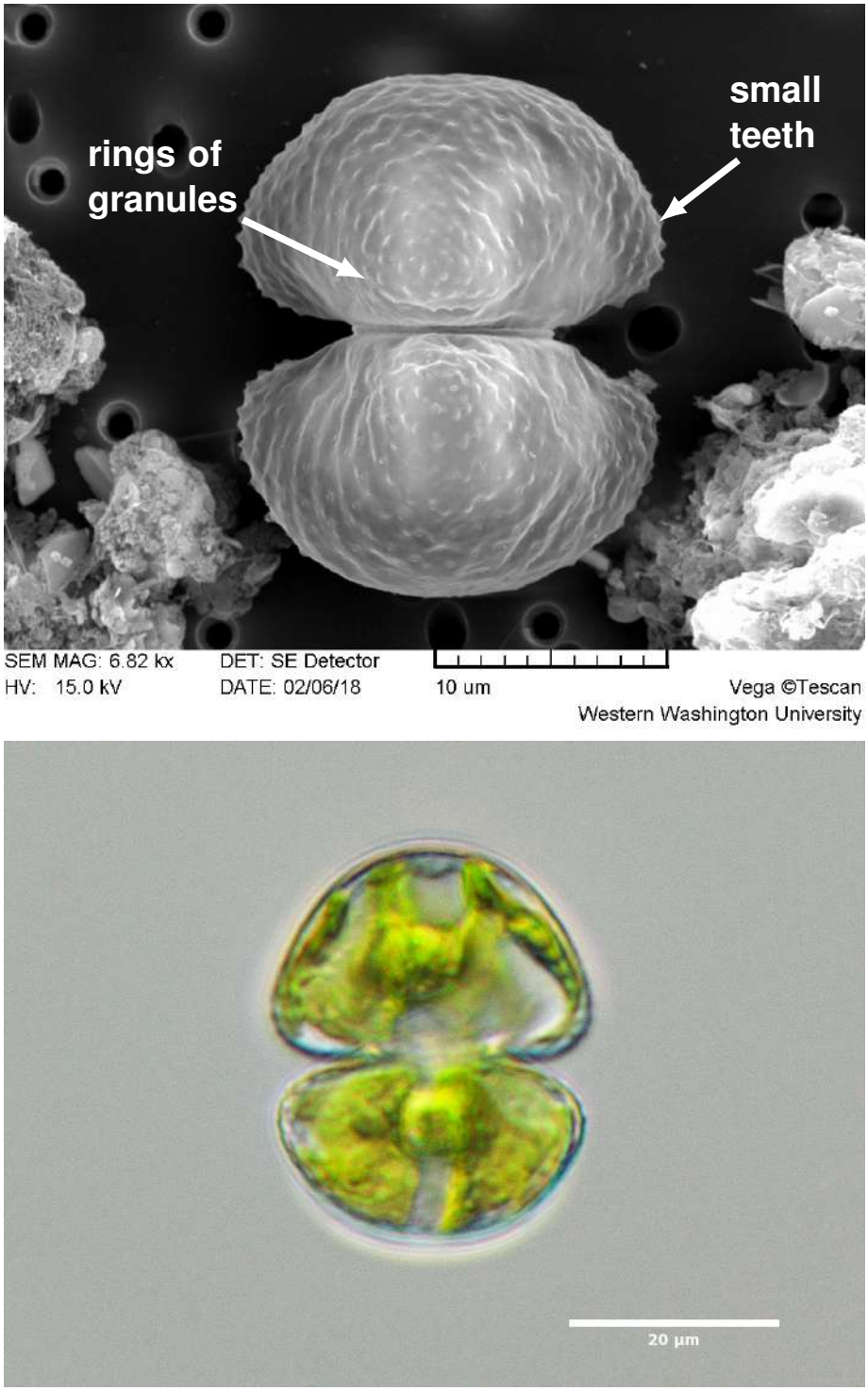


Figure 22.124: *Staurastrum hirsutum* var. *pseudarnellii* (SEM/DIC) tributary to Upper Anderson Lake, Mt. Baker area, Whatcom County (upper/lower images).



Figure 22.125: *Staurastrum hirsutum* var. *pseudarnellii* (DIC/DIC) tributary to Upper Anderson Lake, Mt. Baker area, Whatcom County (upper/lower images).

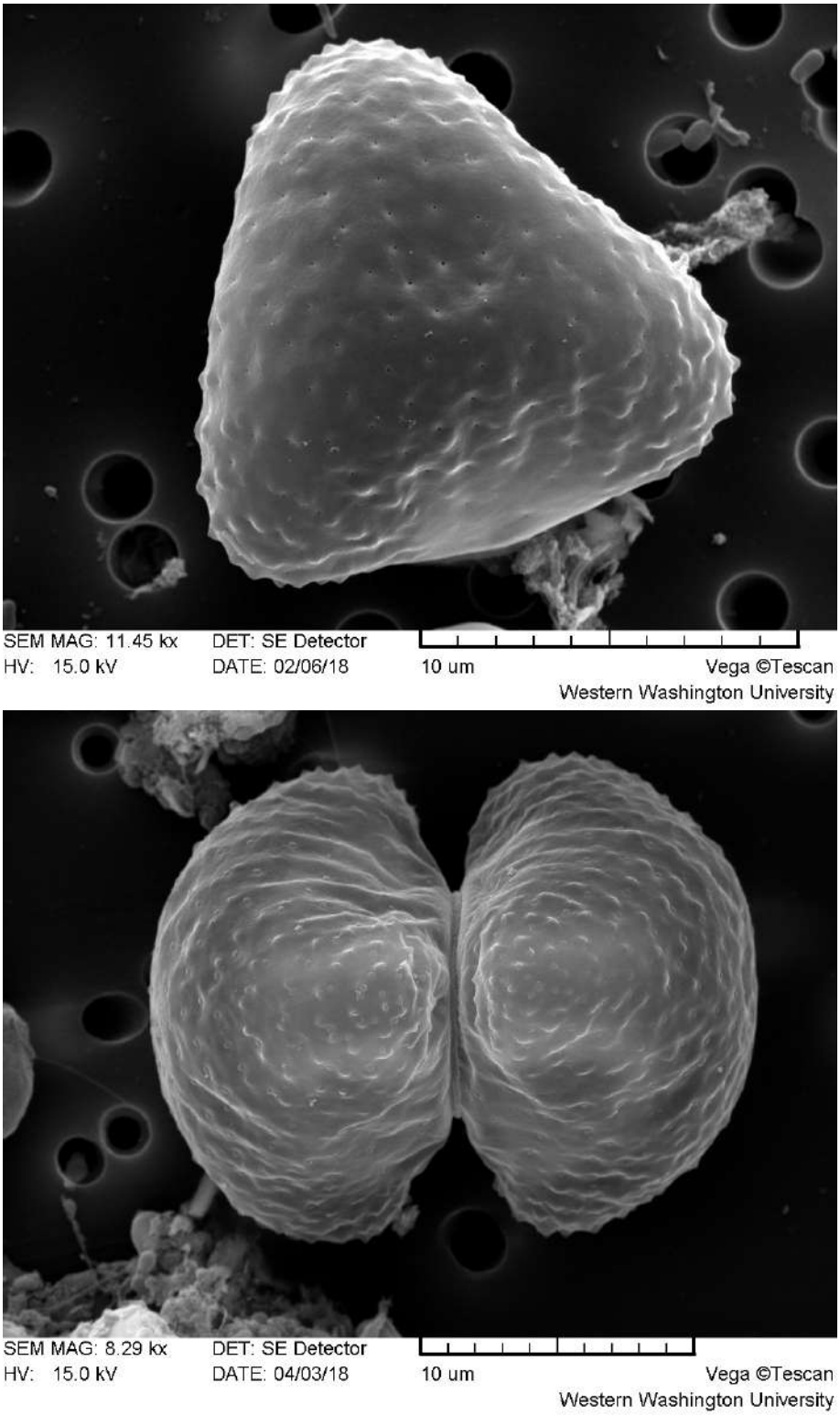


Figure 22.126: *Staurastrum hirsutum* var. *pseudarnellii* (SEM/SEM) tributary to Upper Anderson Lake, Mt. Baker area, Whatcom County (upper/lower images).

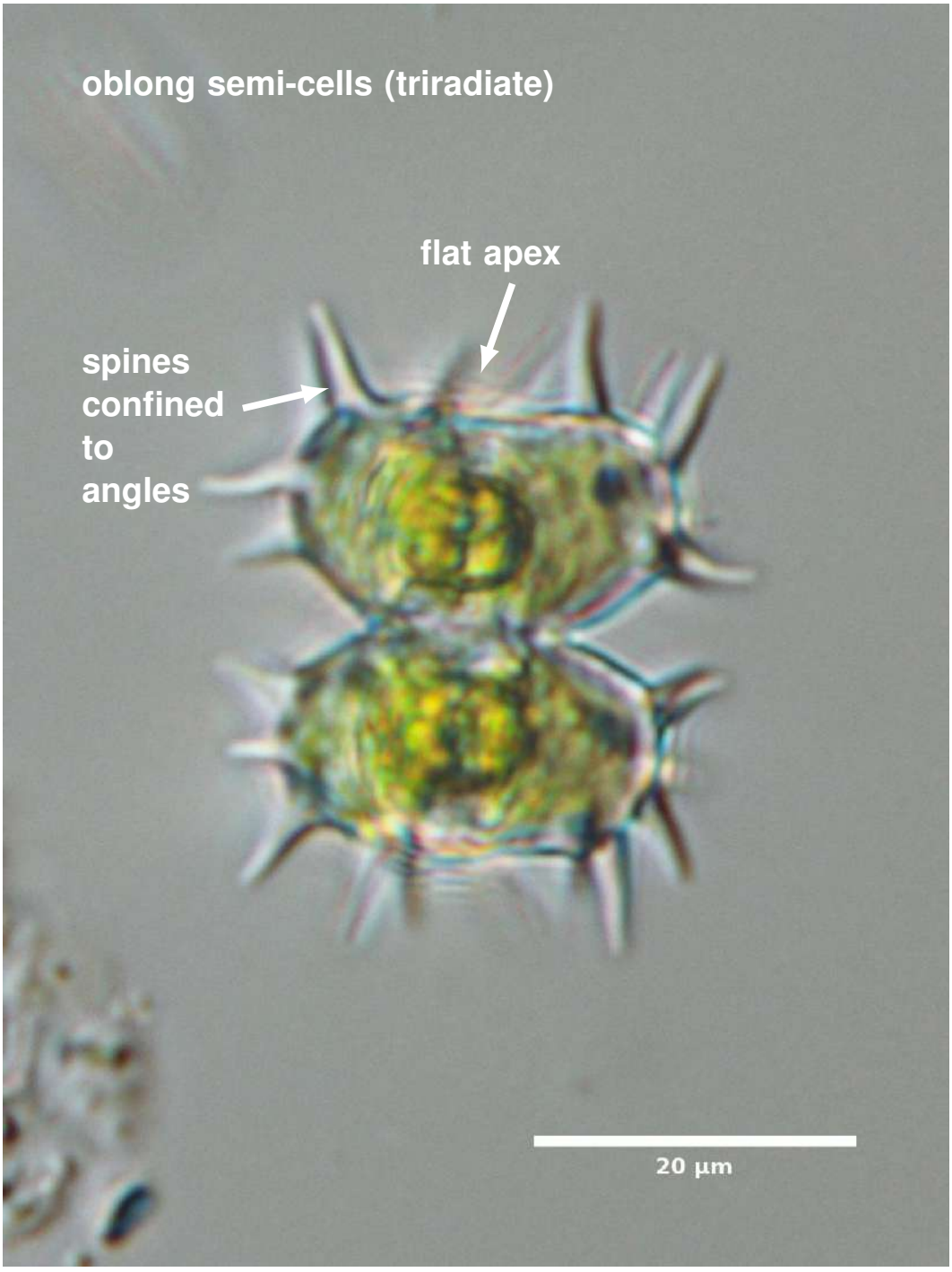


Figure 22.127: *Staurastrum hystrix* (DIC) Island Lake, Mountain Loop Highway, Snohomish County.

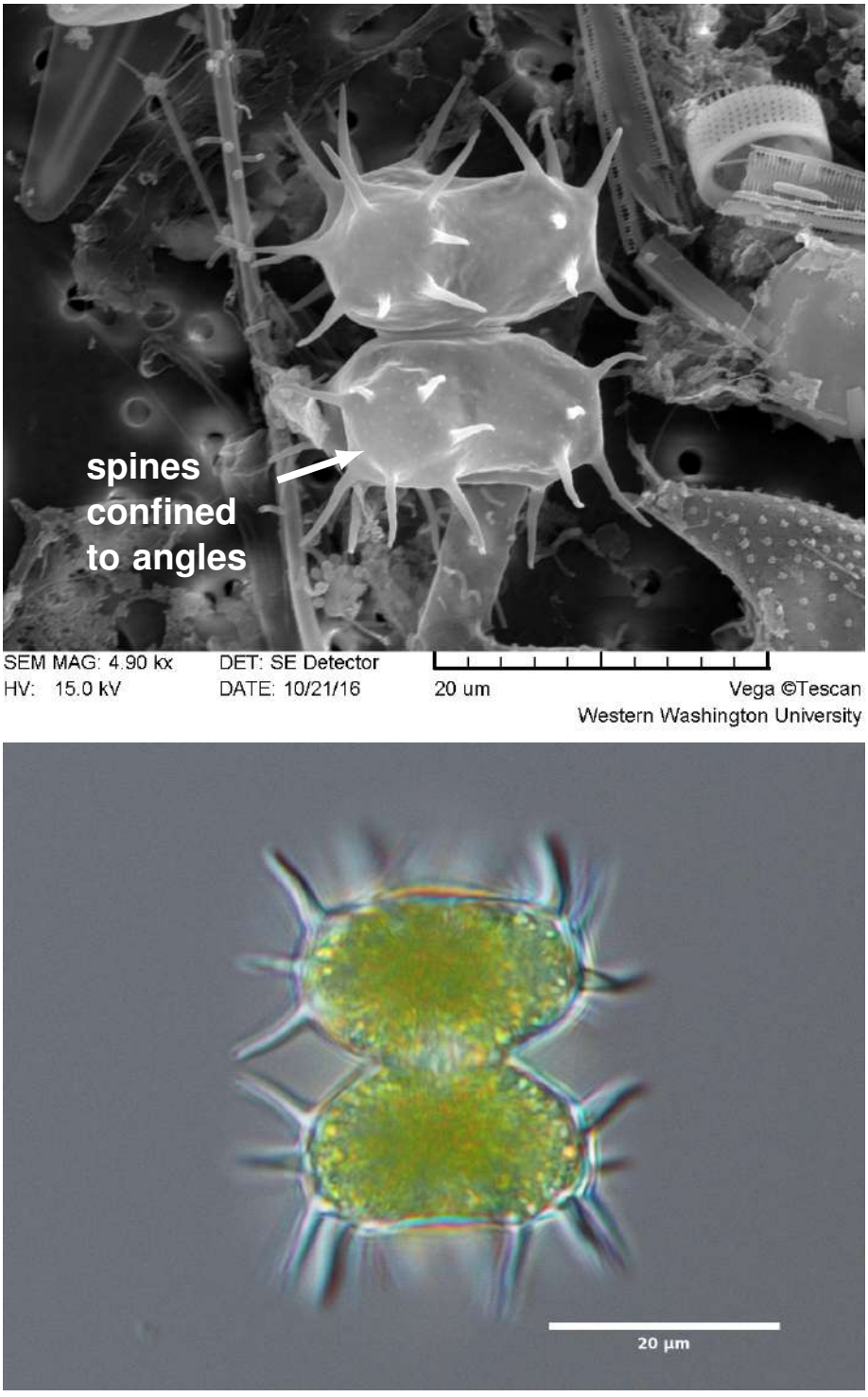


Figure 22.128: *Staurastrum hystrix* (SEM/DIC) Bear Lake, Mountain Loop Highway, Snohomish County (upper/lower images).

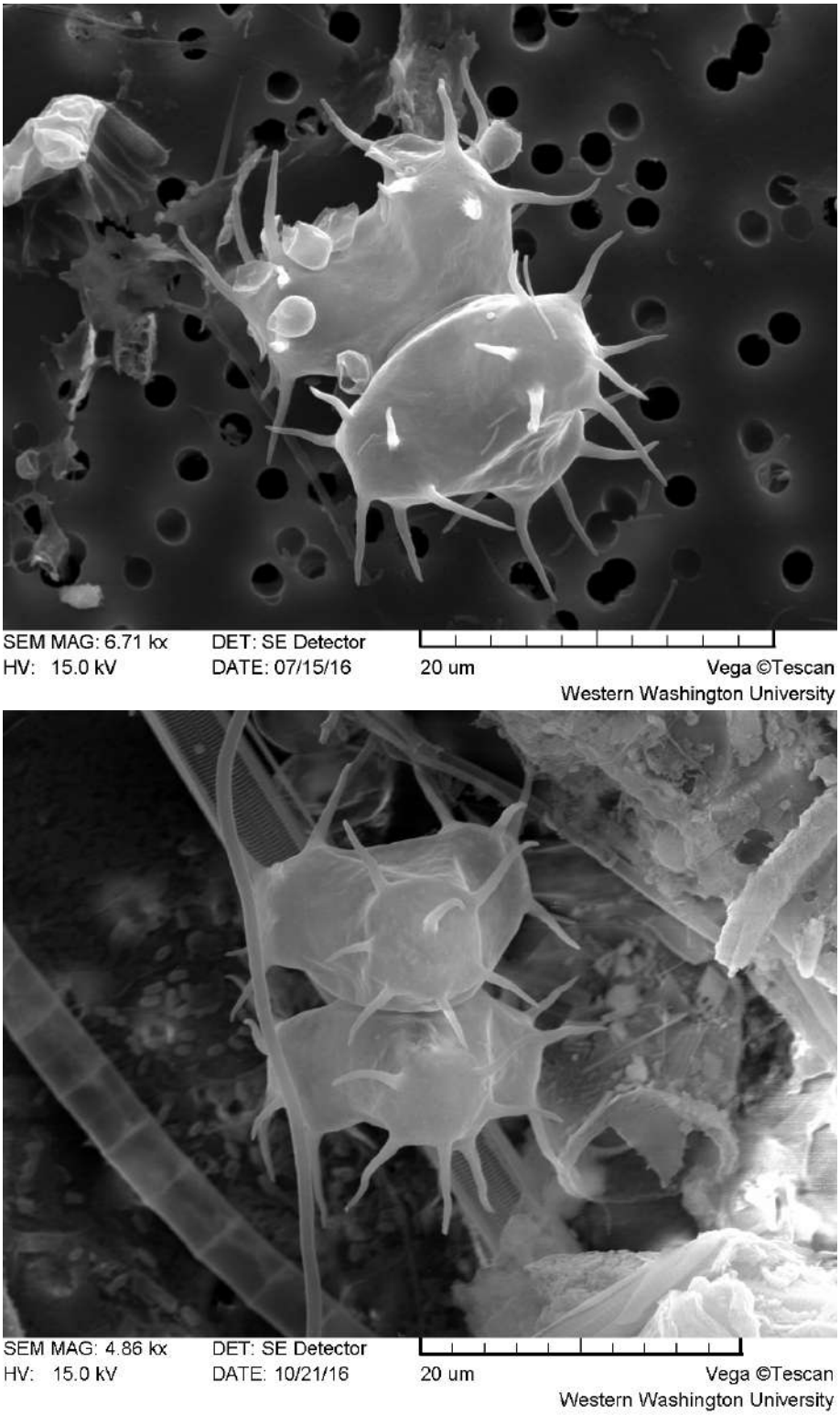


Figure 22.129: *Staurastrum hystrix* (SEM/SEM) Bear Lake, Mountain Loop Highway, Snohomish County (upper/lower images).

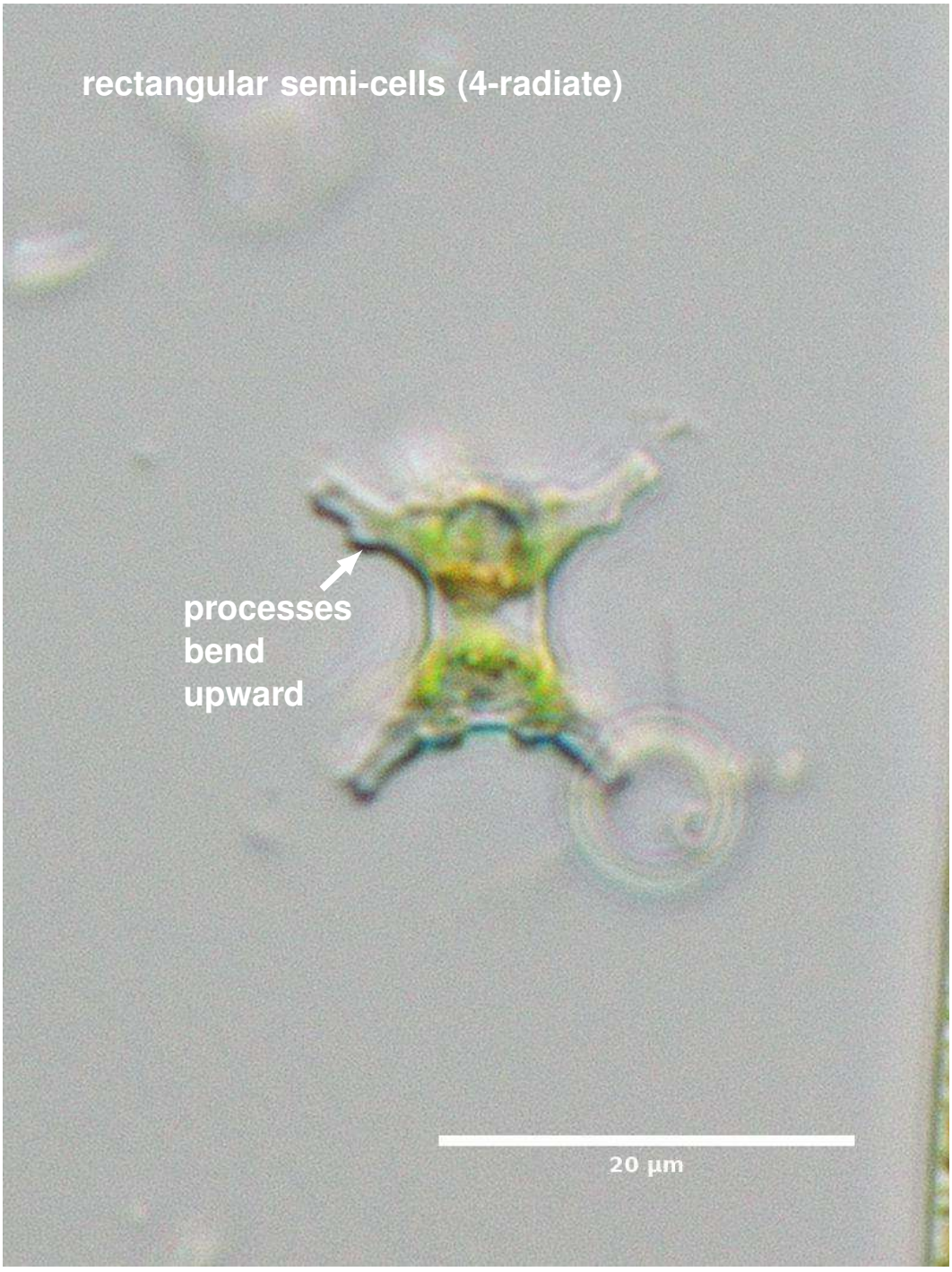


Figure 22.130: *Staurastrum inconspicuum* (DIC) Lake Evan, Mountain Loop Highway, Snohomish County.

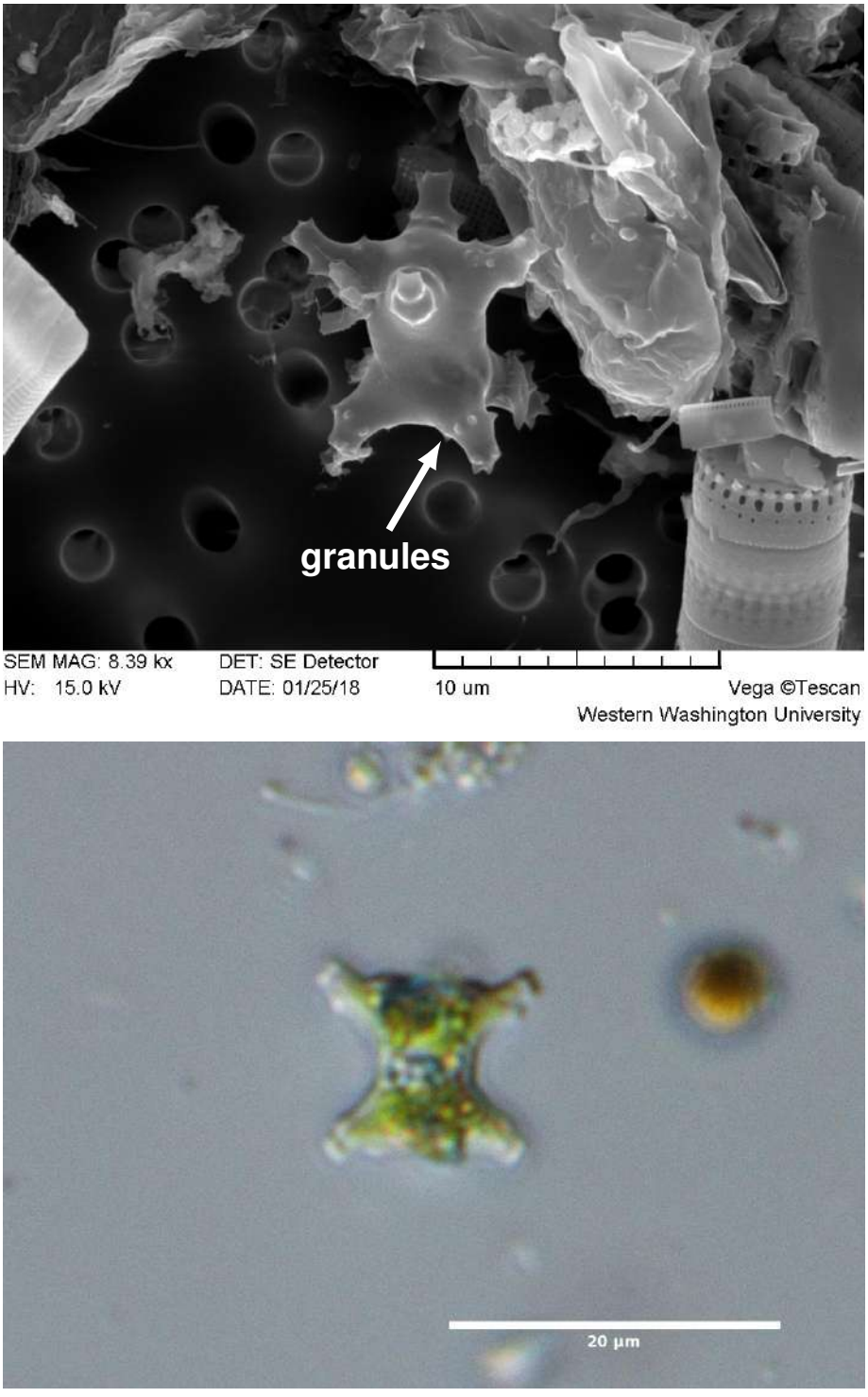


Figure 22.131: *Staurastrum inconspicuum* (SEM/DIC) Lake Evan, Mountain Loop Highway, Snohomish County (upper/lower images).

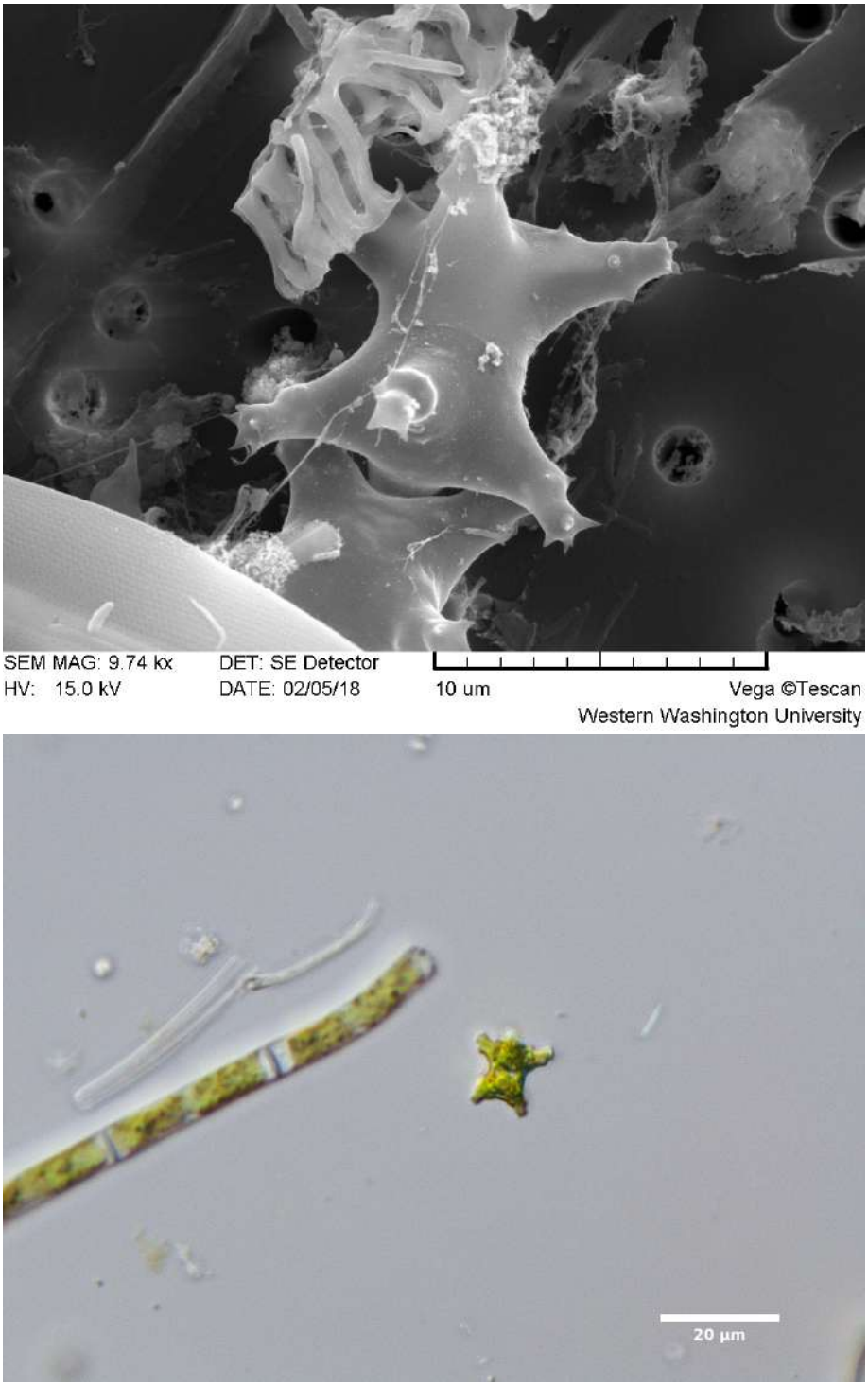


Figure 22.132: *Staurastrum inconspicuum* (SEM/DIC) Bear Lake, Mountain Loop Highway, Snohomish County (upper/lower images).

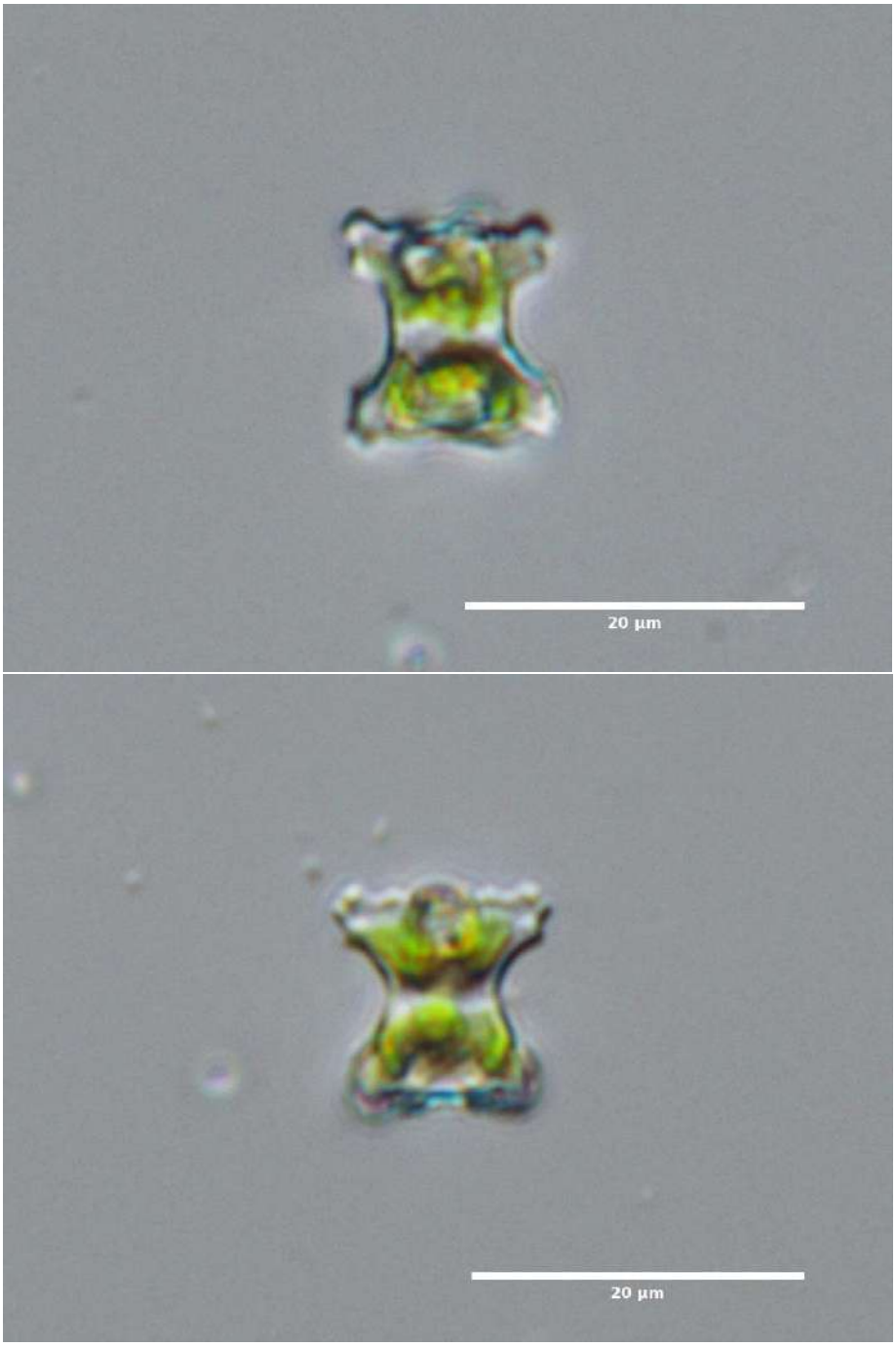


Figure 22.133: *Staurastrum inconspicuum* (DIC/DIC) seep on trail to Lower Ashland Lake, Mountain Loop Highway, Snohomish County (upper/lower images).

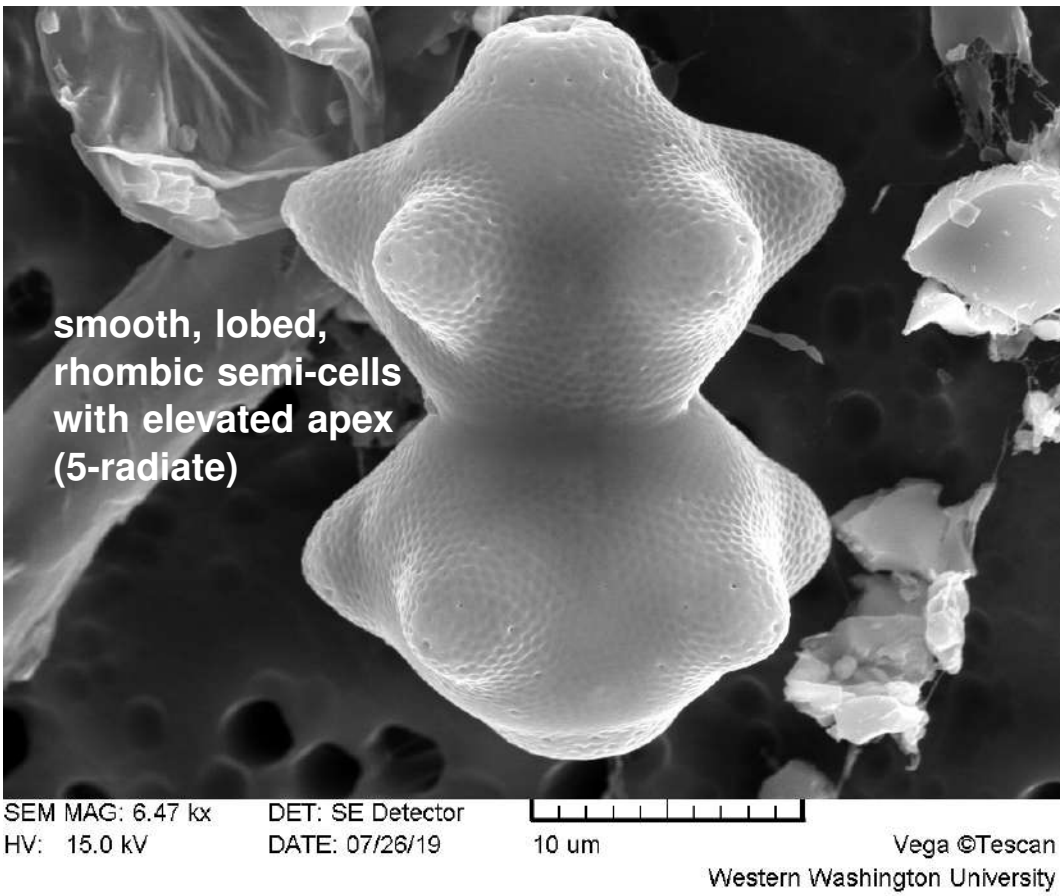


Figure 22.134: *Staurastrum insigne* (SEM) Chain Lake, Gifford Pinchot National Forest, Skamania County.

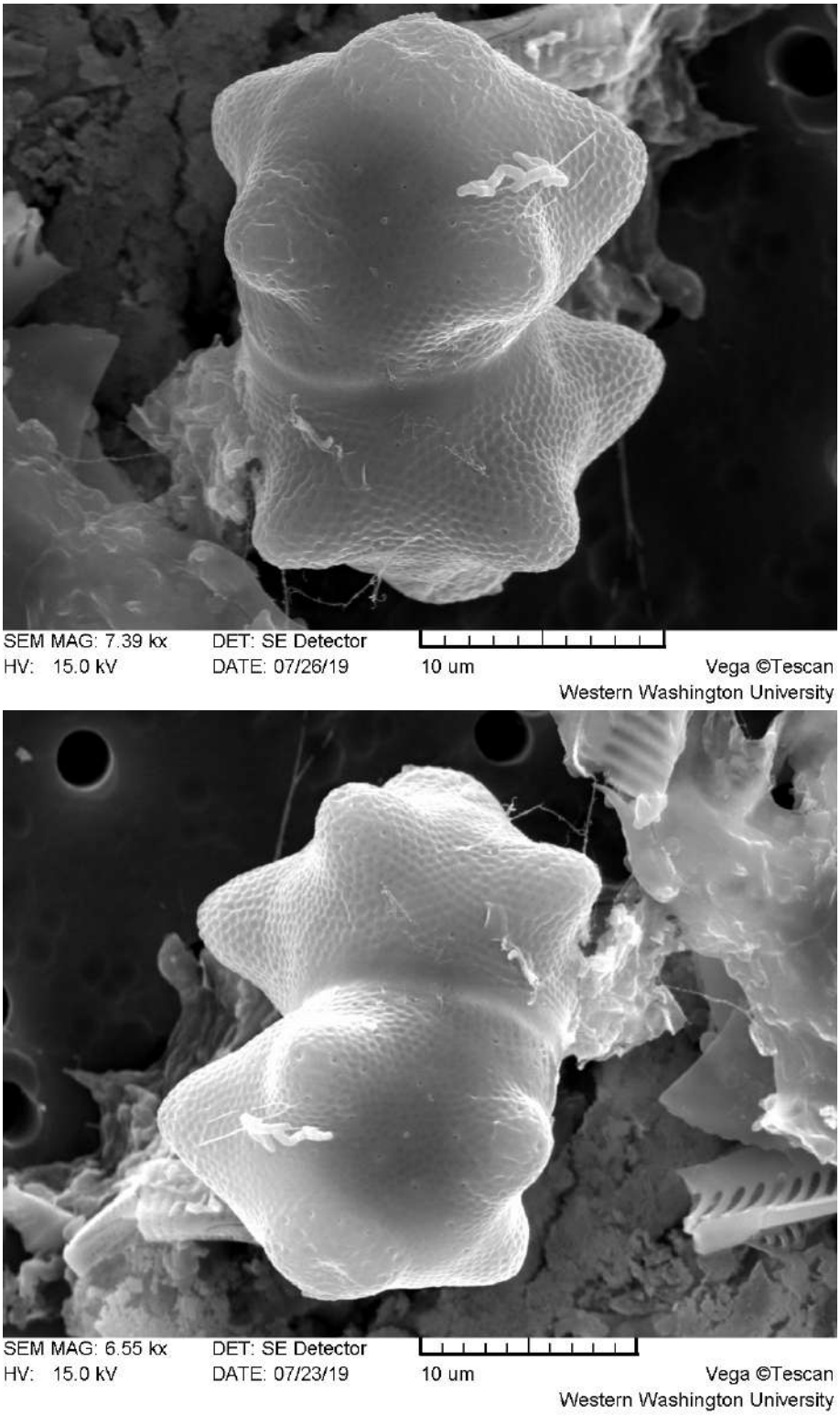


Figure 22.135: *Staurastrum insigne* (SEM/SEM) Chain Lake, Gifford Pinchot National Forest, Skamania County (upper/lower images).

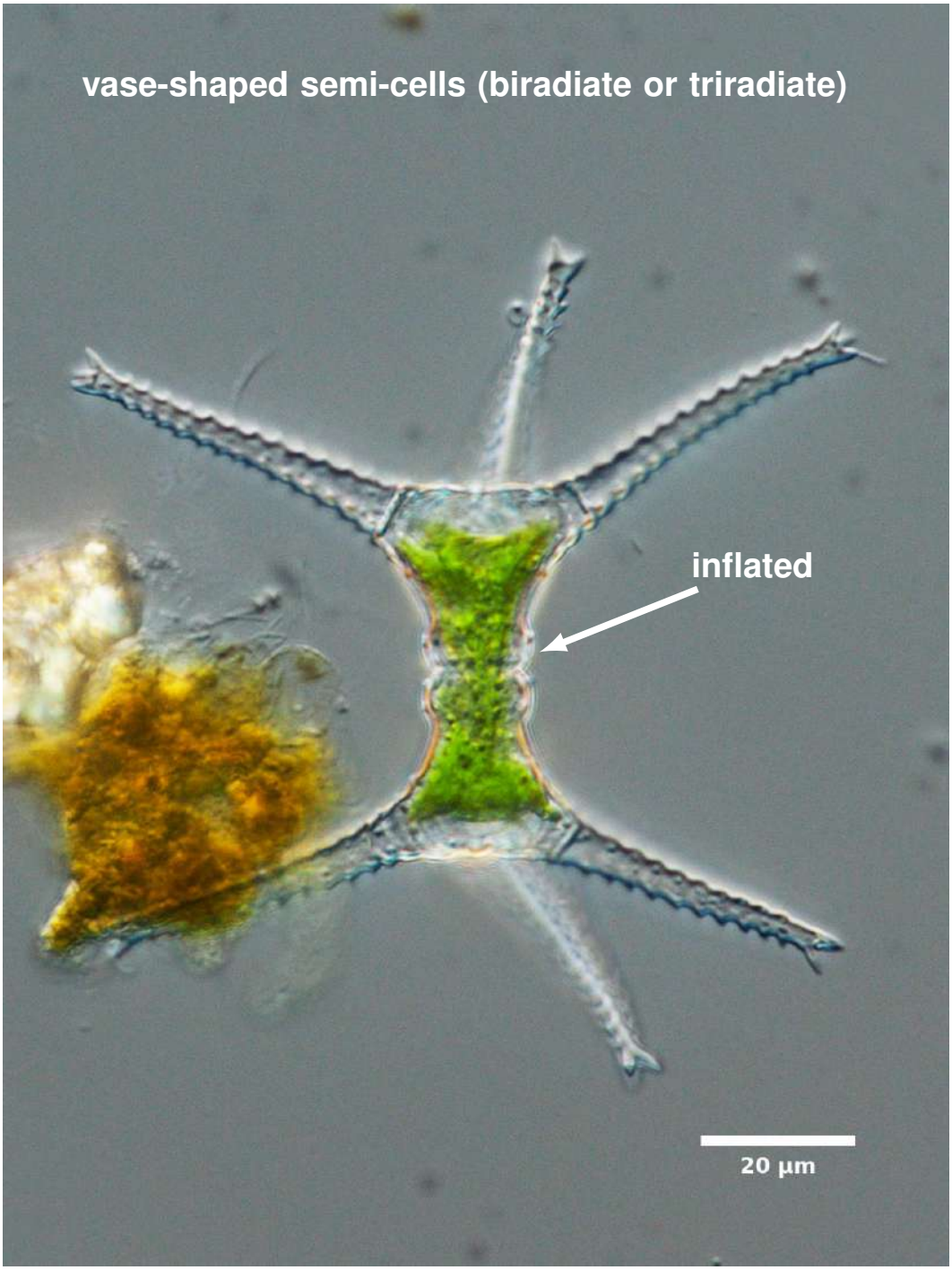


Figure 22.136: *Staurastrum johnsonii* (DIC), Big Lake, Skagit County.

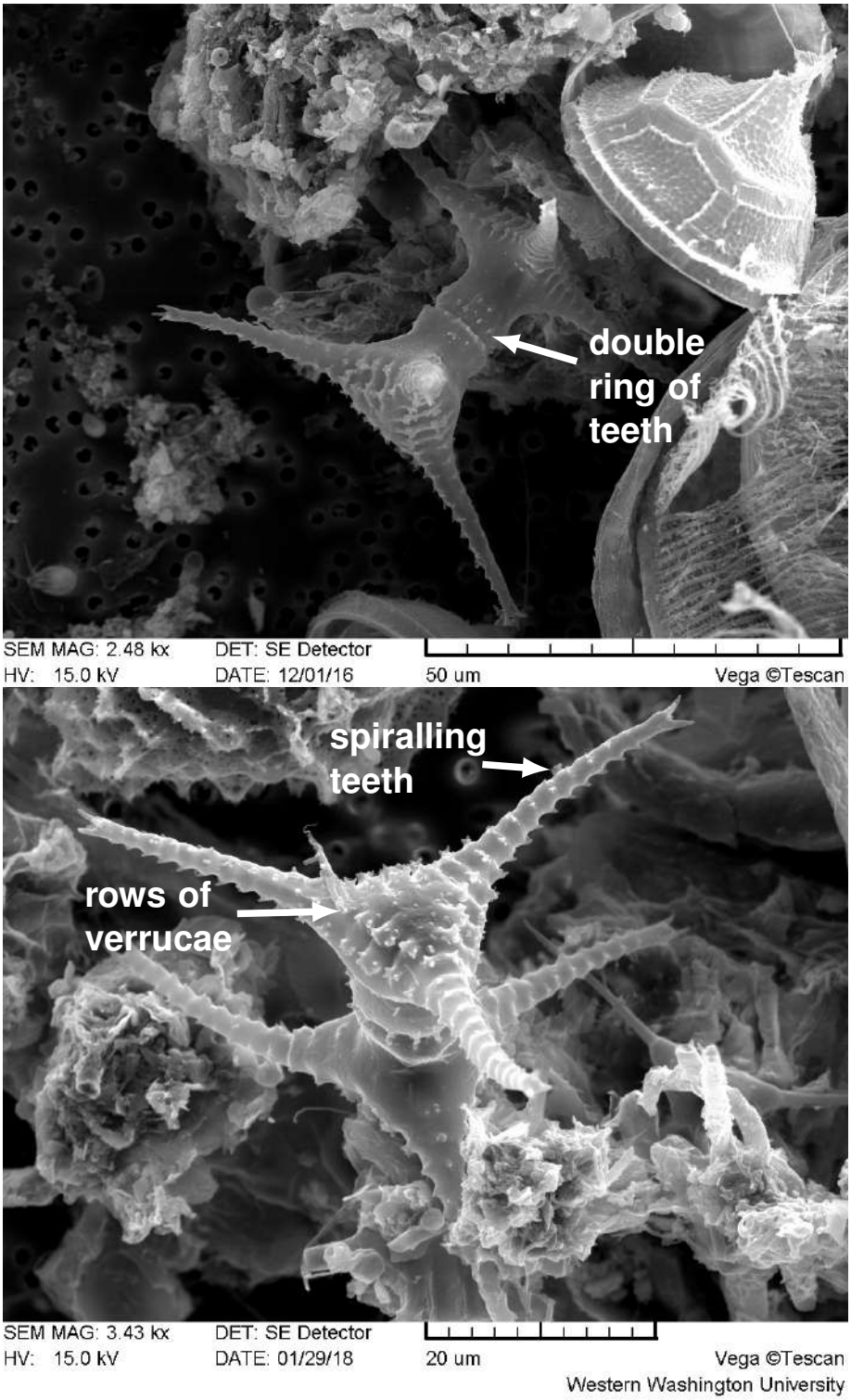


Figure 22.137: *Staurastrum johnsonii* (SEM/SEM), Vogler Lake, Skagit County (upper/lower images).

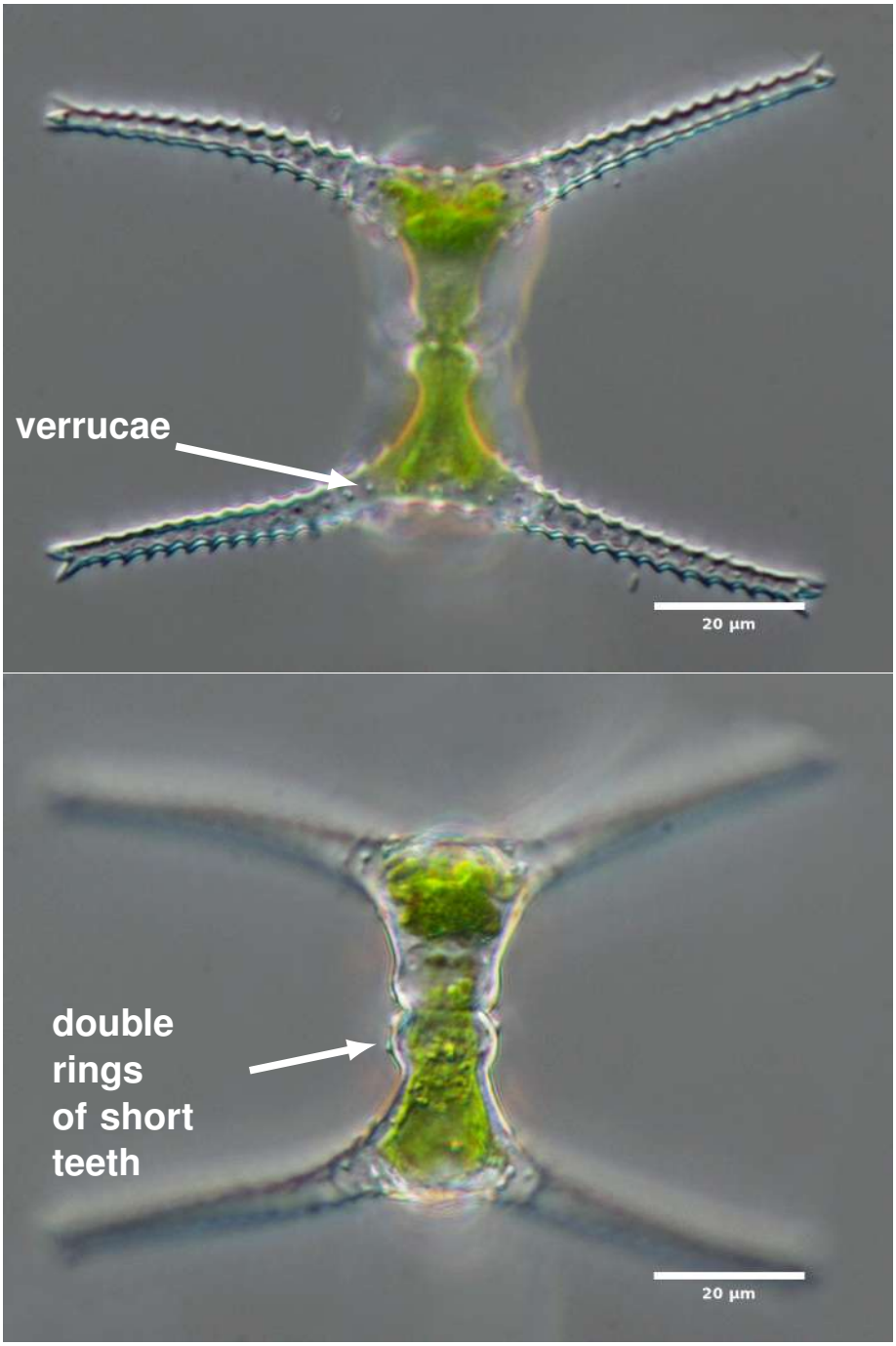


Figure 22.138: *Staurastrum johnsonii* (DIC/DIC), Big Lake, Skagit County (upper/lower images).

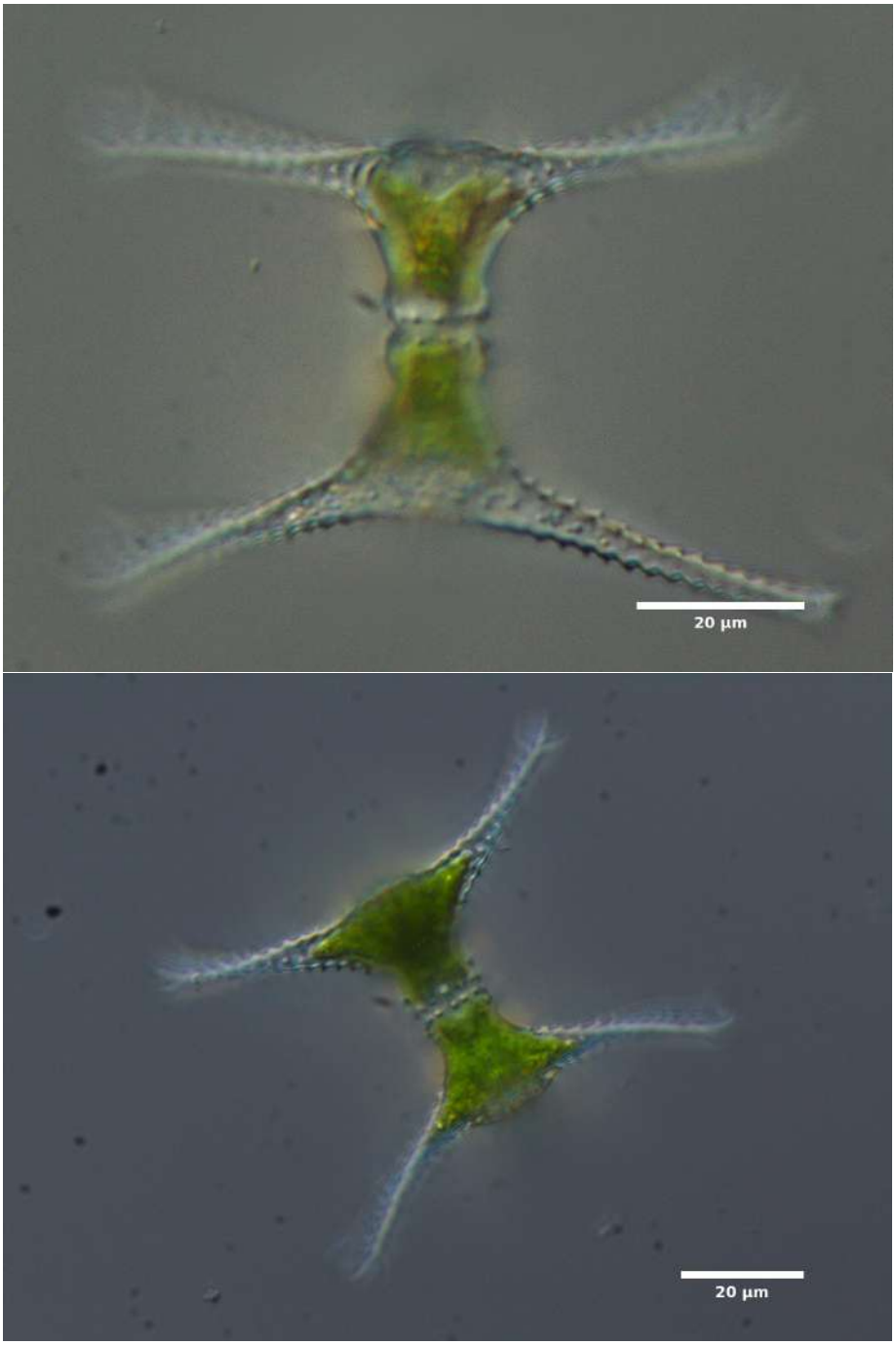


Figure 22.139: *Staurastrum johnsonii* (DIC/DIC), Big Lake, Skagit County (upper image); Vogler Lake, Skagit County (lower image).



Figure 22.140: *Staurastrum kurilense* (DIC), Chain Lake, Gifford Pinchot National Forest, Skamania County.

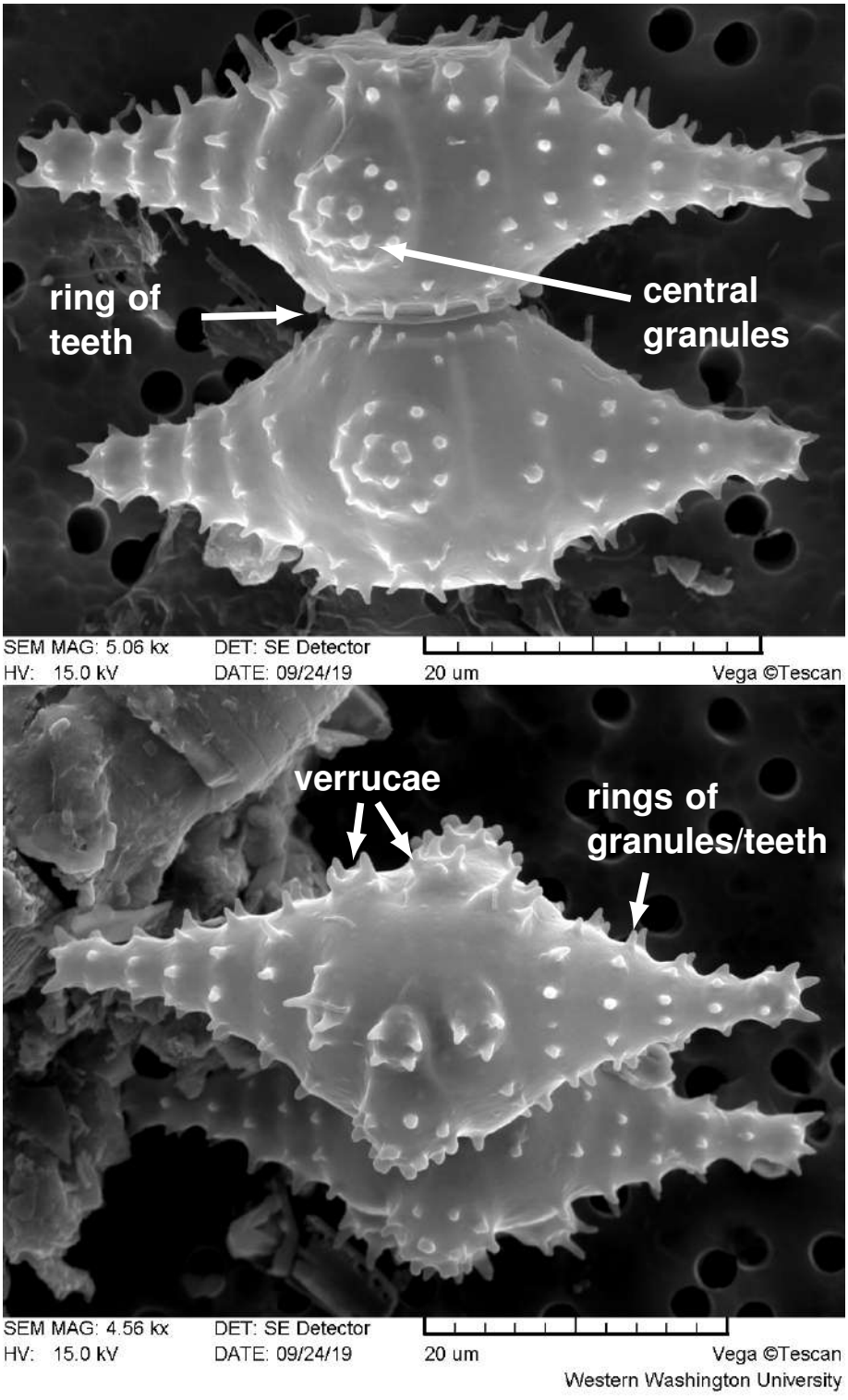


Figure 22.141: *Staurastrum kurilense* (SEM/SEM), Chain Lake, Gifford Pinchot National Forest, Skamania County (upper/lower images).



Figure 22.142: *Staurastrum kurilense* (DIC/DIC), Lower Lower Anderson Lake, Mt. Baker area, Whatcom County (upper/lower images).



Figure 22.143: *Staurastrum kurilense* side view (DIC), Lower Anderson Lake, Mt. Baker area, Whatcom County.



Figure 22.144: *Staurastrum laeve* (DIC) small boggy pond on Morris Valley Road near Harrison BC.

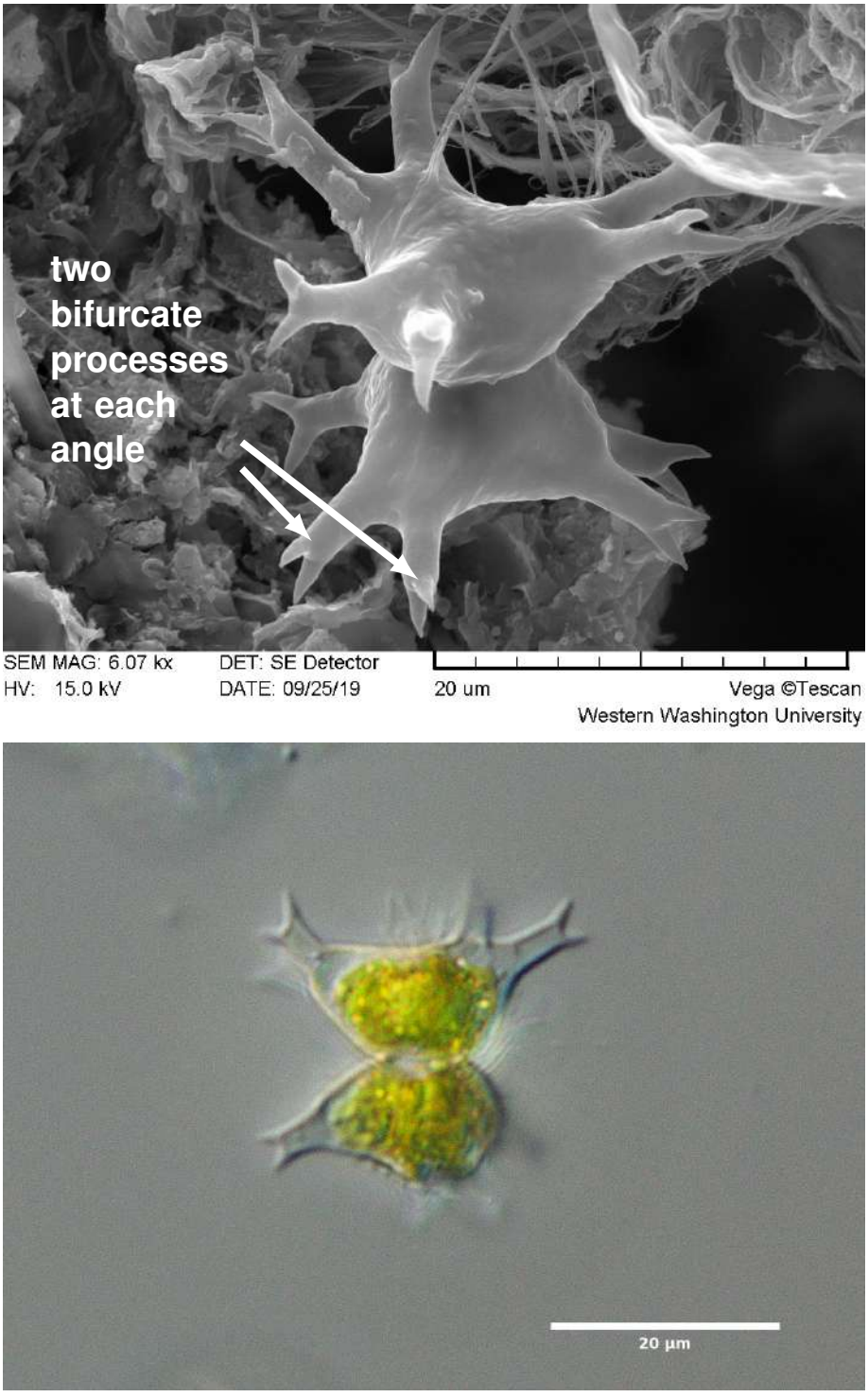


Figure 22.145: *Staurastrum laeve* (SEM/DIC) small boggy pond on Morris Valley Road near Harrison BC (upper/lower images).

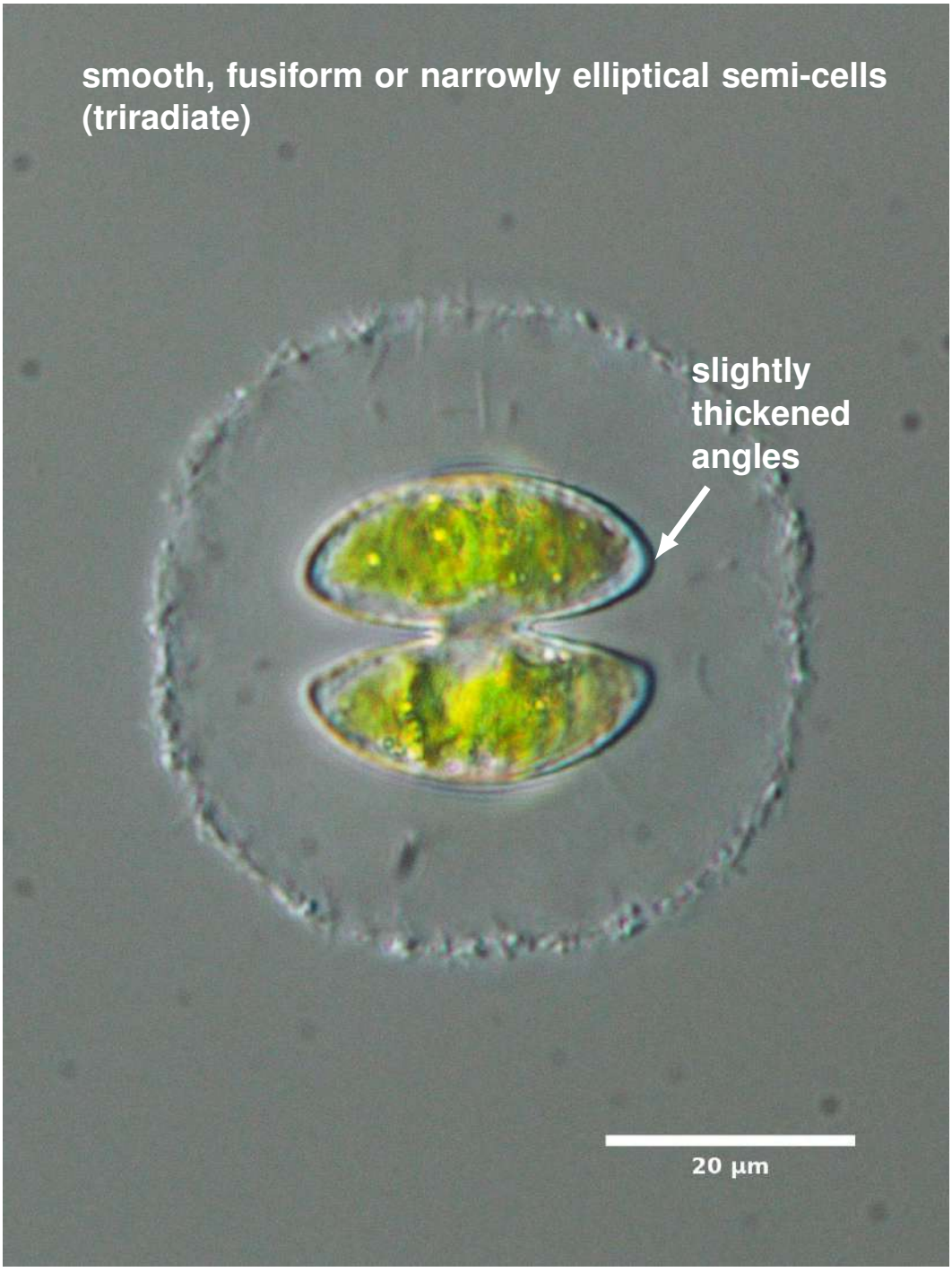


Figure 22.146: *Staurastrum lanceolatum* var. *compressum* (DIC) Picture Lake, Mt. Baker area, Whatcom County.

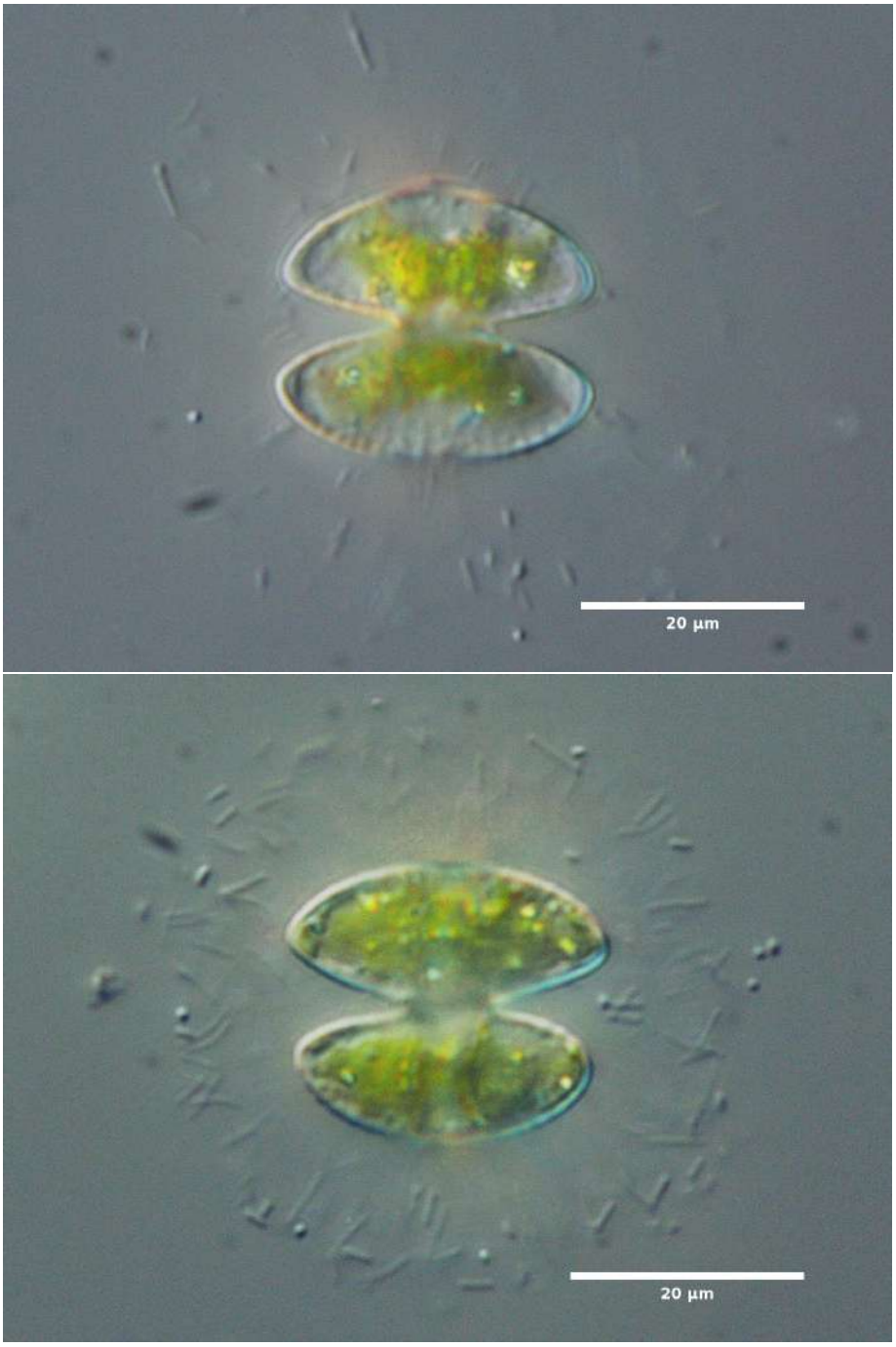


Figure 22.147: *Staurastrum lanceolatum* var. *compressum* (DIC/DIC) Picture Lake, Mt. Baker area, Whatcom County (upper/lower images).

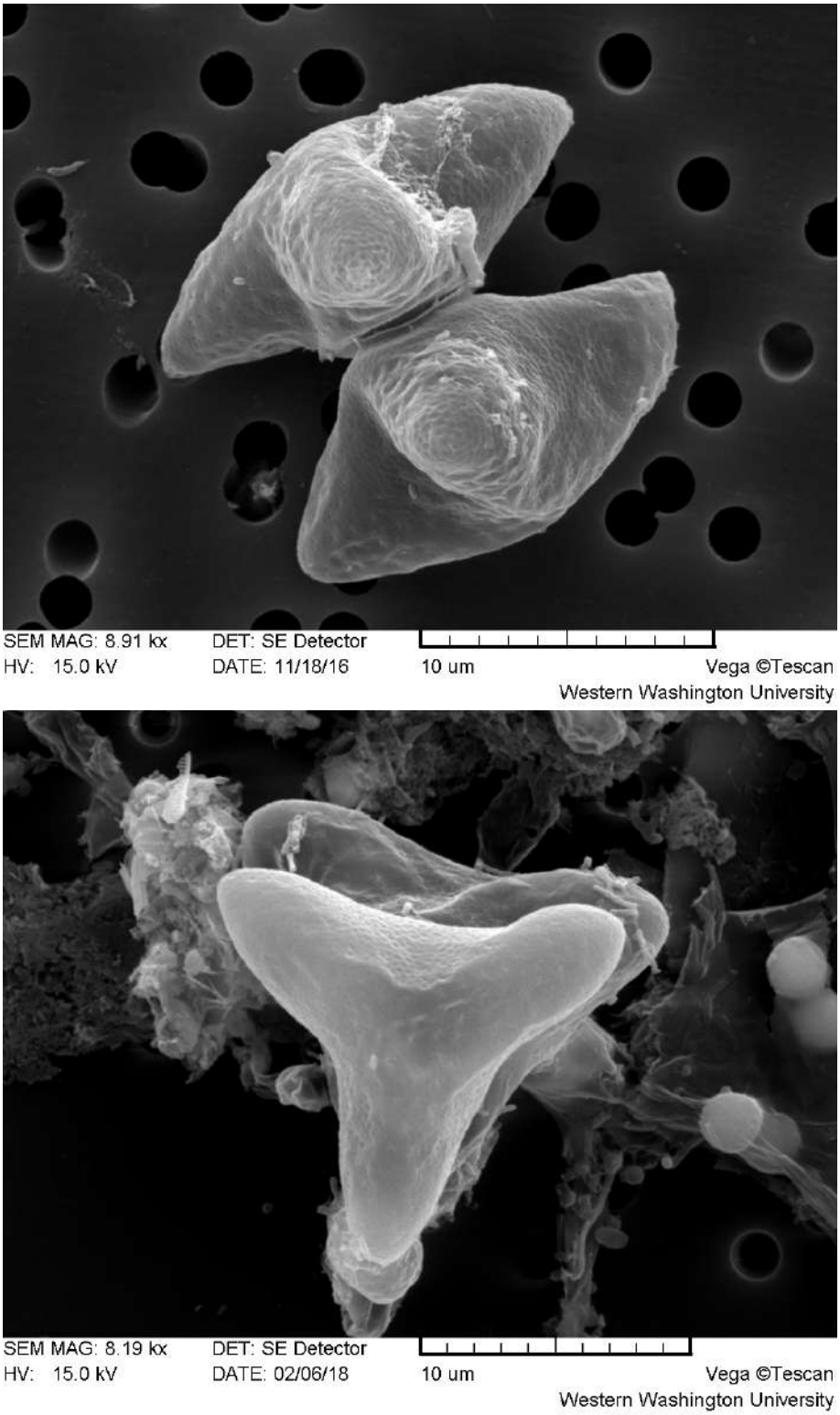


Figure 22.148: *Staurastrum lanceolatum* var. *compressum* (SEM/SEM) Picture Lake, Mt. Baker area, Whatcom County (upper/lower images).

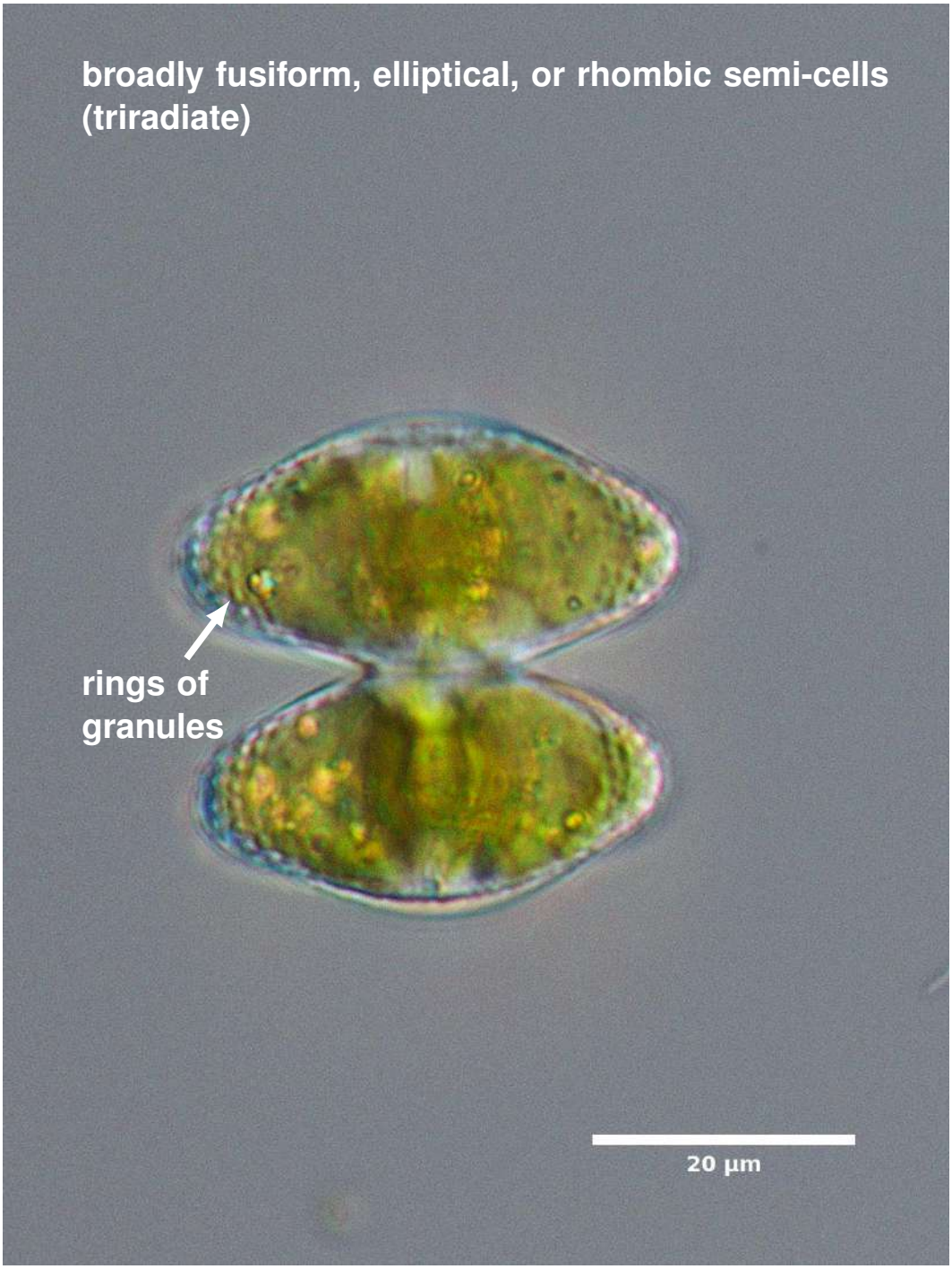


Figure 22.149: *Staurastrum lapponicum* (DIC), Lake Twenty-two, Mountain Loop Highway, Snohomish County.

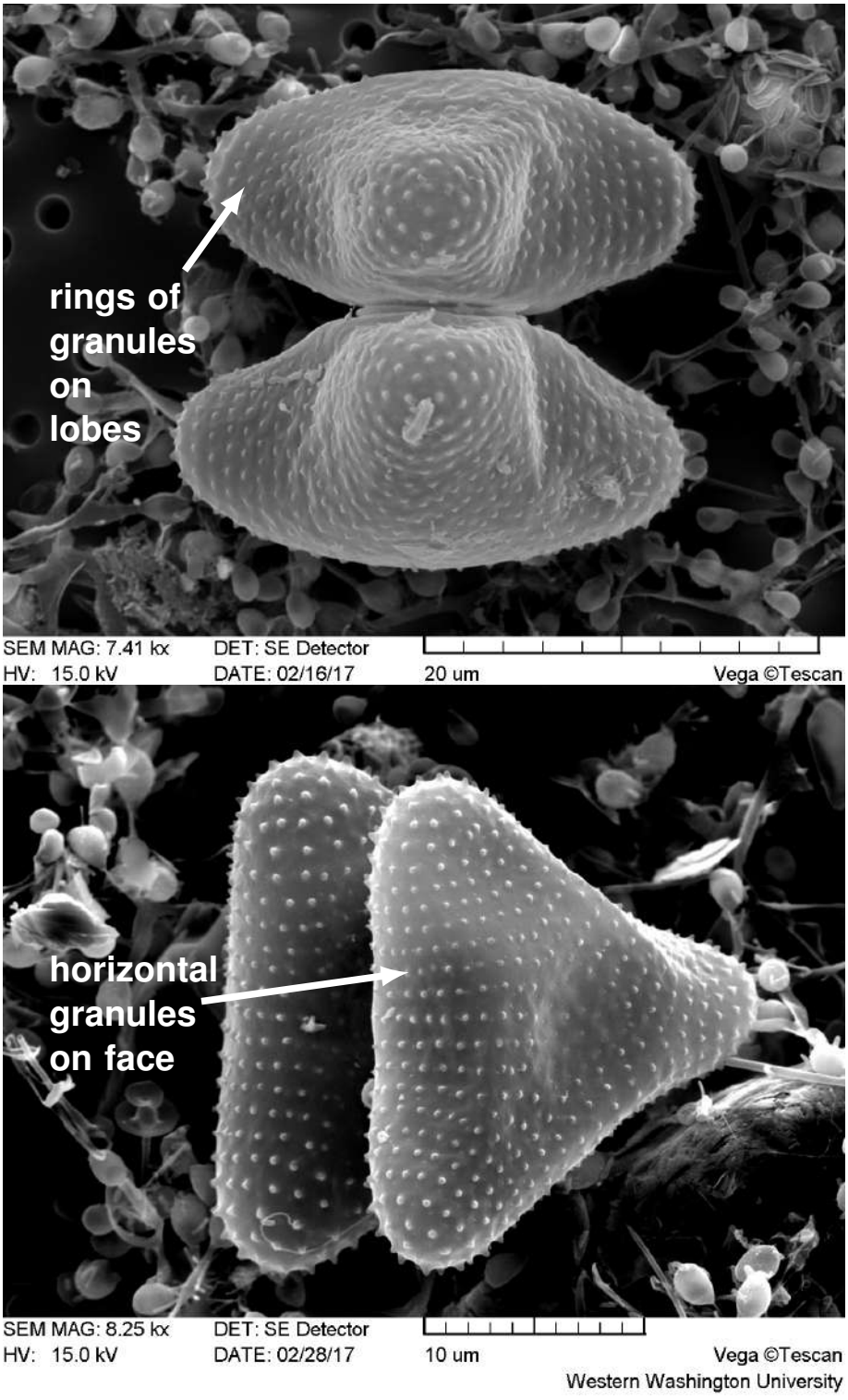


Figure 22.150: *Staurastrum lapponicum* (SEM/SEM), Sunrise Lake, Mt. Baker area, Whatcom County (upper/lower images).



Figure 22.151: *Staurastrum lapponicum* (DIC/DIC), Sunrise Lake, Mt. Baker area, Whatcom County (upper/lower images).

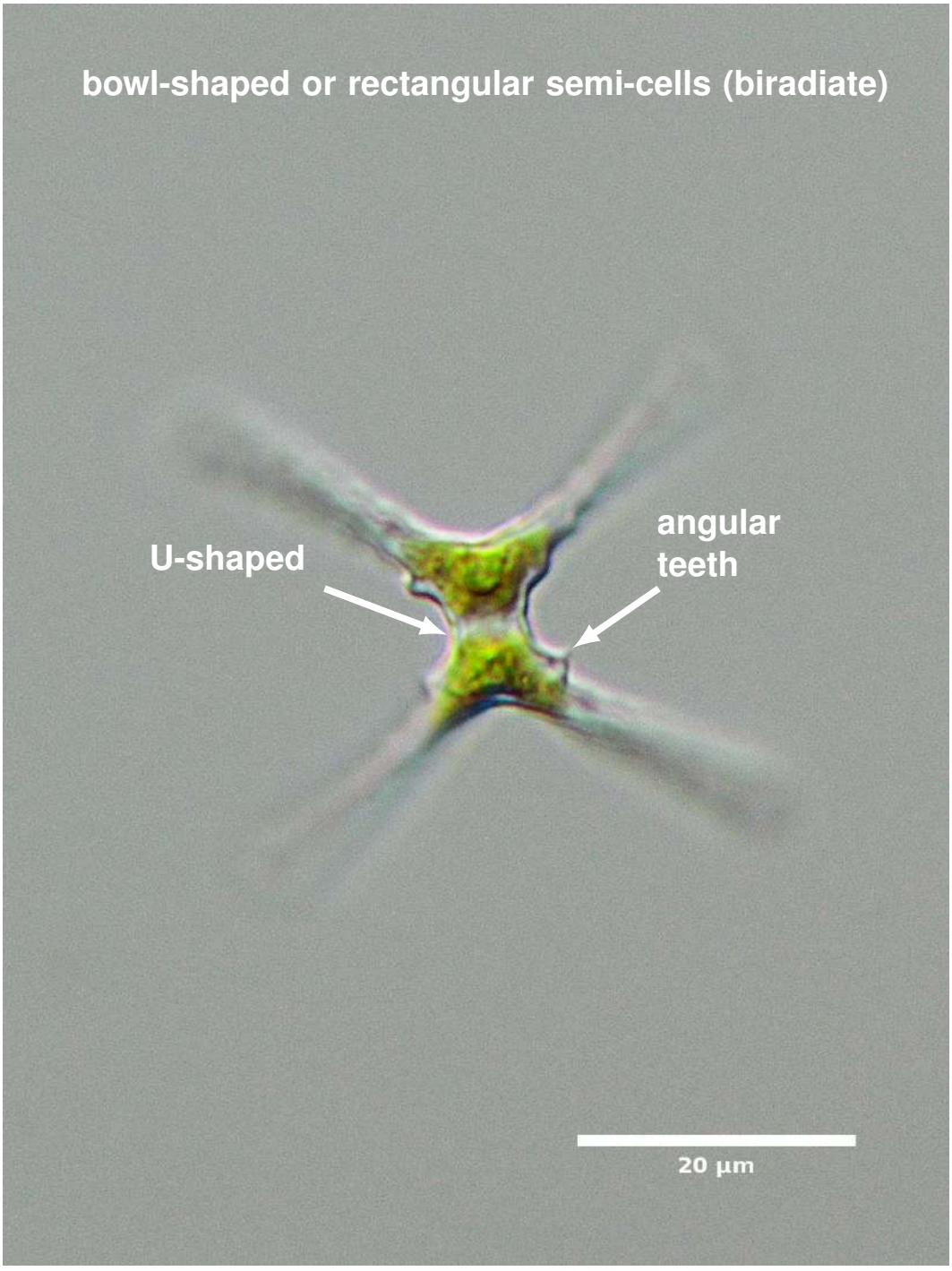


Figure 22.152: *Staurastrum lenzenwegeri* (DIC), Moses Lake (eastern Washington), Grant County.

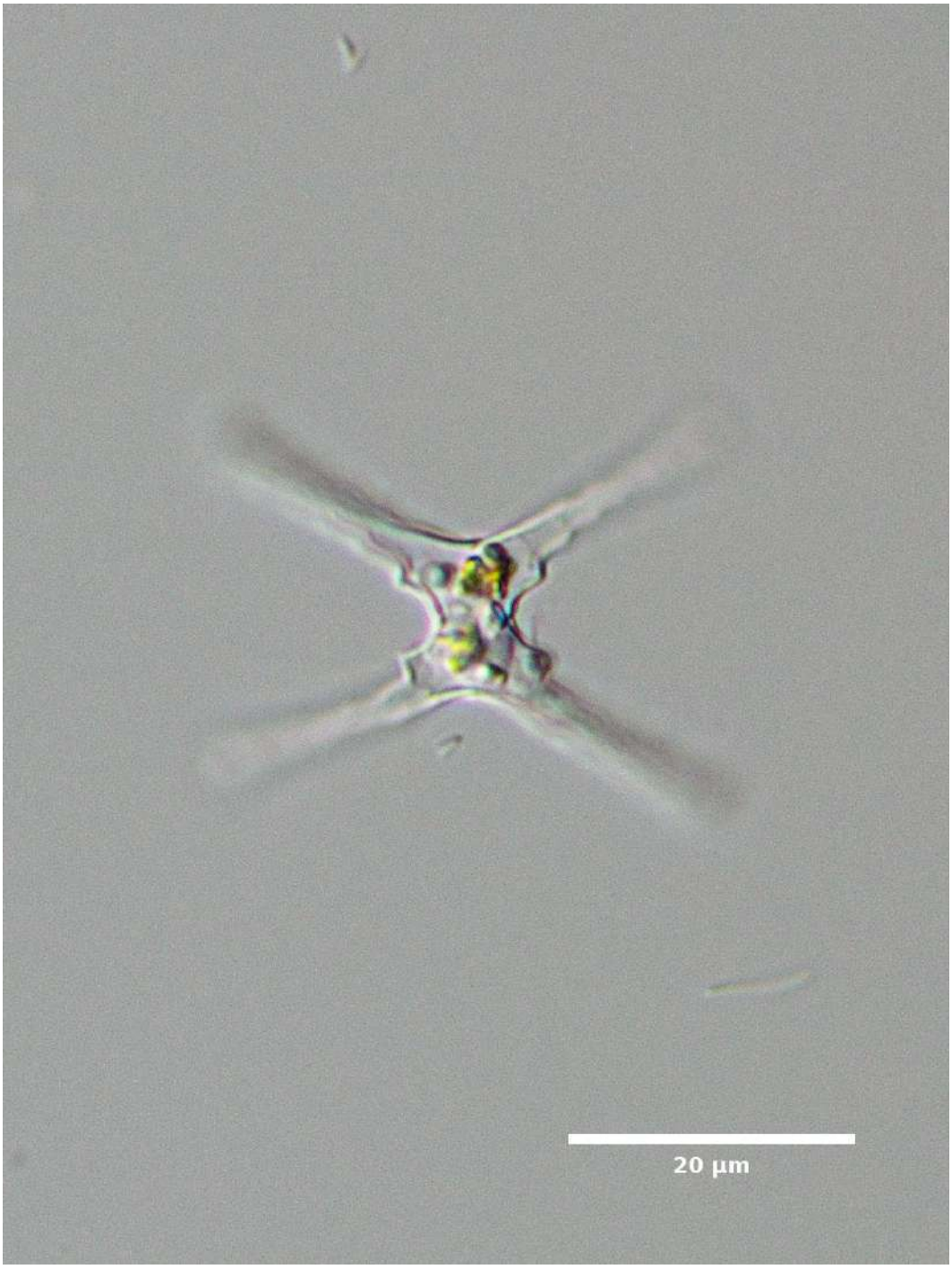


Figure 22.153: *Staurastrum lenzenwegeri* (DIC), Moses Lake (eastern Washington), Grant County.

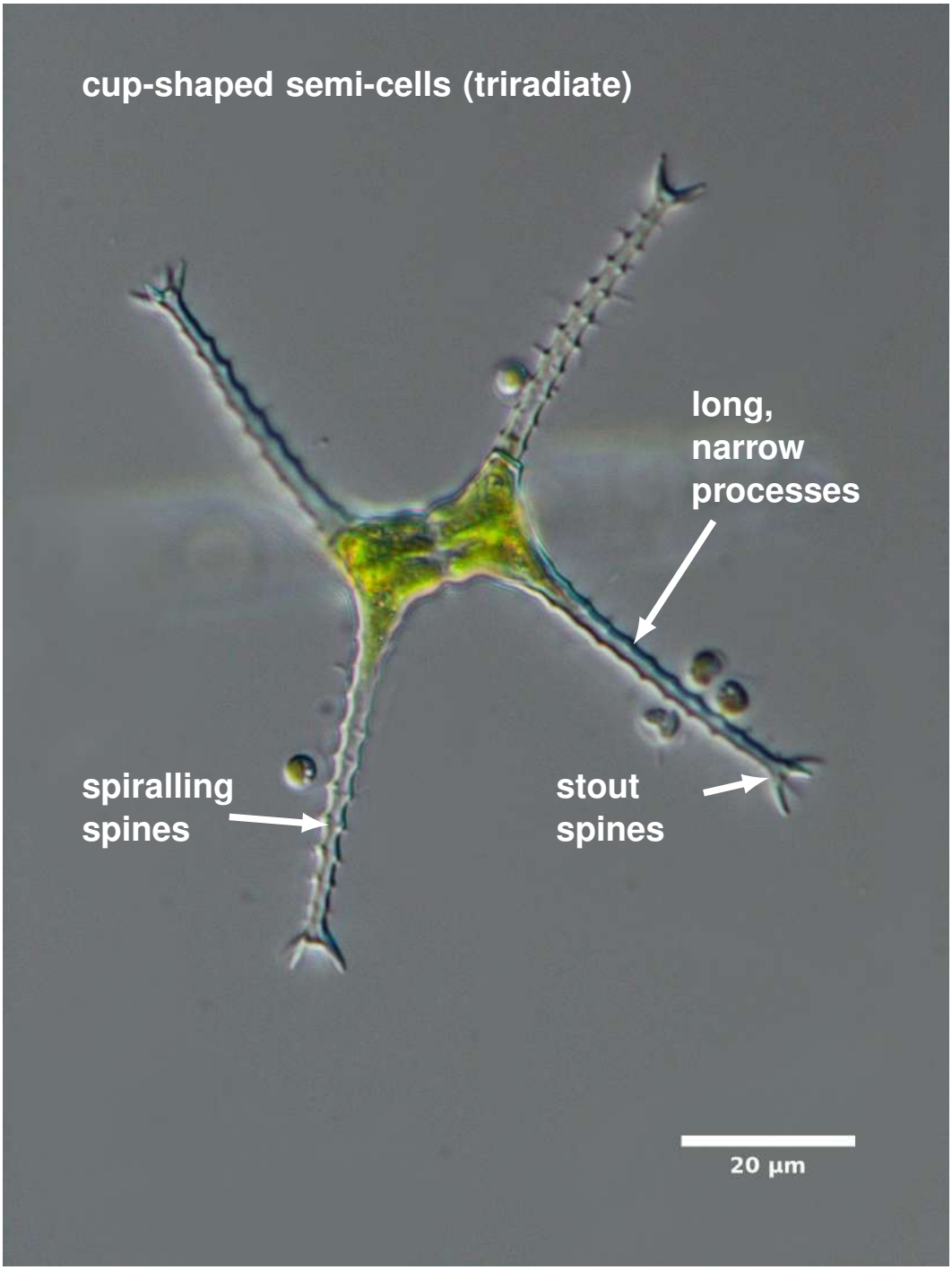


Figure 22.154: *Staurastrum longipes* (DIC), Lake Evan, Mountain Loop Highway, Snohomish County.

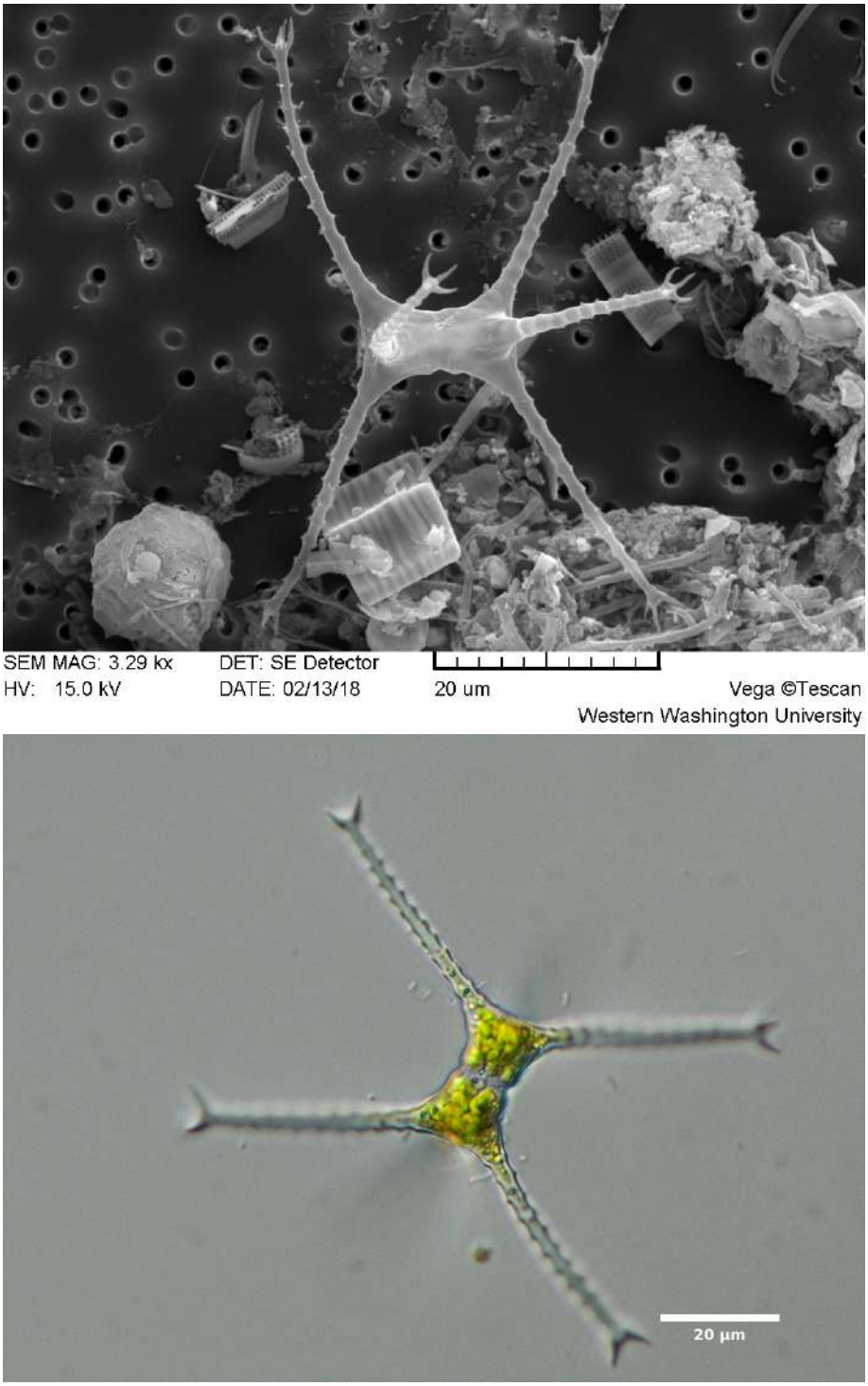


Figure 22.155: *Staurastrum longipes* (SEM/DIC), Lake Evan, Mountain Loop Highway, Snohomish County (upper/lower images).



Figure 22.156: *Staurastrum longipes* (DIC), Lake Evan, Mountain Loop Highway, Snohomish County.



Figure 22.157: *Staurastrum longispinum* (DIC), Boardman Lake, Mountain Loop Highway, Snohomish County.

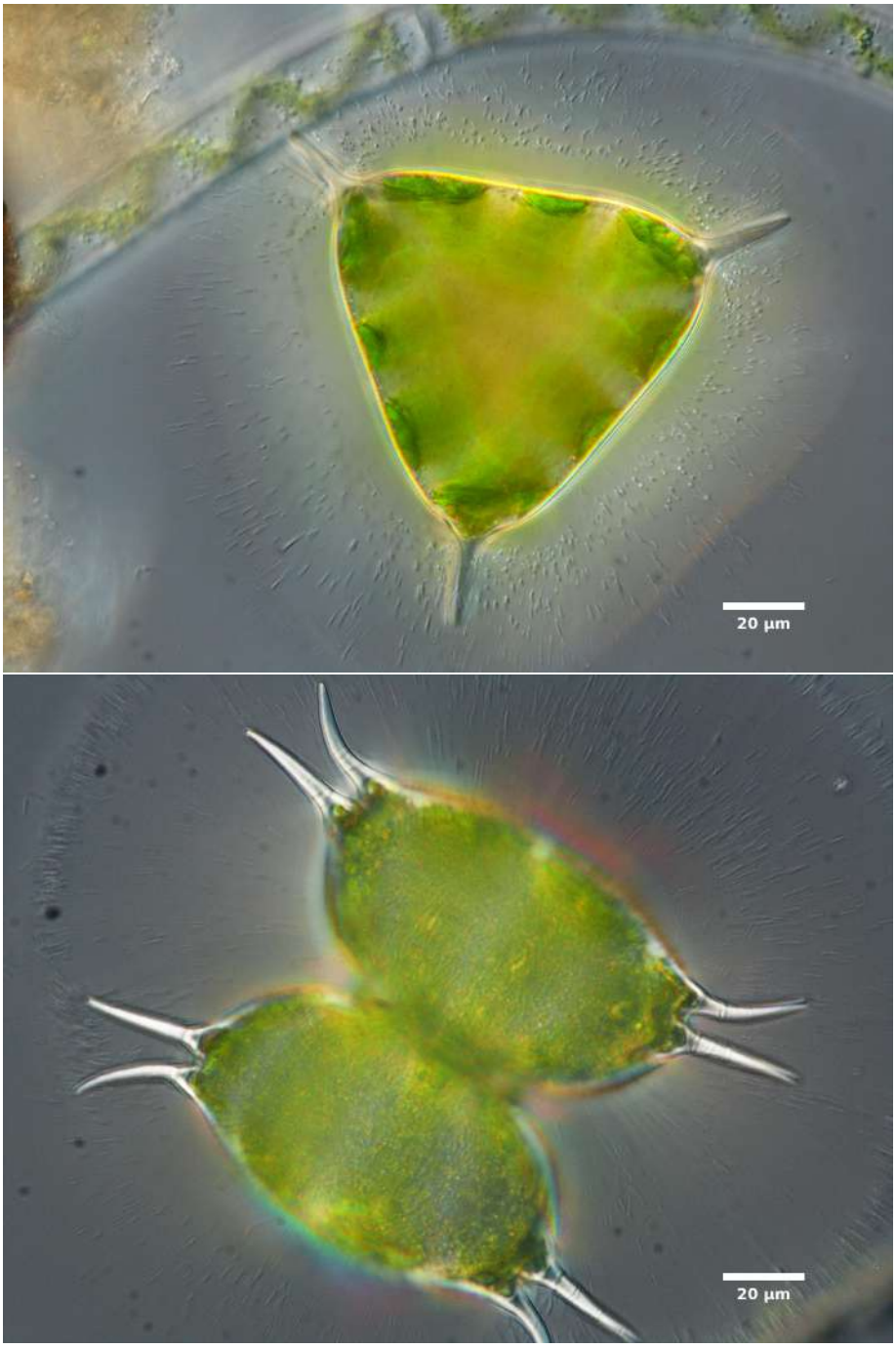


Figure 22.158: *Staurastrum longispinum* (DIC/DIC), Boardman Lake, Mountain Loop Highway, Snohomish County (upper/lower images).



Figure 22.159: *Staurastrum longispinum* (DIC), Boardman Lake, Mountain Loop Highway, Snohomish County.

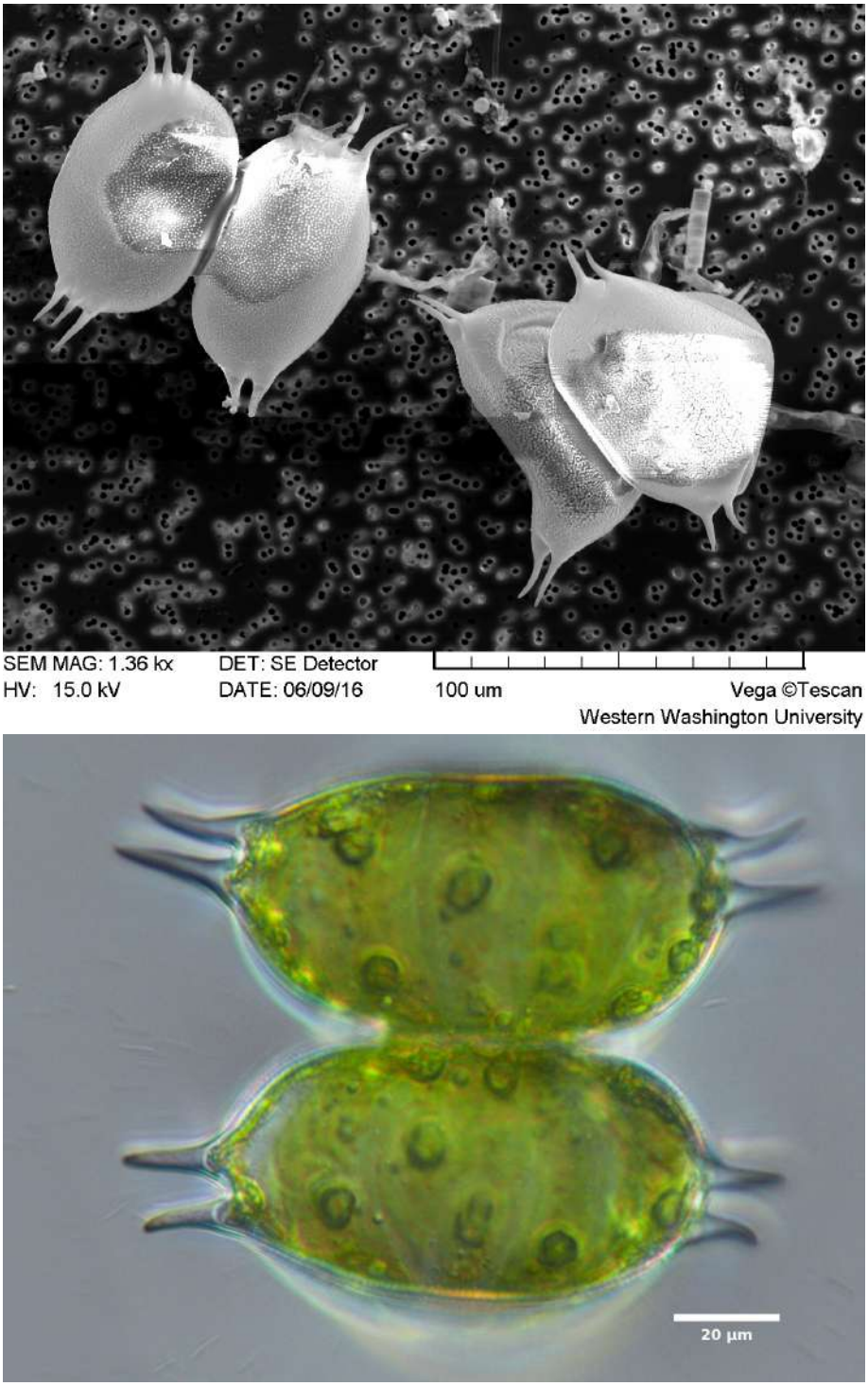


Figure 22.160: *Staurastrum longispinum* (SEM/DIC), Boardman Lake, Mountain Loop Highway, Snohomish County (upper/lower images).

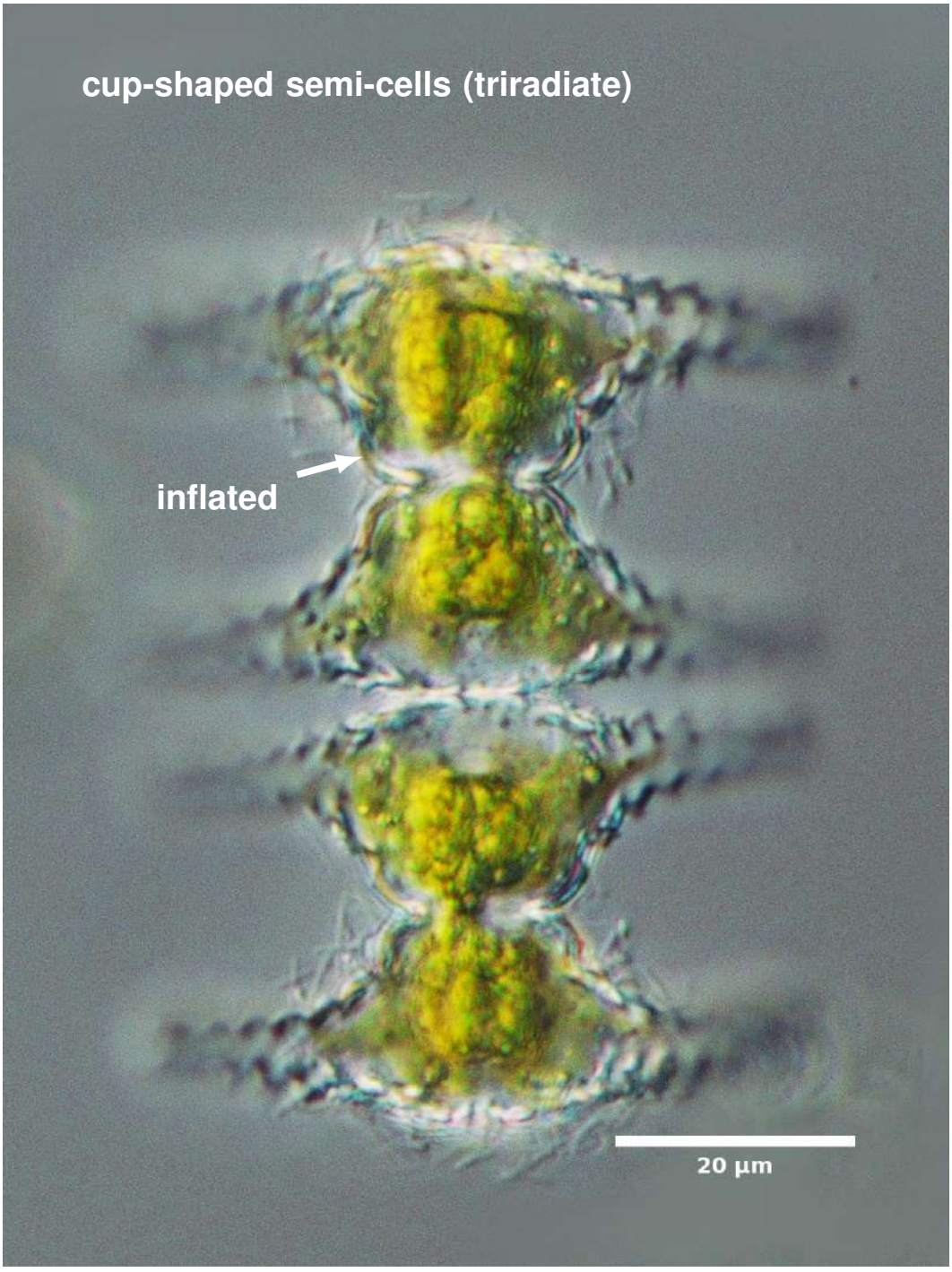


Figure 22.161: *Staurastrum manfeldtii* (DIC), Hoag Pond, Whatcom County.

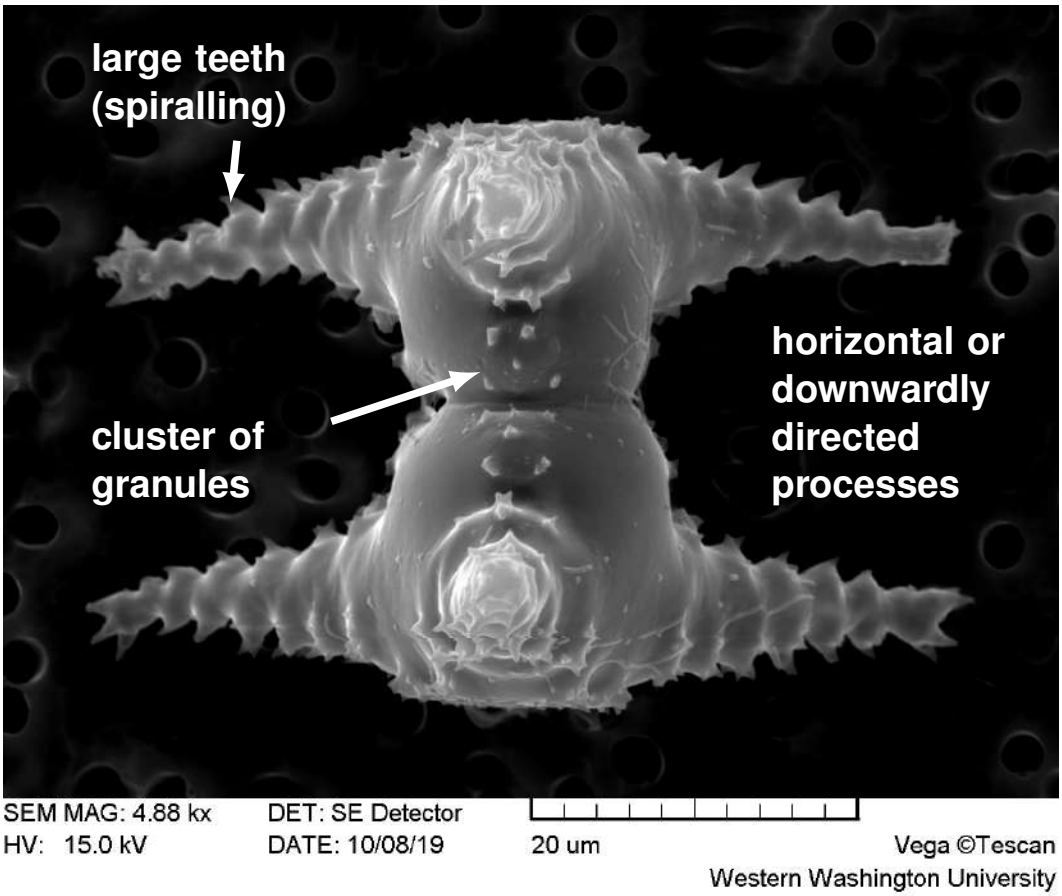


Figure 22.162: *Staurastrum manfeldtii* (SEM), Hoag Pond, Whatcom County.

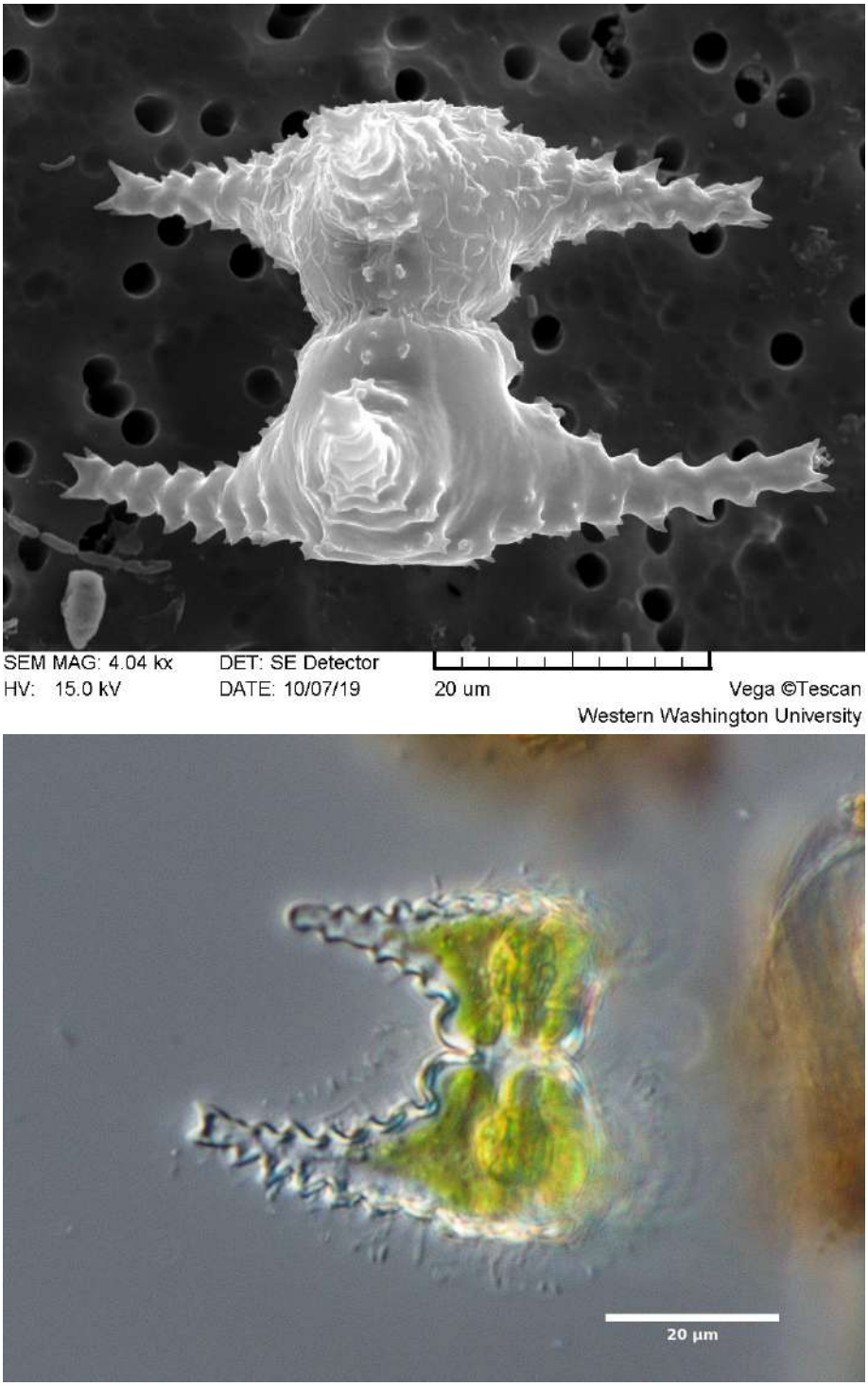


Figure 22.163: *Staurastrum manfeldtii* (SEM/DIC), Hoag Pond, Whatcom County (upper/lower images).

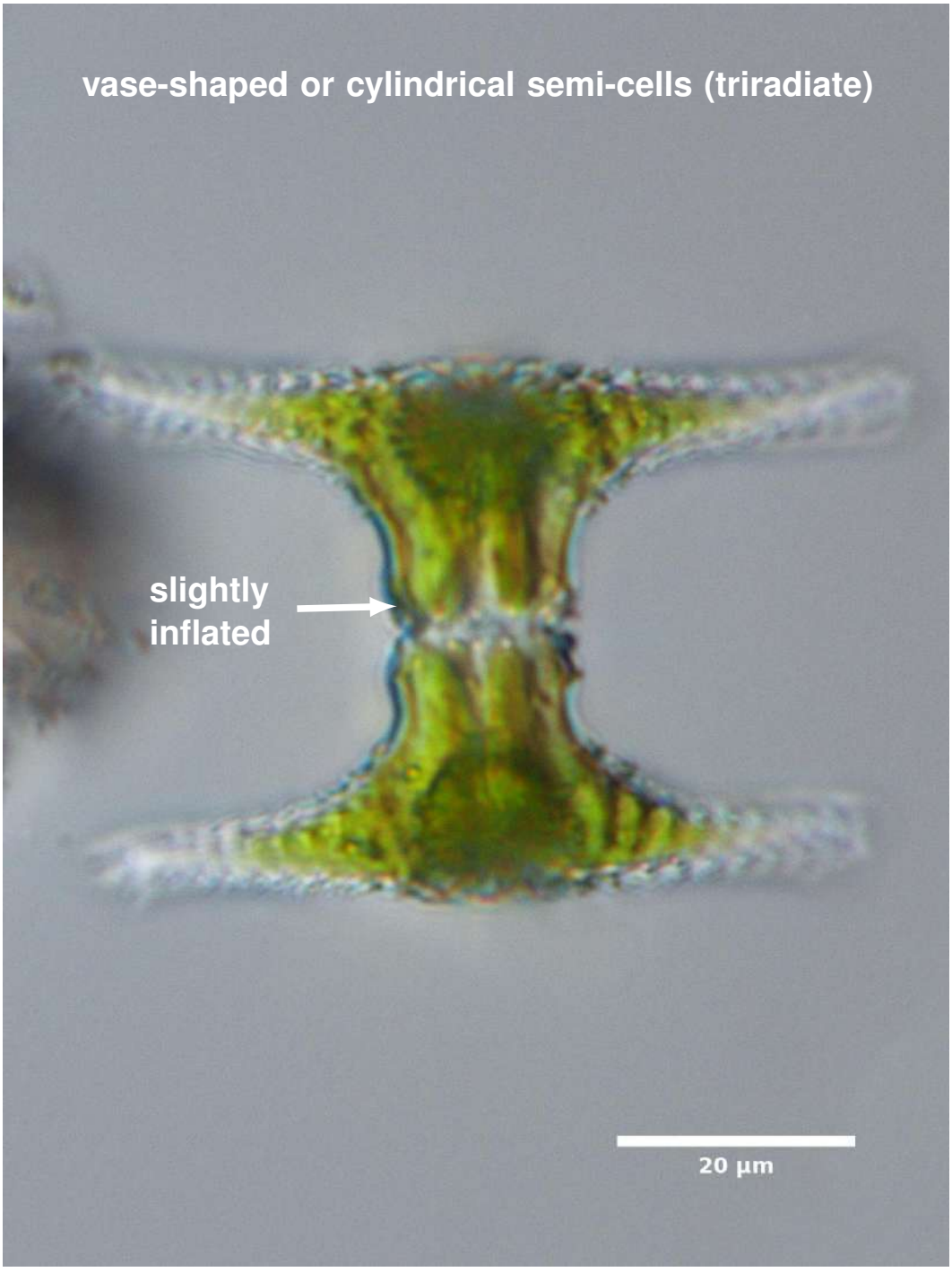


Figure 22.164: *Staurastrum manfeldtii* var. A (DIC), Myrtle Lake, Mountain Loop Highway, Snohomish County.

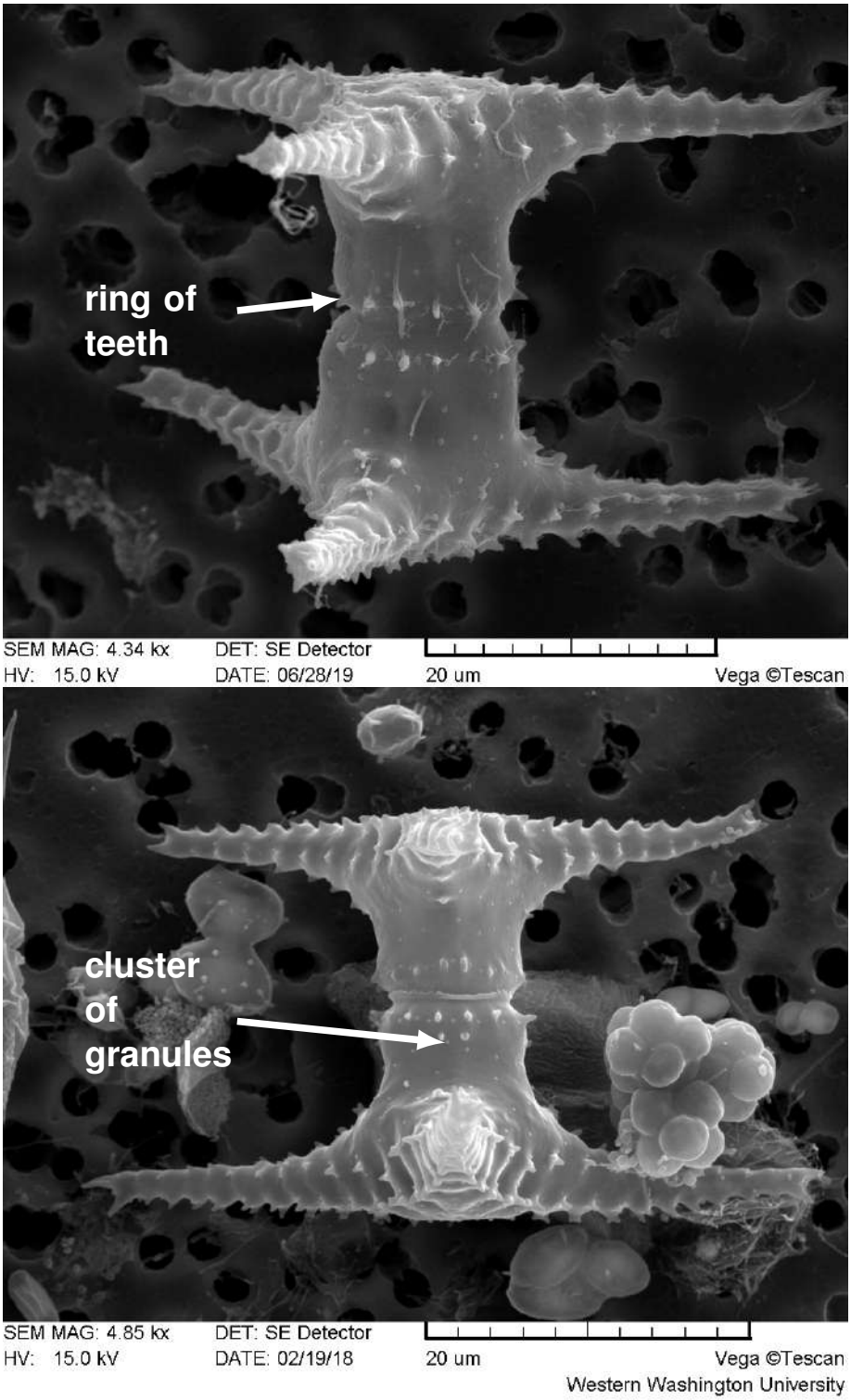


Figure 22.165: *Staurastrum manfeldtii* var. A (SEM/SEM), Myrtle Lake, Mountain Loop Highway, Snohomish County (upper/lower images).

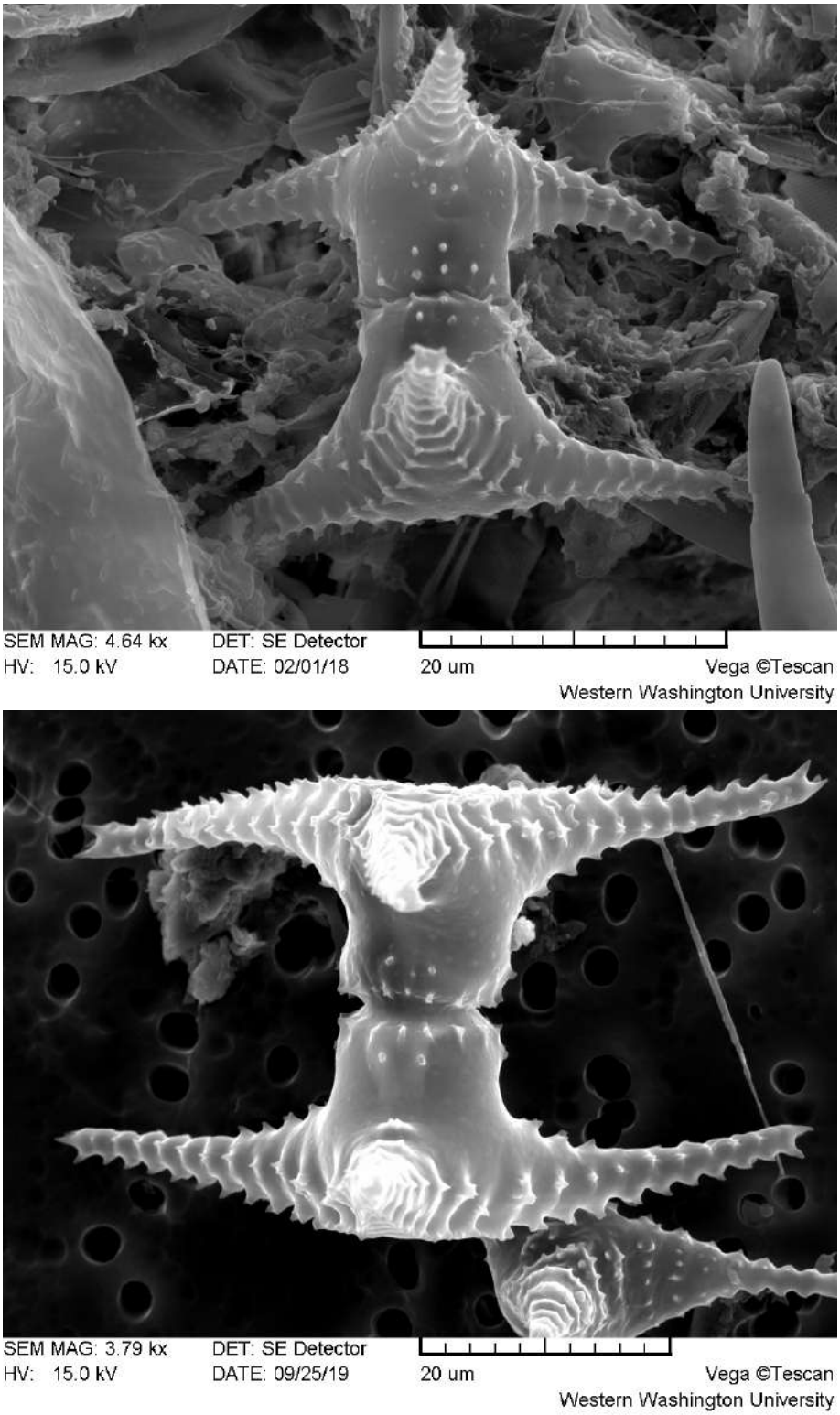


Figure 22.166: *Staurastrum manfeldtii* var. A (SEM/SEM), Myrtle Lake, Mountain Loop Highway, Snohomish County (upper image); small boggy pond on Morris Valley Road near Harrison BC (lower image).



Figure 22.167: *Staurastrum manfeldtii* var. A (DIC/DIC), Myrtle Lake, Mountain Loop Highway, Snohomish County (upper/lower images).



Figure 22.168: *Staurastrum margaritaceum* (DIC), small pond on trail to Lake Ann, Mt. Baker area, Whatcom County.

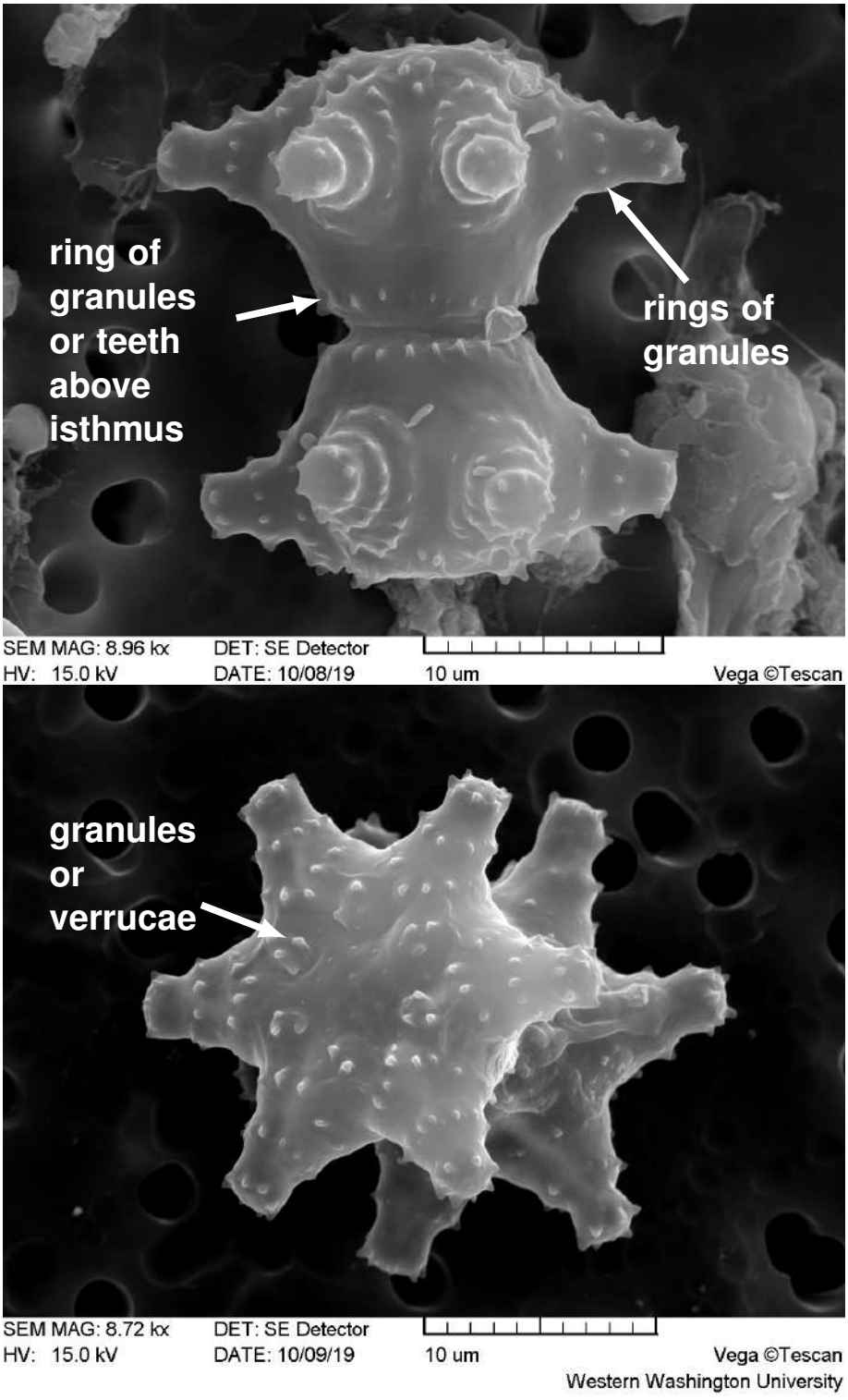


Figure 22.169: *Staurastrum margaritaceum* 6-radiate semi-cells (SEM/SEM), small pond on trail to Lake Ann, Mt. Baker area, Whatcom County (upper/lower images).

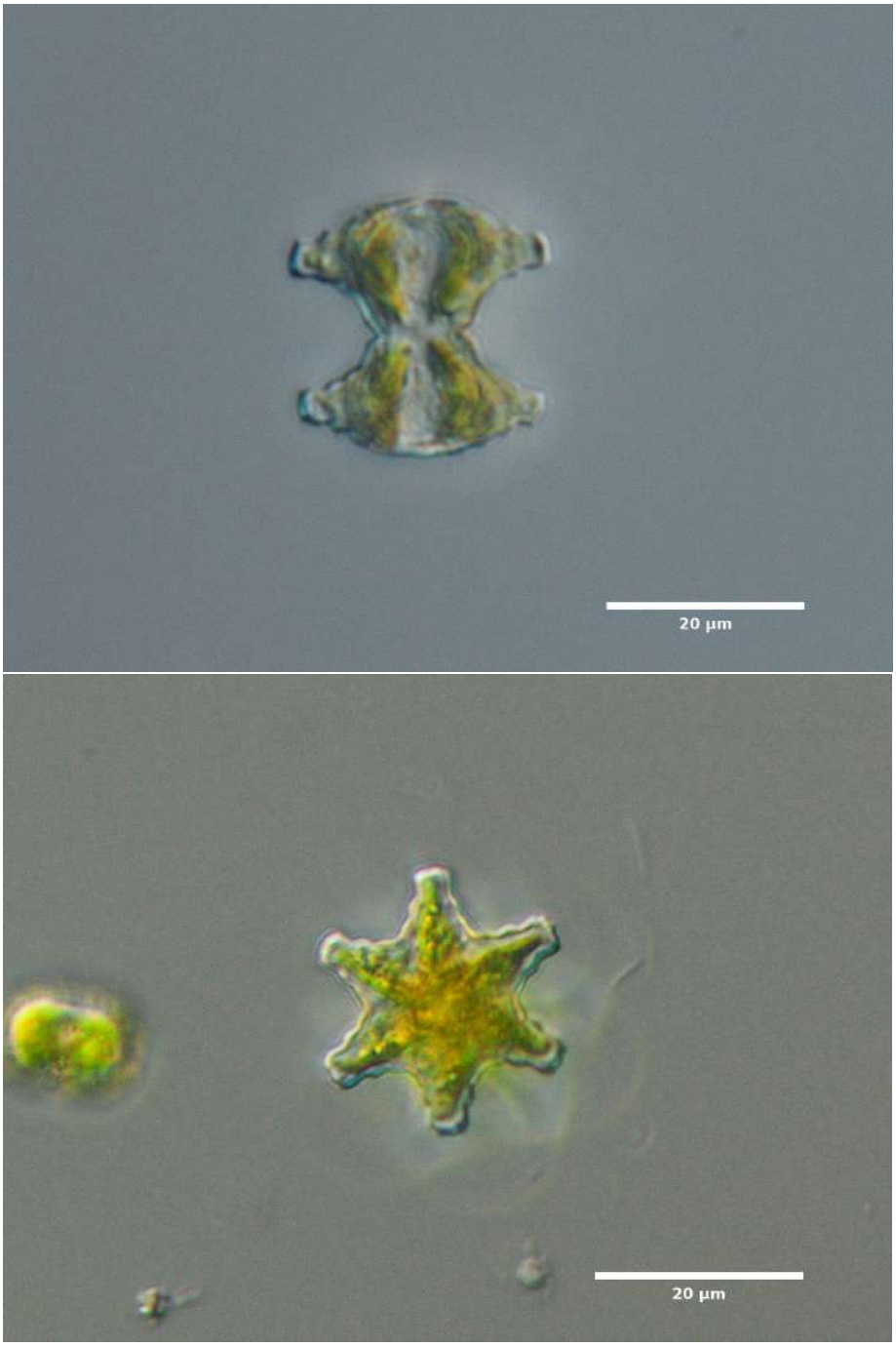


Figure 22.170: *Staurastrum margaritaceum* 6-radiate semi-cells (DIC/DIC), small pond on trail to Lake Ann, Mt. Baker area, Whatcom County (upper/lower images).

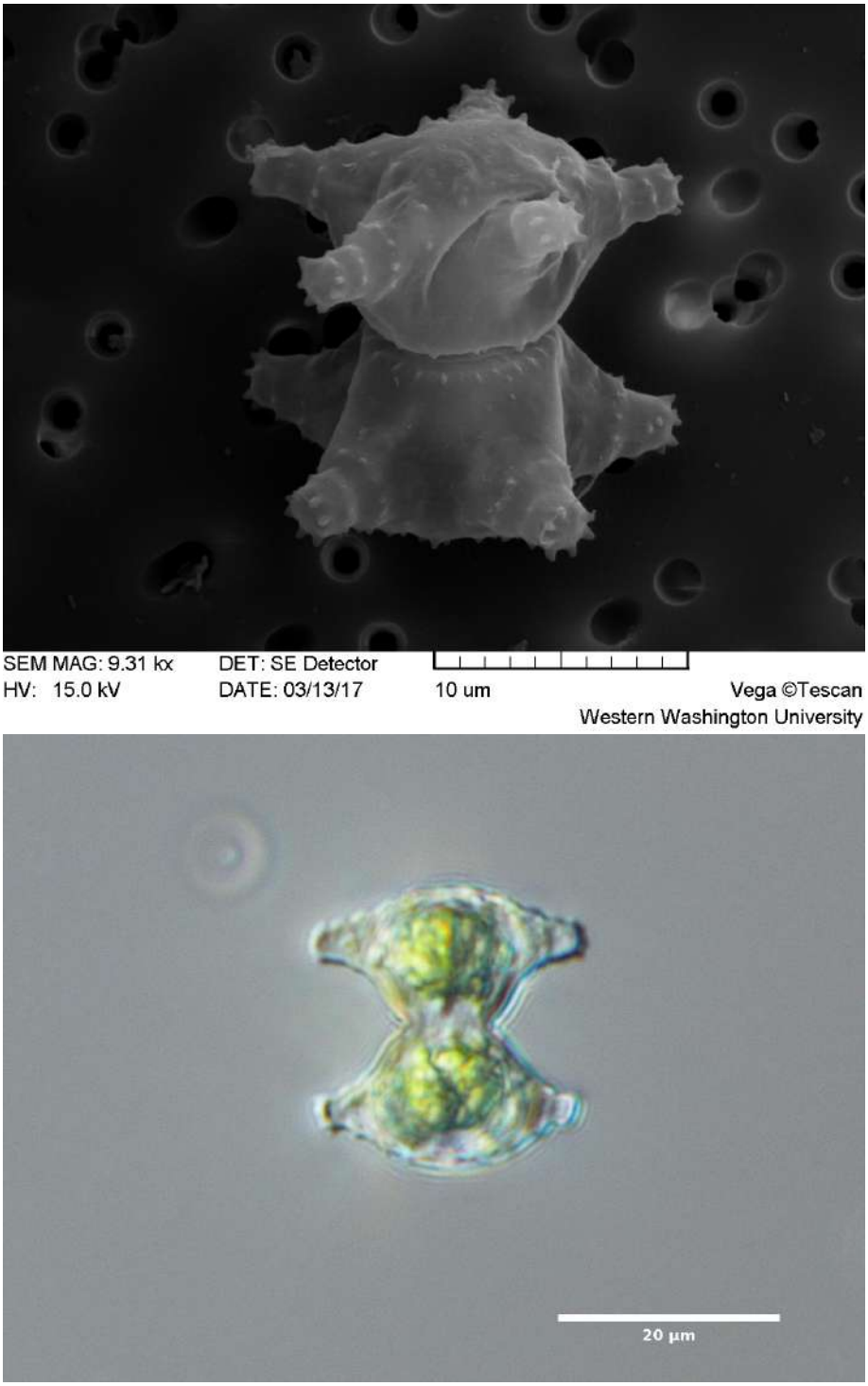


Figure 22.171: *Staurastrum margaritaceum* 5-radiate semi-cells (SEM/DIC), small pond near Canyon Lake, Whatcom County (upper/lower images).

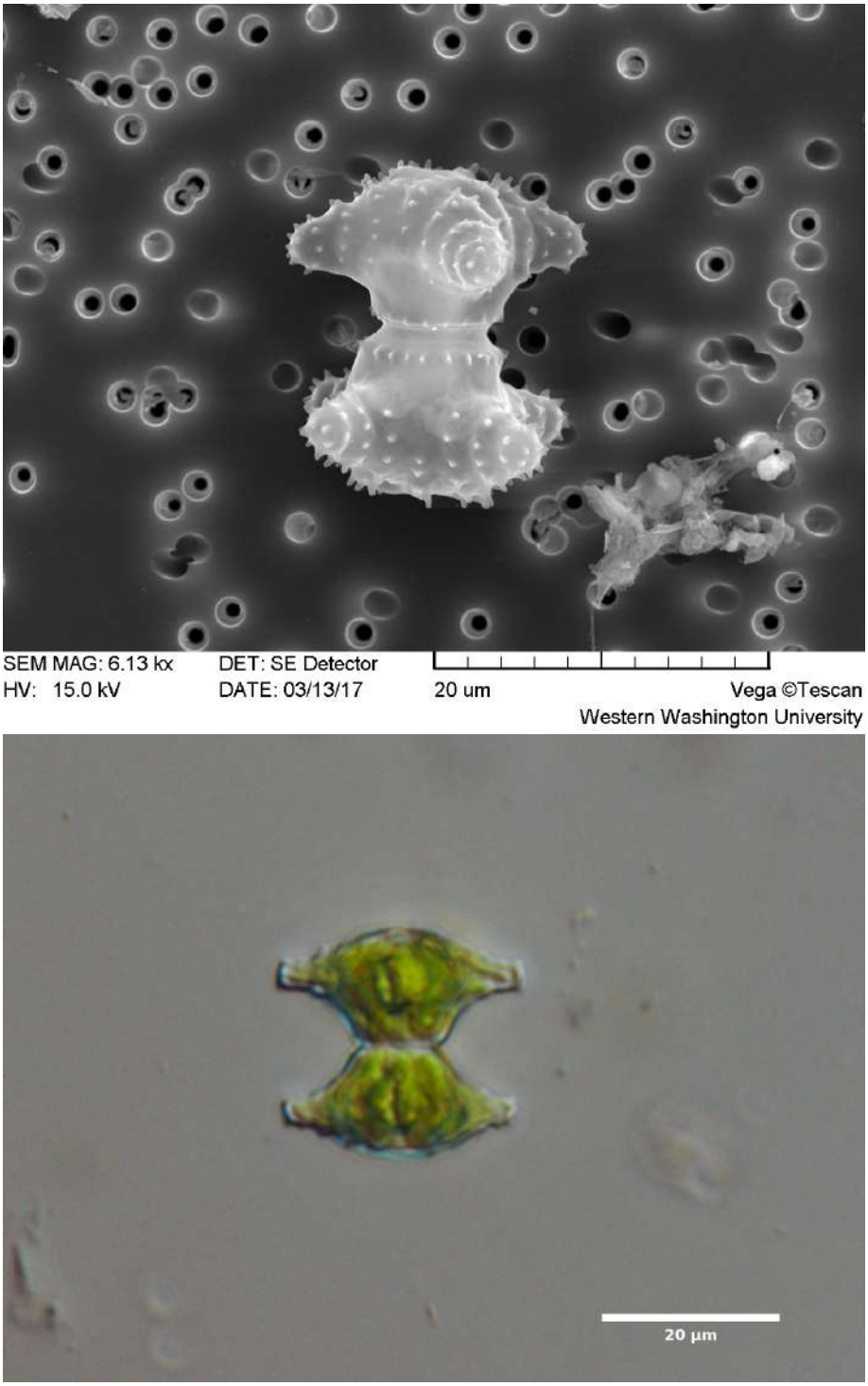


Figure 22.172: *Staurastrum margaritaceum* 4-radiate semi-cells (SEM/DIC), small pond on trail to Dock Butte, Mt. Baker area, Skagit County (upper/lower images).



Figure 22.173: *Staurastrum margaritaceum* var. *alpinum* (DIC), tributary between sections of Upper Anderson Lake, Mt. Baker area, Whatcom County.

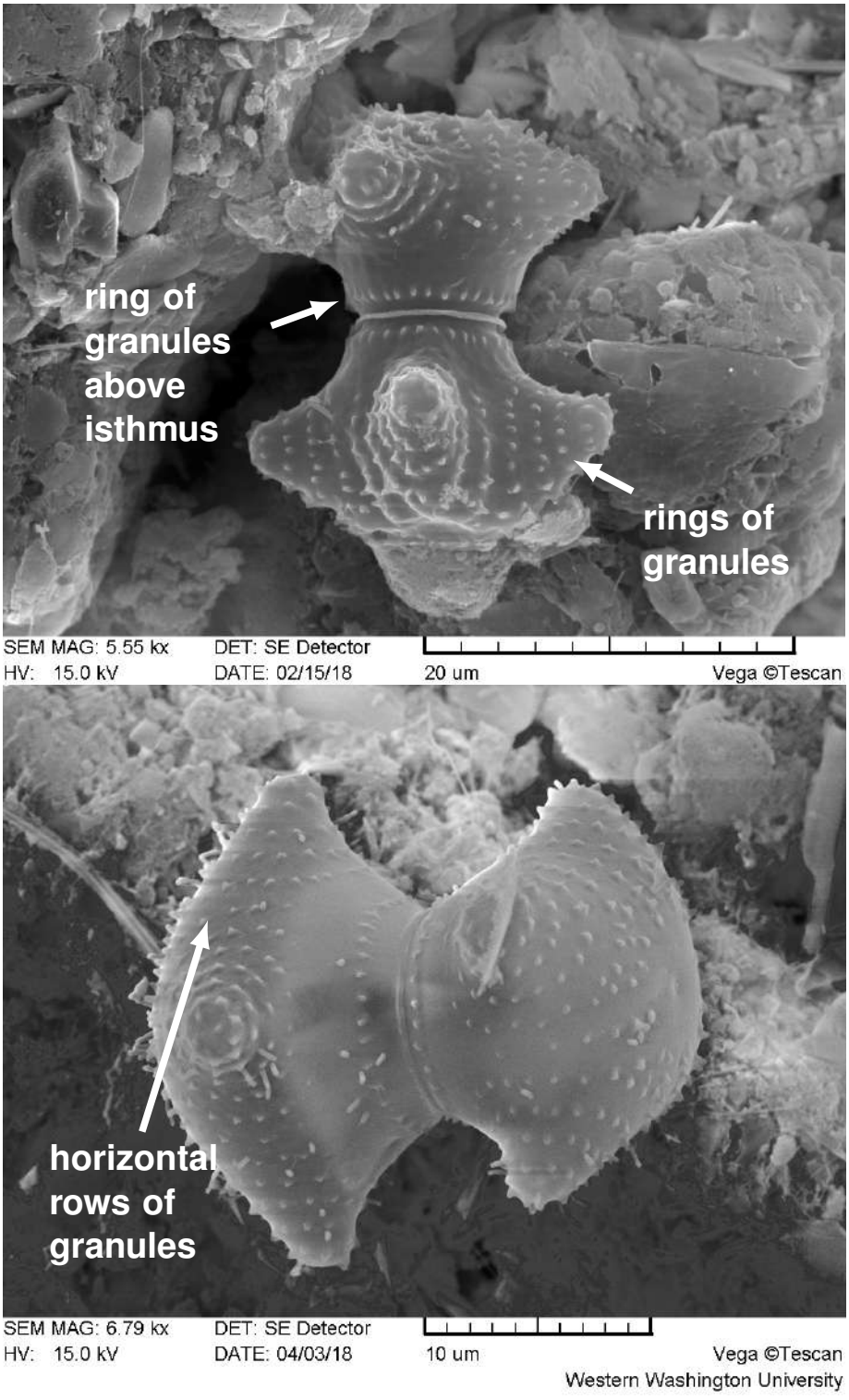


Figure 22.174: *Staurastrum margaritaceum* var. *alpinum* (SEM/SEM), tributary between sections of Upper Anderson Lake, Mt. Baker area, Whatcom County (upper/lower images).

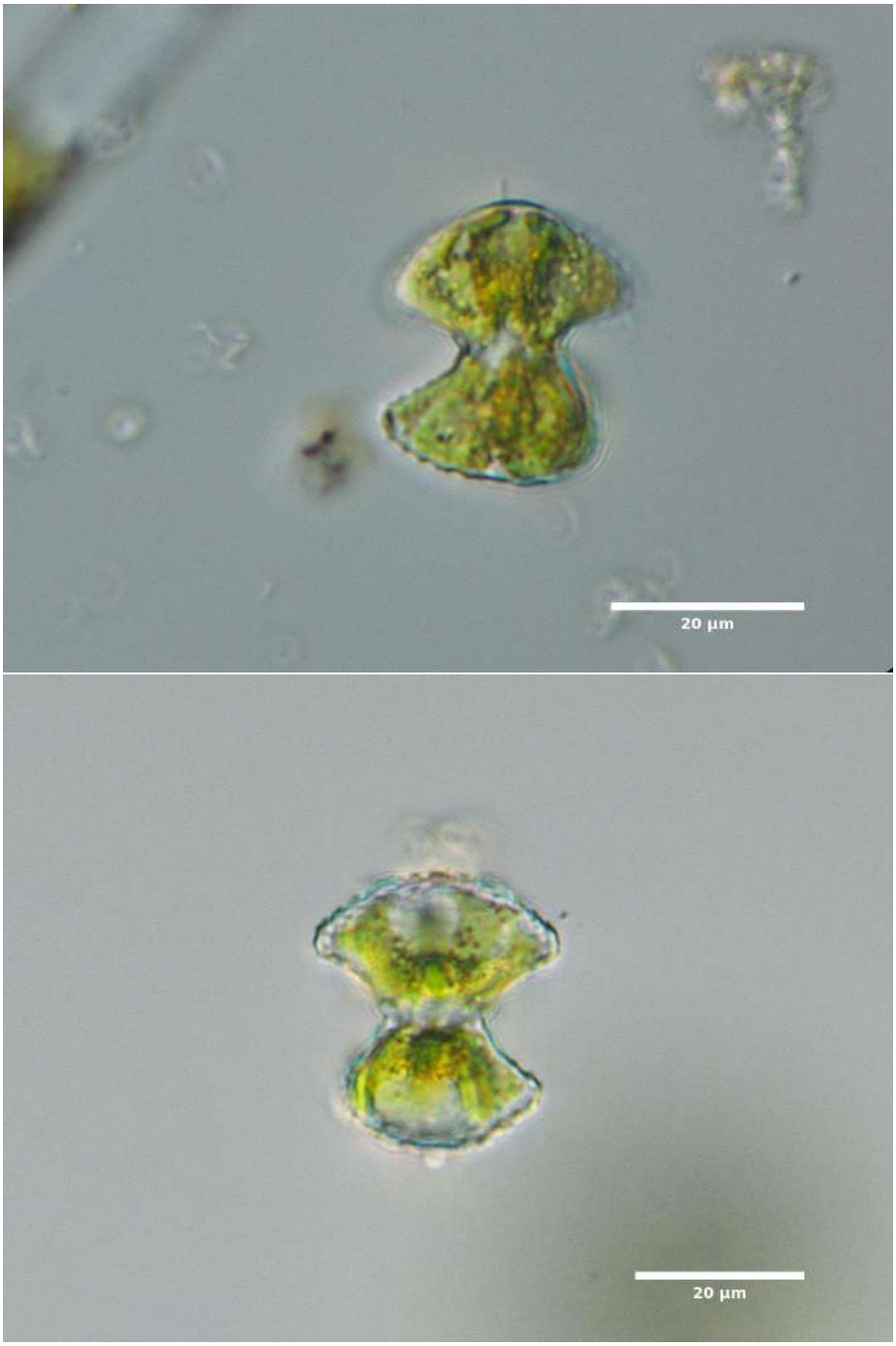


Figure 22.175: *Staurastrum margaritaceum* var. *alpinum* (DIC/DIC), tributary between sections of Upper Anderson Lake, Mt. Baker area, Whatcom County (upper/lower images).



Figure 22.176: *Staurastrum meriani* (DIC/DIC), spray zone from waterfall near Rainy Pass, North Cascades Highway.

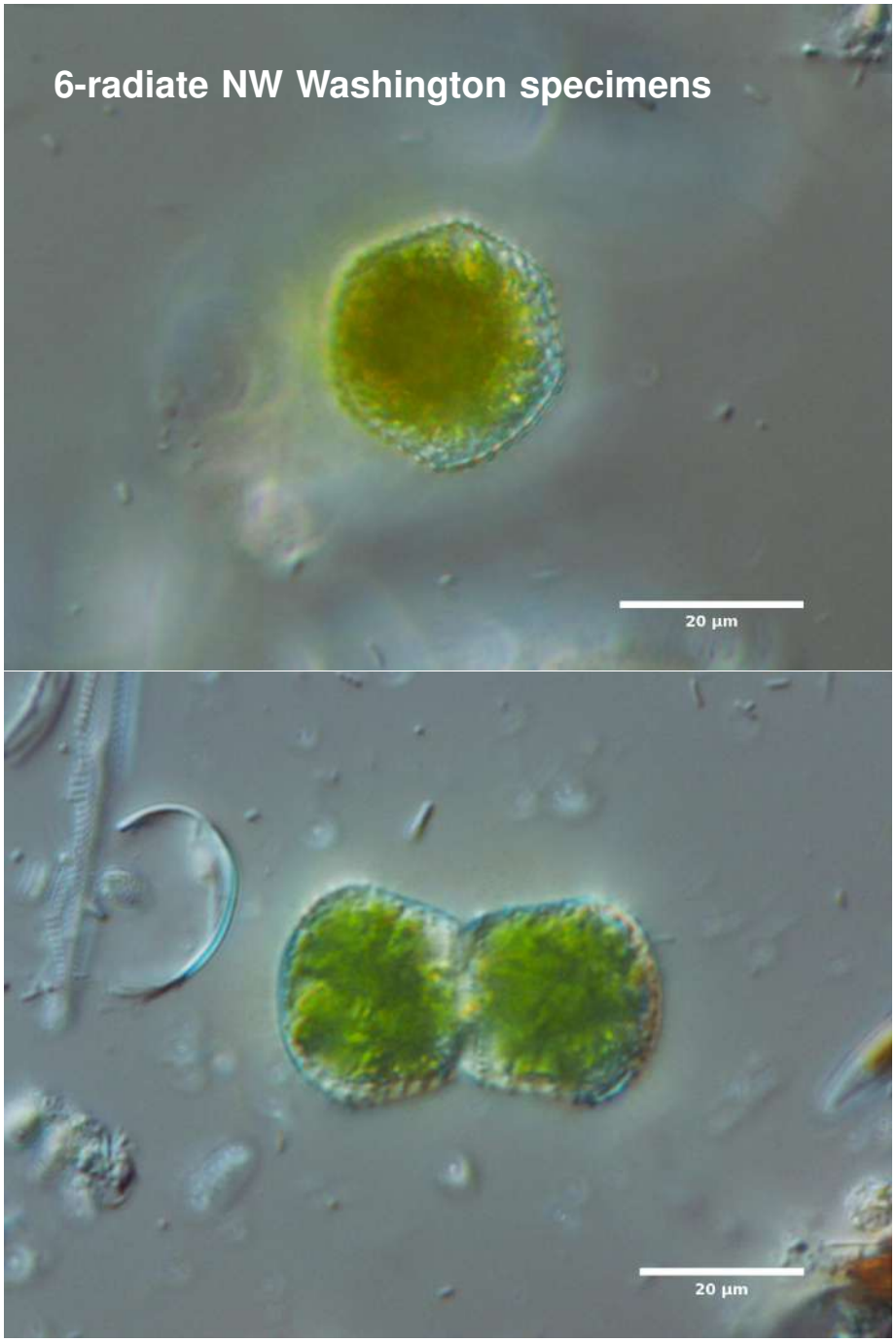


Figure 22.177: *Staurastrum meriani* (DIC/DIC), spray zone from waterfall near Rainy Pass, North Cascades Highway (upper/lower images).

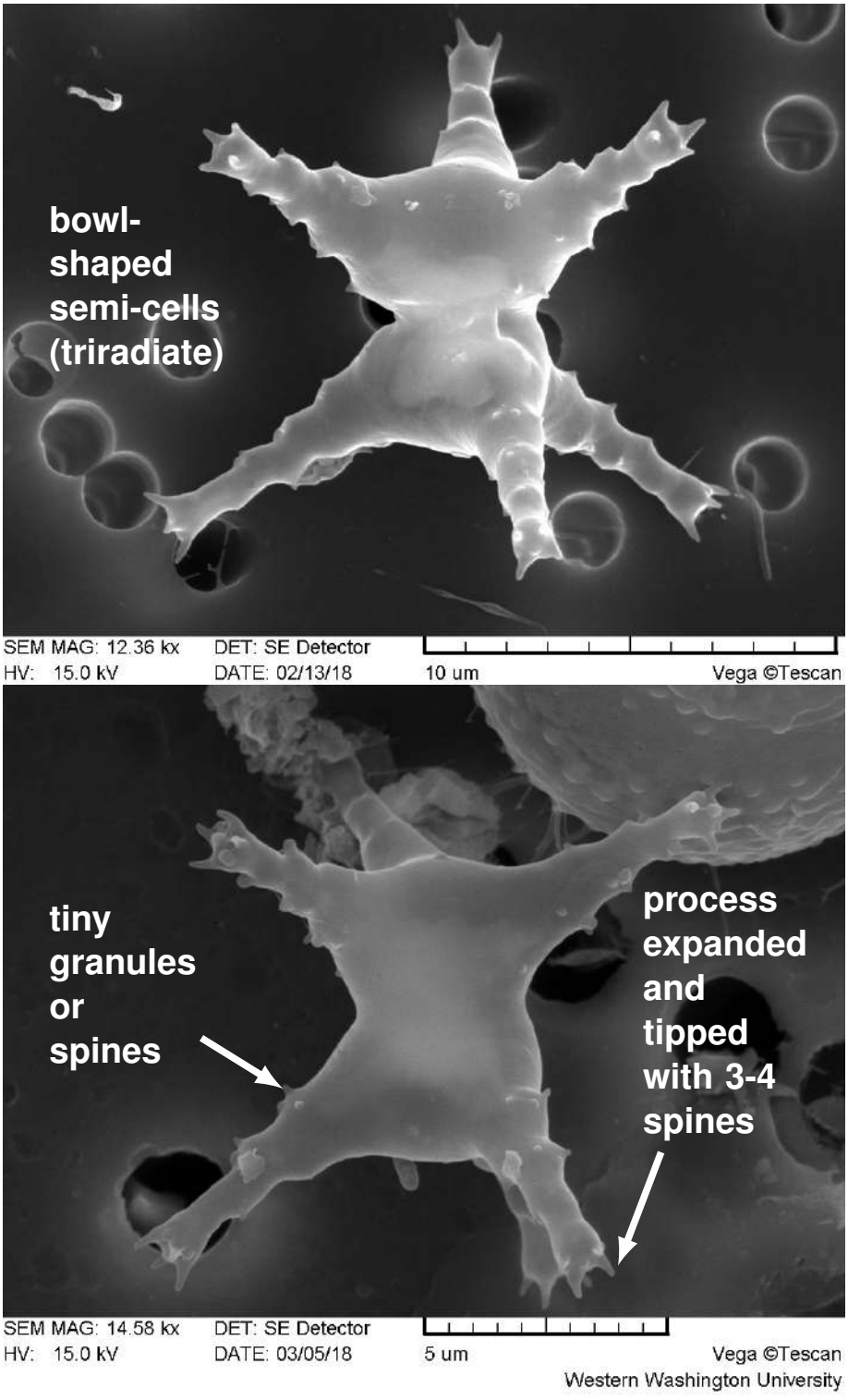


Figure 22.178: *Staurastrum micron* (SEM/SEM), Lake Evan, Mountain Loop Highway, Snohomish County (upper/lower images).

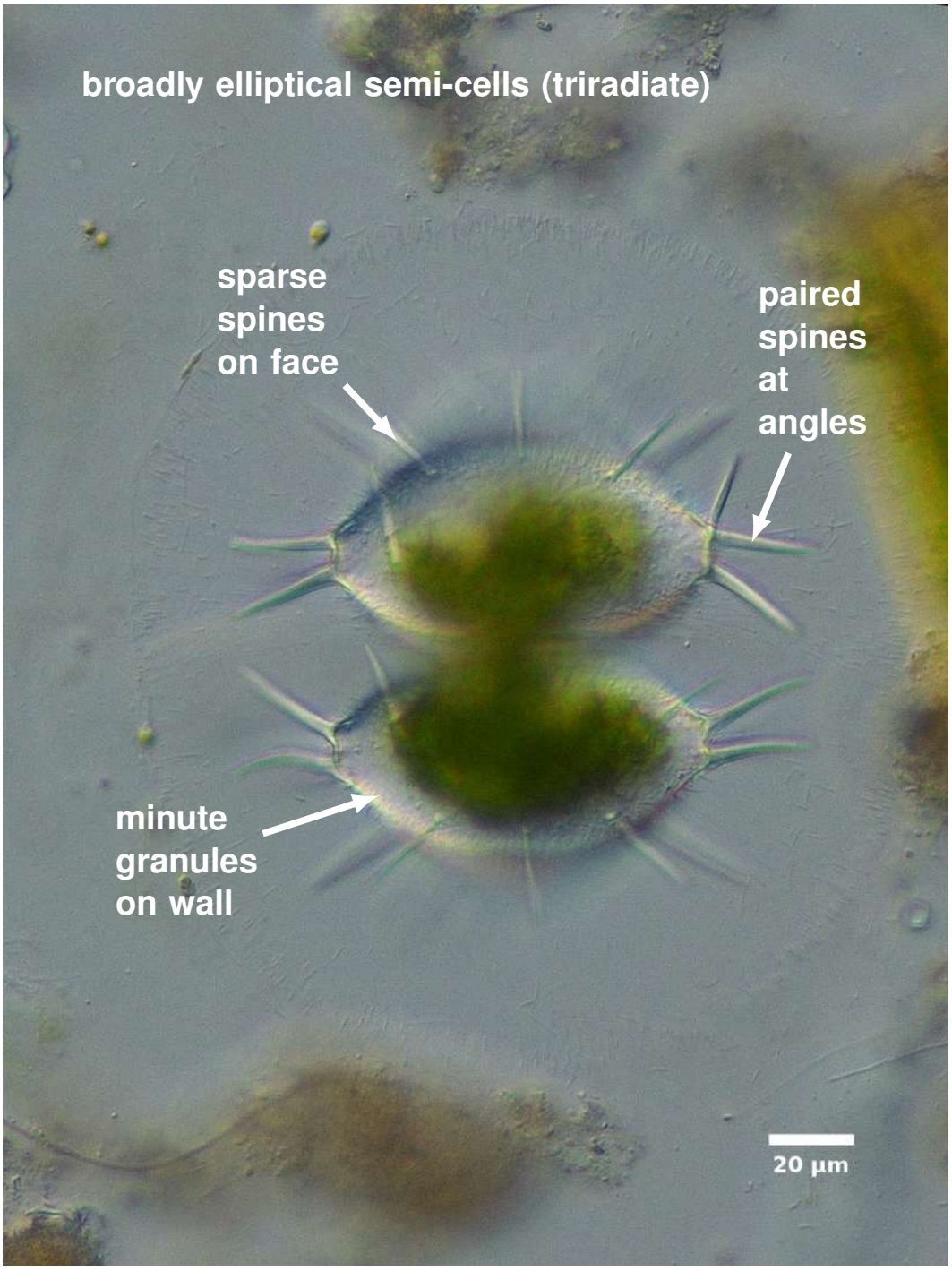


Figure 22.179: *Staurastrum minnesotense* (DIC/DIC), small floating bog along Morris Valley Road near Harrison, BC.

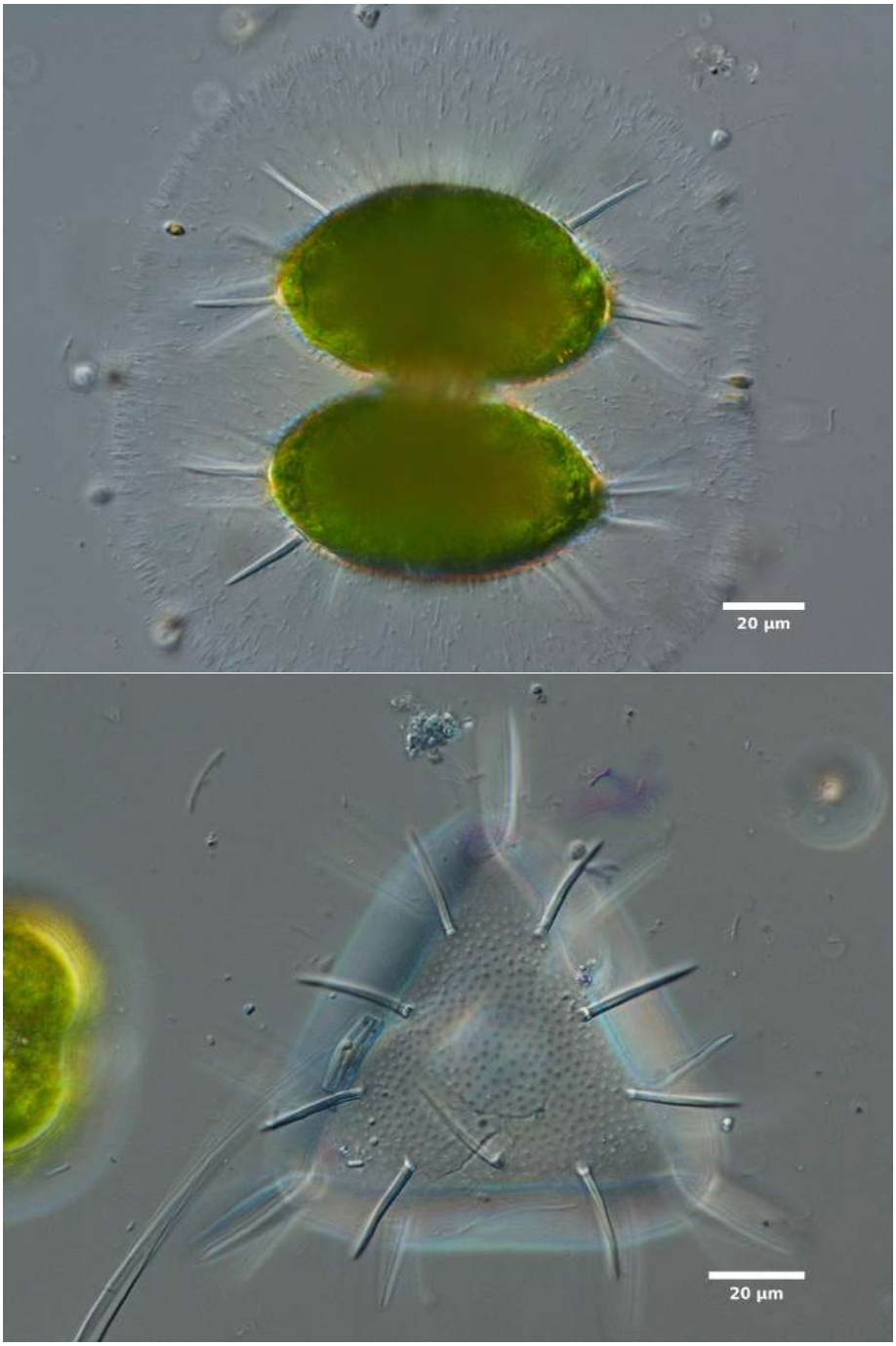


Figure 22.180: *Staurastrum minnesotense* (DIC/DIC), Wood Lake on Morris Valley Road near Harrison, BC (upper image); small floating bog along Morris Valley Road near Harrison, BC (lower image).



Figure 22.181: *Staurastrum minnesotense* (DIC/DIC), Lizard Lake, Skagit County (upper/lower images).

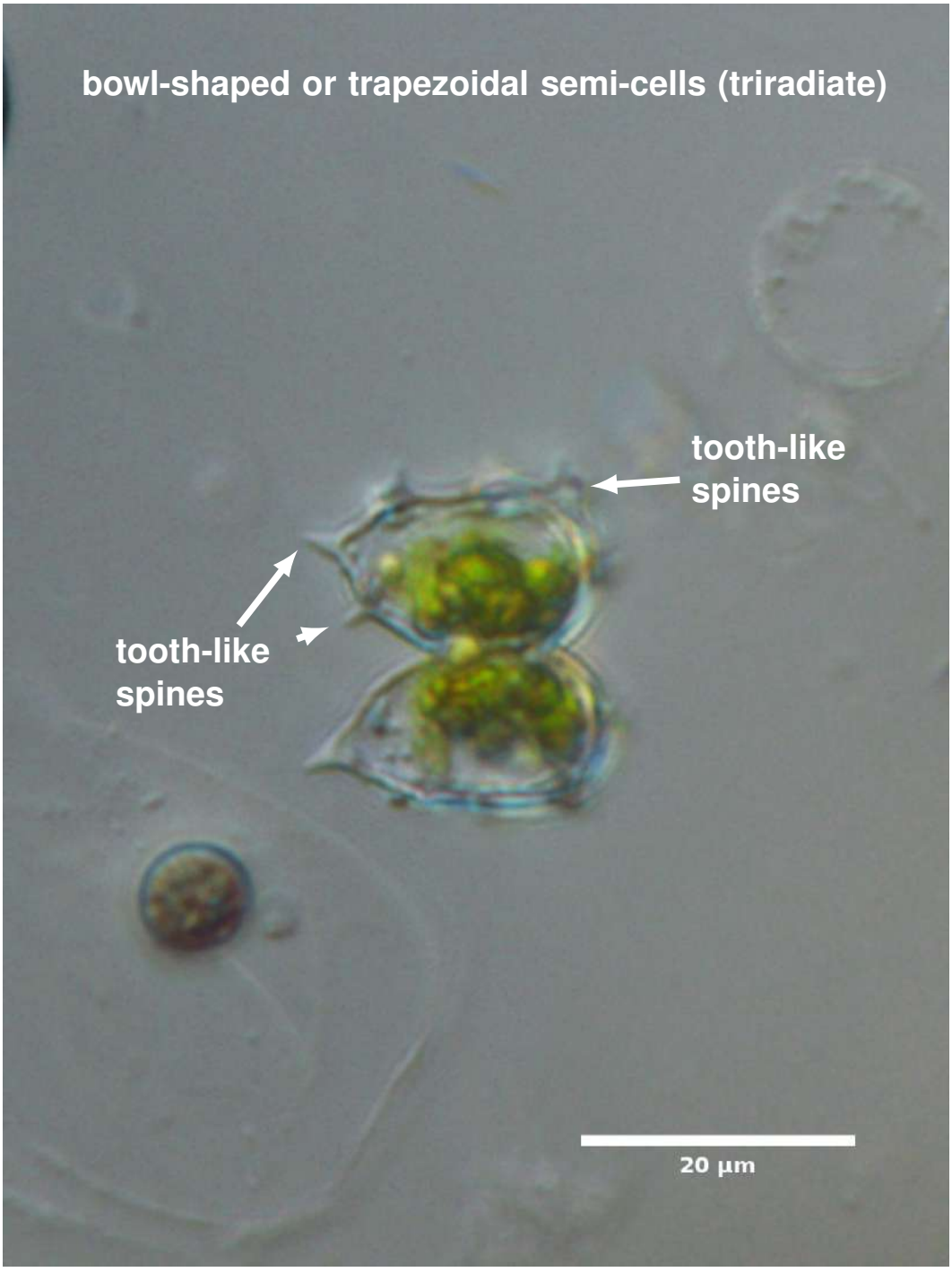


Figure 22.182: *Staurastrum monticulosum* (DIC), small pond on trail to Dock Butte, Mt. Baker area, Skagit County.



Figure 22.183: *Staurastrum muticum* var. A (DIC), small pond near Fairhaven College, Whatcom County.

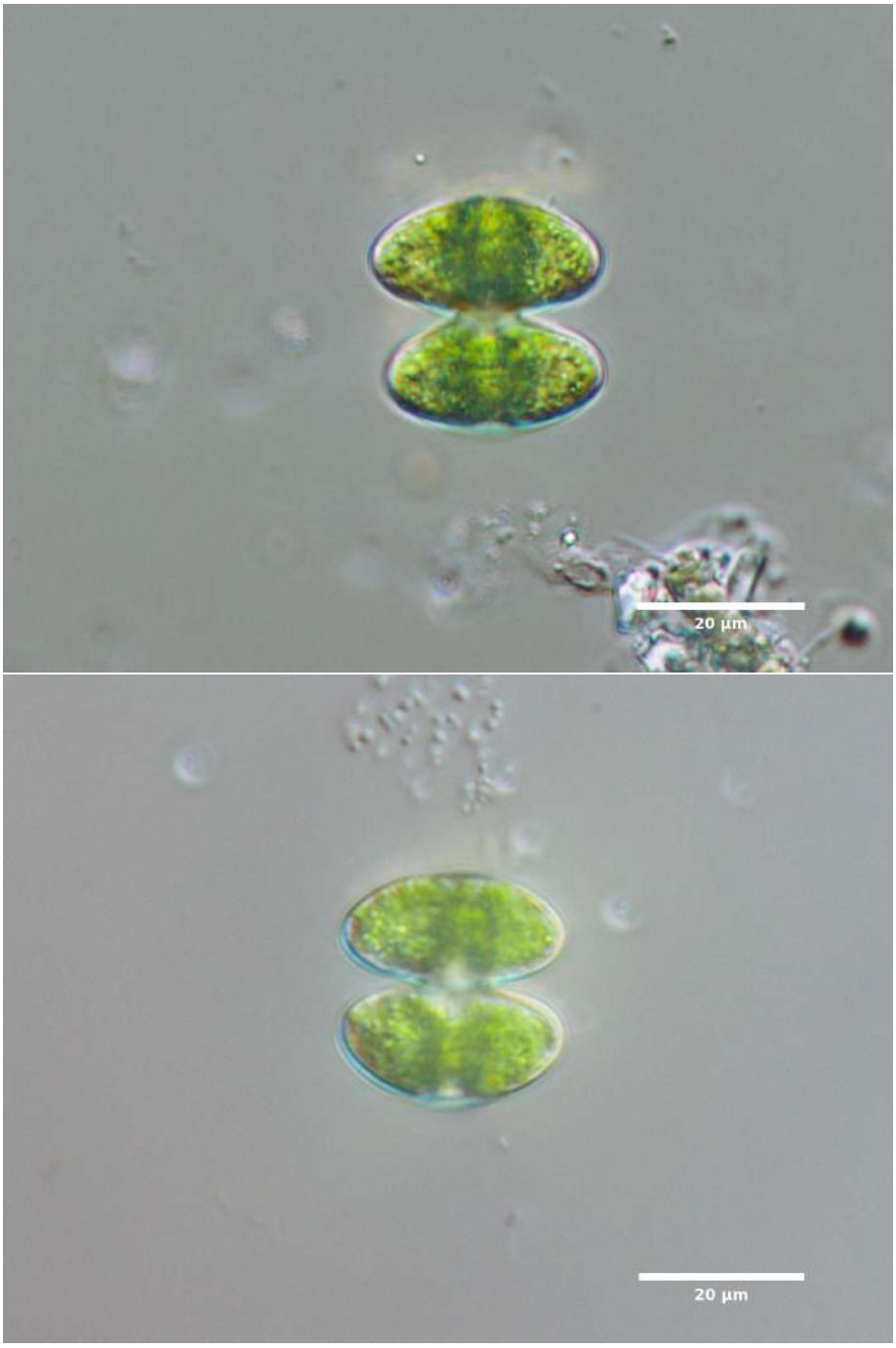


Figure 22.184: *Staurastrum muticum* var. A (DIC/DIC), small pond near Fairhaven College, Whatcom County (upper/lower images).



Figure 22.185: *Staurastrum muticum* var. B (DIC), Heather Lake, Mountain Loop Highway, Snohomish County.

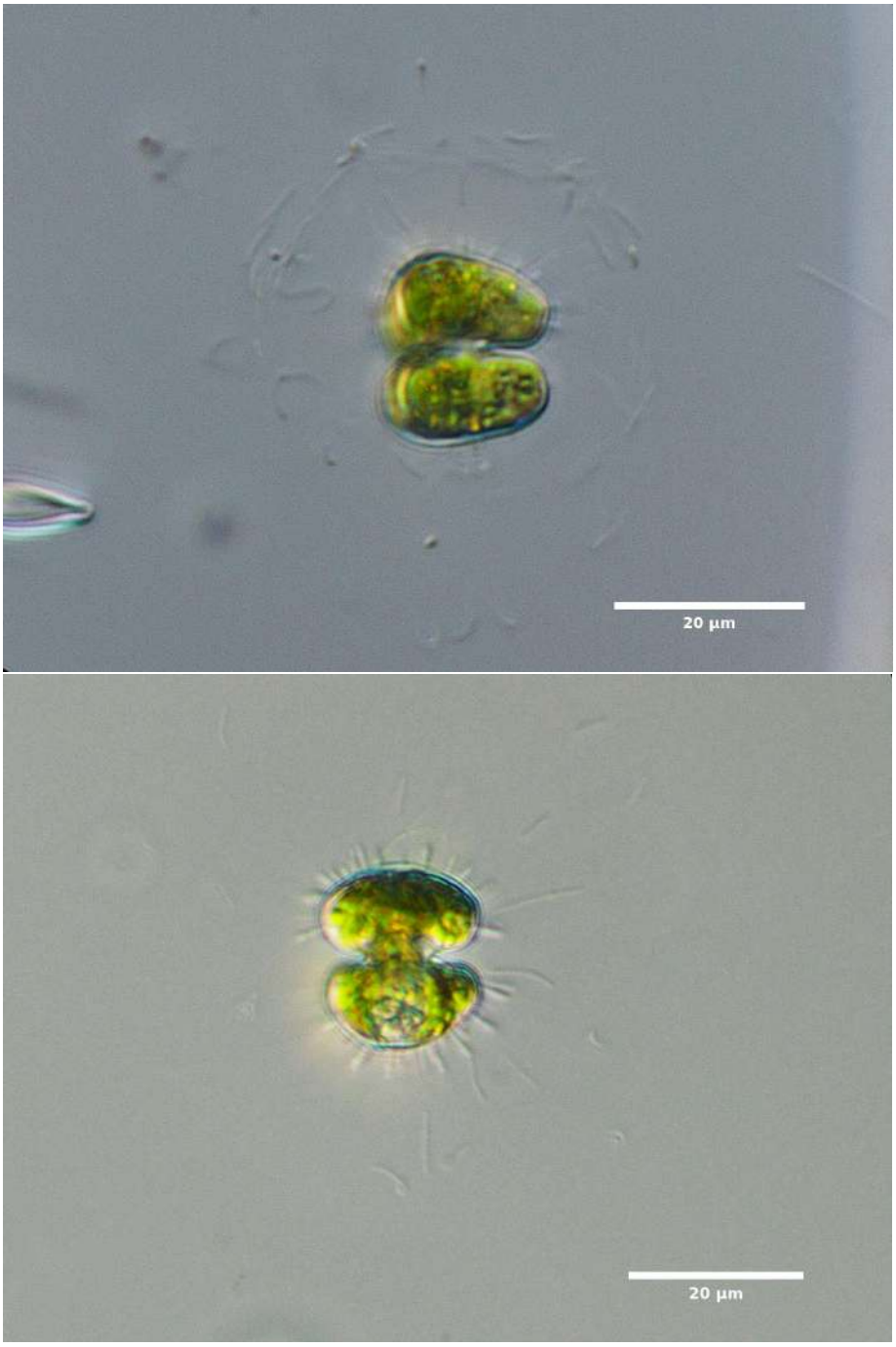


Figure 22.186: *Staurastrum muticum* var. B (DIC/DIC), Heather Lake, Mountain Loop Highway, Snohomish County (upper/lower images).

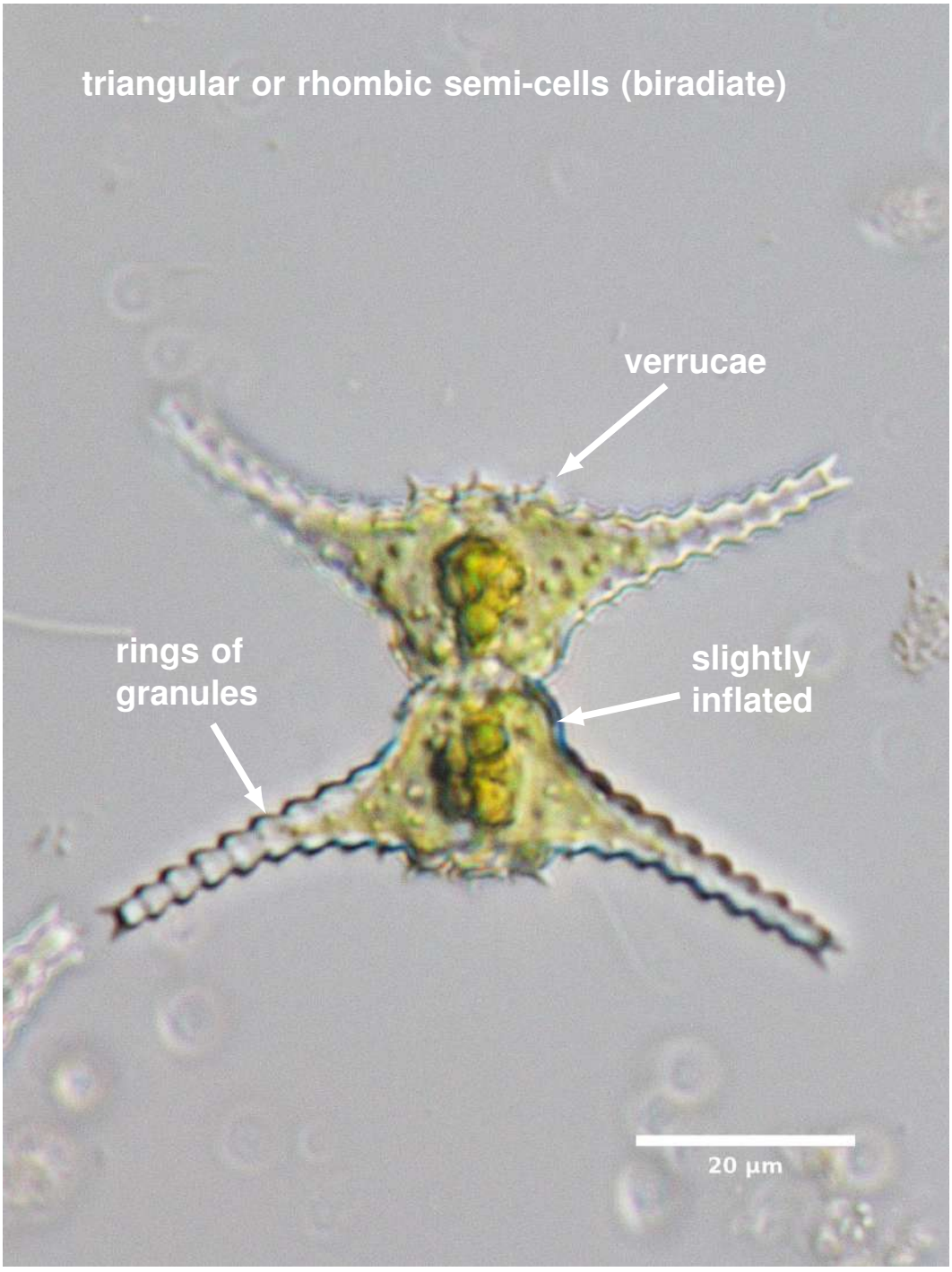


Figure 22.187: *Staurastrum natator* (DIC), Boardman Lake, Mountain Loop Highway, Snohomish County.

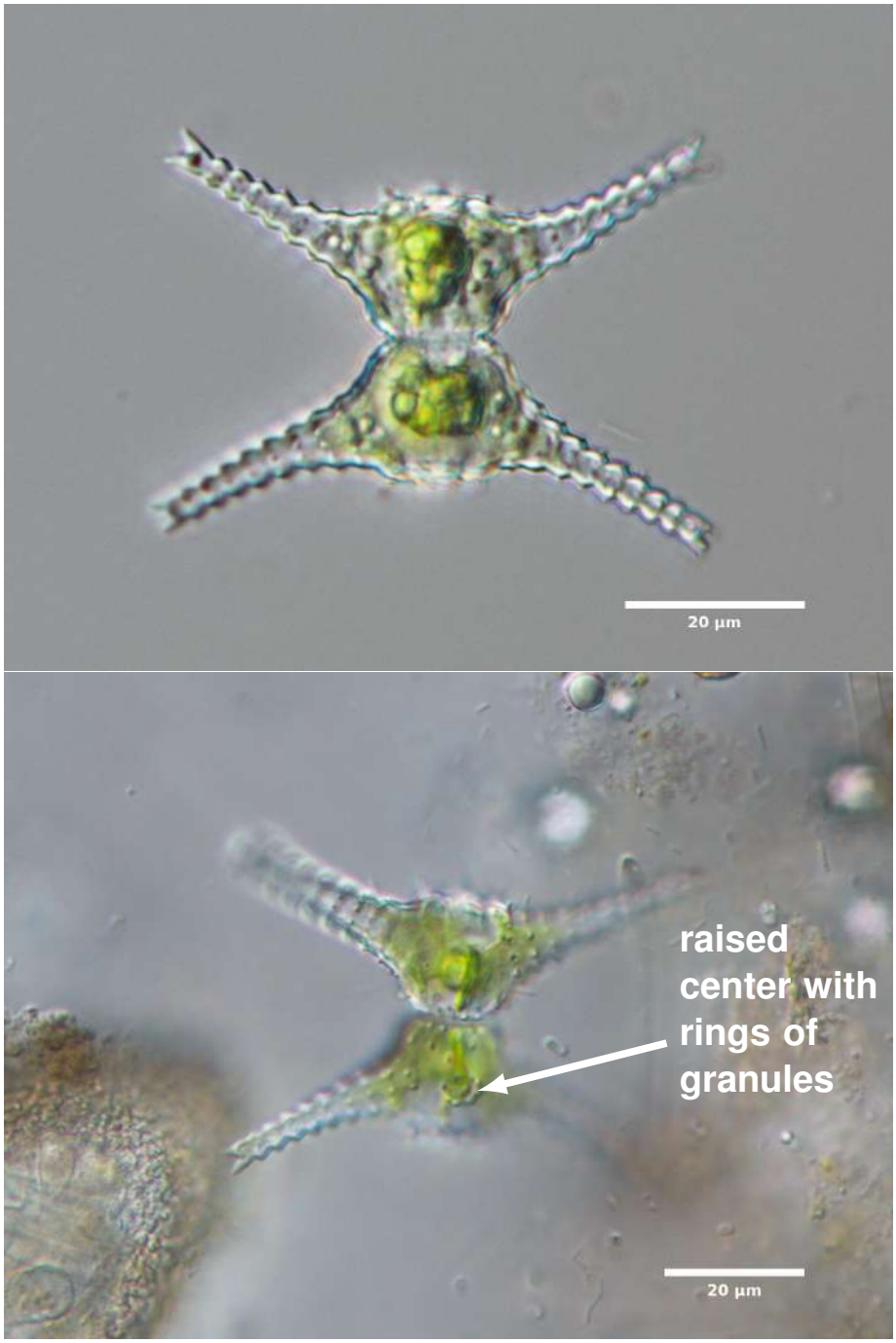


Figure 22.188: *Staurastrum natator* (DIC/DIC), Beaver Lake, Mountain Loop Highway, Snohomish County (upper/lower images).

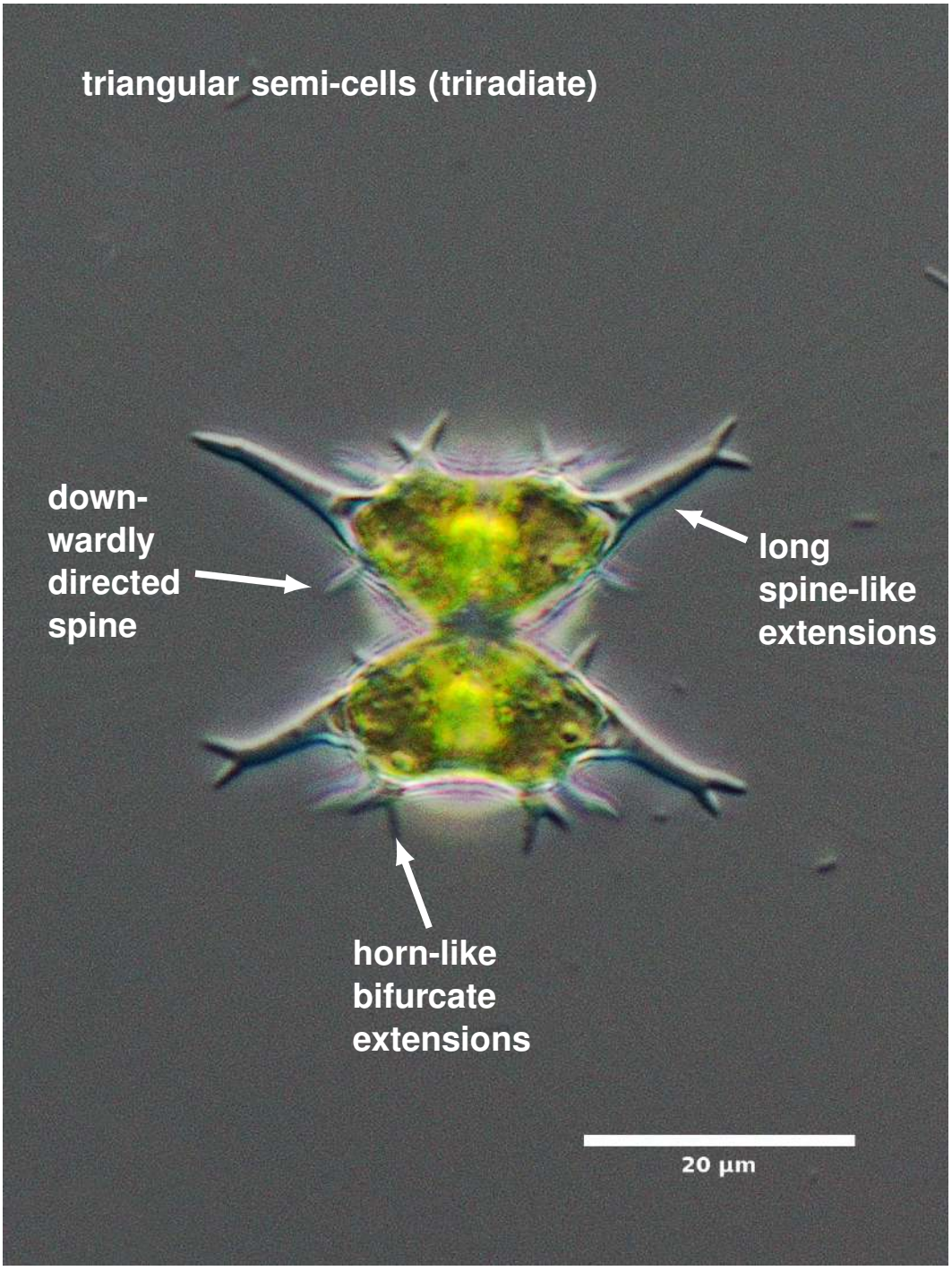


Figure 22.189: *Staurastrum novae-terrae* (DIC), Bear Lake, Mountain Loop Highway, Snohomish County.

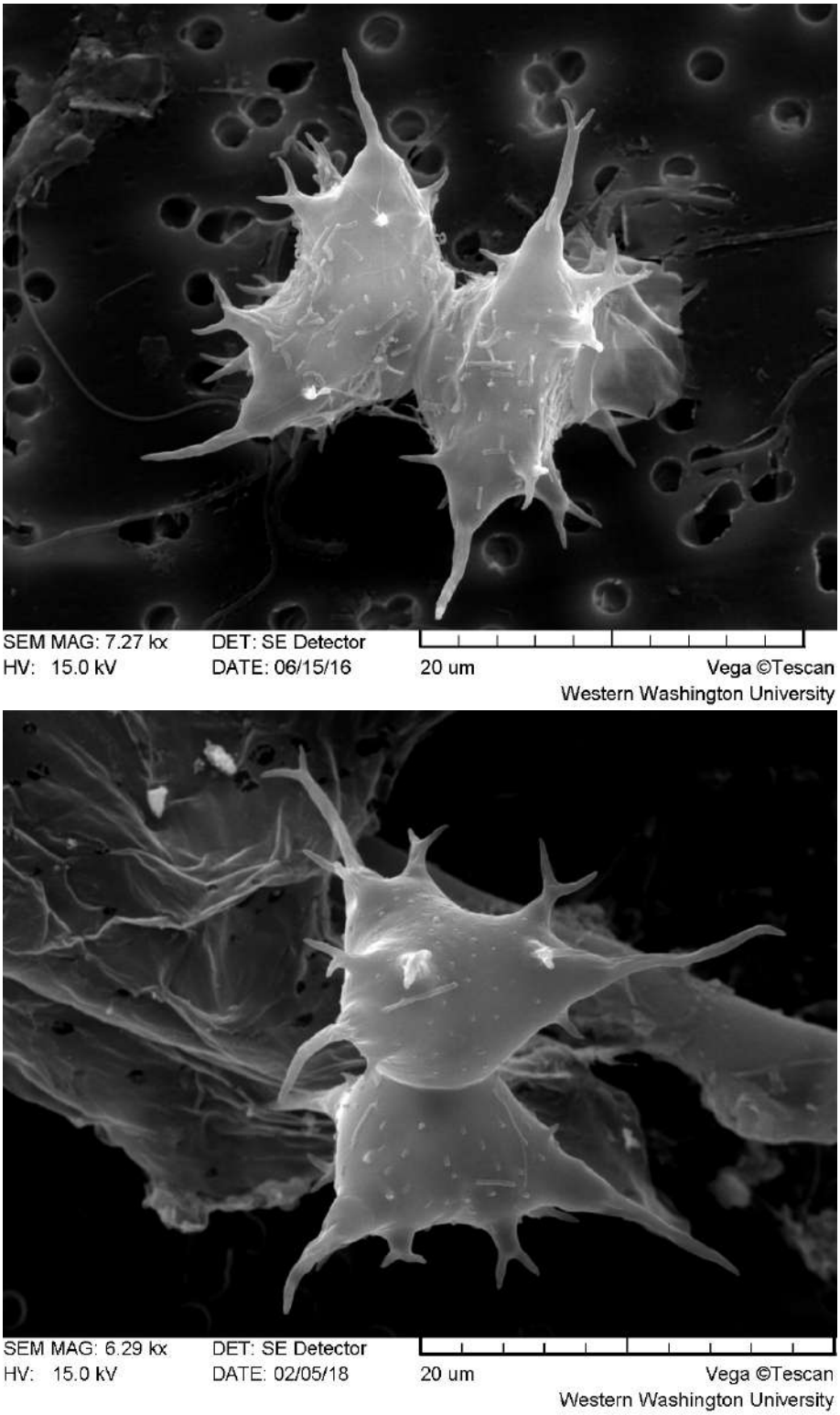


Figure 22.190: *Staurastrum novae-terrae* (SEM/SEM), Bear Lake, Mountain Loop Highway, Snohomish County (upper/lower images).

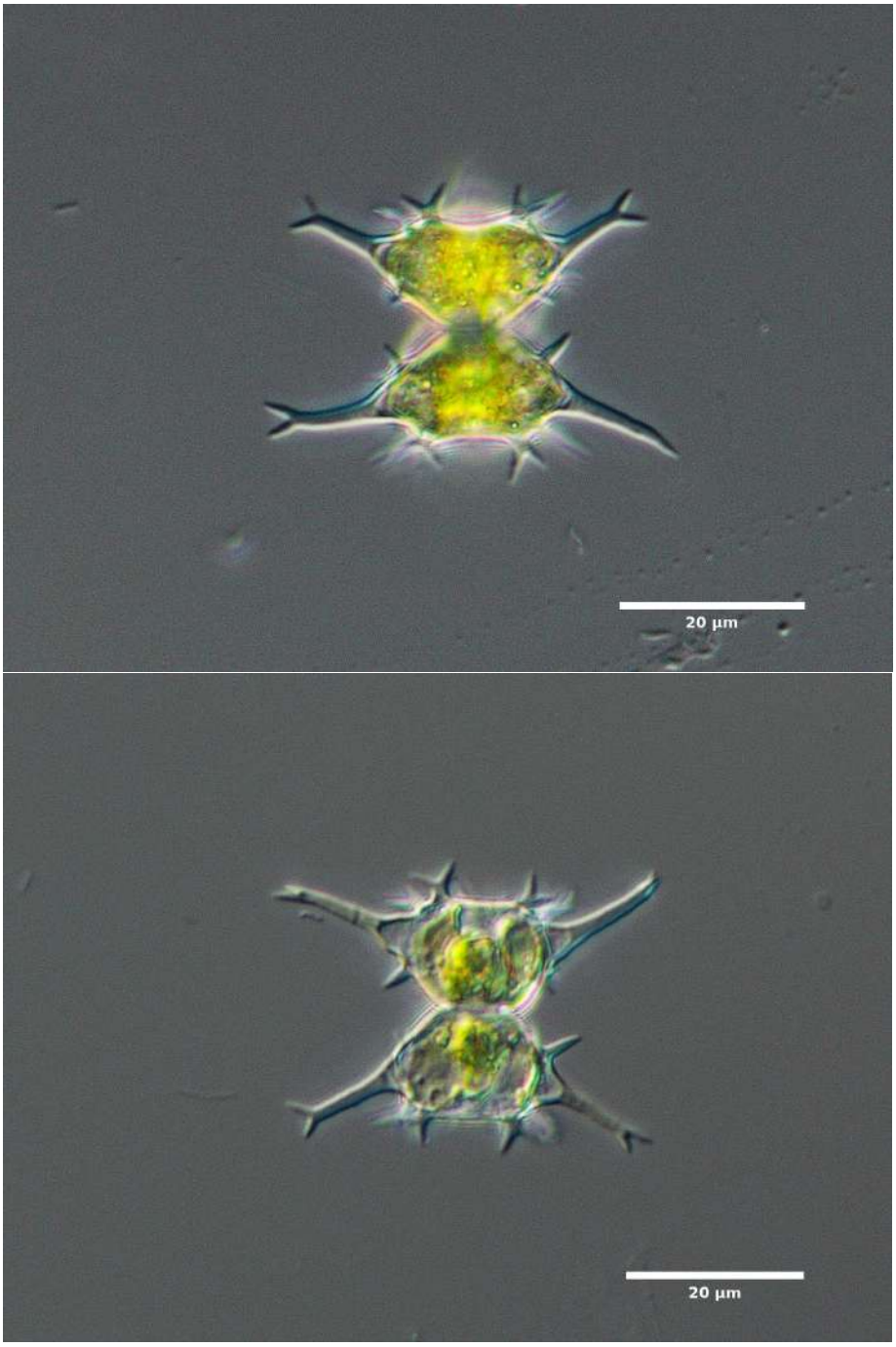


Figure 22.191: *Staurastrum novae-terrae* (DIC/DIC), Bear Lake, Mountain Loop Highway, Snohomish County (upper/lower images).

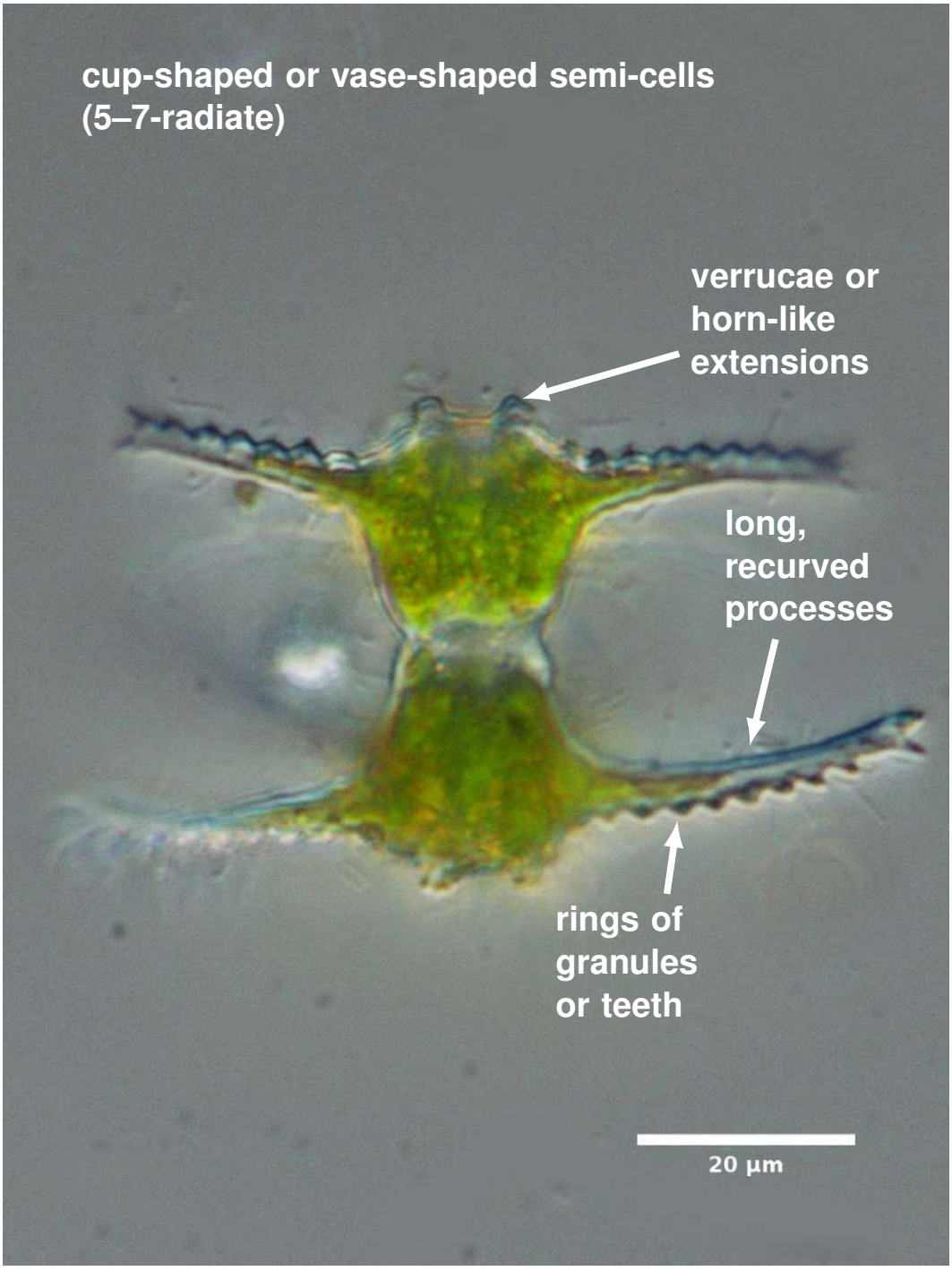


Figure 22.192: *Staurastrum ophiura* (DIC), Vogler Lake, Skagit County.

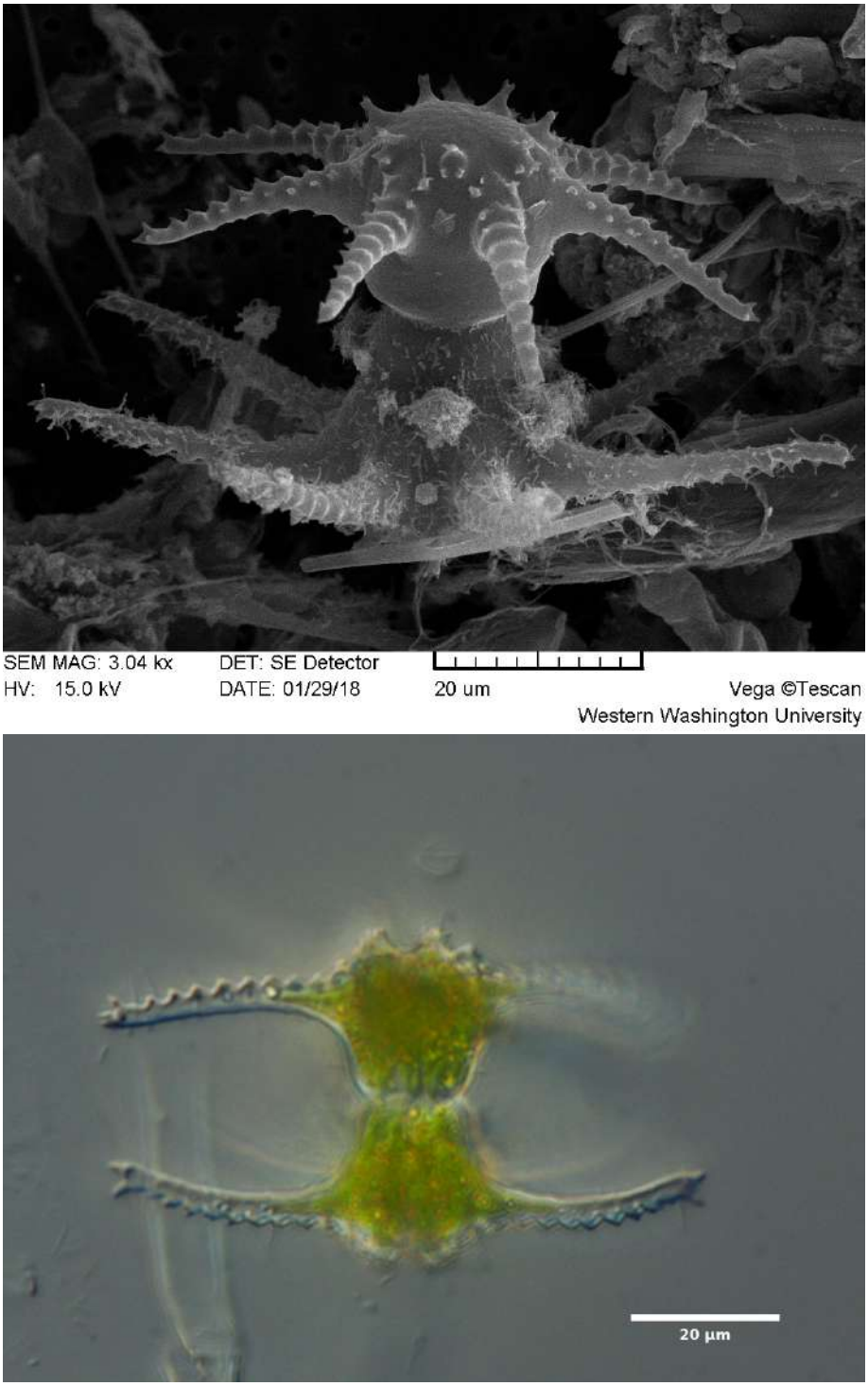


Figure 22.193: *Staurastrum ophiura* (SEM/DIC), Vogler Lake, Skagit County (upper/lower images).

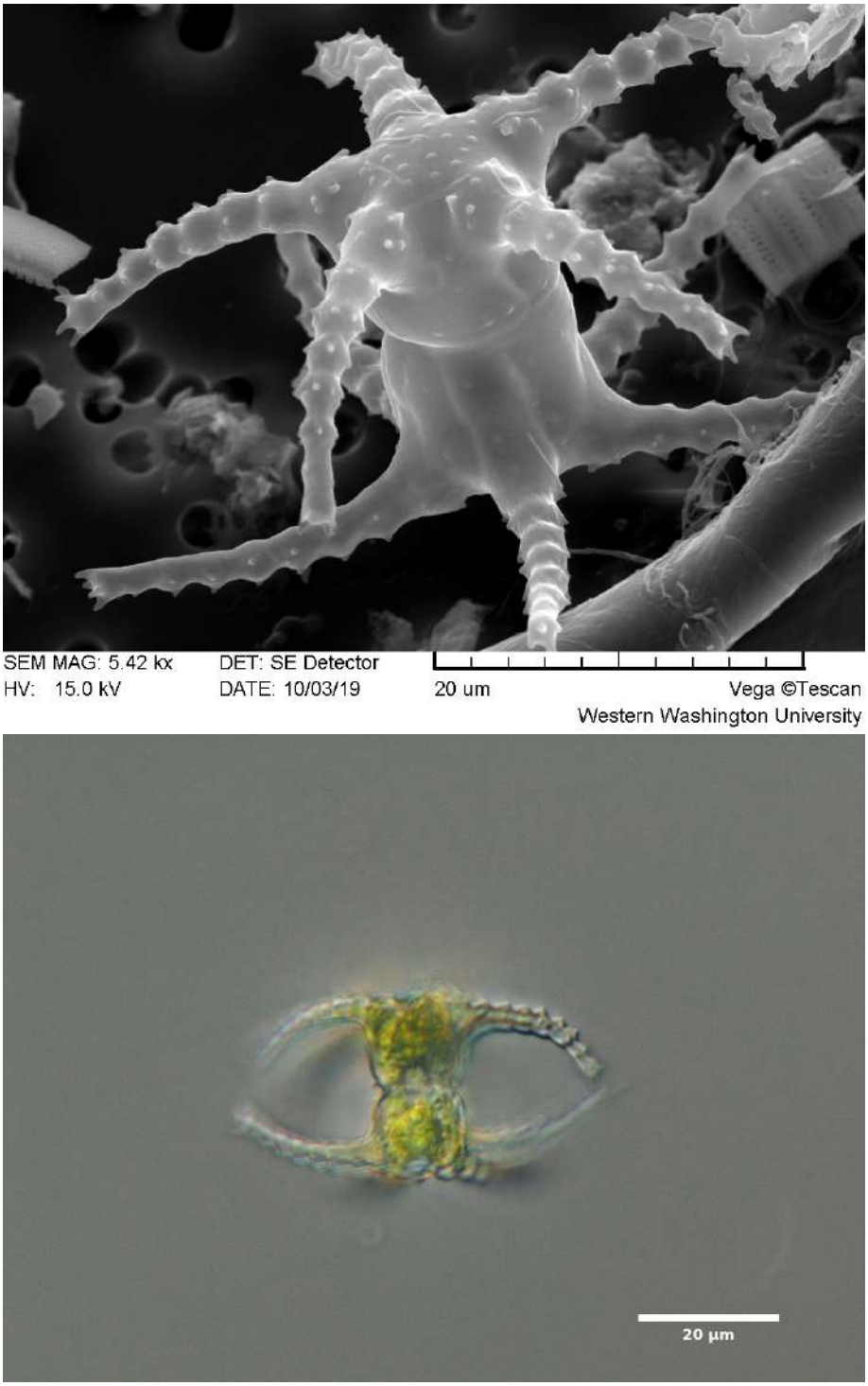


Figure 22.194: *Staurastrum ophiura* 5-radiate semi-cells (SEM/DIC), small floating bog along Morris Valley Road near Harrison, BC (upper/lower images).

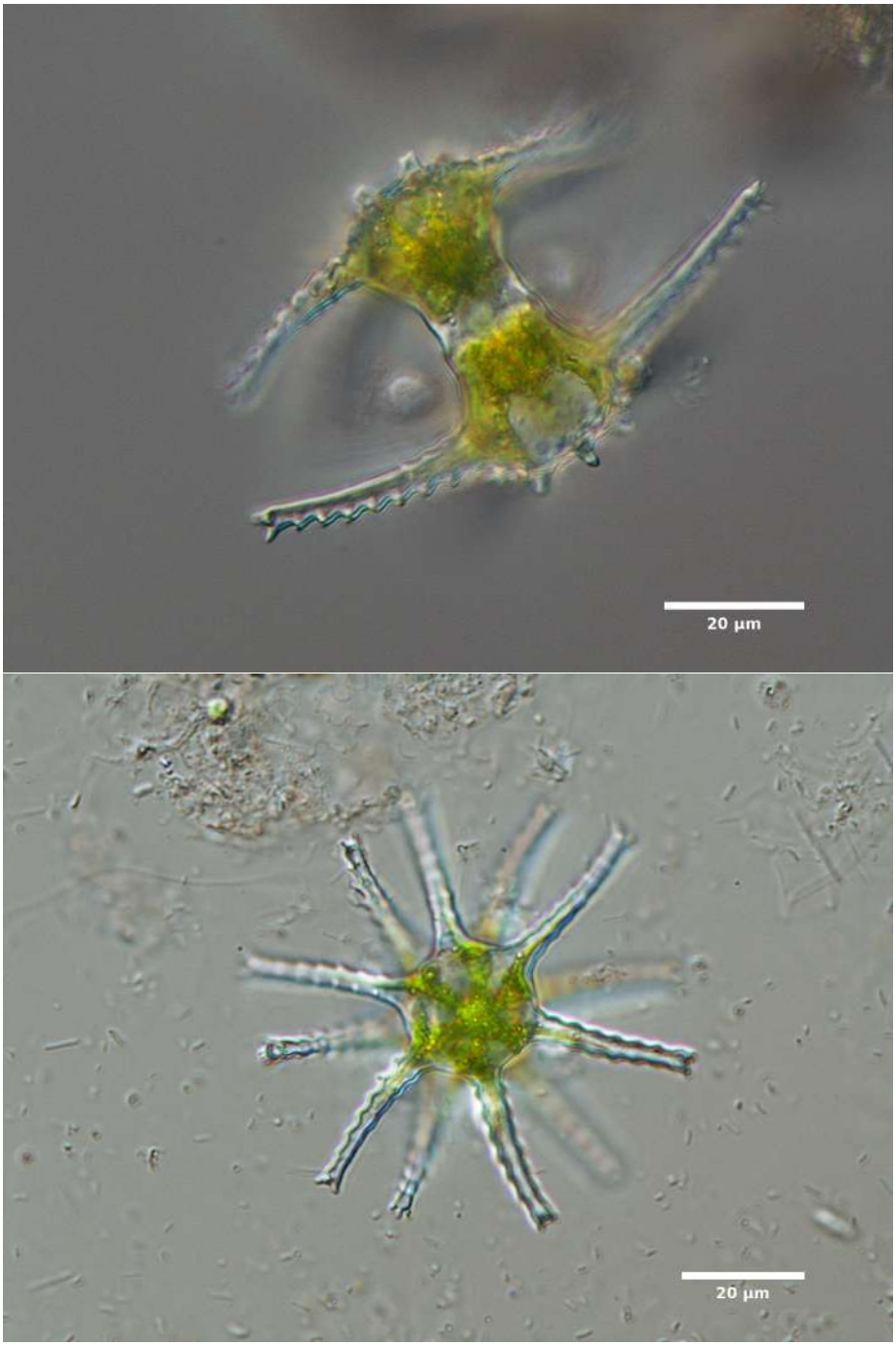


Figure 22.195: *Staurastrum ophiura* 6-radiate semi-cells (DIC/DIC), Bear Lake, Mountain Loop Highway, Snohomish County (upper/lower images).



Figure 22.196: *Staurastrum ophiura* 7-radiate semi-cells (DIC/DIC), Gold Basin Mill Pond, Mountain Loop Highway, Snohomish County (upper/lower images).

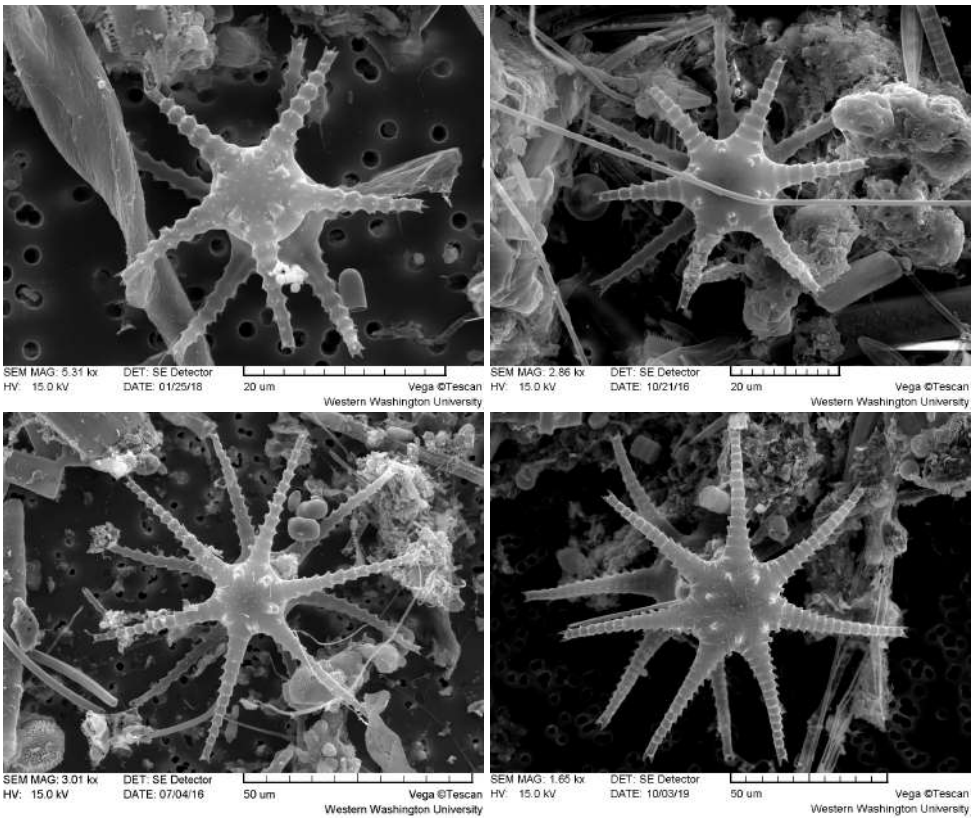


Figure 22.197: SEM images of radial symmetry variations in *Staurastrum ophiura*, Heather Lake Mountain Loop Highway, Snohomish County (upper left image); Bear Lake Mountain Loop Highway, Snohomish County (upper right image); Boardman Lake Mountain Loop Highway, Snohomish County (lower left image); small floating bog along Morris Valley Road near Harrison, BC (lower right image).

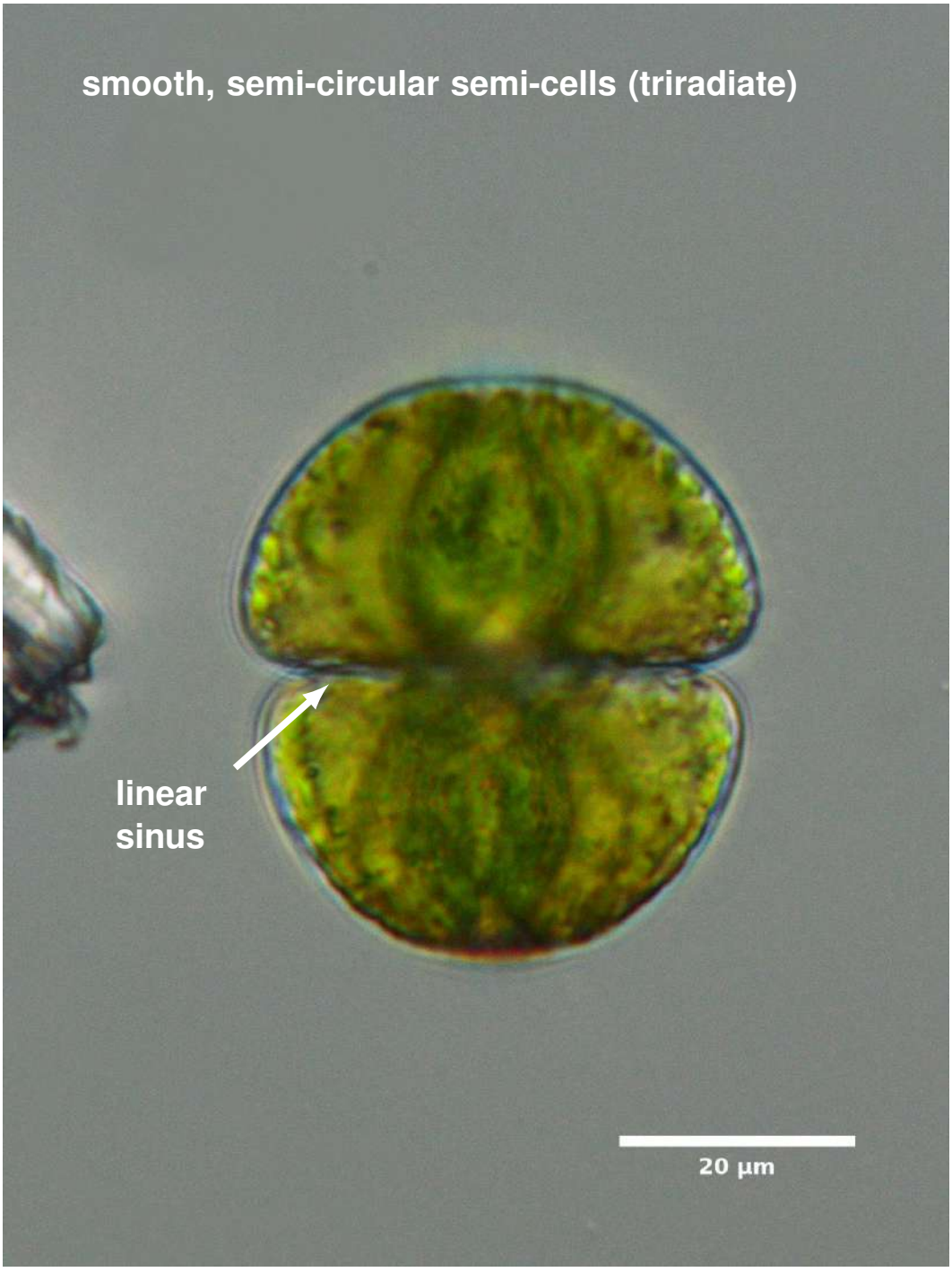


Figure 22.198: *Staurastrum orbiculare* (DIC), Monte Cristo Lake, Mountain Loop Highway, Snohomish County (upper/lower images).



Figure 22.199: *Staurastrum orbiculare* (DIC/DIC), small pond near Fairhaven College, Whatcom County (upper images); small pond on Valley Circle Drive, Bothell WA, Snohomish County (lower images).

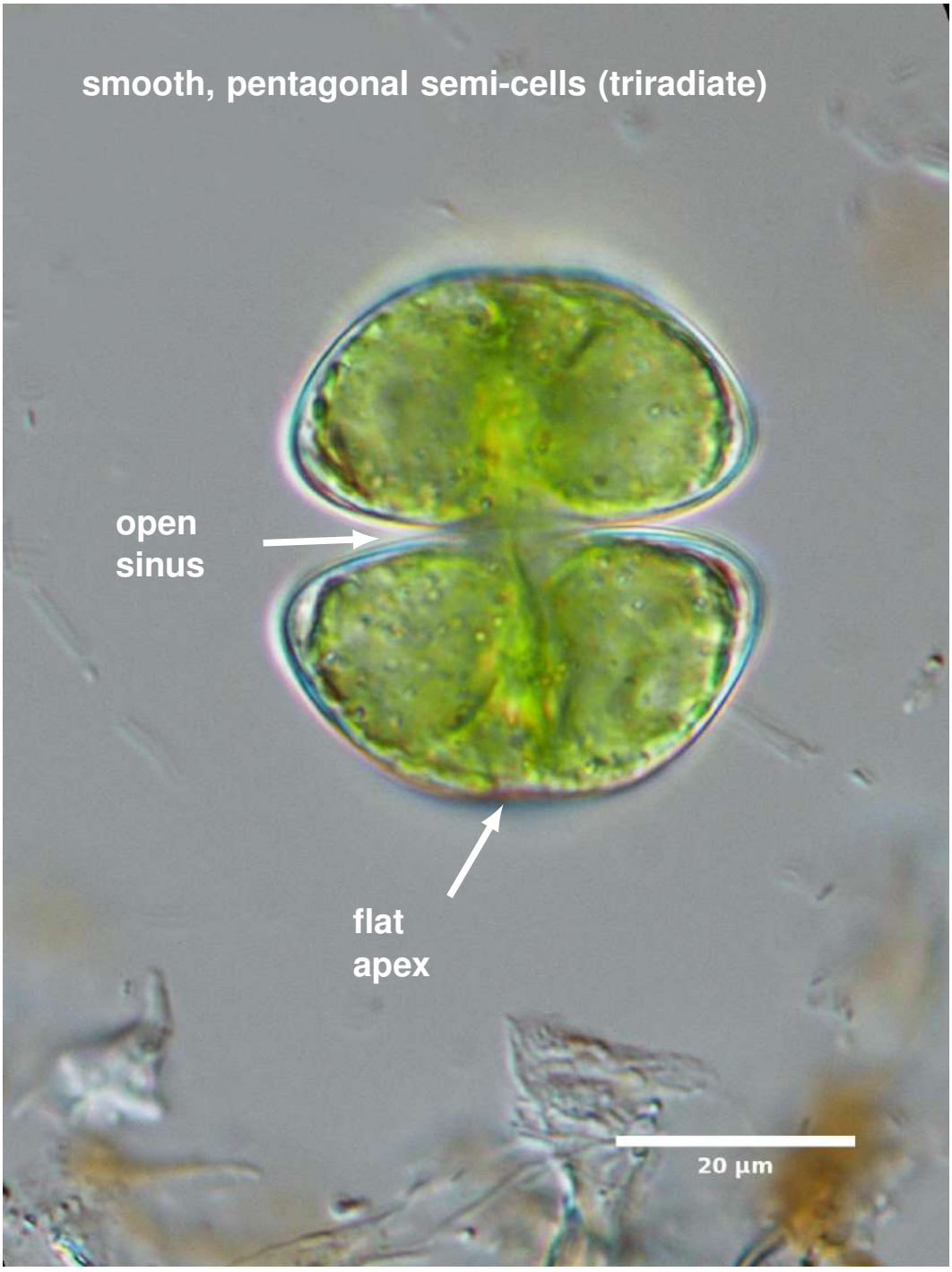


Figure 22.200: *Staurastrum orbiculare* var. *protractum* (DIC), Gold Basin Mill Pond, Mountain Loop Highway, Snohomish County.

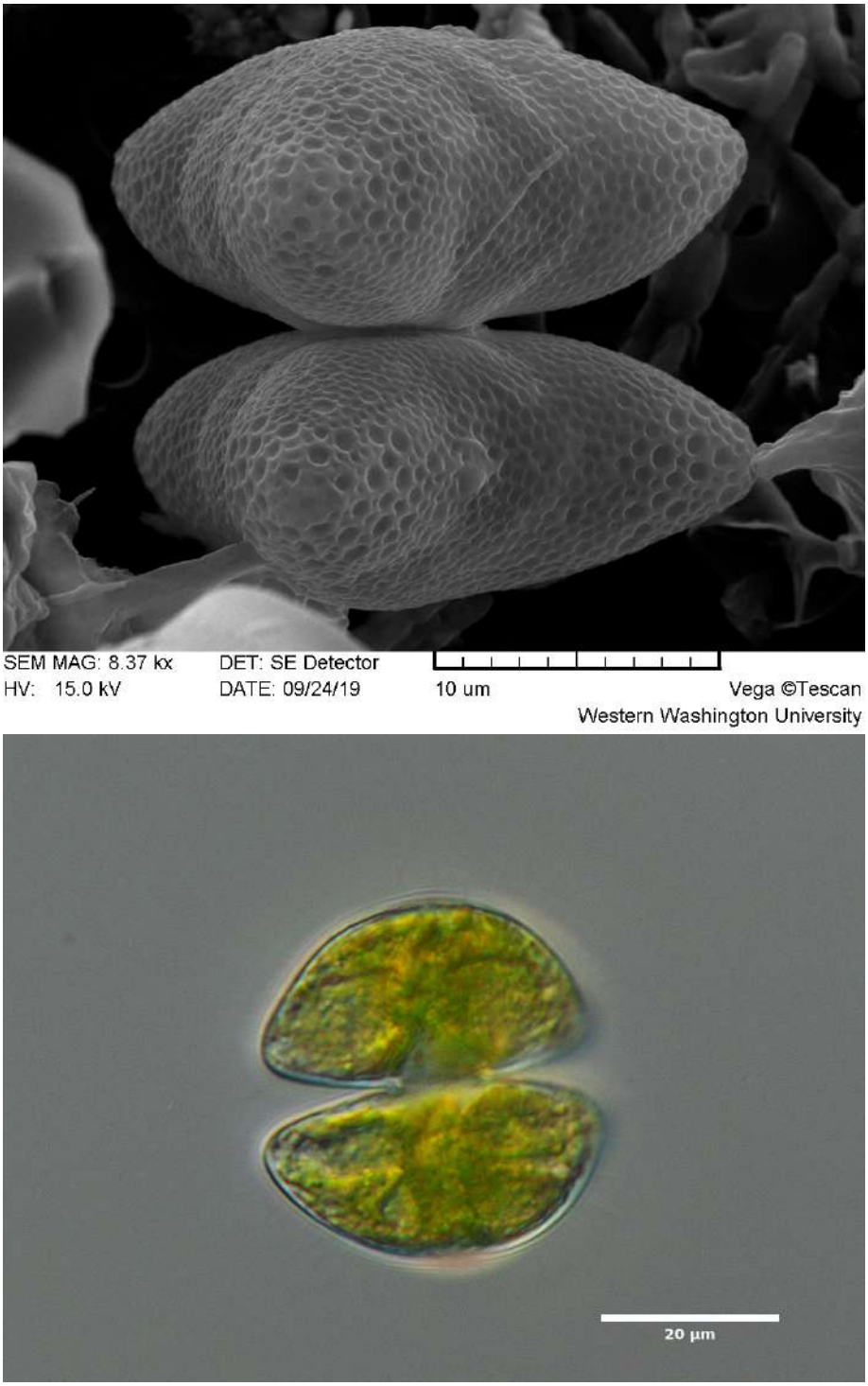


Figure 22.201: *Staurastrum orbiculare* var. *protractum* (SEM/DIC), Chain Lake, Gifford Pinchot National Forest, Skamania County (upper/lower images).

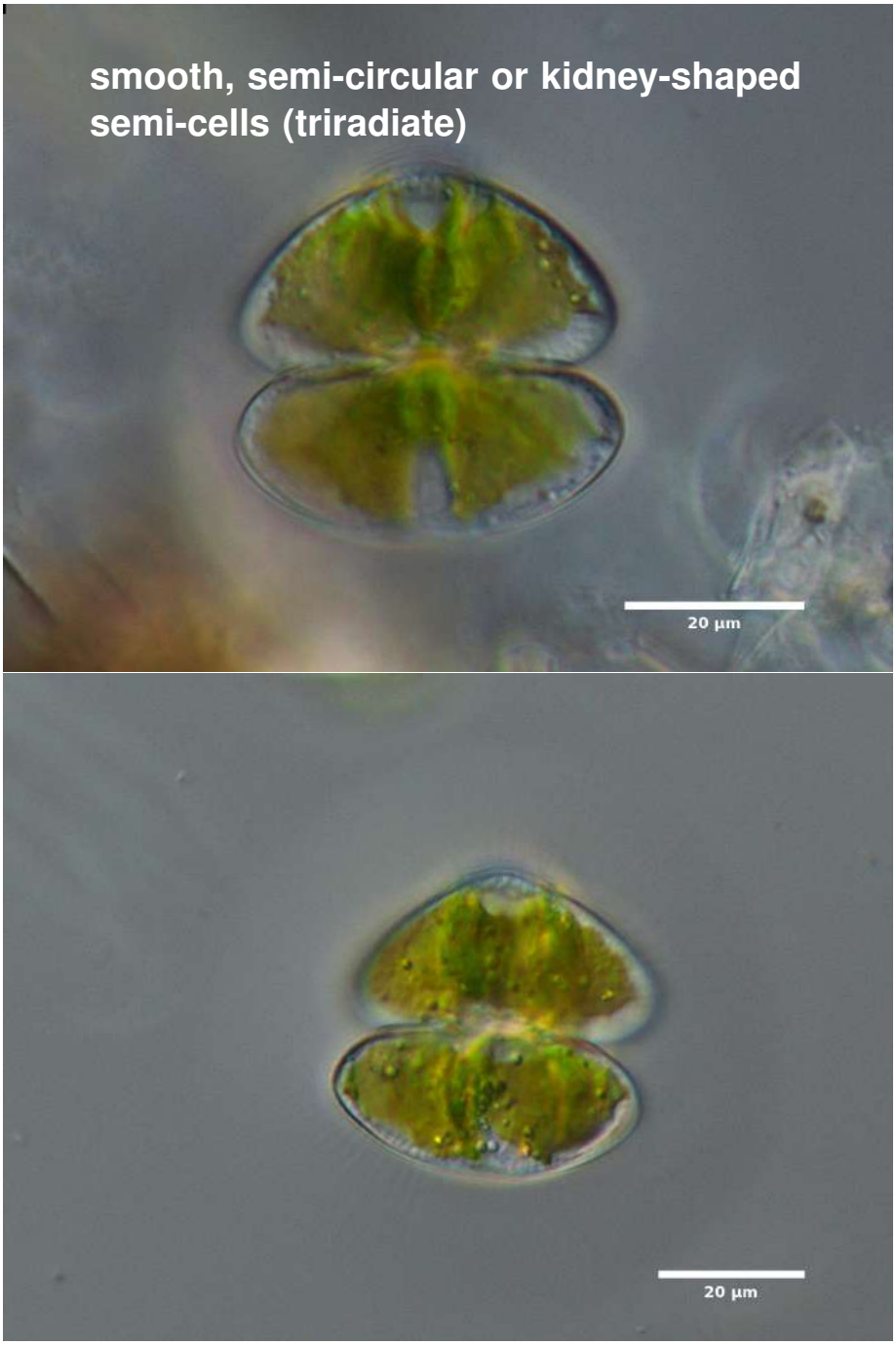


Figure 22.202: *Staurastrum orbiculare* cf. var. *protractum* (DIC/DIC), Big Twin Lake (eastern Washington) Okanogan County (upper/lower images).



Figure 22.203: *Staurastrum* cf. *pachyrhynchum* (DIC), Beaver Lake, Mountain Loop Highway, Snohomish County.

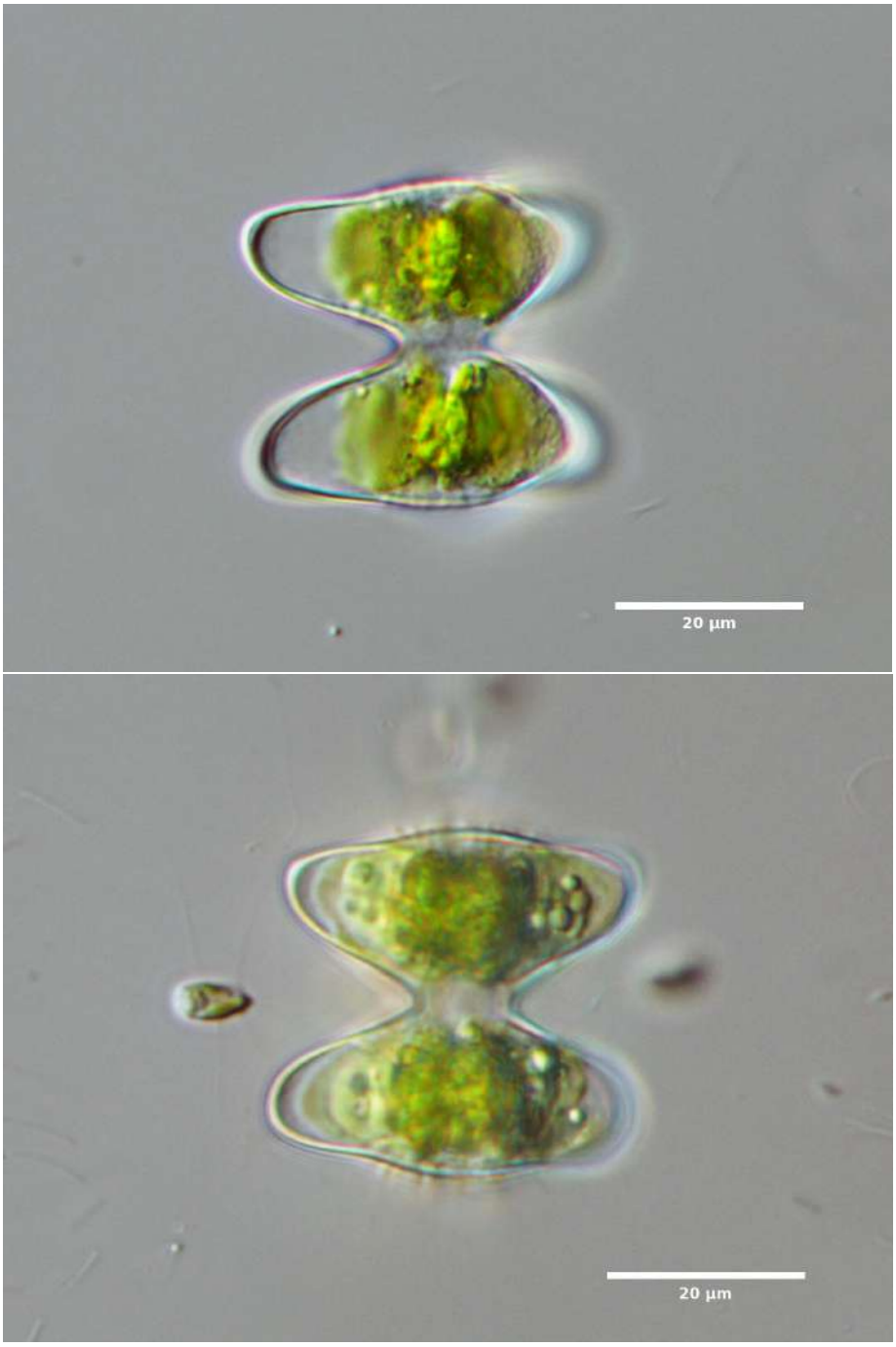


Figure 22.204: *Staurastrum* cf. *pachyrhynchum* (DIC/DIC), Beaver Lake, Mountain Loop Highway, Snohomish County (upper/lower images).



Figure 22.205: *Staurastrum* cf. *pachyrhynchum* var. A (DIC), small pond on trail to Dock Butte, Mt. Baker area, Skagit County.



Figure 22.206: *Staurastrum paradoxum* (DIC), small floating bog near Baby Shoe Pass on road to Takhlakh Lake, Gifford Pinchot National Forest, Skamania County.



Figure 22.207: *Staurastrum paradoxum* (DIC/DIC), small floating bog near Baby Shoe Pass on road to Takhlakh Lake, Gifford Pinchot National Forest, Skamania County (upper/lower images).

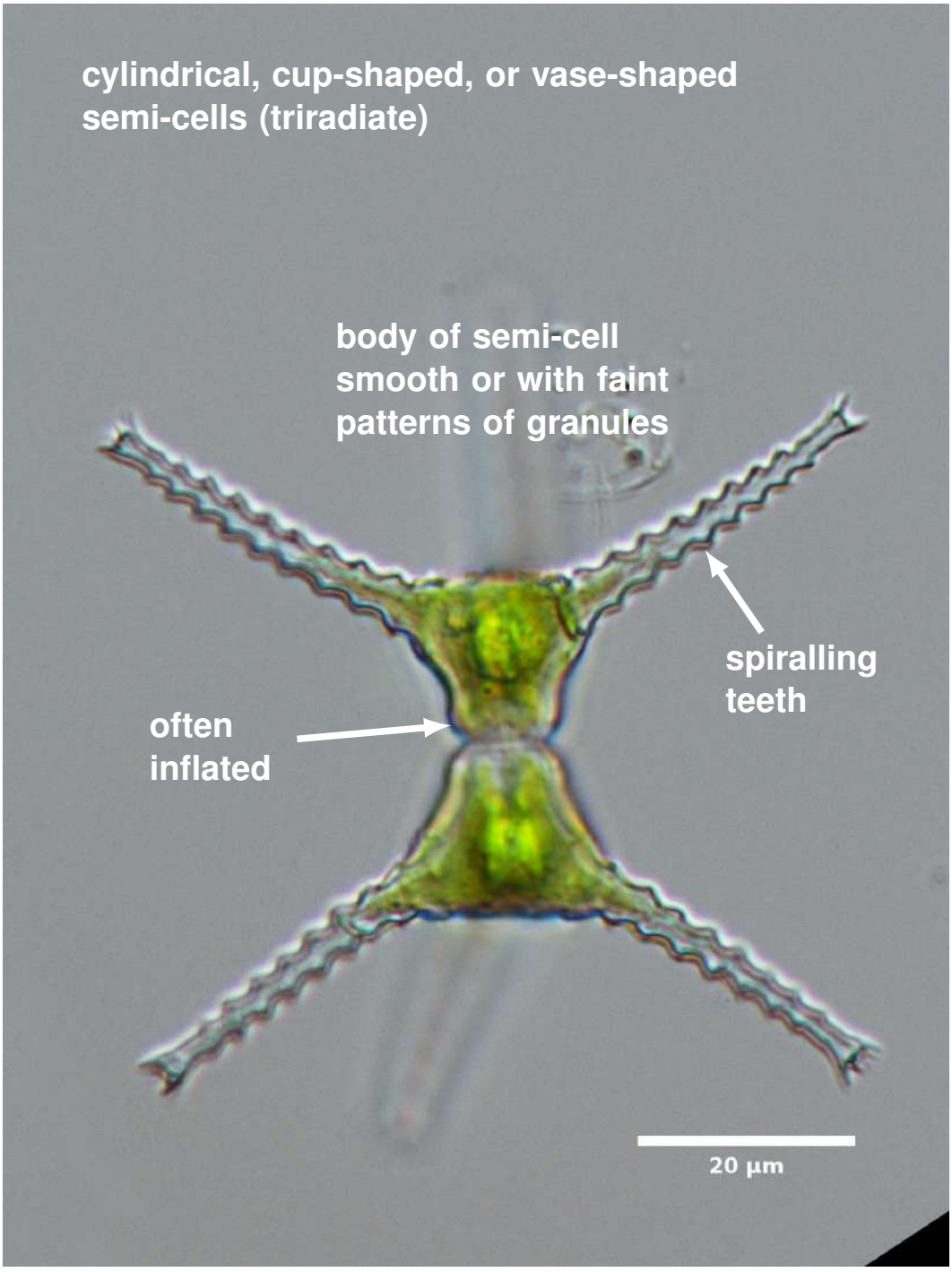


Figure 22.208: *Staurastrum pingue* (DIC), Heart Lake, Skagit County.

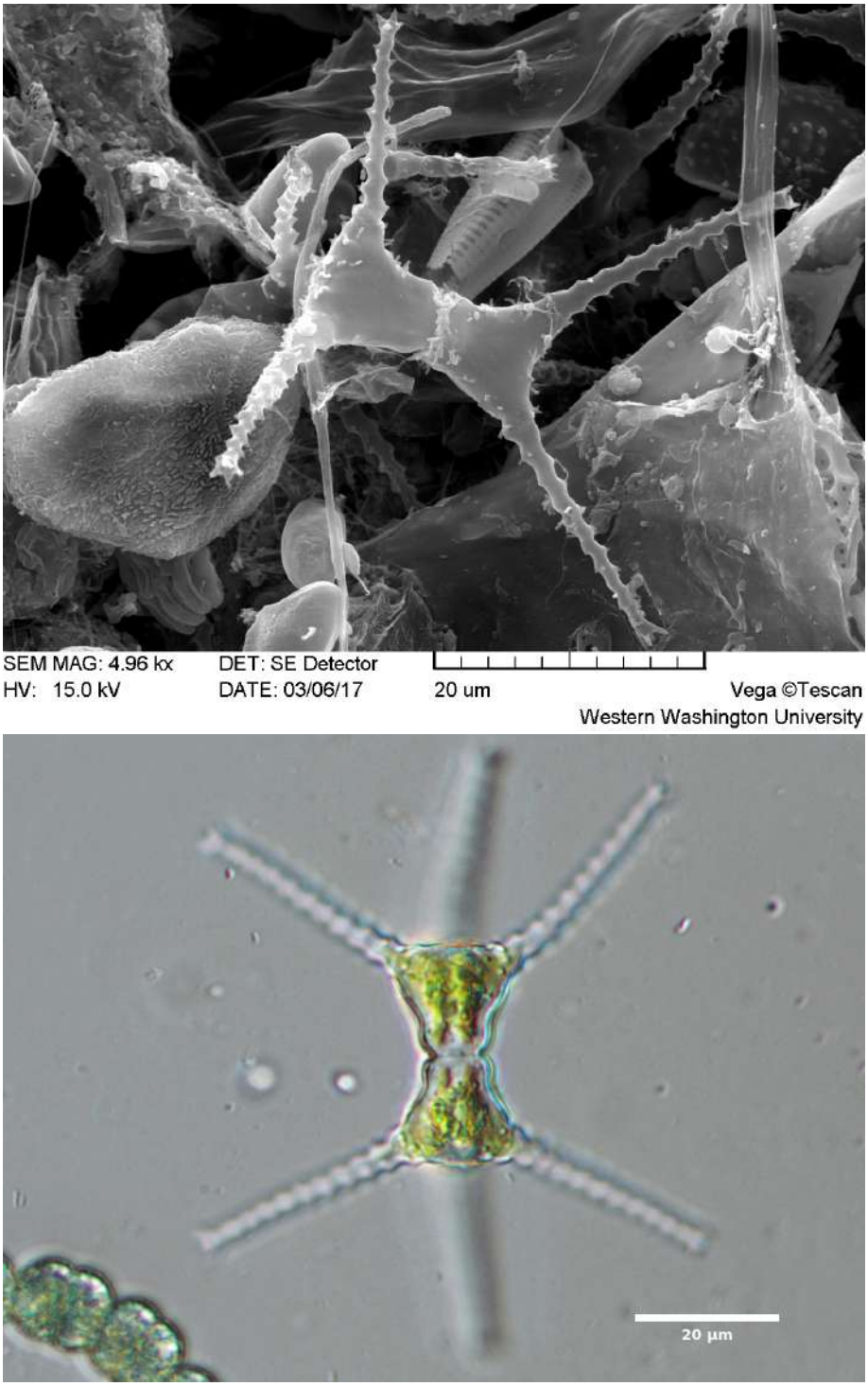


Figure 22.209: *Staurastrum pingue* (SEM/DIC), Heart Lake, Skagit County (upper/lower images).



Figure 22.210: *Staurastrum pingue* (DIC/DIC), Heart Lake, Skagit County (upper/lower images).

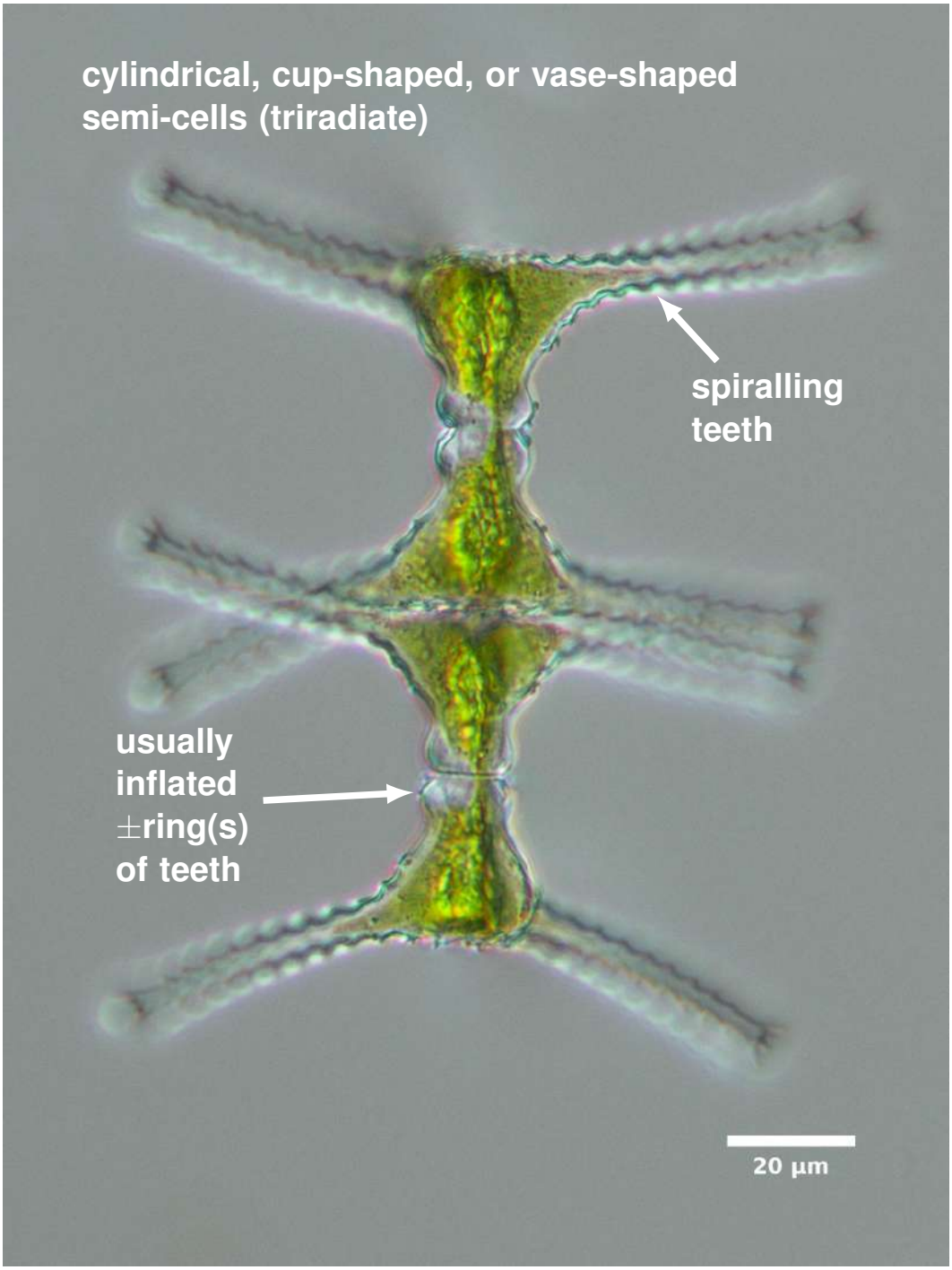


Figure 22.211: *Staurastrum pingue* var. *planctonicum* (DIC), Squalicum Lake, Whatcom County.

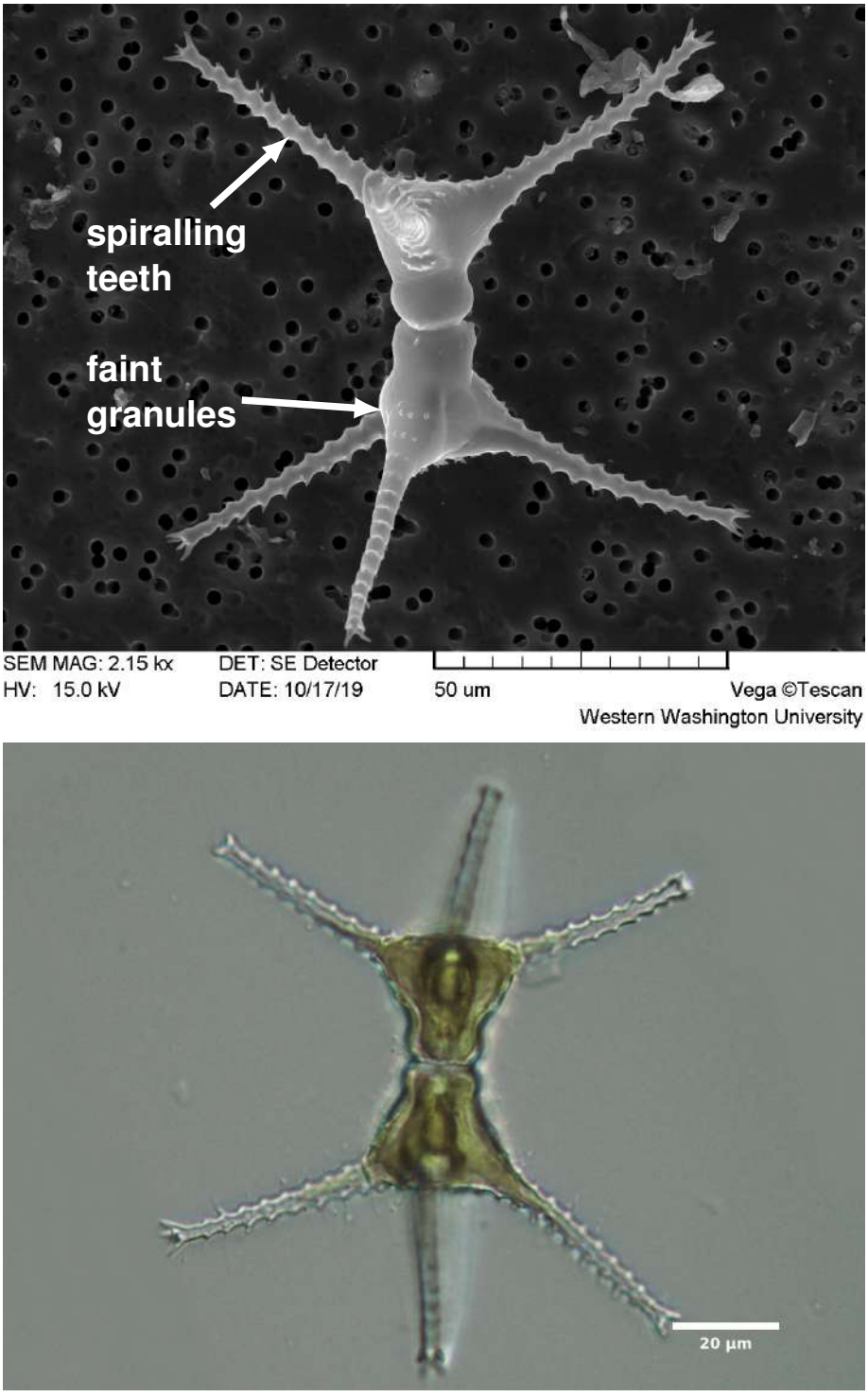


Figure 22.212: *Staurastrum pingue* var. *planctonicum* (SEM/DIC), Lone Lake, Island County.

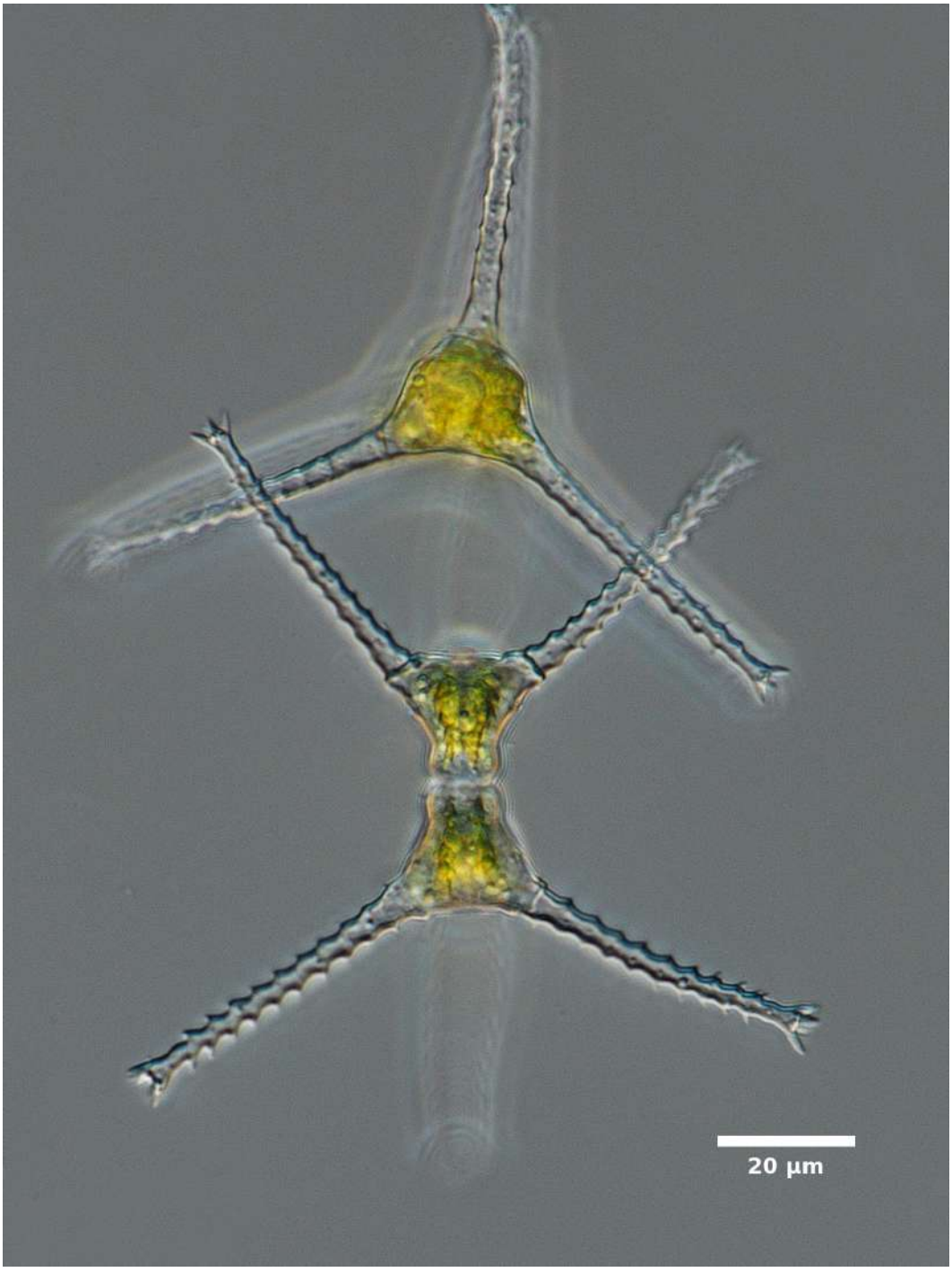


Figure 22.213: *Staurastrum pingue* var. *planctonicum* (DIC), Lone Lake, Island County.

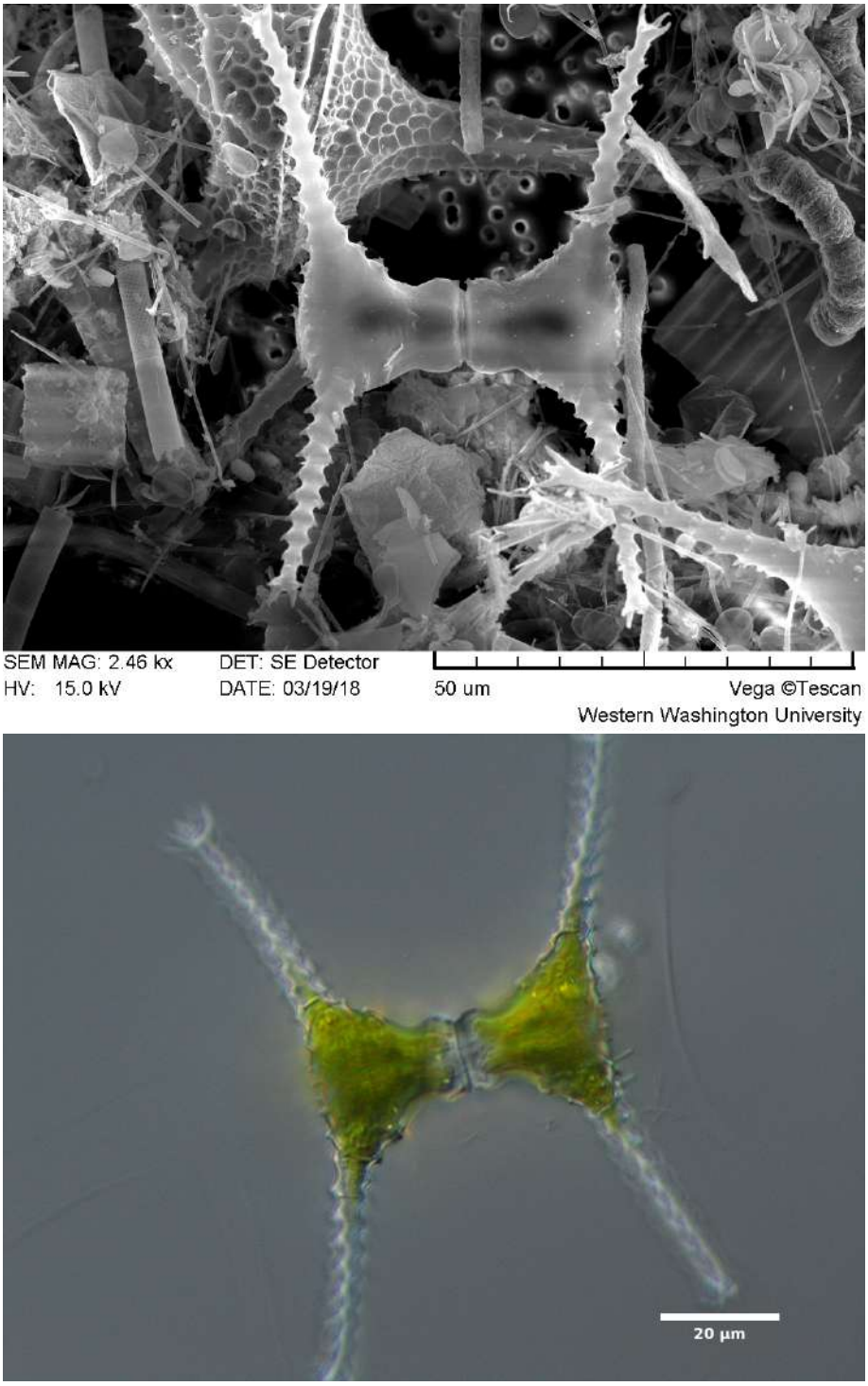


Figure 22.214: *Staurastrum pingue* var. *planctonicum* (SEM/DIC), Lake Fazon, Whatcom County (upper/lower images).

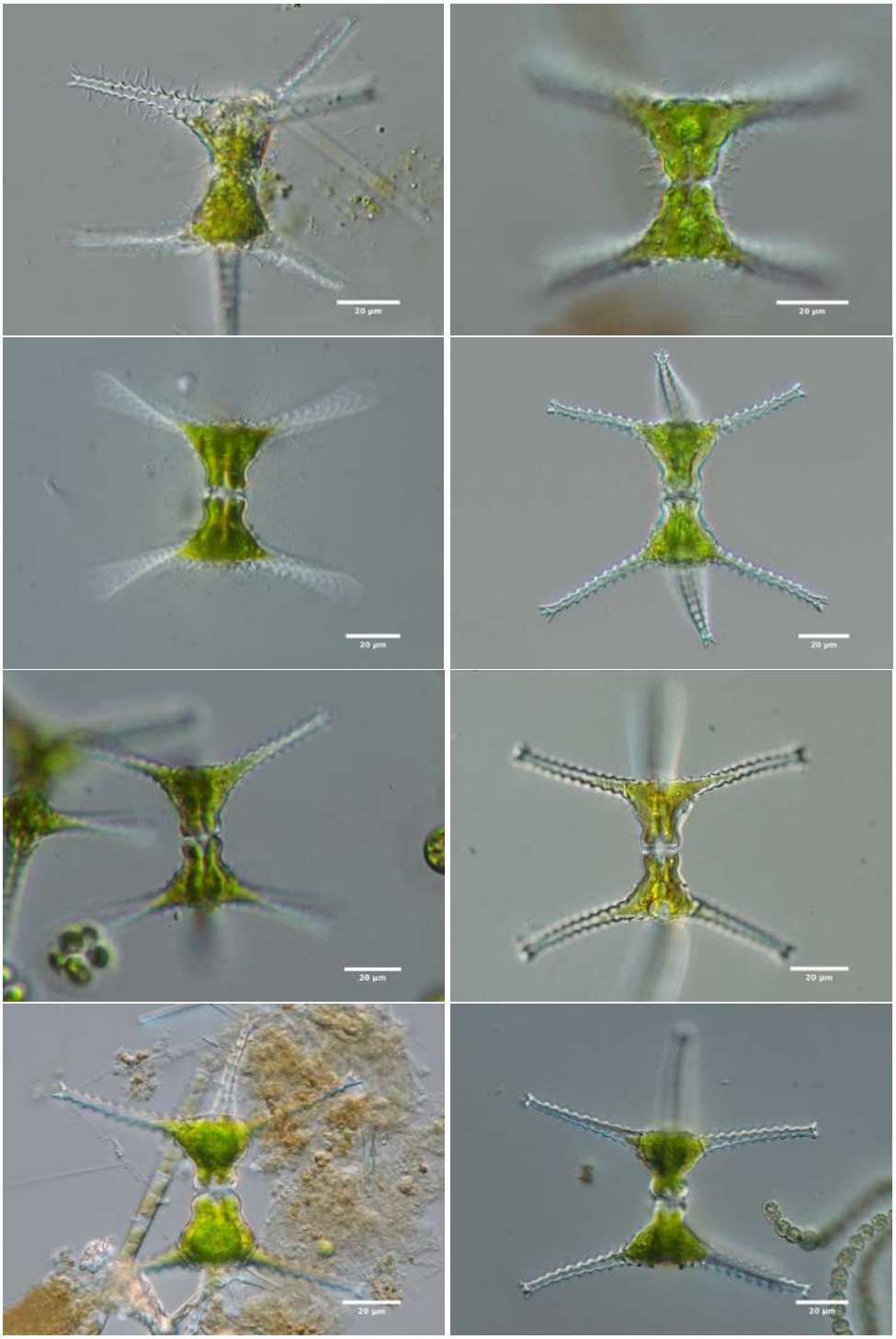


Figure 22.215: Morphological variation in *Staurastrum pingue* var. *planctonicum*, sampling locations from top left: Big Lake (Skagit County), Lake Campbell (Skagit County), Sunday Lake (Snohomish County), Kitsap Lake (Kitsap county), Lake Fazon (Whatcom County), Squalicum Lake (Whatcom County), Wiser Lake (Whatcom County), Lone Lake (Island County).



Figure 22.216: *Staurastrum polytrichum* (DIC), Myrtle Lake, Mountain Loop Highway, Snohomish County.



Figure 22.217: *Staurastrum polytrichum* (DIC/DIC), Myrtle Lake, Mountain Loop Highway, Snohomish County (upper/lower images).

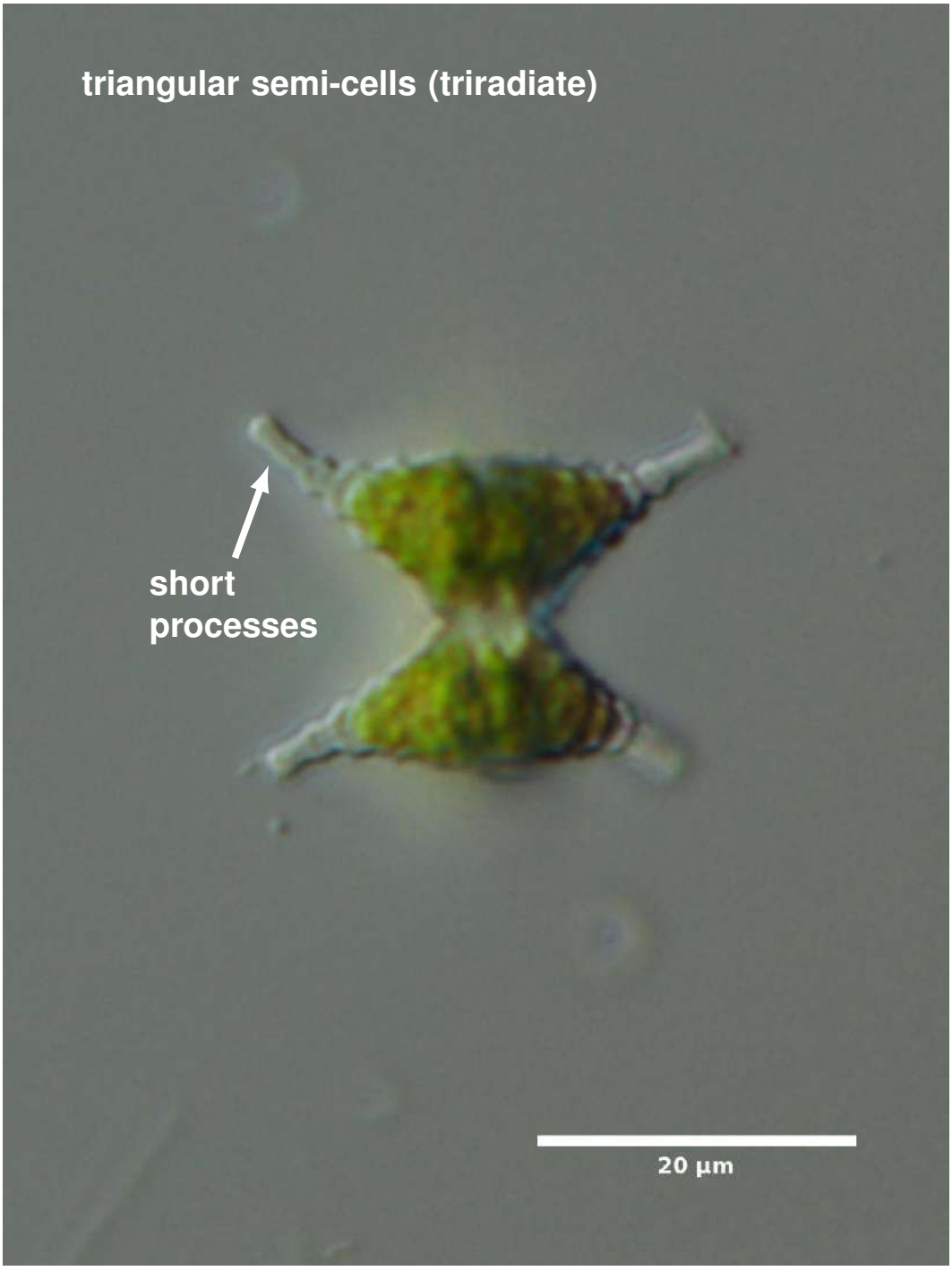


Figure 22.218: *Staurastrum pseudotetracerum* (DIC), Sunday Lake, Snohomish County.

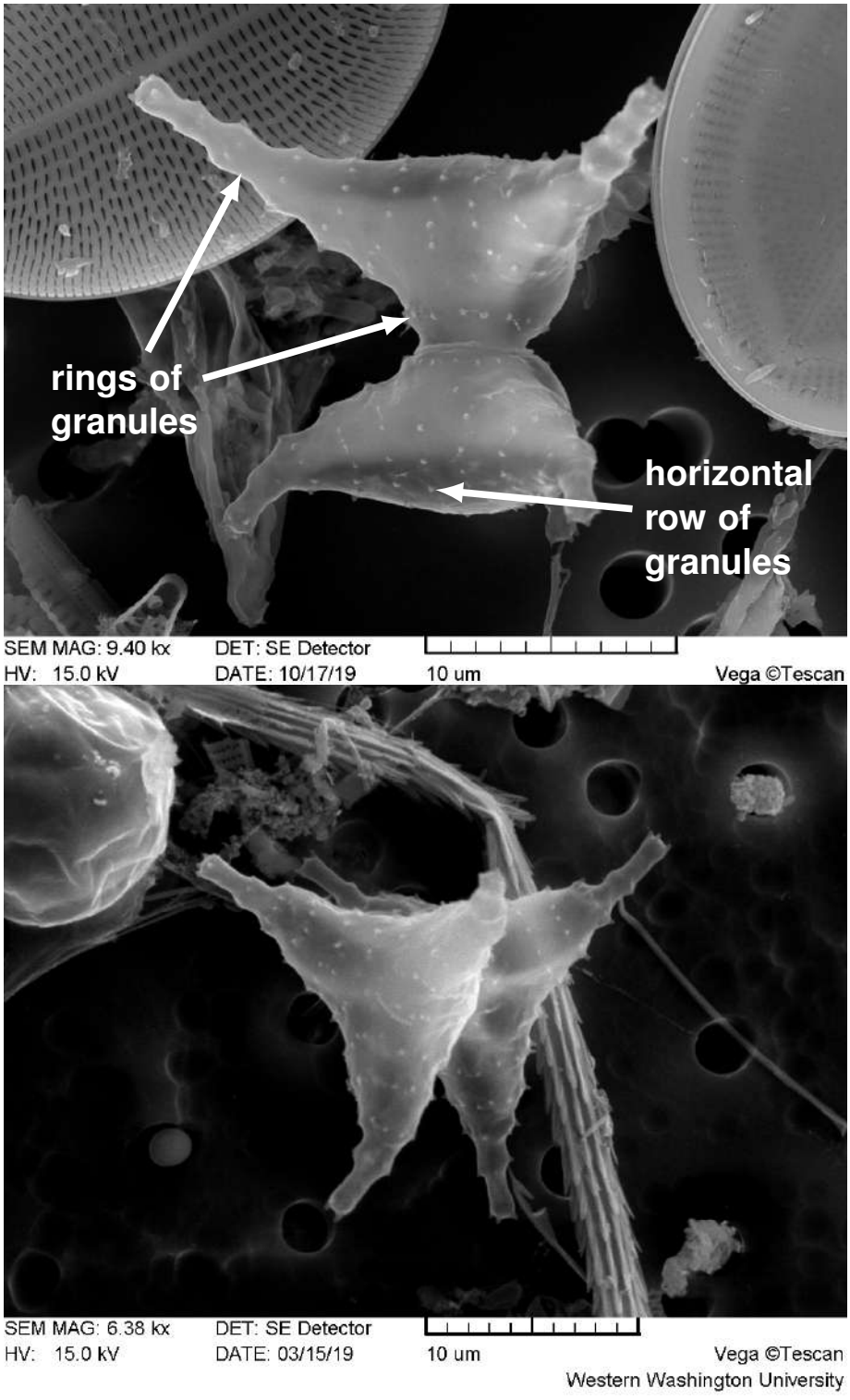


Figure 22.219: *Staurastrum pseudotetracerum* (SEM/SEM), Sunday Lake, Snohomish County (upper/lower images).

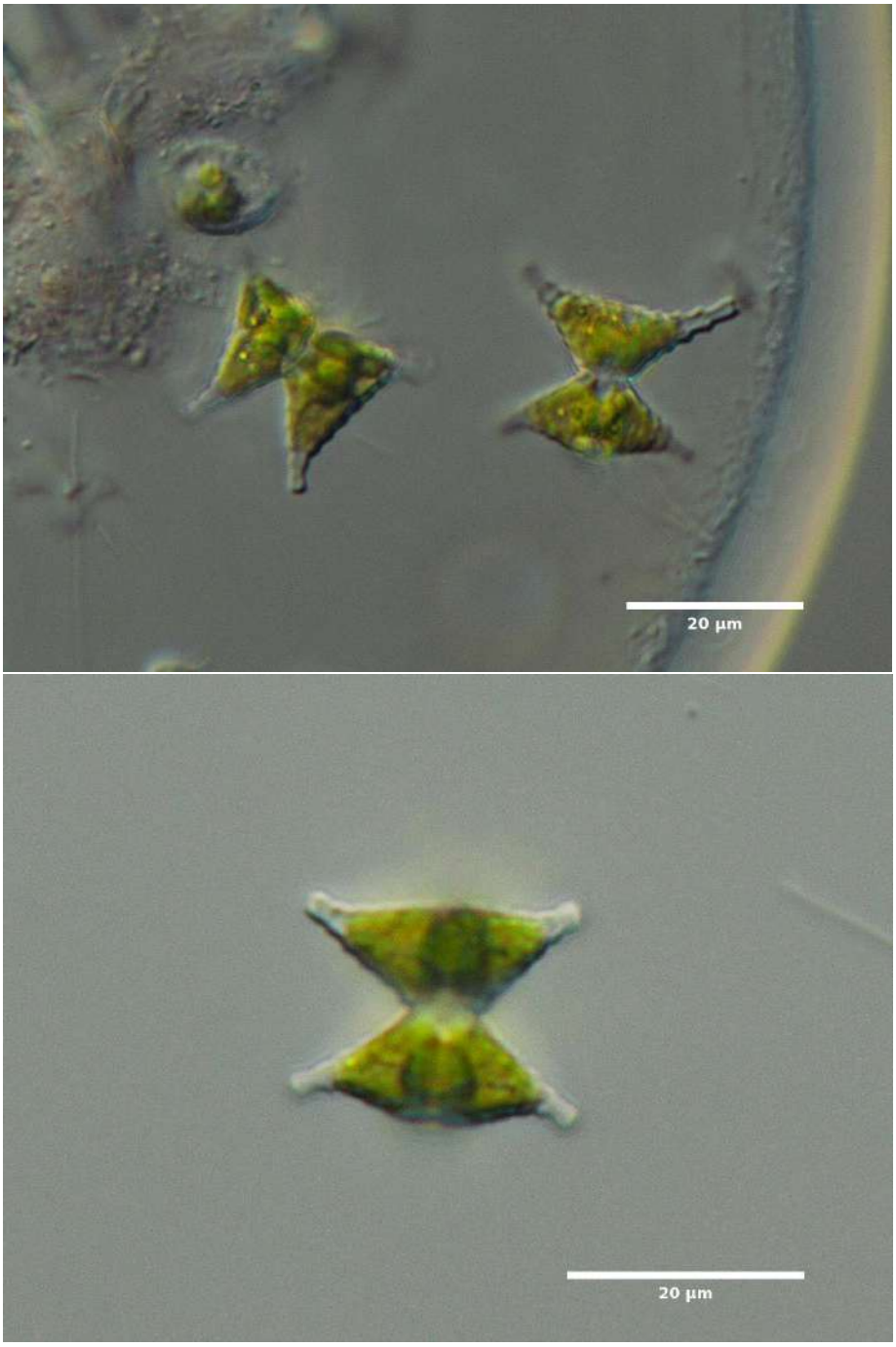


Figure 22.220: *Staurastrum pseudotetracerum* (DIC/DIC), Sunday Lake, Snohomish County (upper/lower images).



Figure 22.221: *Staurastrum punctulatum* (DIC), tributary between sections of Upper Anderson Lake, Mt. Baker area, Whatcom County.

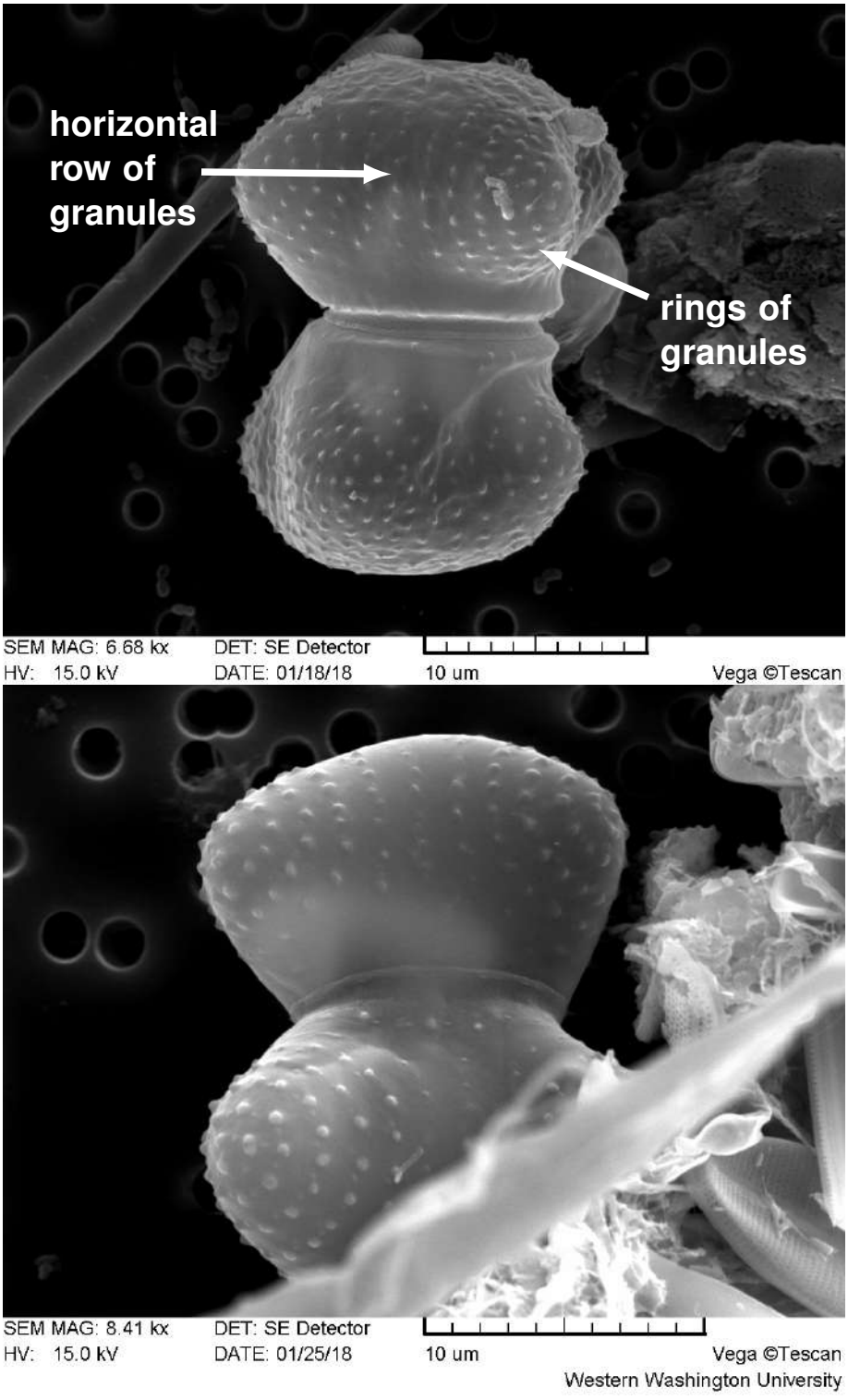


Figure 22.222: *Staurastrum punctulatum* (SEM/SEM),tributary between sections of Upper Anderson Lake, Mt. Baker area, Whatcom County (upper image); Heather Lake, Mountain Loop Highway, Snohomish County (lower image).

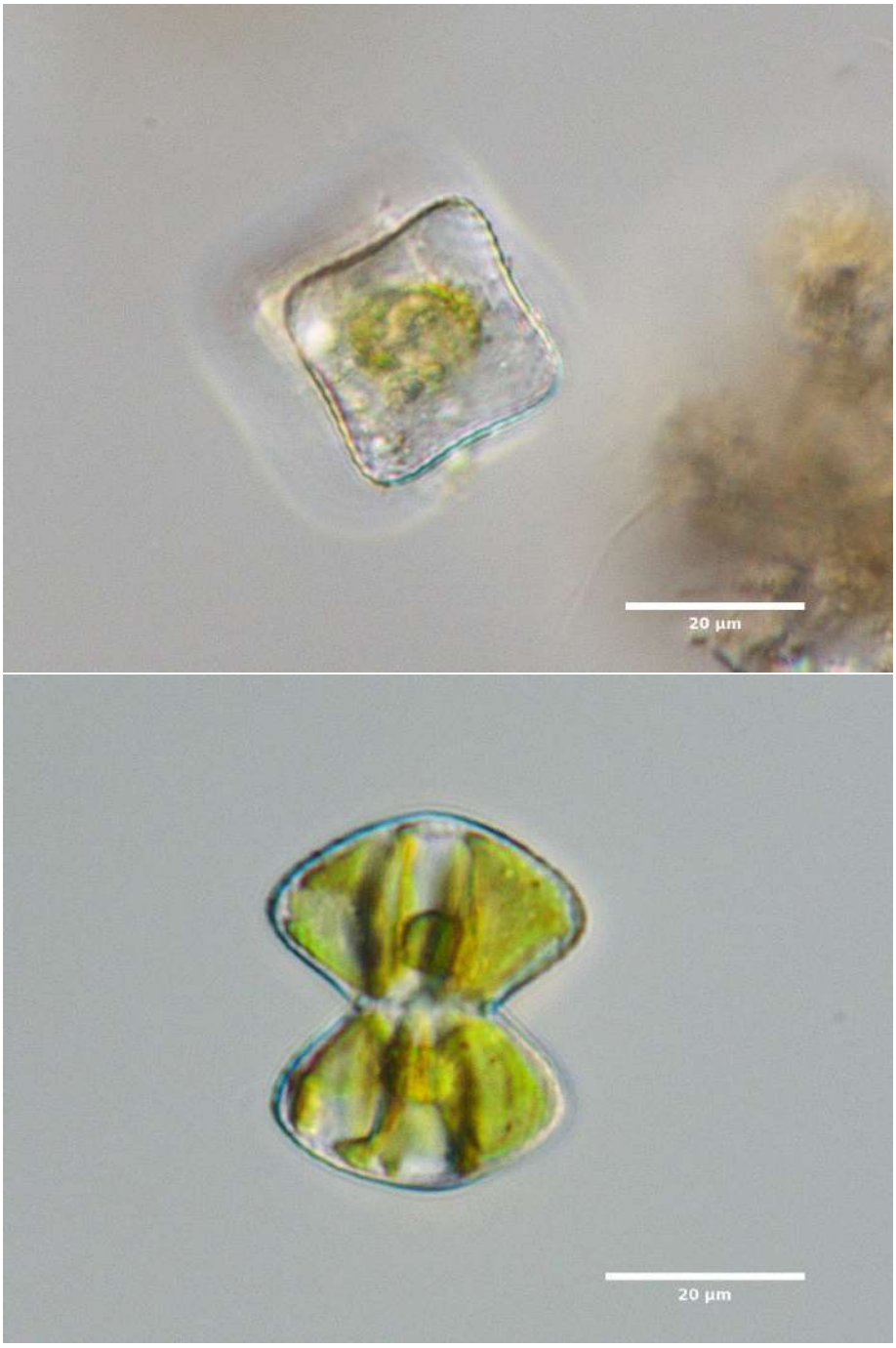


Figure 22.223: *Staurastrum punctulatum* (DIC/DIC), tributary between sections of Upper Anderson Lake, Mt. Baker area, Whatcom County (upper/lower images).

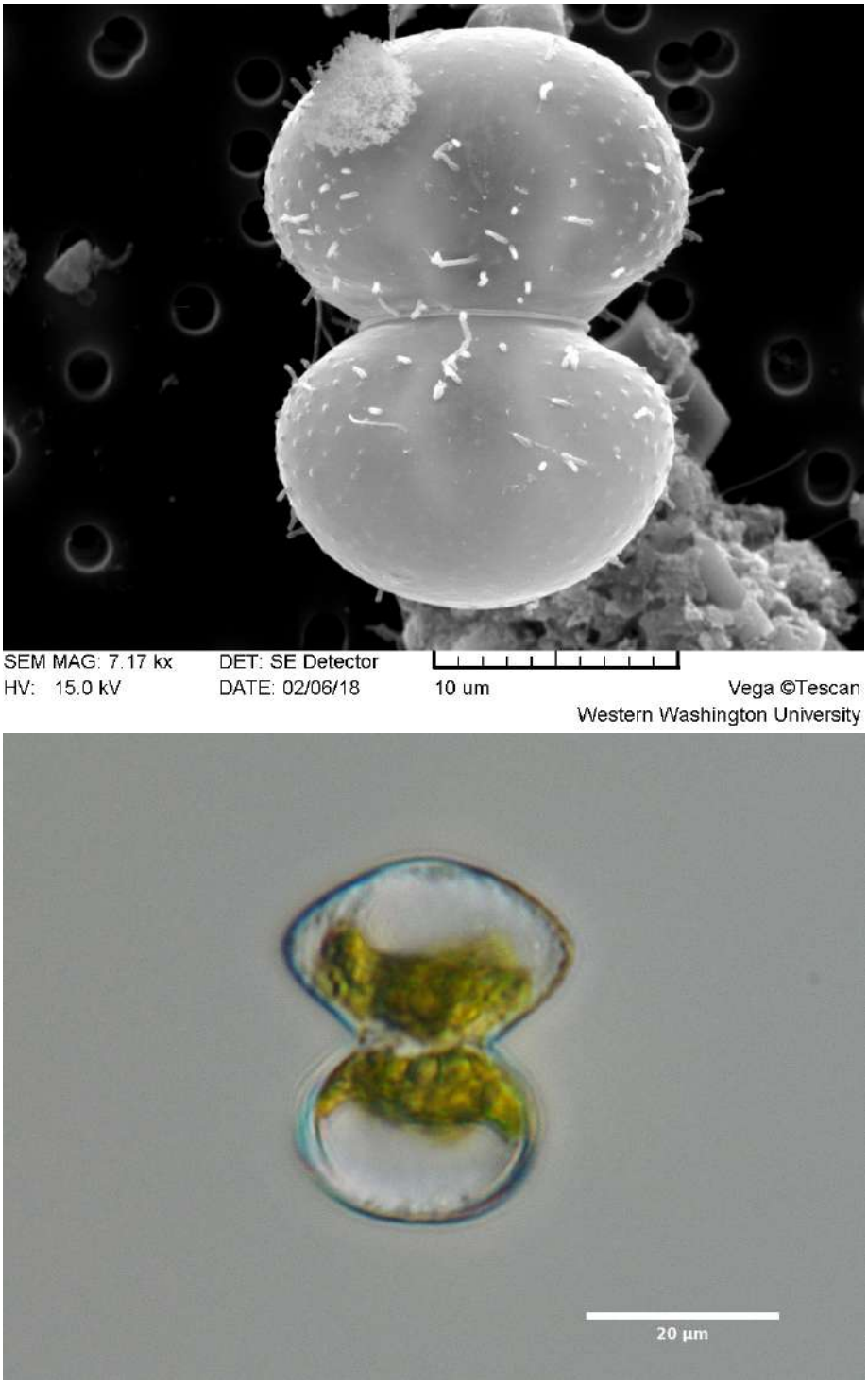


Figure 22.224: *Staurastrum punctulatum* (SEM/DIC), tributary between sections of Upper Anderson Lake, Mt. Baker area, Whatcom County (upper/lower images).



Figure 22.225: *Staurastrum ralfsii* (DIC), Sunrise Lake, Mt. Baker area, Whatcom County.

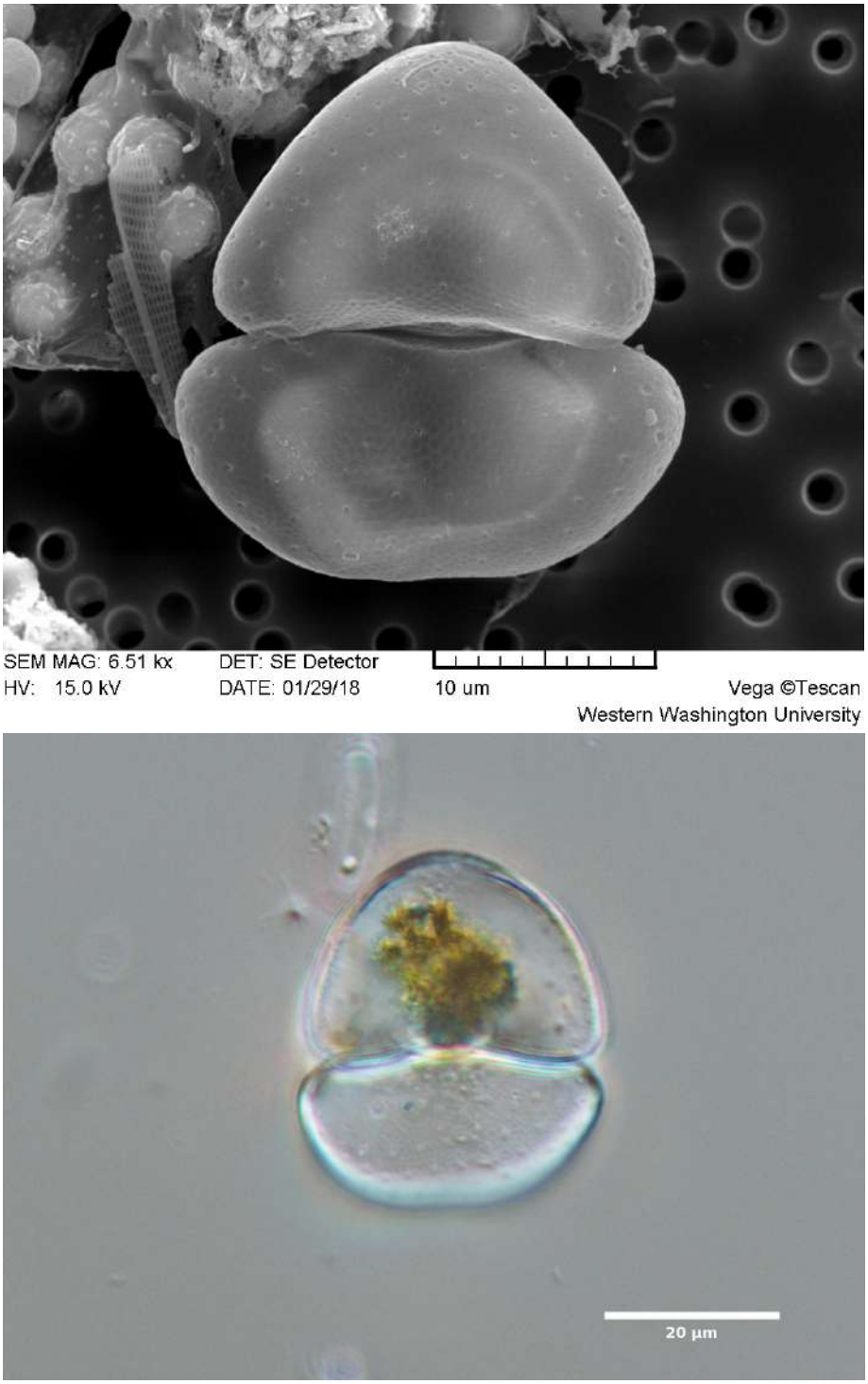


Figure 22.226: *Staurastrum ralfsii* (SEM/DIC), Highwood Lake, Mt. Baker area, Whatcom County (upper image); Summer Lake, Skagit County (lower image).

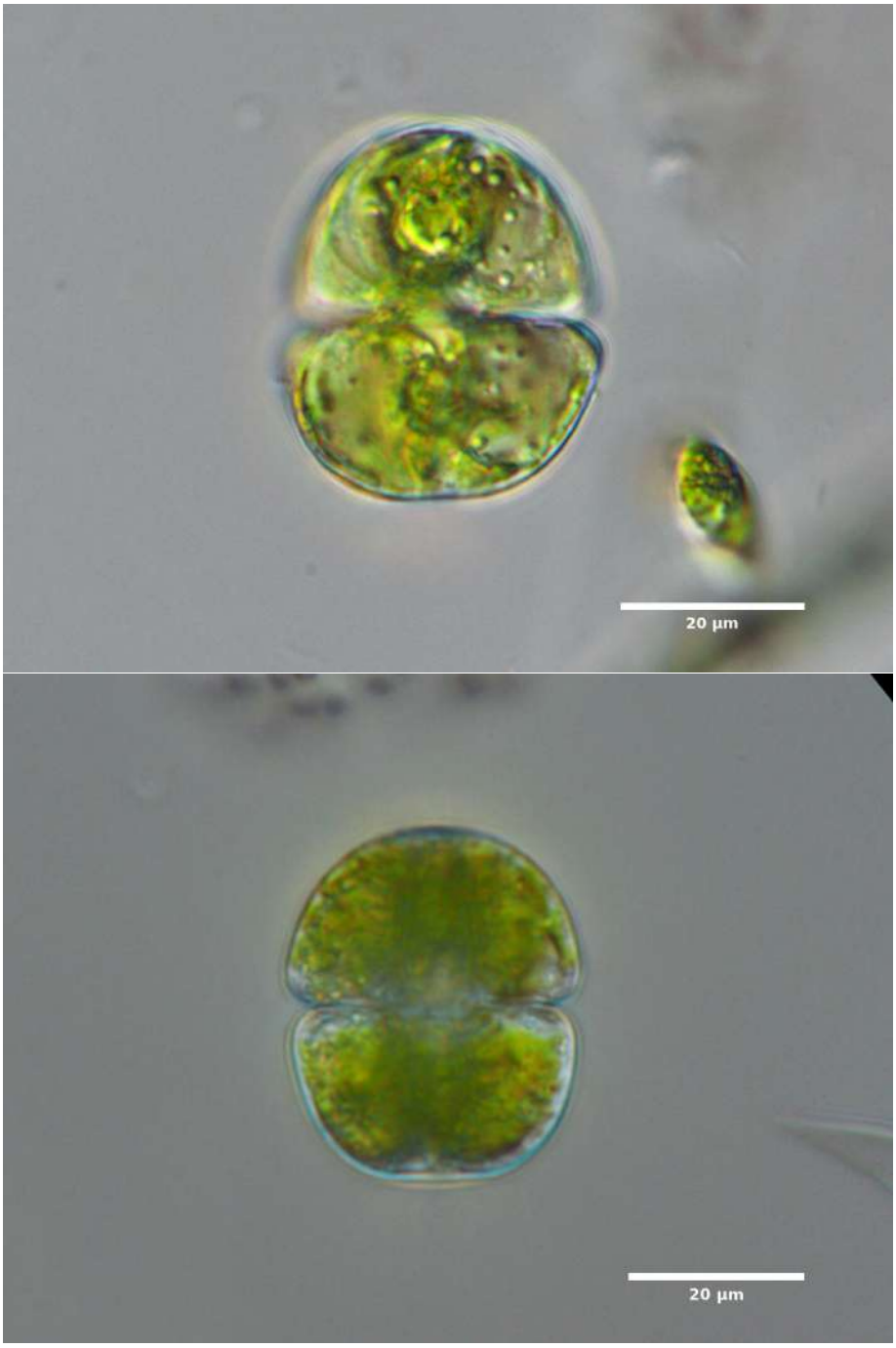


Figure 22.227: *Staurastrum ralfsii* (DIC/DIC), Summer Lake, Skagit County. (upper/lower images)



Figure 22.228: *Staurastrum ralfsii* var. *depressum* (DIC), Myrtle Lake, Mountain Loop Highway, Snohomish County.

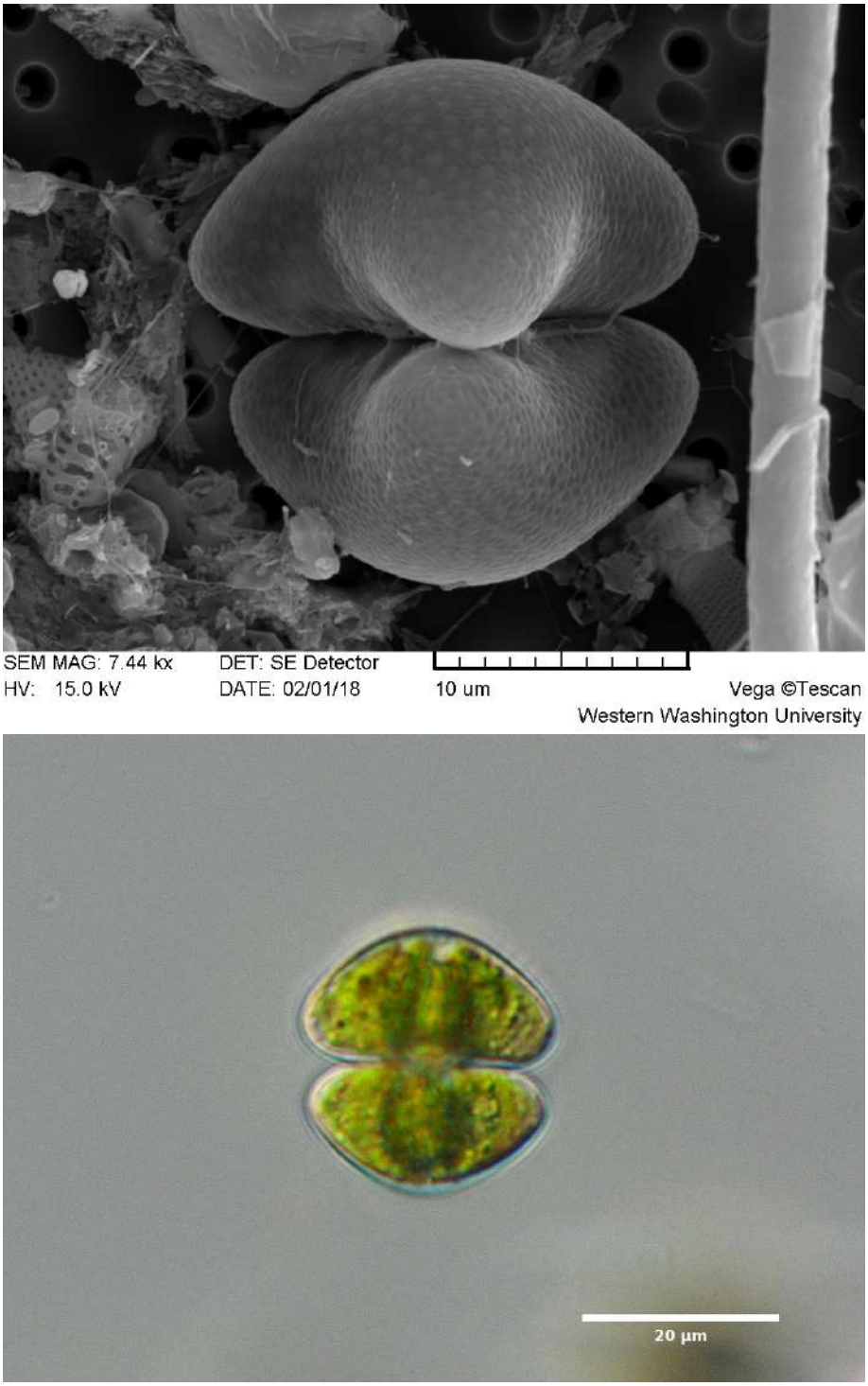


Figure 22.229: *Staurastrum ralfsii* var. *depressum* (SEM/DIC), Myrtle Lake, Mountain Loop Highway, Snohomish County (upper/lower images).

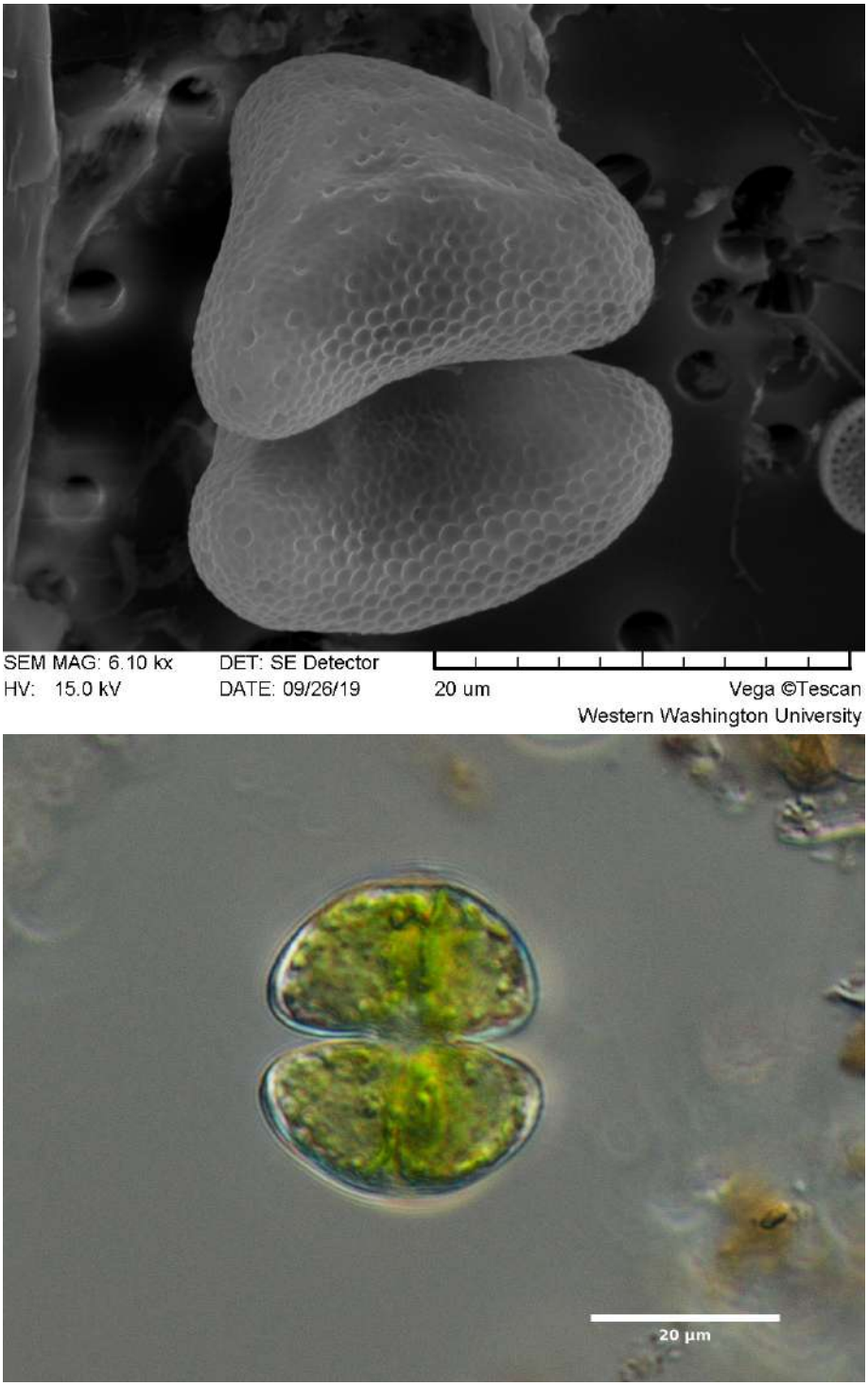


Figure 22.230: *Staurastrum ralfsii* var. *depressum* (SEM/DIC), small floating bog along Morris Valley Road near Harrison, BC (upper/lower images).

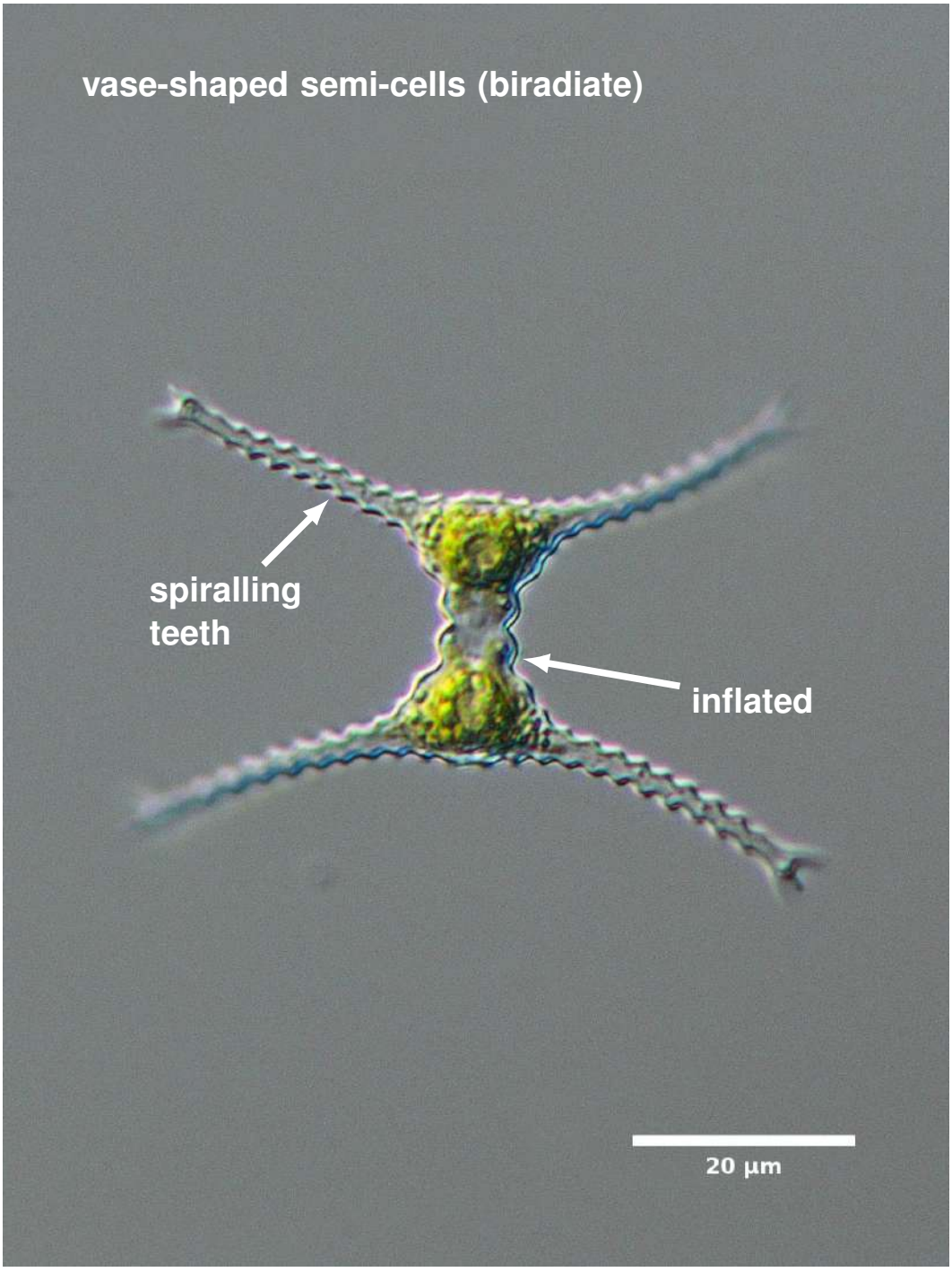
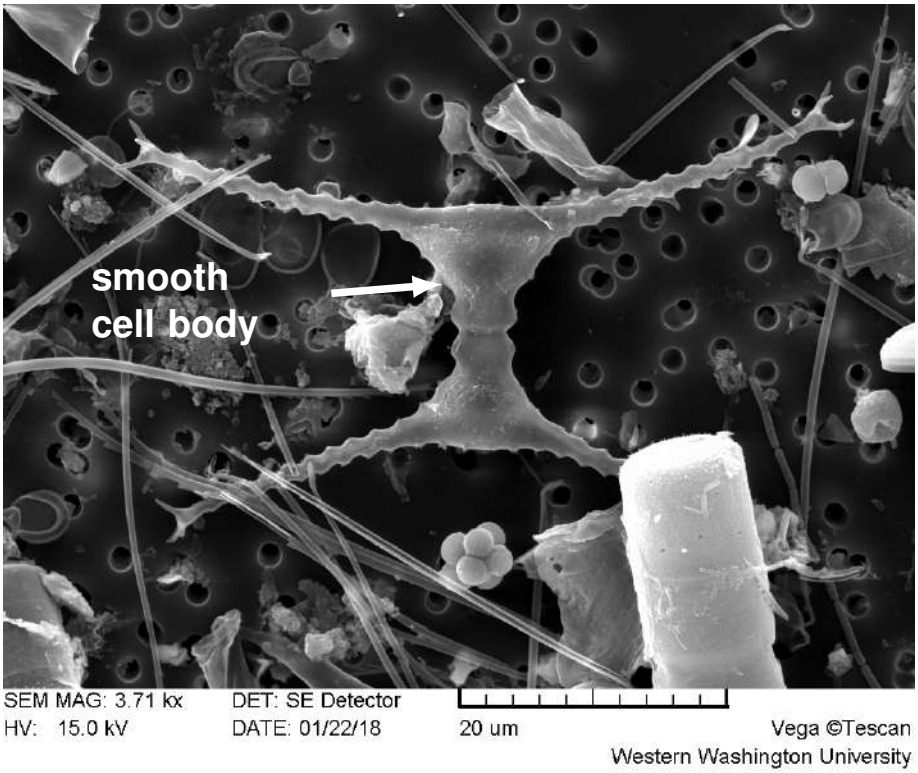


Figure 22.231: *Staurastrum reductum* (DIC), Sunset Lake, Whatcom County.



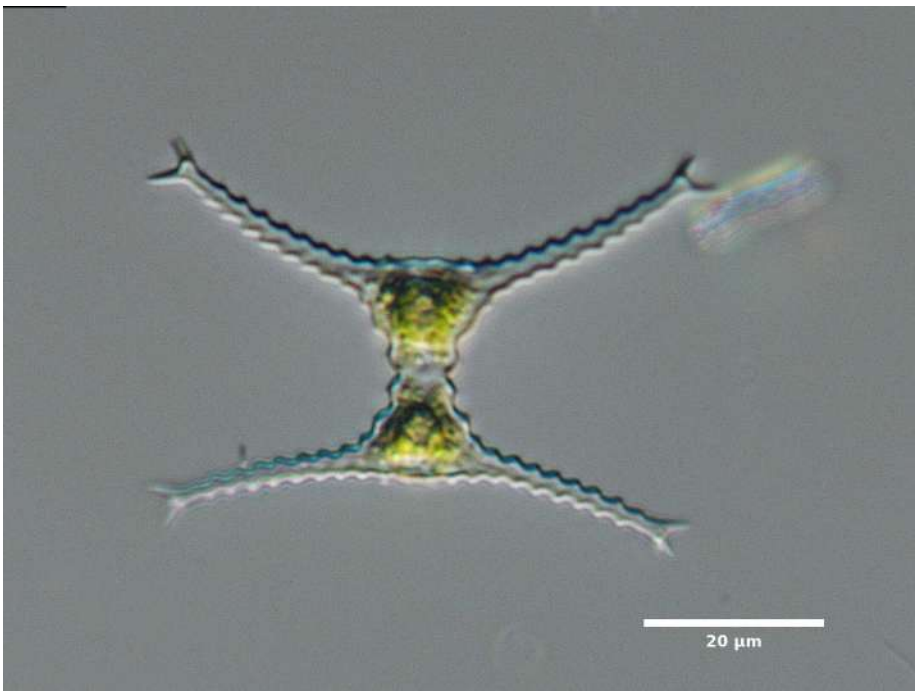


Figure 22.232: *Staurastrum reductum* (SEM/DIC), Bug Lake, Whatcom County (upper images); Sunset Lake, Whatcom County (lower image).

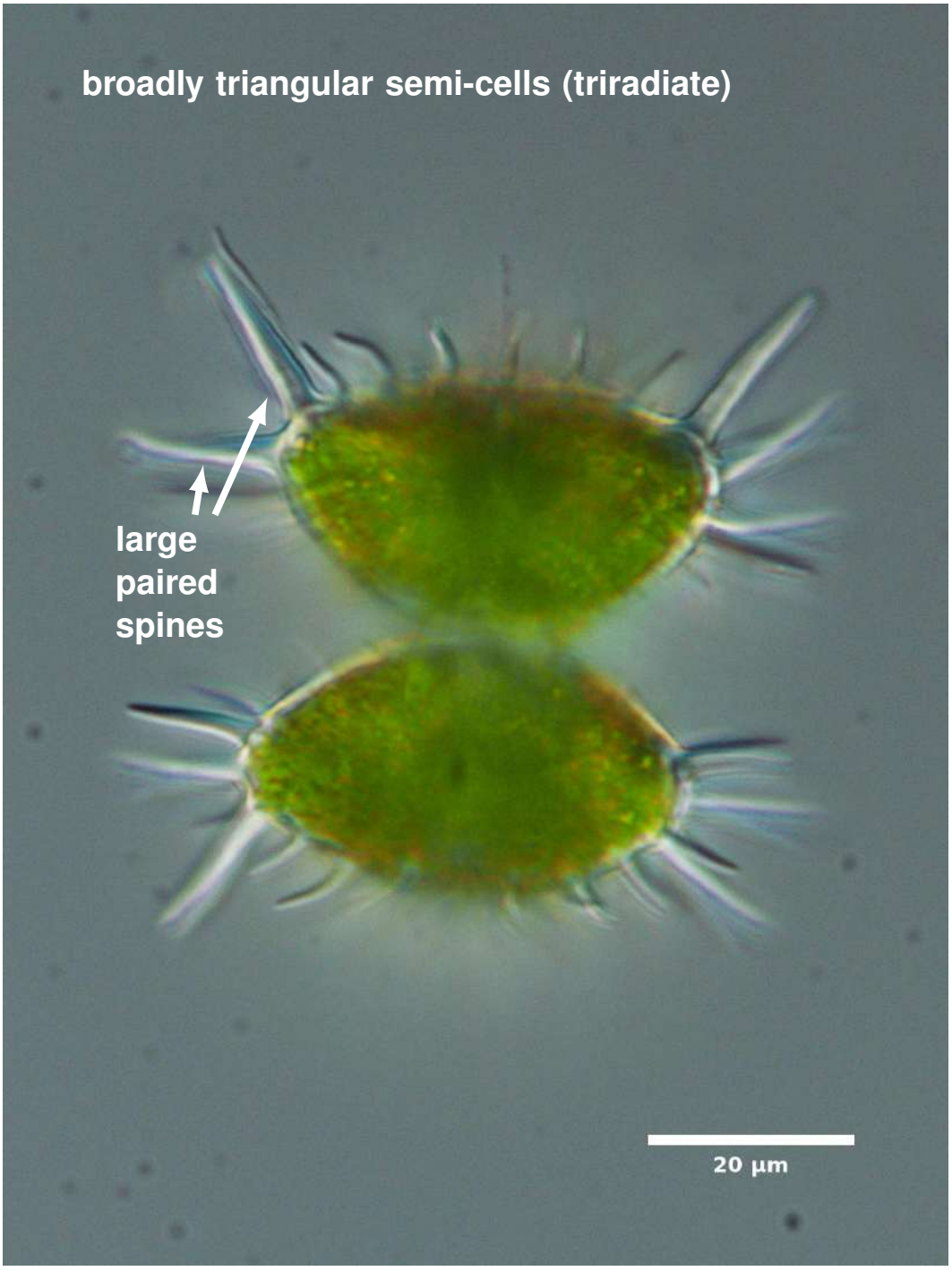


Figure 22.233: *Staurastrum setigerum* (DIC), Lake Evan, Mountain Loop Highway, Snohomish County.

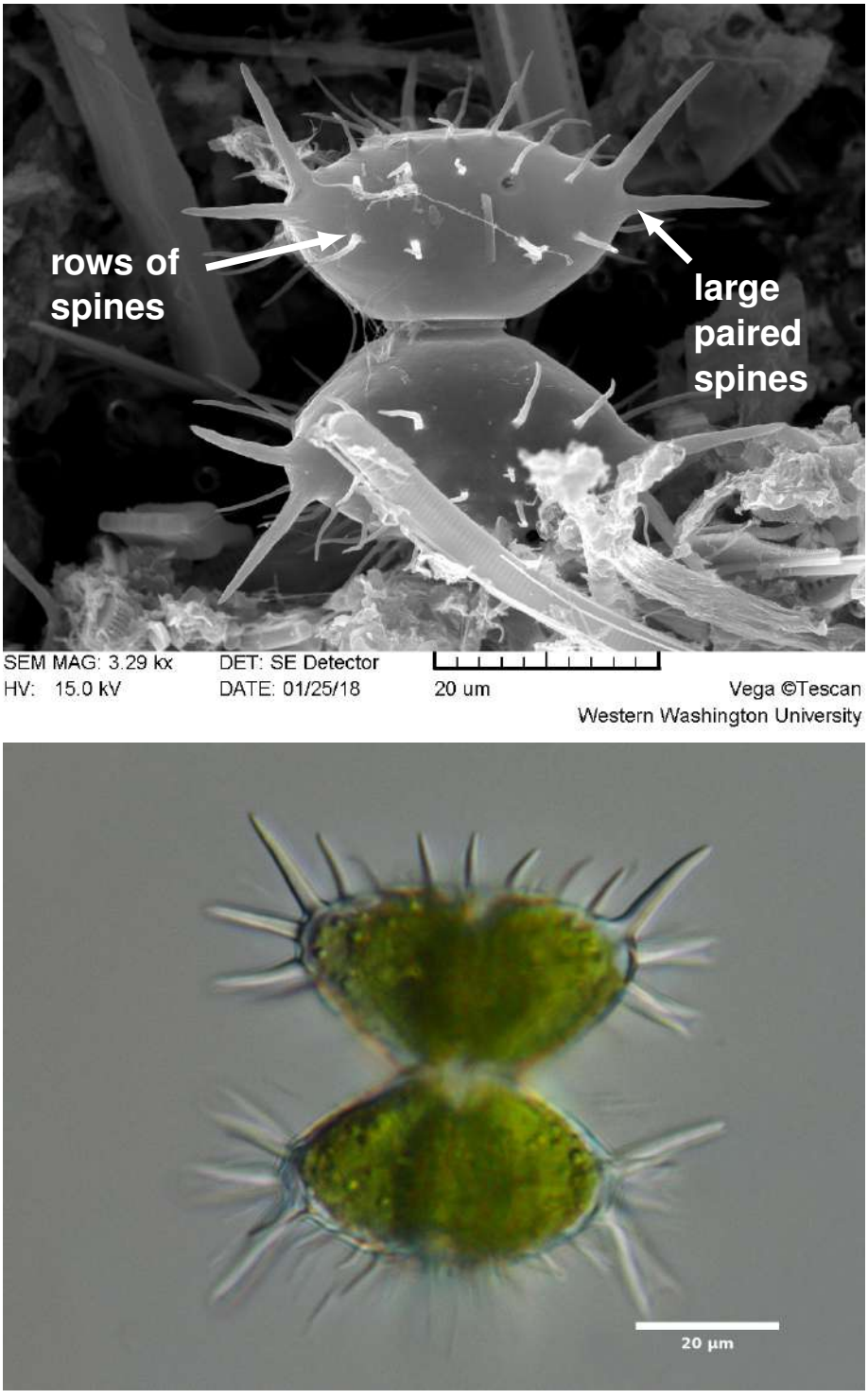


Figure 22.234: *Staurastrum setigerum* (SEM/DIC), Lake Evan, Mountain Loop Highway, Snohomish County (upper/lower images).



Figure 22.235: *Staurastrum setigerum* (DIC/DIC), Boardman Lake, Mountain Loop Highway, Snohomish County (upper image); Lake Evan, Mountain Loop Highway, Snohomish County (lower image).

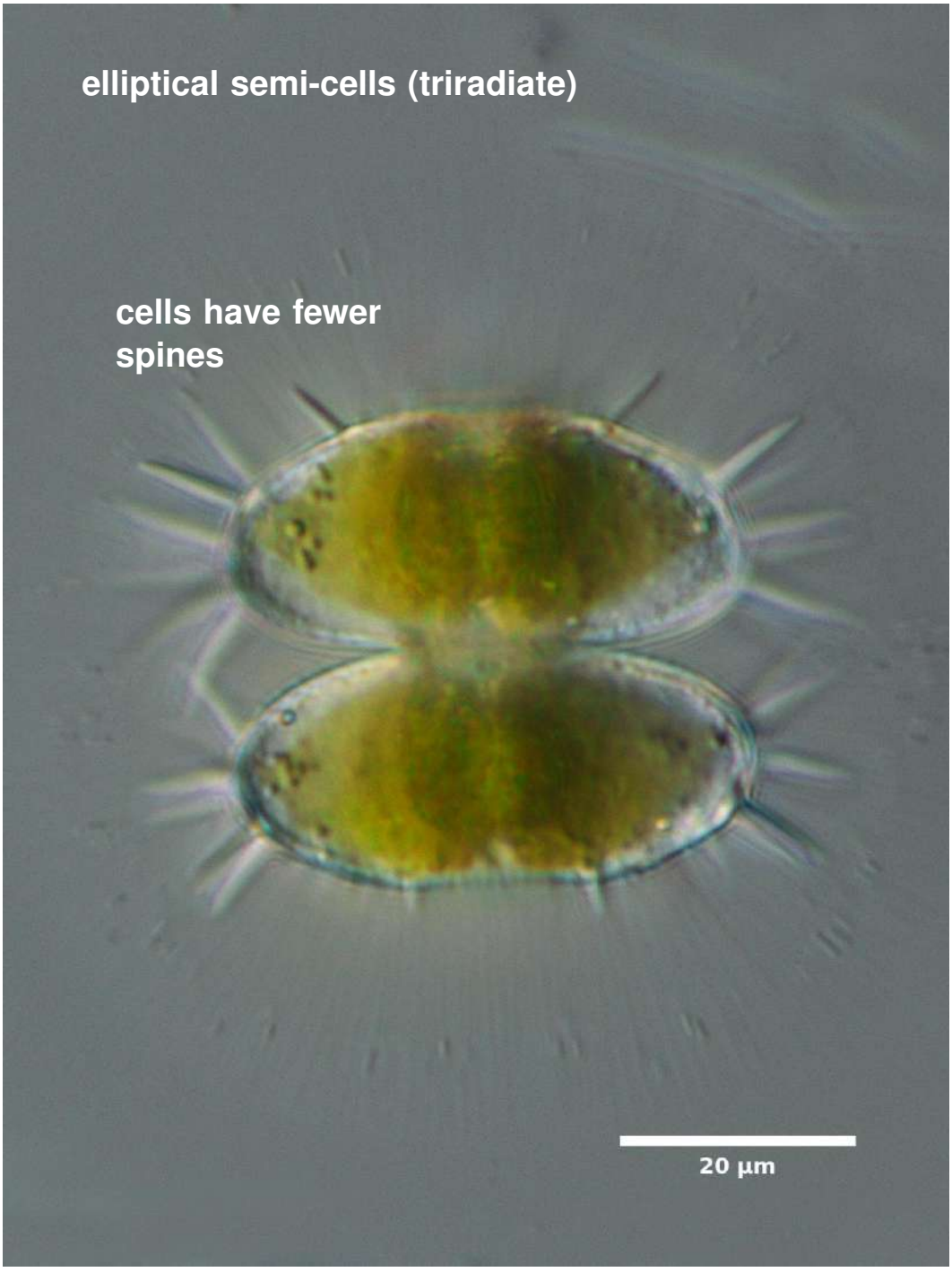


Figure 22.236: *Staurastrum setigerum* cf. var. *occidentale* (DIC/DIC), Big Twin Lake (eastern Washington), Okanogan County.



Figure 22.237: *Staurastrum setigerum* cf. var. *occidentale* (DIC/DIC), Big Twin Lake (eastern Washington), Okanogan County (upper/lower images).

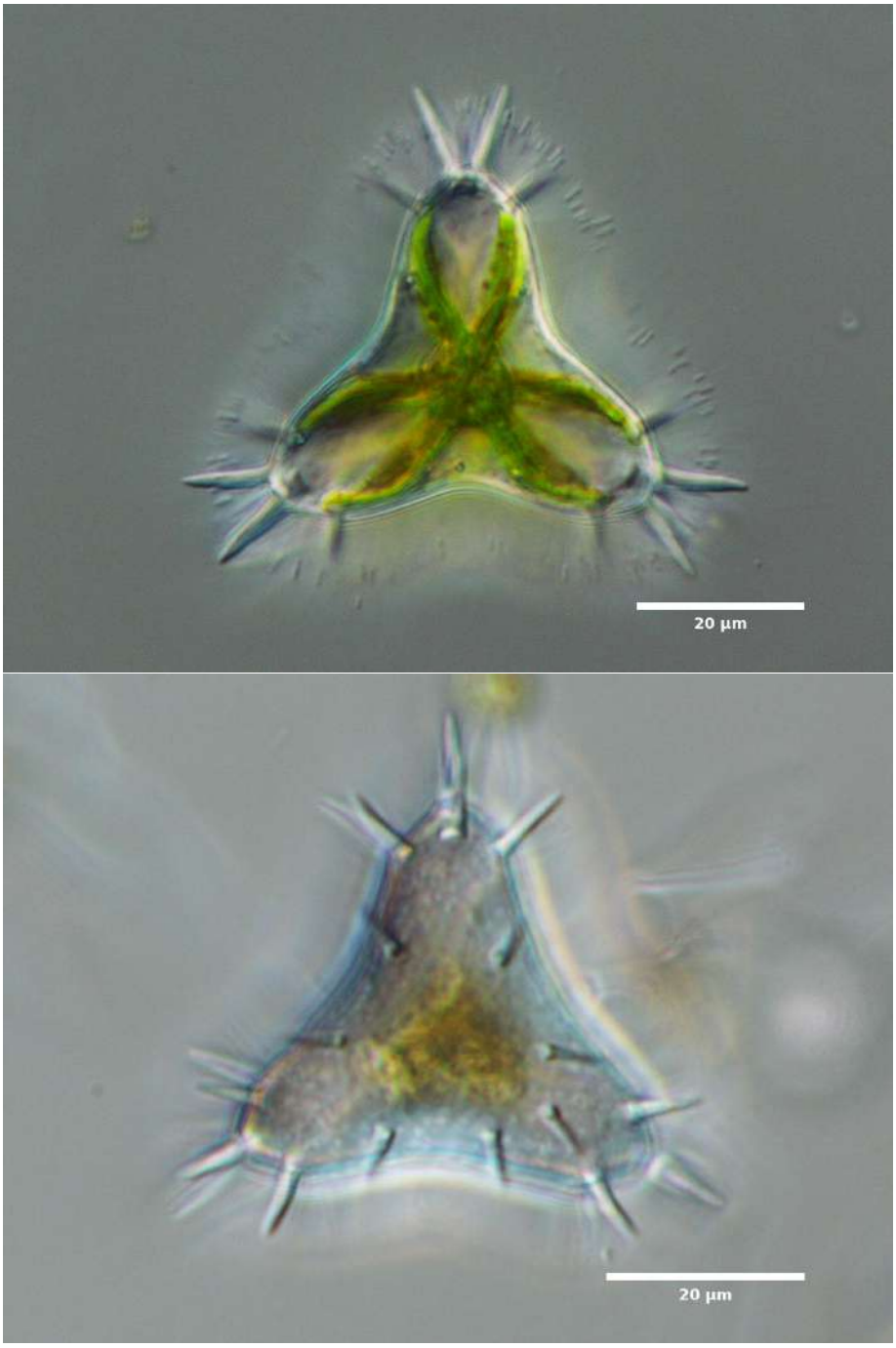


Figure 22.238: *Staurastrum setigerum* cf. var. *occidentale* (DIC/DIC), Big Twin Lake (eastern Washington), Okanogan County (upper image); Lake Everett, Skagit County (lower image).



Figure 22.239: *Staurastrum simonyi* (DIC), Blue Lake, on trail to Dock Butte, Mt. Baker area, Skagit County.

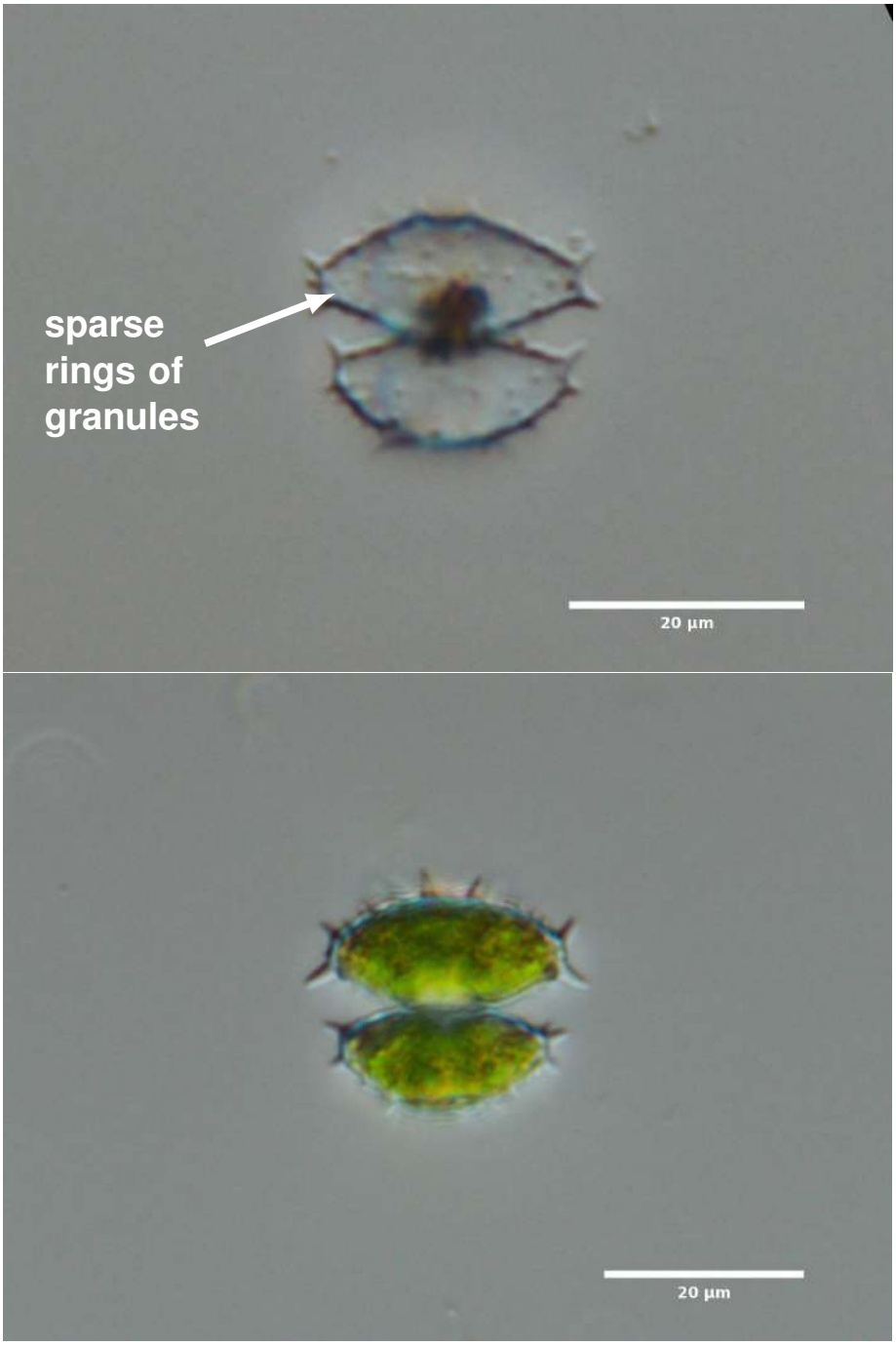


Figure 22.240: *Staurastrum simonyi* (DIC/DIC), Blue Lake, on trail to Dock Butte, Mt. Baker area, Skagit County (upper image); small pond on trail to Dock Butte, Mt. Baker area, Skagit County (lower image).



Figure 22.241: *Staurastrum smithii* (DIC/DIC), Sunset Lake, Whatcom County (upper image); Bug Lake, Whatcom County (lower image).

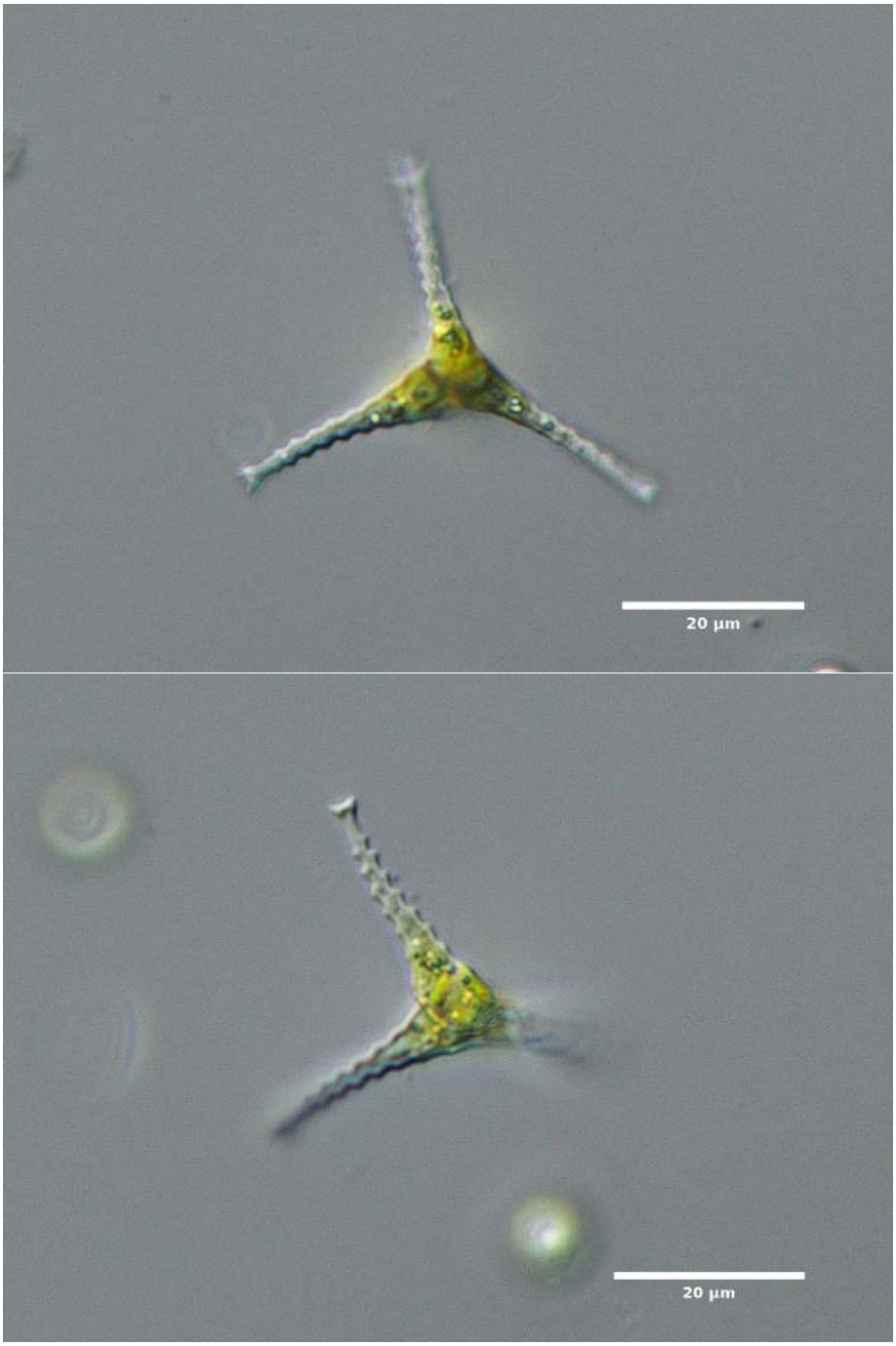


Figure 22.242: *Staurastrum smithii* (DIC/DIC), Sunset Lake, Whatcom County (upper/lower images).



Figure 22.243: *Staurastrum spongiosum* (DIC), Chain Lake, Gifford Pinchot National Forest, Skamania County.

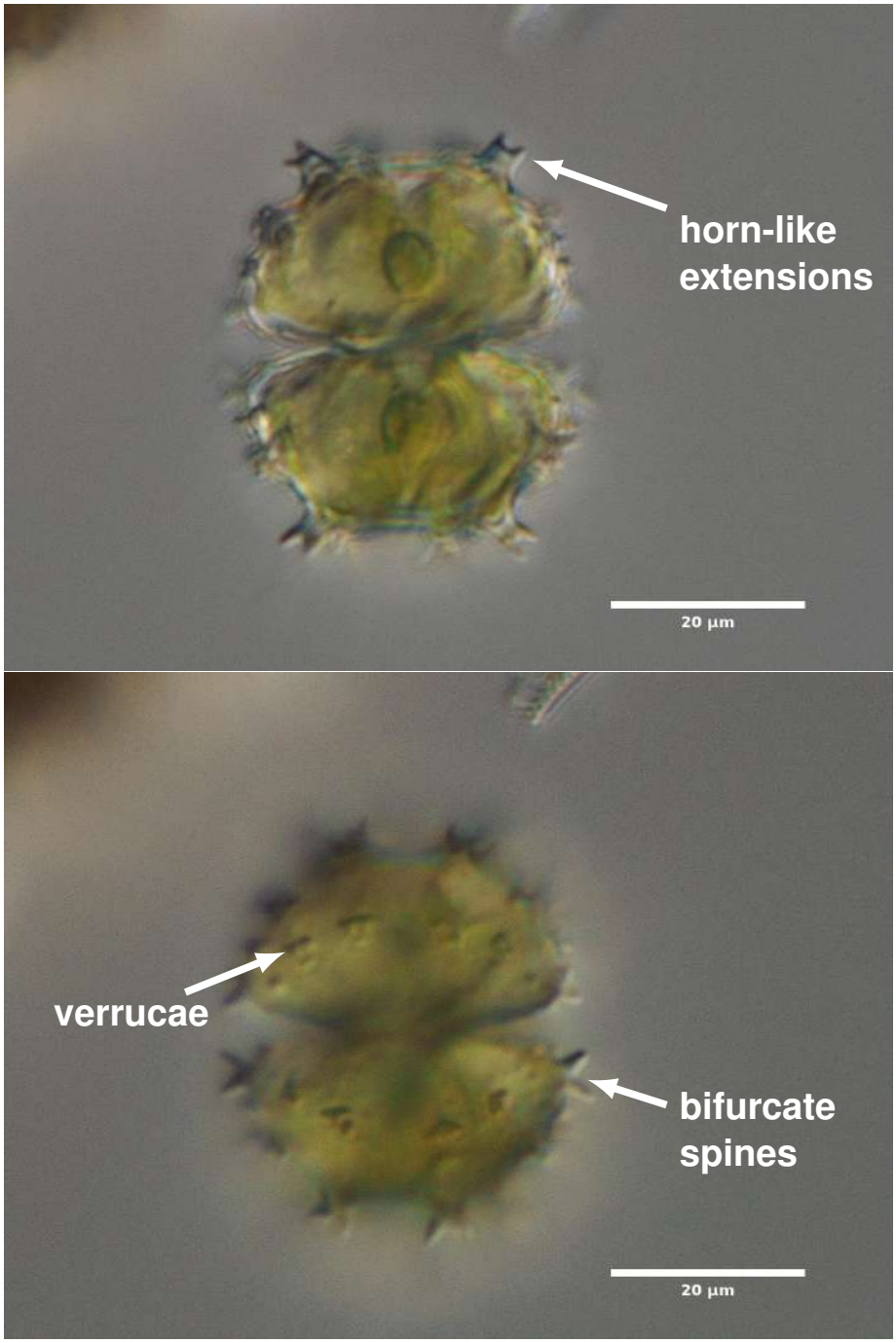


Figure 22.244: *Staurastrum spongiosum* (DIC/DIC), Chain Lake, Gifford Pinchot National Forest, Skamania County (upper/lower images).

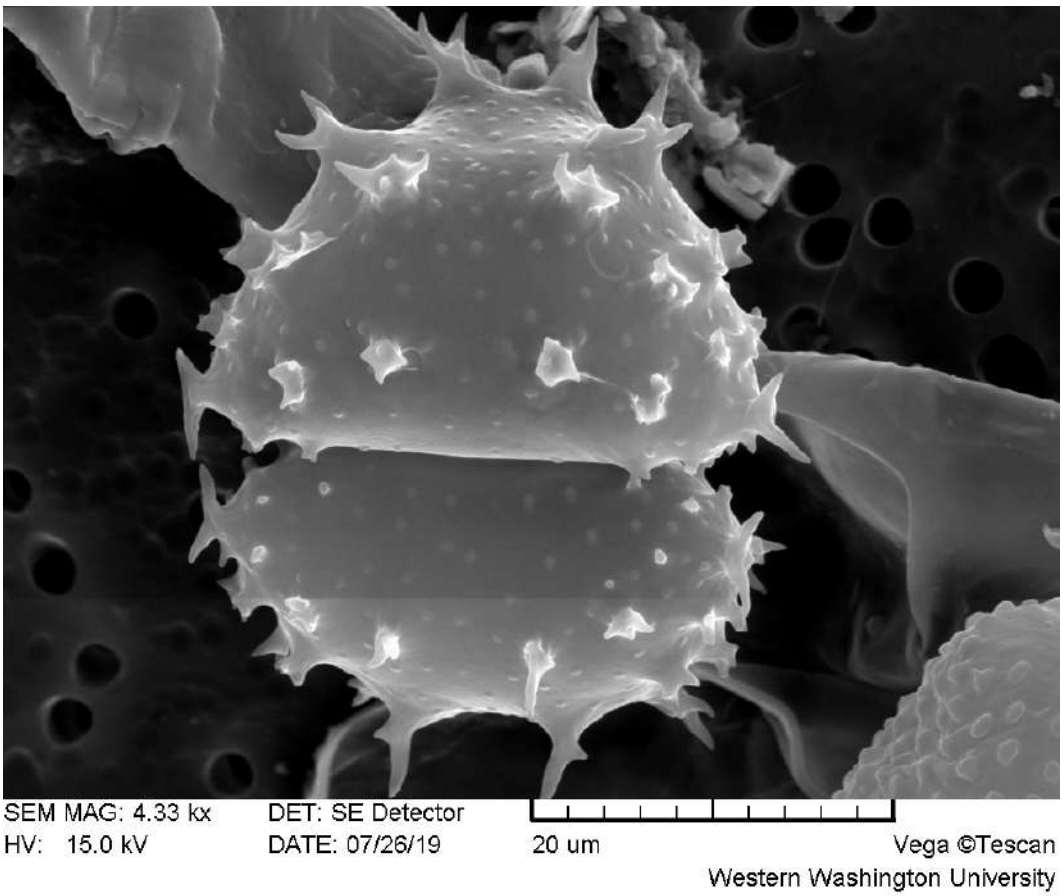


Figure 22.245: *Staurastrum spongiosum* (SEM), Chain Lake, Gifford Pinchot National Forest, Skamania County.

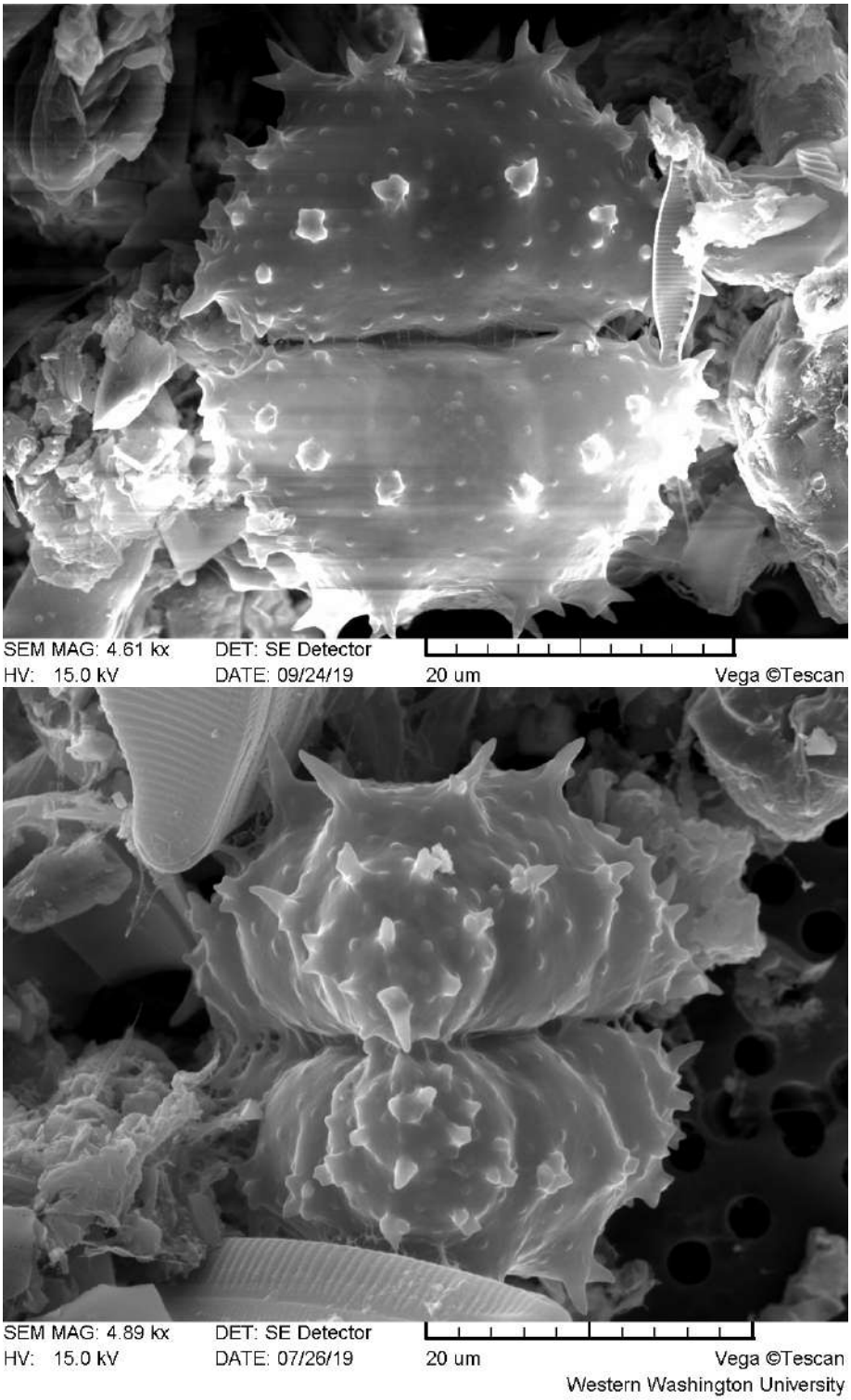


Figure 22.246: *Staurastrum spongiosum* (SEM/SEM), Chain Lake, Gifford Pinchot National Forest, Skamania County (upper/lower images).

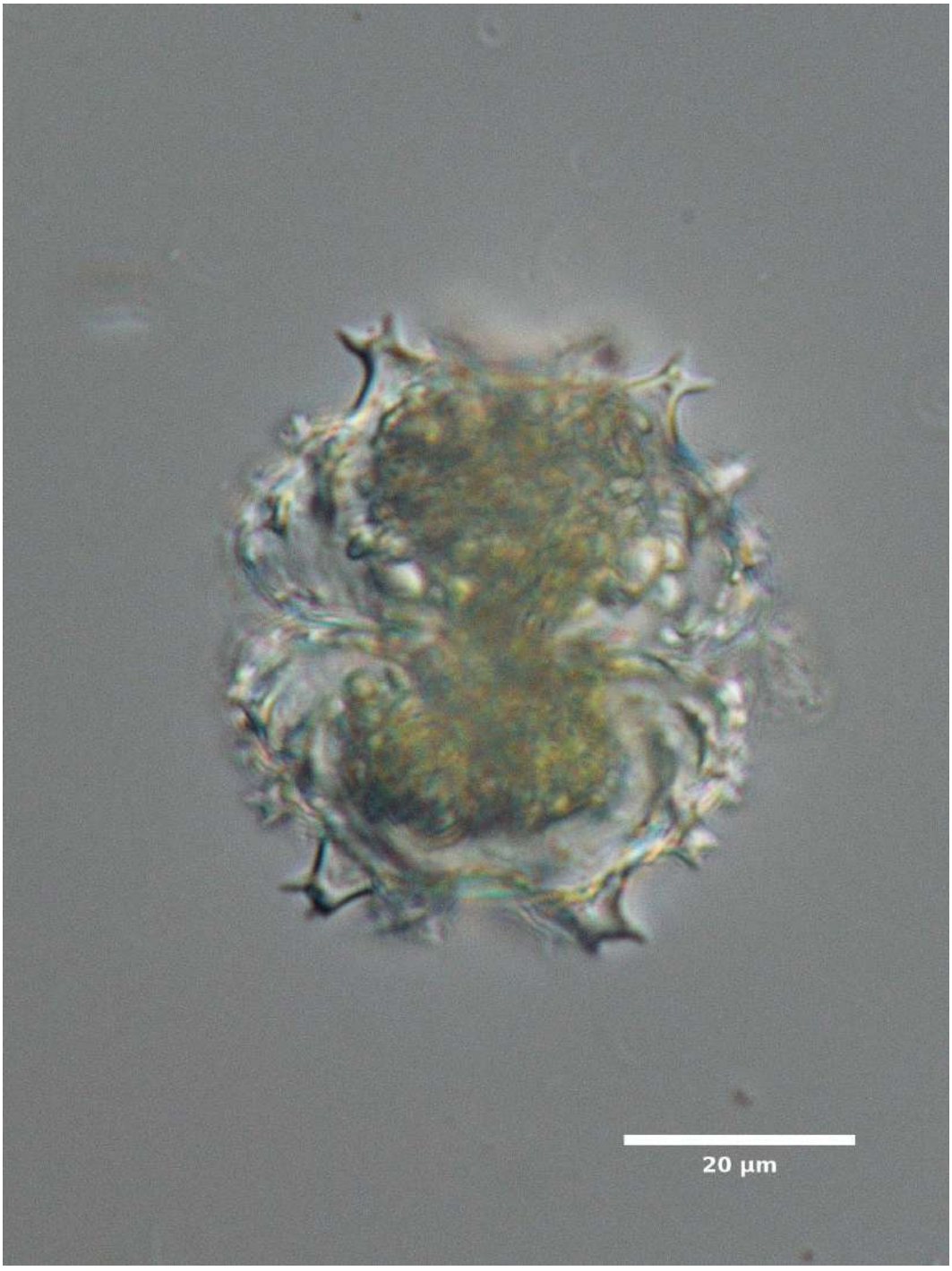


Figure 22.247: *Staurastrum spongiosum* (DIC), Lower Bagley Lake, Mt. Baker area, Whatcom County.

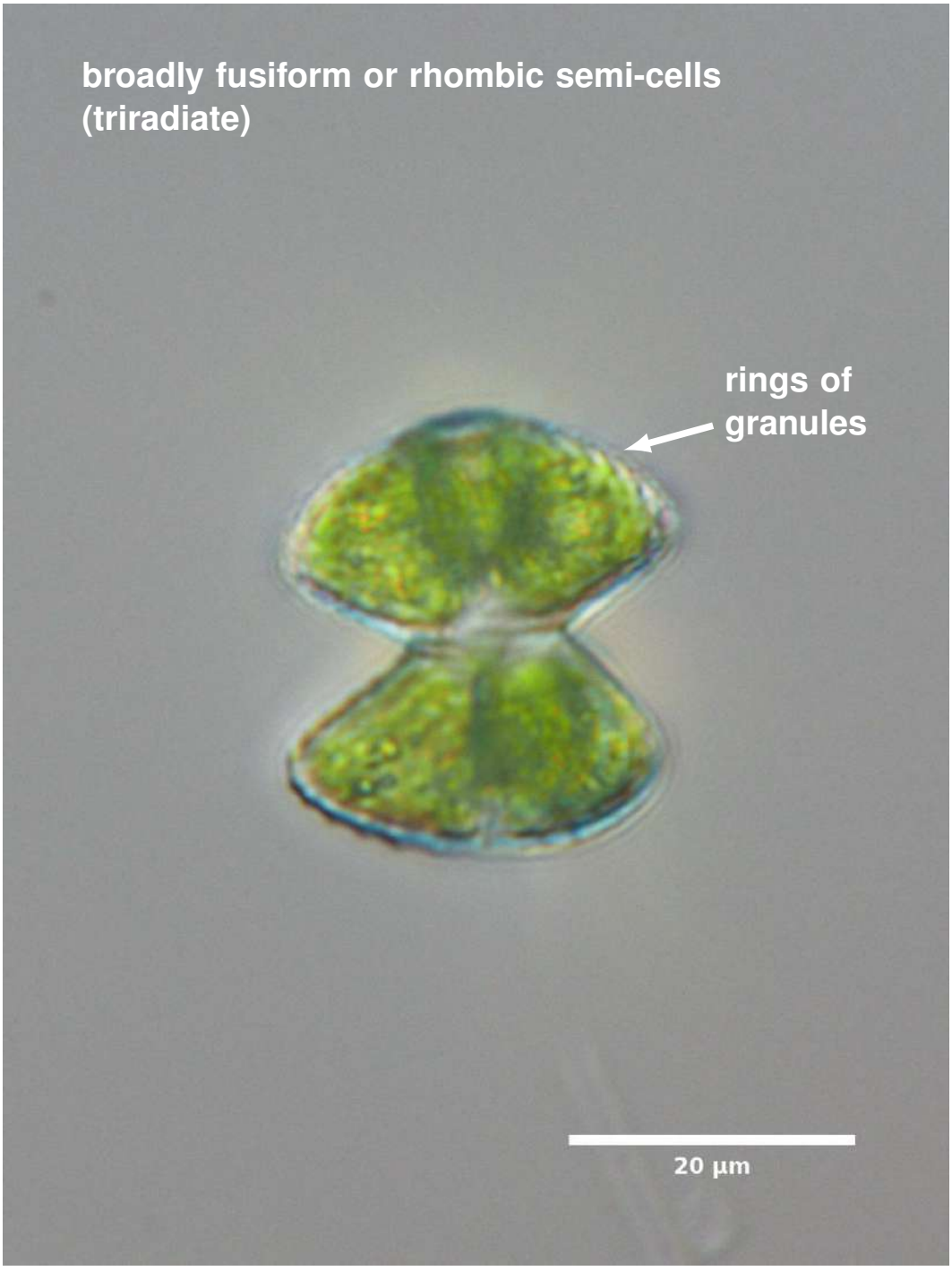


Figure 22.248: *Staurastrum striatum* (DIC), small pond near Fairhaven College, Whatcom County.

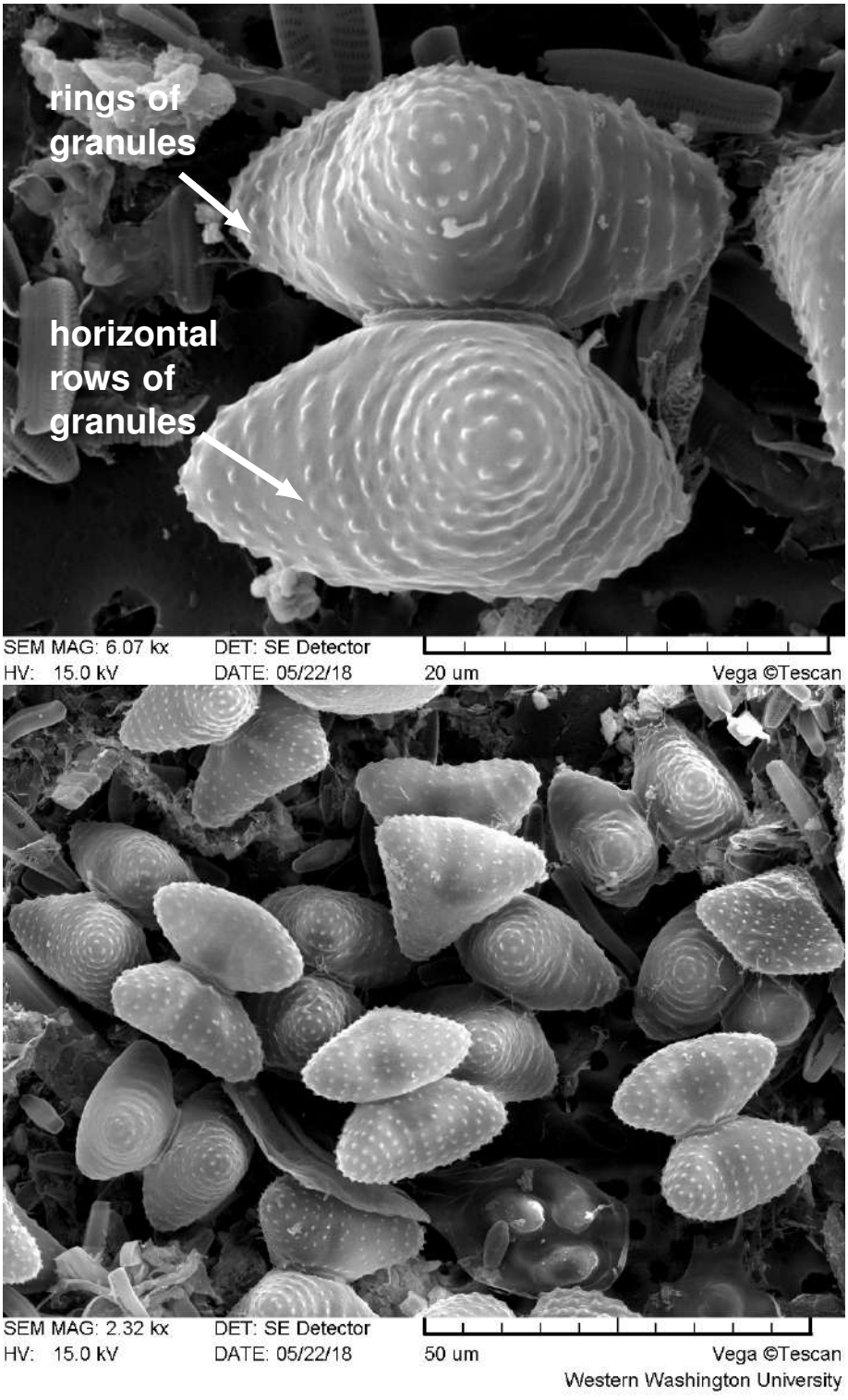


Figure 22.249: *Staurastrum striatum* (SEM/SEM) small pond near Whatcom Community College, Whatcom County (upper/lower images).

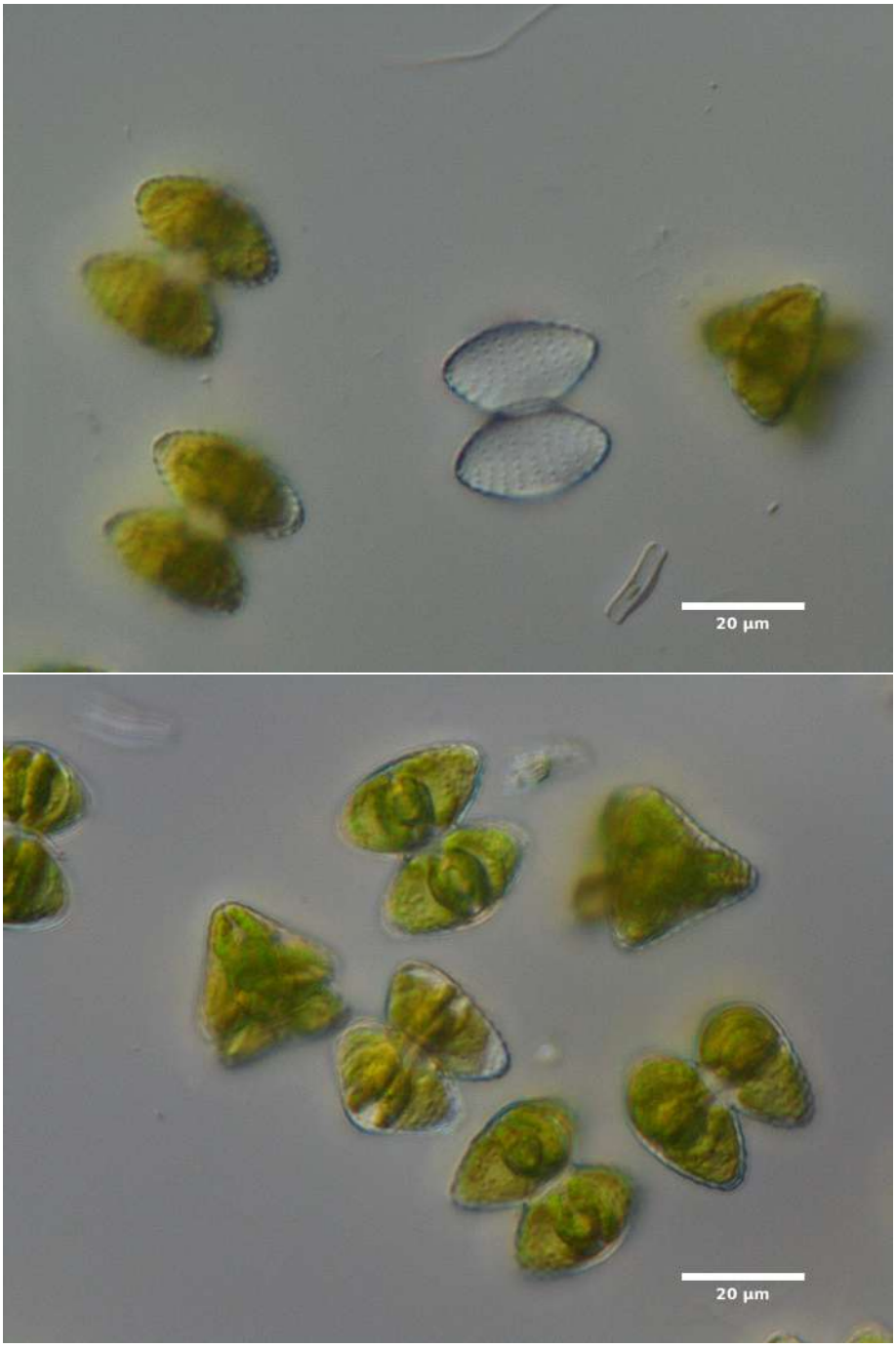


Figure 22.250: *Staurastrum striatum* (DIC/DIC), small pond near Whatcom Community College, Whatcom County (upper/lower images).



Figure 22.251: *Staurastrum* cf. *striatum* (DIC), small pond on trail to Dock Butte, Mt. Baker area, Skagit County.



Figure 22.252: *Staurastrum* cf. *striatum* (DIC/DIC), small pond on trail to Dock Butte, Mt. Baker area, Skagit County (upper/lower images).

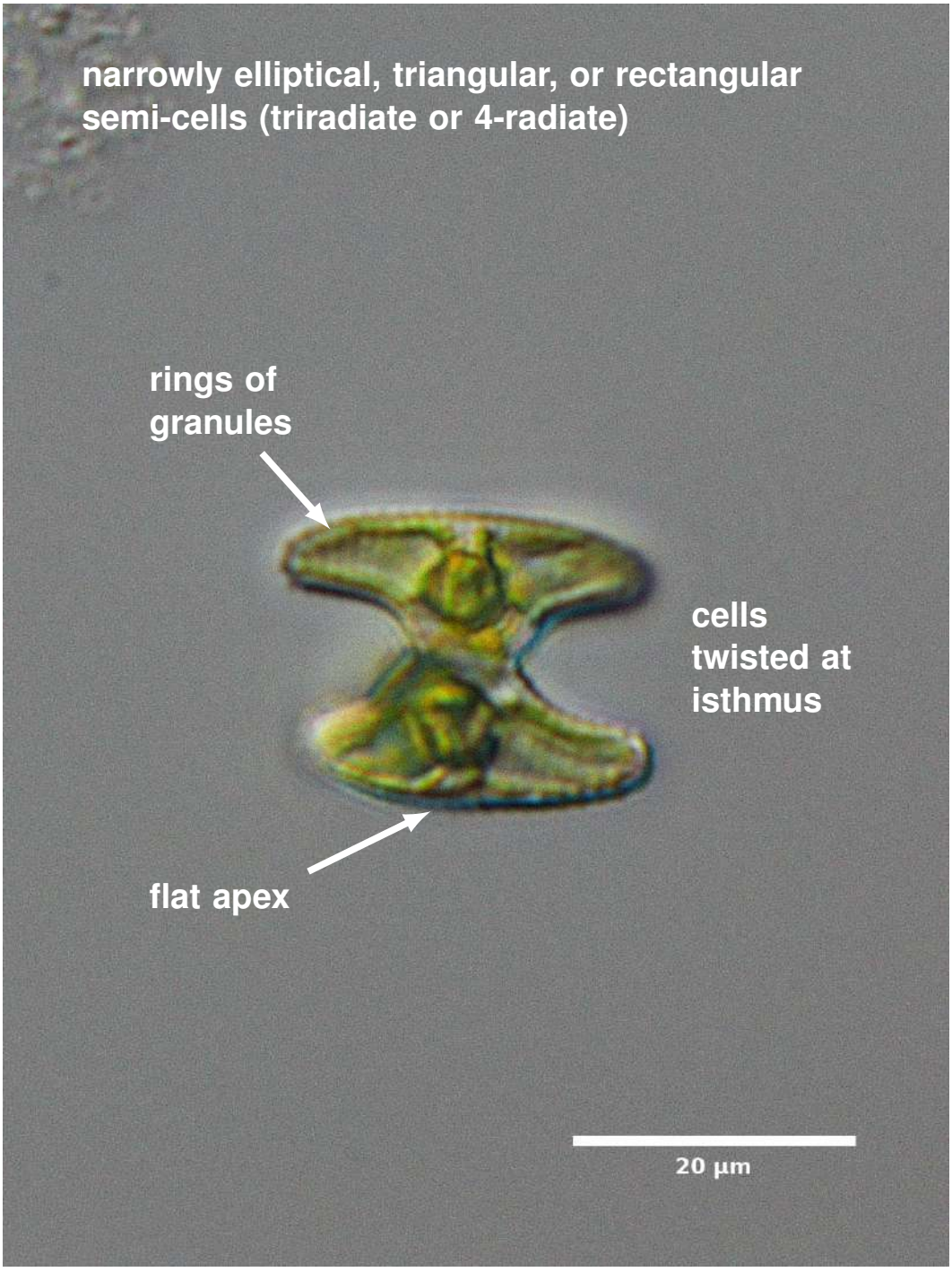


Figure 22.253: *Staurastrum striolatum* (DIC), small pond on Valley Circle Drive, Bothell WA, Snohomish County.

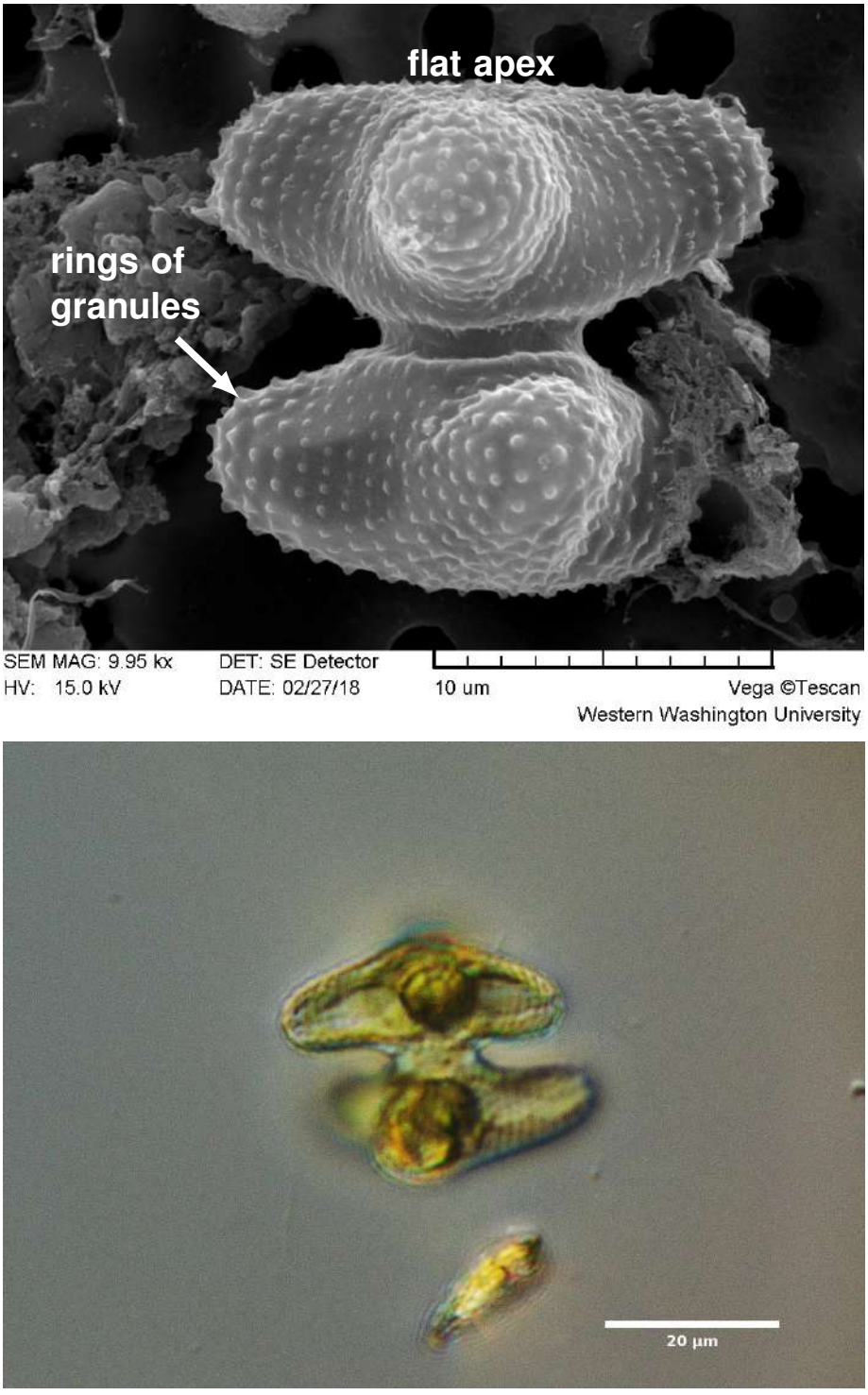


Figure 22.254: *Staurastrum striolatum* (SEM/DIC), Hoag Pond, Whatcom County.

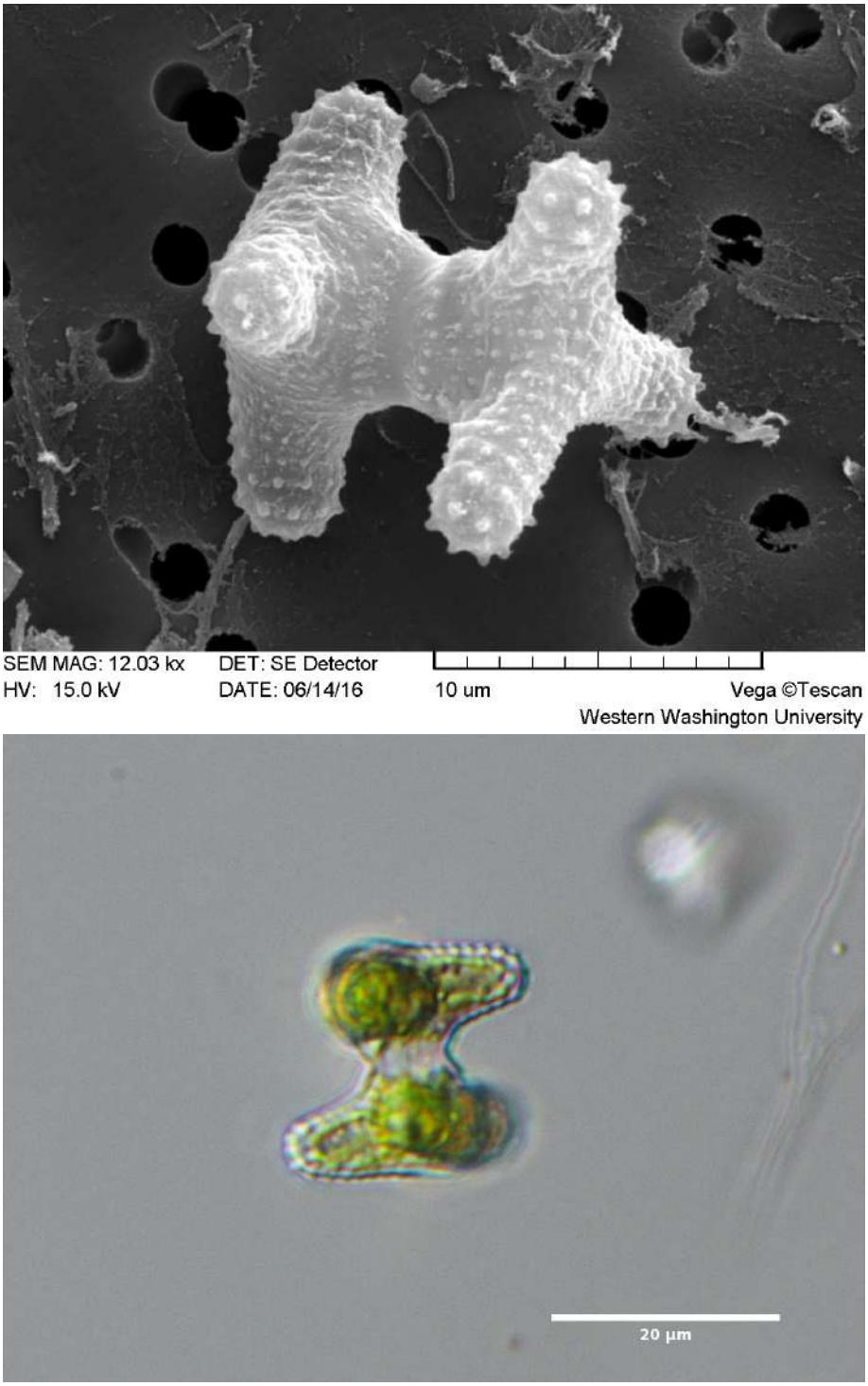


Figure 22.255: *Staurastrum striolatum* (SEM/DIC), Myrtle Pond, Mountain Loop Highway, Snohomish County.



Figure 22.256: *Staurastrum striolatum* (DIC/DIC), Hoag Pond, Whatcom County (upper image); Myrtle Lake, Mountain Loop Highway, Snohomish County (lower image).

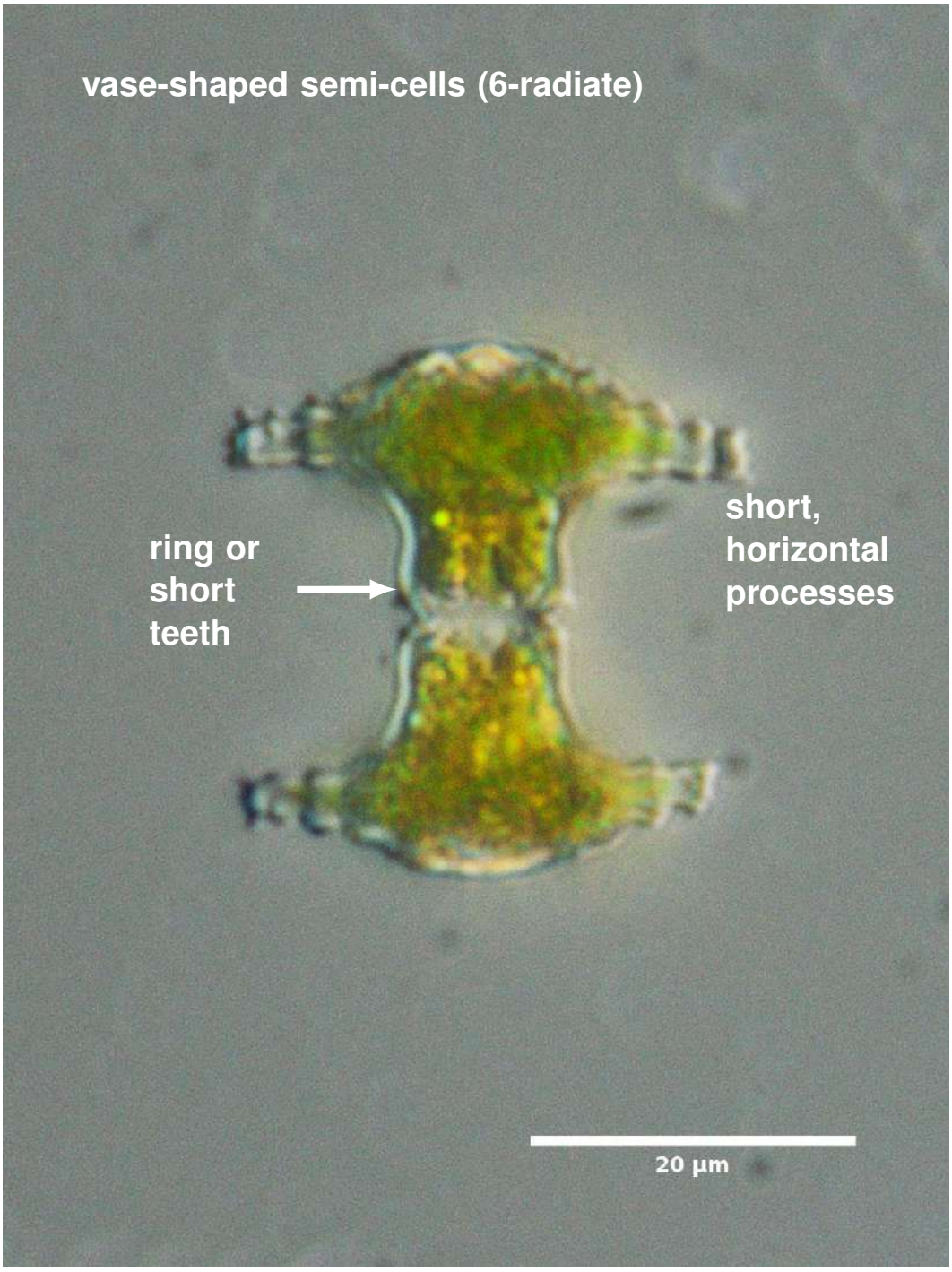
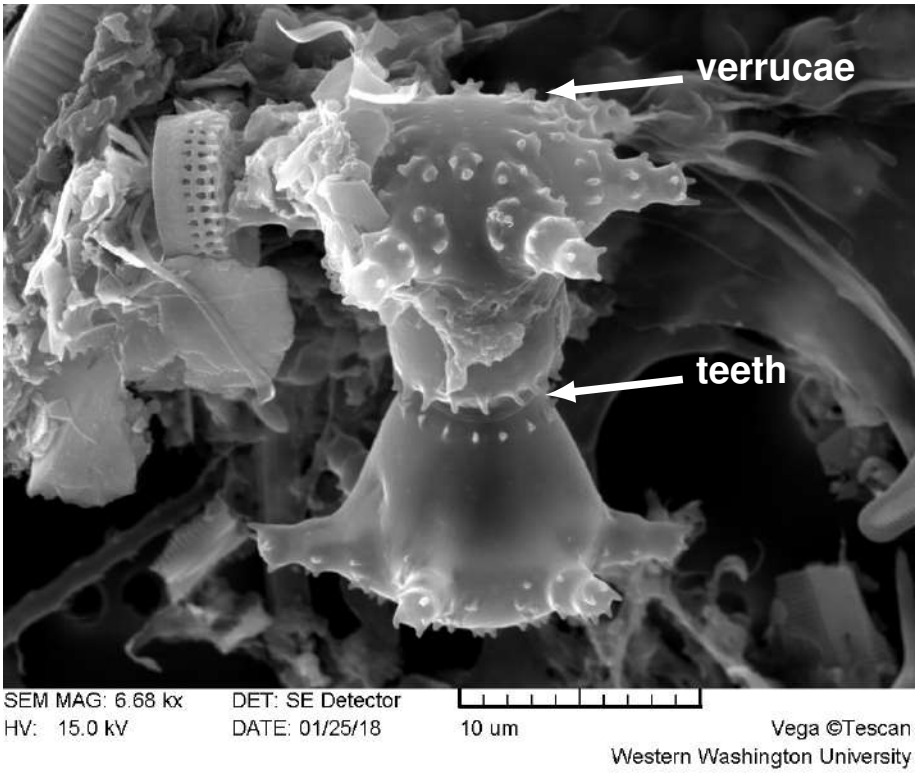


Figure 22.257: *Staurastrum subcomptum* (DIC), Bear Lake, Mountain Loop Highway, Snohomish County.



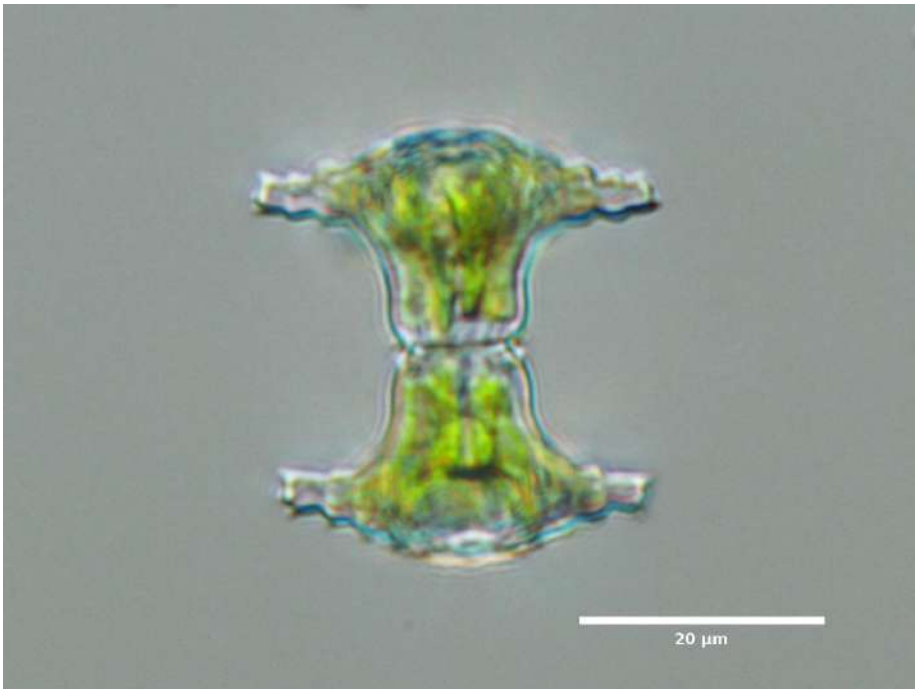


Figure 22.258: *Staurastrum subcomptum* (SEM/DIC), Lake Evan, Mountain Loop Highway, Snohomish County (upper/lower images).



Figure 22.259: *Staurastrum subcomptum* (DIC/DIC), Lake Evan, Mountain Loop Highway, Snohomish County (upper/lower images).



Figure 22.260: *Staurastrum subcomptum* (DIC/DIC), Lake Evan, Mountain Loop Highway, Snohomish County (upper/lower images).

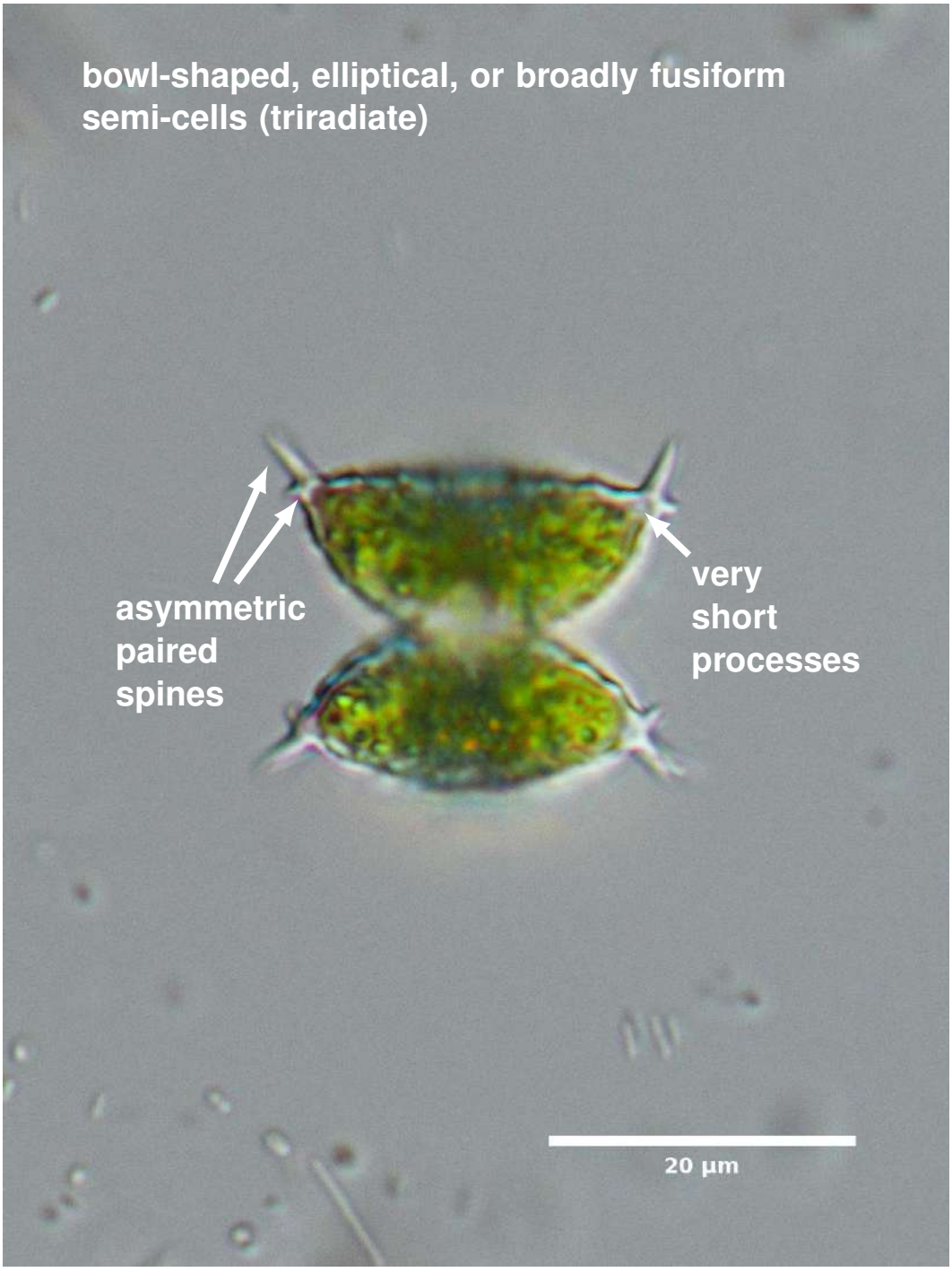


Figure 22.261: *Staurastrum subcruciatum* (DIC), Gold Basin Mill Pond, Mountain Loop Highway, Snohomish County.



Figure 22.262: *Staurastrum subcruciatum* (DIC/DIC), Gold Basin Mill Pond, Mountain Loop Highway, Snohomish County (upper/lower images).



Figure 22.263: *Staurastrum subcruciatum* (DIC/DIC), Lake Twenty-two, Mountain Loop Highway, Snohomish County (upper image); Myrtle Lake, Mountain Loop Highway, Snohomish County (lower image).

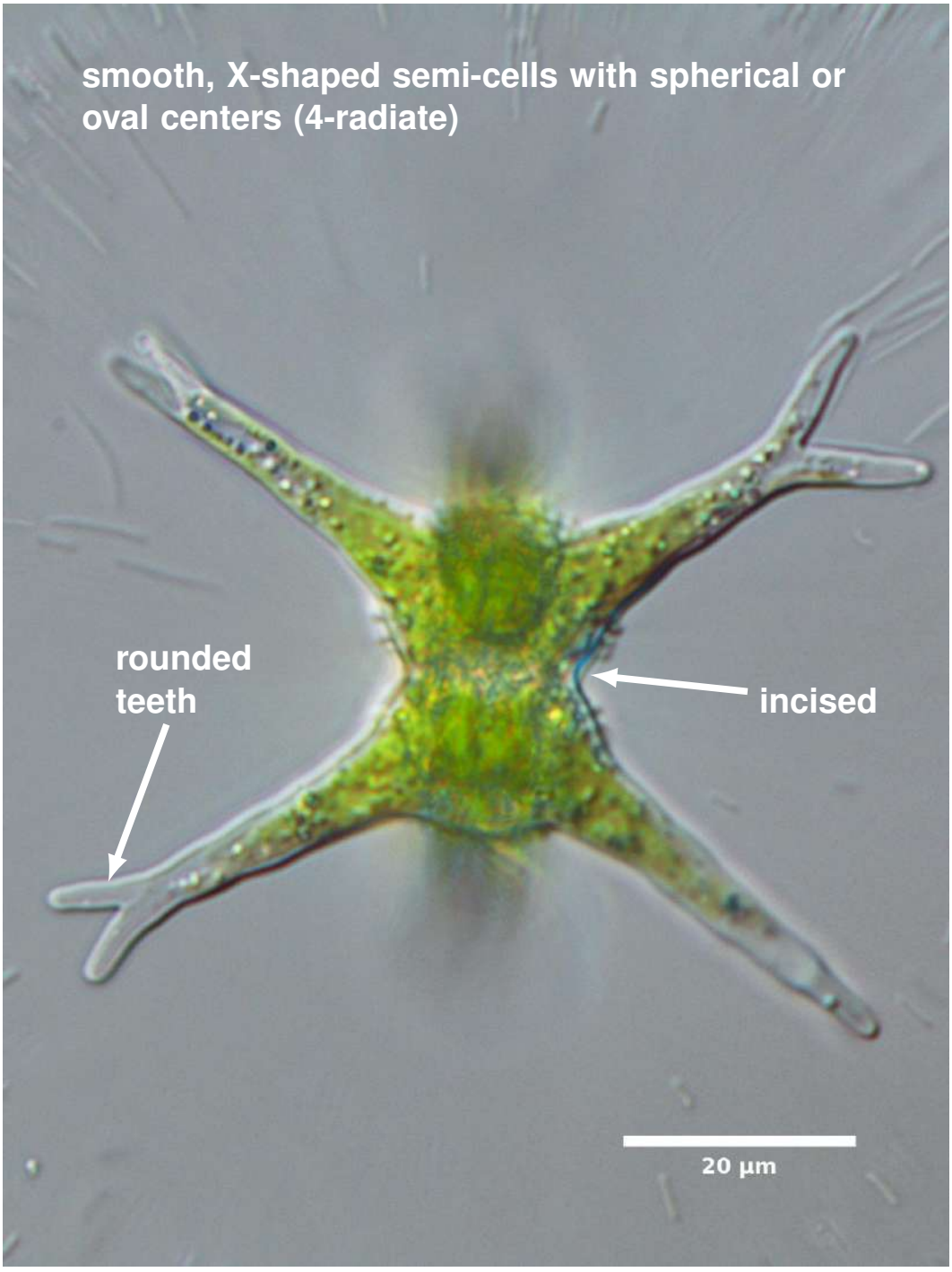
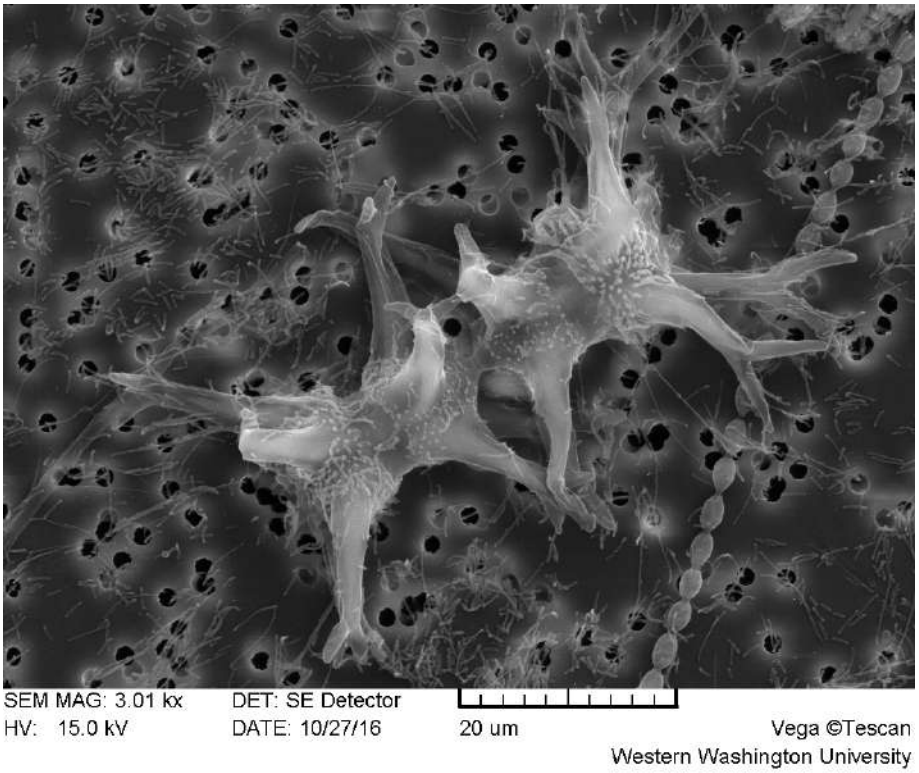


Figure 22.264: *Staurastrum subnudibrachiatum* var. *incisum* (DIC), Lake Evan, Mountain Loop Highway, Snohomish County.



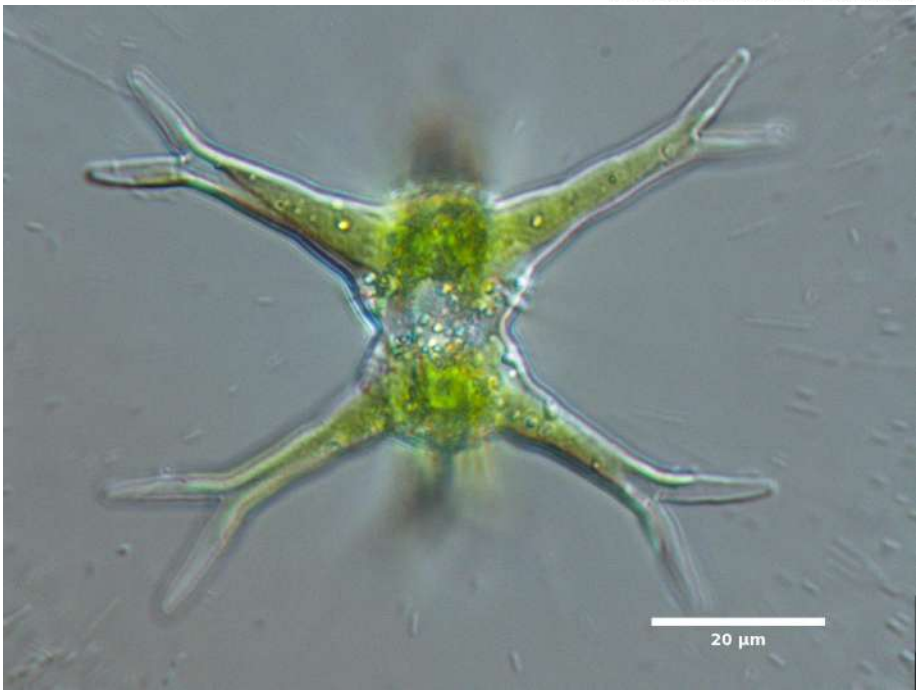


Figure 22.265: *Staurastrum subnudibrachiatum* var. *incisum* (SEM/DIC), Lake Evan, Mountain Loop Highway, Snohomish County.



Figure 22.266: *Staurastrum subnudibrachiatum* var. *incisum* (DIC/DIC), Lake Evan, Mountain Loop Highway, Snohomish County.

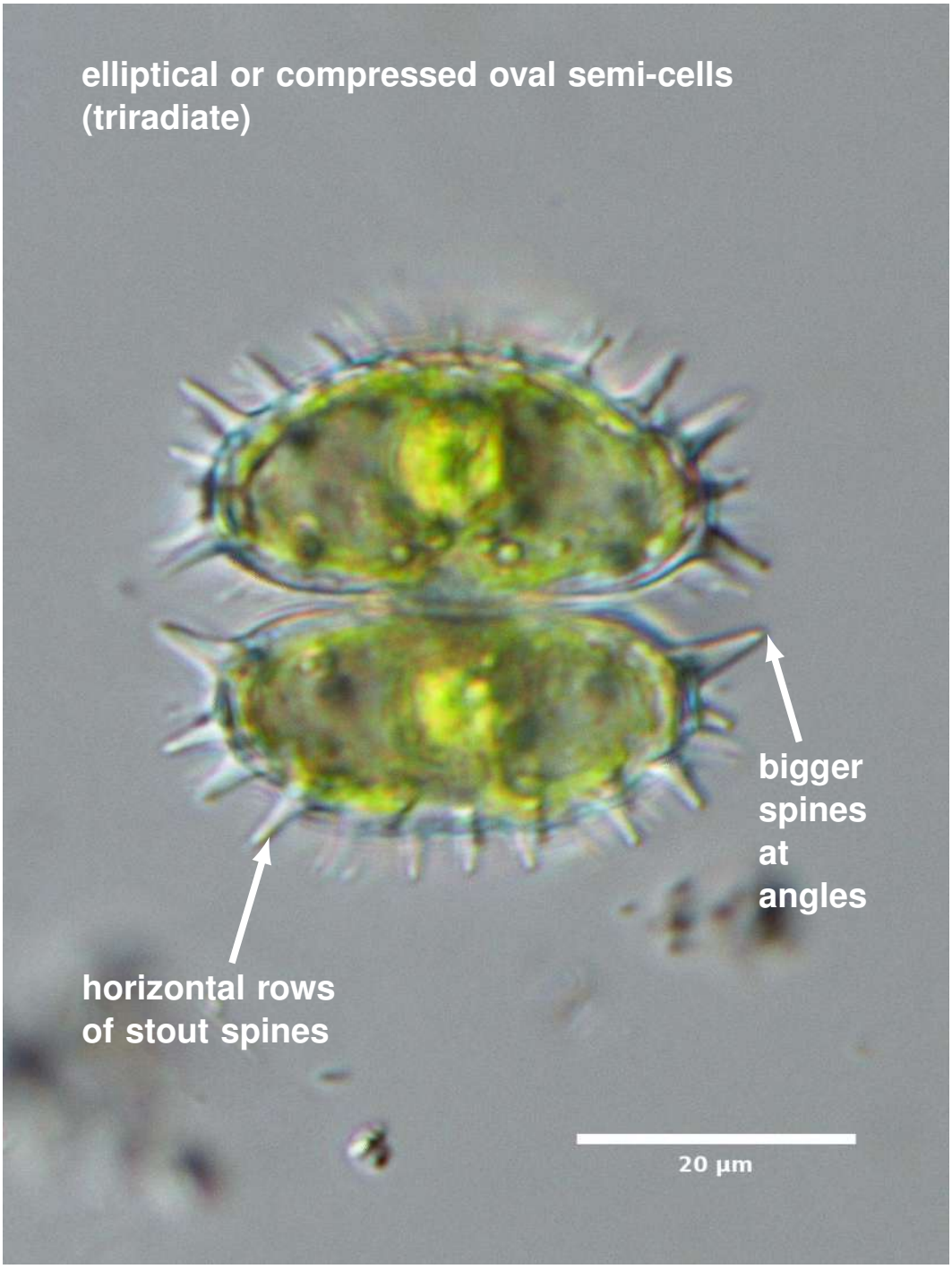
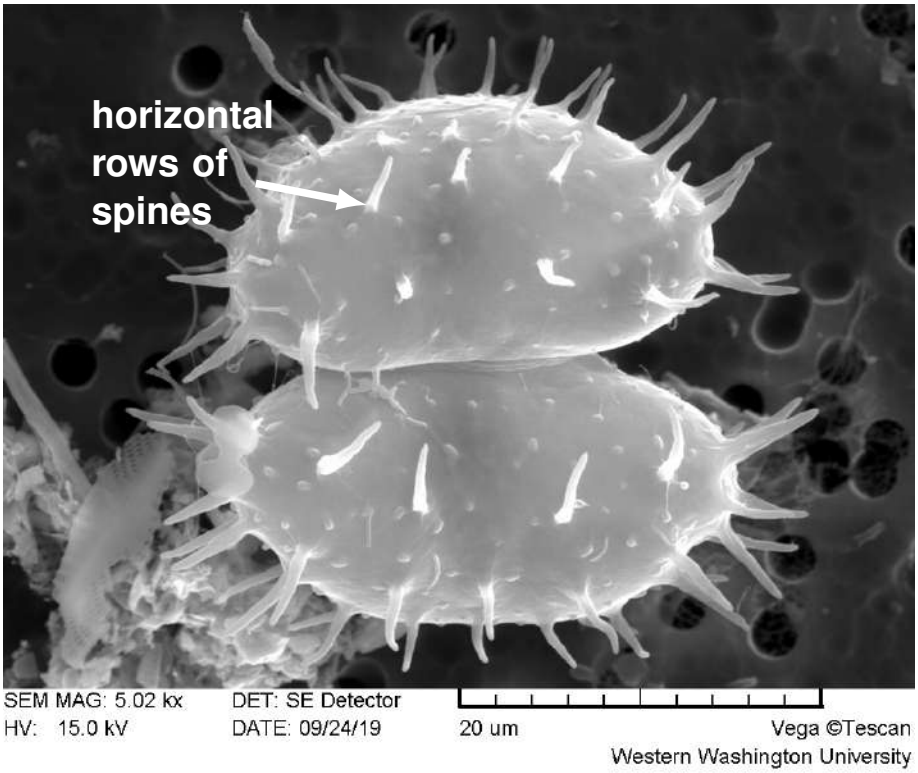


Figure 22.267: *Staurastrum teliferum* var. *gladiosum* (DIC), Myrtle Lake, Mountain Loop Highway, Snohomish County.



Figure 22.268: *Staurastrum teliferum* var. *gladiosum* (DIC/DIC), Myrtle Lake, Mountain Loop Highway, Snohomish County (upper/lower images).



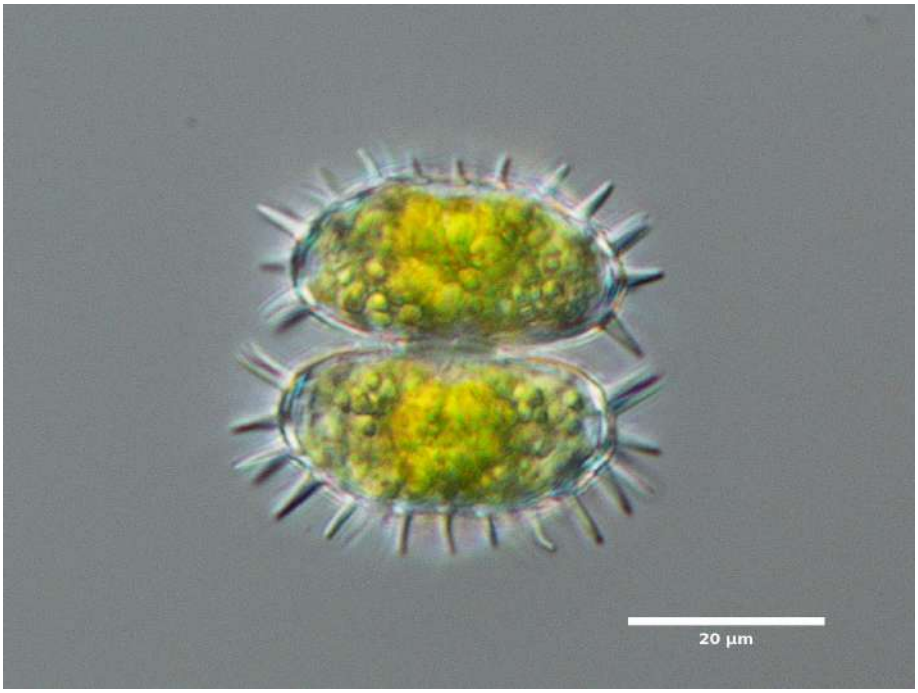


Figure 22.269: *Staurastrum teliferum* var. *gladiosum* (SEM/DIC), Chain Lake, Gifford Pinchot National Forest, Skamania County (upper/lower images).

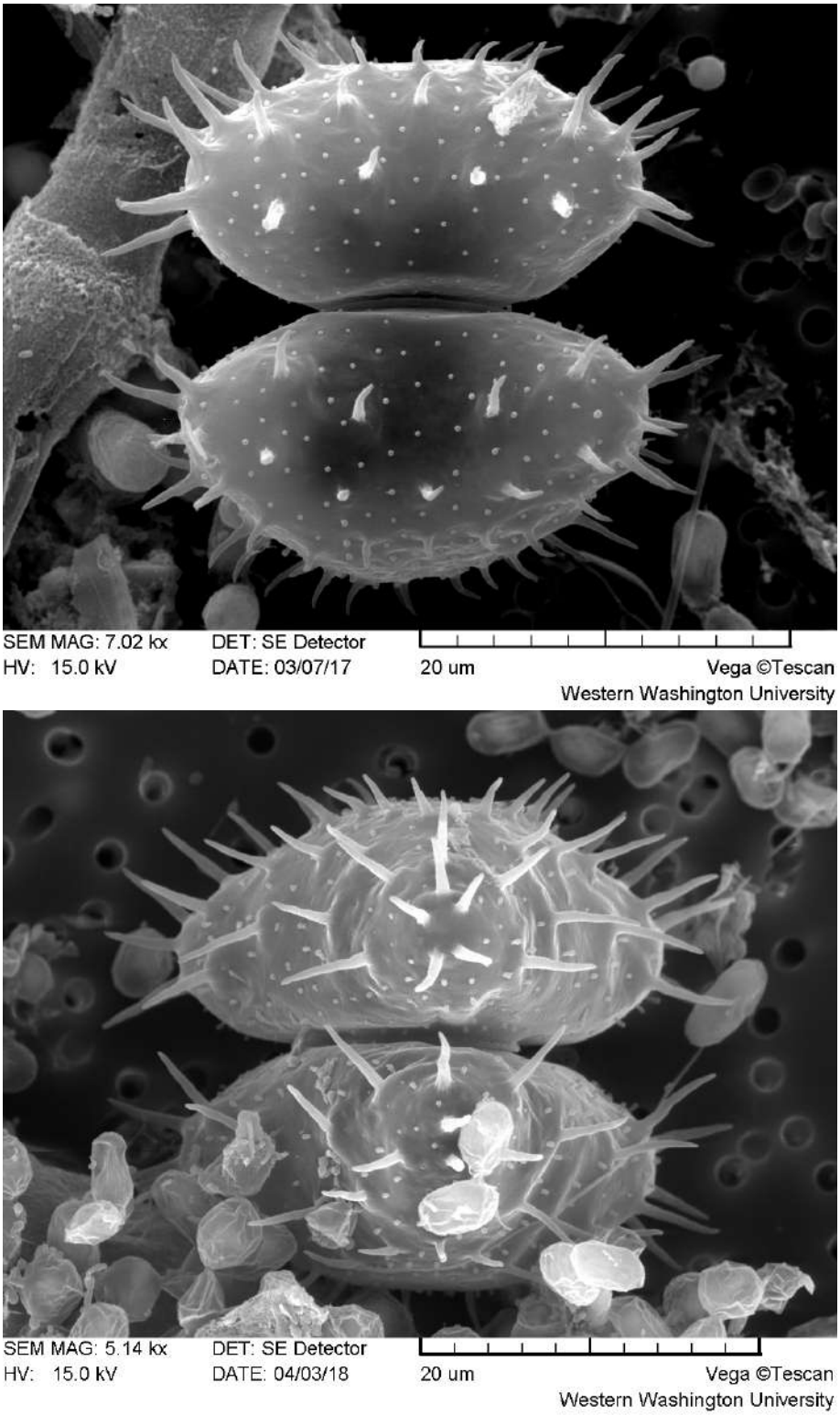


Figure 22.270: *Staurastrum teliferum* var. *gladiosum* (SEM/SEM), Myrtle Lake, Mountain Loop Highway, Snohomish County (upper/lower images).

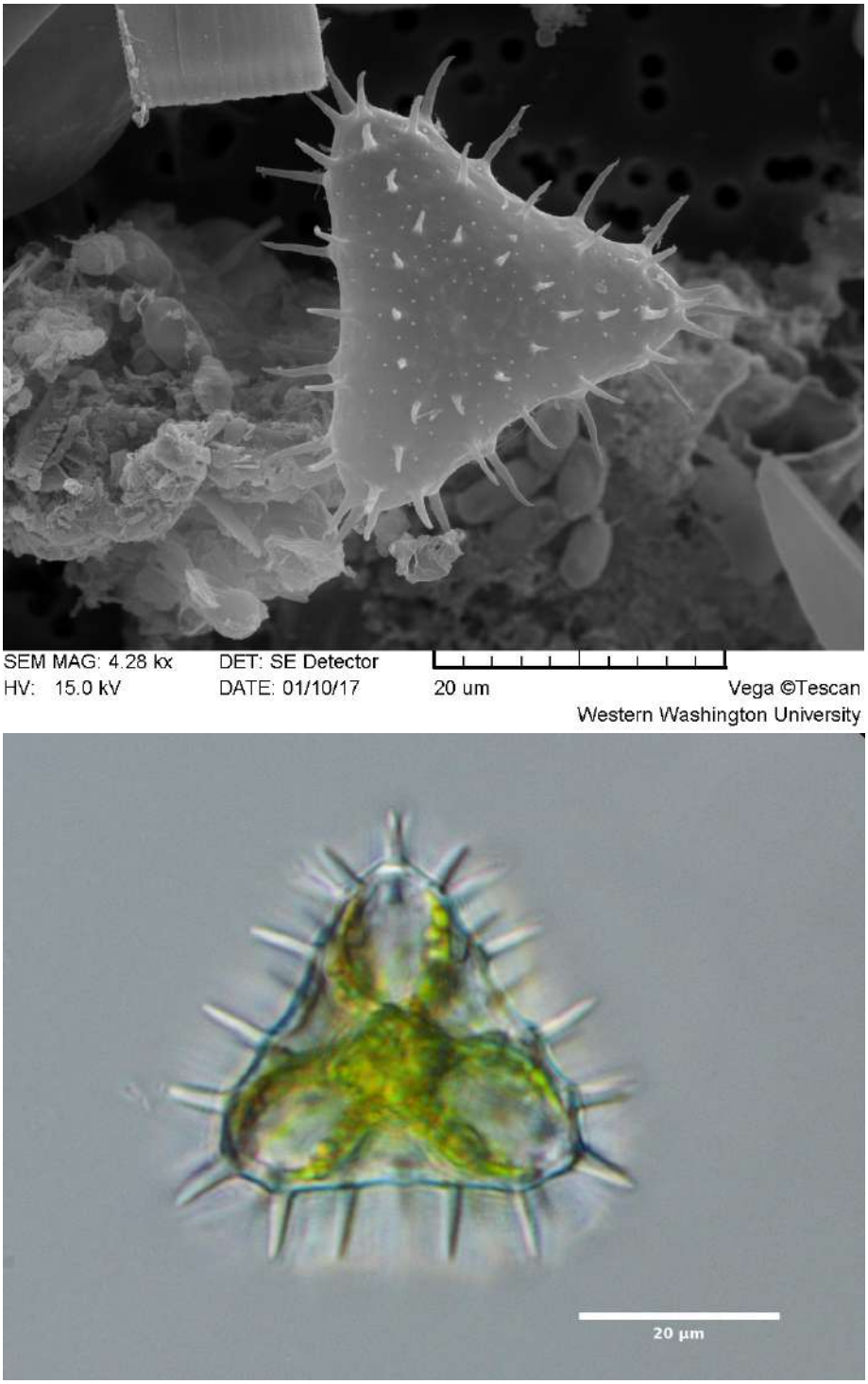


Figure 22.271: *Staurastrum teliferum* var. *gladiosum* (SEM/DIC), Picture Lake, Mt. Baker area, Whatcom County (upper/lower images).

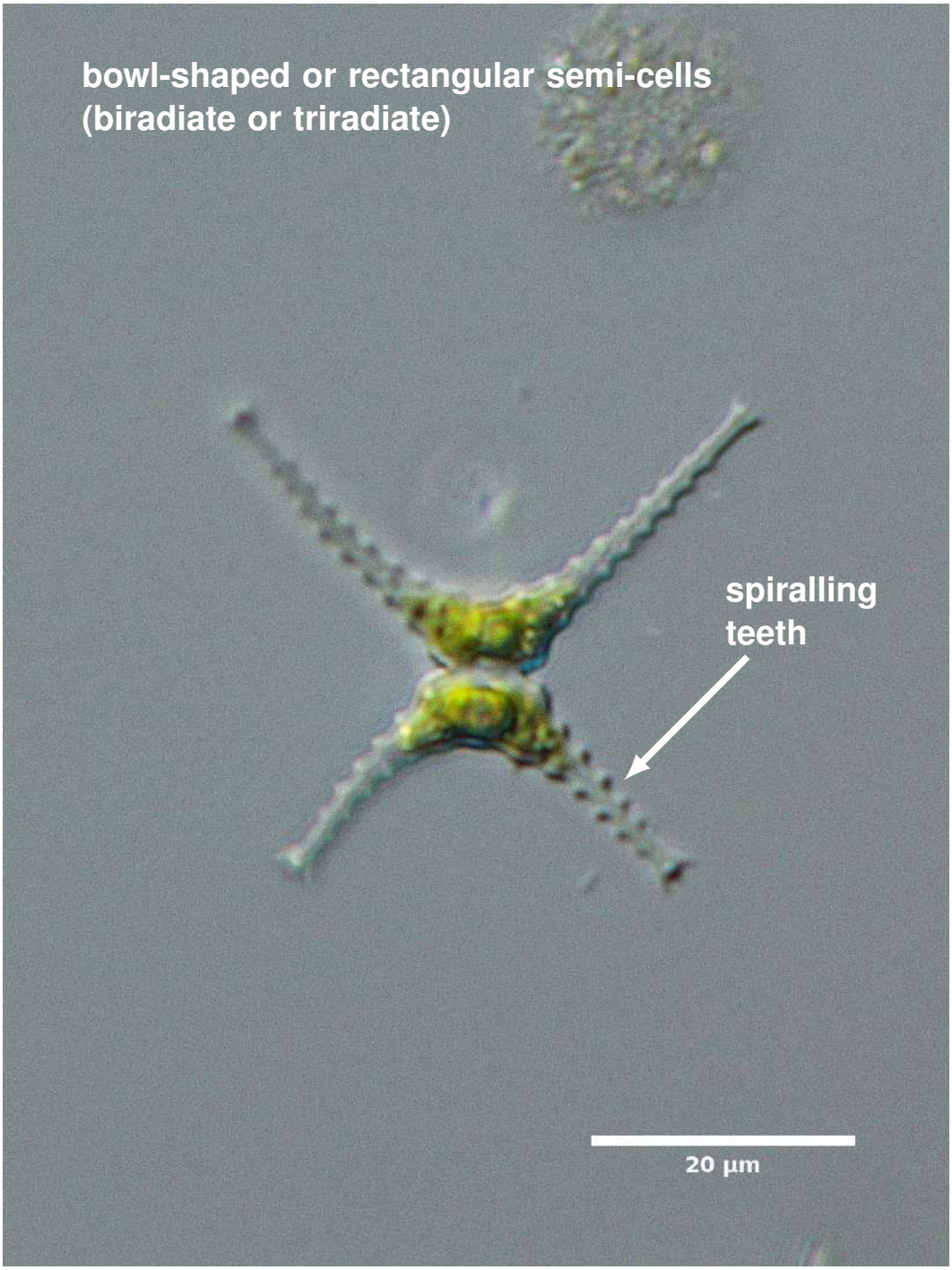


Figure 22.272: *Staurastrum tetracerum* (DIC), Hoag Pond, Whatcom County.

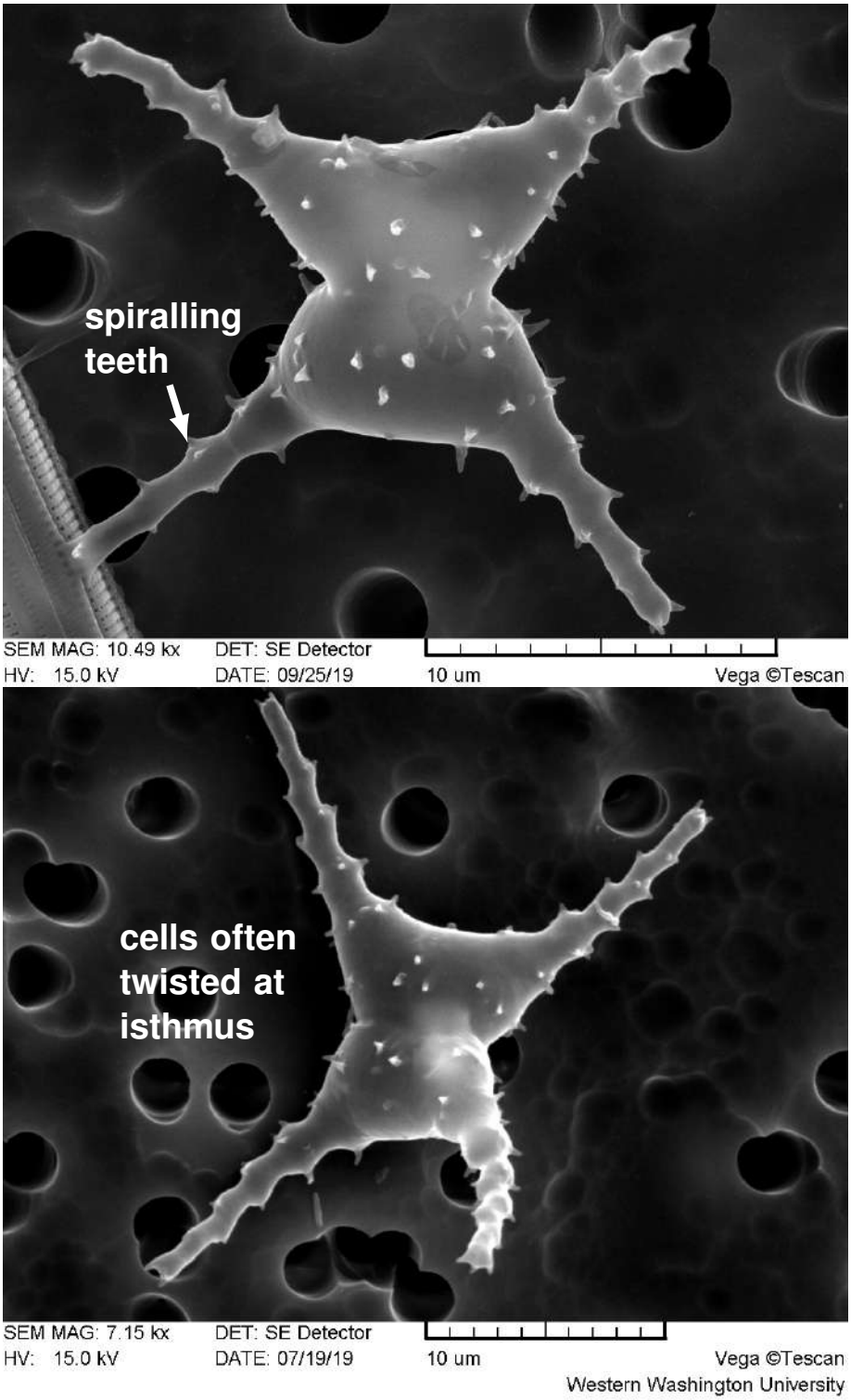


Figure 22.273: *Staurastrum tetracerum* (SEM/SEM), small boggy pond on Morris Valley Road near Harrison BC (upper/lower images).

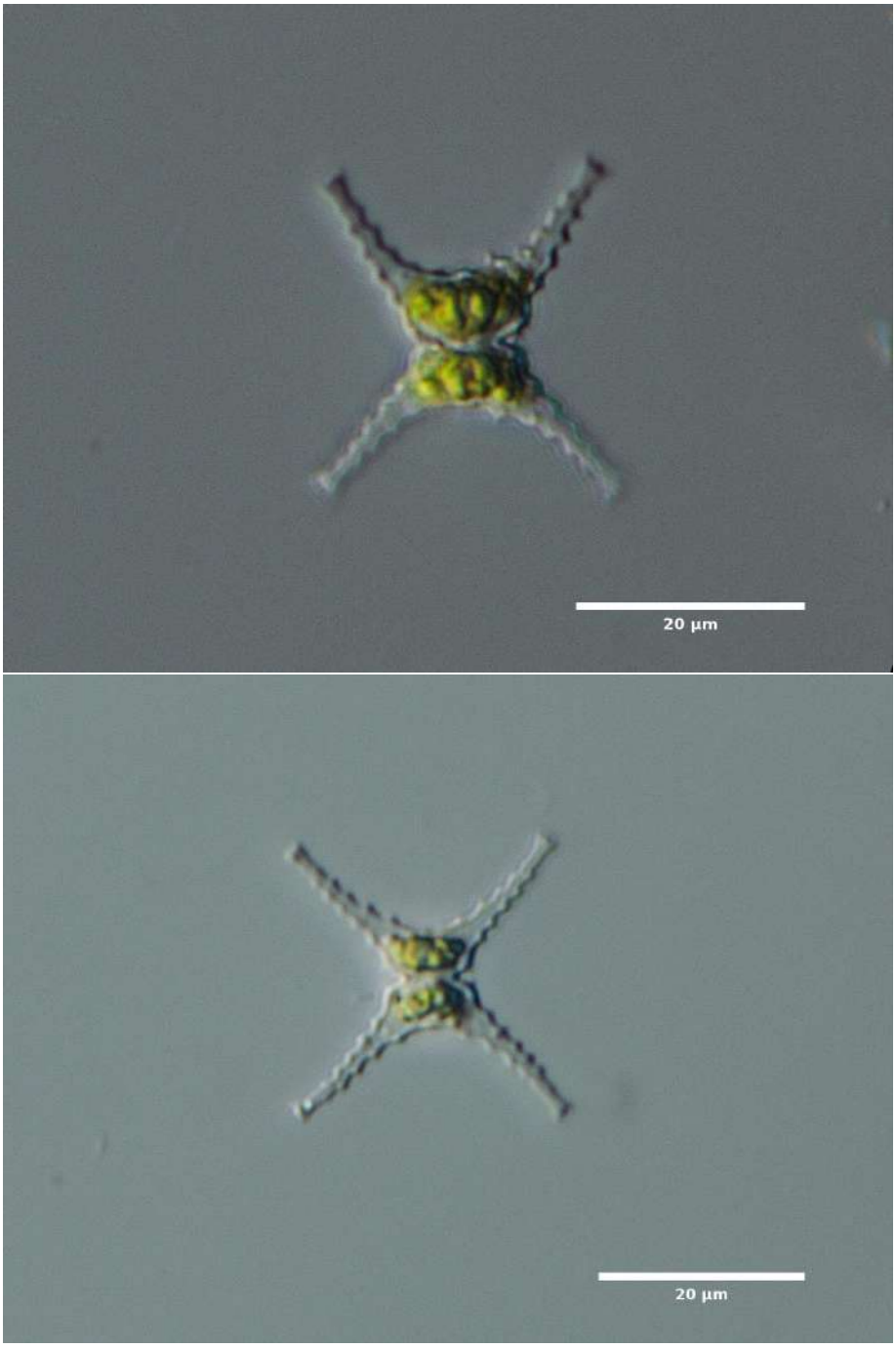


Figure 22.274: *Staurastrum tetracerum* (DIC/DIC), Hoag Pond, Whatcom County (upper image); small boggy pond on Morris Valley Road near Harrison BC (lower image).

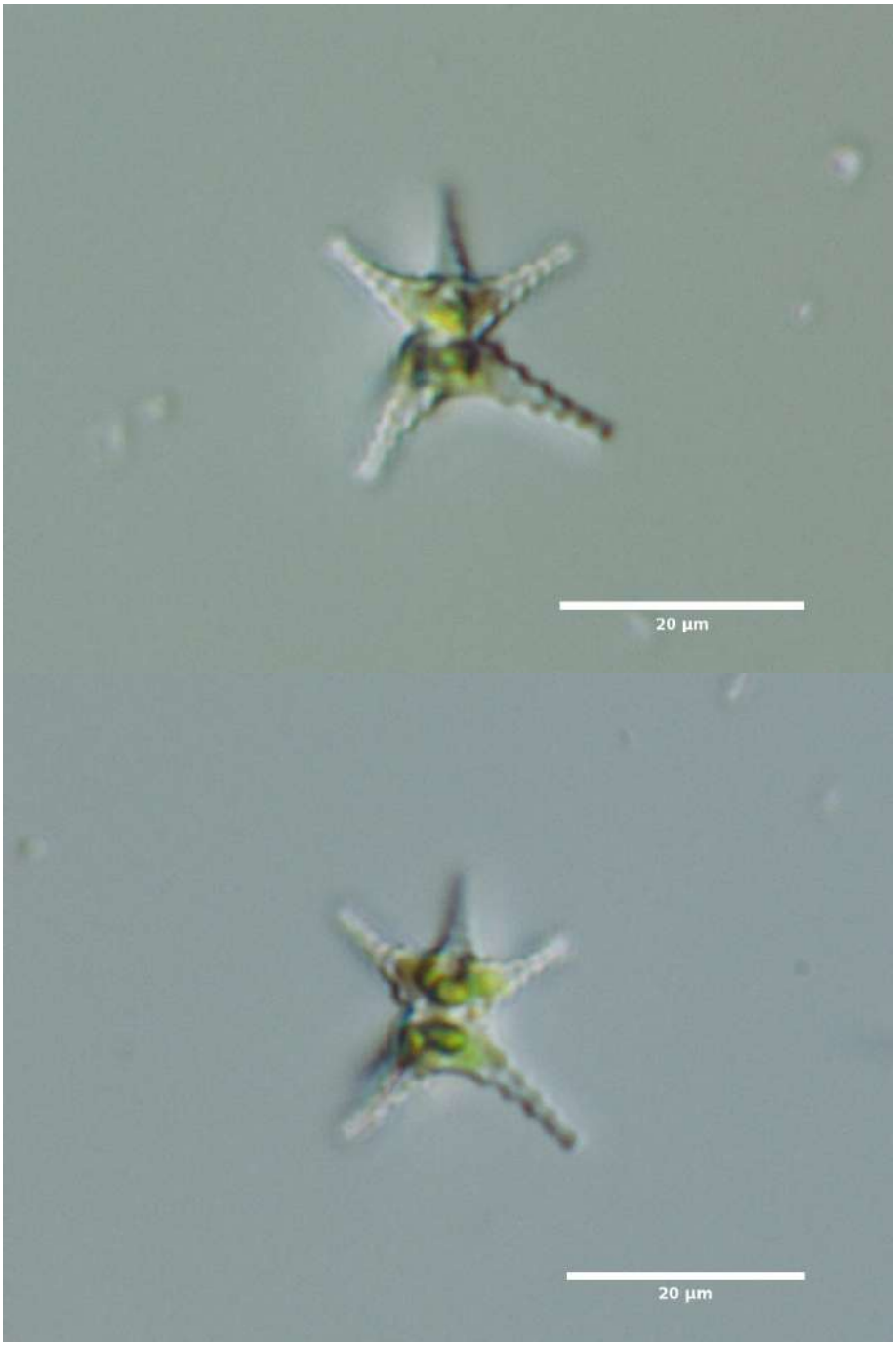


Figure 22.275: *Staurastrum tetracerum* var. *trigonum* (DIC/DIC), Coal Lake, Mountain Loop Highway, Snohomish County (upper/lower images).

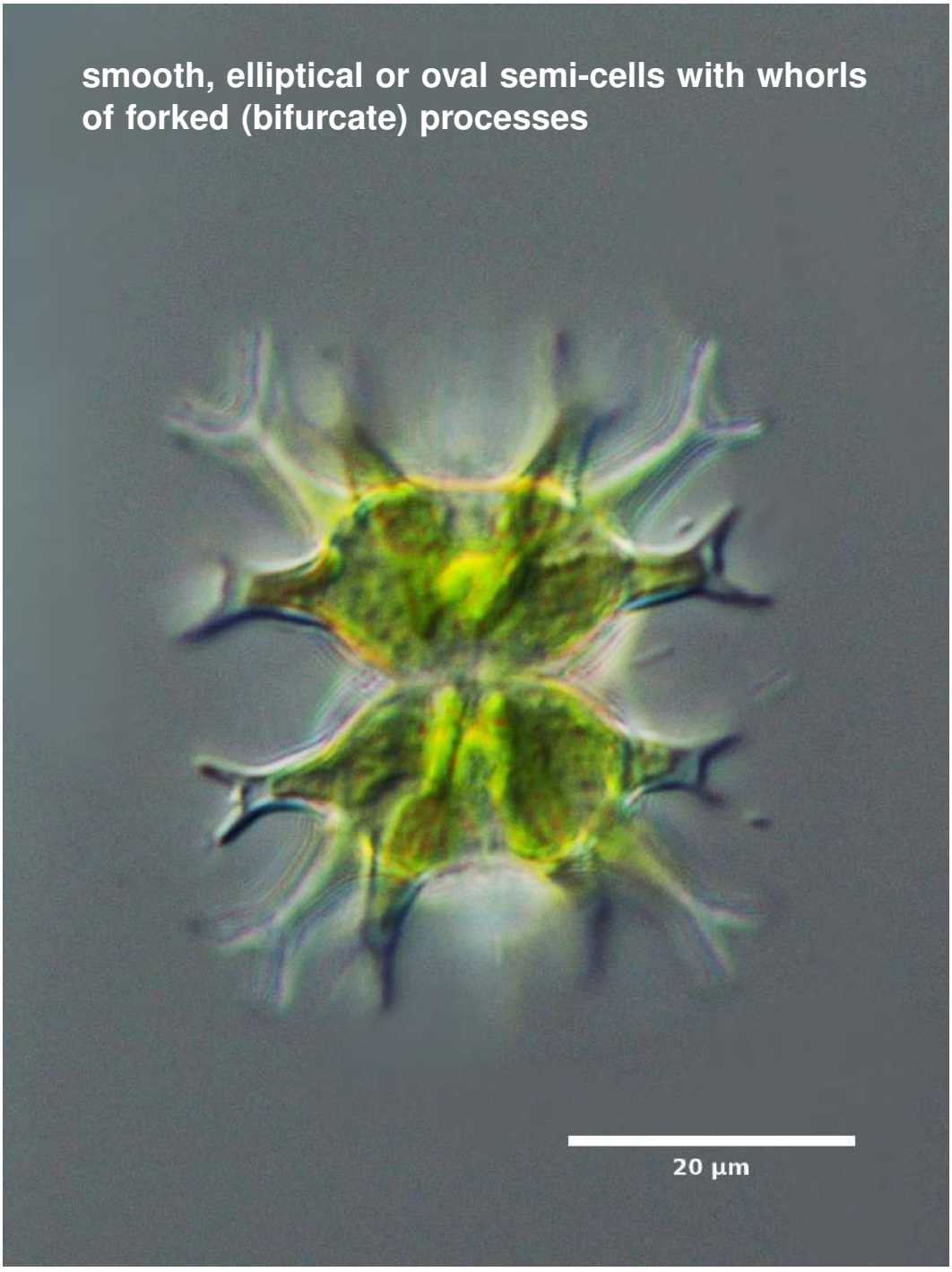


Figure 22.276: *Staurastrum tohopekaligense* (DIC), Myrtle Lake, Mountain Loop Highway, Snohomish County.

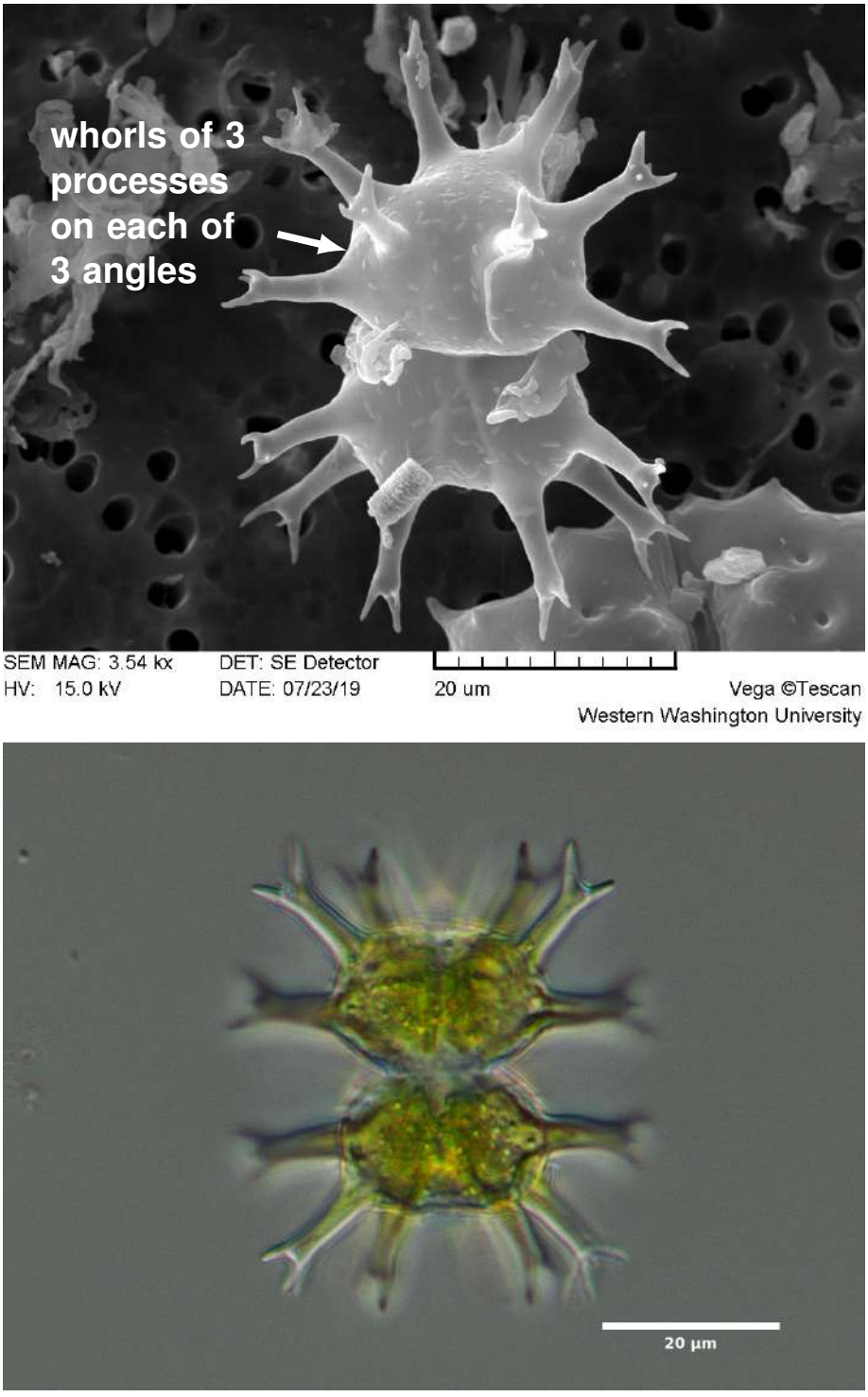


Figure 22.277: *Staurastrum tohopekaligense* (SEM/DIC), Chain Lake, Gifford Pinchot National Forest, Skamania County (upper/lower images).



Figure 22.278: *Staurastrum tohopekaligense* (SEM/DIC), Myrtle Lake, Mountain Loop Highway, Snohomish County (upper/lower images.

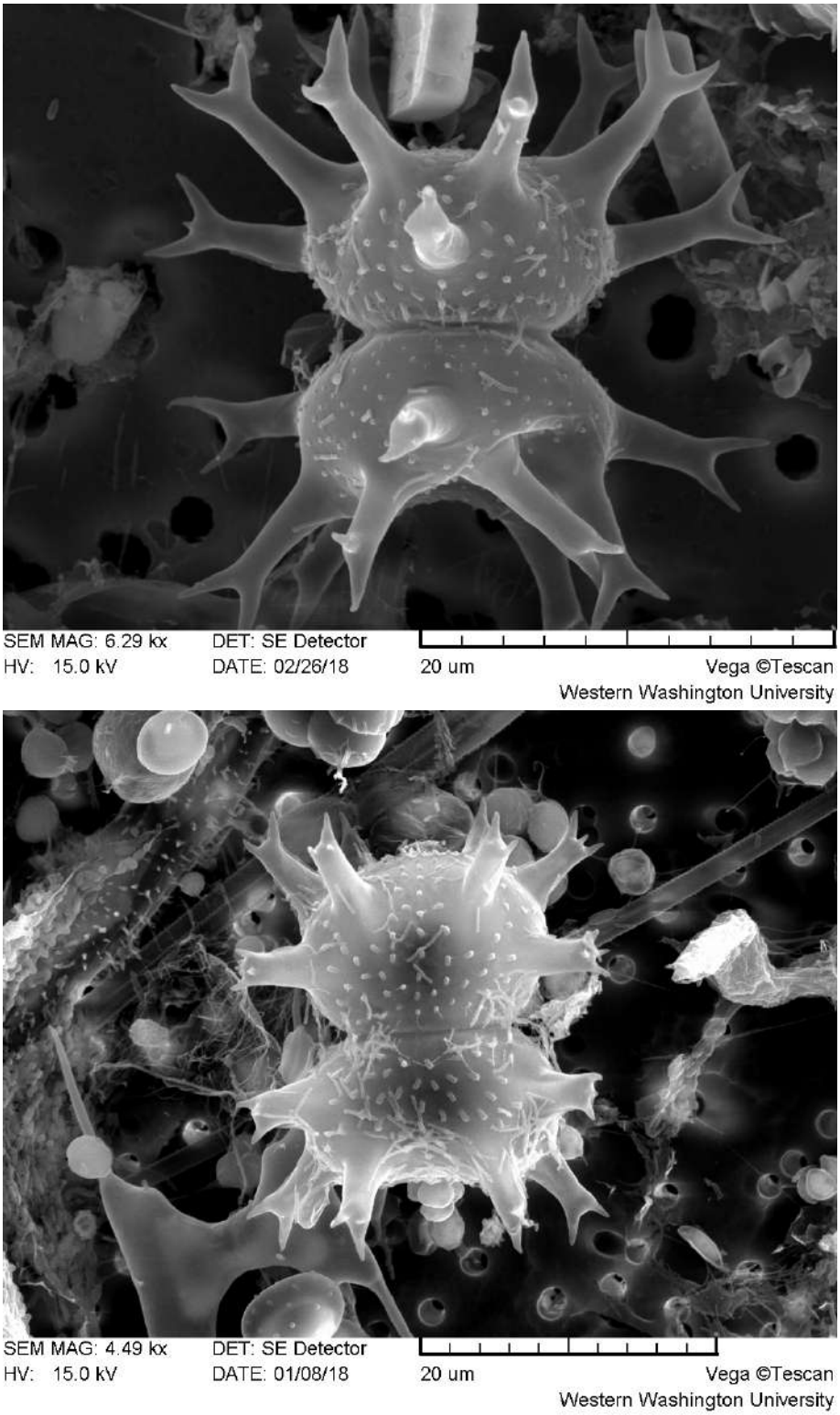


Figure 22.279: Morphological variation in *Staurastrum tohopekaligense* (SEM/SEM), Myrtle Lake, Mountain Loop Highway, Snohomish County (upper/lower images.



Figure 22.280: *Staurastrum trapezioides* (DIC), small floating bog near Baby Shoe Pass on road to Takhlakh Lake, Gifford Pinchot National Forest, Skamania County.



Figure 22.281: *Staurastrum trapezioides* (DIC), small floating bog near Baby Shoe Pass on road to Takhlakh Lake, Gifford Pinchot National Forest, Skamania County.

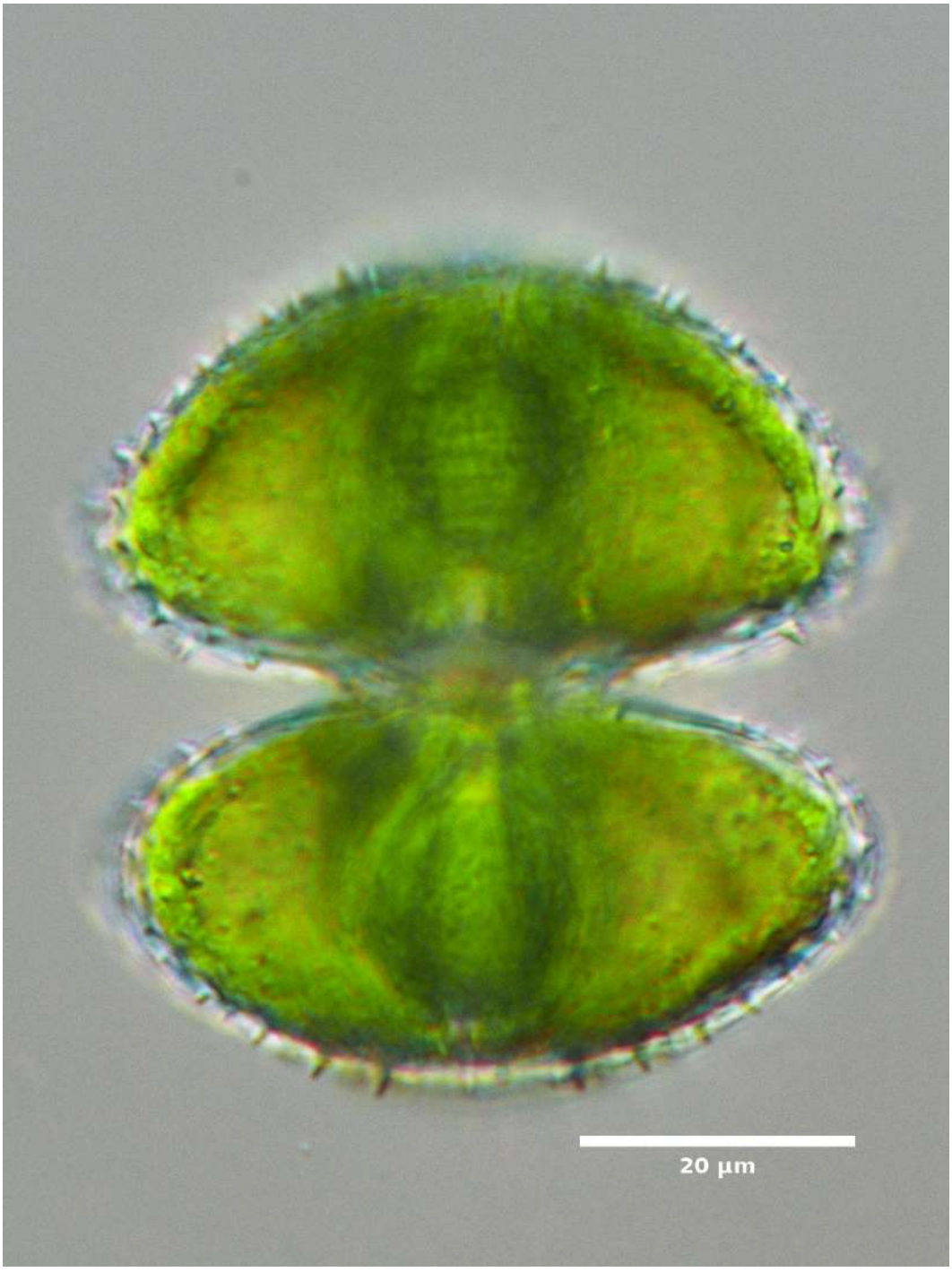


Figure 22.282: *Staurastrum* cf. *trapezioides* (DIC), side channel on Nooksack River, Whatcom County.



Figure 22.283: *Staurastrum trifidum* var. *inflexum* (DIC), Myrtle Lake, Mountain Loop Highway, Snohomish County.

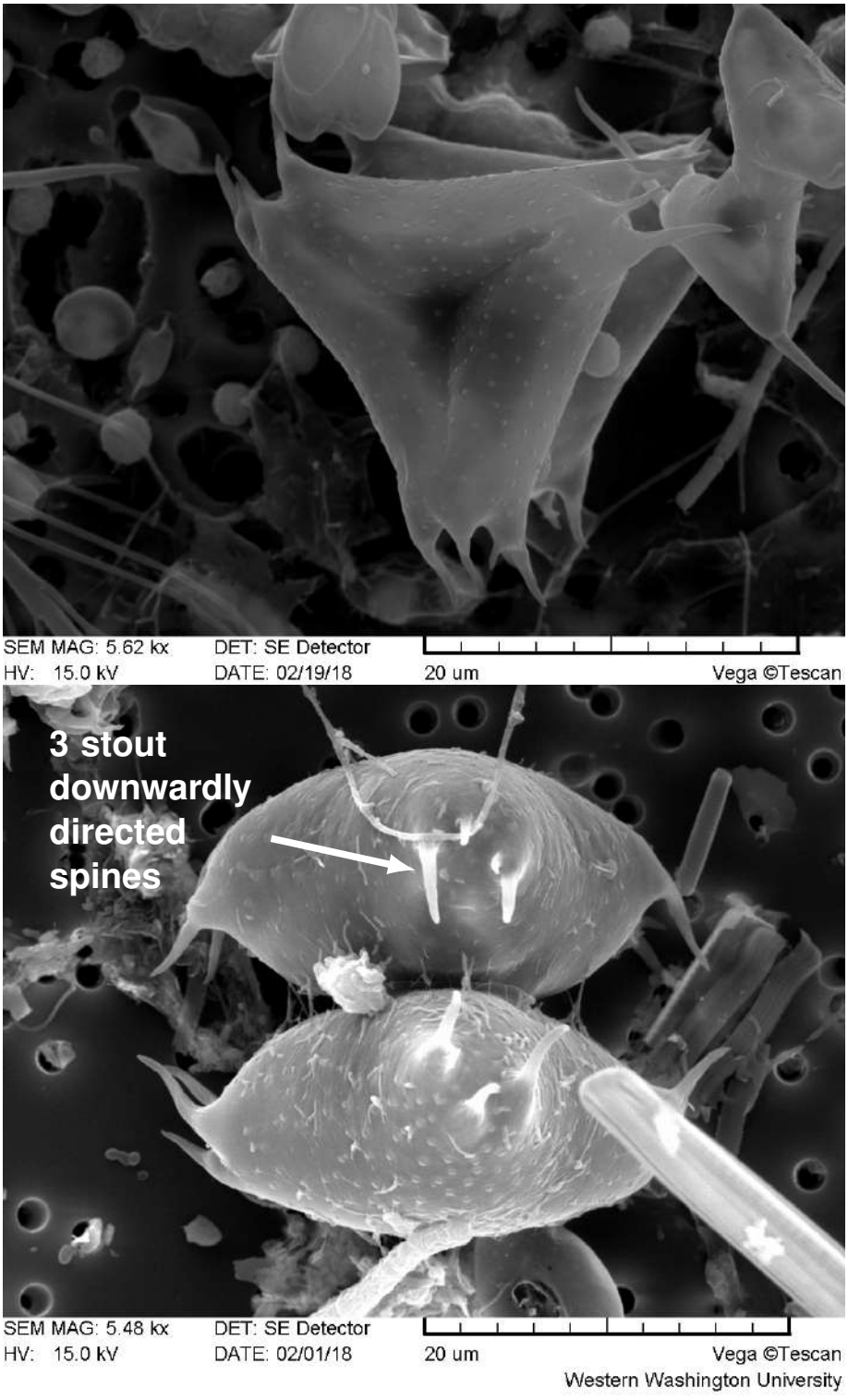


Figure 22.284: *Staurastrum trifidum* var. *inflexum* (SEM/SEM), Myrtle Lake, Mountain Loop Highway, Snohomish County (upper/lower images).



Figure 22.285: *Staurastrum trifidum* var. *inflexum* (DIC/DIC), Myrtle Lake, Mountain Loop Highway, Snohomish County (upper/lower images).



Figure 22.286: *Staurastrum vestitum* (DIC), Lake Twenty-two, Mountain Loop Highway, Snohomish County.

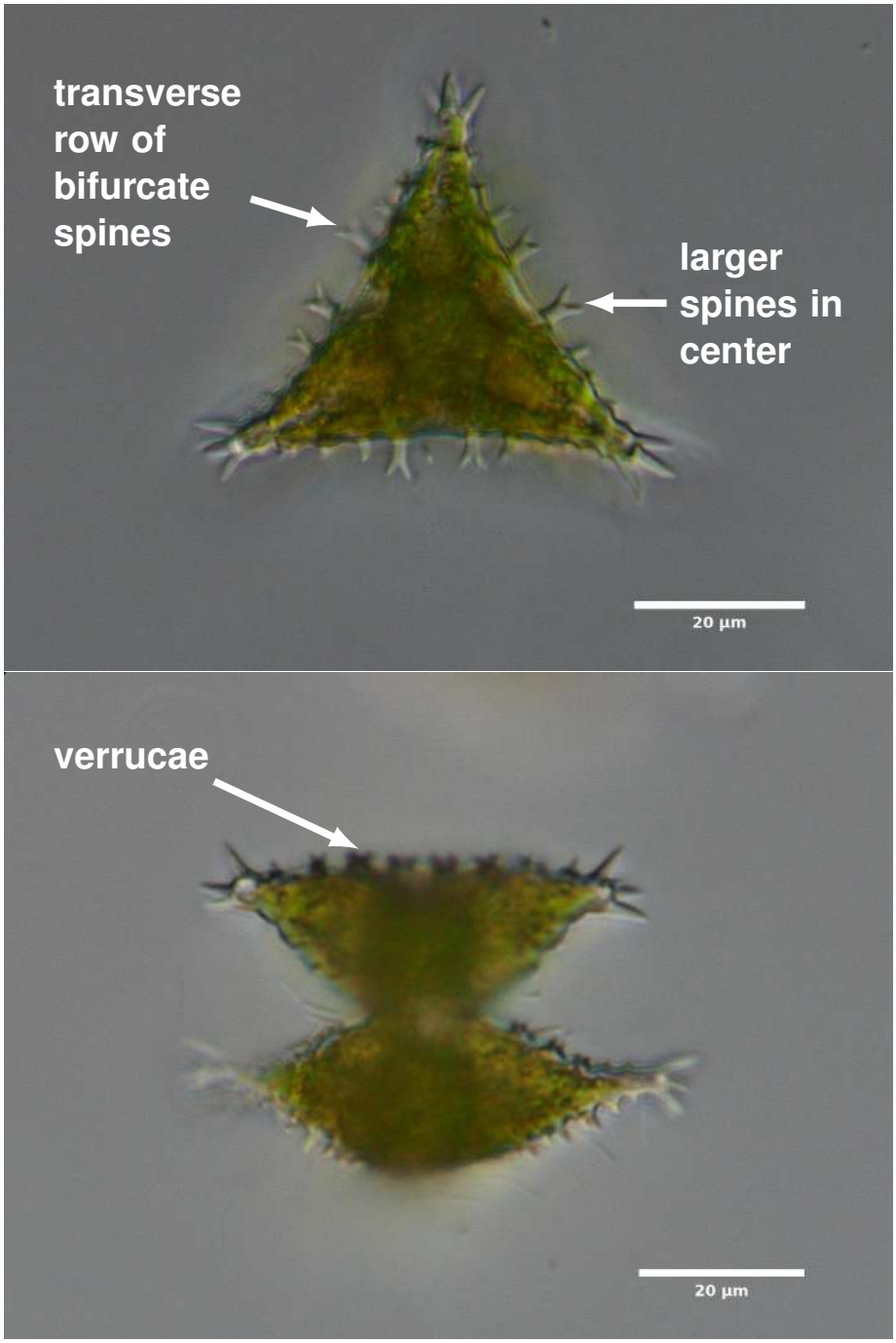


Figure 22.287: *Staurastrum vestitum* (DIC/DIC), Lake Twenty-two, Mountain Loop Highway, Snohomish County (upper/lower images).

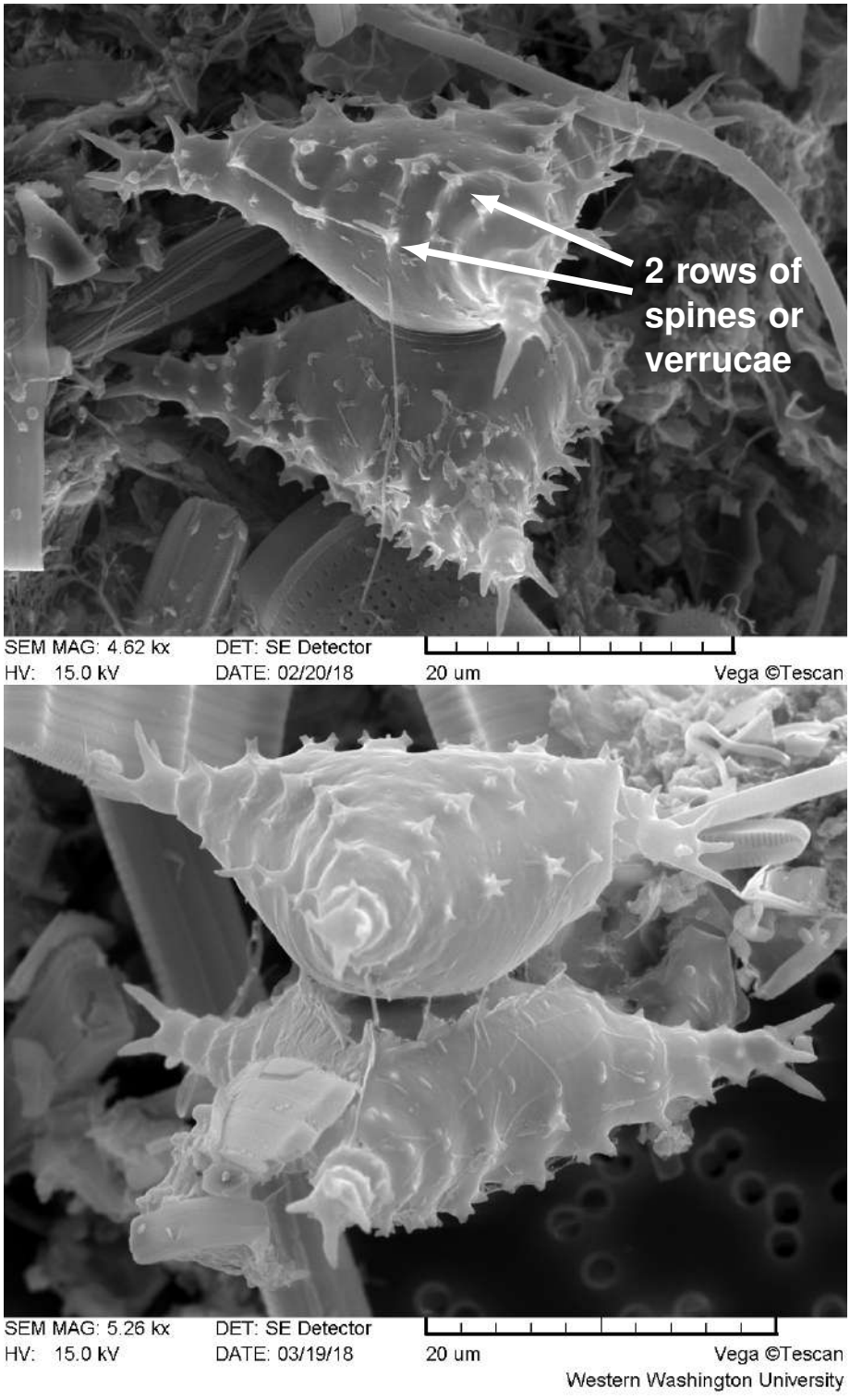


Figure 22.288: *Staurastrum vestitum* (SEM/SEM), Lake Twenty-two, Mountain Loop Highway, Snohomish County (upper/lower images).

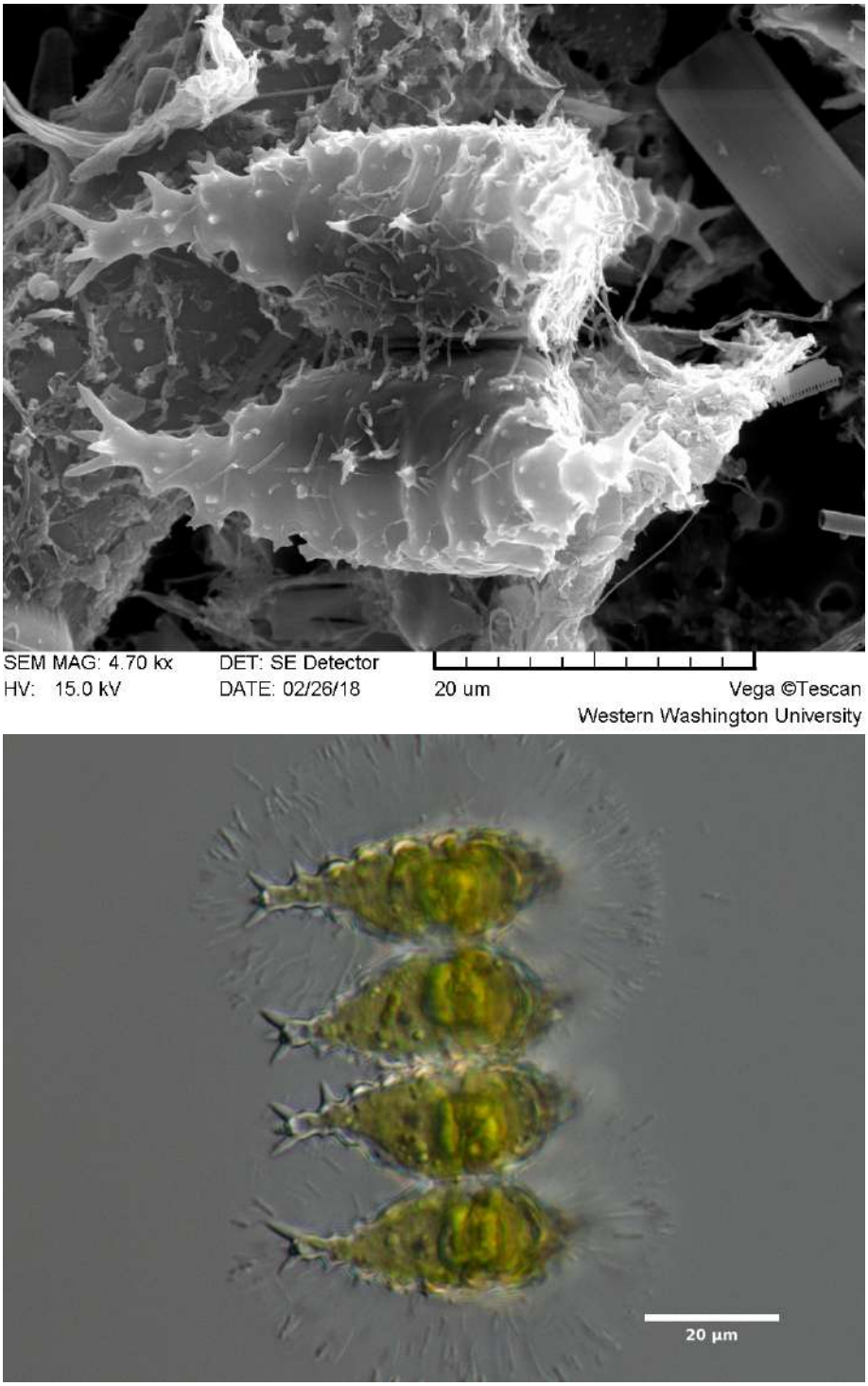


Figure 22.289: *Staurastrum vestitum* (SEM/DIC), Myrtle Lake, Mountain Loop Highway, Snohomish County (upper/lower images).

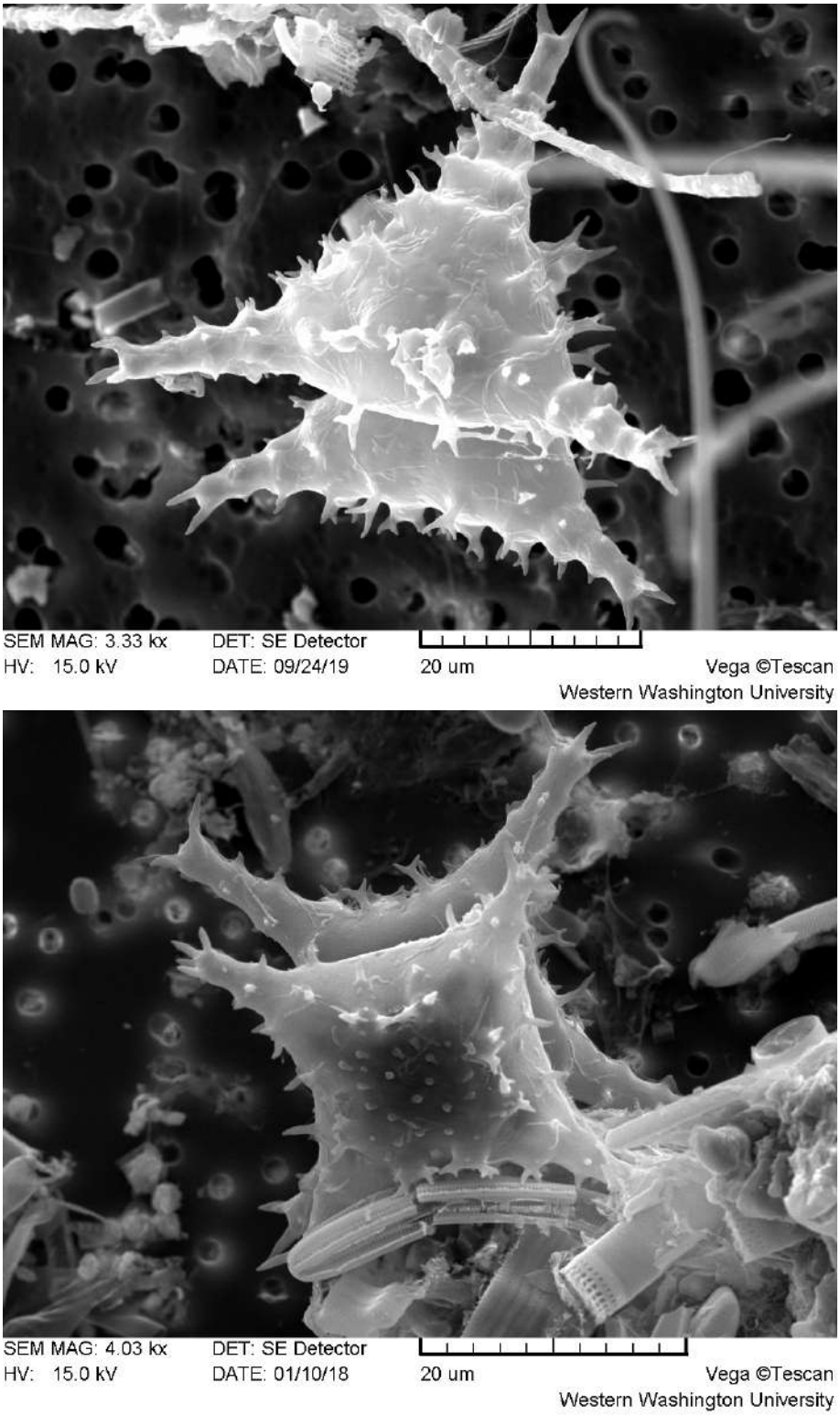


Figure 22.290: *Staurastrum vestitum* triradiate and 4-radiate semi-cells (SEM/SEM), Chain Lake, Gifford Pinchot National Forest, Skamania County (upper image); Bear Lake, Mountain Loop Highway, Snohomish County (lower image).

Chapter 23

Staurodesmus Teiling

Northwest Washington taxa
Staurodesmus bulnheimii (Raciborski) Round & A. J. Brook
Staurodesmus connatus (P. Lundell) Thomasson
Staurodesmus convergens (Ehrenberg ex Ralfs) S. Lillieroth
Staurodesmus cf. *cuspidatus* (Brébisson) Teiling[57]
Staurodesmus cuspidicurvatus Coesel & Meesters
Staurodesmus dejectus (Brébisson) Teiling
Staurodesmus dejectus var. *apiculatus* (Brébisson) Croasdale
Staurodesmus dickiei Hinode
Staurodesmus dickiei var. *circularis* (W. B. Turner) Croasdale
Staurodesmus extensus (O. F. Andersson) Teiling
Staurodesmus extensus var. *isthmosus* (Heimerl) Coesel
Staurodesmus extensus var. *Josh's* (Gutwinski) Teiling
Staurodesmus extensus cf. var. *rectus* (B. Eichler & Raciborski) Coesel & Meesters
Staurodesmus glaber (Ralfs) Teiling
Staurodesmus glaber var. *hirundinella* (Messikommer) Teiling
Staurodesmus incus (Hassal ex Ralfs) Teiling
Staurodesmus megacanthus (P. Lundell) Thunmark
Staurodesmus octocornis (Ehrenberg ex Ralfs) Šťastný, Škaloud & Neustupa
(=*Xanthidium octocorne* Ehrenberg ex Ralfs)
Staurodesmus omearae (W. Archer) Teiling
Staurodesmus patens (Nordstedt) Croasdale

[57] Including *Staurodesmus mamillatus* (Nordstedt) Teiling

Staurodesmus phimus (W. B. Turner) Thomasson
Staurodesmus semilunaris (Schmidle) Coesel & Meesters
Staurodesmus subquadratus (West & G. S. West) Coesel & Meesters
Staurodesmus triangularis (Lagerheim) Teiling
Staurodesmus triangularis var. *brevispina* (V. Allorge & P. Allorge) Coesel & Meesters
Staurodesmus tumidus [Brébisson ex Ralfs] Teiling
(=*Xanthidium tumidum* [Ralfs] Šťastný, Škaloud & Neustupa)

Table 23.1: Key to *Staurodesmus* Species

A	Semi-cells with four long spines (other species have two spines per semi-cell)	*Staurodesmus octocornis* (Figures 23.60–23.62)
B	Cells very large (L>100 μm); spines reduced to blunt teeth	*Staurodesmus tumidus* =*Xanthidium tumidum* (Chapter 27 page 1245)
C	Isthmus elongated with parallel sides	
	C.1 Semi-cells biradiate; trapezoidal	*Staurodesmus extensus* (Figures 23.34–23.43)
	C.2 Semi-cells triradiate; triangular, fusiform, or elliptical	
	C.2a Spines robust, divergent; base of spine as wide as apical angle	*Staurodesmus cuspidicurvatus* (Figures 23.17–23.19)
	C.2b Spines slender, divergent or convergent; base of spine narrower than apical angle	*Staurodesmus* cf. *cuspidatus* (Figures 23.12–23.16)
D	Isthmus not elongated; semi-cells biradiate	Go to to page 1109
E	Isthmus not elongated; semi-cells triradiate	Go to to page 1110

continued on next page

Table 23.1: Key to *Staurodesmus* Species, continued

D	Isthmus not elongated; semi-cells biradiate	
	D.1 Sinus mostly closed except near margin; semi-cells elliptical, broadly rectangular, or broadly fusiform	
	D.1a Spines long and convergent (occasionally horizontal)	*Staurodesmus convergens* (Figures 23.8–23.11)
	D.1b Spines long and divergent	*Staurodesmus bulnheimii* (Figures 23.1–23.4)
	D.2 Sinus widely open; spines convergent or horizontal	
	D.2a Semi-cells triangular; spines horizontal, very long	*Staurodesmus triangularis* (in part) (Figures 23.76–23.78)
	D.2b Semi-cells triangular; spines convergent, shorter than semi-cell width	*Staurodesmus triangularis* (in part) (Figures 23.79–23.81)
	D.2c Semi-cells hexagonal; spines strongly convergent; apical angles recurved	*Staurodesmus glaber* (in part) (Figures 23.49–23.50)
	D.3 Sinus widely open; spines divergent	
	D.3a Semi-cells triangular or cup-shaped; spines very long	*Staurodesmus incus* (Figures 23.54–23.57)

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Table 23.1: Key to *Staurodesmus* Species, continued

	D.3b Semi-cells crescent-shaped; spines moderately long, forming continuous arc with apex	*Staurodesmus semilunaris* (Figures 23.70–23.72)
	D.3c Semi-cells triangular or crescent-shaped; spines short, tooth-like	*Staurodesmus phimus* (Figures 23.68–23.69)
	D.3d Semi-cells trapezoidal or rectangular; spines short, tooth-like	*Staurodesmus subquadratus* (Figures 23.73–23.75)
E	Isthmus not elongated and with parallel sides; semi-cells triradiate	
	E.1 Spines short, tooth-like	
	E.1a Teeth strongly convergent; semi-cells hemispherical	*Staurodesmus dickiei* var. *circularis* (Figures 23.31–23.33)
	E.1b Teeth divergent or vertical; semi-cells bowl-shaped with flat apex	*Staurodesmus dejectus* var. *apiculatus* (Figures 23.23–23.25)
	E.1c Teeth nearly vertical; semi-cells elliptical with convex apex	*Staurodesmus patens* (Figures 23.65–23.67)
	E.2 Spines convergent and moderately long (not tooth-like)	
	E.2a Semi-cells lens-shaped or elliptical	*Staurodesmus dickiei* (Figures 23.26–23.30)
	E.2b Semi-cells triangular or hexagonal	*Staurodesmus glaber* (in part) (Figures 23.44–23.48)

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Table 23.1: Key to *Staurodesmus* Species, continued

E.3	Spines divergent, horizontal, or vertical and moderately long (not tooth-like)	
	E.3a Spines nearly vertical; semi-cells bowl-shaped	*Staurodesmus connatus* (Figures 23.5–23.7)
	E.3b Spines horizontal; semi-cells triangular	*Staurodesmus megacanthus* (Figures 23.58–23.59)
	E.3c Spines divergent; semi-cells cup-shaped	*Staurodesmus omearae* (Figures 23.63–23.64)
	E.3d Spines divergent; semi-cells bowl-shaped or broadly crescent-shaped	*Staurodesmus dejectus* (Figures 23.20–23.22)

Table 23.2: *Staurodesmus* Cell Measurements

		Cell Width	Cell Length	Isthmus Width	L/W Ratio
Staurodesmus bulnheimii (without spines)	min	23.1 μm	24.7 μm	6.9 μm	0.6
	med	25.6 μm	30.6 μm	7.8 μm	1.2
	max	42.7 μm	33.4 μm	8.5 μm	1.3
Staurodesmus bulnheimii (with spines)	min	55.2 μm	40.8 μm	6.9 μm	0.7
	med	58.7 μm	43.2 μm	7.8 μm	0.8
	max	61.9 μm	46.8 μm	8.5 μm	0.8
Staurodesmus connatus (without spines)	min	23.1 μm	24.3 μm	6.0 μm	1.0
	med	24.9 μm	26.6 μm	7.1 μm	1.1
	max	27.3 μm	27.9 μm	8.2 μm	1.2
Staurodesmus connatus (with spines)	min	26.7 μm	29.6 μm	6.0 μm	0.7
	med	28.9 μm	41.0 μm	7.1 μm	1.4
	max	43.7 μm	44.1 μm	8.2 μm	1.7

[†]*summary statistics based on <5 cells*

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Table 23.2: *Staurodesmus* Cell Measurements, continued

		Cell Width	Cell Length	Isthmus Width	L/W Ratio
Staurodesmus convergens	min	32.5 μm	32.3 μm	7.8 μm	0.9
(without spines)	med	38.2 μm	38.1 μm	10.7 μm	1.0
	max	47.1 μm	46.6 μm	11.5 μm	1.1
Staurodesmus convergens	min	45.7 μm	32.3 μm	7.8 μm	0.6
(with spines)	med	61.7 μm	38.1 μm	10.7 μm	0.6
	max	69.5 μm	46.6 μm	11.5 μm	0.8
Staurodesmus	min	19.7 μm	21.5 μm	5.1 μm	0.8
cf. *cuspidatus*	med	23.7 μm	23.9 μm	5.9 μm	1.1
(without spines)	max	29.4 μm	32.5 μm	6.9 μm	1.3
Staurodesmus	min	36.4 μm	20.2 μm	5.1 μm	0.5
cf. *cuspidatus*	med	45.0 μm	23.9 μm	5.9 μm	0.6
(with spines)	max	61.9 μm	42.6 μm	6.9 μm	0.8
Staurodesmus	min	25.4 μm	26.8 μm	5.4 μm	0.9
cf. *cuspidicurvatus*	med	27.6 μm	29.7 μm	6.2 μm	1.1
(without spines)	max	38.2 μm	34.8 μm	7.6 μm	1.2
Staurodesmus	min	36.4 μm	26.2 μm	5.4 μm	0.6
cf. *cuspidicurvatus*	med	46.0 μm	32.8 μm	6.2 μm	0.7
(with spines)	max	71.6 μm	52.4 μm	7.6 μm	1.0
Staurodesmus dejectus	min	25.6 μm	24.7 μm	5.9 μm	0.9
(without spines)	med	26.8 μm	26.3 μm	7.2 μm	1.0
	max	33.2 μm	32.4 μm	9.4 μm	1.0
Staurodesmus dejectus	min	27.1 μm	33.0 μm	5.9 μm	0.9
(with spines)	med	31.3 μm	38.7 μm	7.2 μm	1.2
	max	38.7 μm	42.2 μm	9.4 μm	1.5

†*summary statistics based on <5 cells*

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Table 23.2: *Staurodesmus* Cell Measurements, continued

		Cell Width	Cell Length	Isthmus Width	L/W Ratio
Staurodesmus dejectus	min	18.2 μm	18.4 μm	4.6 μm	0.7
var. *apiculatus*	med	21.8 μm	20.9 μm	5.8 μm	1.0
(without spines)	max	32.0 μm	29.4 μm	8.5 μm	1.4
Staurodesmus dejectus	min	19.3 μm	18.6 μm	4.6 μm	0.7
var. *apiculatus*	med	24.8 μm	25.7 μm	5.8 μm	1.0
(with spines)	max	40.8 μm	38.6 μm	8.5 μm	1.3
Staurodesmus dickiei	min	33.5 μm	37.5 μm	10.7 μm	0.8
(without spines)	med	45.1 μm	43.7 μm	12.7 μm	1.0
	max	53.8 μm	47.1 μm	13.9 μm	1.1
Staurodesmus dickiei	min	54.5 μm	37.5 μm	10.7 μm	0.6
(with spines)	med	62.0 μm	43.7 μm	12.7 μm	0.7
	max	76.4 μm	47.1 μm	13.9 μm	0.8
Staurodesmus dickiei	min	38.1 μm	39.3 μm	11.7 μm	1.0
var. *circularis*	med	41.9 μm	44.0 μm	13.7 μm	0.1
(without spines)	max	43.6 μm	45.7 μm	18.6 μm	1.0
Staurodesmus dickiei	min	42.9 μm	39.3 μm	11.7 μm	0.8
var. *circularis*	med	47.9 μm	44.0 μm	13.7 μm	0.9
(with spines)	max	50.5 μm	45.7 μm	18.6 μm	1.0
Staurodesmus dickiei	min	23.1 μm	23.7 μm	7.0 μm	0.8
cf. var. *circularis*	med	29.3 μm	28.8 μm	8.5 μm	0.9
(without spines)	max	34.6 μm	32.0 μm	12.7 μm	1.0
Staurodesmus dickiei	min	24.1 μm	23.7 μm	7.0 μm	0.8
cf. var. *circularis*	med	34.8 μm	28.8 μm	8.5 μm	0.9
(with spines)	max	38.0 μm	32.0 μm	12.7 μm	1.0

†*summary statistics based on <5 cells*

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Table 23.2: *Staurodesmus* Cell Measurements, continued

		Cell Width	Cell Length	Isthmus Width	L/W Ratio
Staurodesmus extensus	min	13.5 μm	16.3 μm	4.9 μm	1.0
(without spines)	med	17.1 μm	21.1 μm	6.2 μm	1.2
	max	20.5 μm	22.6 μm	7.6 μm	1.4
Staurodesmus extensus	min	30.5 μm	16.3 μm	4.9 μm	0.5
(with spines)	med	36.1 μm	27.4 μm	6.2 μm	0.7
	max	40.5 μm	30.7 μm	7.6 μm	0.8
Staurodesmus extensus	min	11.6 μm	11.6 μm	6.4 μm	1.0
var. *isthmosus*	med	12.2 μm	13.0 μm	7.0 μm	1.0
(without spines)	max	13.9 μm	13.7 μm	7.3 μm	1.1
Staurodesmus extensus	min	15.6 μm	15.0 μm	6.4 μm	0.8
var. *isthmosus*	med	19.5 μm	15.7 μm	7.0 μm	0.8
(with spines)	max	22.5 μm	18.6 μm	7.3 μm	1.2
Staurodesmus extensus	min	14.7 μm	19.0 μm	6.2 μm	1.1
var. *joshuae*	med	20.7 μm	26.4 μm	7.8 μm	1.3
(without spines)	max	29.9 μm	38.7 μm	10.5 μm	1.4
Staurodesmus extensus	min	38.9 μm	22.2 μm	6.2 μm	0.4
var. *joshuae*	med	54.8 μm	27.1 μm	7.8 μm	0.5
(with spines)	max	79.6 μm	43.9 μm	10.5 μm	0.6
Staurodesmus extensus	min	12.9 μm	13.7 μm	5.2 μm	1.0
cf. var. *rectus*	med	14.3 μm	15.5 μm	5.7 μm	1.1
(without spines)	max	15.7 μm	19.1 μm	6.6 μm	1.3
Staurodesmus extensus	min	19.1 μm	13.7 μm	5.2 μm	0.7
cf. var. *rectus*	med	20.2 μm	15.5 μm	5.7 μm	0.7
(with spines)	max	15.6 μm	19.2 μm	6.6 μm	0.8

†*summary statistics based on <5 cells*

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Table 23.2: *Staurodesmus* Cell Measurements, continued

		Cell Width	Cell Length	Isthmus Width	L/W Ratio
Staurodesmus glaber	min	30.0 μm	28.7 μm	7.0 μm	0.8
(without spines)	med	34.3 μm	31.8 μm	8.2 μm	0.9
	max	41.0 μm	39.6 μm	11.5 μm	1.0
Staurodesmus glaber	min	49.0 μm	28.7 μm	7.0 μm	0.5
(with spines)	med	50.7 μm	31.8 μm	8.2 μm	0.6
	max	58.0 μm	39.6 μm	11.5 μm	0.7
Staurodesmus glaber	min	18.8 μm	18.7 μm	7.5 μm	1.0
var. *hirundinella*[†]	med	19.0 μm	19.1 μm	8.5 μm	1.0
(without spines)	max	19.2 μm	19.6 μm	9.5 μm	1.0
Staurodesmus glaber	min	30.9 μm	18.7 μm	7.5 μm	0.6
var. *hirundinella*[†]	med	31.4 μm	19.1 μm	8.5 μm	0.6
(with spines)	max	31.8 μm	19.6 μm	9.5 μm	0.6
Staurodesmus glaber	min	26.9 μm	25.4 μm	8.1 μm	0.9
var. A	med	30.5 μm	27.9 μm	9.8 μm	0.9
(without spines)	max	32.3 μm	30.5 μm	10.2 μm	1.0
Staurodesmus glaber	min	39.8 μm	25.4 μm	8.1 μm	0.5
var. A	med	45.1 μm	27.9 μm	9.8 μm	0.6
(with spines)	max	56.1 μm	30.5 μm	10.2 μm	0.7
Staurodesmus glaber	min	14.2 μm	16.5 μm	6.5 μm	0.8
var. B	med	17.6 μm	18.3 μm	7.0 μm	1.0
(without spines)	max	24.6 μm	20.5 μm	8.9 μm	1.3
Staurodesmus glaber	min	21.8 μm	16.5 μm	6.5 μm	0.5
var. B	med	27.0 μm	18.3 μm	7.0 μm	0.6
(with spines)	max	34.0 μm	20.5 μm	8.9 μm	0.8

[†]*summary statistics based on <5 cells*

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Table 23.2: *Staurodesmus* Cell Measurements, continued

		Cell Width	Cell Length	Isthmus Width	L/W Ratio
Staurodesmus incus	min	16.8 μm	20.1 μm	6.2 μm	1.1
(without spines)	med	18.2 μm	21.1 μm	6.6 μm	1.2
	max	19.3 μm	22.6 μm	7.5 μm	1.2
Staurodesmus incus	min	63.9 μm	31.0 μm	6.2 μm	0.5
(with spines)	med	66.2 μm	34.1 μm	6.6 μm	0.5
	max	69.5 μm	36.7 μm	7.5 μm	0.6
Staurodesmus	min	35.3 μm	34.1 μm	9.1 μm	0.7
megacanthus	med	44.1 μm	39.5 μm	10.8 μm	0.8
(without spines)	max	62.0 μm	41.7 μm	11.8 μm	1.0
Staurodesmus	min	69.9 μm	34.1 μm	9.1 μm	0.4
megacanthus	med	72.8 μm	39.5 μm	10.0 μm	0.5
(with spines)	max	86.8 μm	41.7 μm	11.8 μm	0.6
Staurodesmus octocornis	min	13.3 μm	18.0 μm	5.4 μm	1.0
(without spines)	med	15.8 μm	19.9 μm	6.1 μm	1.3
	max	19.7 μm	24.5 μm	7.4 μm	1.4
Staurodesmus octocornis	min	23.5 μm	25.7 μm	5.4 μm	1.0
(with spines)	med	31.4 μm	35.3 μm	6.1 μm	1.1
	max	39.2 μm	38.8 μm	7.4 μm	1.2
Staurodesmus omearae	min	16.1 μm	16.2 μm	7.2 μm	0.9
(without spines)	med	16.8 μm	17.2 μm	7.9 μm	1.0
	max	19.0 μm	19.4 μm	8.5 μm	1.2
Staurodesmus omearae	min	28.5 μm	22.8 μm	7.2 μm	0.6
(with spines)	med	33.2 μm	23.4 μm	7.9 μm	0.8
	max	39.4 μm	28.2 μm	8.5 μm	0.8

[†]*summary statistics based on <5 cells*

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Table 23.2: *Staurodesmus* Cell Measurements, continued

		Cell Width	Cell Length	Isthmus Width	L/W Ratio
Staurodesmus patens	min	20.2 μm	19.1 μm	5.5 μm	0.9
(without spines)	med	24.5 μm	24.5 μm	7.2 μm	1.0
	max	26.5 μm	25.5 μm	8.0 μm	1.1
Staurodesmus patens	min	20.2 μm	19.1 μm	5.5 μm	0.8
(with spines)	med	26.3 μm	24.5 μm	7.2 μm	0.9
	max	27.5 μm	25.5 μm	8.0 μm	1.0
Staurodesmus phimus[†]	min	16.3 μm	16.4 μm	6.7 μm	0.9
(without spines)	med	17.9 μm	17.9 μm	8.3 μm	1.0
	max	19.9 μm	19.0 μm	9.6 μm	1.1
Staurodesmus phimus[†]	min	21.8 μm	18.3 μm	6.7 μm	0.8
(with spines)	med	22.4 μm	19.0 μm	8.3 μm	0.8
	max	24.2 μm	22.0 μm	9.6 μm	1.0
Staurodesmus semilunaris	min	22.1 μm	20.1 μm	8.8 μm	0.8
(without spines)	med	23.4 μm	21.7 μm	9.8 μm	0.9
	max	25.7 μm	23.1 μm	11.2 μm	1.0
Staurodesmus semilunaris	min	37.3 μm	29.8 μm	8.8 μm	0.7
(with spines)	med	40.3 μm	35.5 μm	9.8 μm	0.9
	max	49.1 μm	47.0 μm	11.2 μm	1.1
Staurodesmus	min	12.5 μm	18.9 μm	9.7 μm	1.1
subquadratus	med	15.2 μm	19.4 μm	10.0 μm	1.3
(without spines)	max	17.6 μm	20.0 μm	10.5 μm	1.6
Staurodesmus	min	18.5 μm	18.9 μm	9.7 μm	0.9
subquadratus	med	20.4 μm	19.8 μm	10.0 μm	1.0
(with spines)	max	22.4 μm	20.4 μm	10.5 μm	1.1

[†]*summary statistics based on <5 cells*

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Table 23.2: *Staurodesmus* Cell Measurements, continued

		Cell Width	Cell Length	Isthmus Width	L/W Ratio
Staurodesmus triangularis	min	15.3 μm	16.8 μm	4.9 μm	0.9
(without spines)	med	21.5 μm	22.8 μm	7.4 μm	1.0
	max	26.9 μm	31.3 μm	10.3 μm	1.2
Staurodesmus triangularis	min	28.3 μm	16.8 μm	4.9 μm	0.3
(with spines)	med	51.0 μm	22.8 μm	7.4 μm	0.4
	max	81.5 μm	31.3 μm	10.3 μm	0.6
Staurodesmus triangularis	min	18.3 μm	19.1 μm	6.9 μm	0.9
var. *brevispina*	med	21.0 μm	21.5 μm	7.4 μm	1.0
(without spines)	max	23.8 μm	23.2 μm	8.2 μm	1.1
Staurodesmus triangularis	min	30.7 μm	19.1 μm	6.9 μm	0.5
var. *brevispina*	med	36.6 μm	21.5 μm	7.4 μm	0.6
(with spines)	max	40.9 μm	23.2 μm	8.2 μm	0.7

[†]*summary statistics based on <5 cells*

Description

The genus *Staurodesmus* contains many species that are inadequately described in the literature and may be polymorphic within the same population. The genus was introduced by Teiling (1948), who merged species characterized by smooth-walled cells[58] that have single spines (monospinous) extending from each of the apical angles and have two sides (biradiate), three sides (triradiate), or more (pluriradiate). Previously, biradiate species were mostly assigned to the genus *Arthrodesmus*, while triradiate/pluriradiate species were mostly placed in the genus *Staurastrum* (see Section 22, page 755). Unfortunately, this revision does not always work, in part because specimens with different numbers of sides could be found within a single species and there are "Janus-form" cells that have different numbers of sides on opposite semi-cells. To further complicate matters, *Xanthidium octocorne*,

[58]Some of the *Staurodesmus* species described in this chapter have faint, but regular patterns of small, mucilage pores that may form rounded mucilage plugs resembling granules on the cell surface. The patterns are generally only visible in SEM images.

which has four spines on each semi-cell,[59] was renamed *Staurodesmus octocornis* based on genetic analyses (Šťastný, et al., 2013). Because of the polymorphy in this genus, it is important to examine more than one cell before trying to identify the species. The *Staurodesmus* key in this guide is based on whether the semi-cells are *usually* oval in cross-section (two-sided/biradiate) or triangular in cross-section (three-sided/triradiate). Janus-form cells and quadradiate (four-sided) species are moderately common, but the *Staurodesmus* species described in this guide will be predominately biradiate or triradiate.

Staurodesmus bulnheimii semi-cells are biradiate in cross-section and elliptical or broadly rectangular in outline (Figures 23.1–23.4). The sinus is closed near the isthmus, but opens slightly near the margin of the cell. The apex is convex, with long, divergent, subapical spines. The cell surface is exceptionally smooth, with a few scattered mucilage pores that are visible in SEM images (Figures 23.3–23.4).

Staurodesmus connatus semi-cells are triradiate in cross-section and bowl-shaped in outline, with a flat or slightly convex apex and strongly curved lateral margin (Figures 23.5–23.7). The sinus is open to the isthmus; the spines are long and either vertical or slightly divergent. The lobe surfaces contain concentric rings of mucilage pores that are visible in the SEM images (Figures 23.6–23.7). *Staurodesmus connatus* is somewhat similar to *Staurodesmus dejectus* (Figure 23.20), which has a more strongly concave apex and distinctly divergent spines.

Staurodesmus convergens semi-cells are biradiate in cross-section and broadly fusiform or elliptical in outline (Figures 23.8–23.11). The spines are convergent and located about half way down the lateral margin. The sinus is closed near the isthmus but open for most of its length. The cell wall is smooth except for numerous evenly spaced mucilage pores (Figure 23.9). *Staurodesmus convergens* is morphologically variable, especially with respect to the length, position, and angle of spine deflection. It is common to see semi-cells missing one or more of the lateral spines, and the spines may be absent or only partially developed in specimens collected in the same samples (Figure 23.11). This species resembles *Staurodesmus dickiei* (Figure 23.26), which is triradiate in cross-section.

Staurastrum* cf. *cuspidatus semi-cells are triradiate, broadly triangular, fusiform, or elliptical, with an elongated isthmus that has parallel lateral margins (Figures 23.12–23.16). The apex is slightly convex or nearly flat. The spines are usually divergent, but can also be divergent or horizontal. The semi-cell lobes are broadly

[59] Note, however, that *Staurodesmus octocornis* has trapezoidal semi-cells, with four angles per semi-cell, each with a single spine.

rounded so the base of the spines are narrower than the apical angle at the point of insertion. The surface of the semi-cell is smooth, but SEM images reveal rings of small mucilage pores or rounded mucilage plugs at the end of each angle (point of spine insertion) and a triangular patch at the apex (Figures 23.13–23.14). The distribution of these mucilage pores seems to be consistent for the species because the same patterns were present on all of the SEM images (Figure 23.14). With its elongated isthmus, this species should be simple to identify, but it is highly polymorphic, with many of the forms having been given separate species or variety names. The specimens in Figure 23.15, for example, resemble *Staurodesmus mamillatus* (Nordstedt) Teiling, with strongly convergent spines that extend from an inflated or capitate marginal angle. *Staurodesmus mamillatus* is currently considered a synonym for *Staurodesmus cuspidatus*.[60] *Staurodesmus* cf. *cuspidatus* is also very similar to *Staurodesmus cuspidicurvatus*, which has stout spines with a wider base that merges smoothly at the point of attachment to the semi-cell body (see comparison in Figure 23.16).

Staurodesmus cuspidicurvatus is characterized by wide, triangular semi-cells that are triradiate in cross-section (Figures 23.17–23.19). The apex can be flat, slightly concave, or slightly convex. The lateral angles extend in a straight line into the robust, divergent spines, which, at the point of insertion, are approximately equal in width to the semi-cell apical angle. The cells often have an elongated isthmus, making this species difficult to distinguish from *Staurodesmus cuspidatus*; *Staurodesmus cuspidicurvatus* will have robust spines and a more triangular semi-cell outline (see comparison in Figure 23.16). Another possible difference, which is only visible using SEM (Figure 23.18), is that *Staurodesmus cuspidicurvatus* does not appear to have the same pattern of mucilage pore ornamentation that was visible on the *Staurodesmus cuspidatus* SEM images (Figures 23.13–23.14). Only one SEM image is available for *Staurodesmus cuspidicurvatus* (Figure 23.18), so this difference can't be confirmed.

Staurodesmus dejectus semi-cells are triradiate and range from triangular or bowl-shaped, with a nearly flat or slightly domed apex, to broadly crescent-shaped, with a concave apex (Figures 23.20–23.22). The lateral margins are straight (or slightly convex) from the sinus to just below the apical spines. The spines are upwardly divergent, moderately long, and merge smoothly with the acute apical angles. The sinus is open to the isthmus and specimens with a slightly elongated isthmus are common. As a result, this species can be difficult to separate from *Staurodesmus cuspidicurvatus* and similar species described above. The SEM images reveal faint

[60] Guiry and Guiry, 2023

concentric rings of mucilage pores or rounded mucilage plugs at the base of each lobe (Figure 23.21). ***Staurodesmus dejectus* var. *apiculatus*** has triradiate, bowl-shaped semi-cells with a nearly flat apex and convex lateral margins (Figure 23.23–23.25). The apical spines are relatively short and more upwardly directed than the nominate variety.[61] The SEM image in Figure 23.24 reveals a faint mucilage pore pattern similar to that observed for *Staurodesmus dejectus* in Figure 23.21. *Staurodesmus dejectus* var. *apiculatus* is similar in appearance to *Staurodesmus patens* (Figure 23.65), which is slightly smaller and has elliptical semi-cells with a convex apex.

Staurodesmus dickiei semi-cells are triradiate and lens-shaped or elliptical in outline (Figures 23.26–23.30). Except in some varieties, the sinus open over most of its length. The apex may be slightly flattened or convex. The spines are convergent, originating from the lateral angles, and often form a continuous arc with the apical margin. The cell wall is smooth except for numerous, scattered mucilage pores visible in SEM images (Figures 23.27–23.28). The specimens in Figure 23.30 are tentatively identified as *Staurodesmus dickiei*, but the semi-cells are more rounded (elliptical), the spines are shorter, and the sinus is closed except near the margin. The features are within the morphological variation expected within the species, but the samples could represent a different variety than the nominate.[62] *Staurodesmus dickiei* resembles *Staurodesmus convergens* (Figure 23.8), which is biradiate. ***Staurodesmus dickiei* var. *circularis*** is an easily recognized variety characterized by nearly hemispherical semi-cells (circular cells) with short, tooth-like, convergent spines (Figures 23.31–23.32). The sinus is closed except near the margin. The specimen in Figure 23.33 is tentatively identified as *Staurodesmus dickiei* var. *circularis*, but the cells are atypical, with a more open sinus and more strongly compressed semi-cells than expected for this variety.

Staurodesmus extensus semi-cells are small, biradiate, and trapezoidal in outline (Figures 23.34–23.43). The isthmus is elongated, with nearly parallel sides. The apex may be nearly flat or slightly concave, and the spines may be divergent or horizontal, depending on the variety. The cell wall is smooth except for a few scattered mucilage pores. Several varieties of *Staurodesmus extensus* were present in the northwest Washington samples. All of the varieties have trapezoidal semi-cells; the most distinctive separation features were variations in spine length and orientation. ***Staurodesmus extensus* var. *extensus*** has relatively long cells (L≥W, excluding spines) with slender, divergent spines that are slightly

[61] *Staurodesmus dejectus* var. *dejectus*
[62] *Staurodesmus dickiei* var. *dickiei*

shorter than the width of the semi-cell (Figures 23.34–23.35). ***Staurodesmus extensus* var. *isthmosus*** cells are more compact, with short, robust, horizontal or divergent spines (Figures 23.36–23.38). ***Staurodesmus extensus* var. *joshuae*** is characterized by large, robust cells with long, horizontal spines that are approximately the same length as the semi-cell width (Figures 23.39–23.41). ***Staurodesmus extensus* cf. var. *rectus*** is characterized by small cells with short, robust, horizontal or convergent spines (Figures 23.42–23.43). These specimens resemble *Staurodesmus extensus* var. *isthmosus* (see above), but have slightly recurved apical angles, a feature that was apparent in the *Staurodesmus extensus* var. *isthmosus* specimens.

Staurodesmus glaber semi-cells are triradiate (biradiate for some varieties) and triangular or broadly hexagonal in outline, with a deep, open sinus (Figures 23.44–23.48). The spines are usually convergent but may be nearly parallel in some specimens. The nominate variety[63] has broadly triangular semi-cells with a slightly concave apex and long, convergent spines (Figures 23.44–23.46). The SEM image shows concentric rings of mucilage pores circling the isthmus and base of each arm (Figure 23.45). Several varieties of *Staurodesmus glaber* were present in the northwest Washington samples, including both triradiate and biradiate taxa. ***Staurodesmus glaber* var. *hirundinella*** semi-cells are small, triradiate, and have a distinctly concave apex, and strongly convergent, tooth-like spines (Figures 23.47–23.48). ***Staurodesmus glaber* var. A** semi-cells are biradiate and irregularly hexagonal in outline, with long spines that are so strongly convergent that they nearly touch (Figures 23.49–23.50). The apical and lateral margins are somewhat irregular (wavy) and the apical angles are slightly recurved at the base of the spines. These specimens resemble a variety that was originally listed as *Arthrodesmus incus* f. *brebissonii* Raciborski, then renamed *Staurodesmus glabrus* subsp. *brebissonii* (Raciborski) Teiling, and finally merged as a synonym for *Staurodesmus glaber*.[64] These specimens were separated from *Staurodesmus glaber* because of the unusual hexagonal shape of the semi-cells. ***Staurodesmus glaber* var. B** semi-cells are small, triradiate, broadly triangular or elliptical in outline, with a slightly convex apex (Figures 23.51–23.53). The lateral margin is straight or slightly convex and often recurved at the base of the spines. The spines short, strongly convergent, and thickened at the base. All of the northwest Washington specimens were collected in shallow, slightly acidic high elevation ponds or lakes, so they may be an undescribed variety.

[63] *Staurodesmus glaber* var. *glaber*
[64] Guiry and Guiry, 2023

Staurodesmus incus semi-cells are small, biradiate, and triangular or cup-shaped, with very long, divergent spines and a nearly flat apex (Figures 23.54–23.57). The sinus is moderately deep and open and the isthmus may be slightly elongated but will not have a center section with parallel sides. The cell wall is smooth except for a few scattered mucilage pores (Figure 23.55). *Staurodesmus incus* resembles *Staurodesmus extensus*, which will have trapezoidal semi-cells and a distinctly elongated isthmus with parallel sides; and *Staurodesmus triangularis*, which will have horizontal or convergent spines and a slightly convex apex (see comparison in Figure 23.57). *Staurodesmus incus* is often planktonic and may form blooms.

Staurodesmus megacanthus semi-cell are triradiate and triangular or elliptical in outline, with a deep, open sinus, and a very slightly convex lateral margin (Figures 23.58–23.59). The apex is flat or slightly convex, with acute angles that merge without narrowing into long, stout, nearly horizontal spines. The most distinctive feature of this species is its large size, with a median semi-cell width (including spines) for specimens from northwest Washington of 72.8 μm. This species resembles *Staurodesmus glaber* (Figure 23.44), which can be distinguished by its slightly smaller size. The species identification is somewhat uncertain because only a few specimens were collected for analysis and some varieties of *Staurodesmus glaber* can be nearly as large as *Staurodesmus megacanthus*.

Staurodesmus octocornis cells are small, approximately rectangular in outline, and strongly flattened (Figures 23.60–23.62). The semi-cells are trapezoidal, with a concave apex, a broad sinus with parallel sides, and four long, stout spines on the outer marginal angles of each semi-cell. This species will be listed in most taxonomic guides as ***Xanthidium octocorne***, but genetic analyses by Šťastný, et al. (2013) indicated a closer relationship to the genus *Staurodesmus*.

Staurodesmus omearae semi-cells are small, triradiate (sometimes biradiate) and broadly cup-shaped or wedge-shaped in outline, with a deep, open sinus (Figures 23.63–23.64). The apex is concave, and extends into stout, divergent spines that merge smoothly with the apical angles, forming straight line from the lateral margins. Although *Staurodesmus omearae* is reported to have both biradiate and triradiate semi-cells (Coesel and Meesters, 2013), only triradiate forms were collected in the northwest Washington samples. *Staurodesmus omearae* resembles *Staurodesmus phimus*, which is similar in size, but is usually biradiate, with short, tooth-like spines (Figure 23.68). *Staurodesmus omearae* is very similar to *Staurodesmus pterosporus* (no image available), which has shorter spines that transition more abruptly into the apical angles.

Staurodesmus patens semi-cells are small, bowl-shaped or elliptical, with a convex apex and widely open sinus (Figures 23.65–23.67) The spines are short and slightly divergent or vertical. *Staurodesmus patens* closely resembles *Staurodesmus dejectus* var. *apiculatus*, which has a flat or slightly concave apex and distinctly bowl-shaped semi-cells (Figure 23.23). Not surprisingly, a synonym for *Staurodesmus patens* is *Staurastrum dejectus* var. *patens* Nordstedt. This species is often planktonic and occasionally form blooms (Figure 23.67).

Staurodesmus phimus semi-cells are small, biradiate, crescent-shaped or triangular in outline, with an widely open sinus (Figures 23.68–23.69). The apex is concave or nearly flat, with short, tooth-like, divergent spines on the angles. All of the northwest Washington specimens were twisted so that the semi-cells were in different planes. *Staurodesmus phimus* resembles *Staurodesmus omearae* (Figure 23.63), which can be distinguished by its longer spines and (usually) triradiate semi-cells.

Staurodesmus semilunaris semi-cells are biradiate and crescent-shaped, with a concave apex and widely open sinus (Figures 23.70–23.72). The long, divergent spines form a continuous arc with the concave apex. The cell surface is smooth except for scattered mucilage pores or mucilage plugs (Figures 23.71–23.72). *Staurodesmus semilunaris* resembles *Staurodesmus omearae* (Figure 23.63), which is usually triradiate; and *Staurodesmus phimus* (Figure 23.68), which is smaller and has much shorter spines. *Staurodesmus semilunaris* was common in plankton samples from large, soft water, oligo-mesotrophic, low elevation northwest Washington lakes.

Staurodesmus subquadratus semi-cells are biradiate and trapezoidal or rectangular in outline, with a shallow sinus, slightly convex apex and lateral margins, and short, divergent spines (Figures 23.73–23.75). Numerous specimens of this tiny *Staurodesmus* were collected in a small, boggy snow-melt pond along the trail to Lake Ann in the Mt. Baker Recreational Area. The SEM image reveals that the surface is covered with tiny mucilage pores or rounded mucilage plugs.

Staurodesmus triangularis semi-cells are biradiate and triangular or slightly hexagonal in outline, with a flat or slightly convex apex, and long, horizontal spines (Figures 23.76–23.78). The sinus is deep and open, often with a slightly elongated isthmus. Specimens with slightly hexagonal semi-cells may resemble *Staurodesmus extensus* (Figure 23.34), but will not have a greatly elongated isthmus with parallel sides. *Staurodesmus triangularis* closely resembles *Staurodesmus incus*, which has upwardly directed (divergent) spines (see comparison in Figure

23.57). ***Staurodesmus triangularis* var. *brevispina*** is a common variety found in many lakes along the Mt. Loop Highway in the North Cascades. The semi-cells are triangular or slightly hexagonal, a nearly flat apex (Figures 23.79–23.81). The variety is distinguished by having shorter spines (spines are usually less than $\frac{2}{3}$ width of the semi-cell; Coesel and Meesters, 2013). The spines can be nearly horizontal, but all of the northwest Washington specimens had convergent spines.

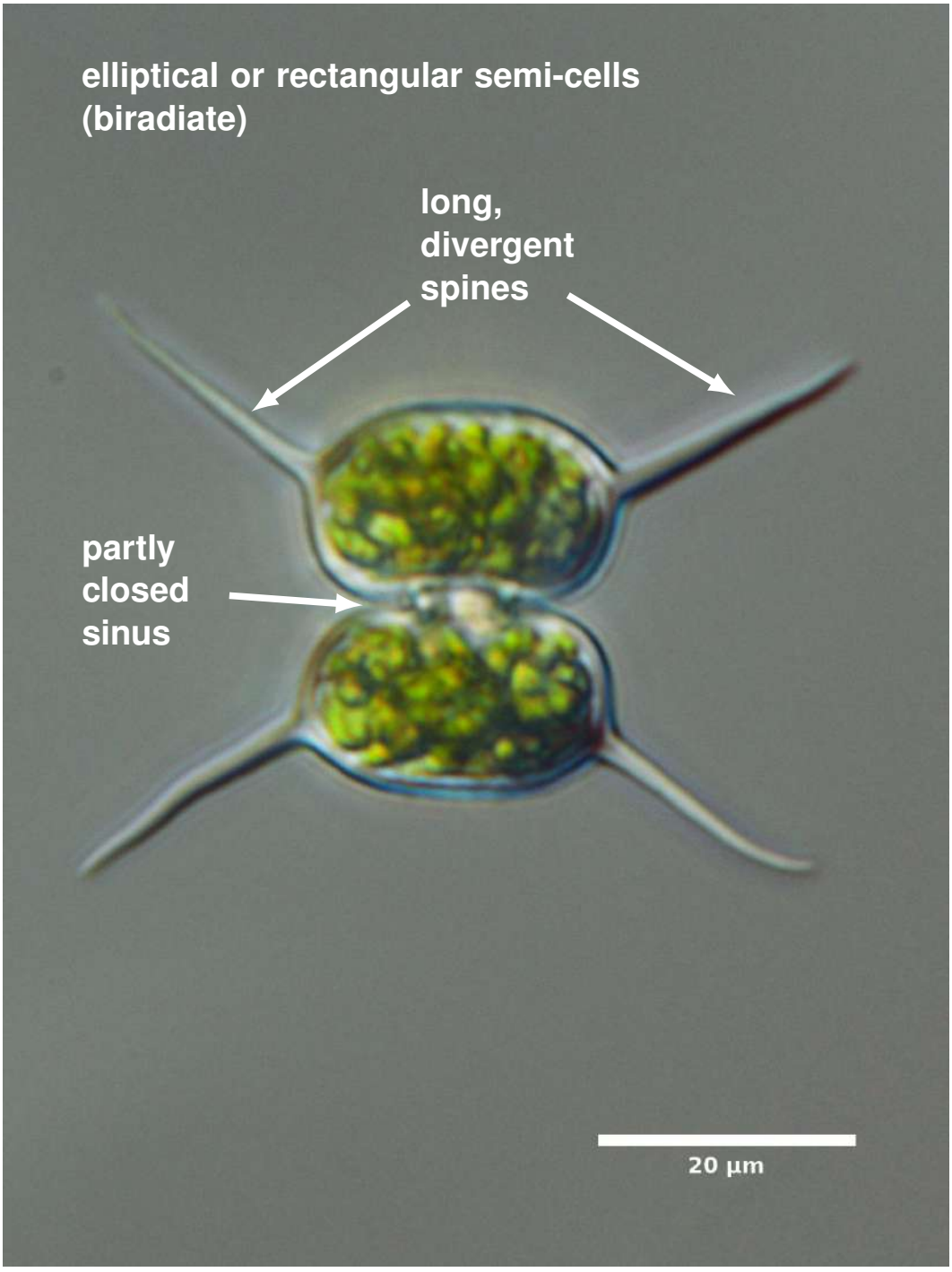
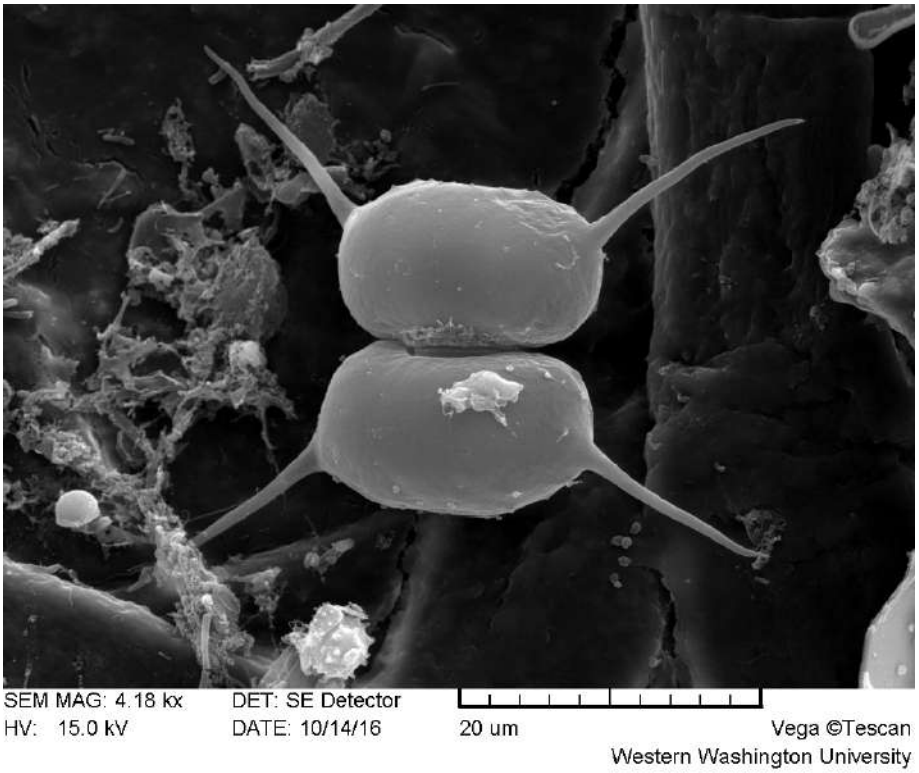


Figure 23.1: *Staurodesmus bulnheimii* (DIC), Bear Lake, Mountain Loop Highway, Snohomish County.



Figure 23.2: *Staurodesmus bulnheimii* (DIC), Bear Lake, Mountain Loop Highway, Snohomish County.



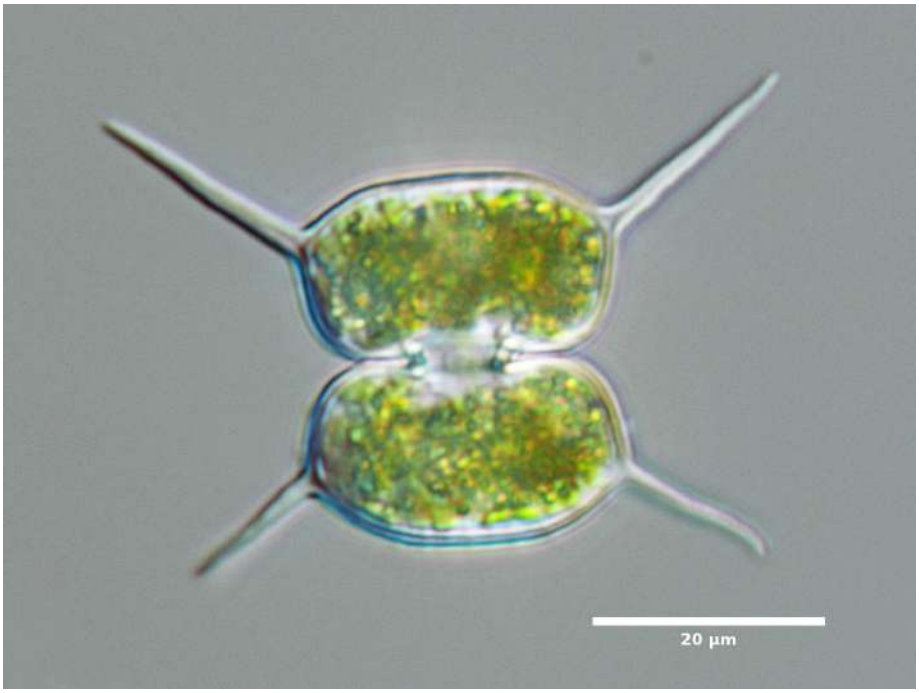


Figure 23.3: *Staurodesmus bulnheimii* (SEM/DIC), Bear Lake, Mountain Loop Highway, Snohomish County (upper/lower images).

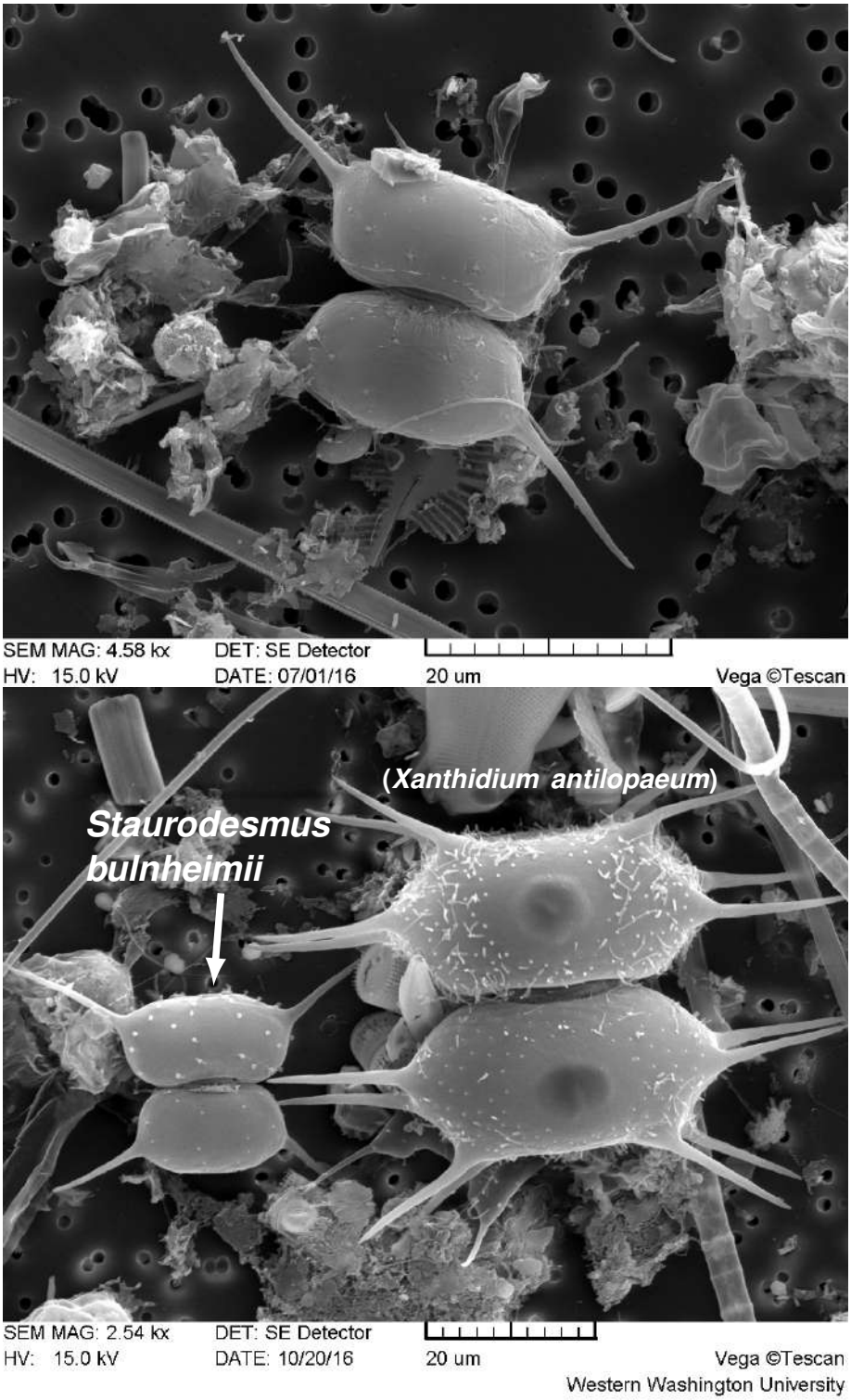


Figure 23.4: *Staurodesmus bulnheimii* (SEM/SEM), Goat Lake, Mountain Loop Highway, Snohomish County (upper image); Bear Lake, Mountain Loop Highway, Snohomish County (lower image). Note size difference compared to *Xanthidium antilopaeum* in lower image.

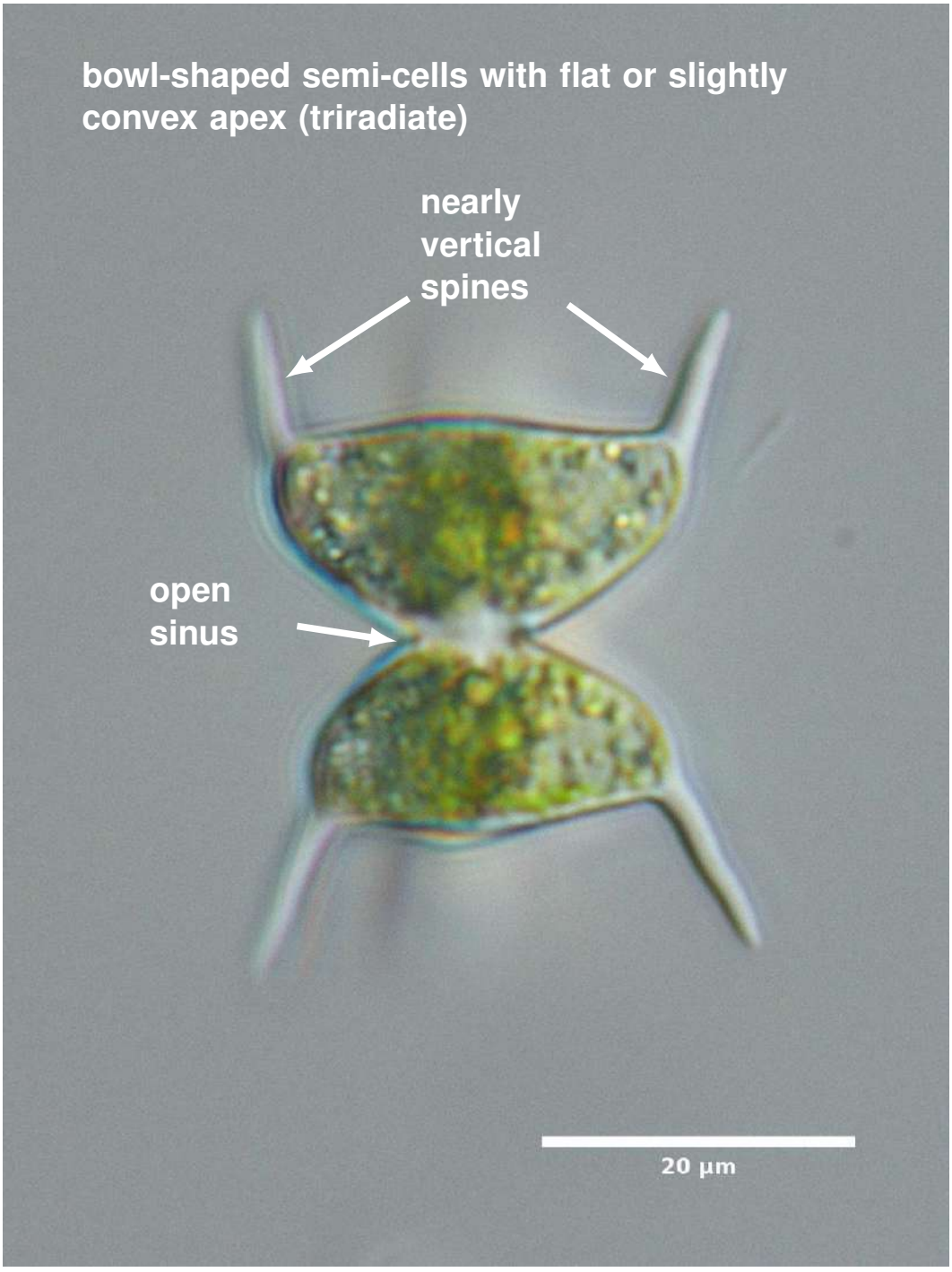


Figure 23.5: *Staurodesmus connatus* (DIC), Bear Lake, Mountain Loop Highway, Snohomish County.

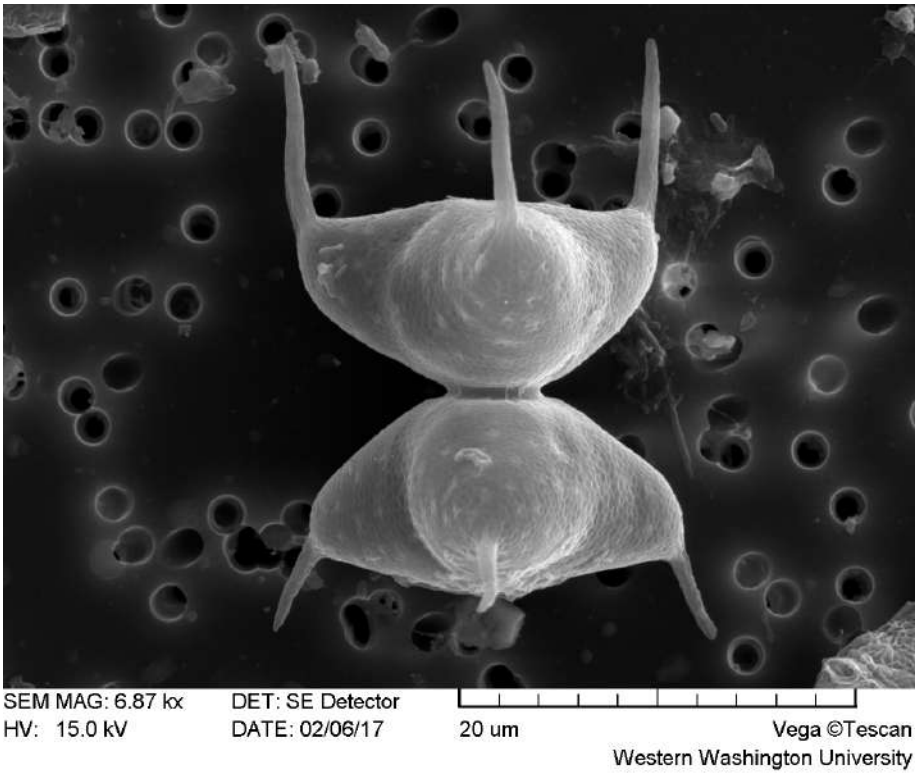




Figure 23.6: *Staurodesmus connatus* (SEM/DIC), Bear Lake, Mountain Loop Highway, Snohomish County (upper/lower images).

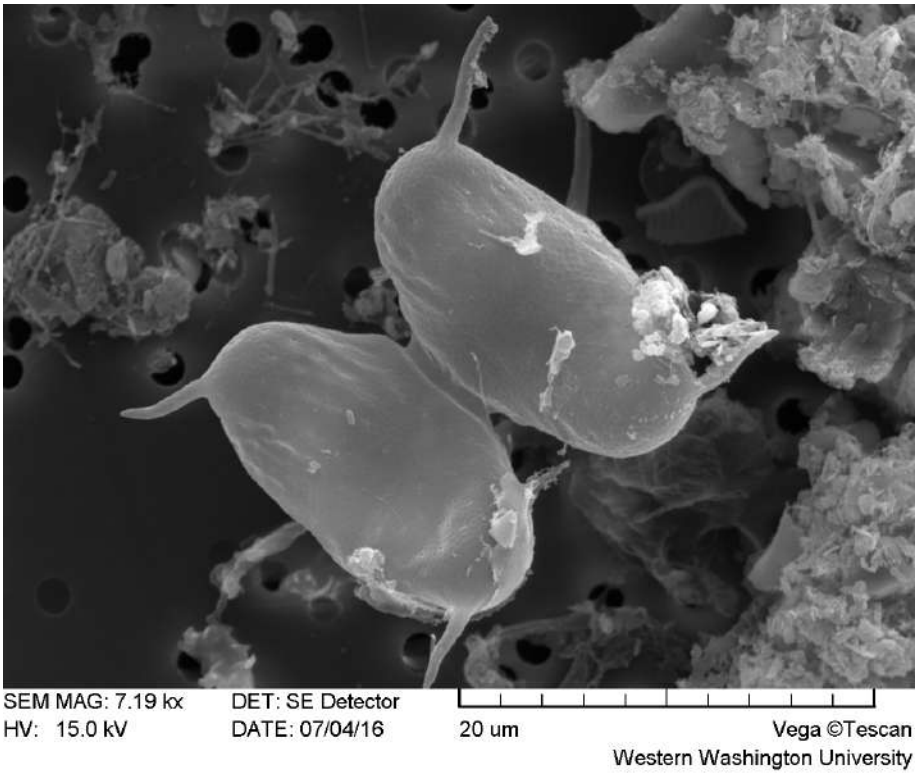




Figure 23.7: *Staurodesmus connatus* (SEM/DIC), Boardman Lake, Mountain Loop Highway, Snohomish County (upper/lower images).

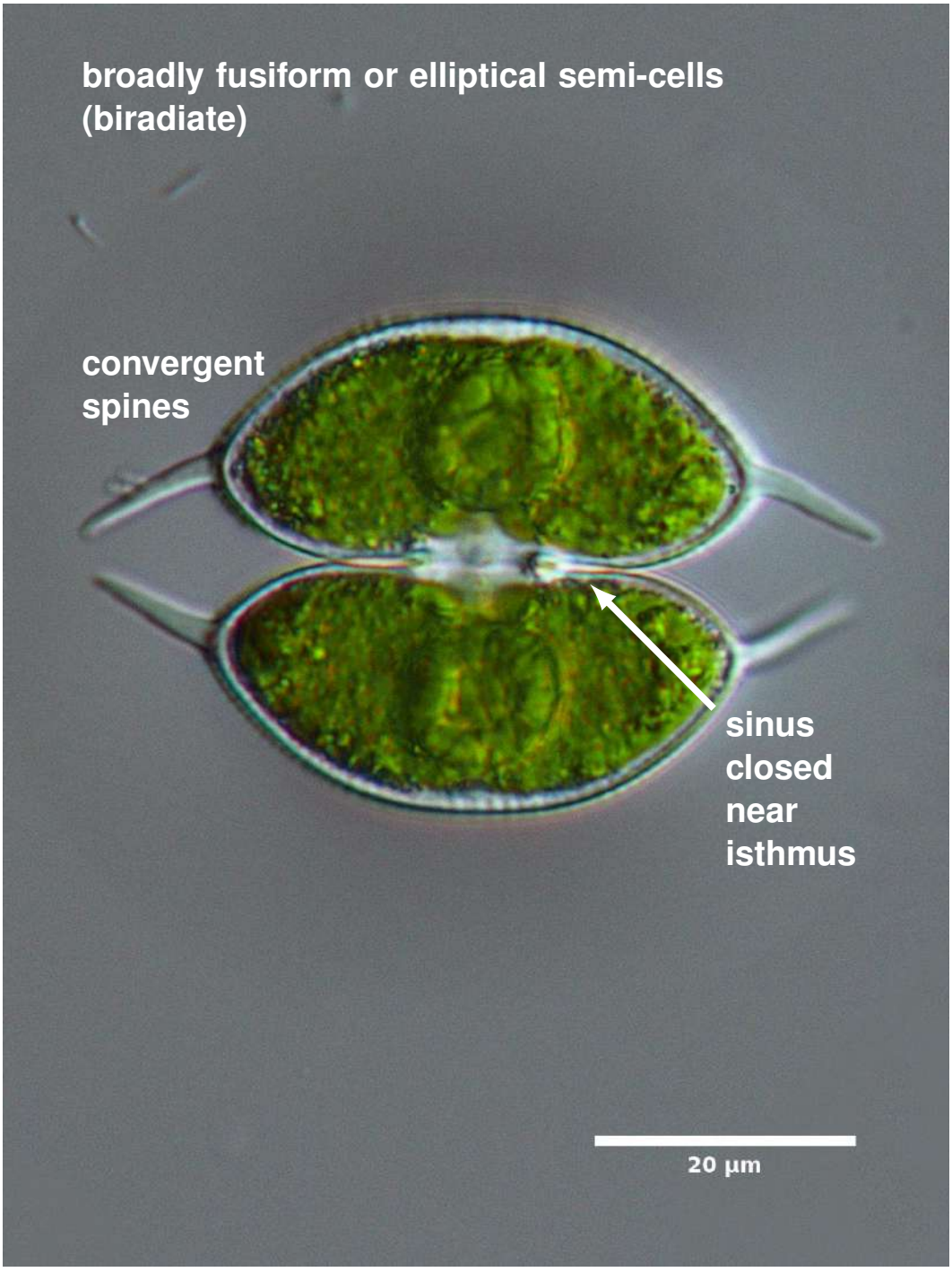


Figure 23.8: *Staurodesmus convergens* (DIC), Myrtle Lake, Mountain Loop Highway, Snohomish County.

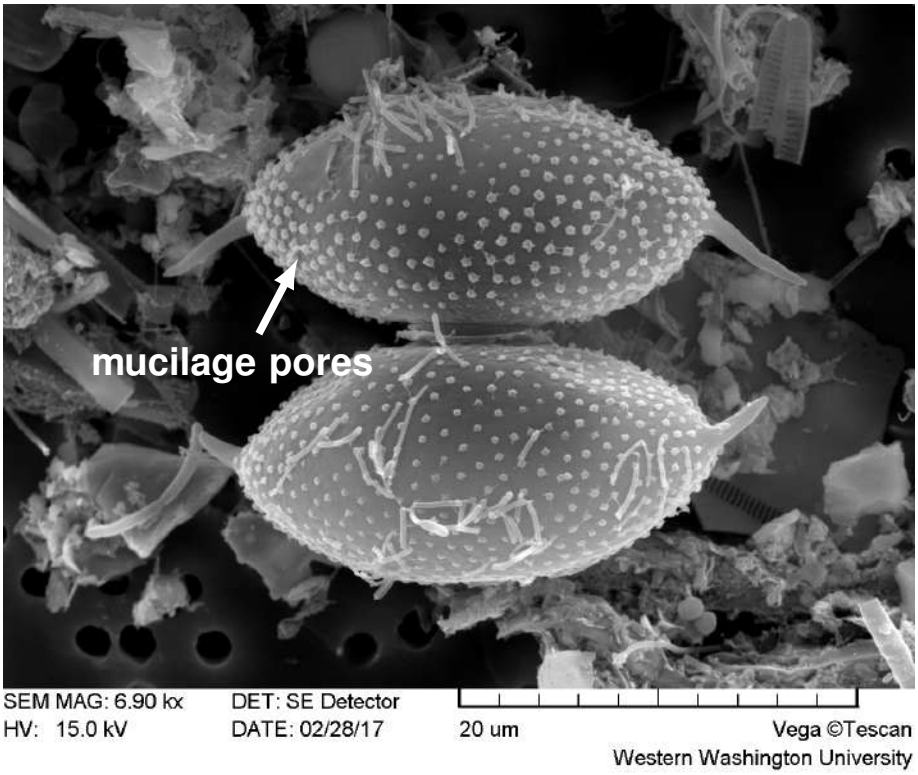




Figure 23.9: *Staurodesmus convergens* (SEM/DIC), Myrtle Lake, Mountain Loop Highway, Snohomish County (upper/lower images).

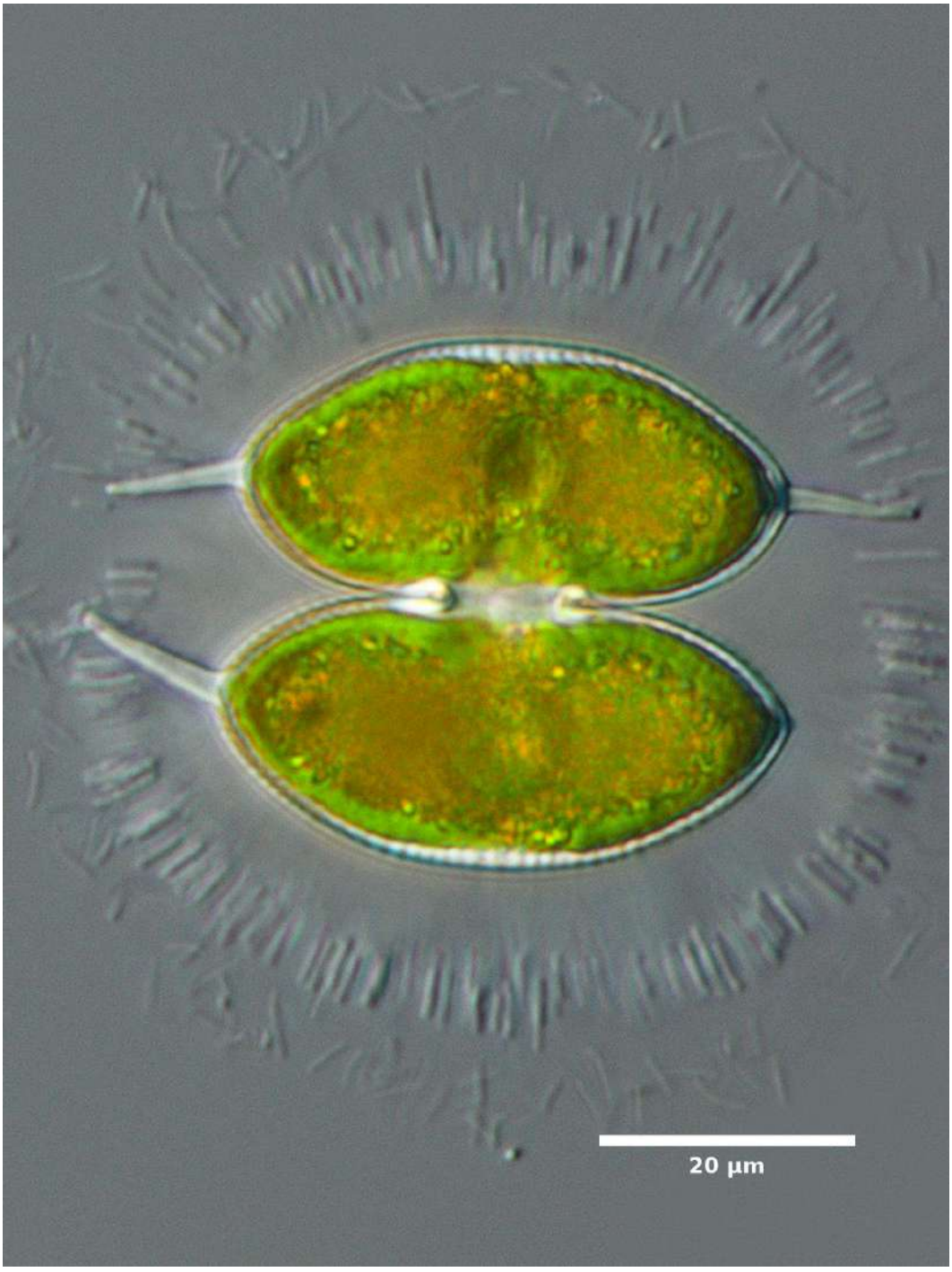


Figure 23.10: *Staurodesmus convergens* (DIC), small pond on trial to Big Four Ice Caves, Mountain Loop Highway, Snohomish County.

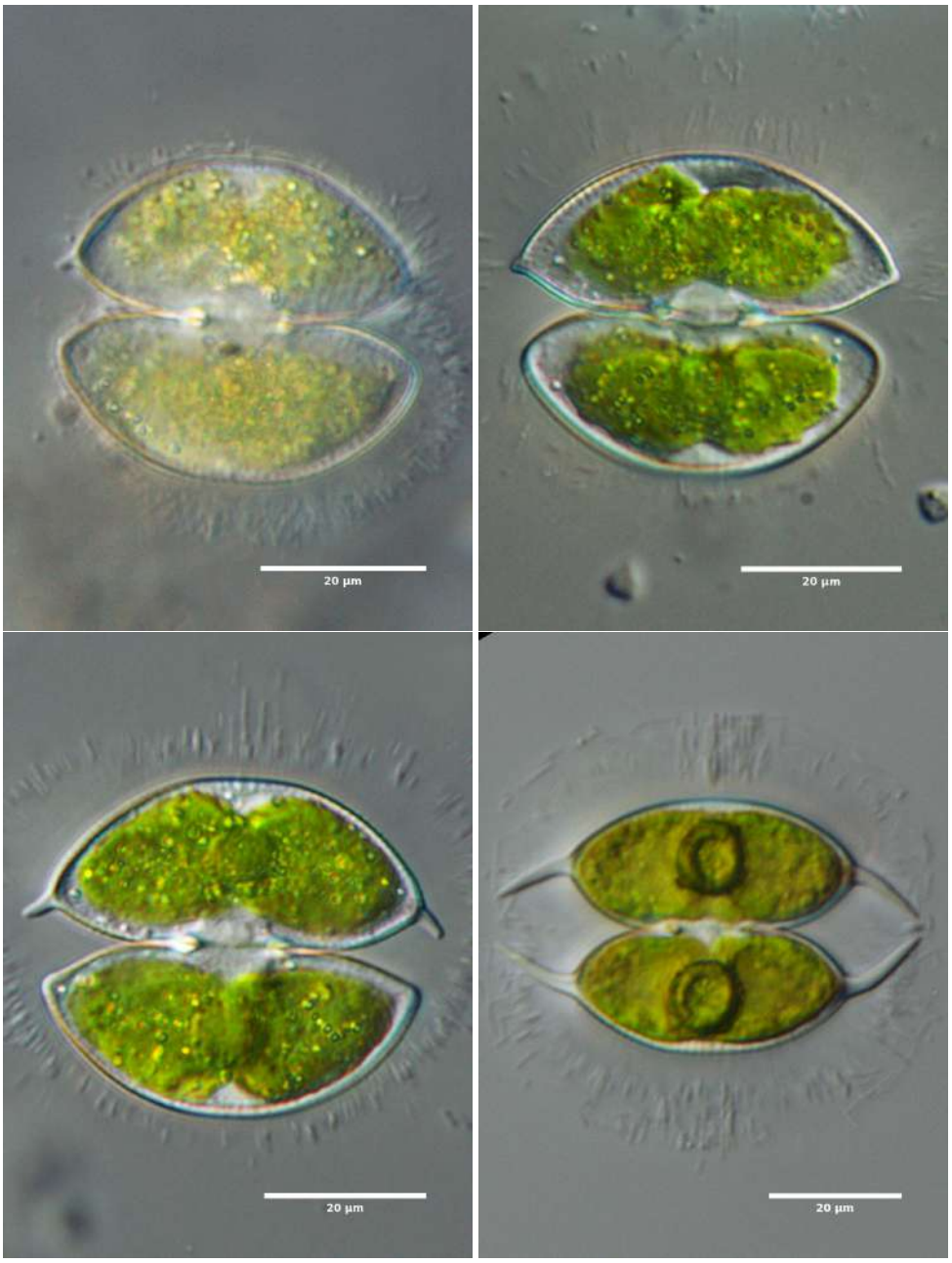


Figure 23.11: *Staurastrum convergens* spines variations (DIC), Lake Geneva, Whatcom County (all images).

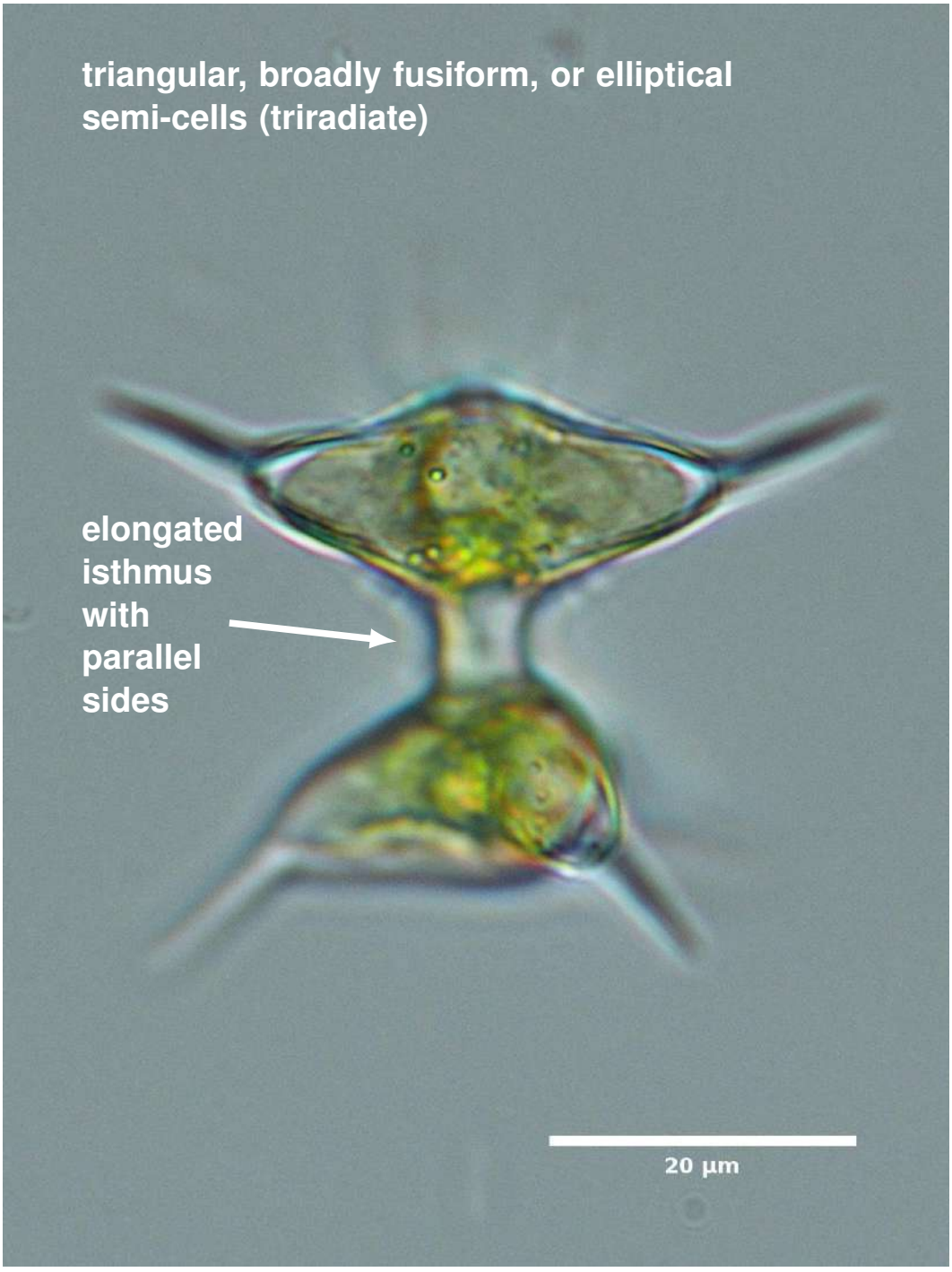
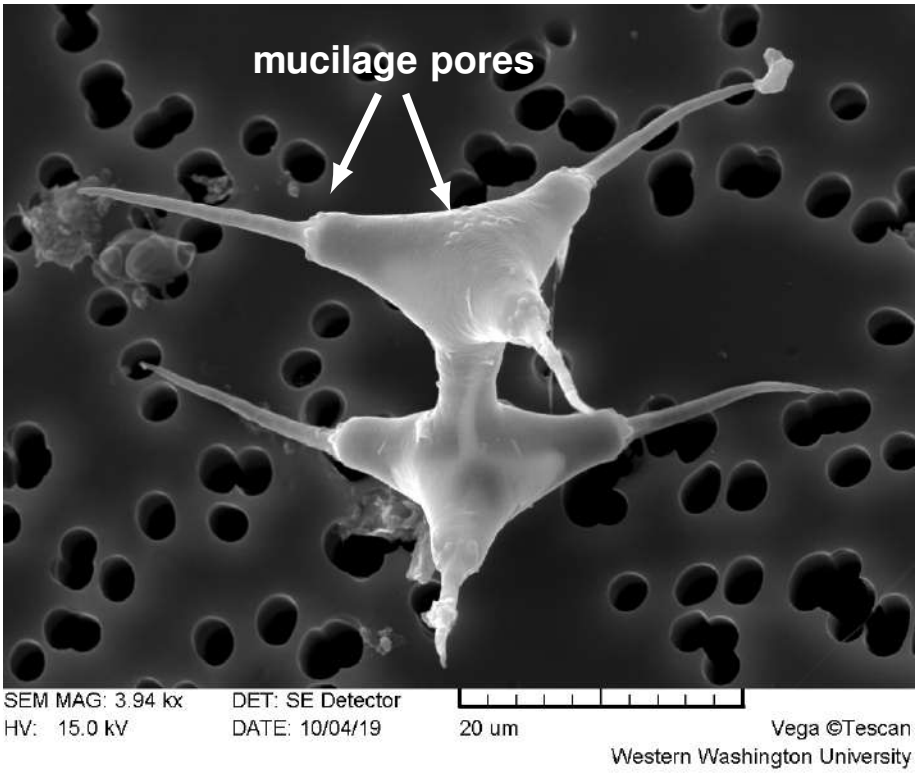


Figure 23.12: *Staurodesmus* cf. *cuspidatus* (DIC), Lake Whatcom, Whatcom County.



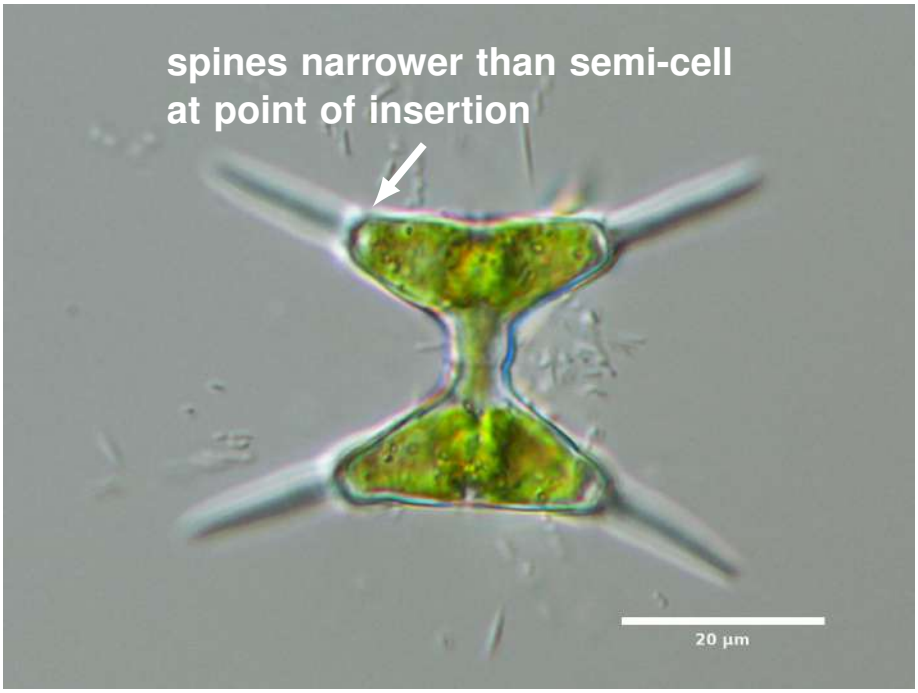


Figure 23.13: *Staurodesmus* cf. *cuspidatus* (SEM/DIC), Big Lake, Skagit County (upper/lower images).

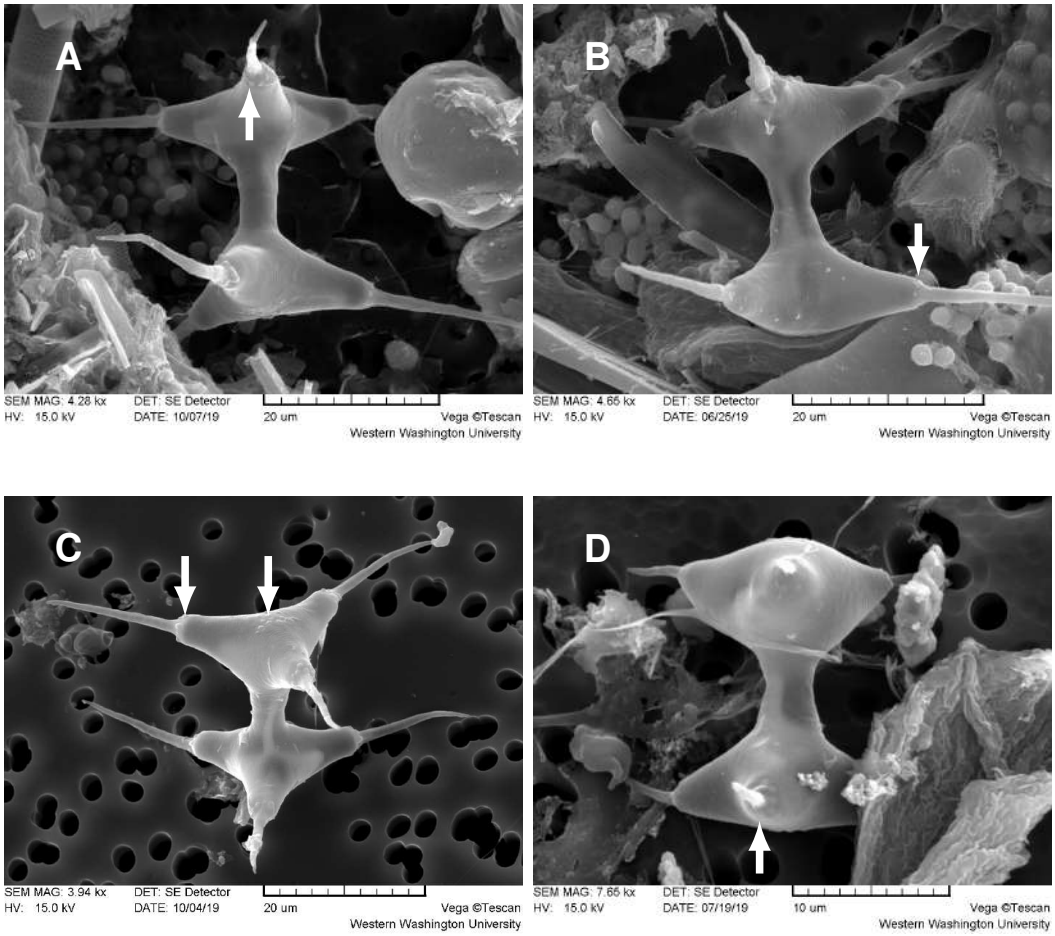


Figure 23.14: *Staurodesmus* cf. *cuspidatus* variations (SEM), A-B: Lake Whatcom, Whatcom County; C: Big Lake, Skagit County; D: small boggy pond along Morris Valley Road near Harrison BC. Note mucilage pore pattern on all cells (arrows).

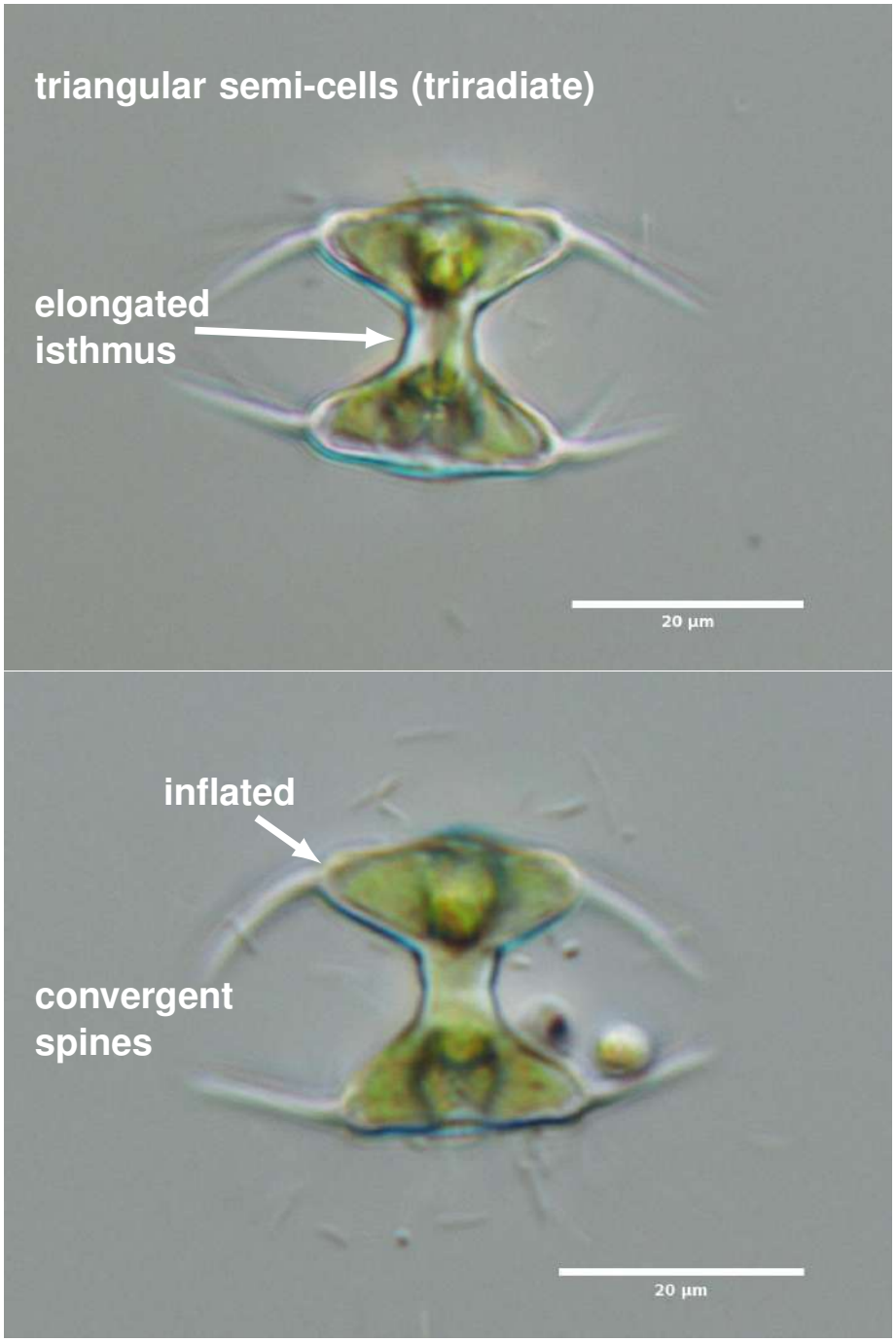


Figure 23.15: *Staurodesmus* cf. *cuspidatus*/*Staurodesmus mamillatus* (DIC/DIC), Beaver Lake, Mountain Loop Highway, Snohomish County (upper/lower images).

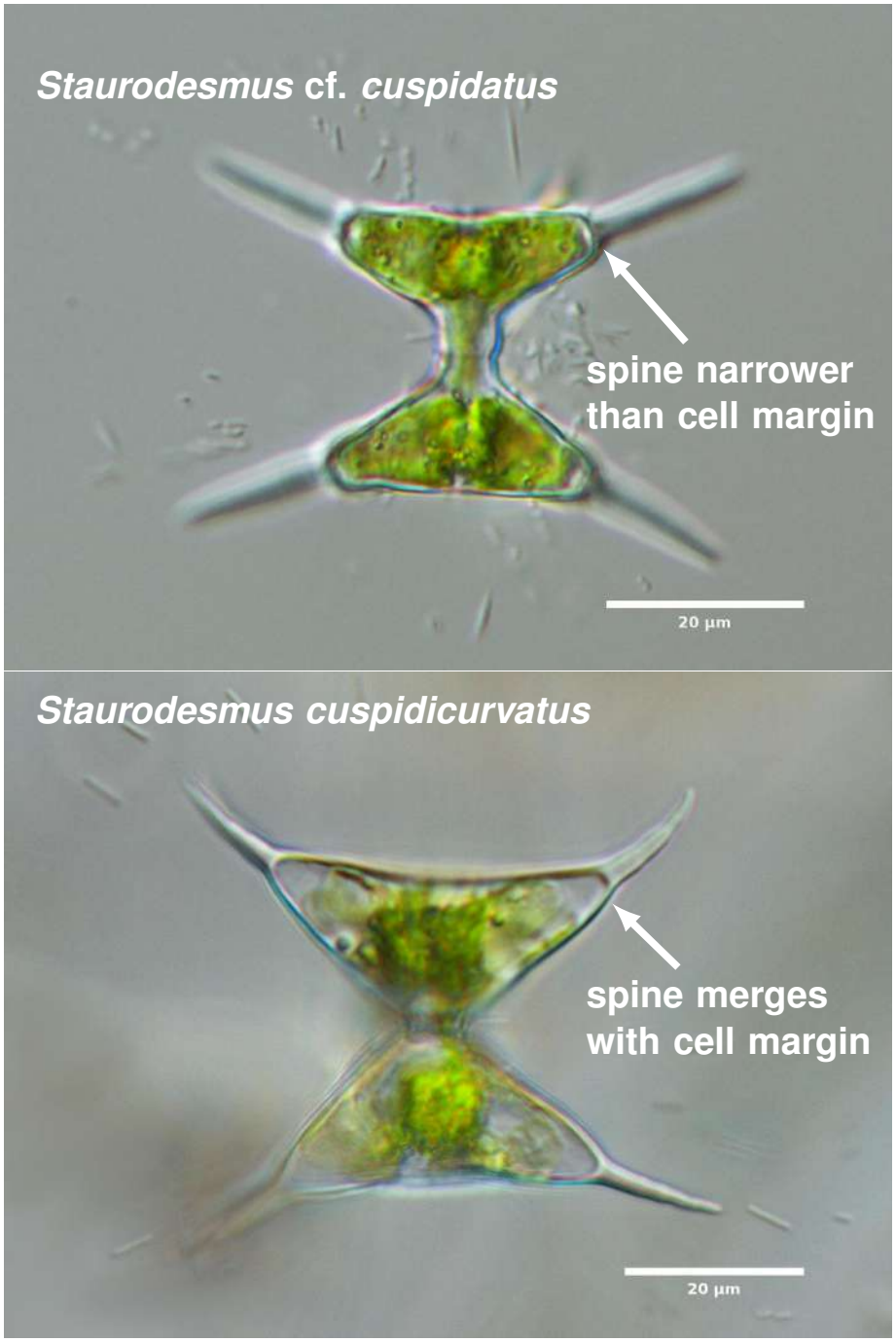


Figure 23.16: *Staurodesmus* cf. *cuspidatus* vs. *Staurodesmus cuspidicurvatus* (DIC/DIC), Big Lake, Skagit County (upper image); Lake Padden, Whatcom County (lower image).

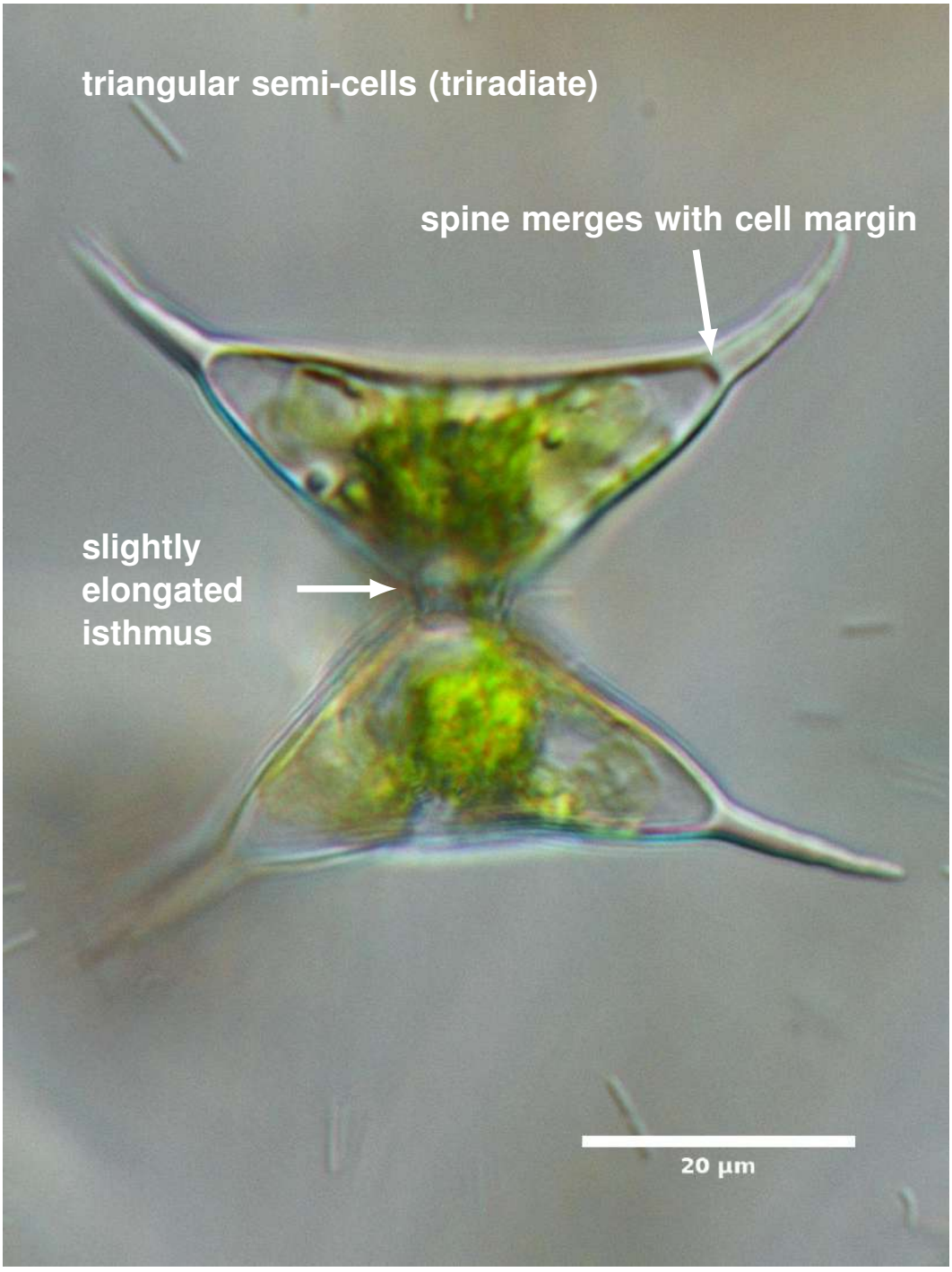
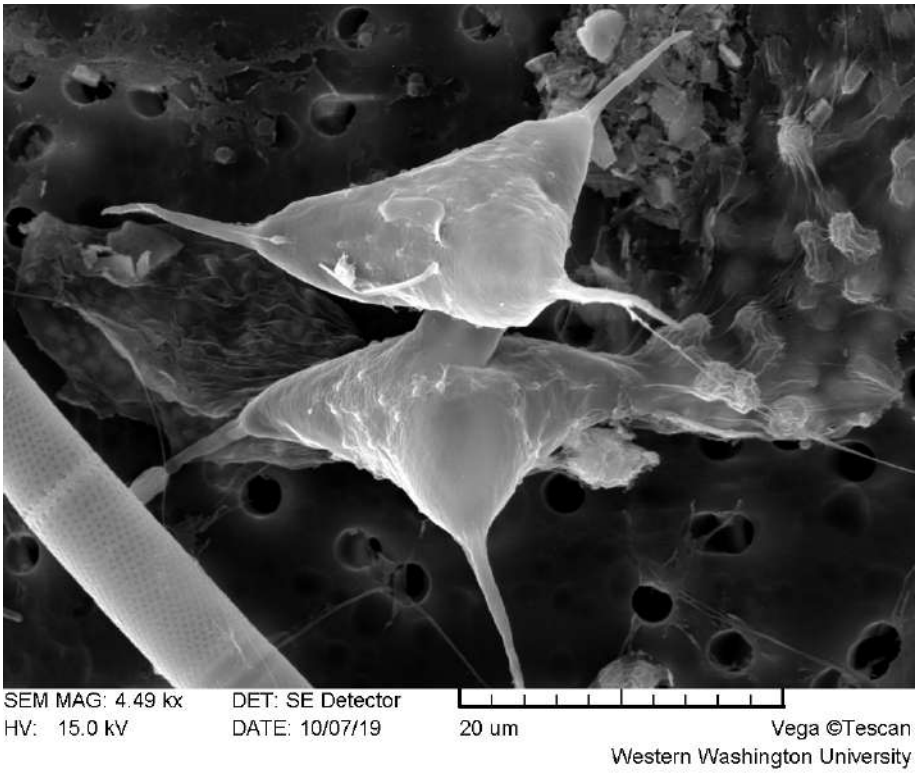


Figure 23.17: *Staurodesmus cuspidicurvatus* (DIC), Lake Padden, Whatcom County.



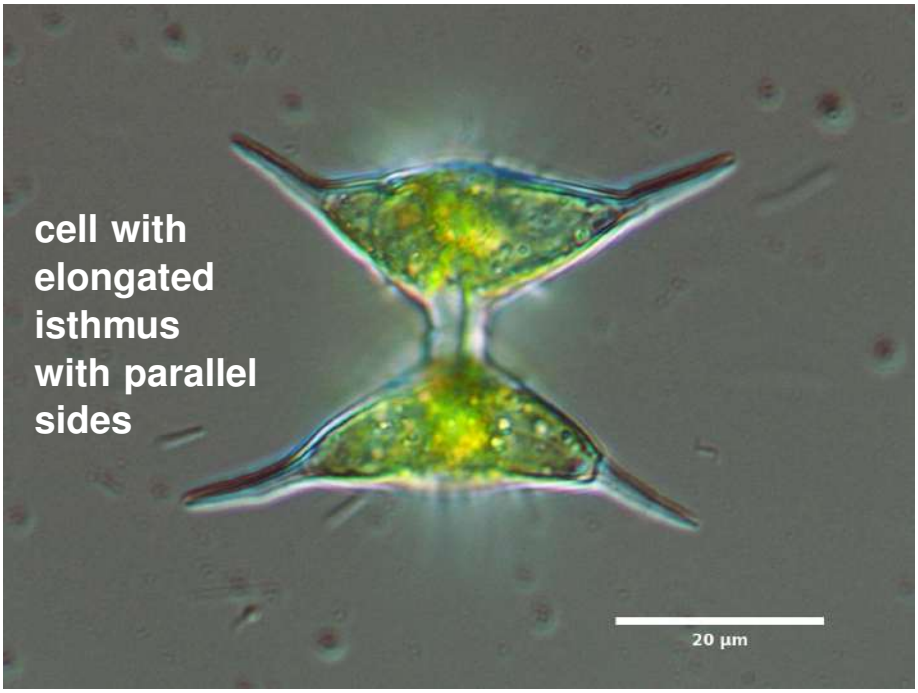


Figure 23.18: *Staurodesmus cuspidicurvatus* (SEM/DIC), Lake Whatcom, Whatcom County (upper/lower images).



Figure 23.19: *Staurodesmus cuspidicurvatus* (DIC/DIC), Lake Samish, Whatcom County (upper image); Squalicum Lake, Whatcom County (lower image).

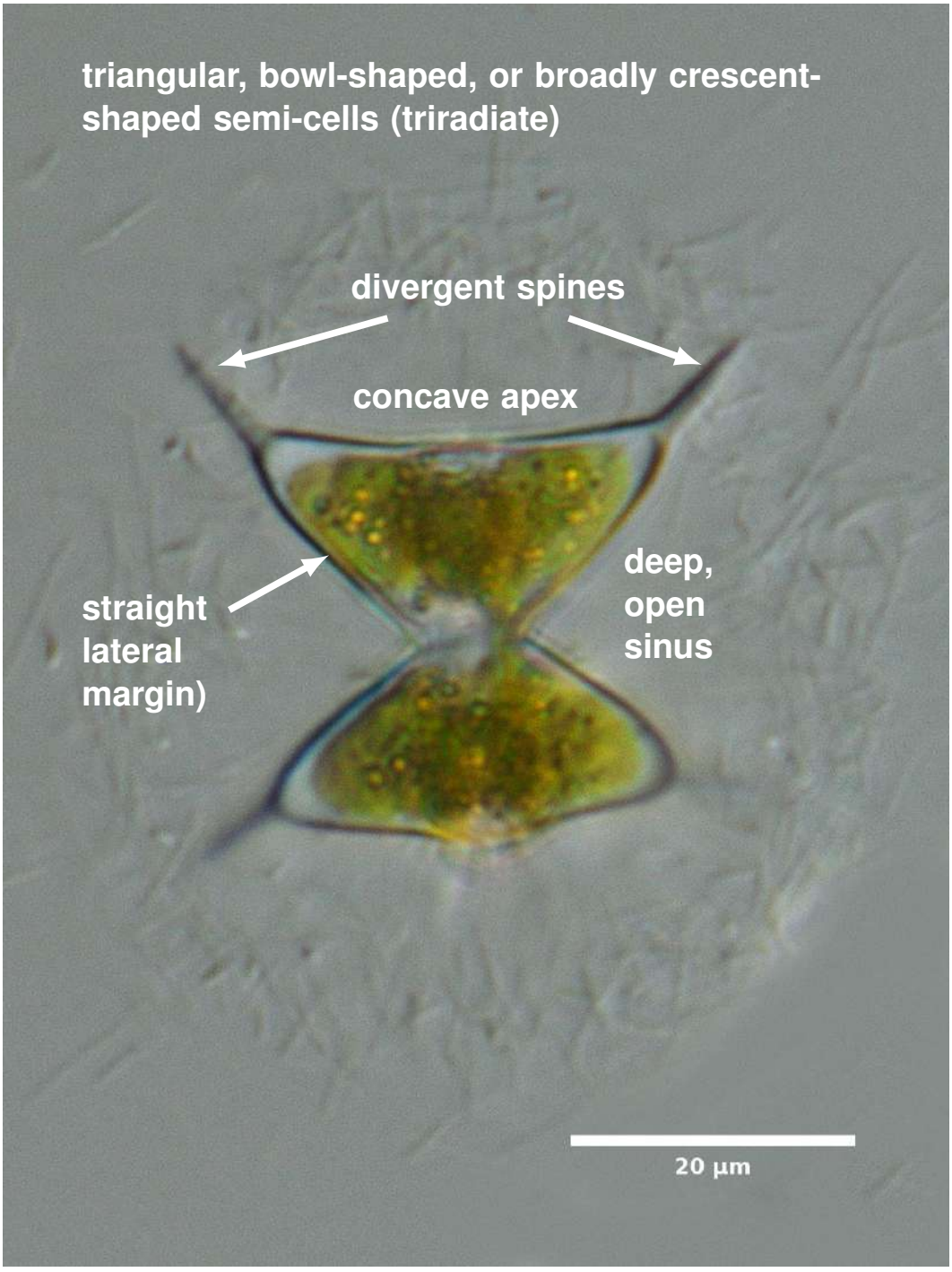


Figure 23.20: *Staurodesmus dejectus* (DIC), Lake Evan, Mountain Loop Highway, Snohomish County.

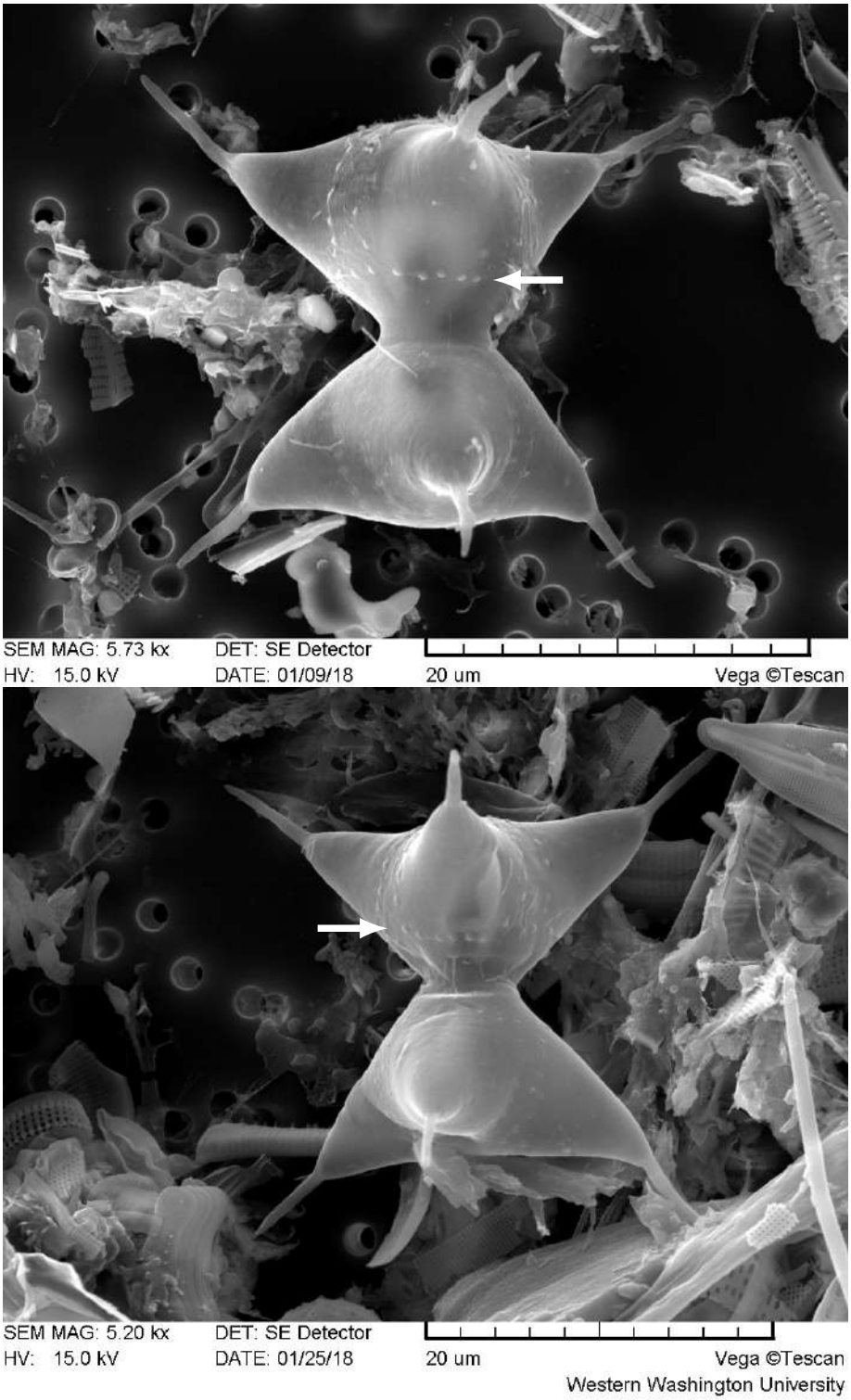


Figure 23.21: *Staurodesmus dejectus* (SEM/SEM), Lake Evan, Mountain Loop Highway, Snohomish County (upper/lower images). Note mucilage pore pattern on all cells (arrows)

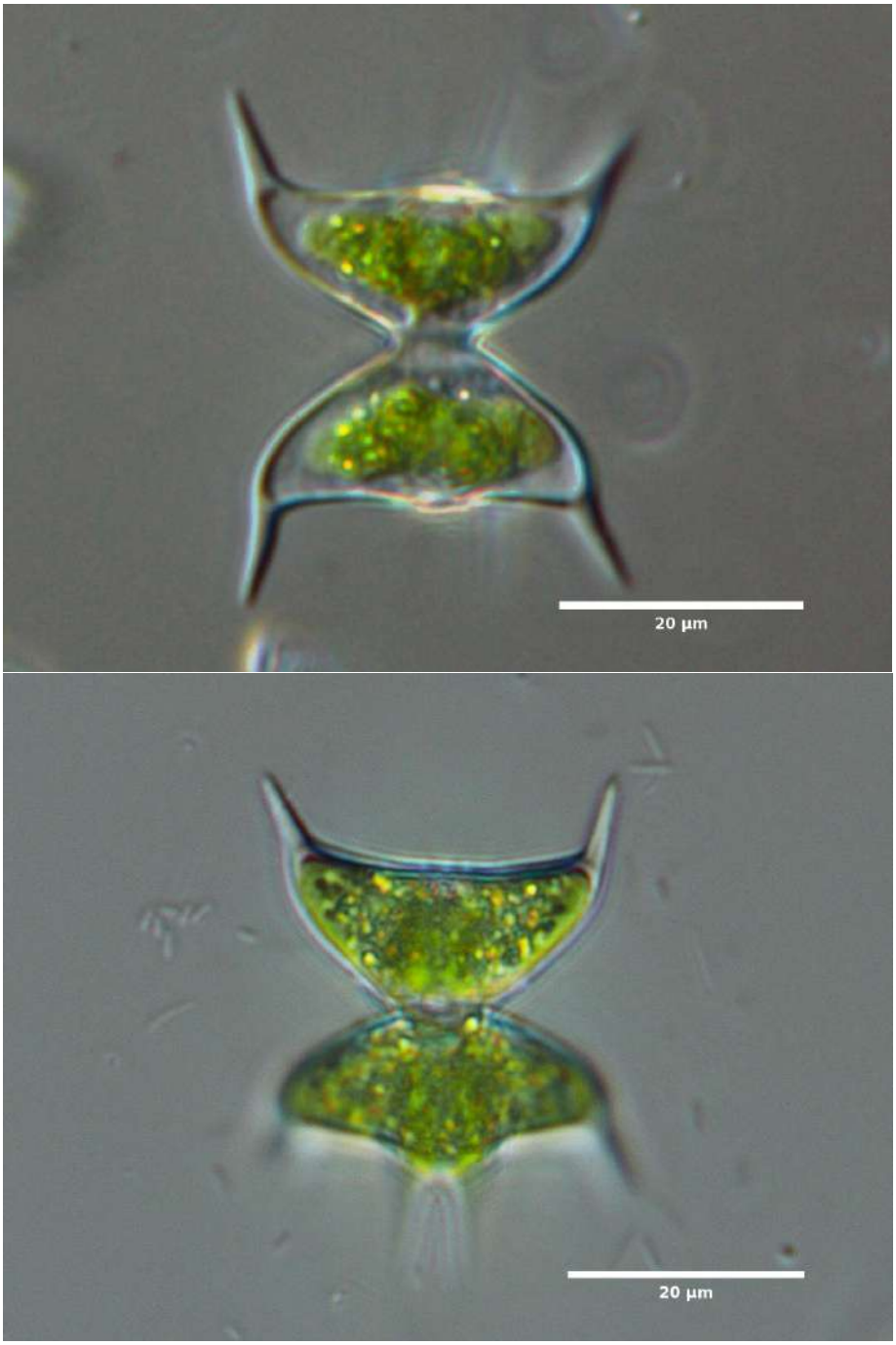


Figure 23.22: *Staurodesmus dejectus* (DIC/DIC), Myrtle Lake, Mountain Loop Highway, Snohomish County (upper/lower images).

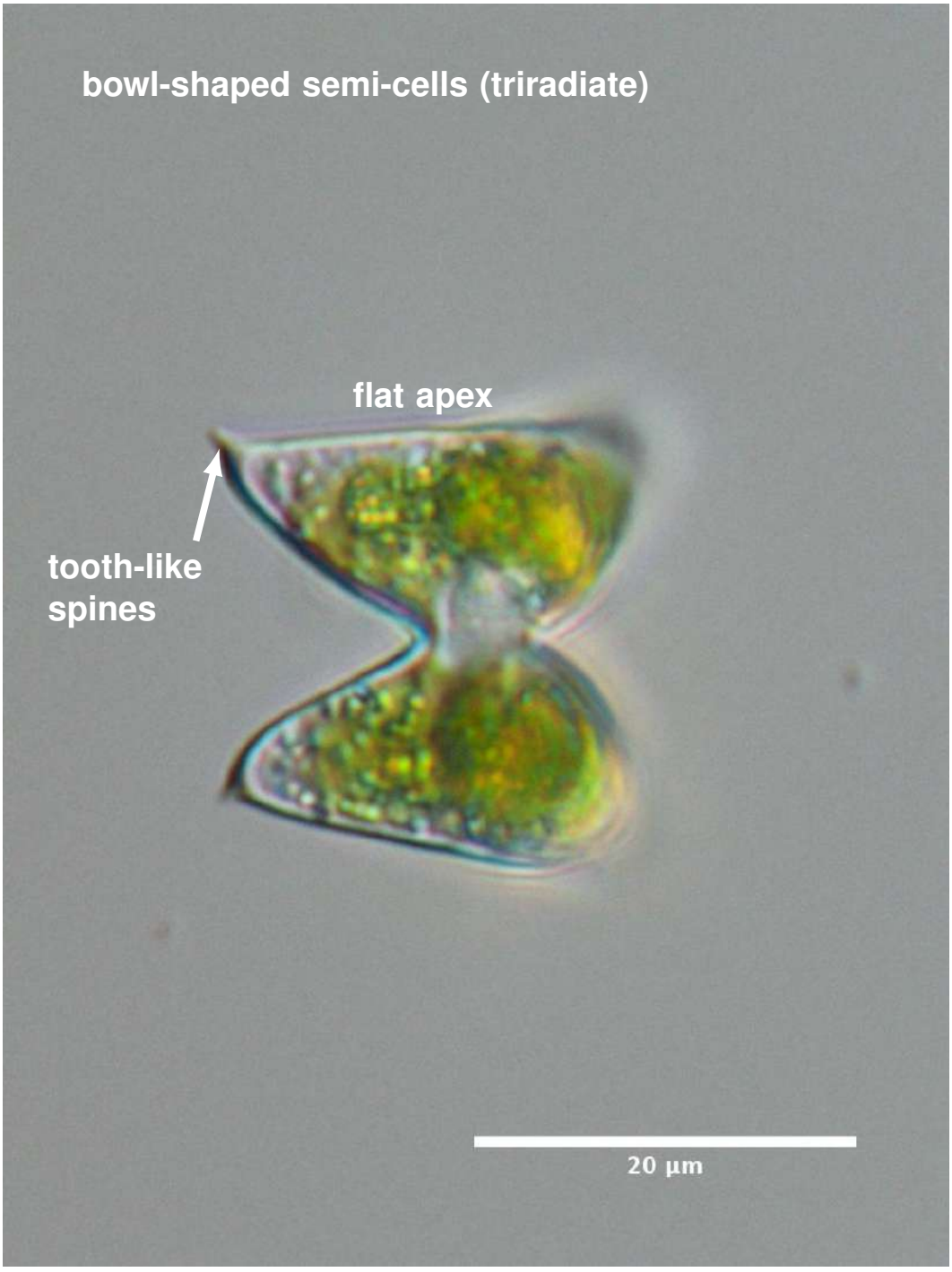
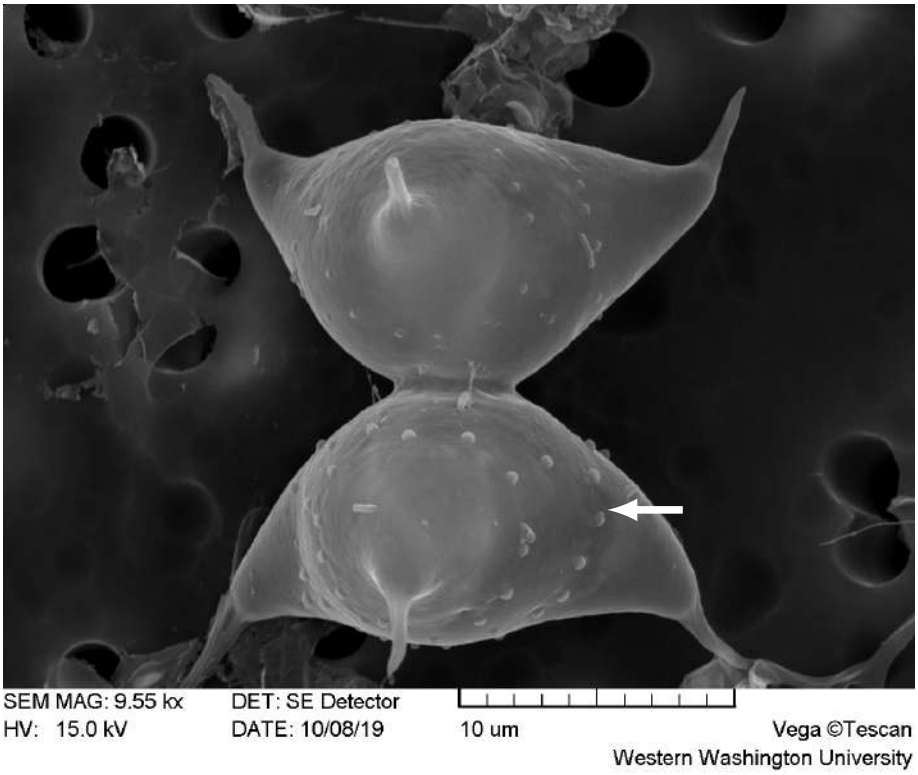


Figure 23.23: *Staurodesmus dejectus* var. *apiculatus* (DIC), Bear Lake, Mountain Loop Highway, Snohomish County.



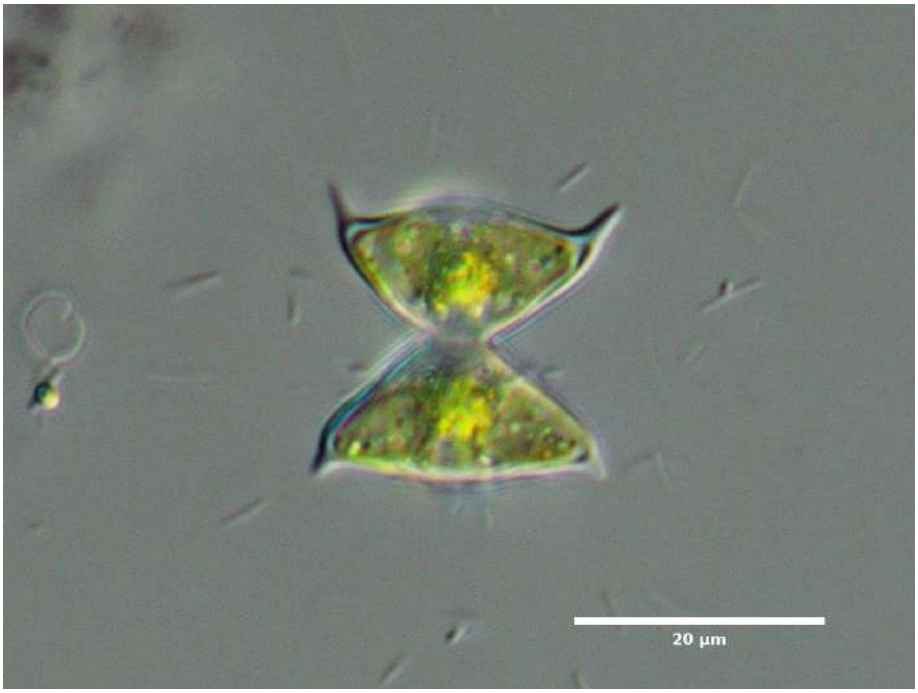


Figure 23.24: *Staurodesmus dejectus* var. *apiculatus* (SEM/DIC), small pond on trail to Lake Ann, Mt. Baker area, Whatcom County (upper/lower images) Note mucilage pore pattern on all cells (arrows).



Figure 23.25: *Staurodesmus dejectus* var. *apiculatus* (DIC), small pond on trail to Big Four Ice Caves, Mountain Loop Highway, Snohomish County.

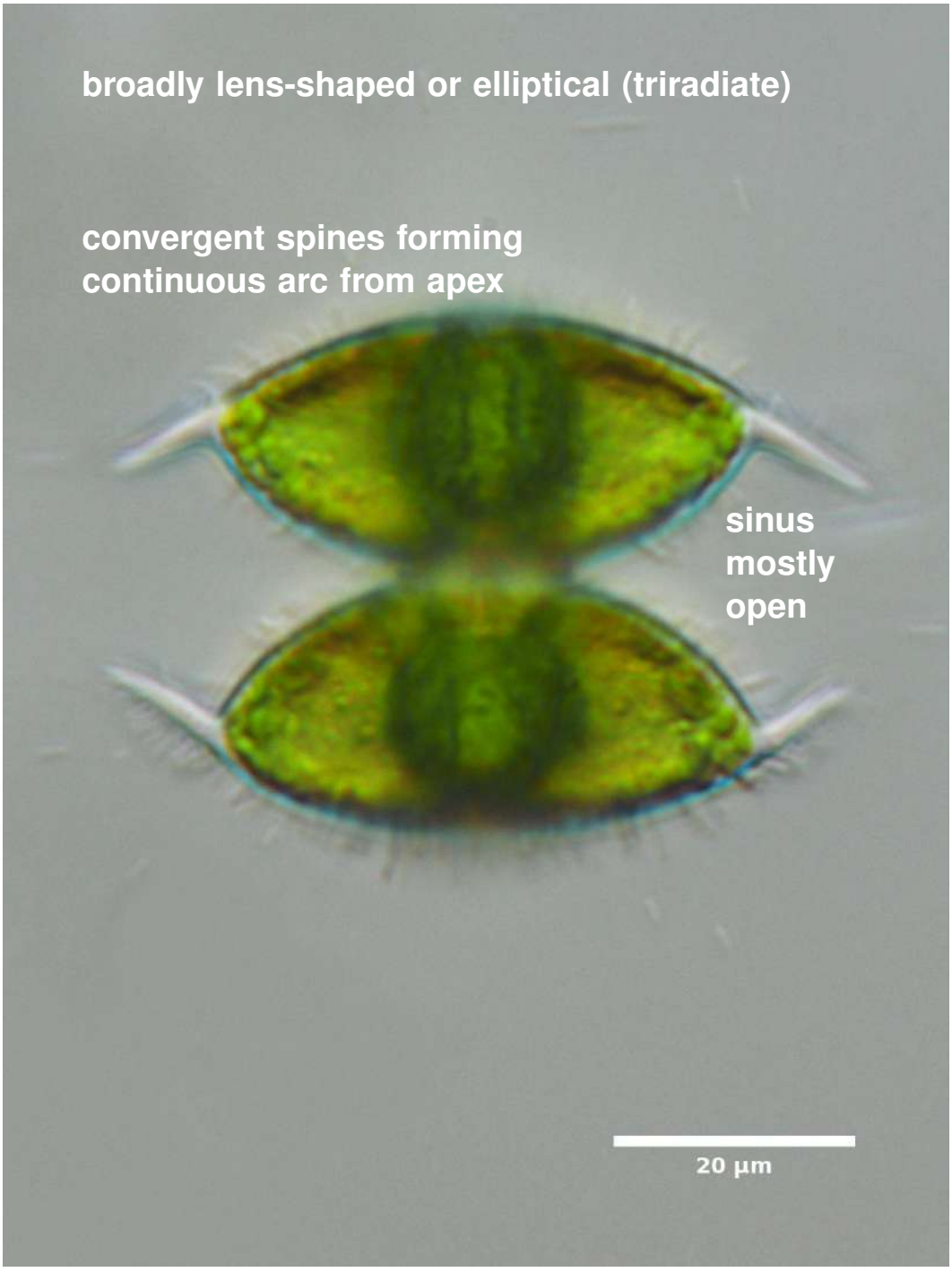
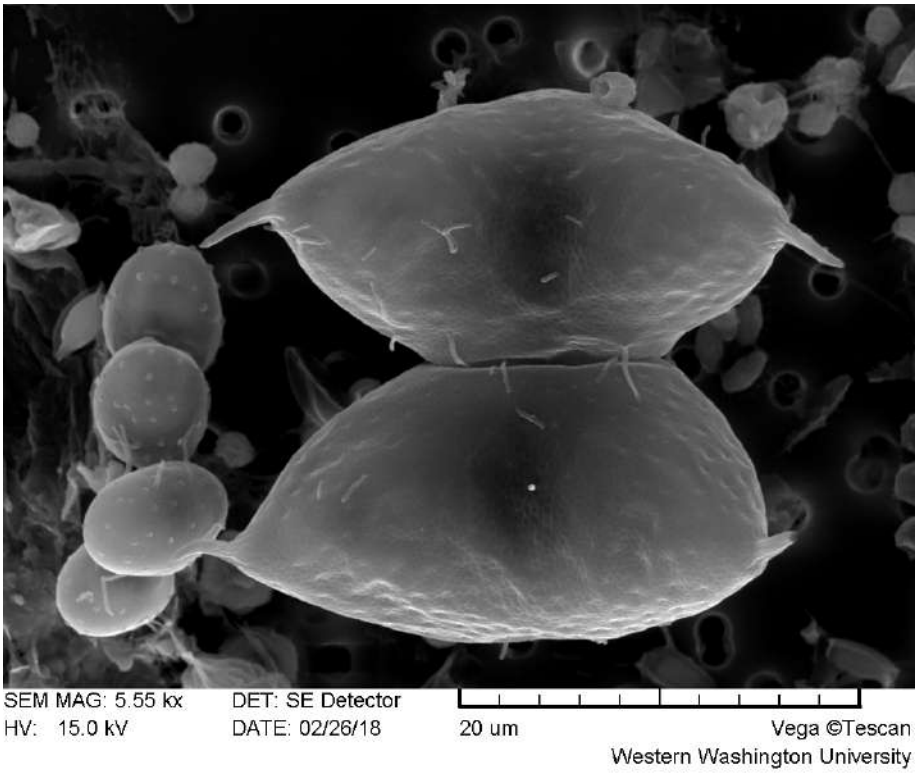


Figure 23.26: *Staurodesmus dickiei* (DIC), Myrtle Lake, Mountain Loop Highway, Snohomish County.



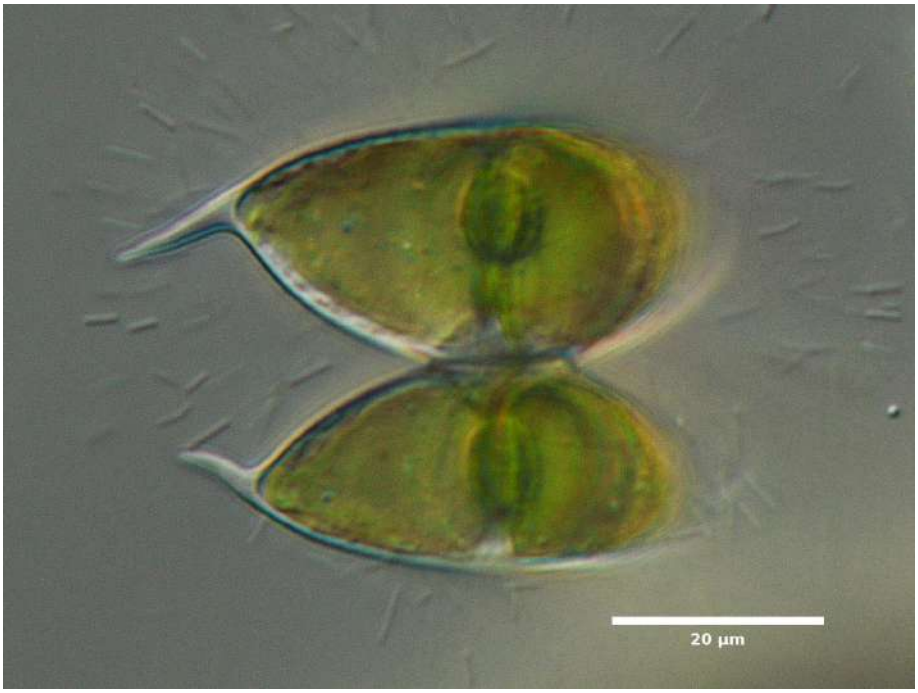


Figure 23.27: *Staurodesmus dickiei* (SEM/DIC), Myrtle Lake, Mountain Loop Highway, Snohomish County (upper/lower images).

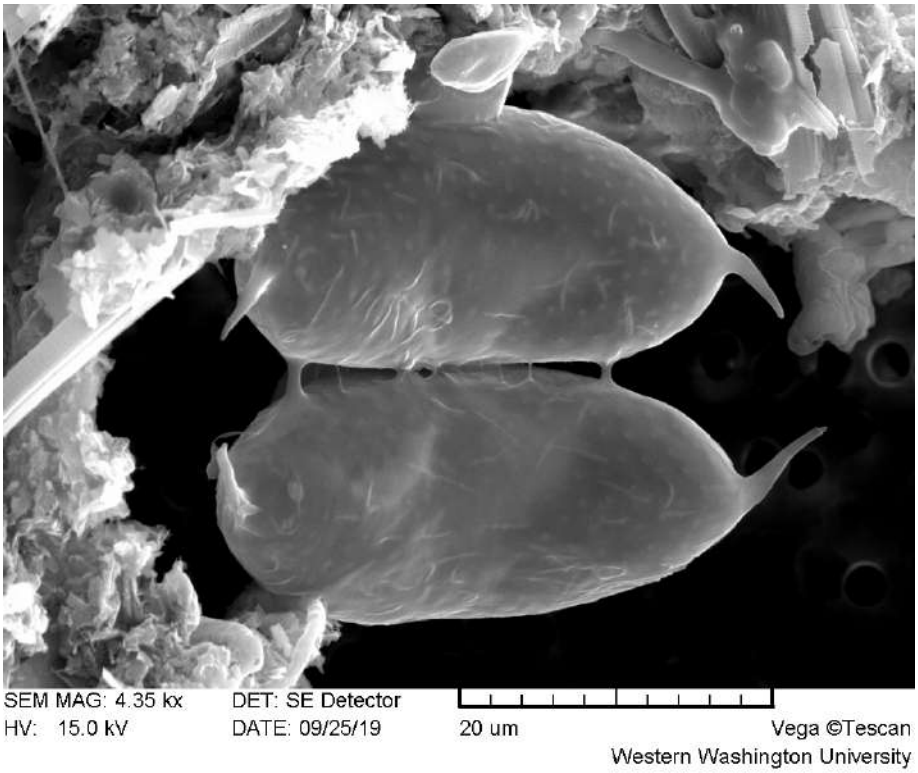




Figure 23.28: *Staurodesmus dickiei* (SEM/DIC), small boggy pond along Morris Valley Road near Harrison BC (upper/lower images).



Figure 23.29: *Staurodesmus dickiei* (DIC), Myrtle Lake, Mountain Loop Highway, Snohomish County.



Figure 23.30: *Staurodesmus* cf. *dickiei* (DIC/DIC), Big Twin Lake (eastern Washington), Okanogan County (upper image); Little Twin Lake (eastern Washington), Okanogan County (lower image).

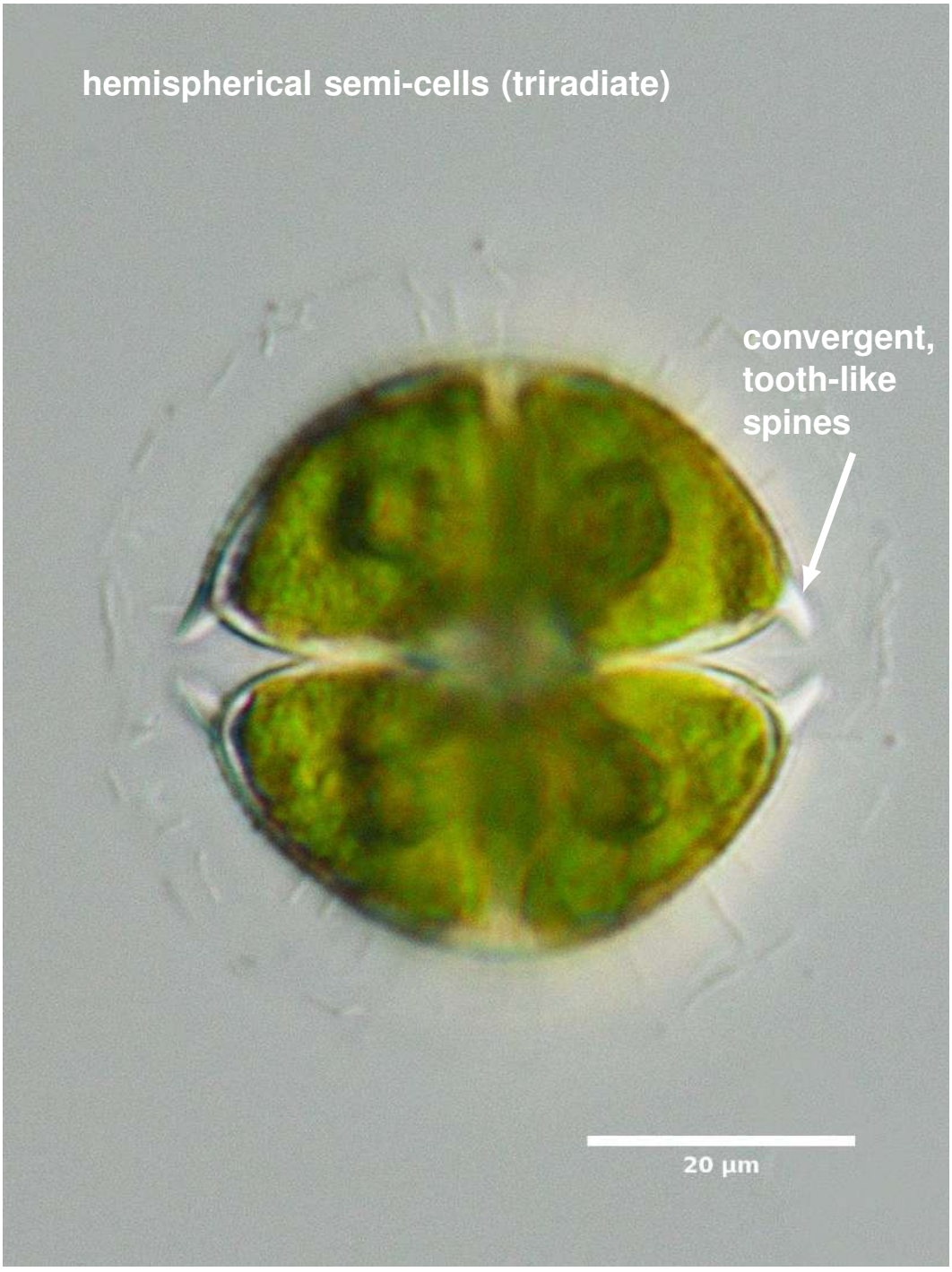


Figure 23.31: *Staurodesmus dickiei* var. *circularis* (DIC), Myrtle Lake, Mountain Loop Highway, Snohomish County.

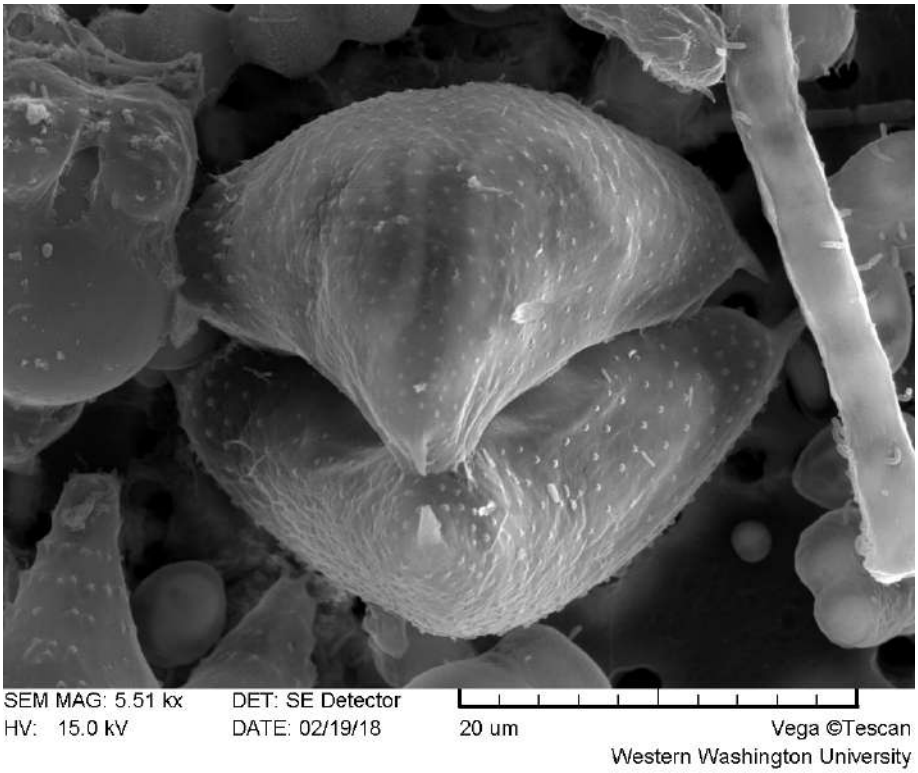




Figure 23.32: *Staurodesmus dickiei* var. *circularis* (SEM/DIC), Myrtle Lake, Mountain Loop Highway, Snohomish County (upper/lower images).



Figure 23.33: *Staurodesmus dickiei* cf. var. *circularis* atypical cell (DIC), small pond near Lynnwood, Snohomish County.

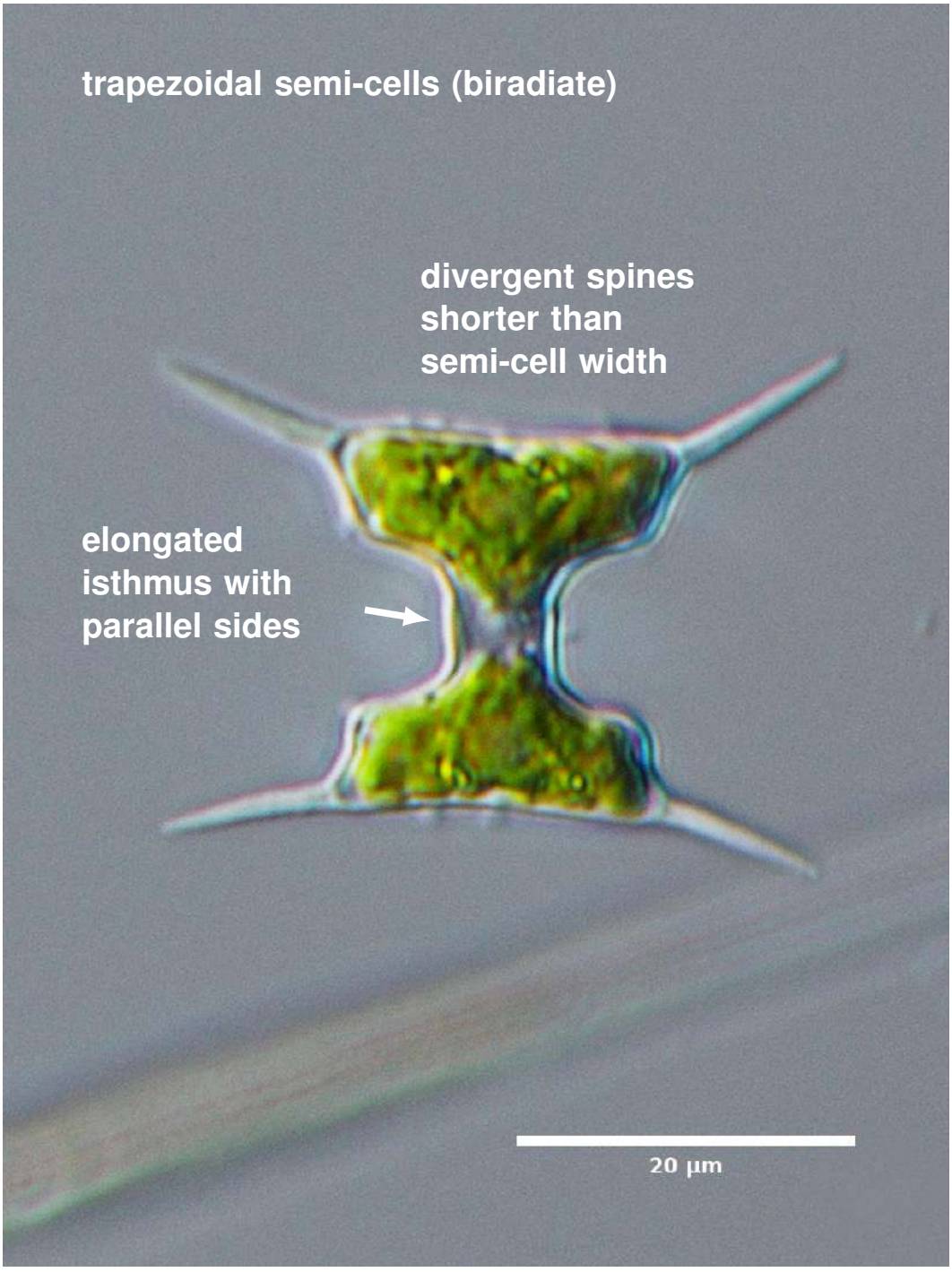
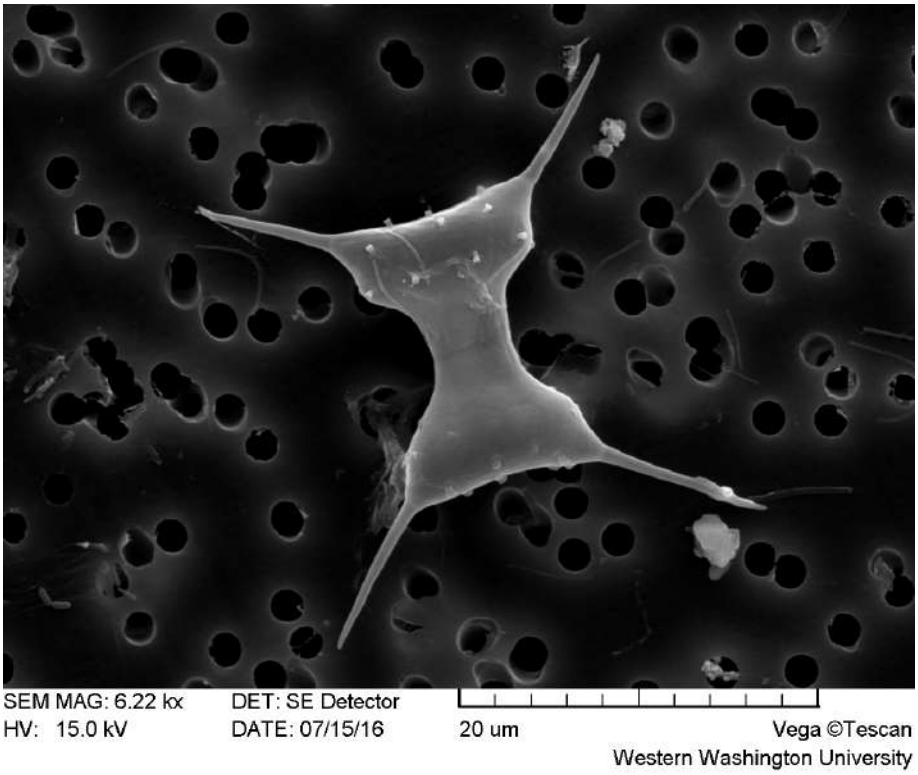


Figure 23.34: *Staurodesmus extensus* (DIC), Lake Terrell, Whatcom County.



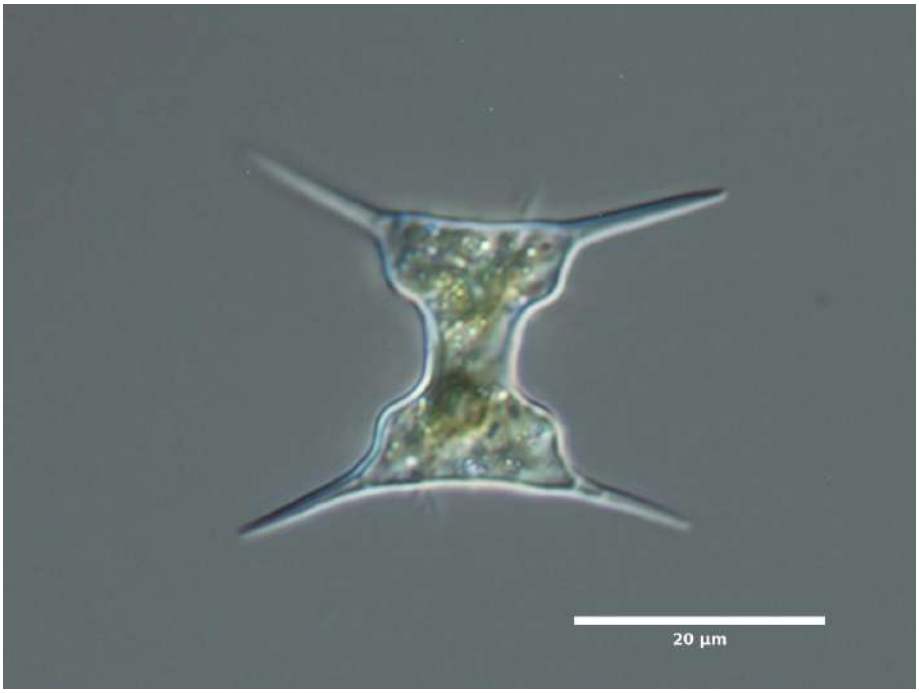


Figure 23.35: *Staurodesmus extensus* (SEM/DIC), Bear Lake, Mountain Loop Highway, Snohomish County (upper/lower images).

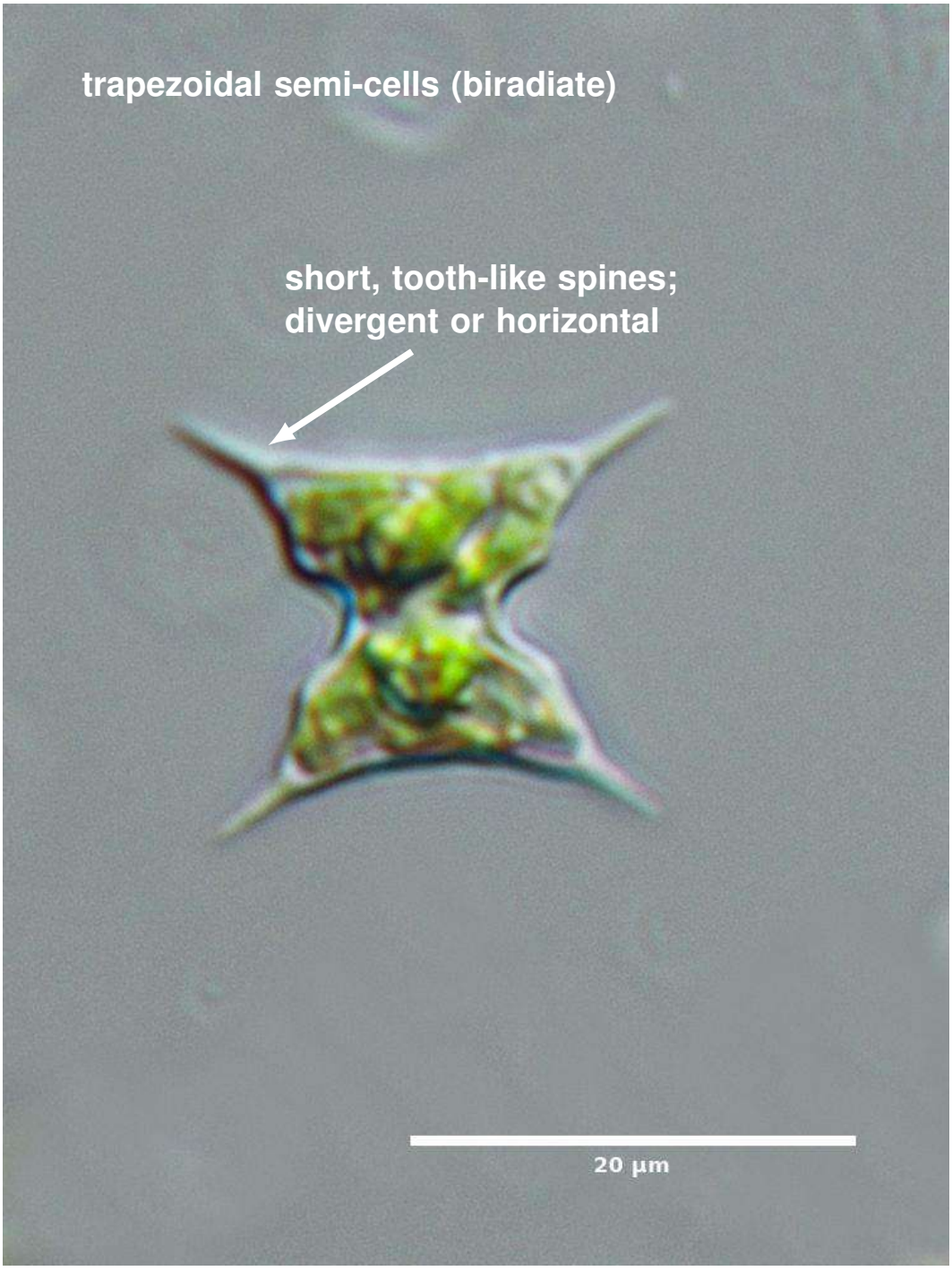


Figure 23.36: *Staurodesmus extensus* var. *isthmosus* (DIC), small pond on trail to Dock Butte, Mt. Baker area, Skagit County.

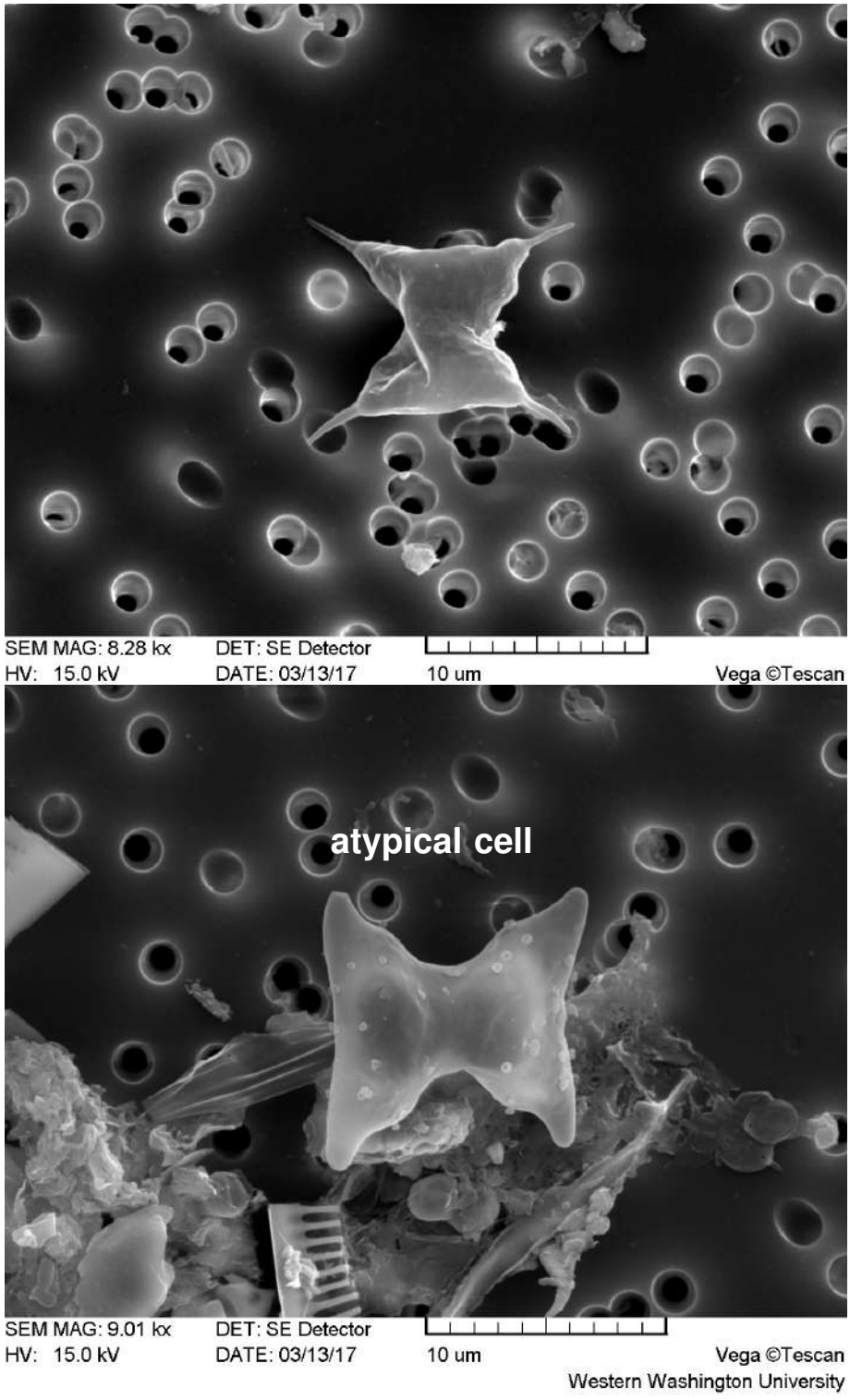


Figure 23.37: *Staurodesmus extensus* var. *isthmosus* (SEM/SEM), small pond on trail to Dock Butte, Mt. Baker area, Skagit County (upper/lower images).

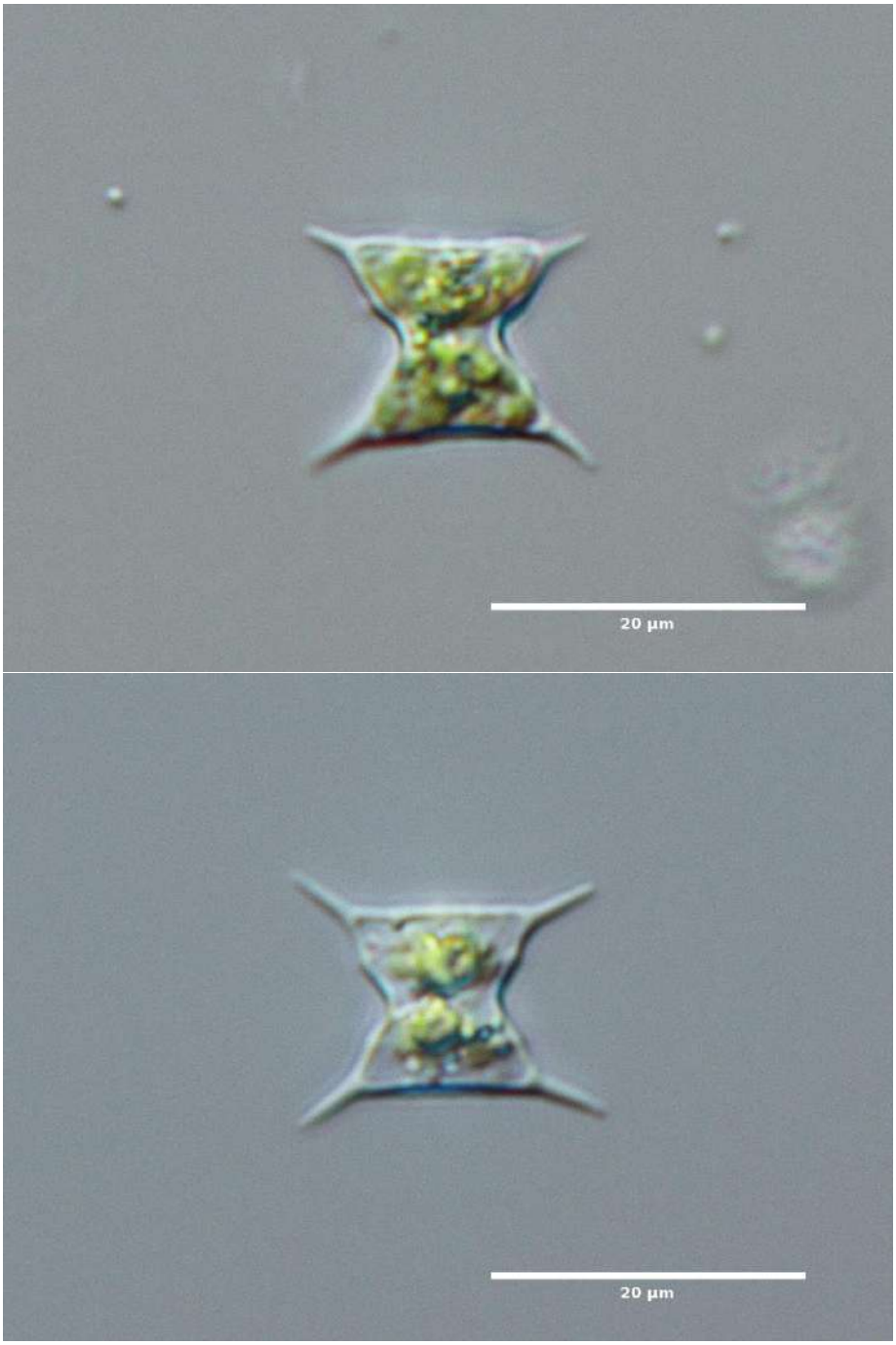


Figure 23.38: *Staurodesmus extensus* var. *isthmosus* (DIC/DIC), small pond on trail to Dock Butte, Mt. Baker area, Skagit County (upper/lower images).

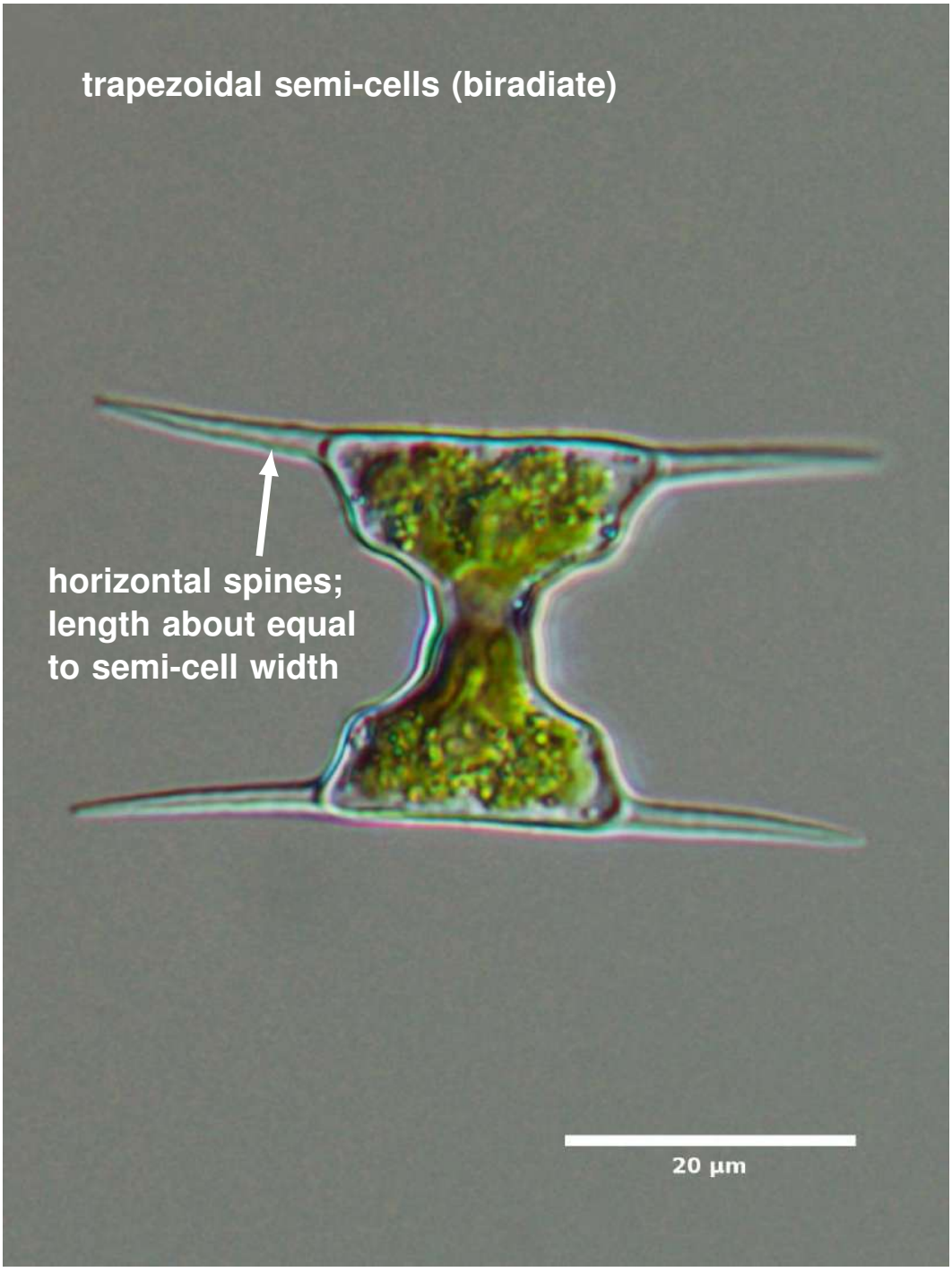


Figure 23.39: *Staurodesmus extensus* var. *joshuae* (DIC), Myrtle Lake, Mountain Loop Highway, Snohomish County.

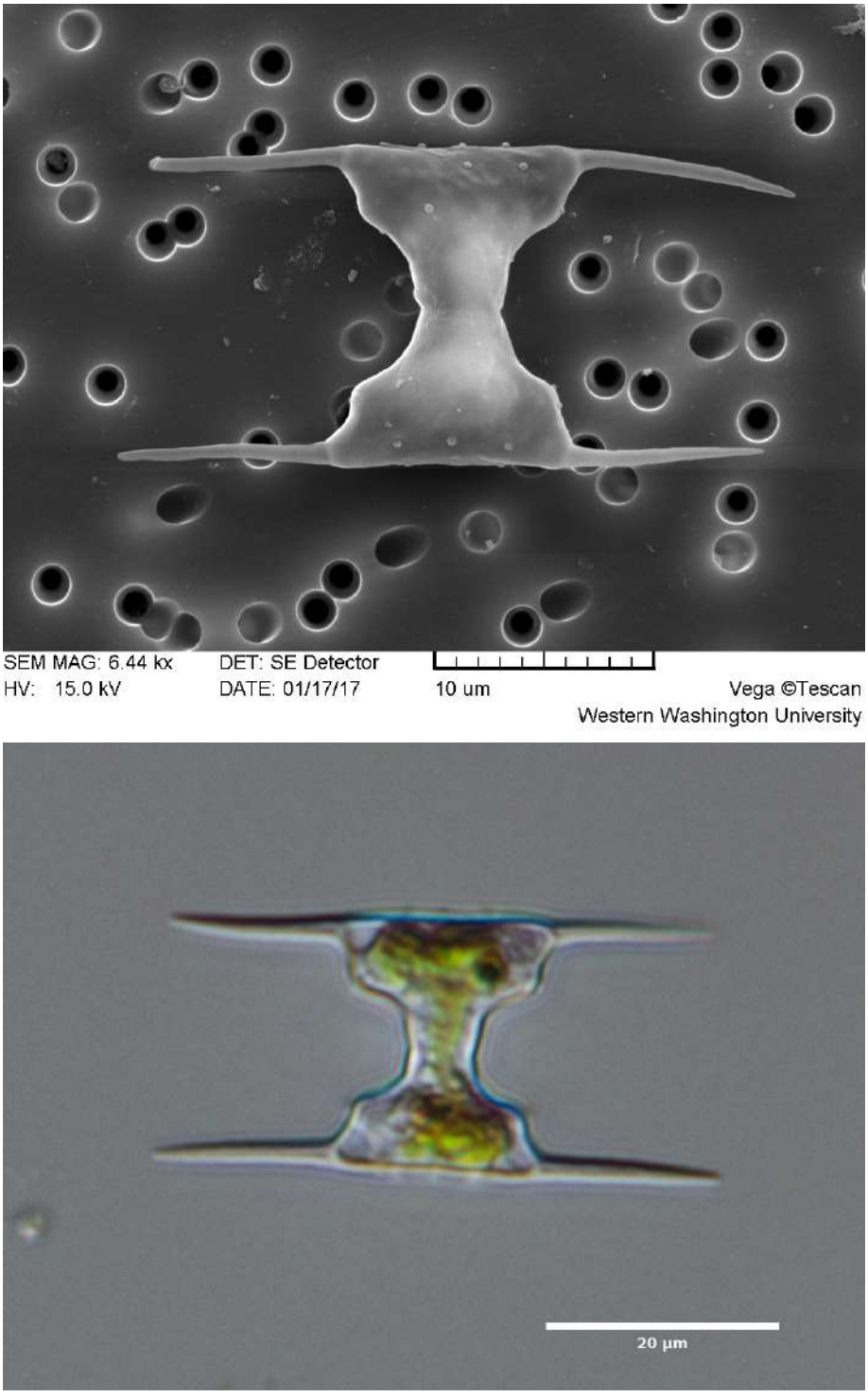


Figure 23.40: *Staurodesmus extensus* var. *joshuae* (SEM/DIC), Myrtle Lake, Mountain Loop Highway, Snohomish County (upper/lower images).

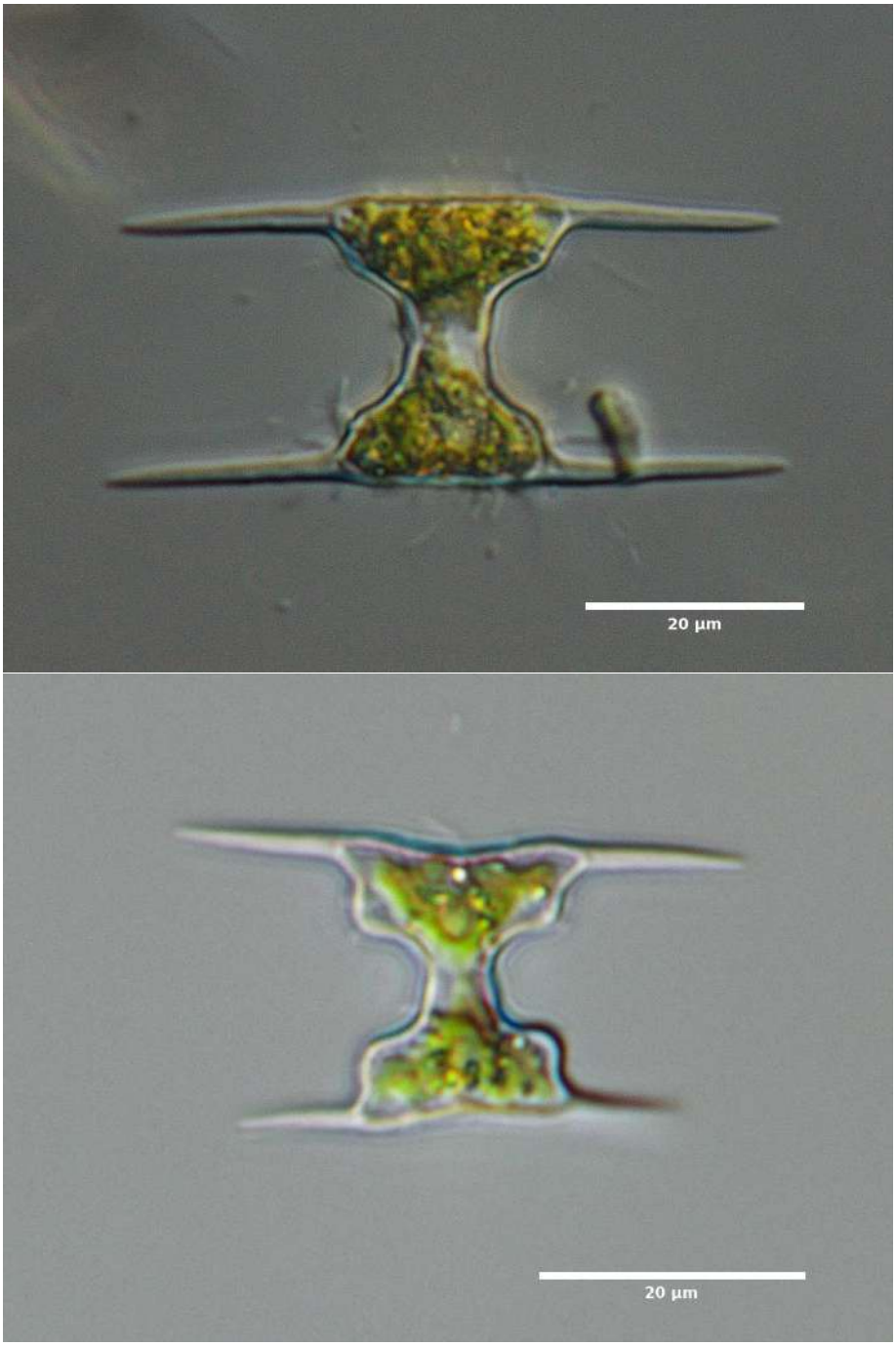


Figure 23.41: *Staurodesmus extensus* var. *joshuae* (DIC/DIC), Takhlakh Lake, Gifford Pinchot National Forest, Skamania County (upper image); small residential pond on Valley Circle Drive, Snohomish County (lower image).

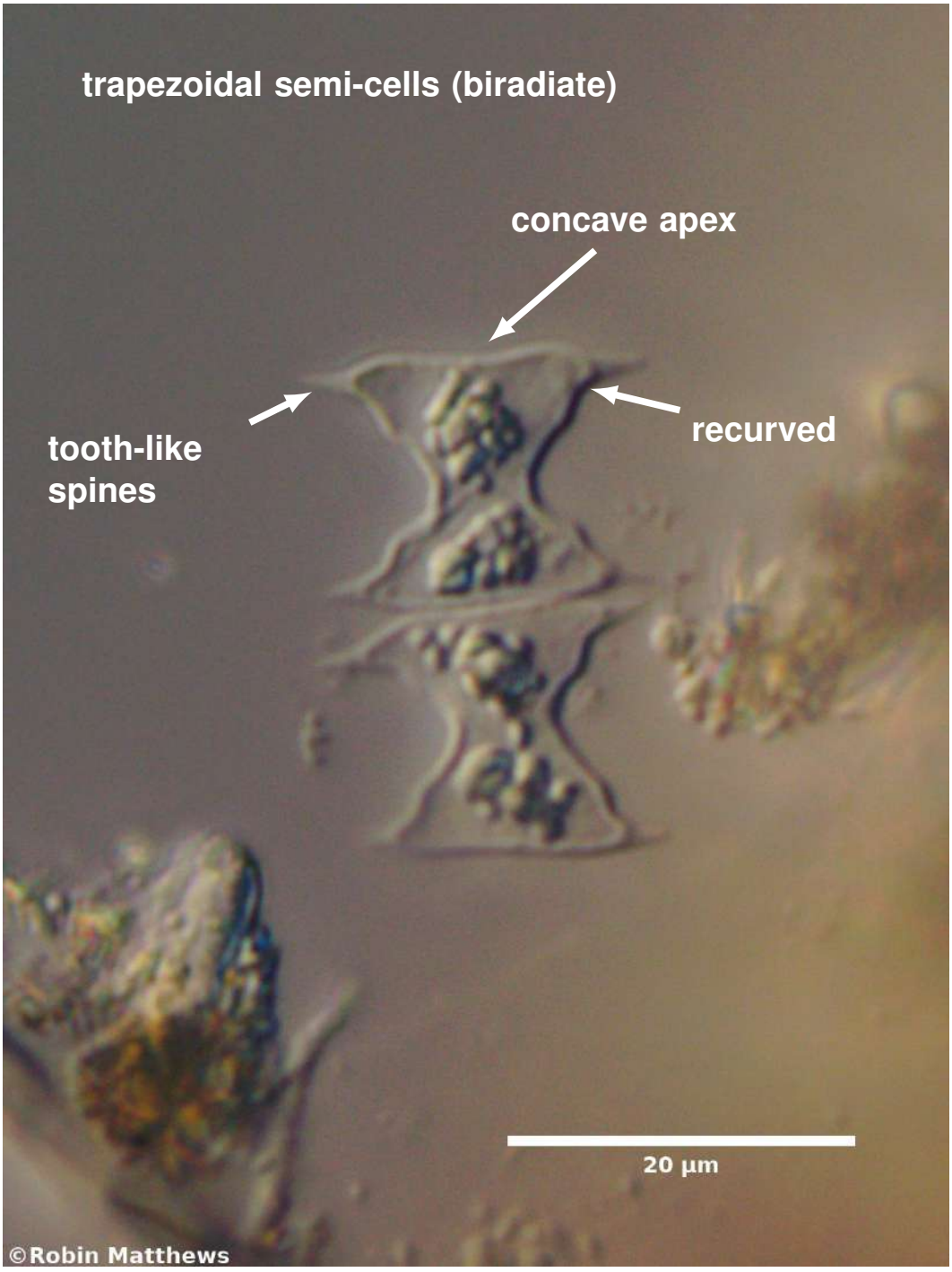


Figure 23.42: *Staurodesmus extensus* cf. var. *rectus* (DIC), Lake Twenty-two, Mountain Loop Highway, Snohomish County.

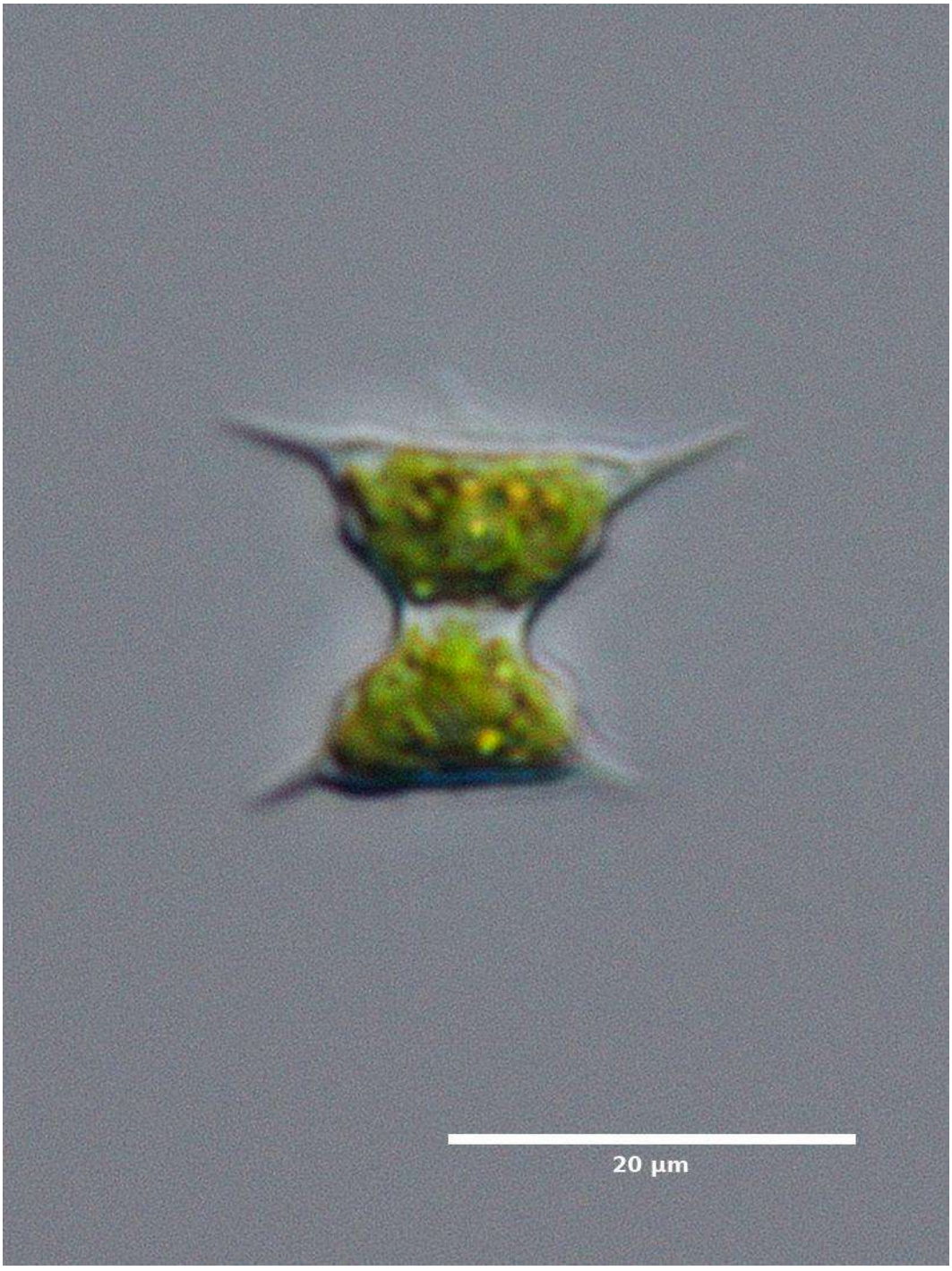


Figure 23.43: *Staurodesmus extensus* cf. var. *rectus* (DIC), Lake Twenty-two, Mountain Loop Highway, Snohomish County.

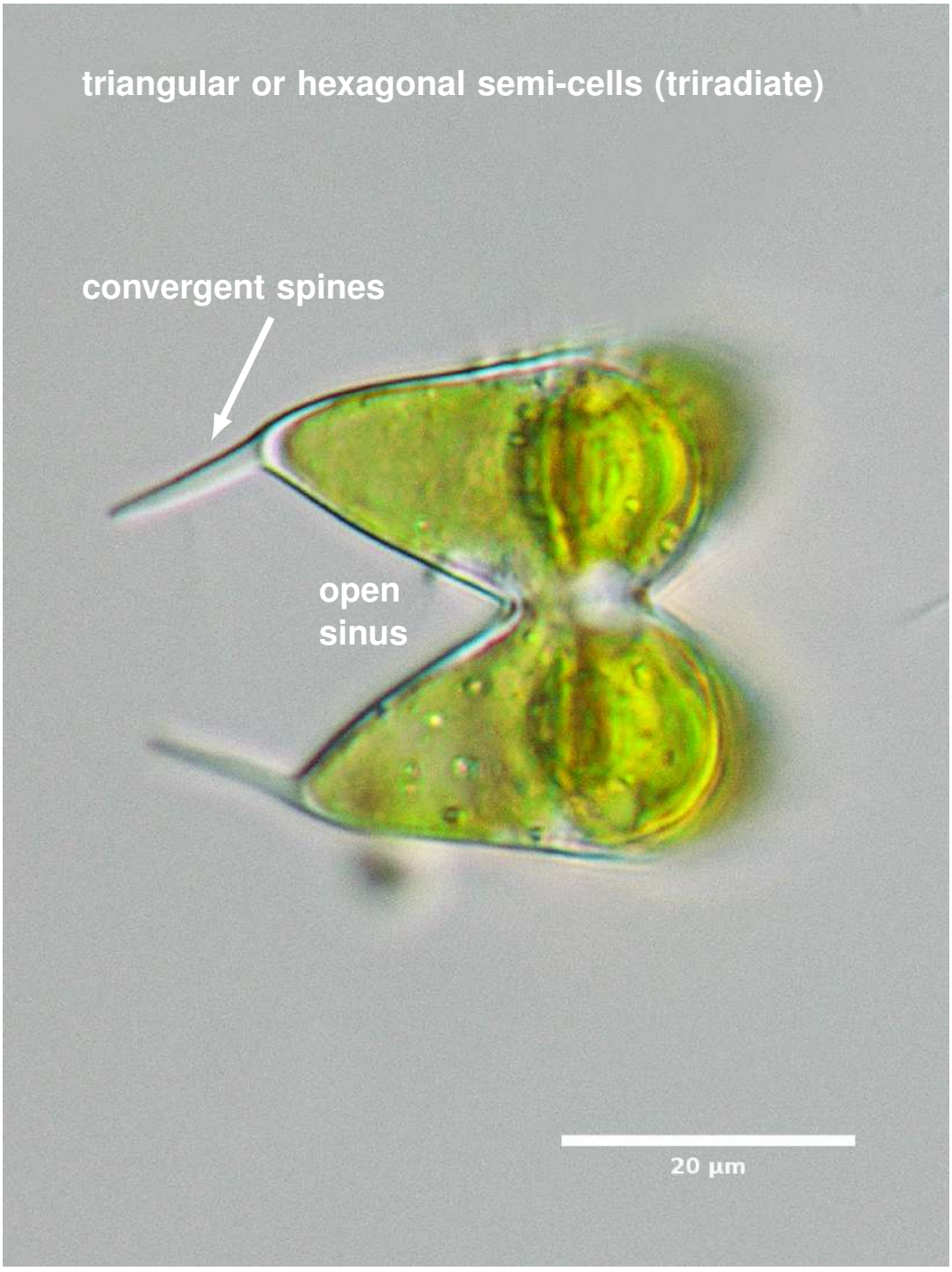
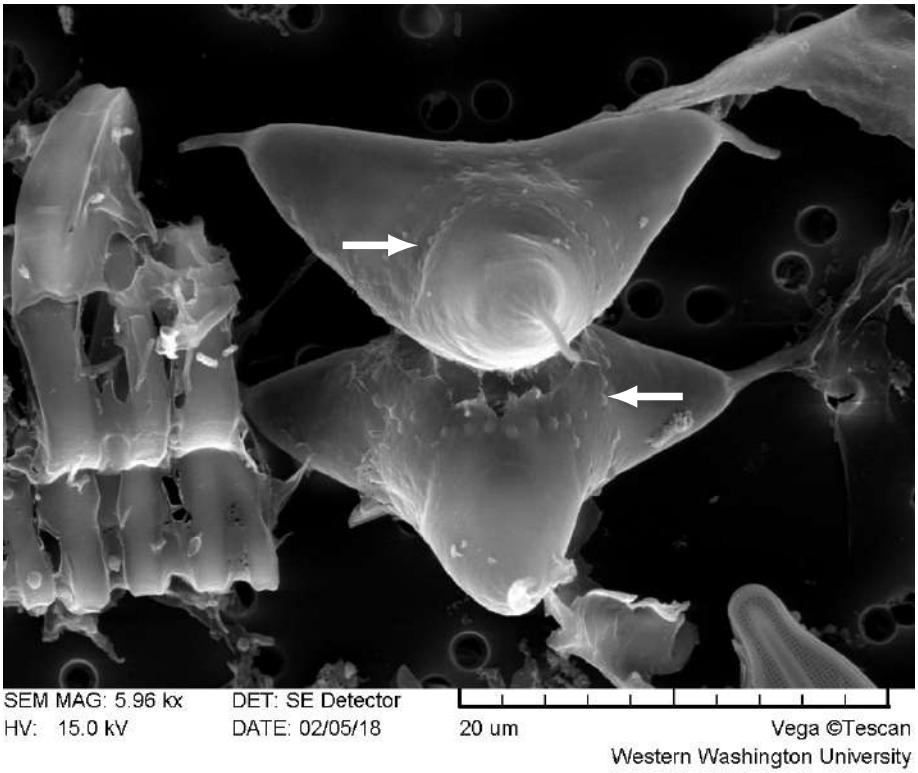


Figure 23.44: *Staurodesmus glaber* (DIC), Lake Evan, Mountain Loop Highway, Snohomish County.



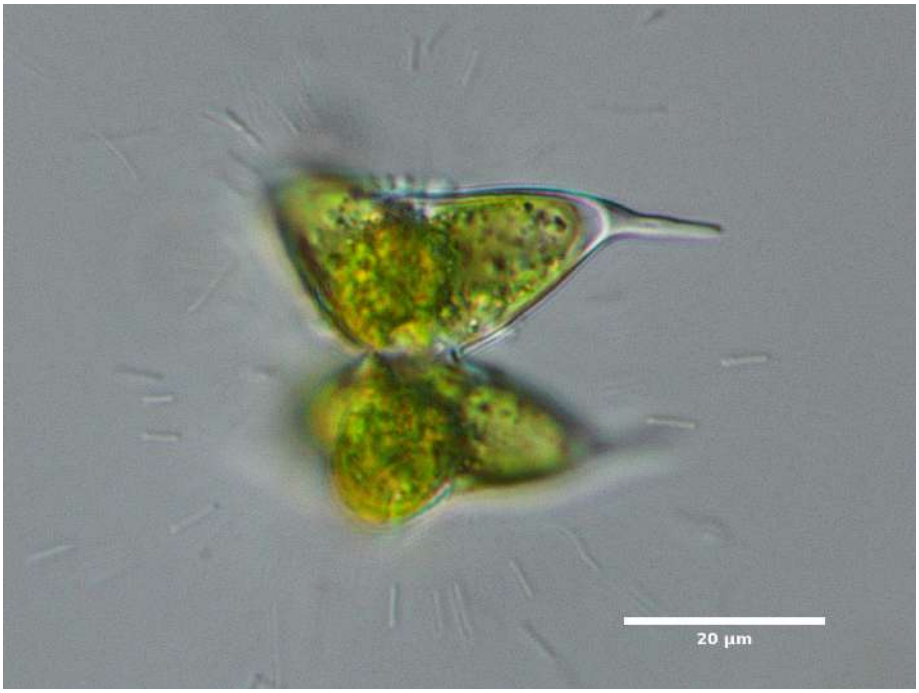


Figure 23.45: *Staurodesmus glaber* (SEM/DIC), Bear Lake, Mountain Loop Highway, Snohomish County (upper/lower images) Note mucilage pore pattern on cell (arrows).

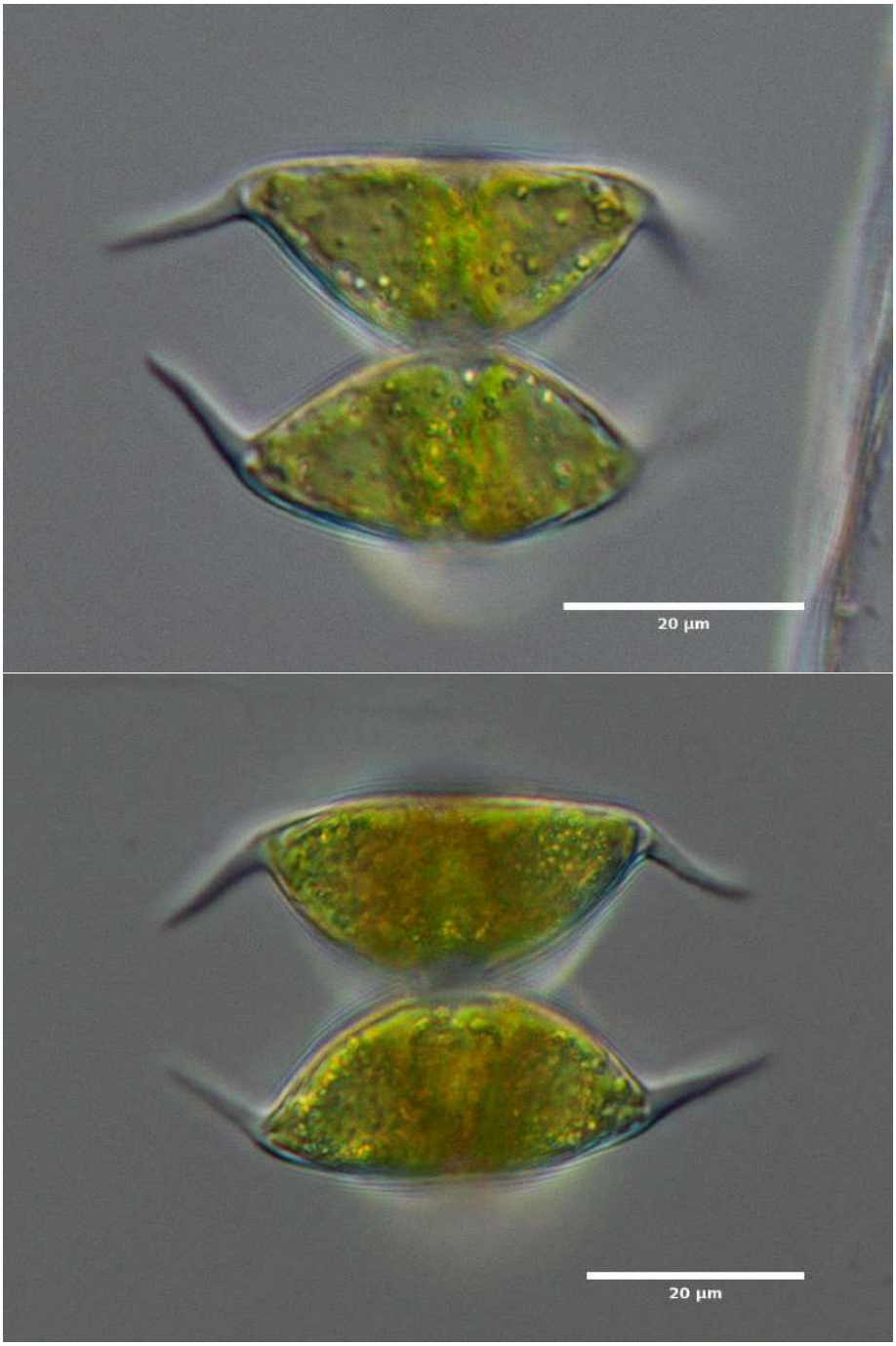


Figure 23.46: *Staurodesmus glaber* (DIC/DIC), Chain Lake, Gifford Pinchot National Forest, Skamania County (upper/lower images).

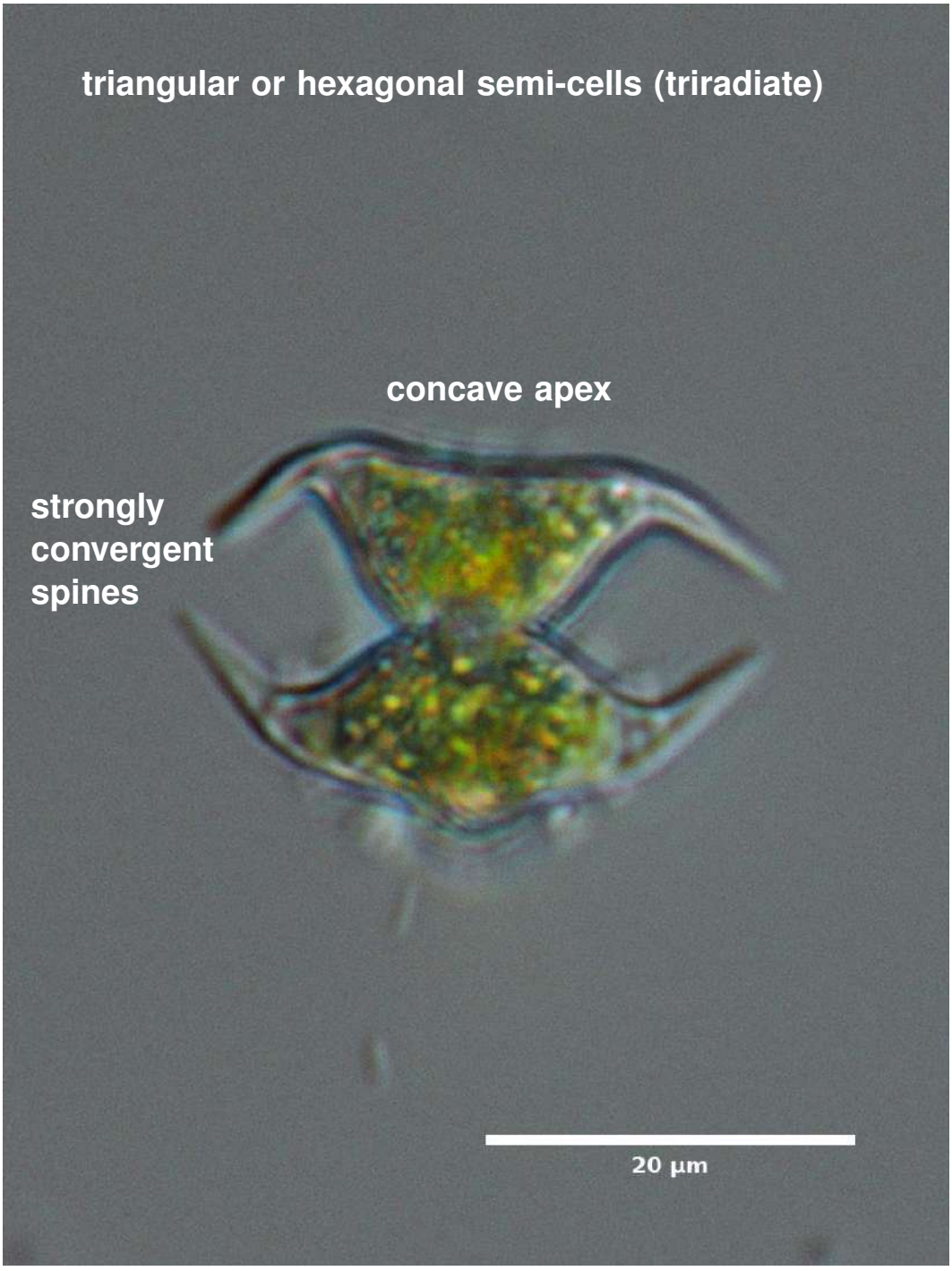


Figure 23.47: *Staurodesmus glaber* var. *hirundinella* (DIC), small pond near Damfino Lake, Mt. Baker area, Whatcom County

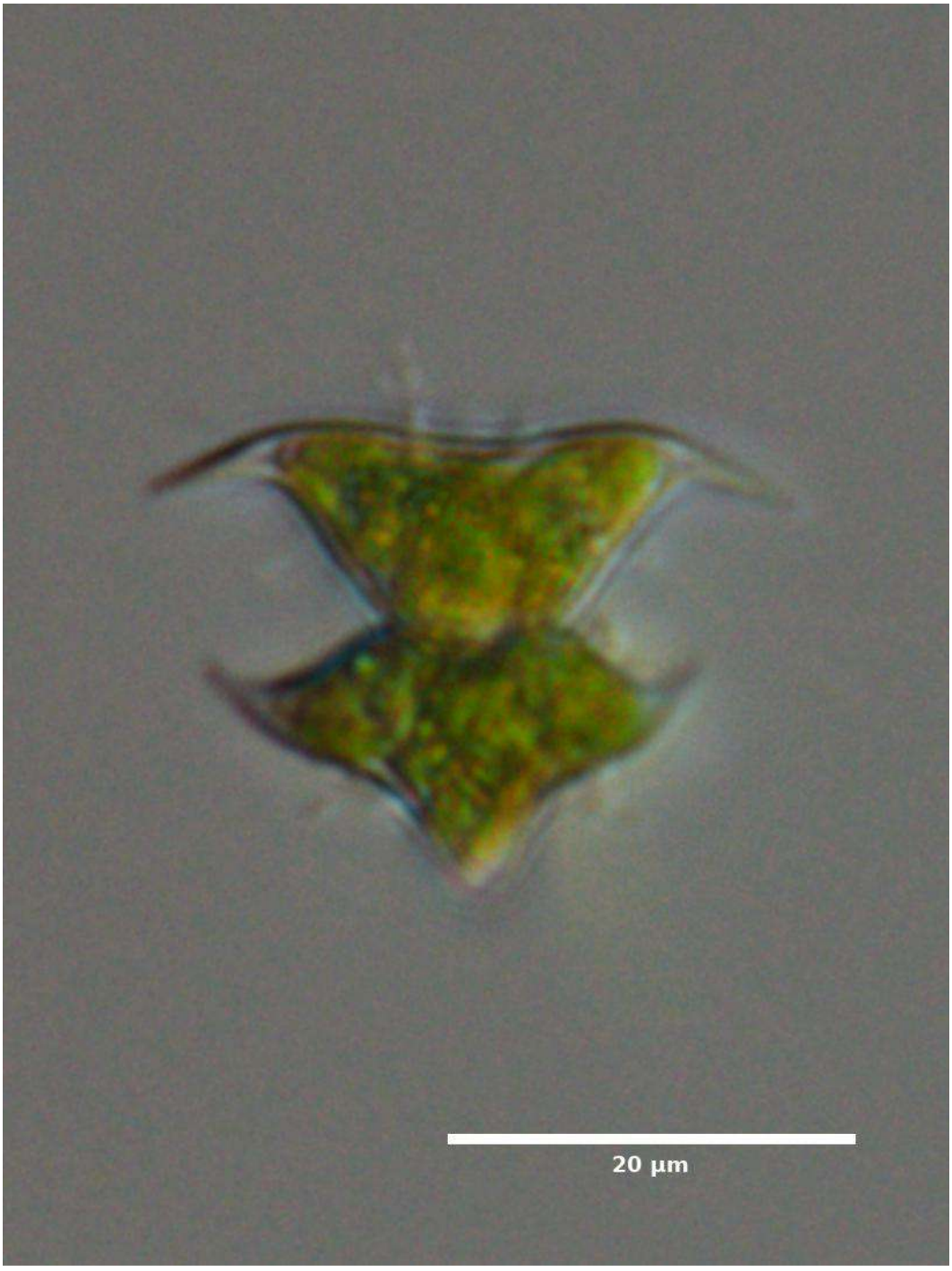


Figure 23.48: *Staurodesmus glaber* var. *hirundinella* (DIC) small pond on trail to Lake Ann, Mt. Baker area, Whatcom County.

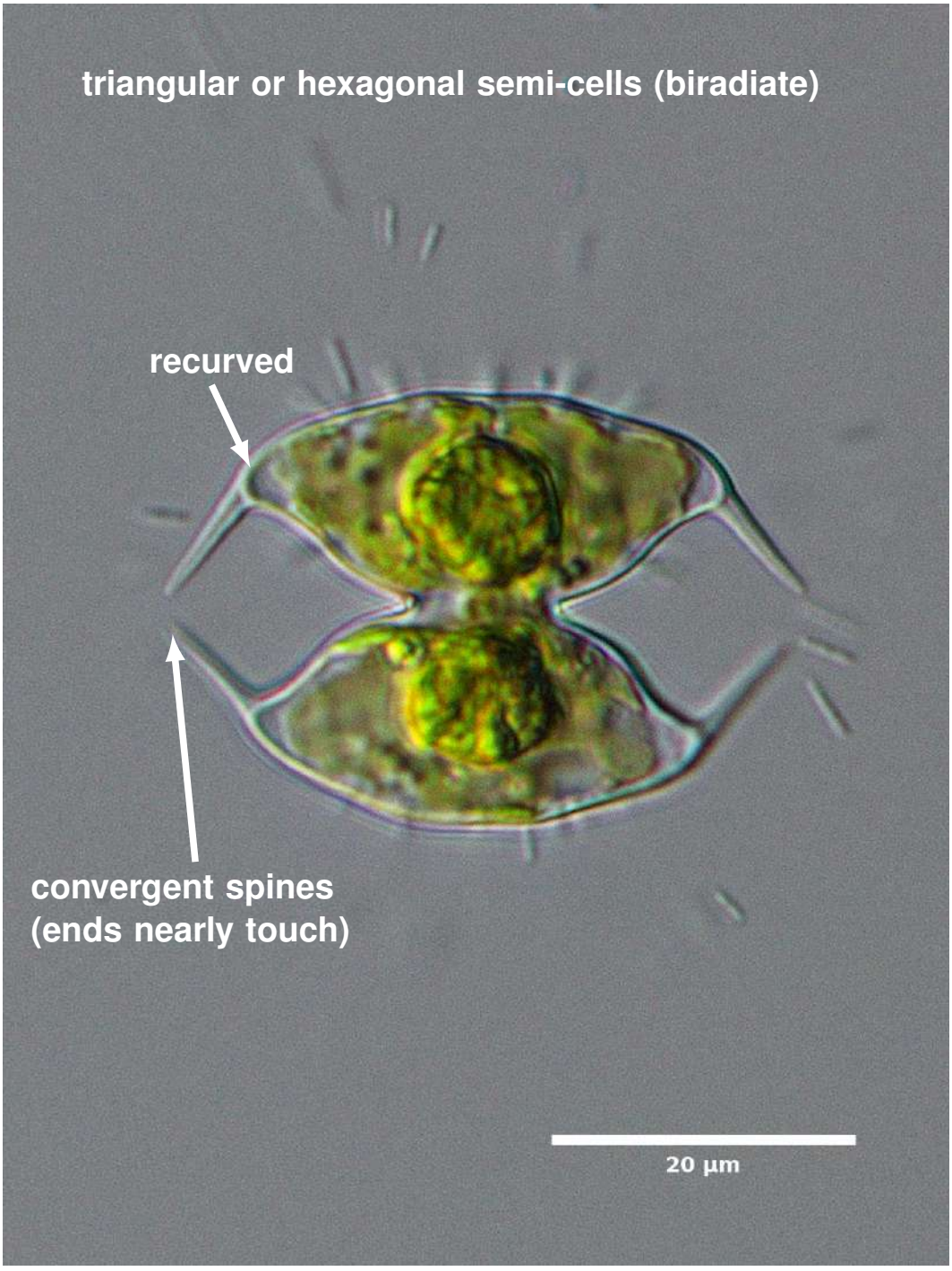


Figure 23.49: *Staurodesmus glaber* var. A (DIC), Beaver Lake, Skagit County.

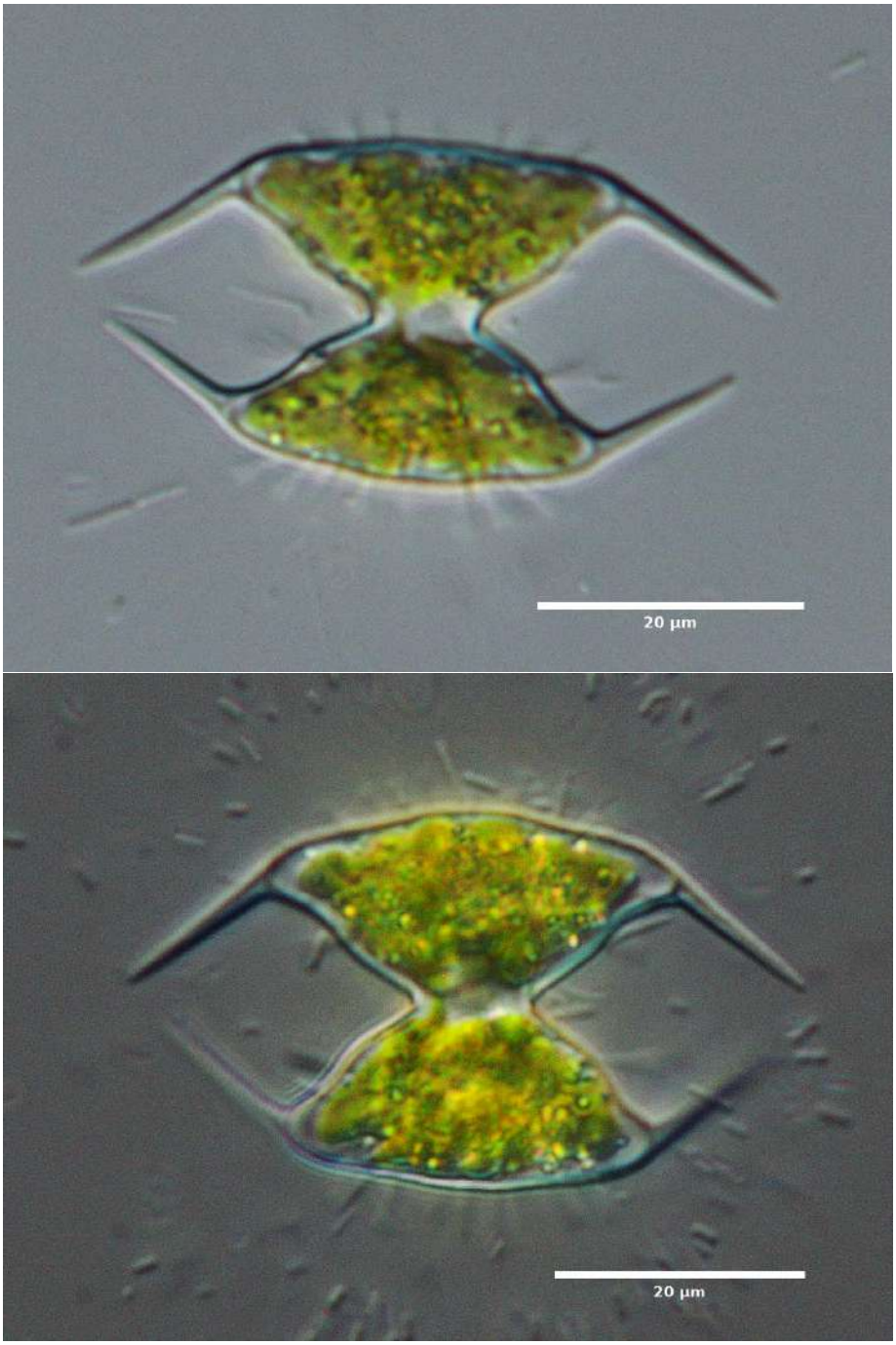


Figure 23.50: *Staurodesmus glaber* var. A (DIC/DIC), Clear Lake, Skagit County (upper image); Lake Padden, Whatcom County (lower image).

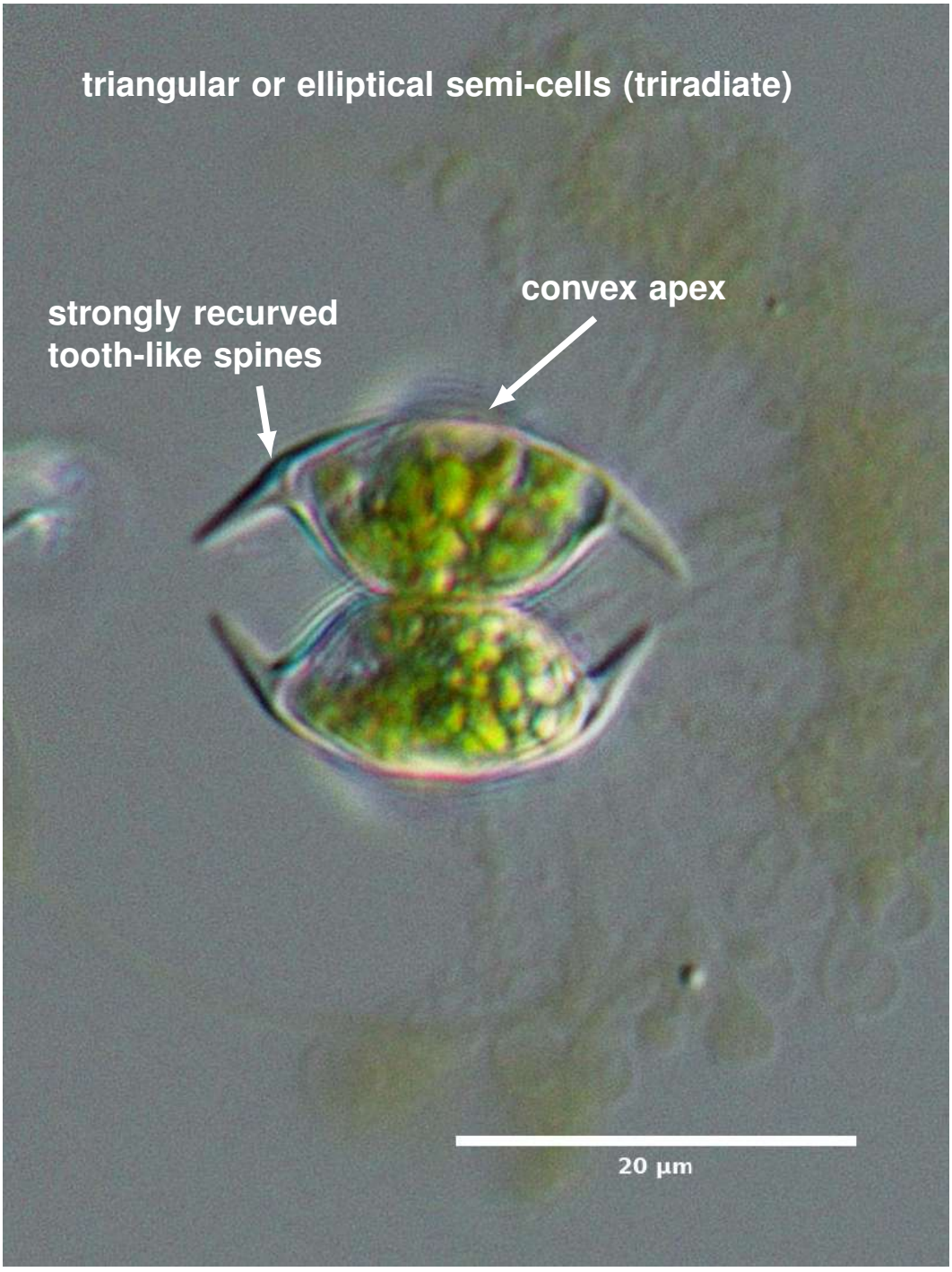


Figure 23.51: *Staurodesmus glaber* var. B (DIC) small pond on trail to Lake Ann, Mt. Baker area, Whatcom County.

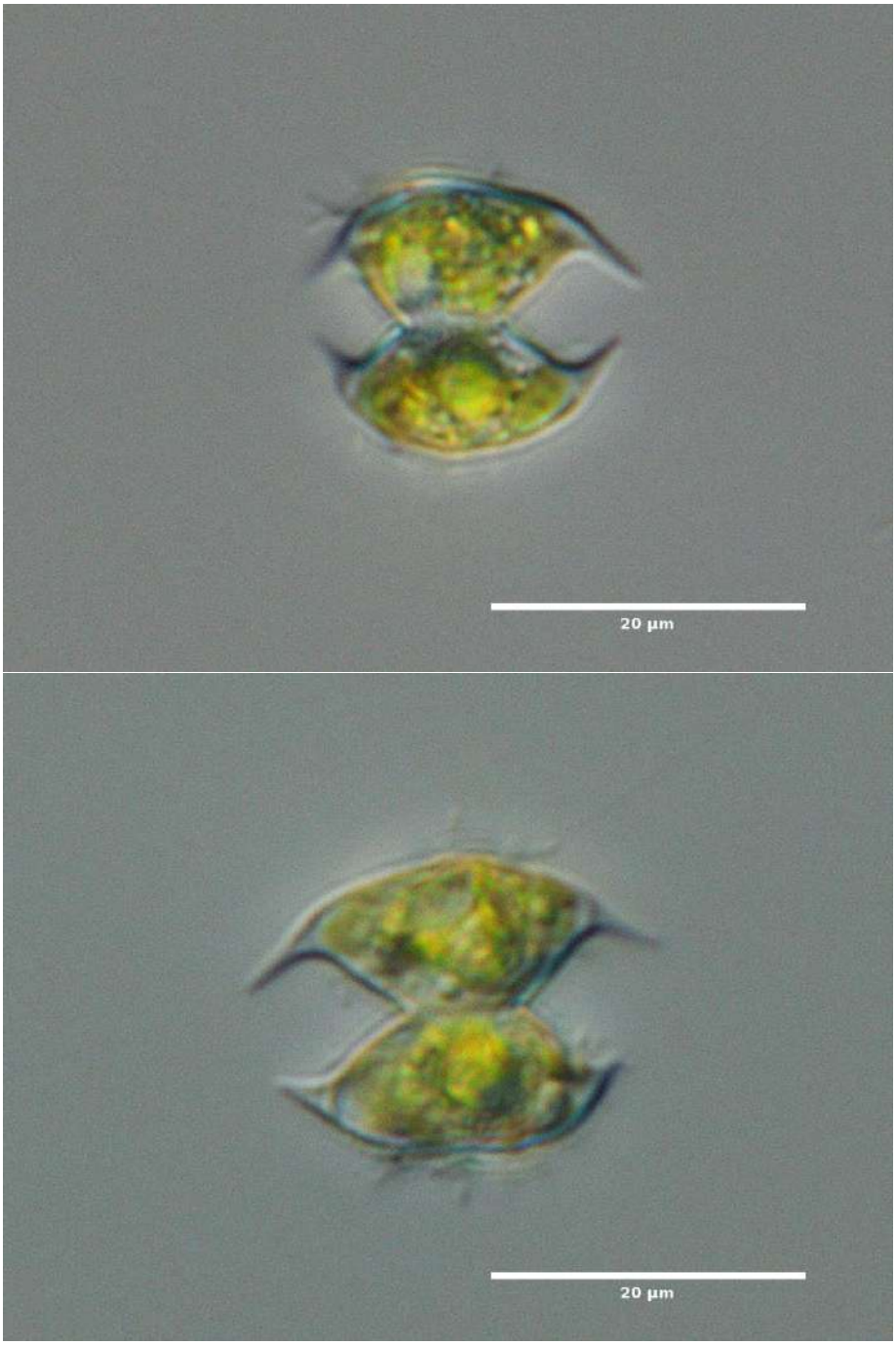


Figure 23.52: *Staurodesmus glaber* var. B (DIC/DIC), small pond on trail to Lake Ann, Mt. Baker area, Whatcom County (upper/lower images).

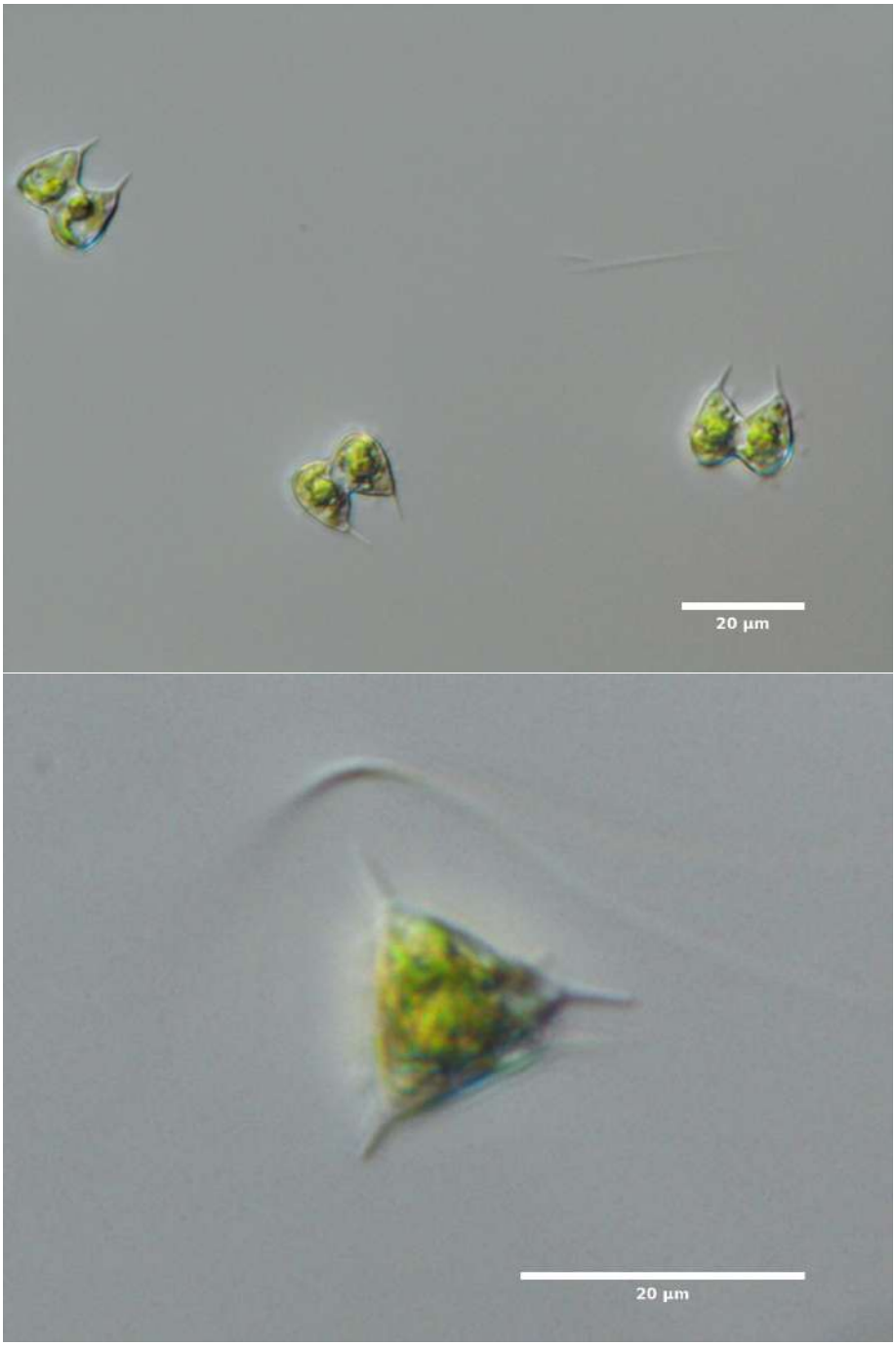


Figure 23.53: *Staurodesmus glaber* var. B (DIC/DIC), small pond near Artist Point Ridge trail, Mt. Baker area, Whatcom County (upper/lower images).

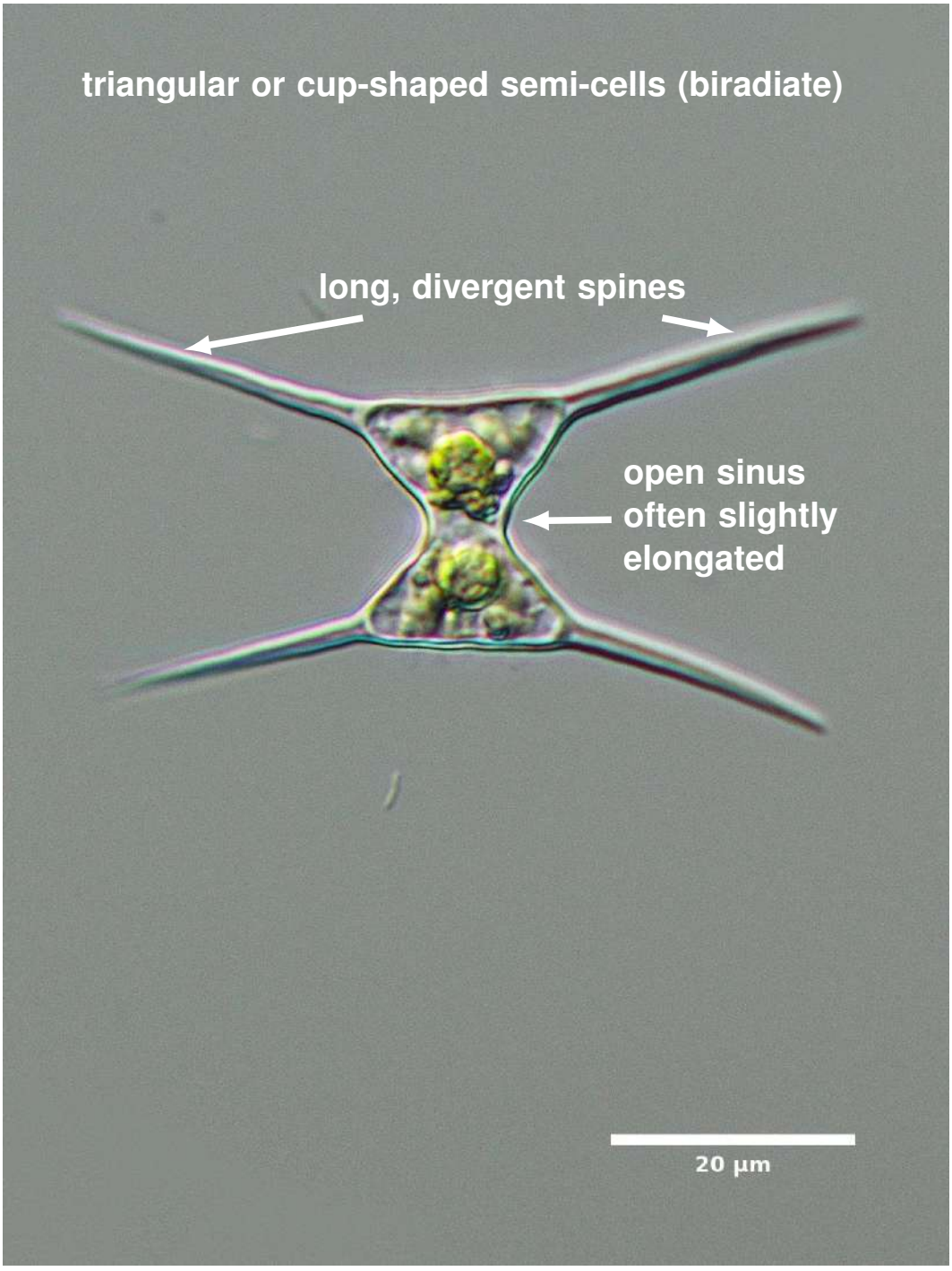
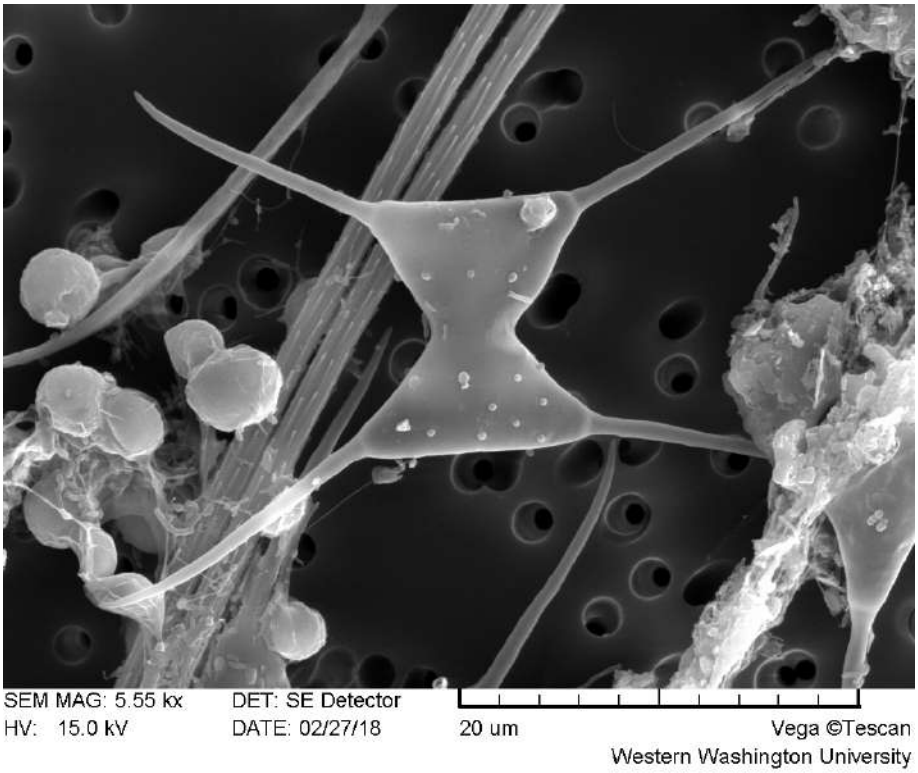


Figure 23.54: *Staurodesmus incus* (DIC), Vogler Lake, Skagit County.



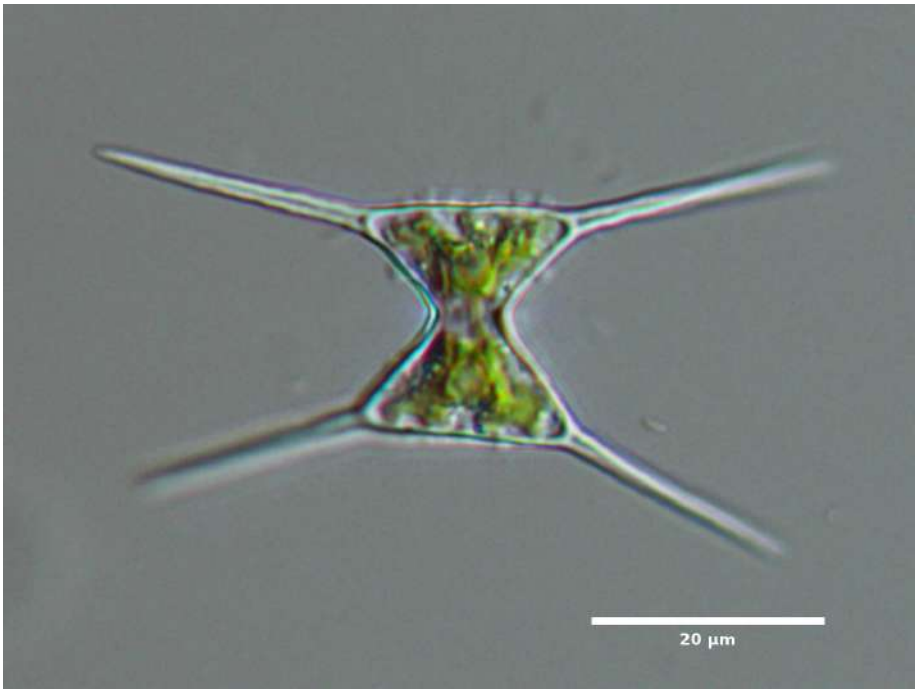


Figure 23.55: *Staurodesmus incus* (SEM/DIC), Vogler Lake, Skagit County (upper/lower images).

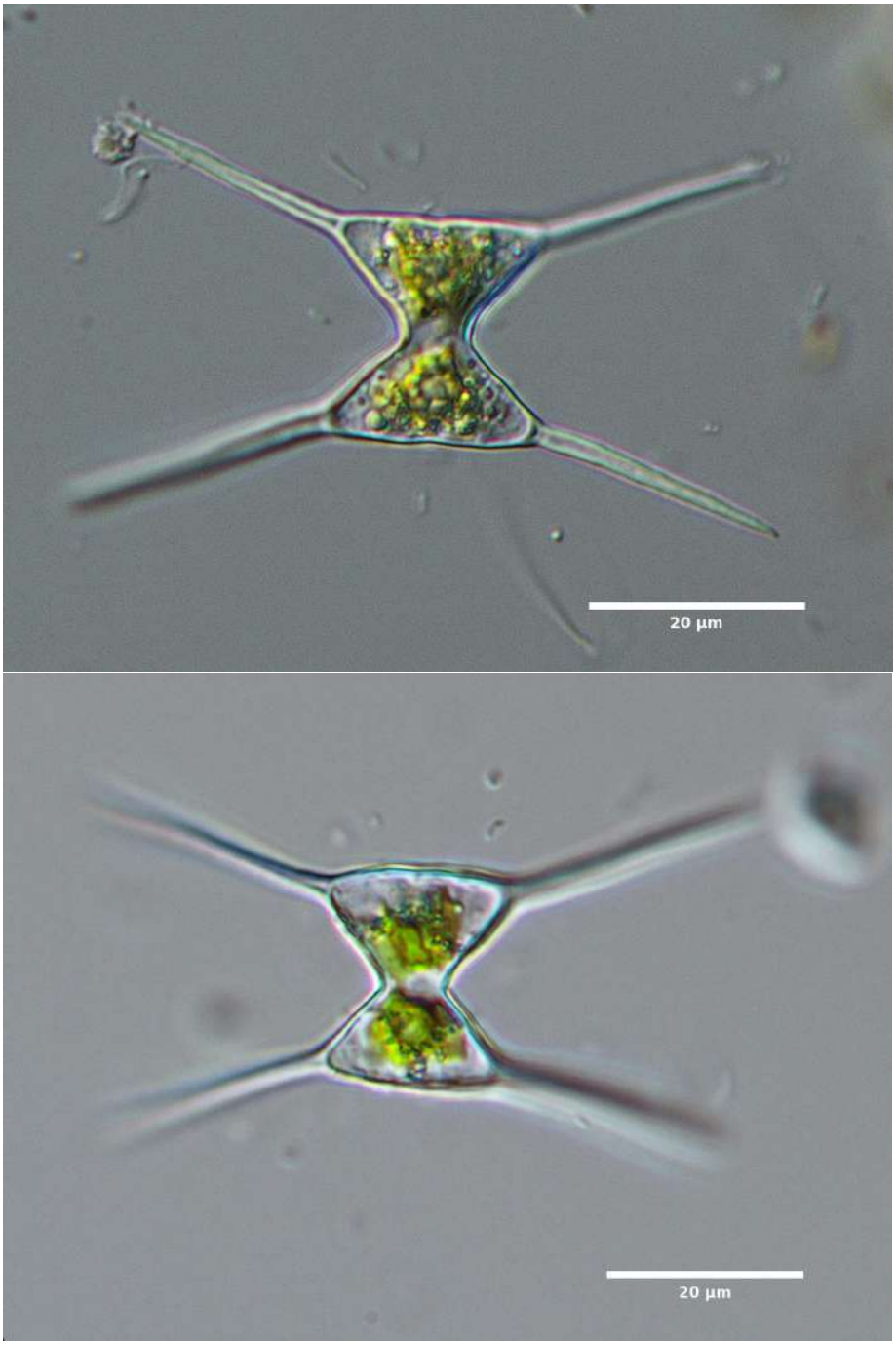


Figure 23.56: *Staurodesmus incus* (DIC/DIC), Grandy Lake, Skagit County (upper image); Lake Shannon, Skagit County (lower image).

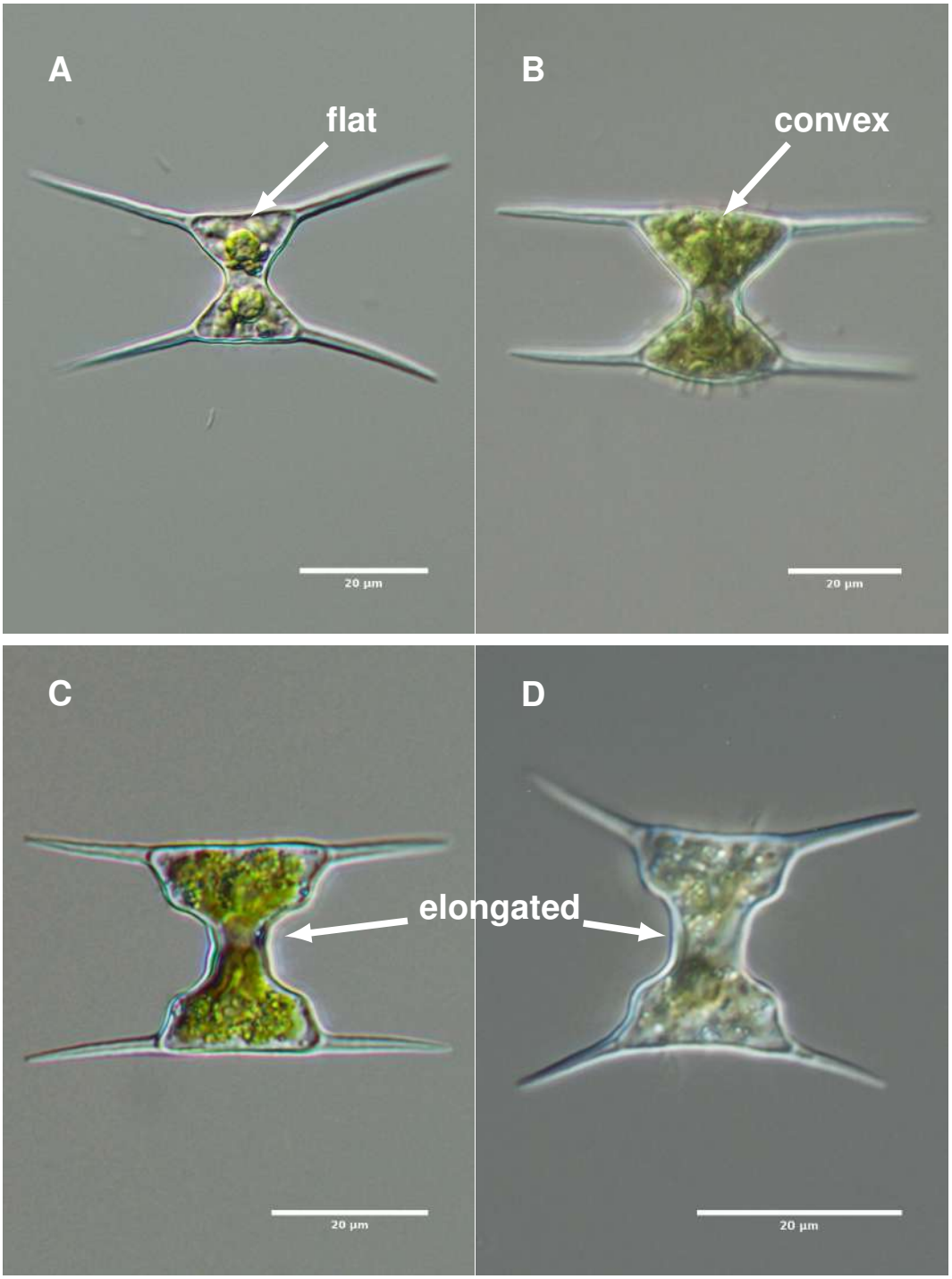


Figure 23.57: *Staurodesmus incus* (A) compared to *Staurodesmus triangularis* (B) and *Staurodesmus extensus* (C–D).



Figure 23.58: *Staurodesmus megacanthus* (DIC), small pond on trail to Lily Lake near Oyster Dome, Skagit County.

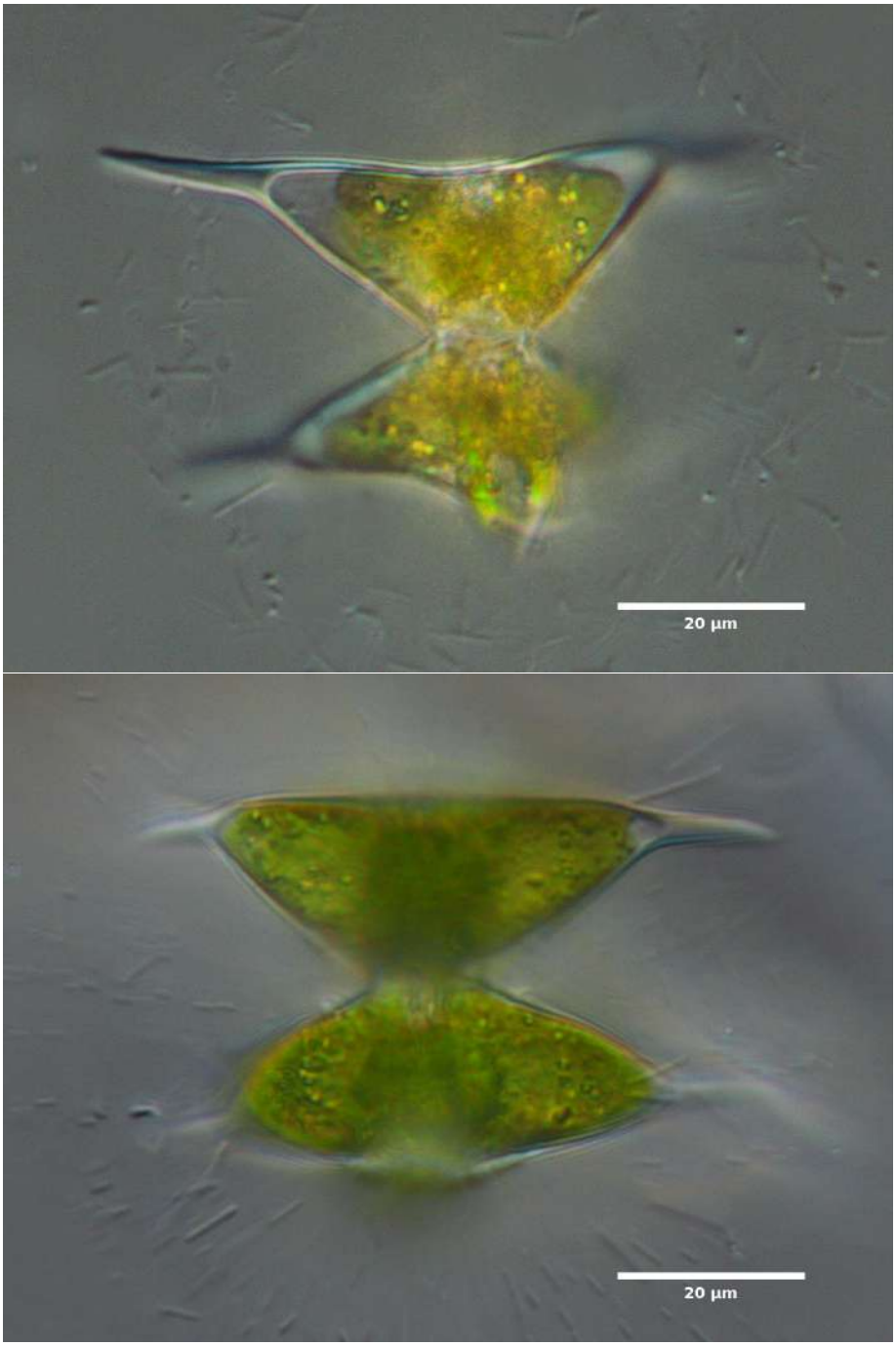


Figure 23.59: *Staurodesmus megacanthus* (DIC/DIC), Storm Lake, Snohomish County (upper image); Canyon Lake, Whatcom County (lower image).

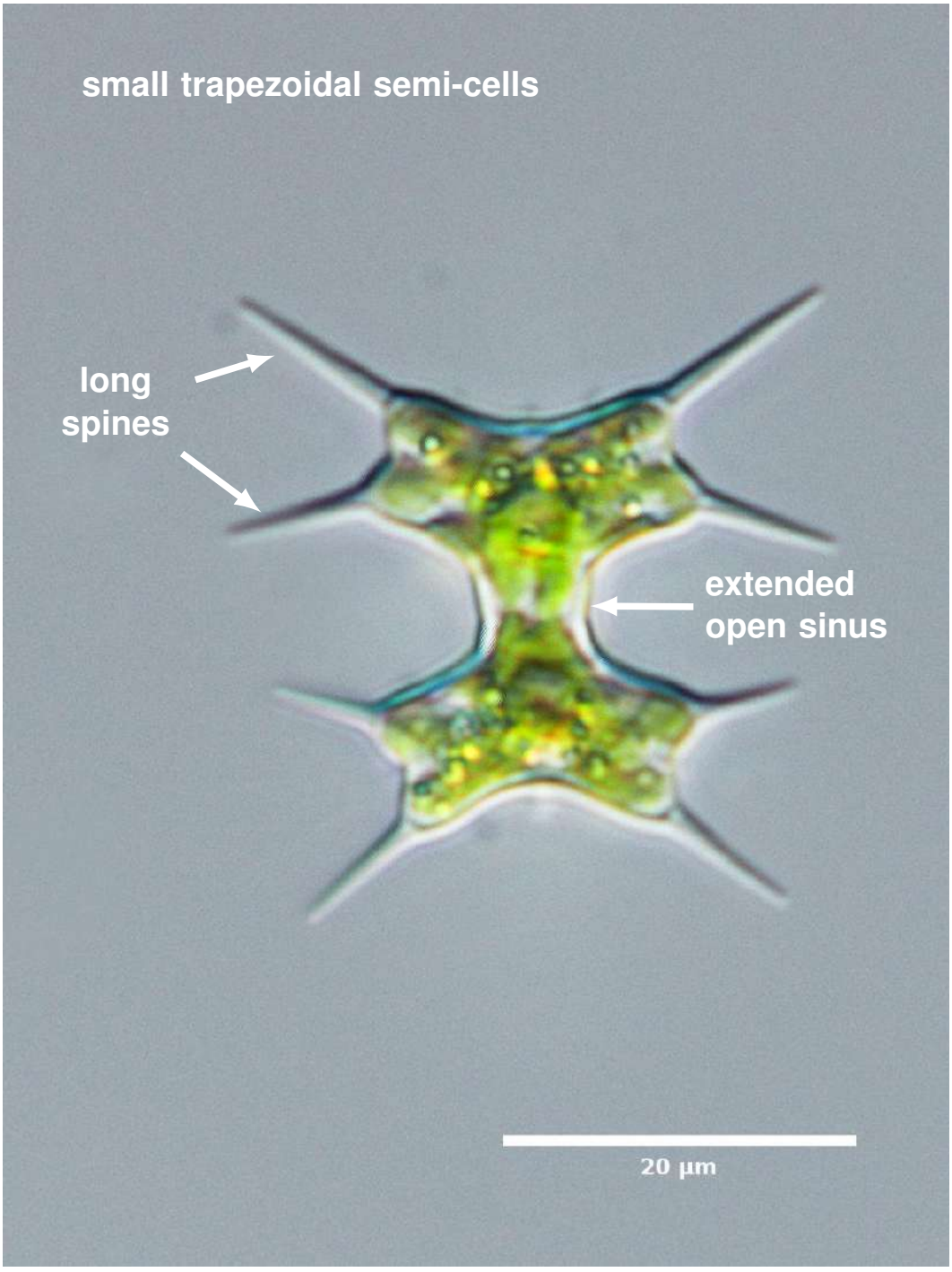
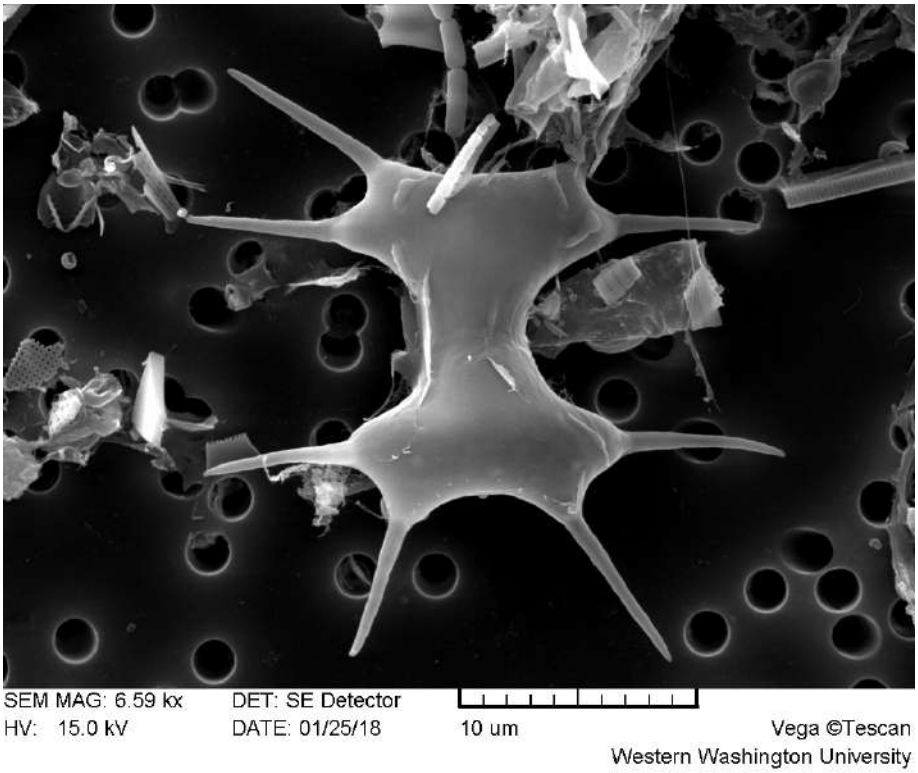


Figure 23.60: *Staurodesmus octocornis* (DIC), small pond on trail to Big Four Ice Caves, Mountain Loop Highway, Snohomish County.



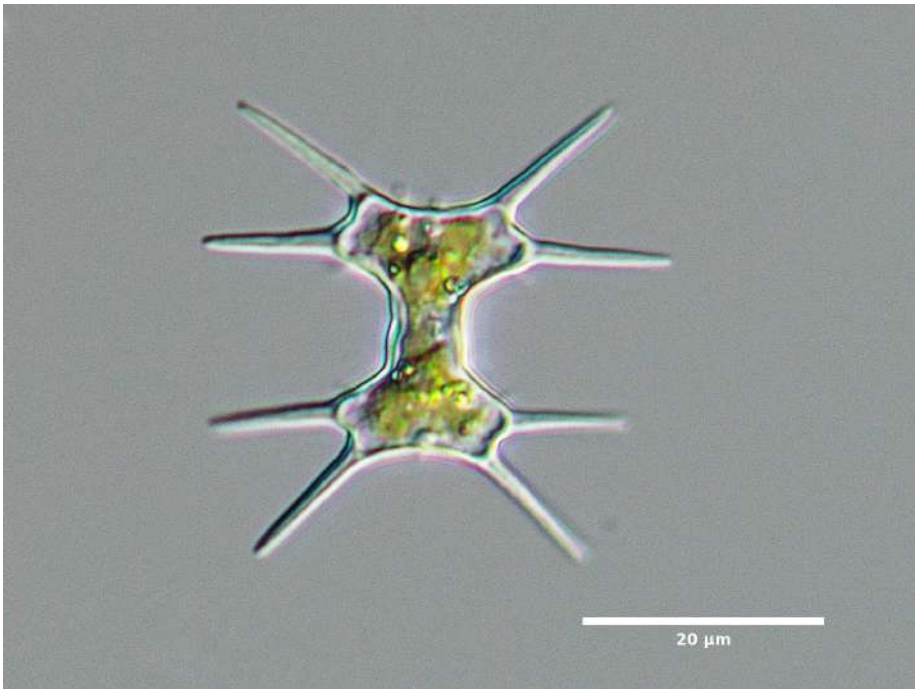


Figure 23.61: *Staurodesmus octocornis* (SEM/DIC), Lake Evan, Mountain Loop Highway, Snohomish County (upper/lower images).

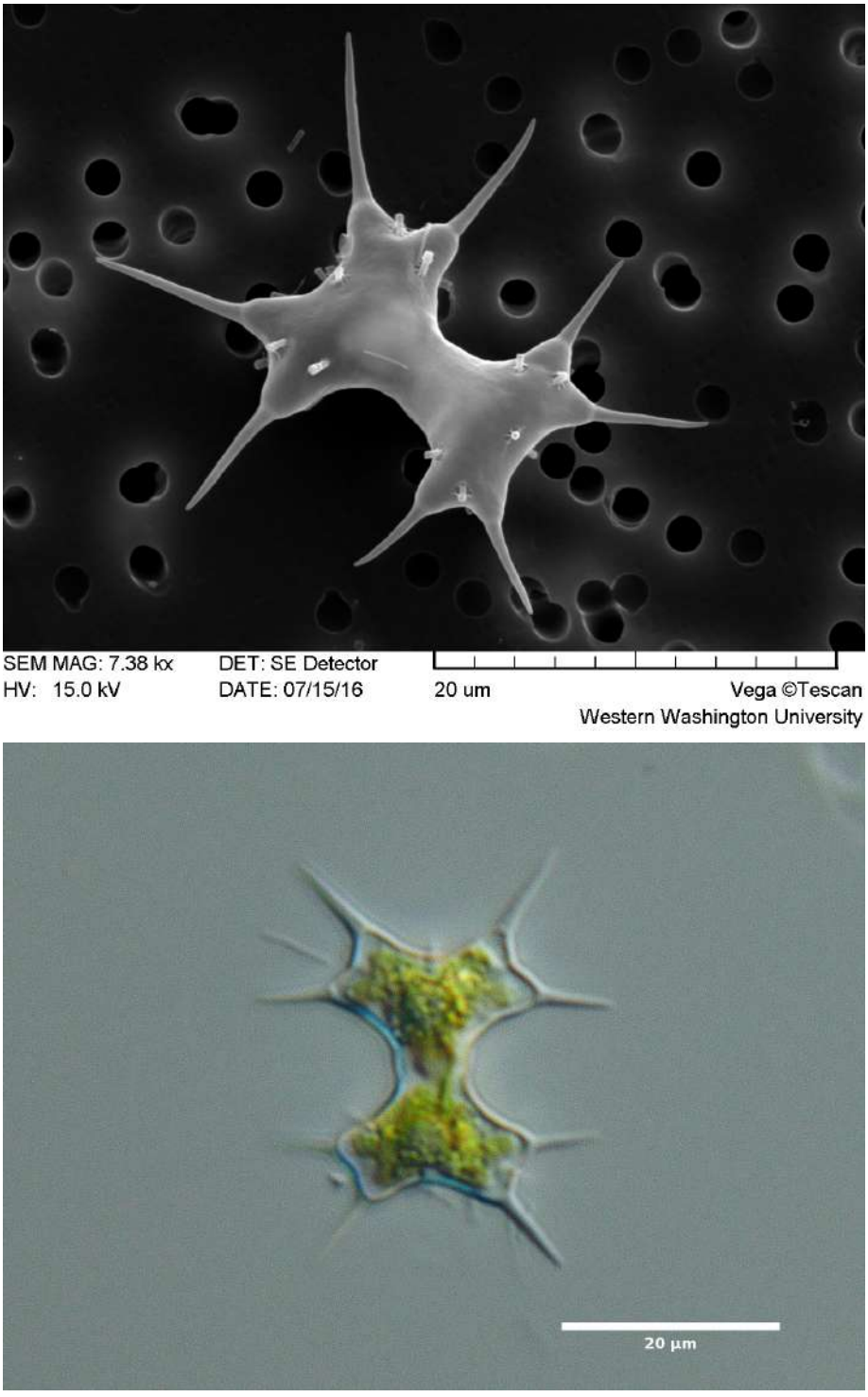


Figure 23.62: *Staurodesmus octocornis* (SEM/DIC), Bear Lake, Mountain Loop Highway, Snohomish County (upper/lower images).

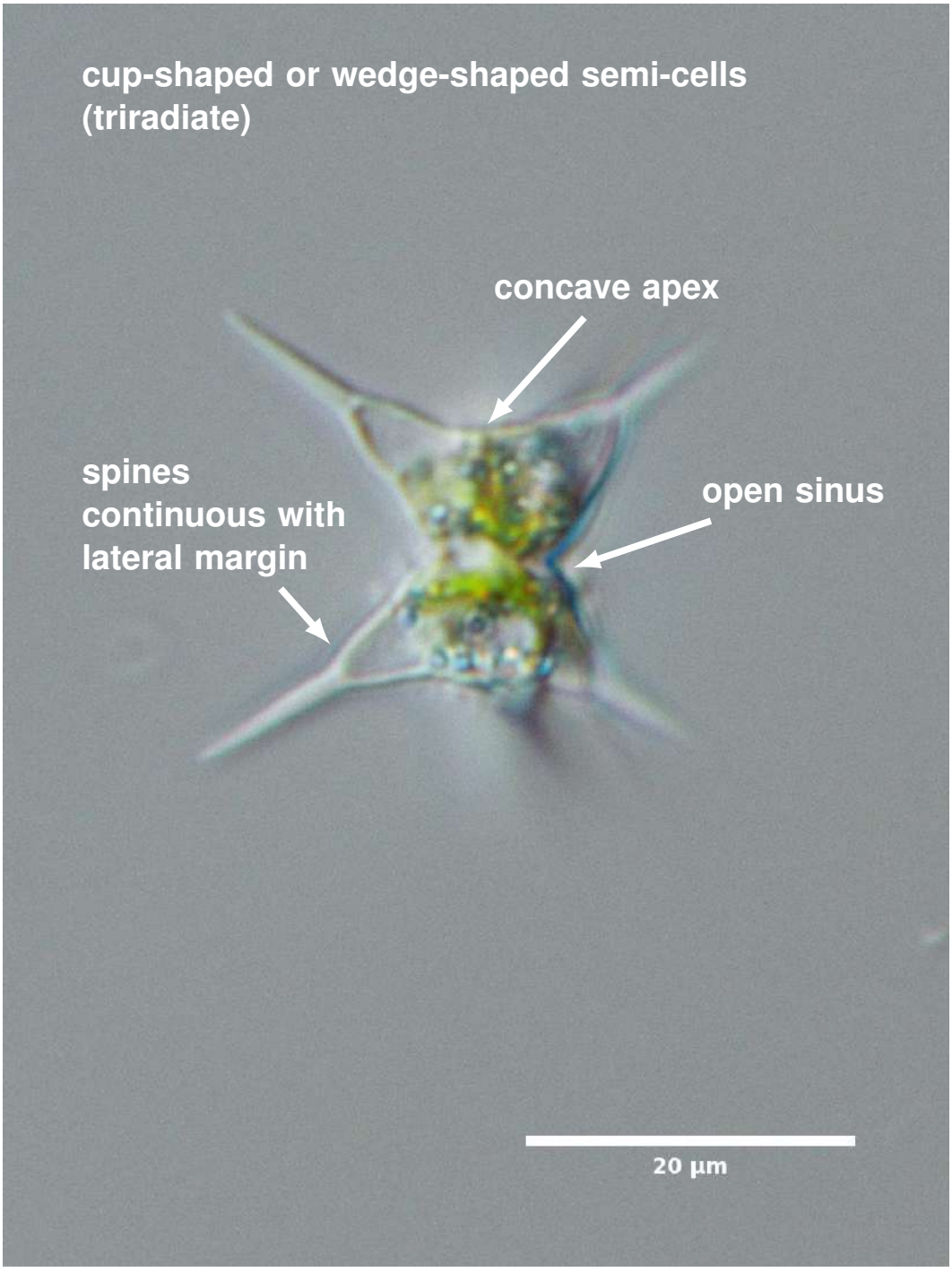


Figure 23.63: *Staurodesmus omearae* (DIC), Bear Lake, Mountain Loop Highway, Snohomish County.

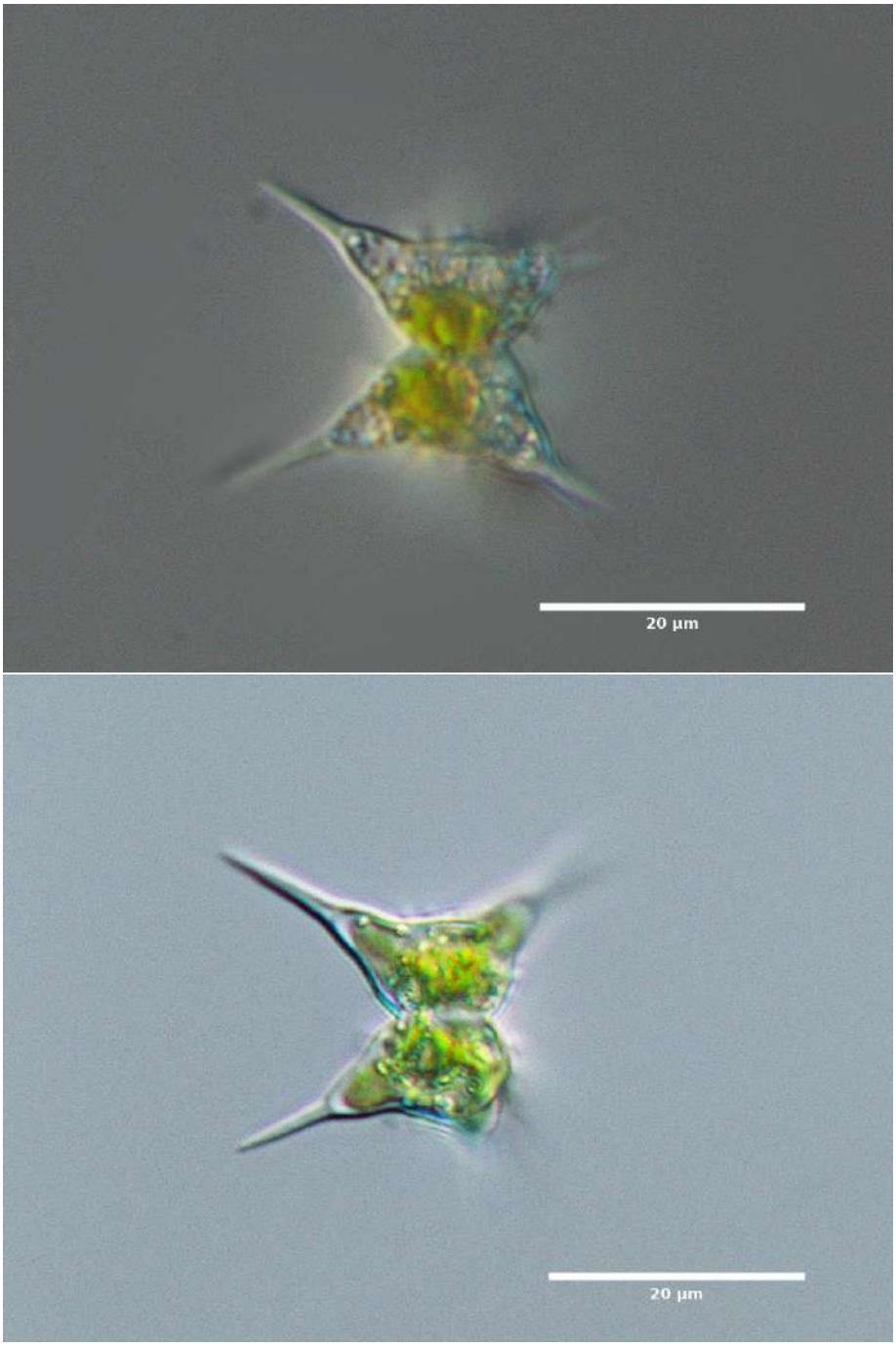


Figure 23.64: *Staurodesmus omearae* (DIC/DIC), Bear Lake, Mountain Loop Highway, Snohomish County (upper/lower images).

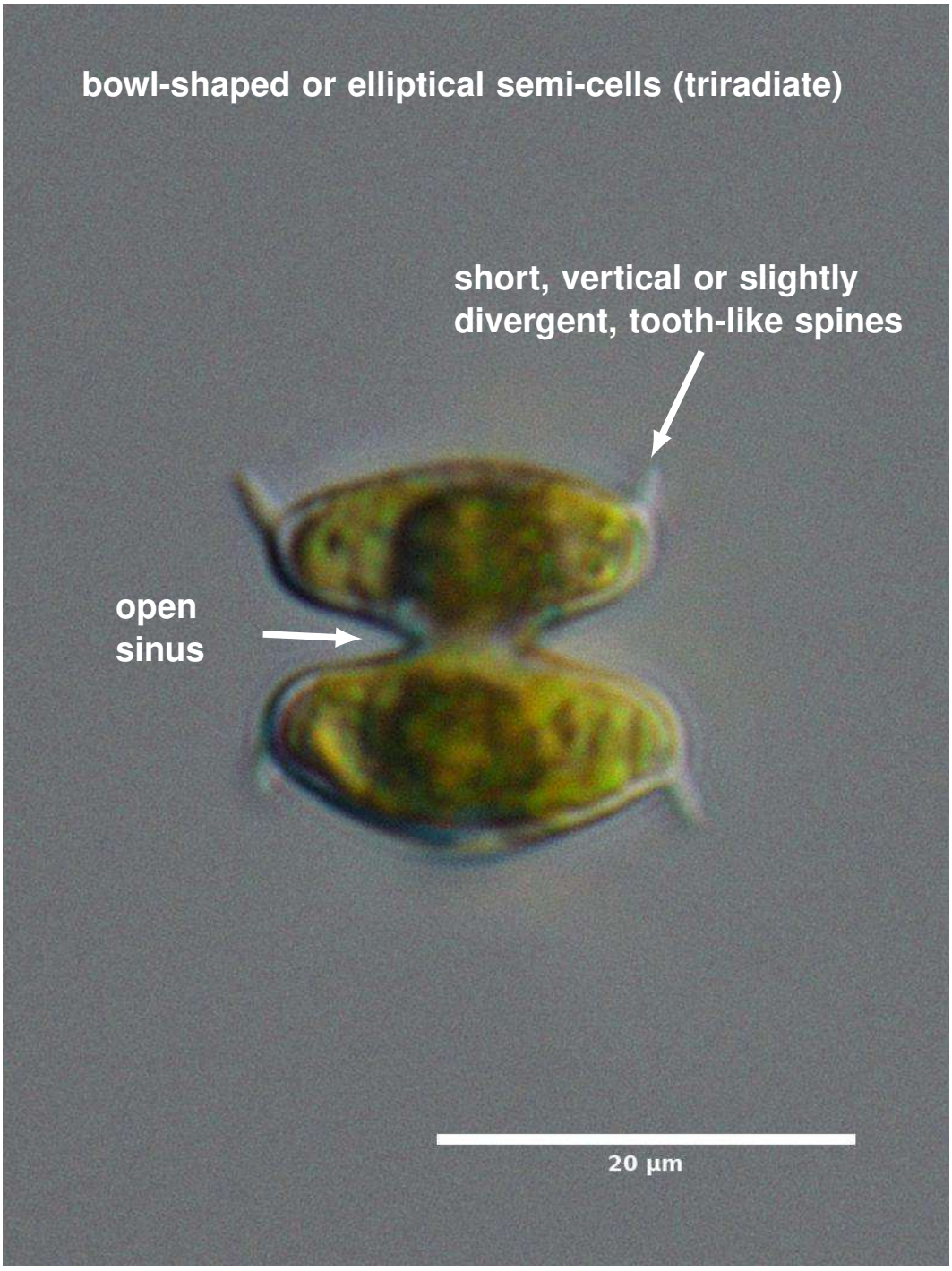


Figure 23.65: *Staurodesmus patens* (DIC), Reed Lake, Whatcom County.



Figure 23.66: *Staurodesmus patens* (DIC), Blue Lake, on trail to Dock Butte, Mt. Baker area, Skagit County.

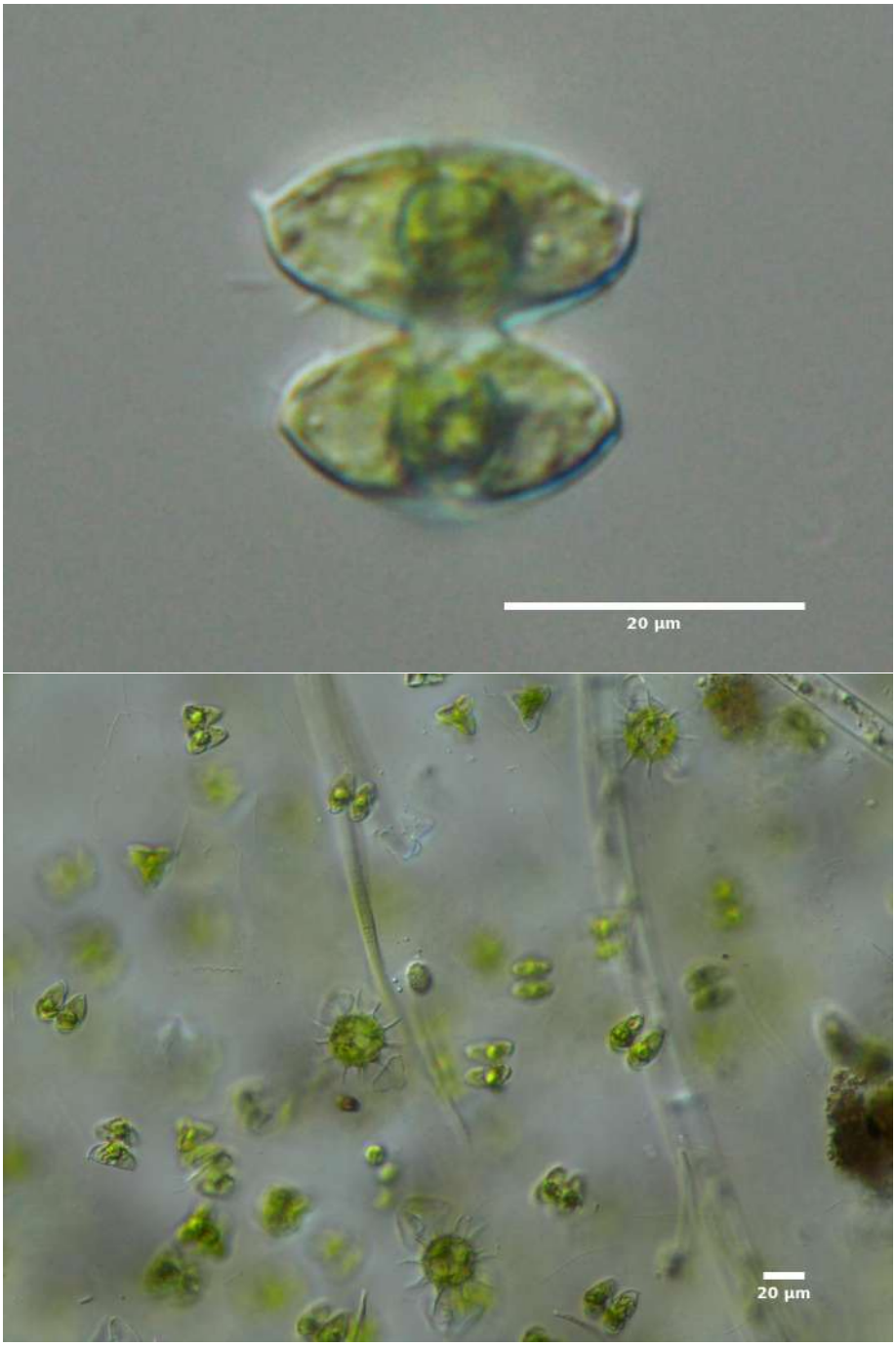


Figure 23.67: *Staurodesmus patens* (DIC/DIC), small pond near Lynnwood, Snohomish County (upper/lower images).

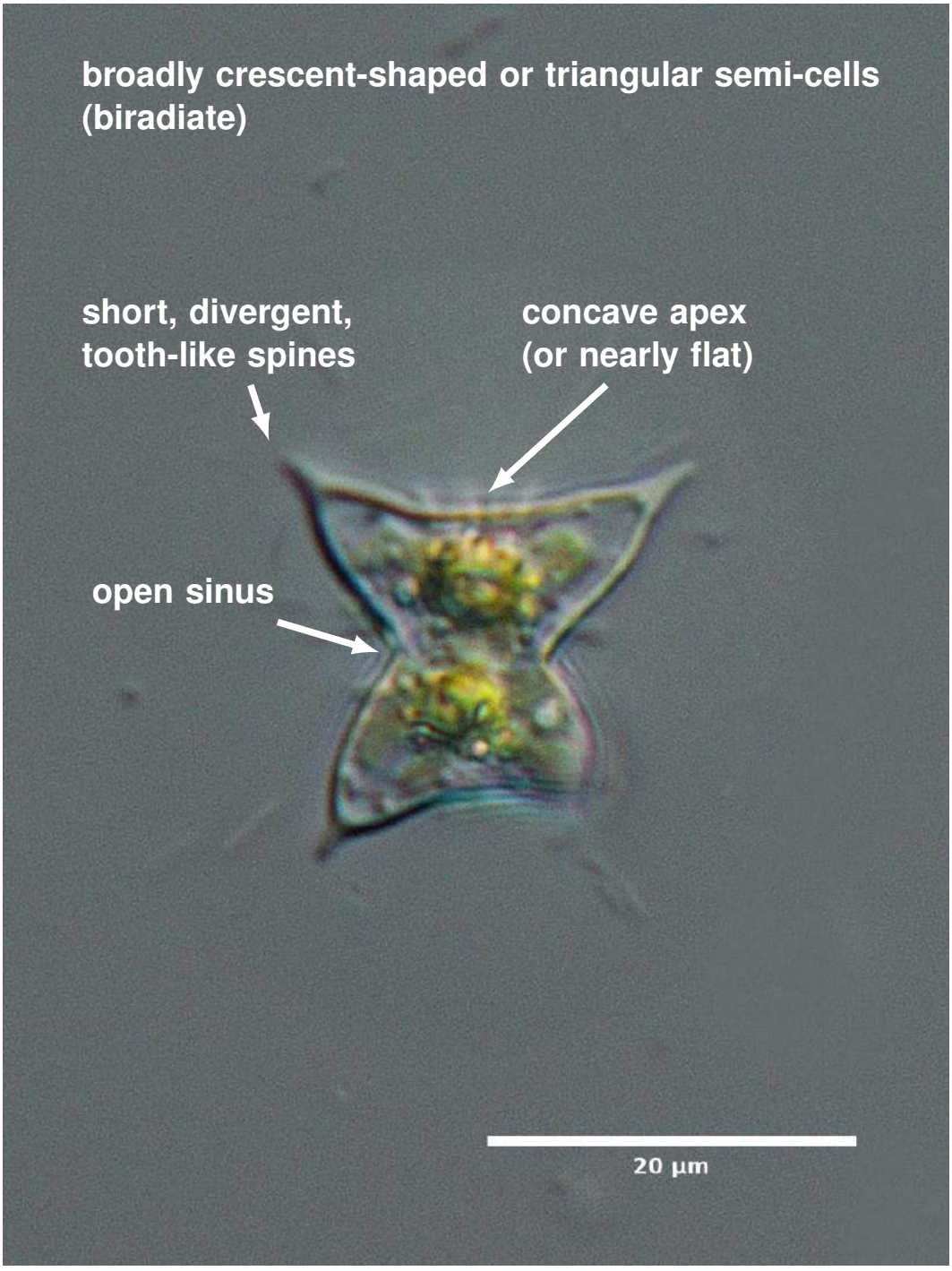


Figure 23.68: *Staurodesmus phimus* (DIC), small boggy pond along Morris Valley Road near Harrison BC.



Figure 23.69: *Staurodesmus phimus* (DIC), small boggy pond along Morris Valley Road near Harrison BC.

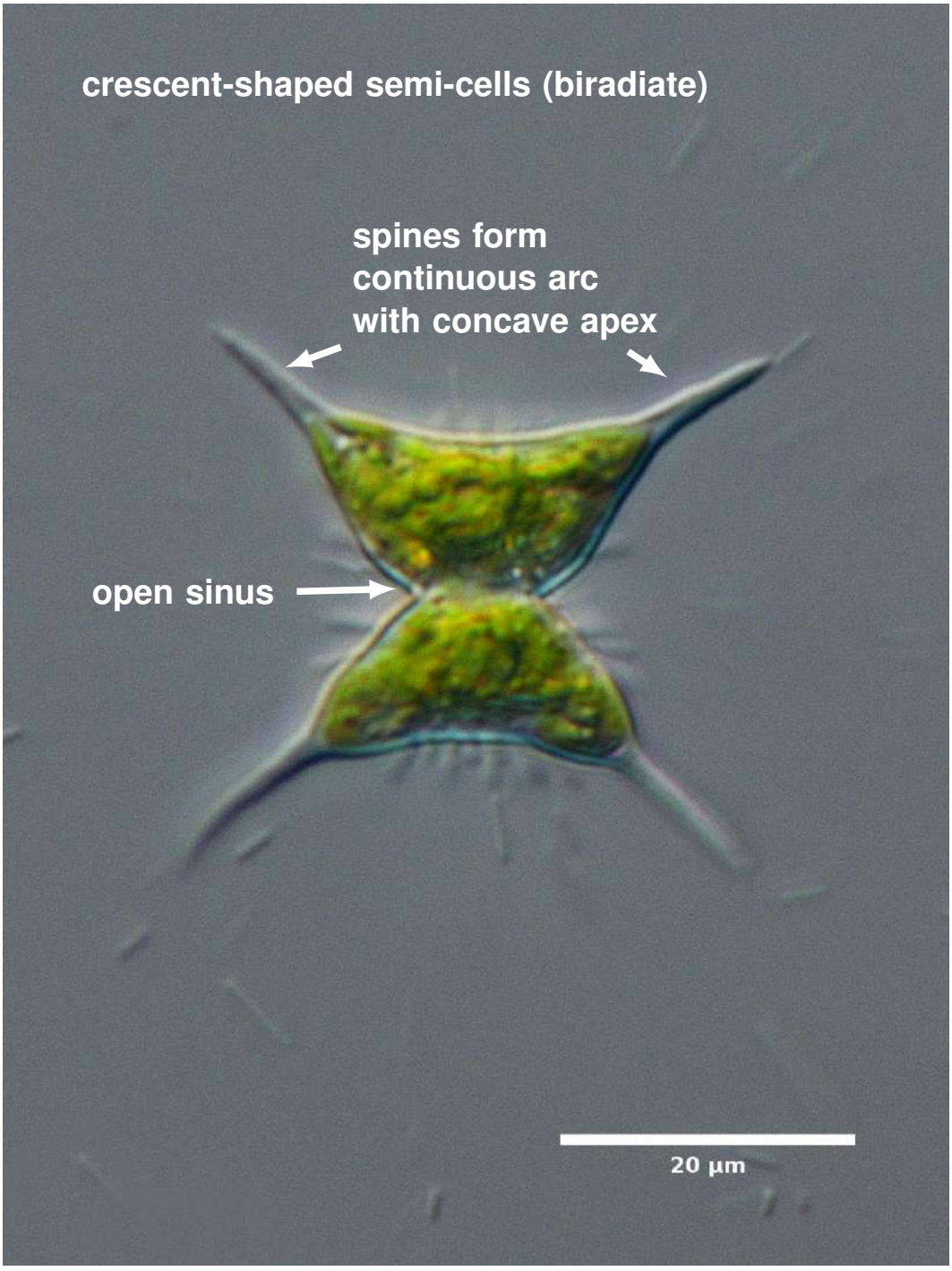
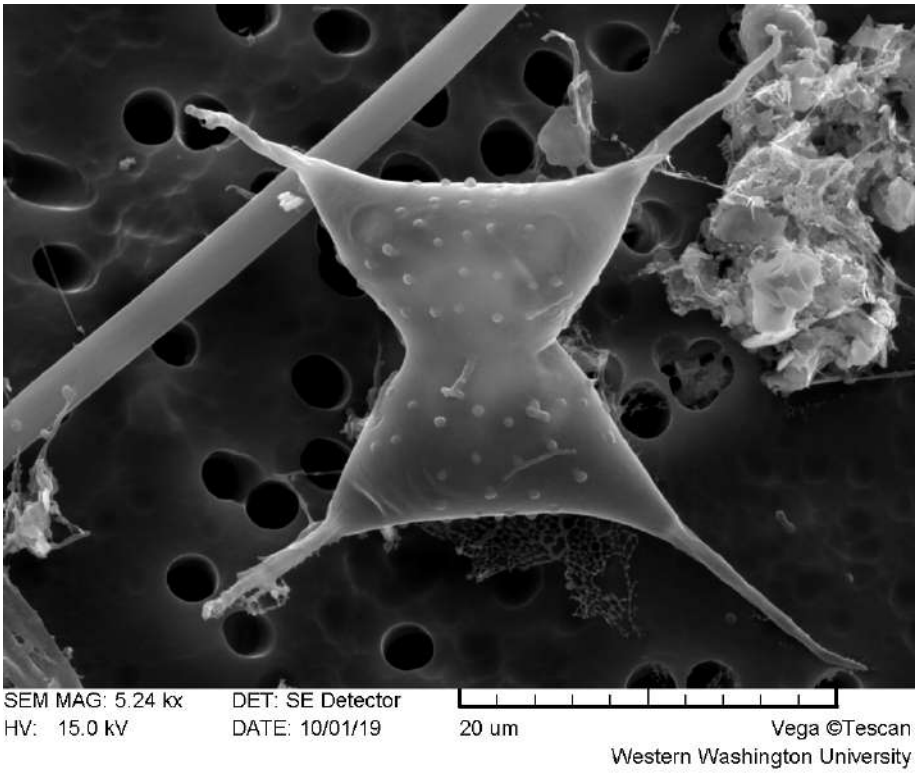


Figure 23.70: *Staurodesmus semilunaris* (DIC), Lake Cavanaugh, Skagit County.



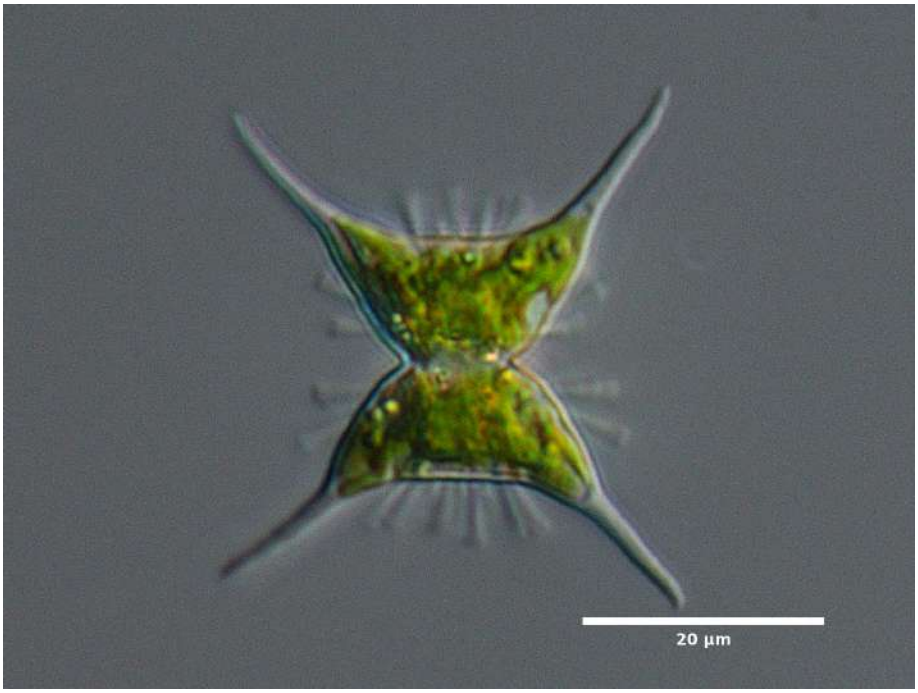
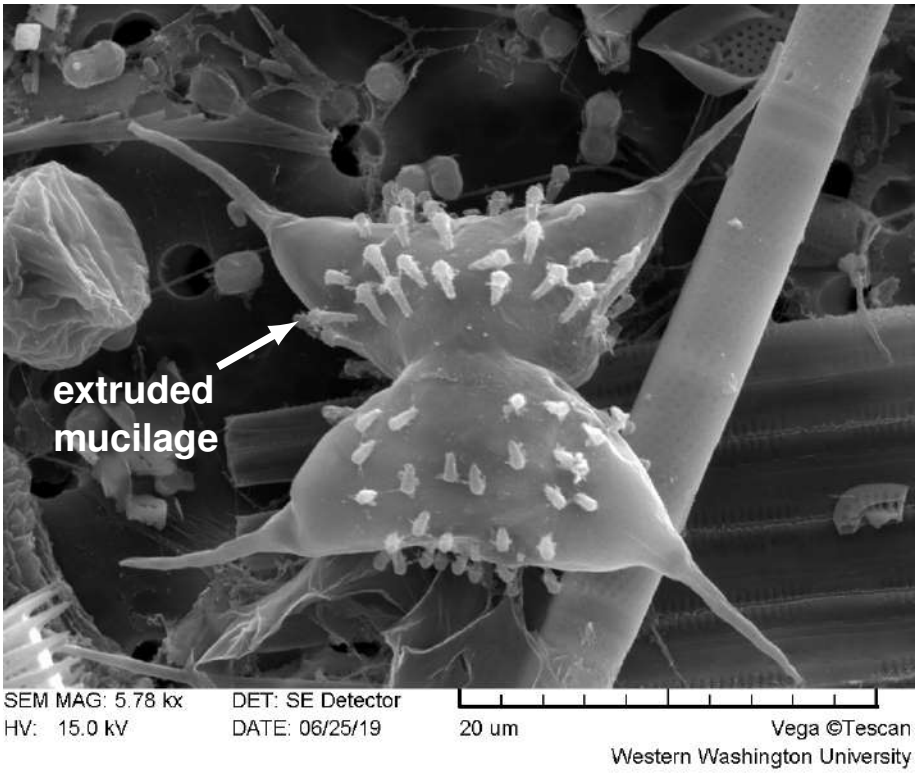


Figure 23.71: *Staurodesmus semilunaris* (SEM/DIC), Lake Cavanaugh, Skagit County (upper/lower images).



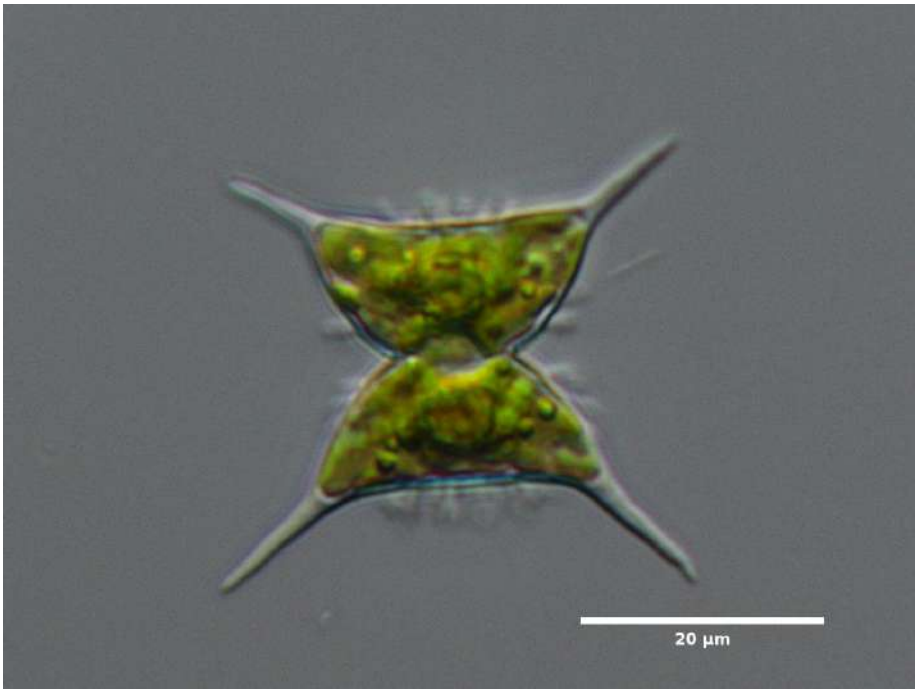


Figure 23.72: *Staurodesmus semilunaris* (SEM/DIC), Lake Whatcom, Whatcom County (upper/lower images).

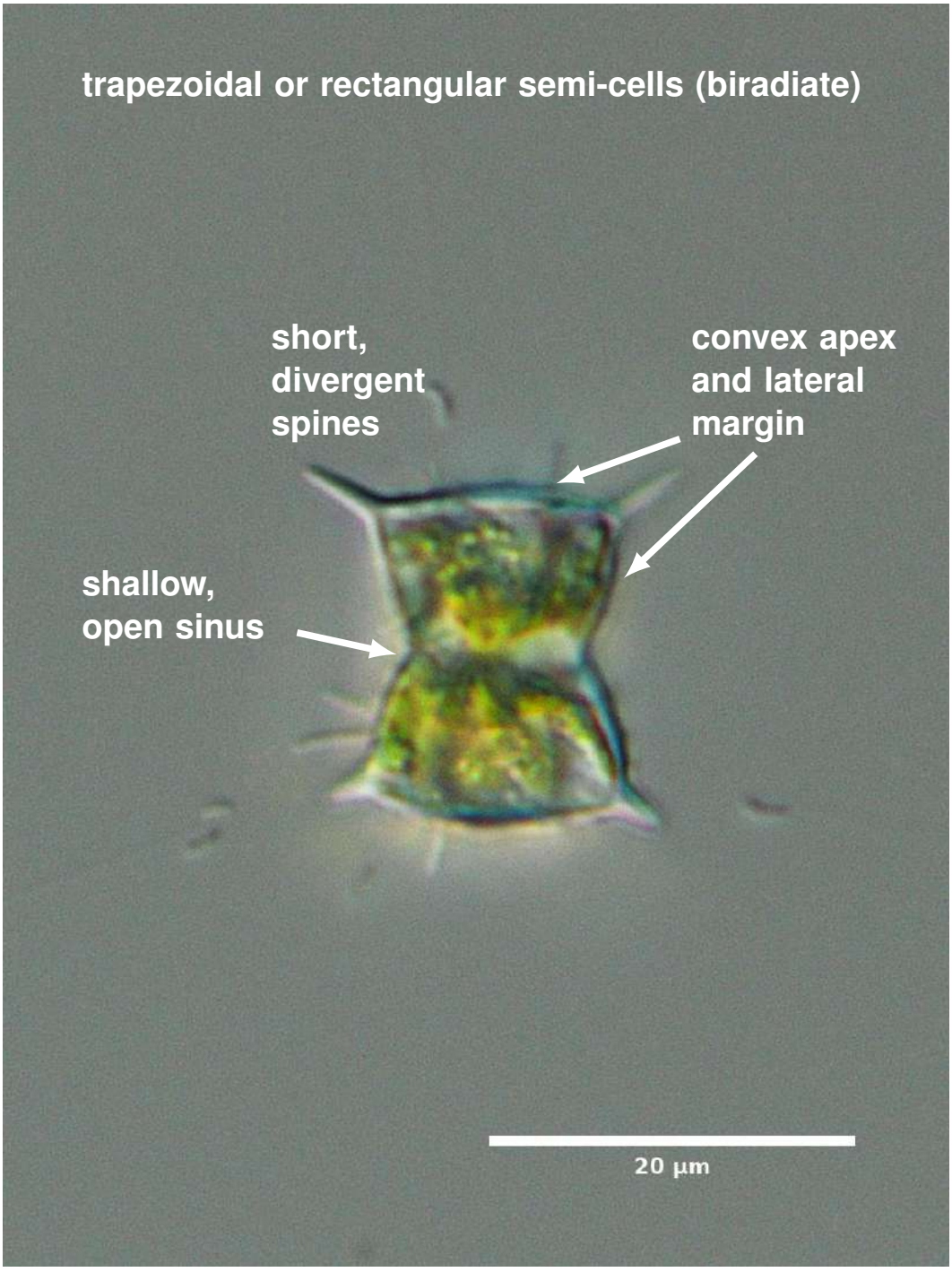
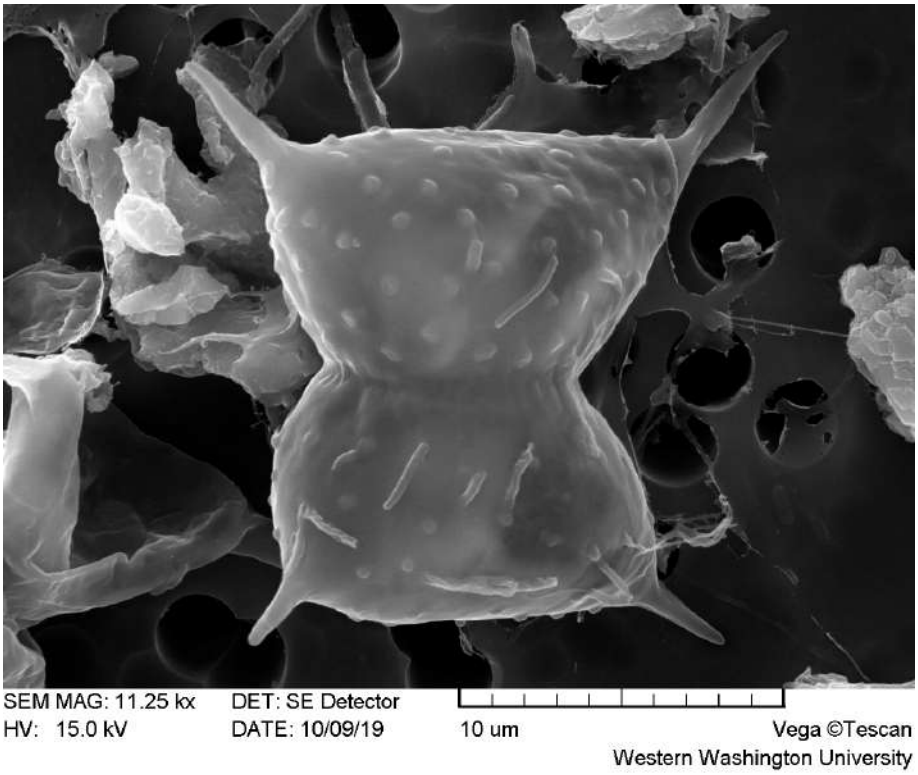


Figure 23.73: *Staurodesmus subquadratus* (DIC), small pond on trail to Lake Ann, Mt. Baker area, Whatcom County.



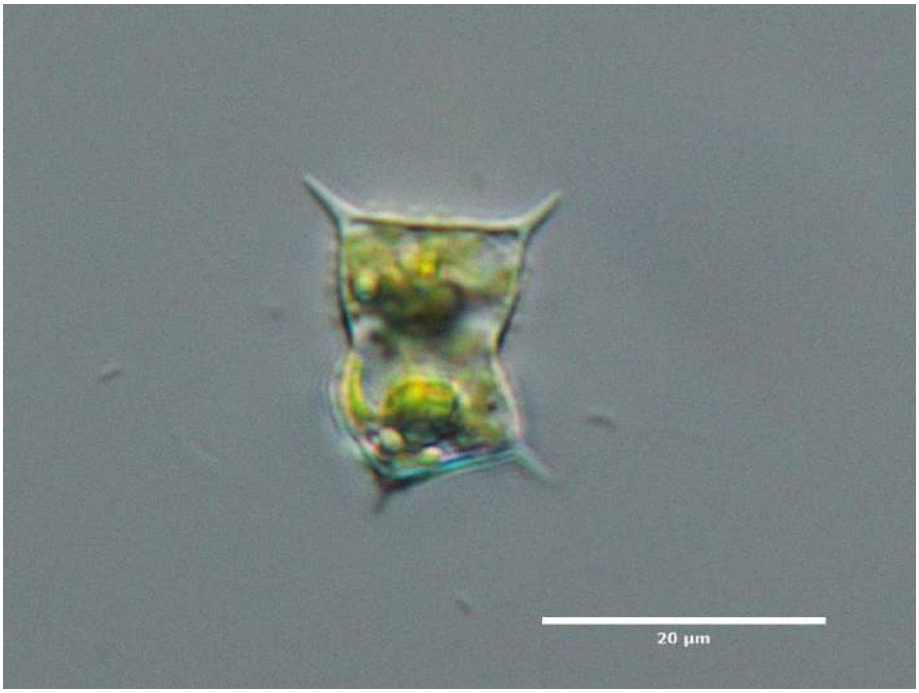
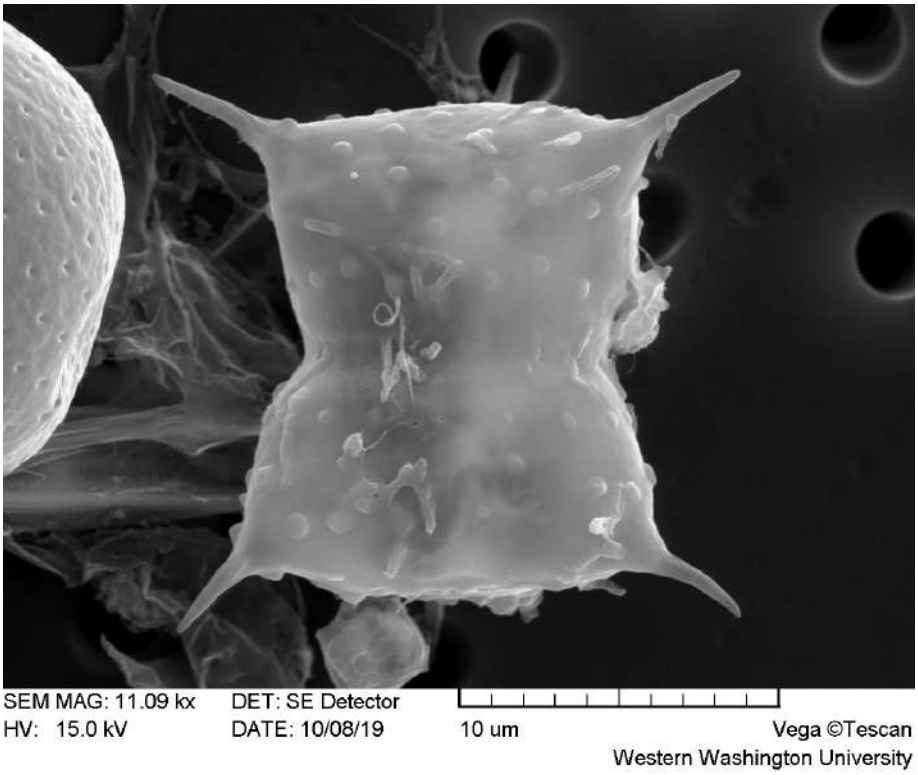


Figure 23.74: *Staurodesmus subquadratus* (SEM/DIC), small pond on trail to Lake Ann, Mt. Baker area, Whatcom County (upper/lower images).



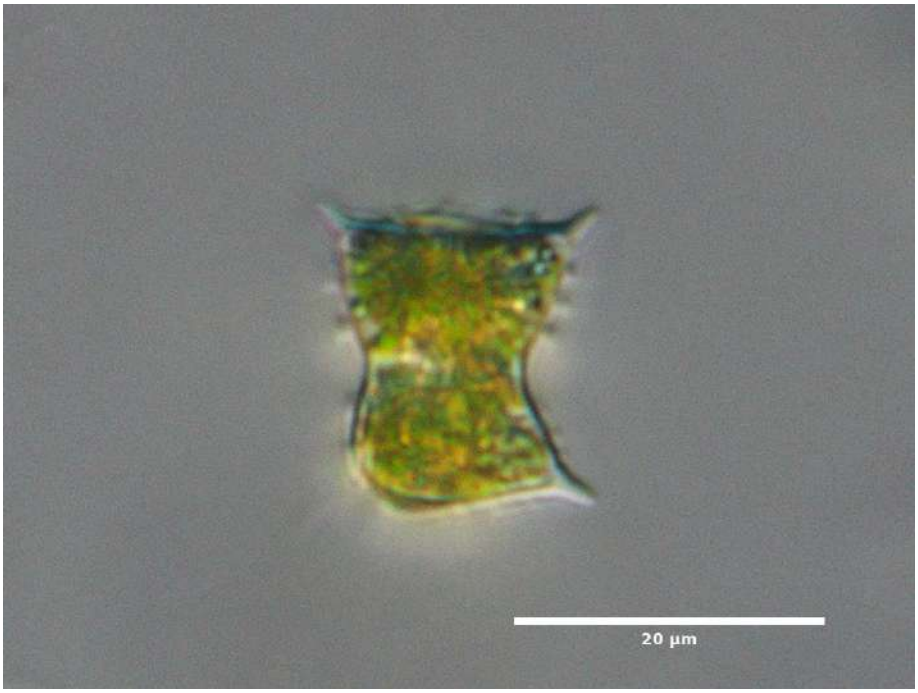


Figure 23.75: *Staurodesmus subquadratus* (SEM/DIC), small pond on trail to Lake Ann, Mt. Baker area, Whatcom County (upper/lower images).

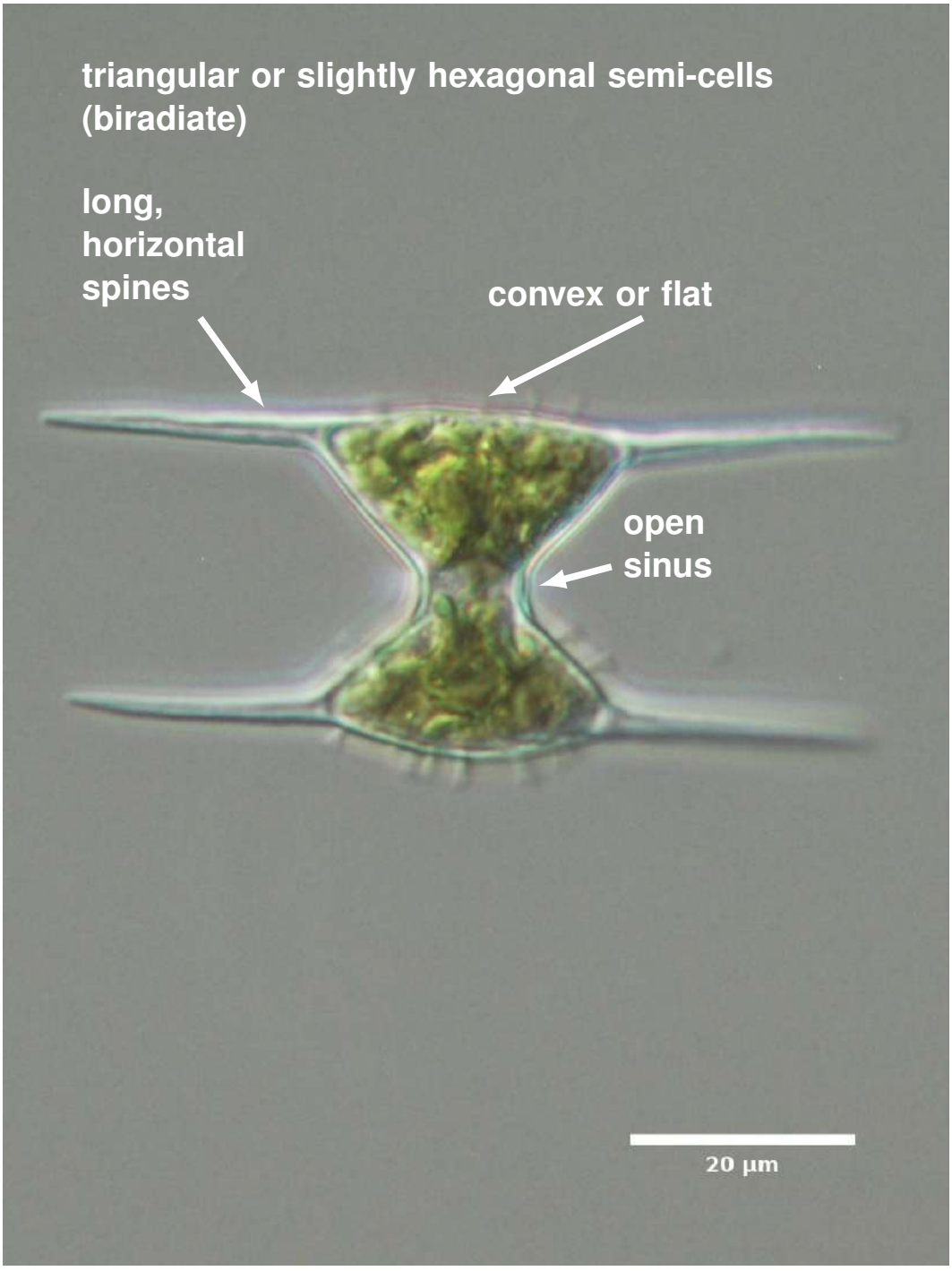
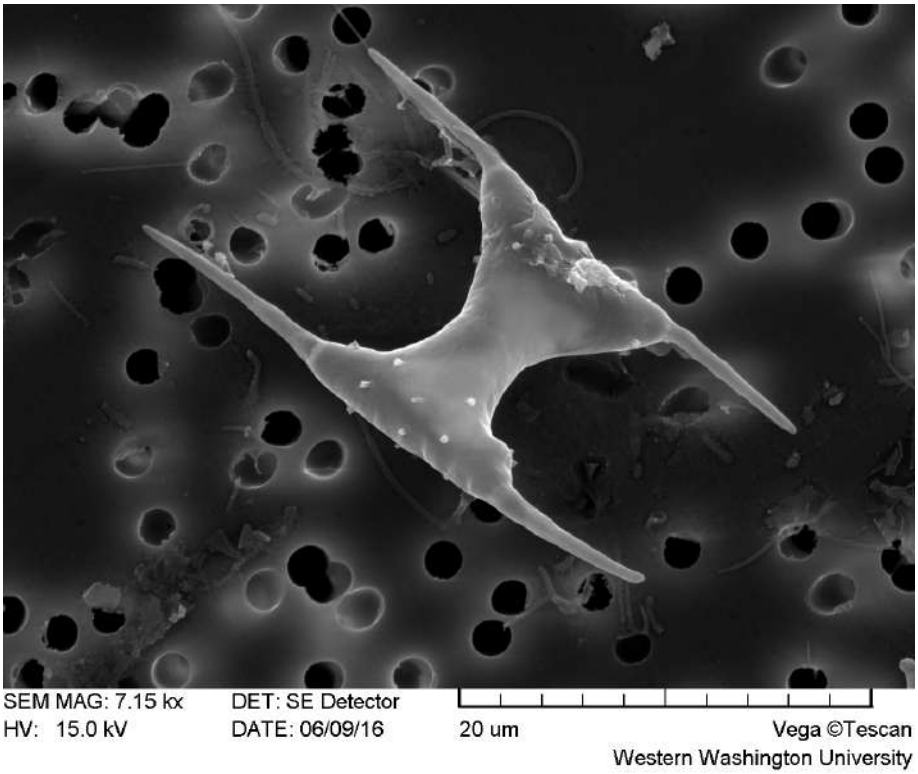


Figure 23.76: *Staurodesmus triangularis* (DIC), Judy Reservoir, Skagit County.



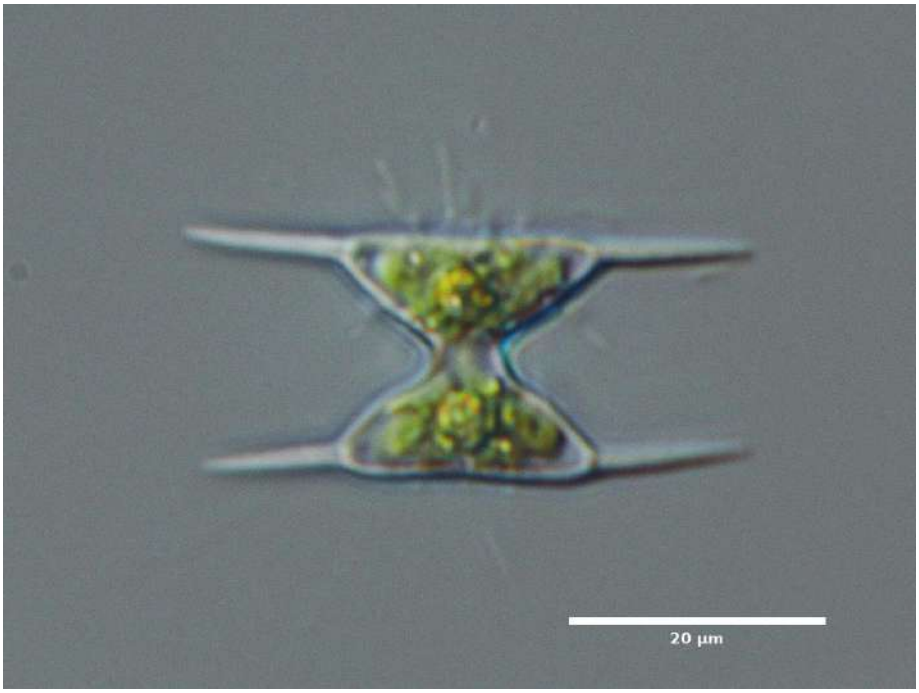


Figure 23.77: *Staurodesmus triangularis* (SEM/DIC), Boardman Lake, Mountain Loop Highway, Snohomish County (upper image); Lake Twenty-two, Mountain Loop Highway, Snohomish County (lower image).

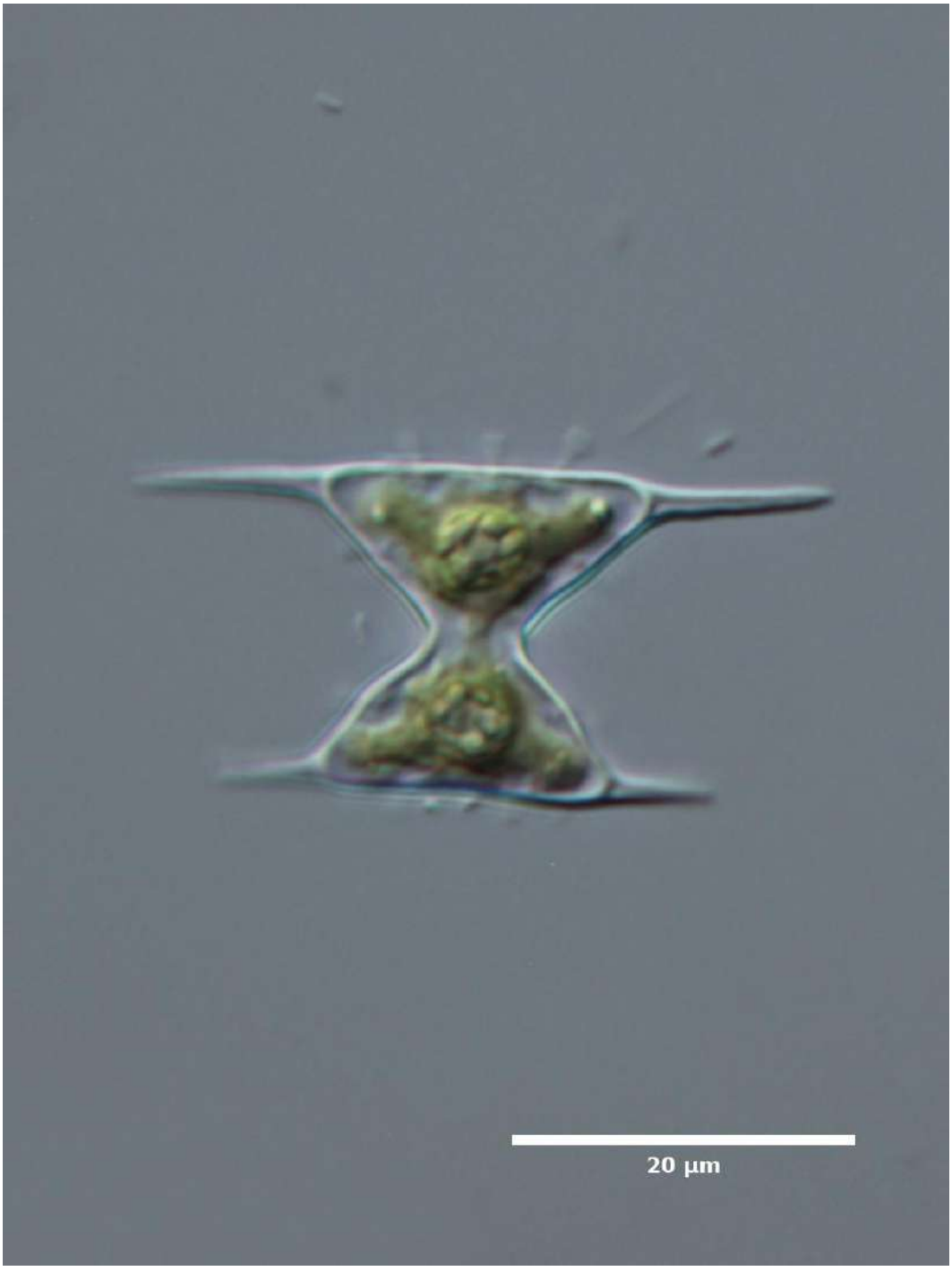


Figure 23.78: *Staurodesmus triangularis* (DIC), Picture Lake, Mt. Baker area, Whatcom County.

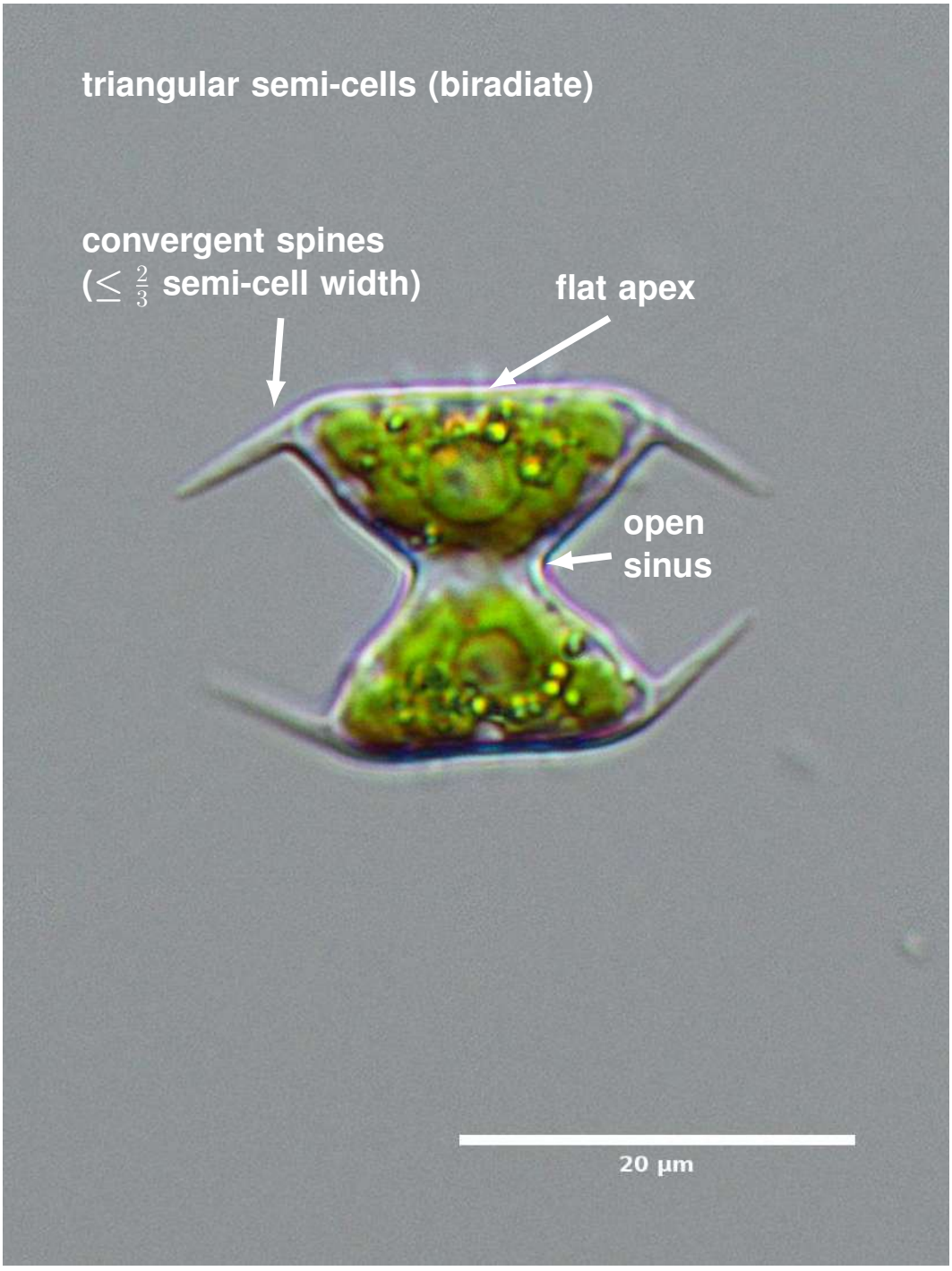
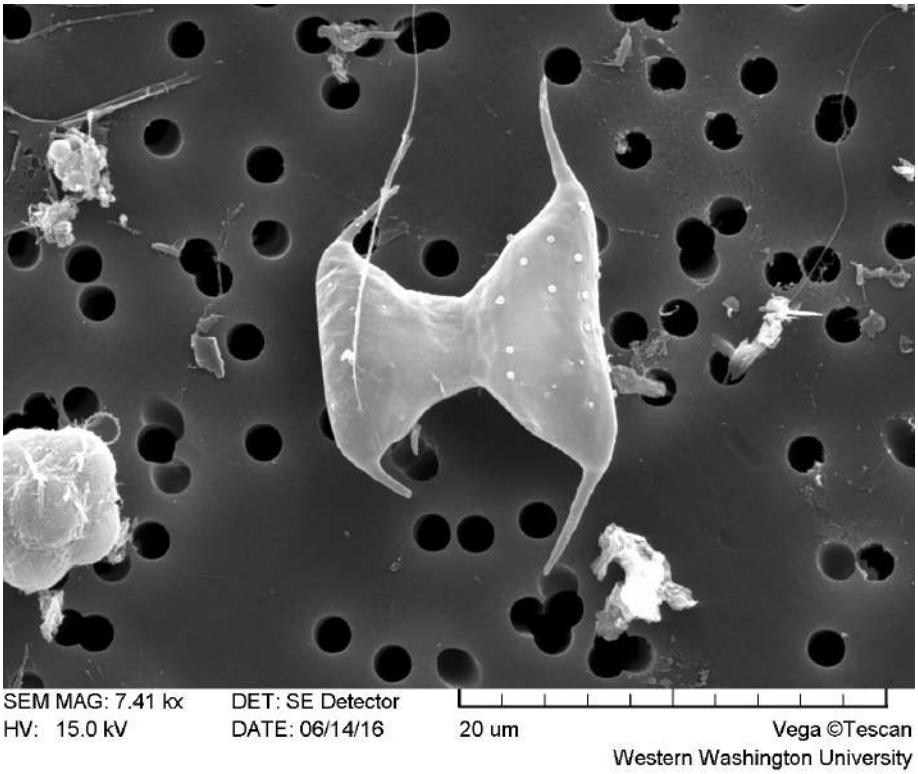


Figure 23.79: *Staurodesmus triangularis* var. *brevispina* (DIC), Gold Basin Mill Pond, Mountain Loop Highway, Snohomish County.



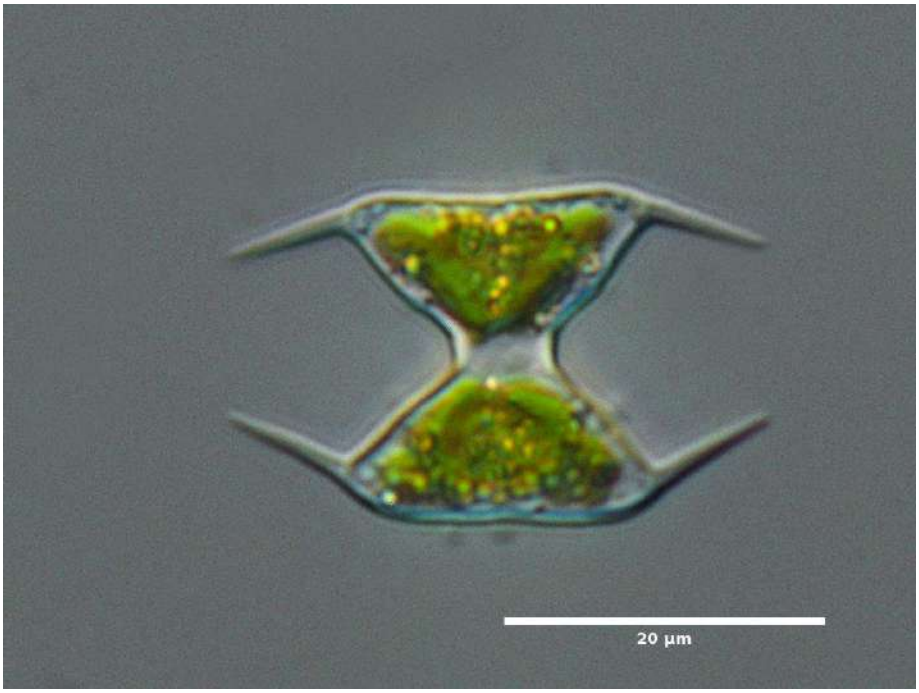
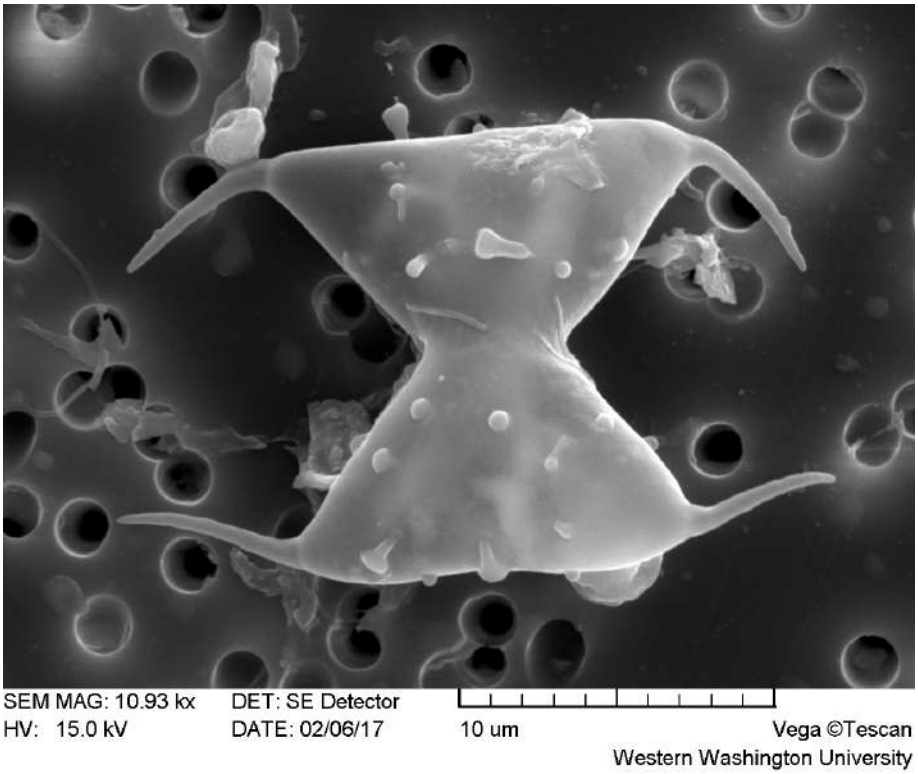


Figure 23.80: *Staurodesmus triangularis* var. *brevispina* (SEM/DIC), Myrtle Lake, Mountain Loop Highway, Snohomish County (upper/lower images).



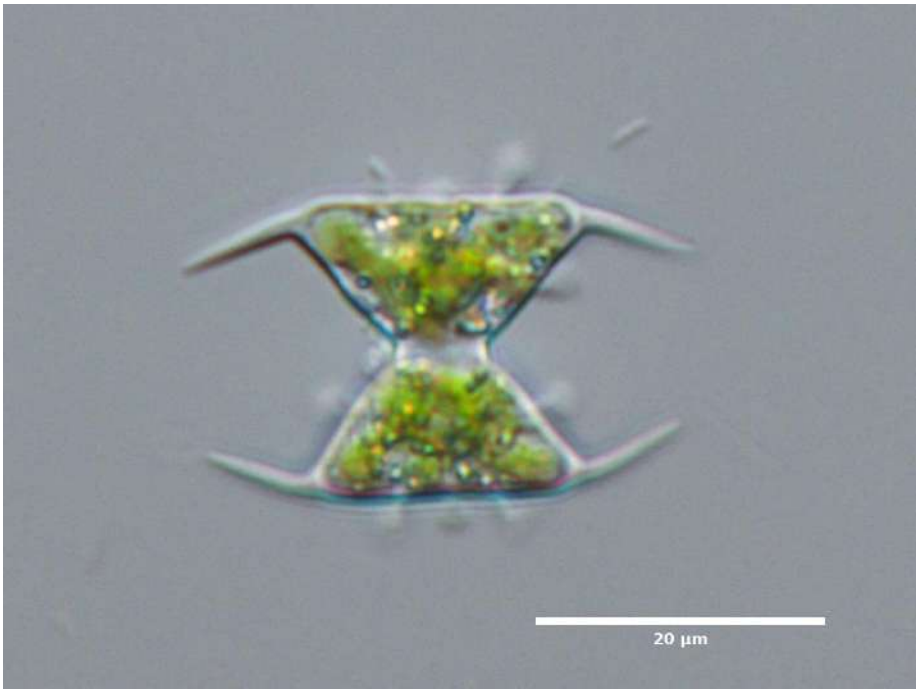


Figure 23.81: *Staurodesmus triangularis* var. *brevispina* (SEM/DIC), Bear Lake, Mountain Loop Highway, Snohomish County (upper/lower images).

Chapter 24

Teilingia Bourrelly

Northwest Washington taxa
Teilingia excavata (Ralfs ex Ralfs) Bourrelly
Teilingia granulata (J. Roy & Bisset) Bourrelly
Teilingia sp. 1

Table 24.1: Key to *Teilingia* Species

A	Sinus shallow, broad; cell margin nearly smooth, with only a few large granules	*Teilingia excavata* (Figures 24.2 – 24.4)
B	Sinus moderately deep, V-shaped; cell margin rough, with clusters of large granules	*Teilingia granulata* (Figures 24.5–24.8)
C	Sinus moderately deep, U-shaped, expanded near isthmus; cell margin smooth or faintly granulated	*Teilingia* sp. 1 (Figures 24.9–24.11)

Table 24.2: *Teilingia* Cell Measurements

		Cell Width	Cell Length	Isthmus Width	L/W Ratio
Teilingia excavata	min	8.0 μm	8.6 μm	4.7 μm	0.9
	med	8.9 μm	9.2 μm	5.3 μm	1.1
	max	10.0 μm	10.3 μm	5.7 μm	1.3
Teilingia granulata	min	9.4 μm	8.1 μm	4.1 μm	0.8
	med	12.4 μm	11.1 μm	5.5 μm	0.9
	max	16.7 μm	15.2 μm	7.2 μm	1.1
Teilingia sp. 1	min	18.3 μm	14.4 μm	6.6 μm	0.7
	med	19.1 μm	14.9 μm	7.1 μm	0.8
	max	20.1 μm	16.0 μm	7.1 μm	0.9

Description

Teilingia cells are small and rectangular, with an open sinus (Figures 24.1–24.11). The apex is flat, but has tiny, inconspicuous granules that are an important identification feature for this genus (Figure 24.3).

Teilingia can be difficult to distinguish from *Onychonema* (Section 15, page 625), *Sphaerozosma* (Section 19, page 707), and *Spondylosium* (Section 21, page 735). Not surprisingly, many of the species in each genus have synonyms from one or more of the other genera in this group. The distinction between *Onychonema*, *Sphaerozosma*, *Spondylosium*, and *Teilingia* is based primarily on the way in which the cells are separated in the filament (Figure 24.1). *Onychonema* and *Sphaerozosma* cells are joined by rod-like structures and the cells are clearly separated from each other in the filament. *Teilingia* is particularly difficult to distinguish from *Spondylosium planum*, which has very similar cells that are joined across a flat, smooth apex (no apical granules).

Teilingia excavata cells are small, with a broad, shallow sinus (Figures 24.2–24.4). The semi-cells are oval or broadly elliptical, with rounded lateral margins and a flattened apex containing the four small granules that connect adjacent cells. The cell surface is smooth except for a few large granules along the lateral margin, and, occasionally, scattered rows of pores that may look like tiny granules (Figure 24.3).

Teilingia granulata is the most common species found in northwest Washington lakes and ponds and is the most likely species to be collected in mesotrophic, low elevation sites. The cells are rectangular and flattened, with a deep, open sinus (Figures 24.5–24.8). The semi-cells are oval or broadly elliptical, with a rounded or slightly truncated lateral margin.[65] In addition to the apical granules, which are a characteristic of the genus, *Teilingia granulata* have clusters of three or more large granules along the lateral margin of the semi-cells and a few large granules scattered across the face of the semi-cell. *Teilingia granulata* is morphologically variable, especially with respect to the degree of granulation along the lateral margins and cell face (compare Figures 24.7 and 24.8). Smooth specimens resemble *Teilingia excavata* (Figure 24.2), which can be distinguished by its broadly open sinus and slightly smaller cells.

The specimens in Figures 24.9–24.11 are tentatively listed as a species of *Teilingia* because there seems to be small granules connecting adjacent cells. The cells are oval in outline, with kidney-shaped or broadly elliptical semi-cells. The sinus is deep, open, and slightly expanded near the isthmus (U-shaped). The lateral margins are rounded and are only faintly granular; however, the SEM image suggests that at least some of the cells in the filament may have a few large granules. The specimens are relatively large and fall outside the cell dimensions listed for *Teilingia granulata* and *Teilingia excavata* by Croasdale, et al. (1983) and Coesel and Meesters (2007).

[65] According to Croasdale, et al. (1983), cells with truncated lateral margins would be placed in the species *Teilingia wallichii*; however, this separation seems to be artificial because rounded and truncated cells can often be found on the same filament. All the *Teilingia* specimens with densely granulated lateral margins were assigned to *Teilingia granulata*.

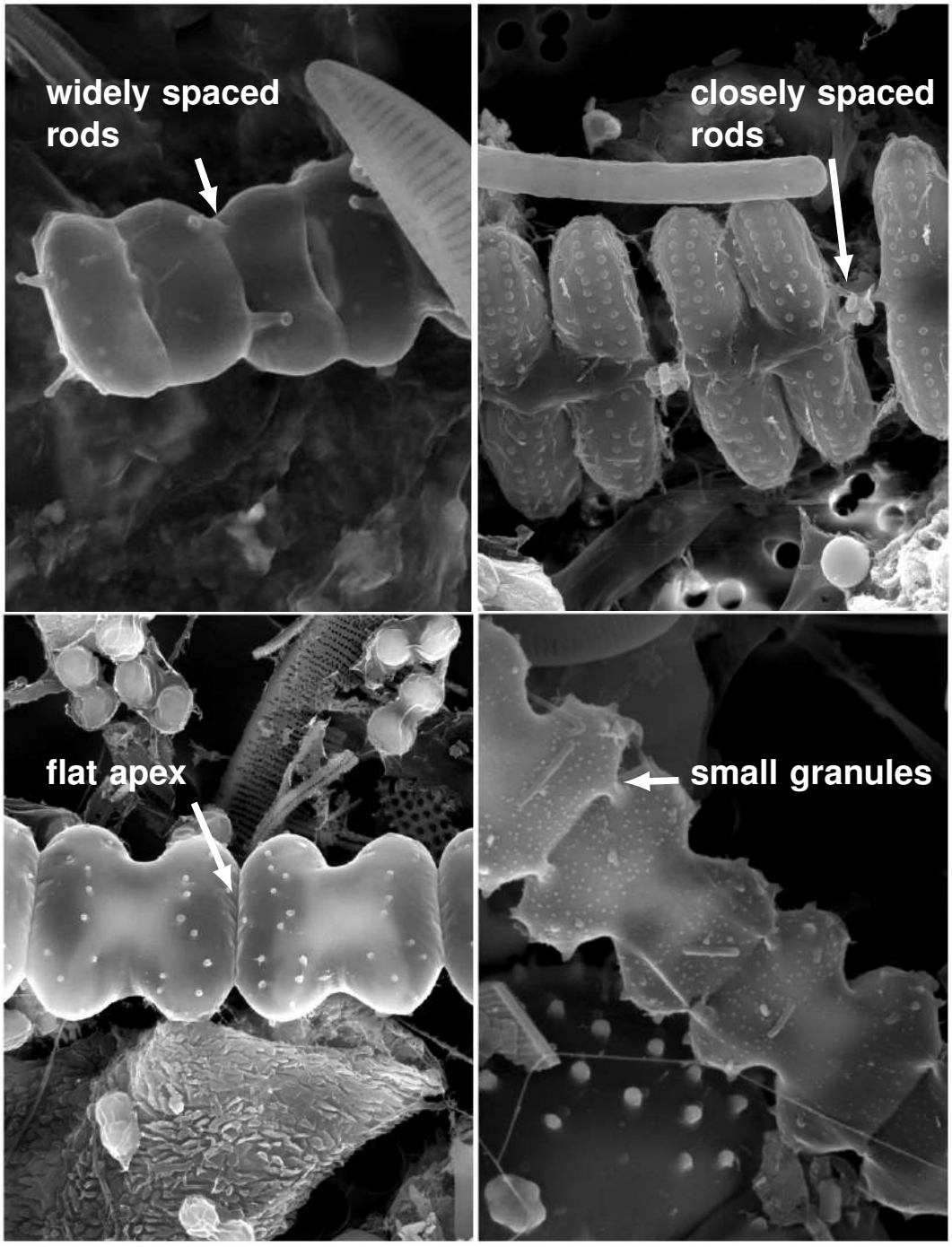


Figure 24.1: Comparison between cell linkages for *Onychonema* (upper left image), *Sphaerozosma* (upper right image), *Spondylosium* (lower left image), and *Teilingia* (lower right image).

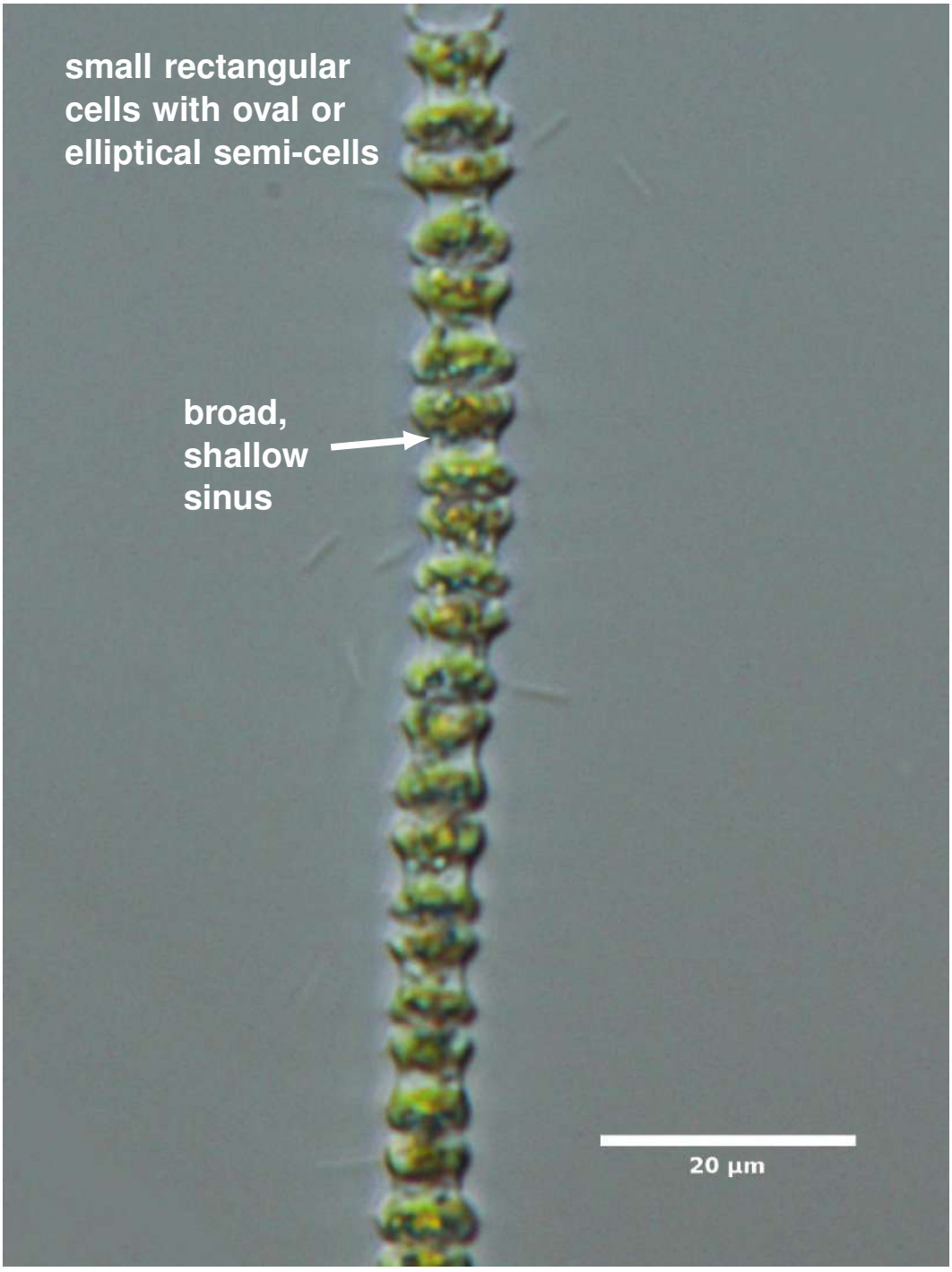


Figure 24.2: *Teilingia excavata* (DIC), small pond near Artist Point Ridge trail, Mt. Baker area, Whatcom County.

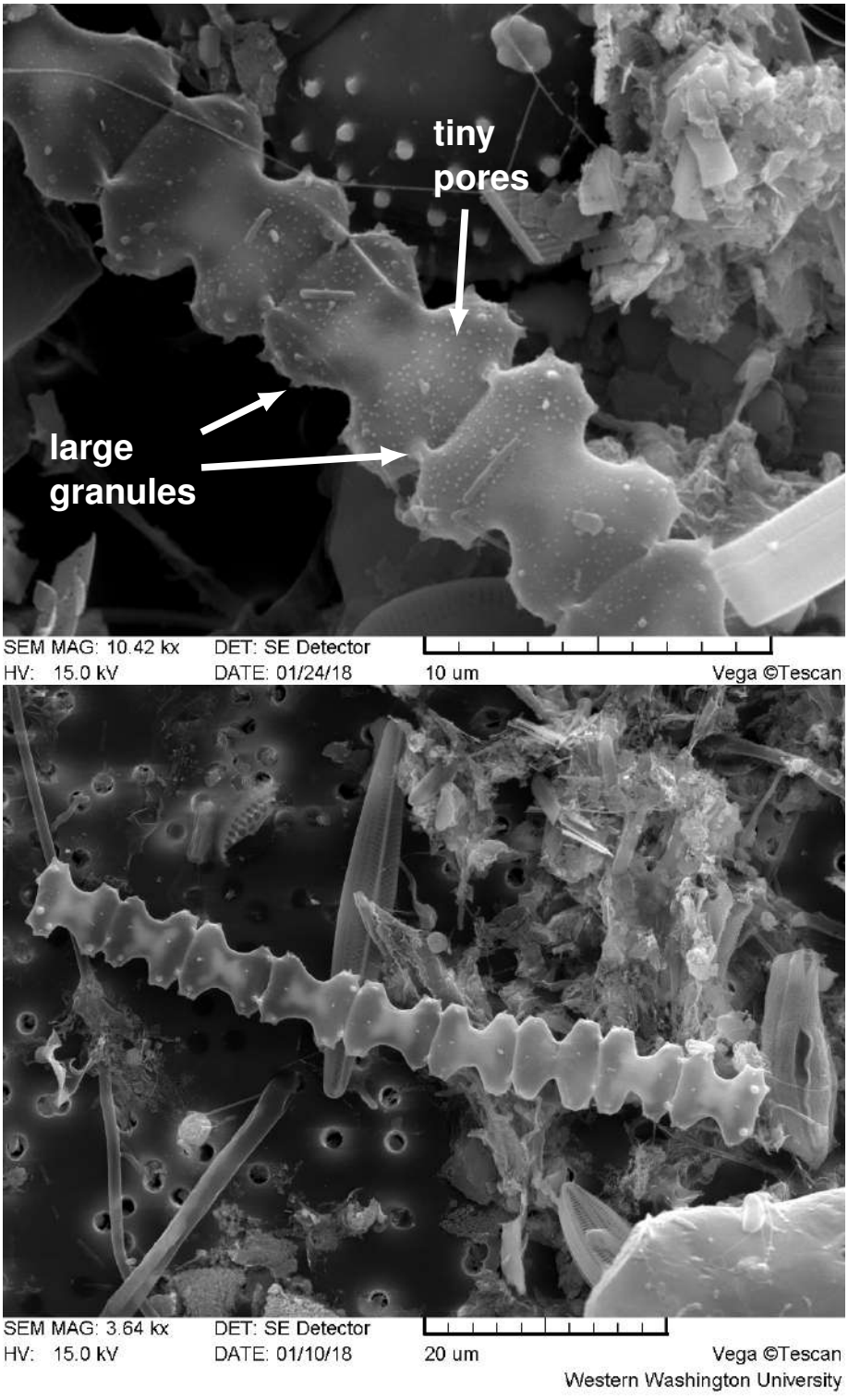


Figure 24.3: *Teilingia excavata* (SEM/SEM), Lake Twenty-two, Mountain Loop Highway, Snohomish County (upper image); Bear Lake, Mountain Loop Highway, Snohomish County (lower image).

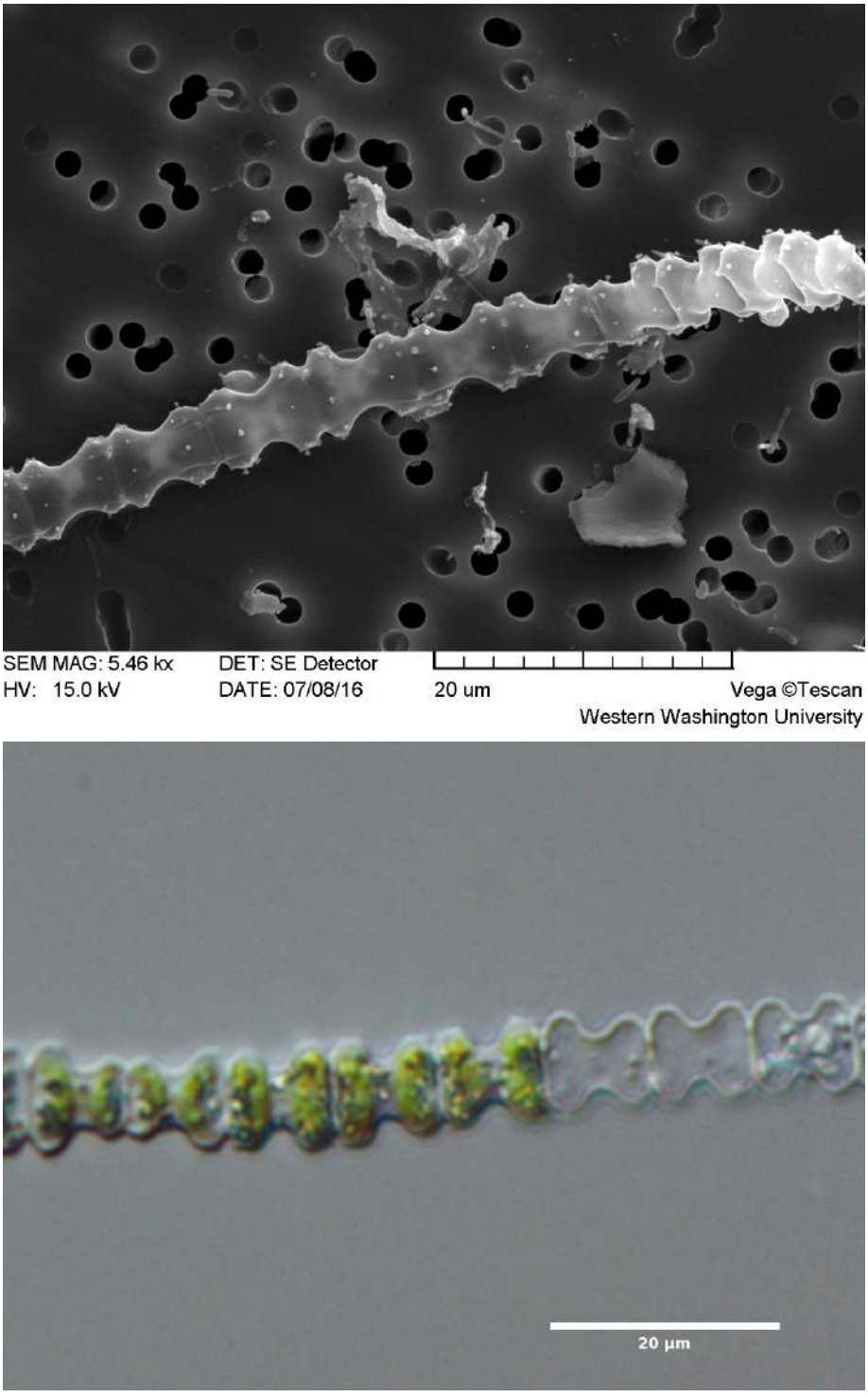


Figure 24.4: *Teilingia excavata* (SEM/DIC), Island Lake, Mountain Loop Highway, Snohomish County (upper image); small pond near Artist Point Ridge trail, Mt. Baker area, Whatcom County (lower image).

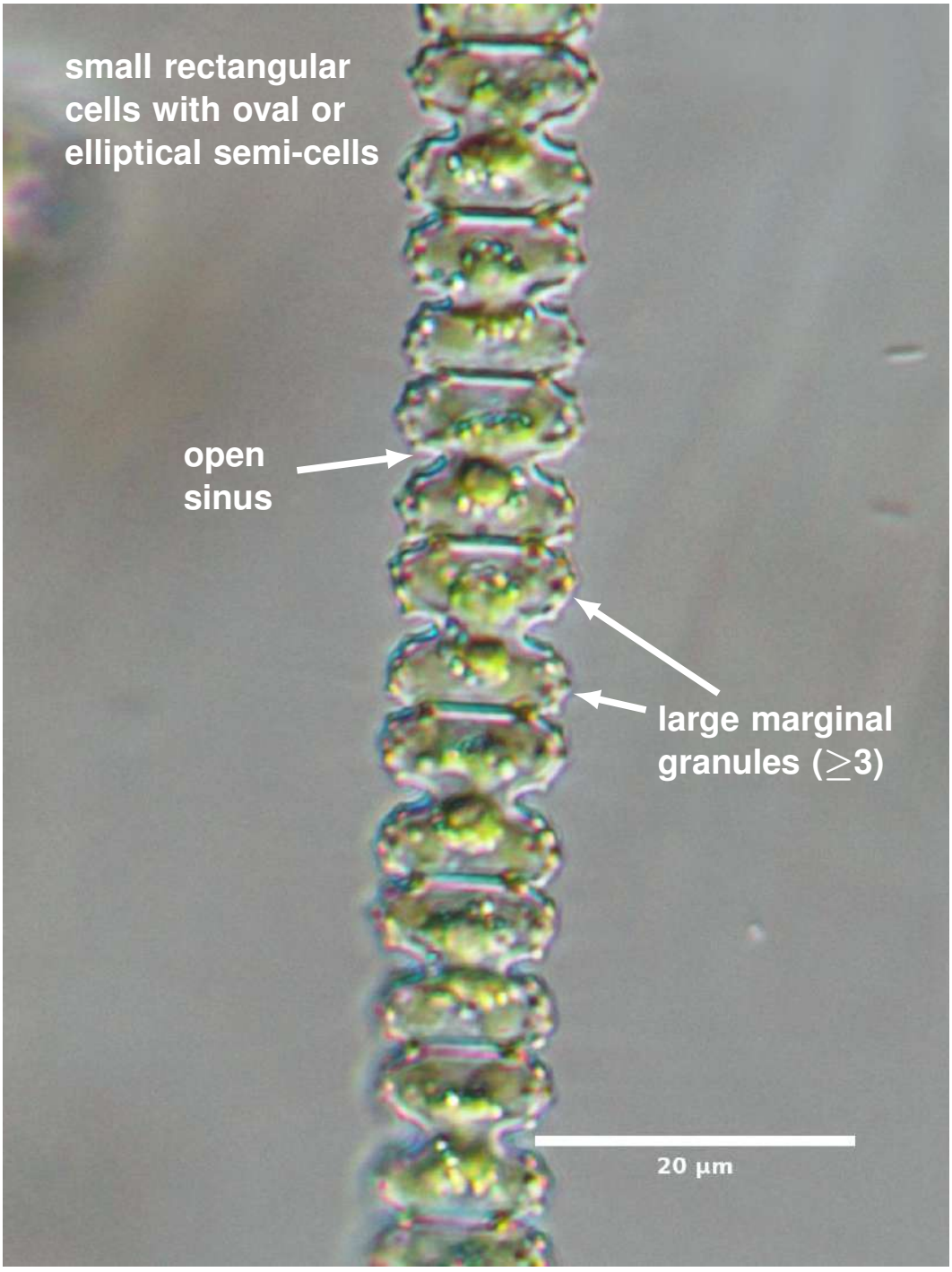


Figure 24.5: *Teilingia granulata* (DIC), Lake Terrell, Whatcom County.

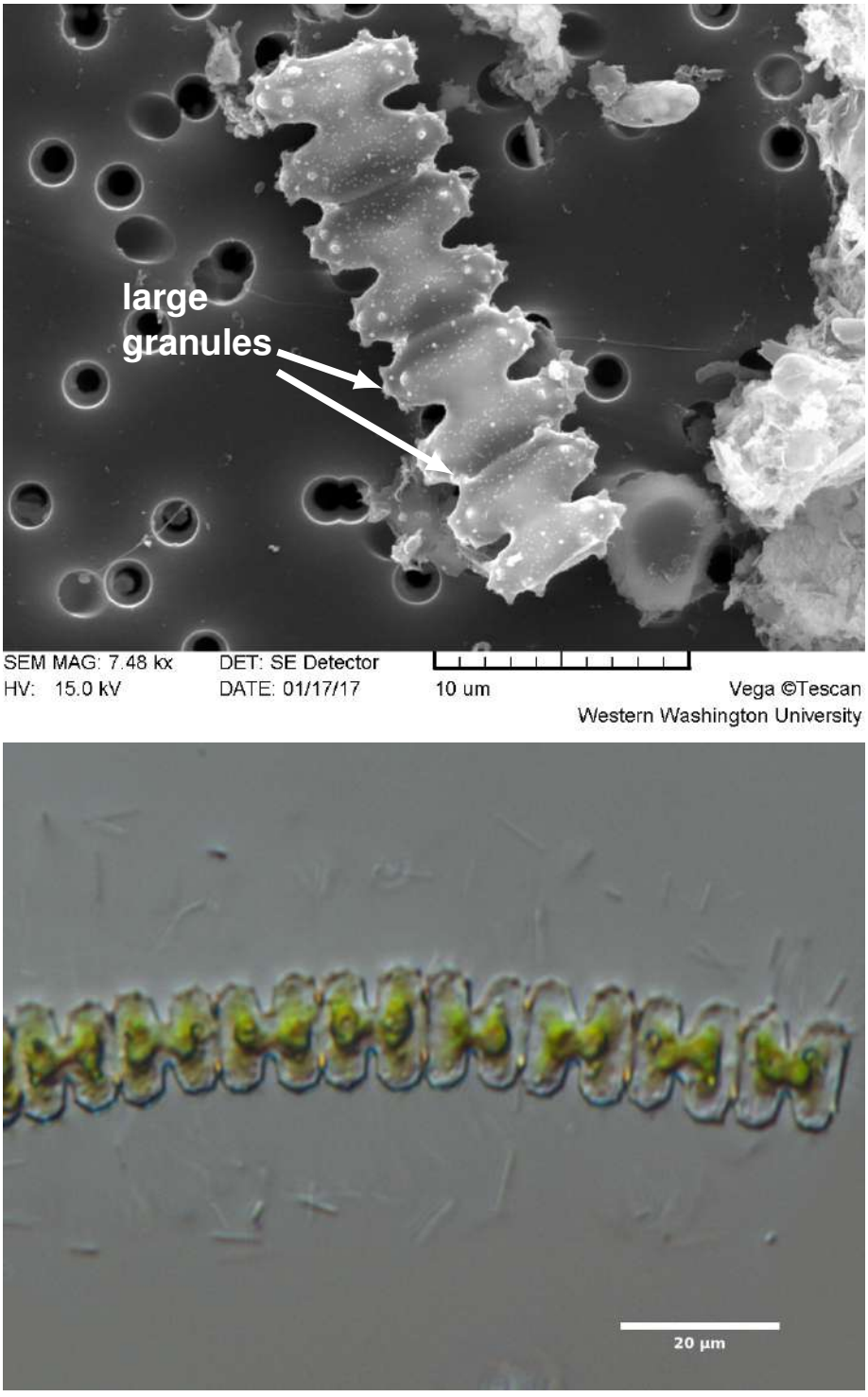


Figure 24.6: *Teilingia granulata* (SEM/DIC), Picture Lake, Mt. Baker area, Whatcom County (upper image); Canyon Lake, Whatcom County (lower image).

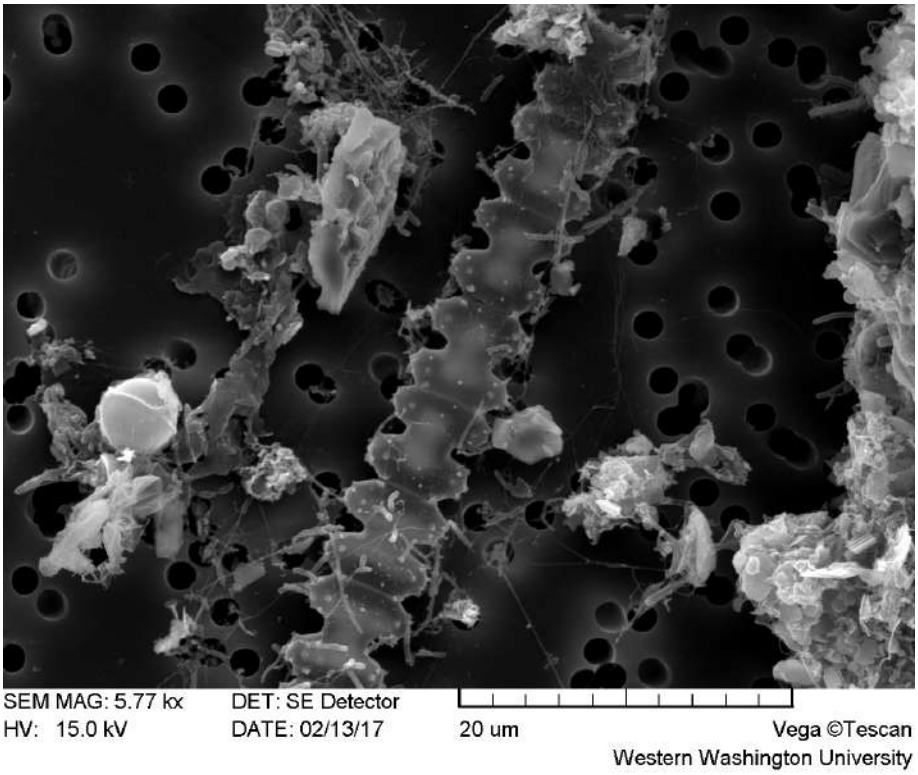




Figure 24.7: *Teilingia granulata* (SEM/DIC), Myrtle Lake, Mountain Loop Highway, Snohomish County (upper/lower images).

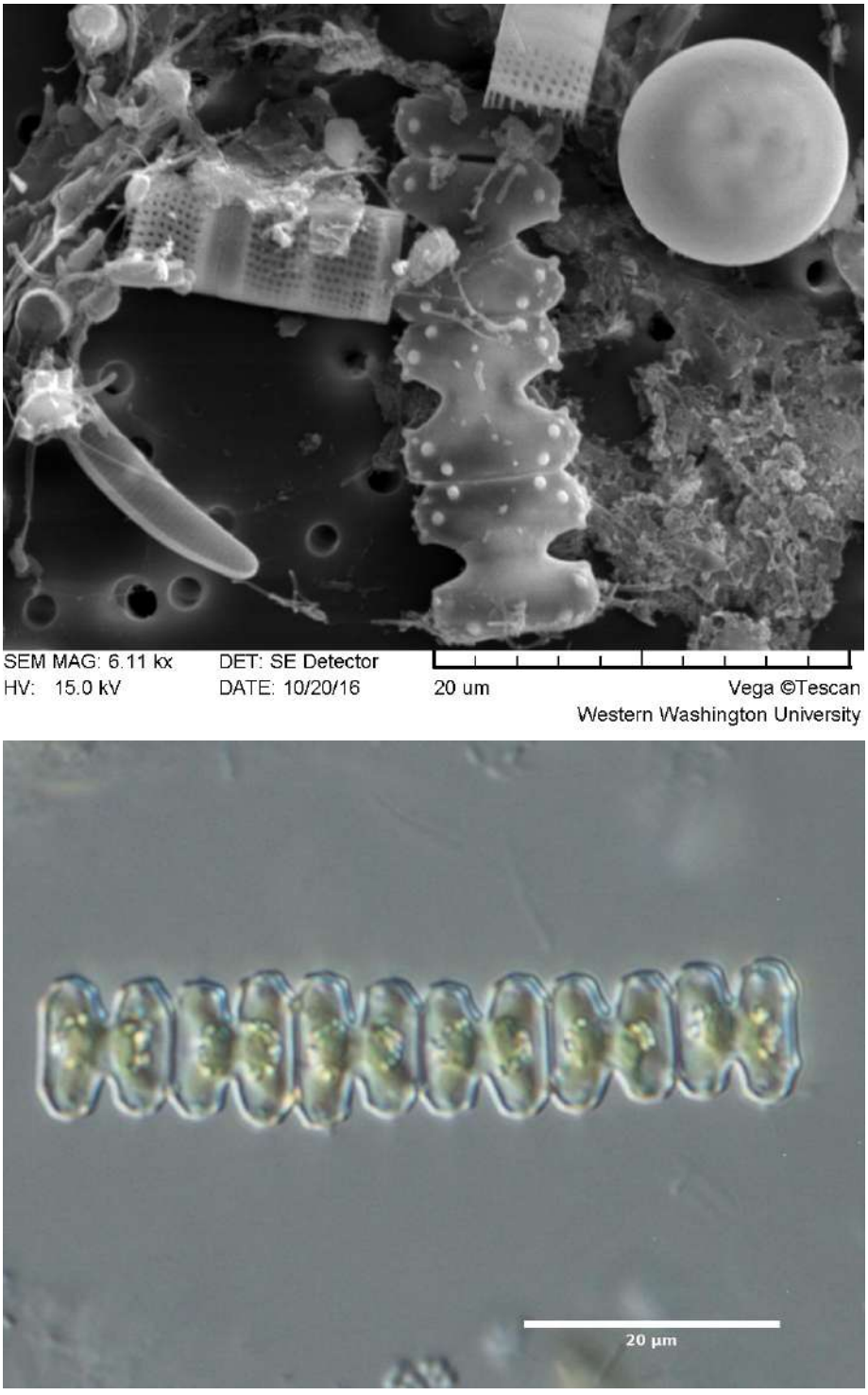


Figure 24.8: *Teilingia granulata* (SEM/DIC), Bear Lake, Mountain Loop Highway, Snohomish County (upper/lower images).

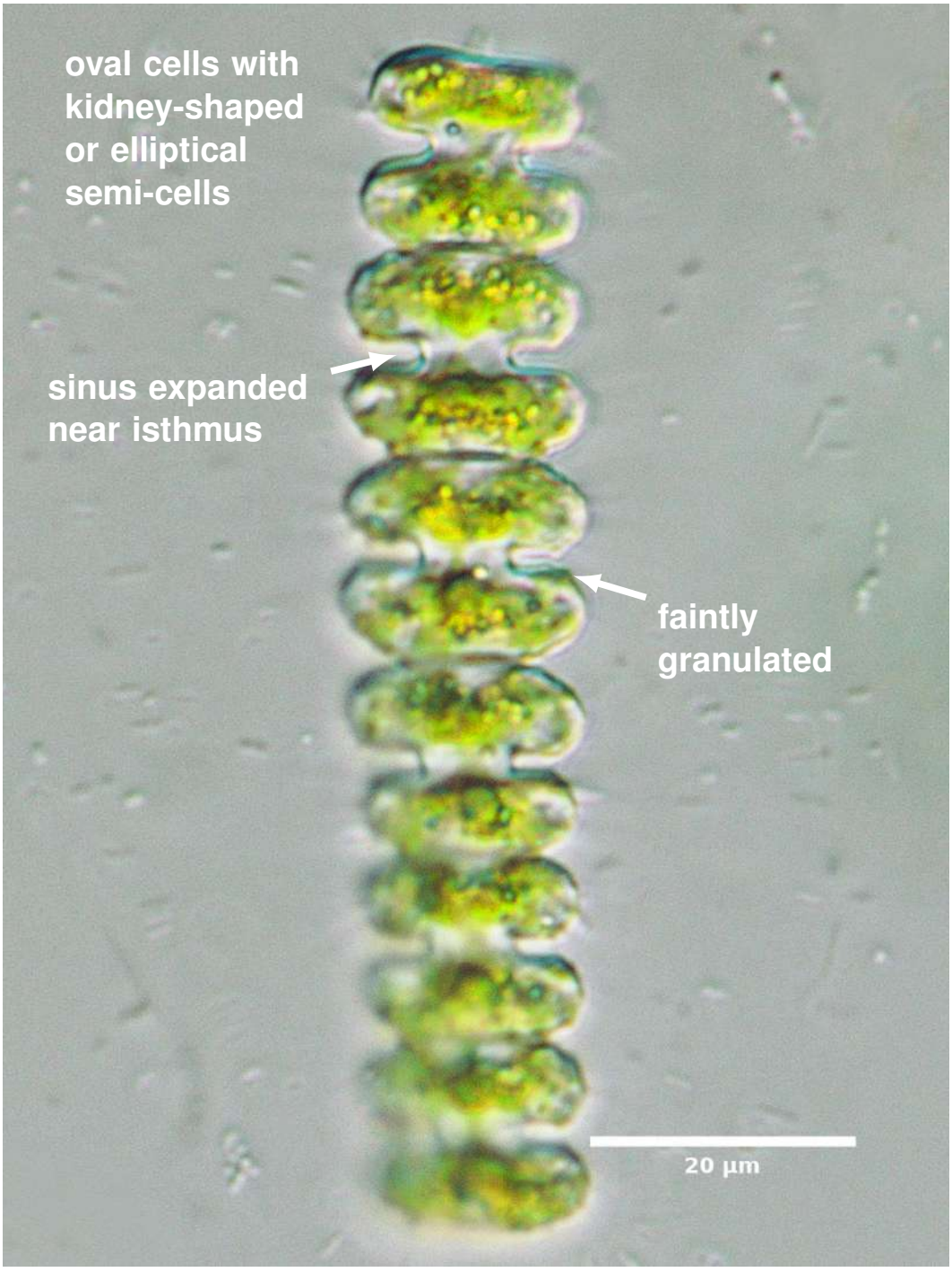


Figure 24.9: *Teilingia* sp. 1 (DIC), Clear Lake, Skagit County.



Figure 24.10: *Teilingia* sp. 1 (DIC), Clear Lake, Skagit County.

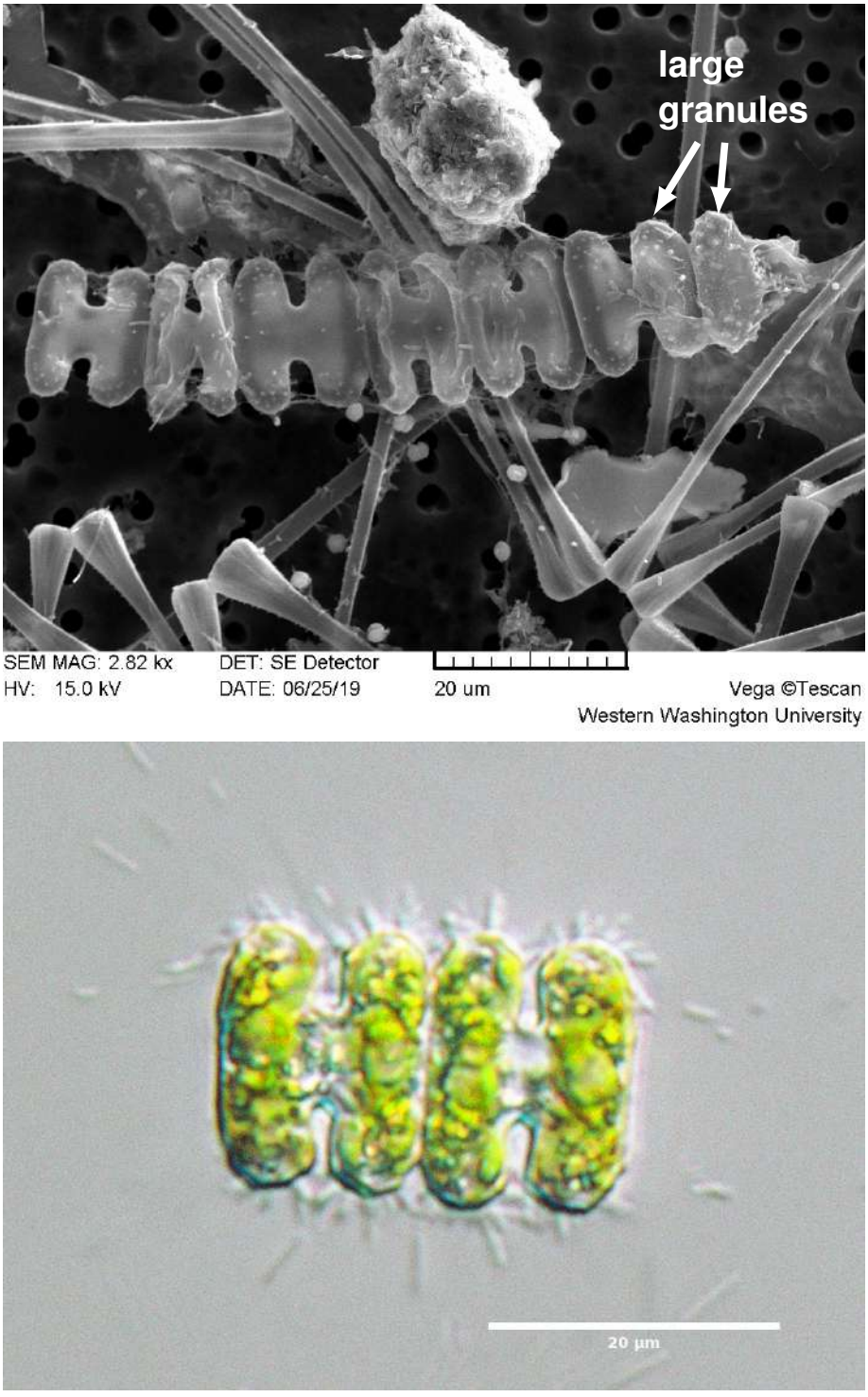


Figure 24.11: *Teilingia* sp. 1 (SEM/DIC), Clear Lake, Skagit County (upper/lower images).

Chapter 25

Tetmemorus Ralfs ex Ralfs

Northwest Washington taxa
Tetmemorus brebissonii Ralfs
Tetmemorus brebissonii var. *minor* De Bary
Tetmemorus granulatus Brébisson ex Ralfs
Tetmemorus laevis Ralfs ex Ralfs

Table 25.1: Key to *Tetmemorus* Species

A	Cell length >150 μm	
A.1	Cells cylindrical, with shallow but distinct sinus; wall covered with rows of elongated pores	*Tetmemorus brebissonii* (Figures 25.1–25.5)
A.2	Cells broadly fusiform, with indistinct sinus; wall covered with small granules	*Tetmemorus granulatus* (Figures 25.9–25.12)

continued on next page

Table 25.1: Key to *Tetmemorus* Species, continued

B	Cell length $\leq$100 μm	
B.1	Cells cylindrical, with shallow but distinct sinus; wall covered with rows of elongated pores	*Tetmemorus brebissonii* var. *minor* (Figures 25.6–25.8)
B.2	Cells elliptical and slightly tapered, with indistinct sinus; wall covered with small granules	*Tetmemorus laevis* (Figures 25.13–25.15)

Table 25.2: *Tetmemorus* Cell Measurements

		Cell Width	Cell Length	Isthmus Width	L/W Ratio
Tetmemorus brebissonii	min	29.3 μm	179.5 μm	20.9 μm	5.5
	med	31.4 μm	195.8 μm	23.7 μm	6.2
	max	32.5 μm	234.4 μm	25.2 μm	7.8
Tetmemorus brebissonii var. *minor*	min	21.3 μm	78.8 μm	16.2 μm	3.4
	med	23.4 μm	80.6 μm	17.2 μm	3.6
	max	24.6 μm	94.0 μm	18.7 μm	3.8
Tetmemorus granulatus	min	27.8 μm	160.2 μm	24.2 μm	5.5
	med	28.7 μm	179.5 μm	25.4 μm	6.3
	max	31.1 μm	193.4 μm	27.6 μm	6.5
Tetmemorus laevis	min	23.1 μm	78.2 μm	21.3 μm	3.1
	med	25.4 μm	82.8 μm	22.5 μm	3.3
	max	27.2 μm	89.0 μm	25.1 μm	3.6

Description

Tetmemorus cells are cylindrical or broadly fusiform, with a deep, central, apical incision. The cells are slightly compressed and usually appear broadly fusiform in side view. Each semi-cell contains one axial, ridged chloroplast with one or more central pyrenoids.

Tetmemorus brebissonii semi-cells are cylindrical, narrowing slightly near the apex, and with a shallow but obvious sinus, and a distinctive apical incision (Figures 25.1–25.5). From the side the cells may often fusiform, and can easily be mistaken for *Tetmemorus granulatus* (Figure 25.9), but the apical incision will not in a central position. The chloroplast contains 3–5 large, central pyrenoids. The cell wall is ornamented with parallel rows of elongated pores; this feature is clearly visible on SEM images (Figures 25.3–25.4). ***Tetmemorus brebissonii* var. *minor*** is morphologically similar, but has much shorter cells (Figures 25.6–25.8). The cell wall in this variety also has parallel rows of elongated pores (Figures 25.7–25.8).

Tetmemorus granulatus cells are broadly fusiform (face and side views), with a very shallow, indistinct sinus (Figures 25.9–25.12). The apex narrows more gradually than *Tetmemorus brebissonii*, but has a similar apical incision and chloroplast with 3–5 central pyrenoids. The *Tetmemorus granulatus* wall is covered with scattered granules, with one or more rings of granules above the isthmus. These granules are clearly visible on the surface of empty cells when using DIC illumination (Figure 25.10).

Tetmemorus laevis cells are short, elliptical, and very slightly tapered, with a shallow, indistinct sinus (Figures 25.13–25.15). Superficially, this species resembles *Tetmemorus brebissonii* var. minor, but can be distinguished by the indistinct sinus and the presence of scattered granules on the cell wall, which can be seen using DIC illumination when examining empty cells (Figure 25.15).

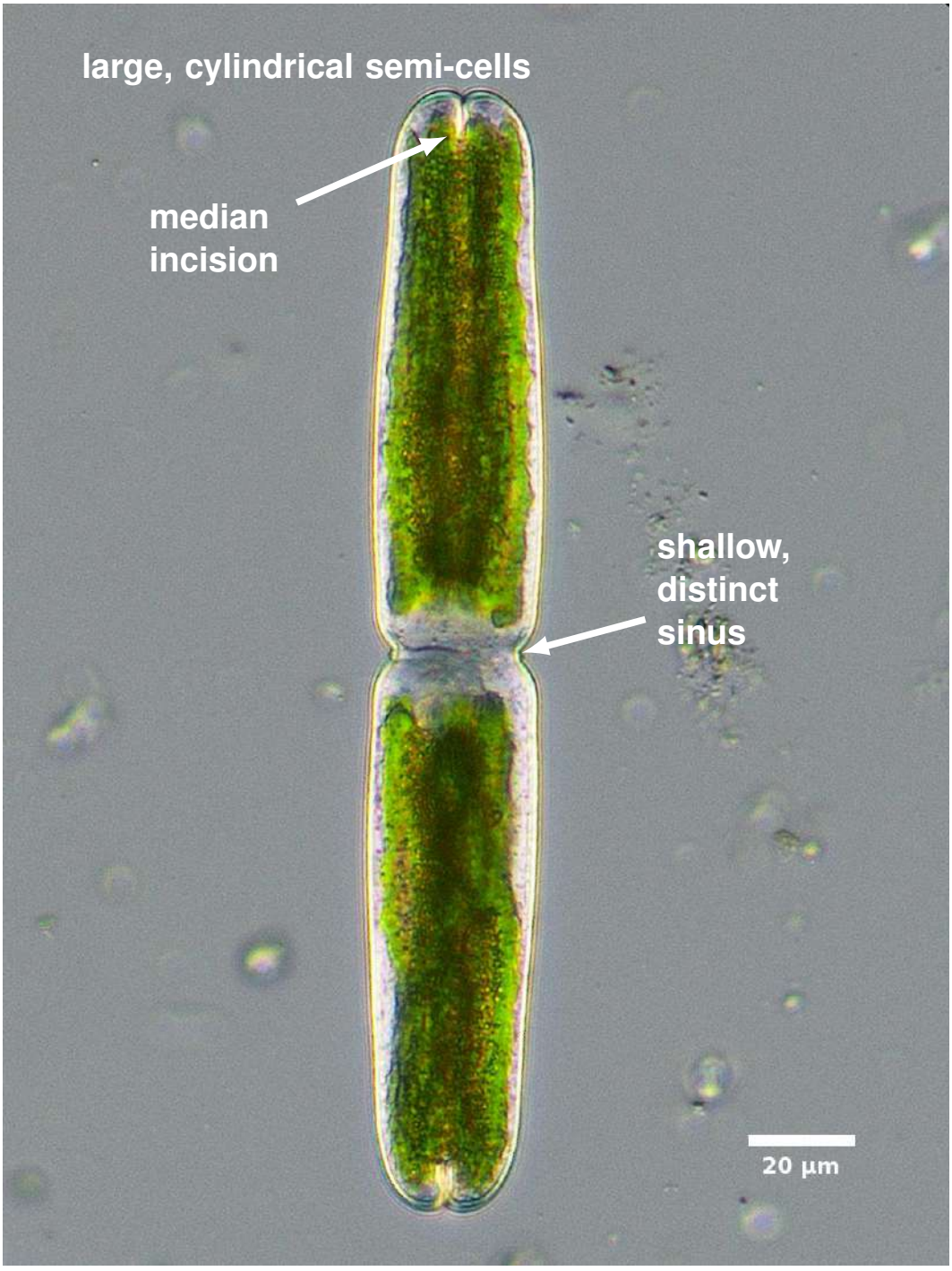


Figure 25.1: *Tetmemorus brebissonii* (DIC), Vogler Lake, Skagit County.

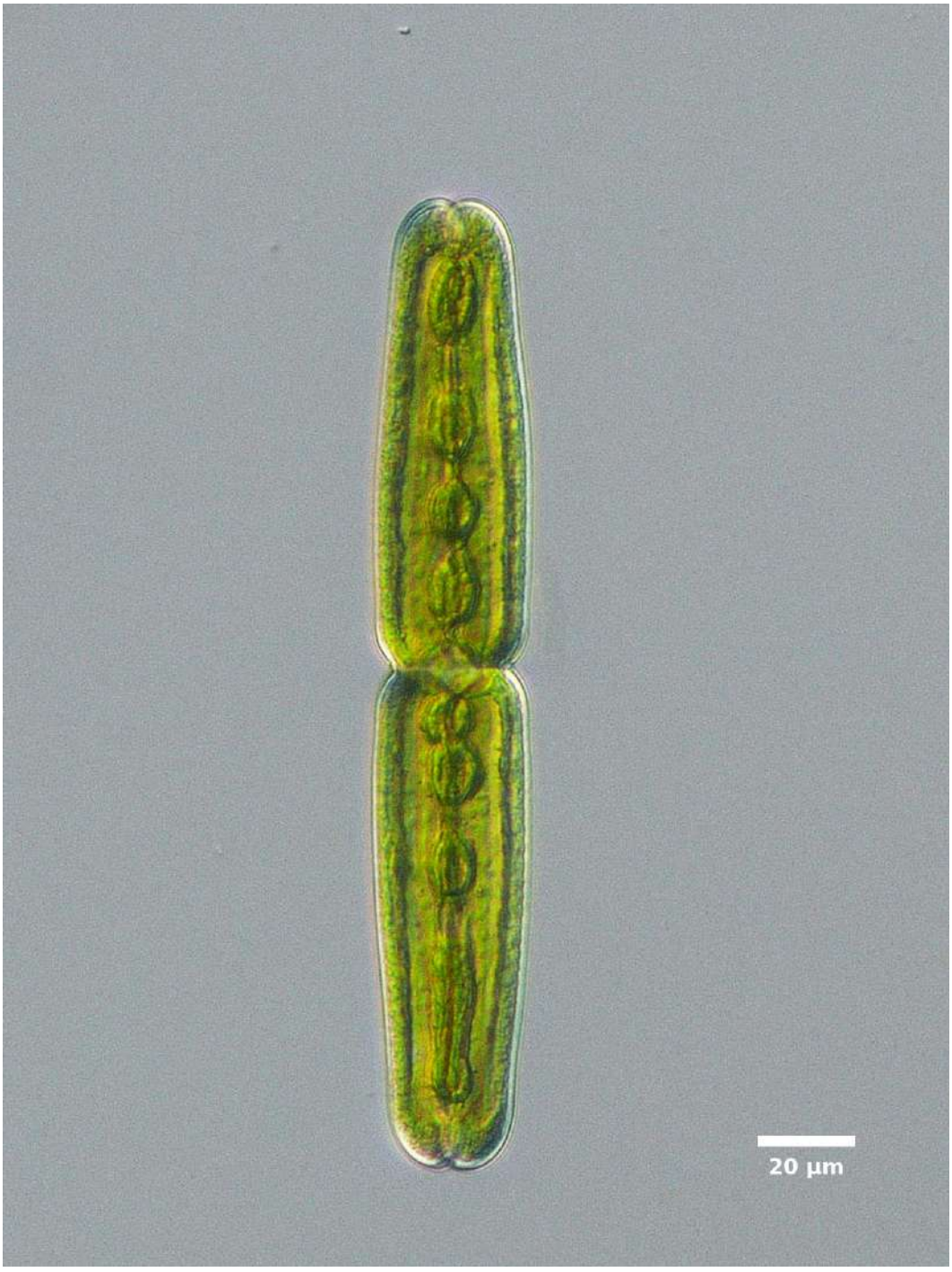


Figure 25.2: *Tetmemorus brebissonii* (DIC), Wood Lake, Morris Valley Rd near Harrison, BC.

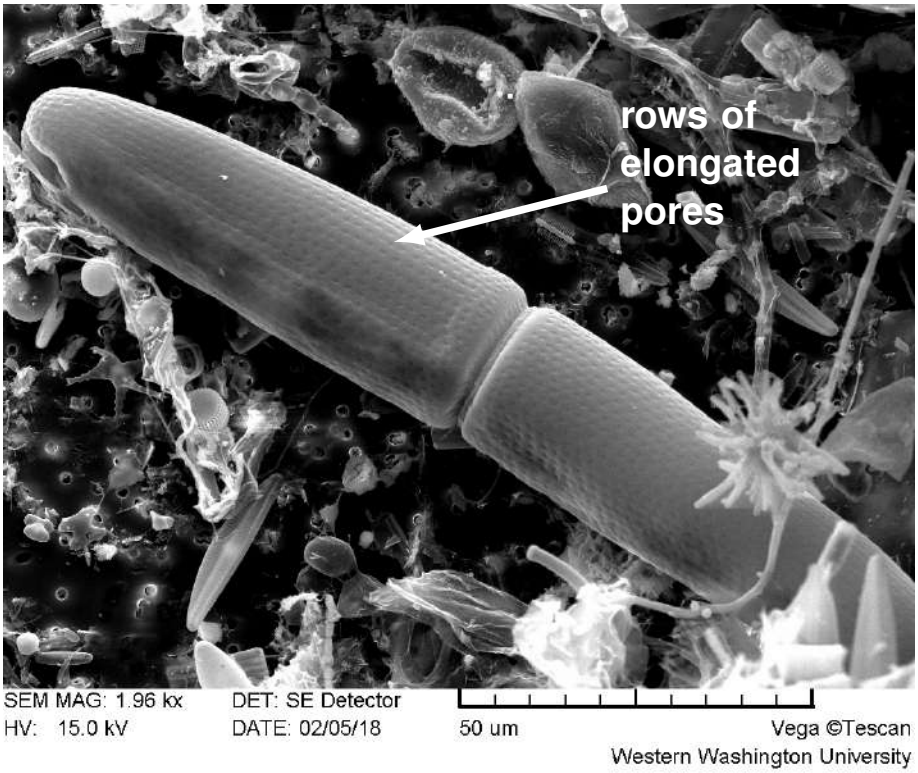




Figure 25.3: *Tetmemorus brebissonii* (SEM/DIC), Bear Lake, Mountain Loop Highway, Snohomish County (upper/lower images).

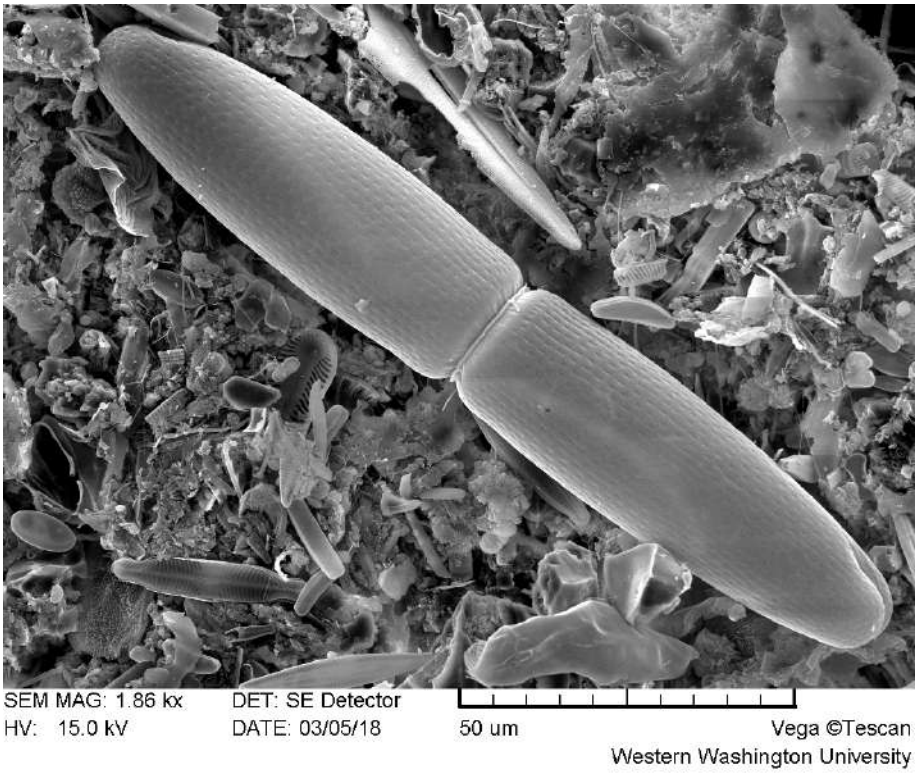




Figure 25.4: *Tetmemorus brebissonii* (SEM/DIC), Heather Lake, Mountain Loop Highway, Snohomish County (upper image); Boardman Lake, Mountain Loop Highway, Snohomish County (lower image).

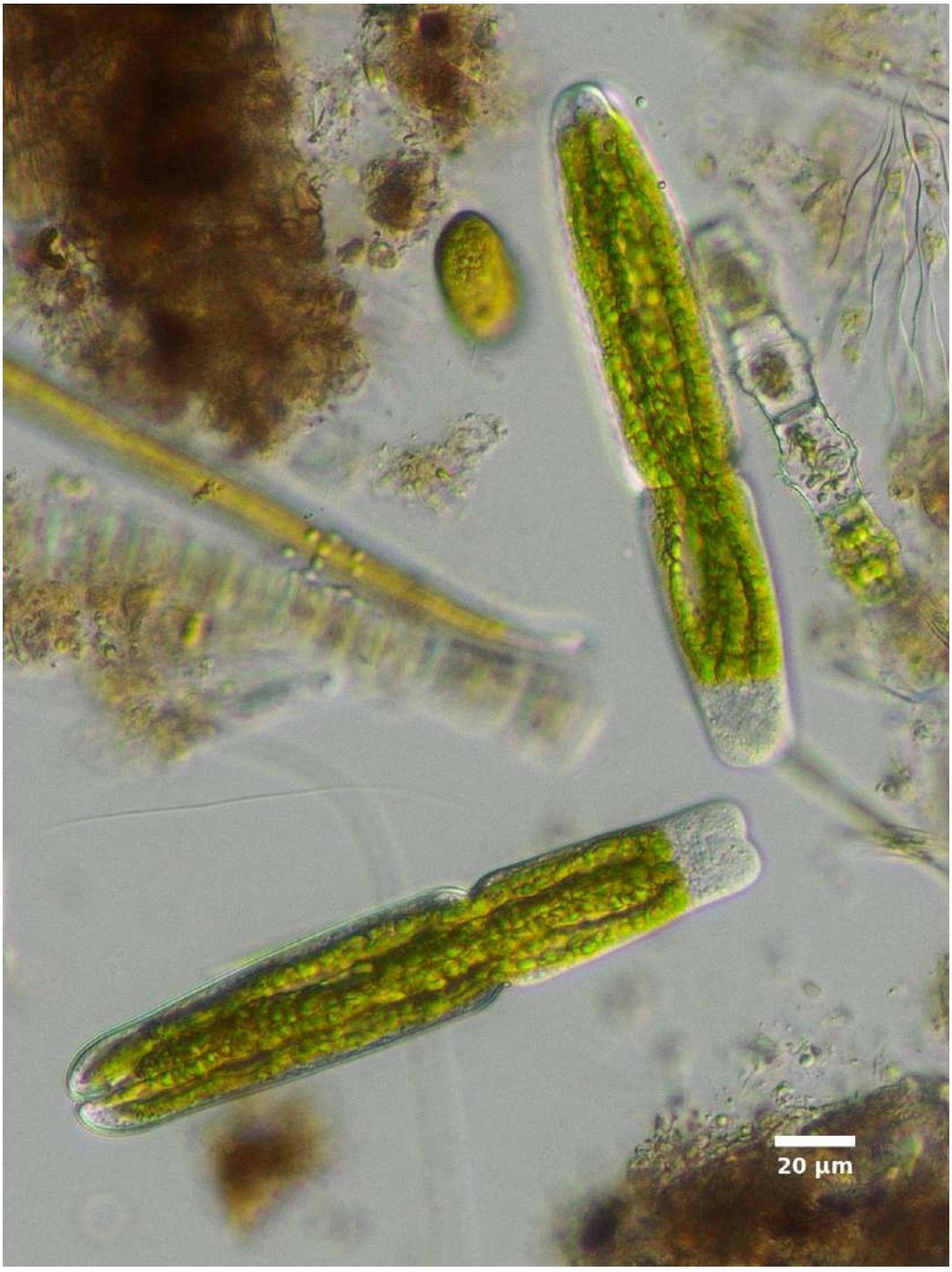


Figure 25.5: *Tetmemorus brebissonii* (DIC), Summer Lake, Skagit County.

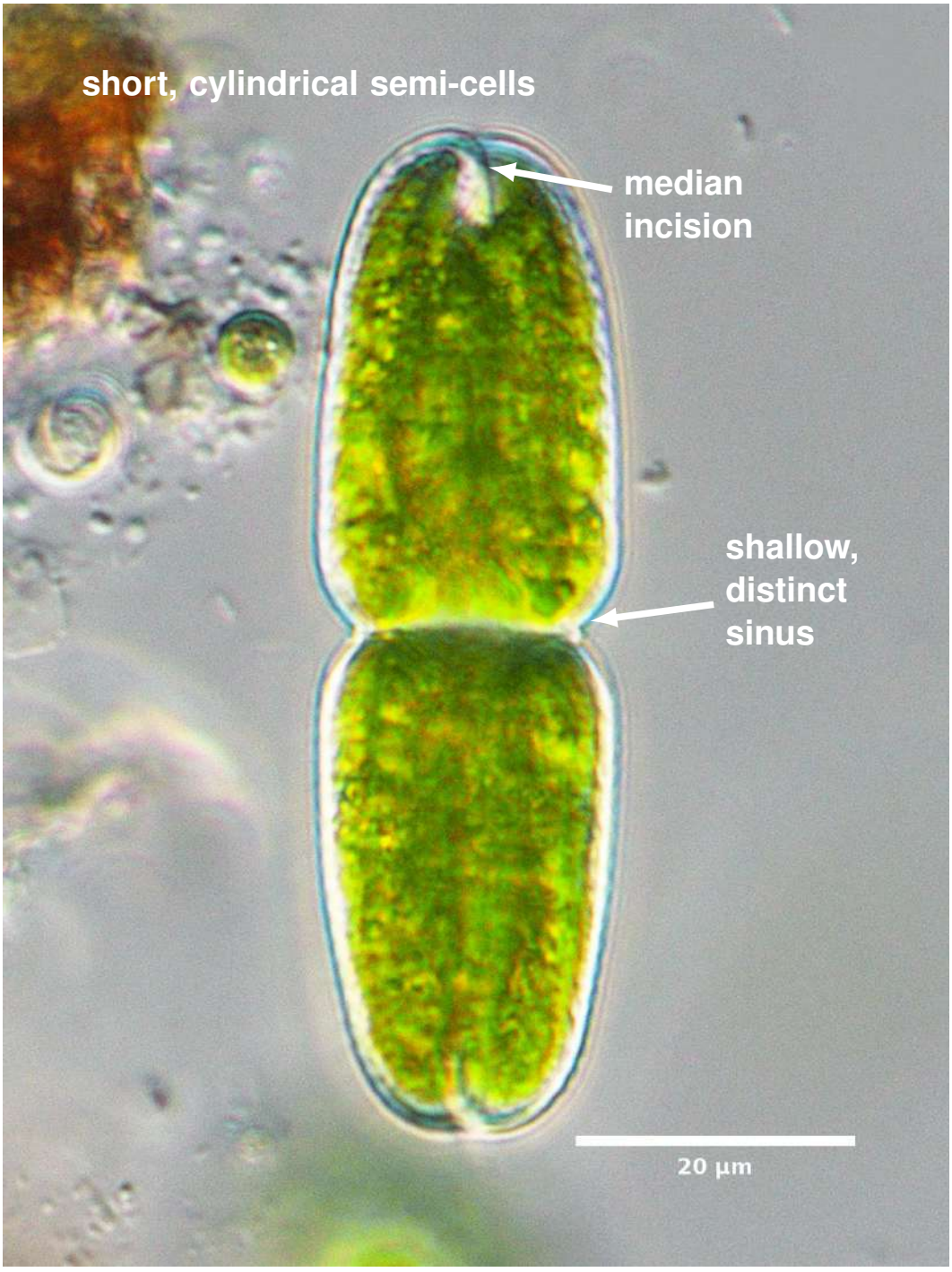


Figure 25.6: *Tetmemorus brebissonii* var. *minor* (DIC), small pond on trail to Lake Ann, Mt. Baker area, Whatcom County.

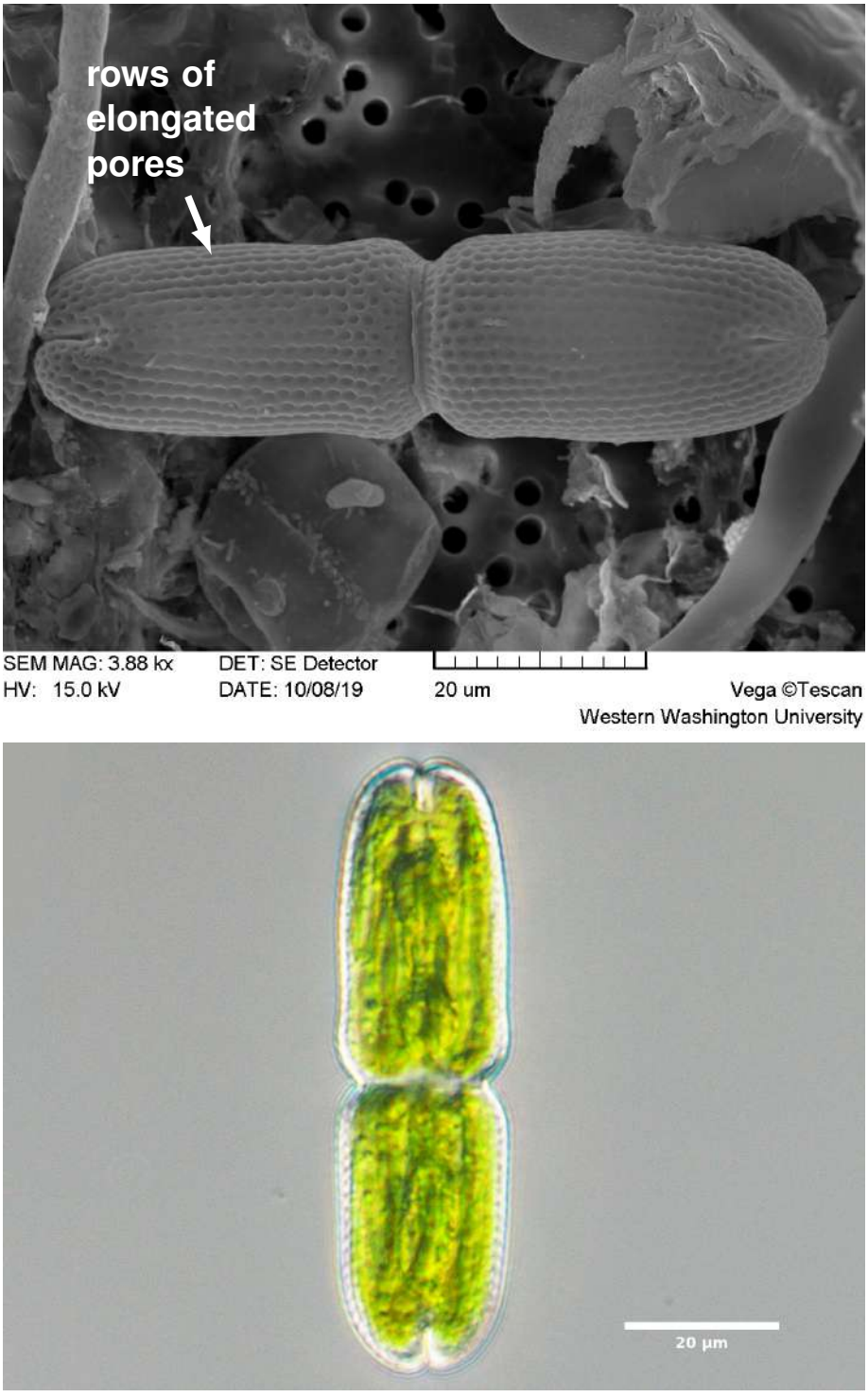


Figure 25.7: *Tetmemorus brebissonii* var. *minor* (SEM/DIC), small ponds and seeps on trail to Lake Ann, Mt. Baker area, Whatcom County (upper/lower images).



Figure 25.8: *Tetmemorus brebissonii* var. *minor* (SEM/DIC), Bear Lake, Mountain Loop Highway, Snohomish County (upper image). Lower Ashland Lake, Mountain Loop Highway, Snohomish County (lower image).

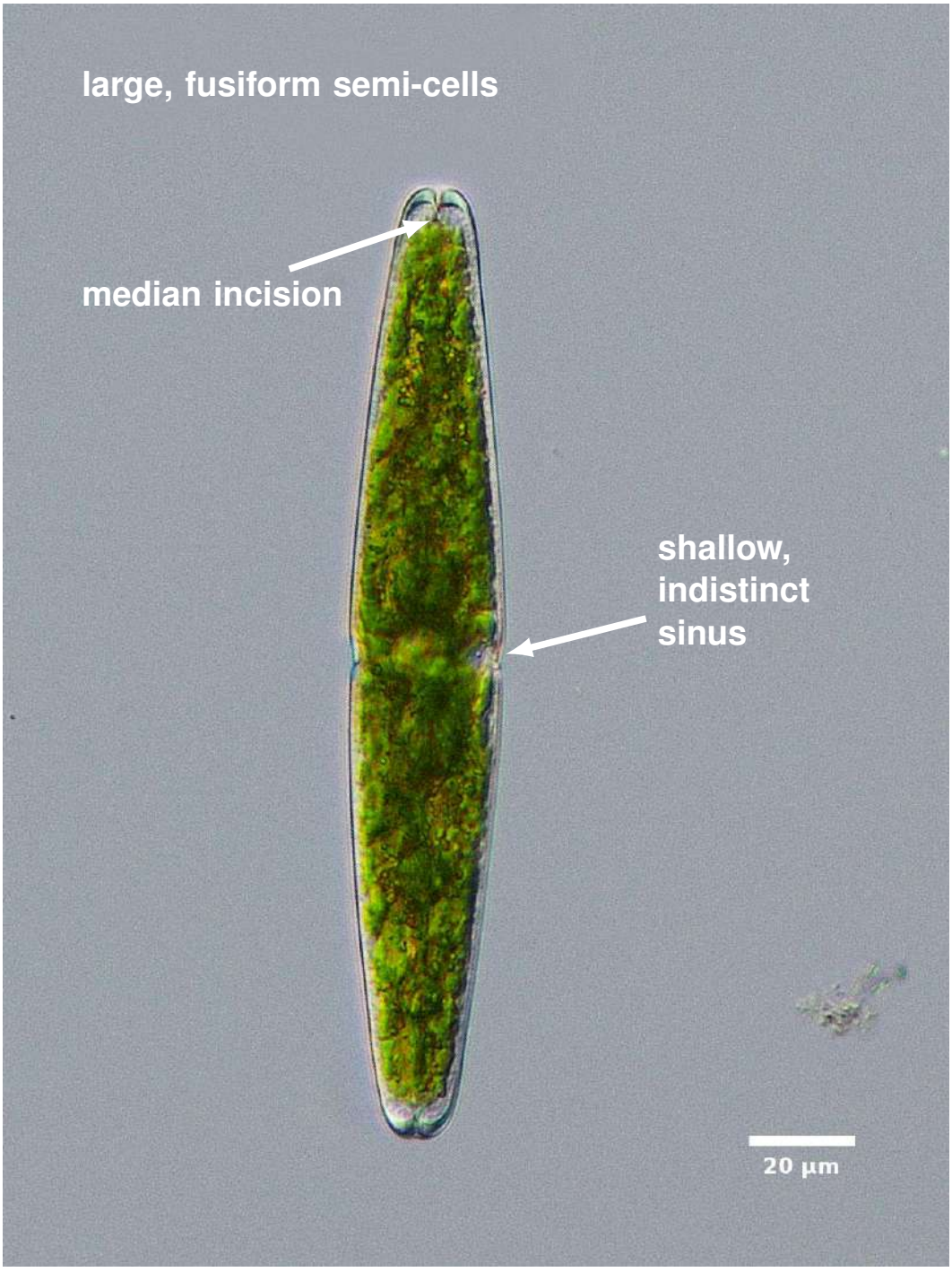


Figure 25.9: *Tetmemorus granulatus* (DIC), Highwood Lake, Mt. Baker area, Whatcom County.



Figure 25.10: *Tetmemorus granulatus* (DIC), Heather Lake, Mountain Loop Highway, Snohomish County.

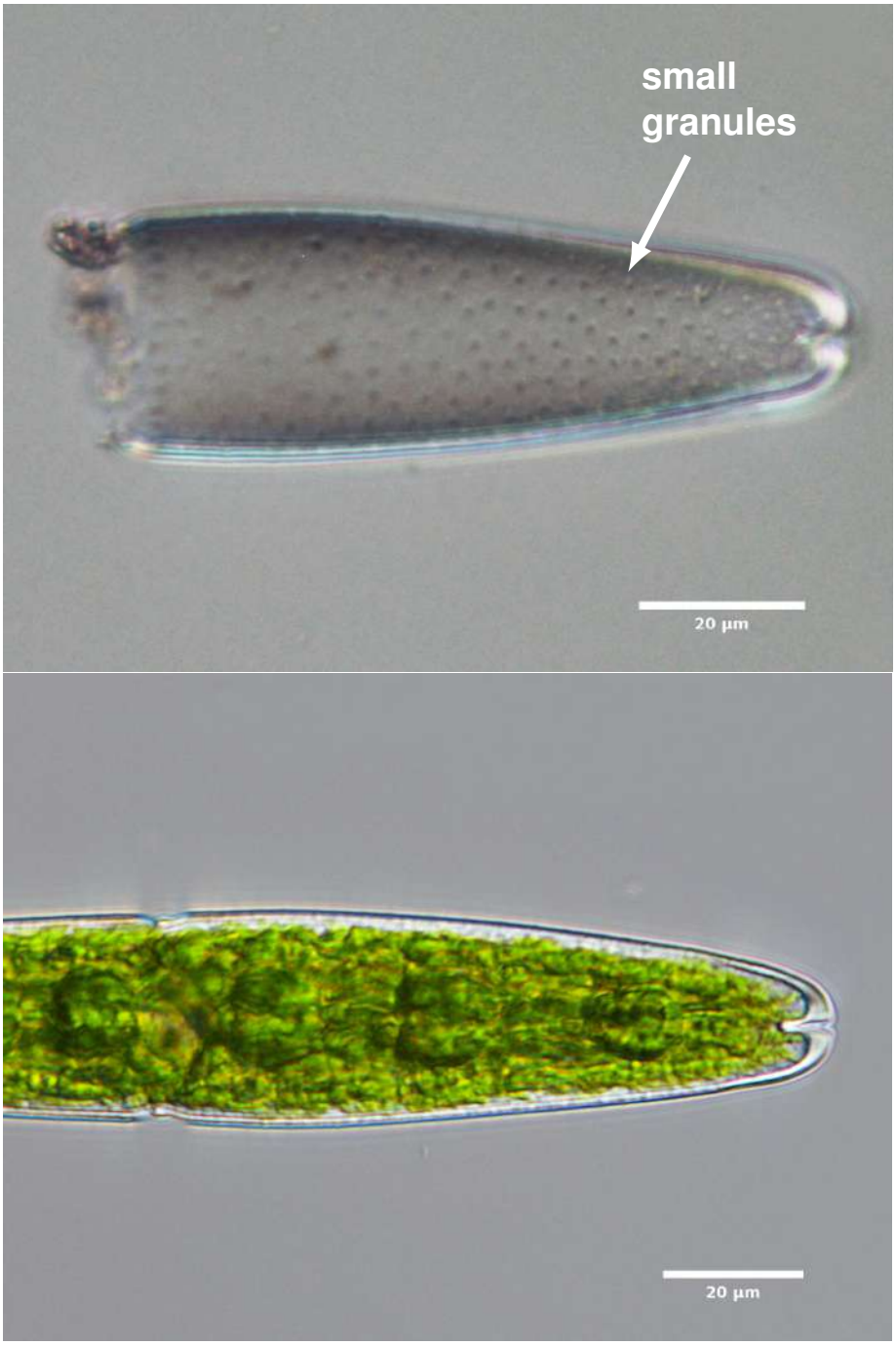
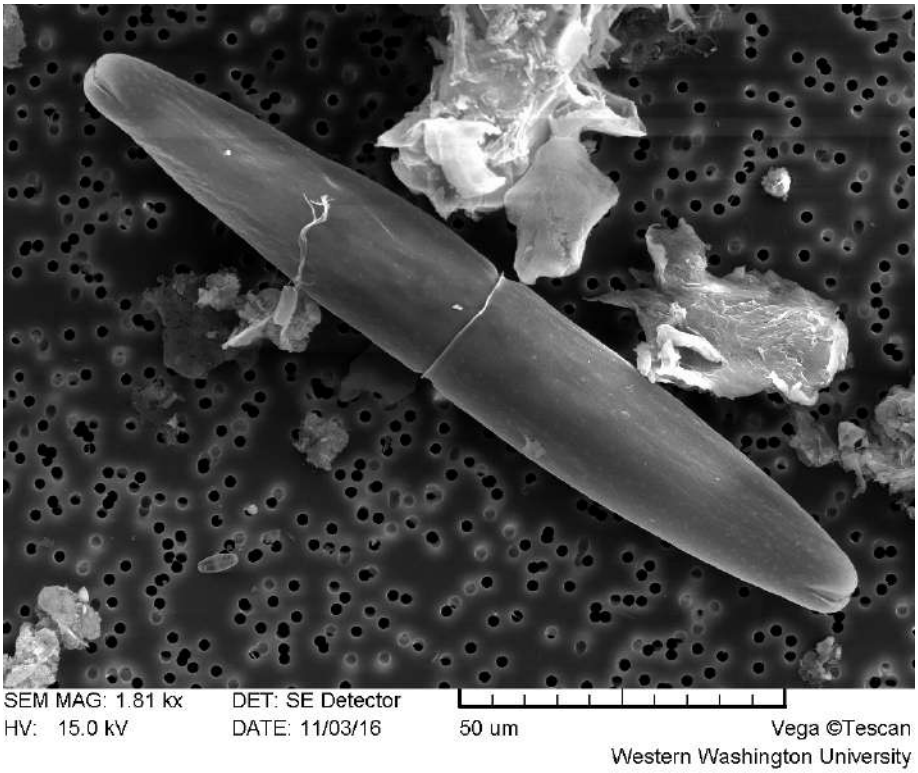


Figure 25.11: *Tetmemorus granulatus* (DIC/DIC), Highwood Lake, Mt. Baker area, Whatcom County (upper/lower images).



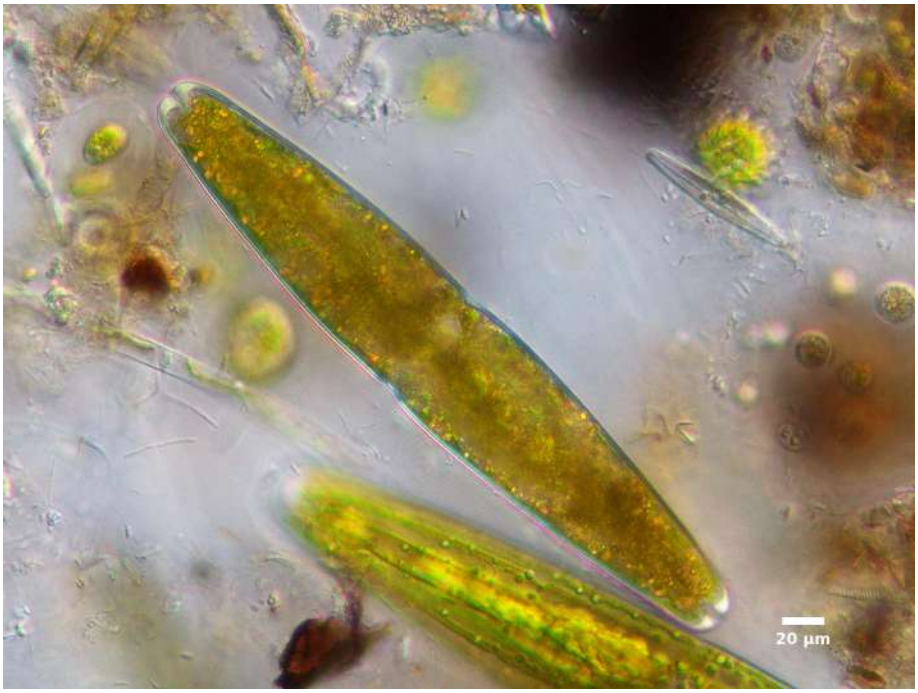


Figure 25.12: *Tetmemorus granulatus* (SEM/DIC), Heather Lake, Mountain Loop Highway, Snohomish County (upper image); Bear Lake, Mountain Loop Highway, Snohomish County (lower image).

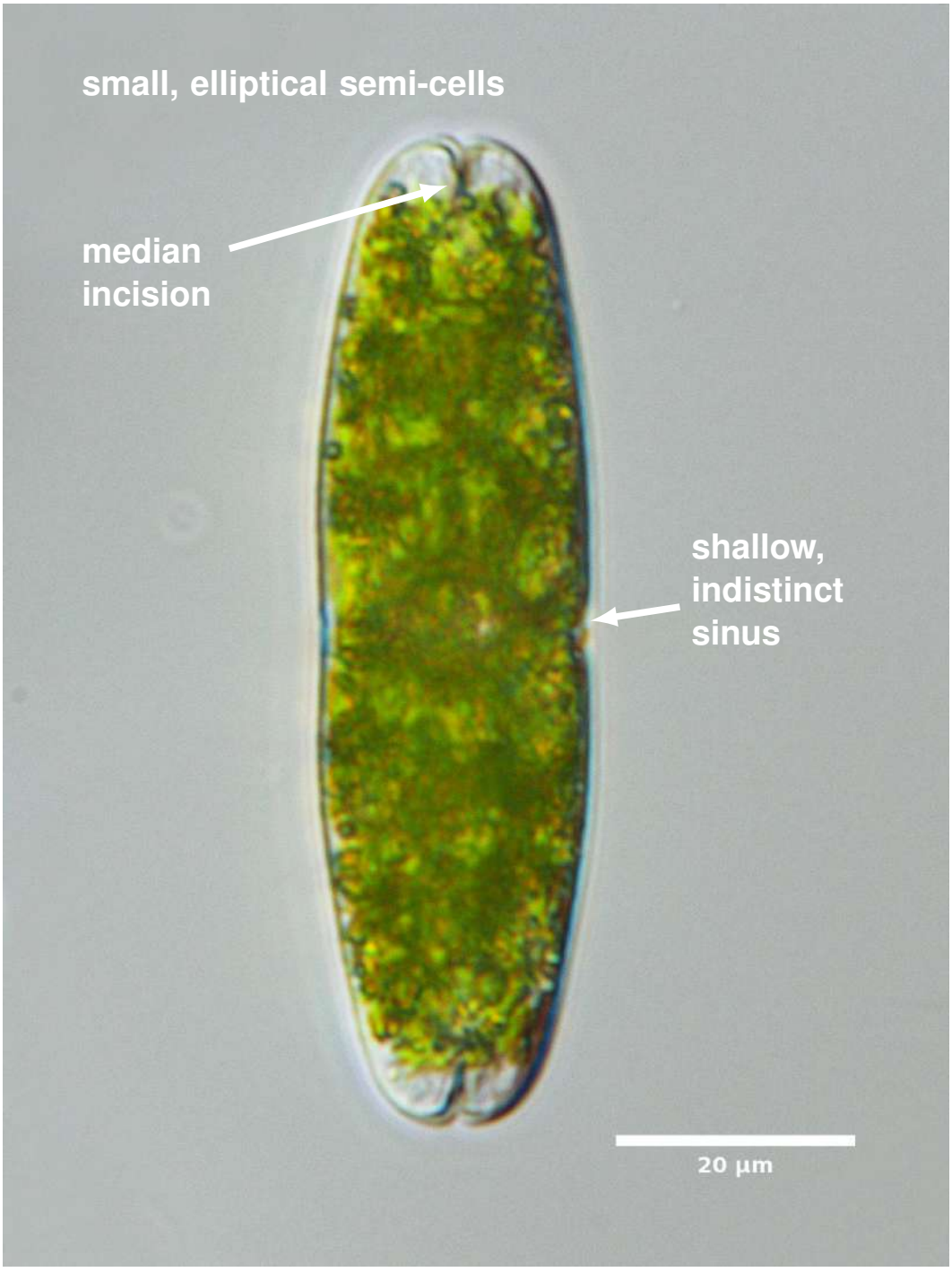


Figure 25.13: *Tetmemorus laevis* (DIC), Gold Basin Mill Pond, Mountain Loop Highway, Snohomish County.



Figure 25.14: *Tetmemorus laevis* (DIC/DIC), small pond along Skyline Divide trail, Mt. Baker area, Whatcom County.



Figure 25.15: *Tetmemorus laevis* (DIC), Lower Anderson Lake at inlet stream, Mt. Baker area, Whatcom County.

Chapter 26

Triploceras Bailey

Northwest Washington taxa
Triploceras gracile Bailey

Table 26.1: *Triploceras* Cell Measurements

		Cell Width	Cell Length	Isthmus Width	L/W Ratio
Triploceras gracile	min	15.2 μm	345.0 μm	12.7 μm	19.0
(without spines)	med	16.9 μm	426.0 μm	16.8 μm	25.0
	max	18.4 μm	474.7 μm	18.3 μm	29.0
Triploceras gracile	min	29.2 μm	345.0 μm	12.7 μm	10.0
(with spines)	med	32.6 μm	426.0 μm	16.8 μm	13.3
	max	35.0 μm	474.7 μm	18.3 μm	16.1

Description
Triploceras cells are distinctive and easily recognized, consisting of long, cylindrical semi-cells separated by a very shallow sinus (Figures 26.1–26.4). The lateral semi-cell margins are inflated to form 10–15 transverse whorls containing short, sharp teeth. The apex is also inflated and spiny, with 3–4 sharp teeth. The toothed whorls make it difficult to see the sinus, which resembles the narrowed

sections between each whorl. All of the specimens we collected in northwest Washington lakes are ***Triploceras gracile***, which has simple stout spines on the transverse whorls and apex. This species resembles some of the ornate species of *Pleurotaenium* (e.g., *Pleurotaenium nodosum*; Figure 17.17), which has smooth (not spiny) inflated transverse whorls. *Triploceras gracile* also resembles *Penium spinulosum* (Figure 16.16), which has thin, curved spines covering the entire cell surface.

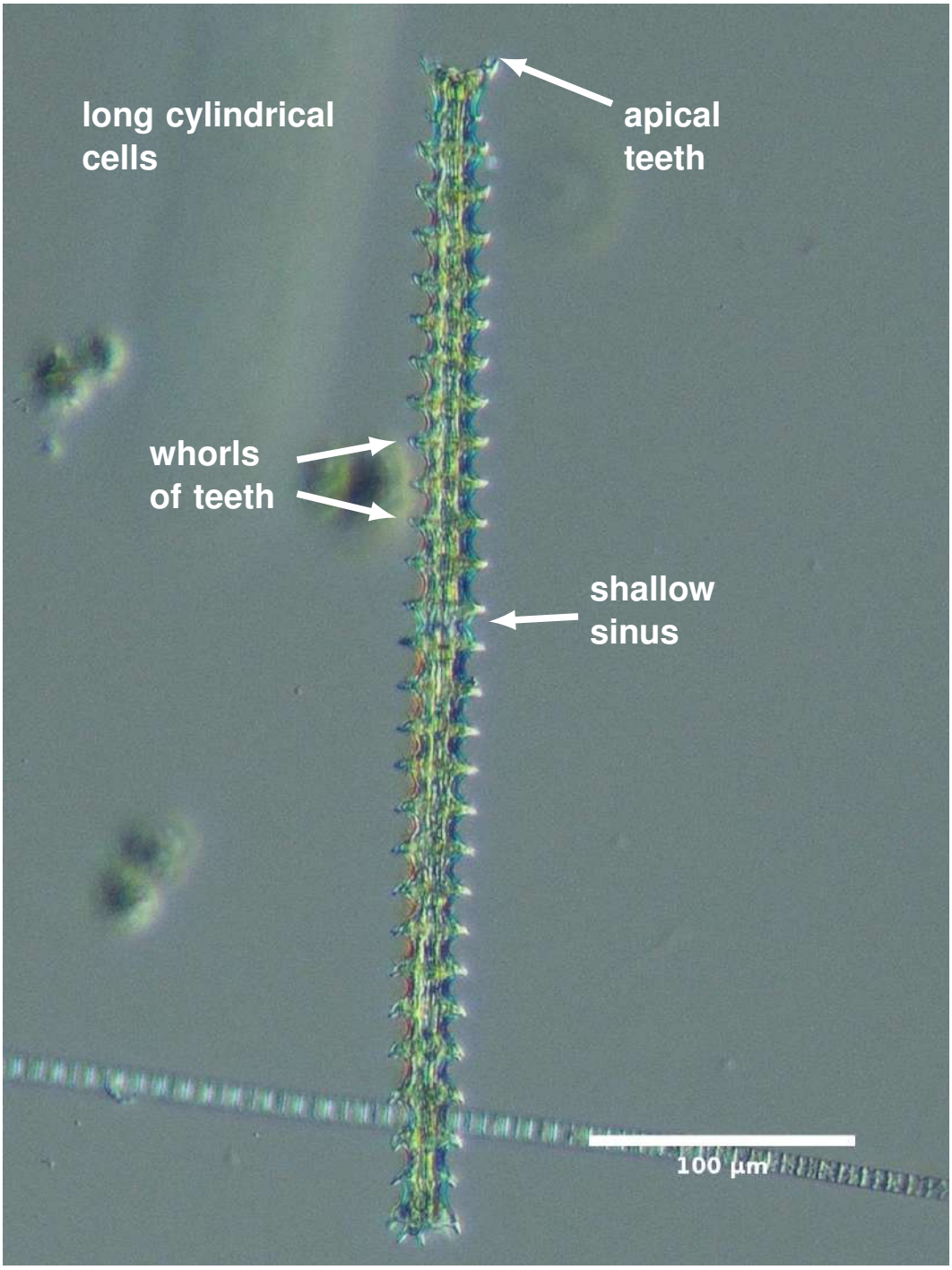


Figure 26.1: *Triploceras gracile* (DIC), Bear Lake, Mountain Loop Highway, Snohomish County.



Figure 26.2: *Triploceras gracile* (DIC), Bear Lake, Mountain Loop Highway, Snohomish County.



Figure 26.3: *Triploceras gracile* (DIC), Lower Ashland Lake, Mountain Loop Highway, Snohomish County.



Figure 26.4: *Triploceras gracile* (DIC), Lower Ashland Lake, Mountain Loop Highway, Snohomish County.

Chapter 27

Xanthidium Ehrenberg ex Ralfs

Northwest Washington taxa
Xanthidium antilopaeum Kützing
Xanthidium antilopaeum var. *depauperatum* West & G. S. West
Xanthidium antilopaeum f. *javanicum* (Nordstedt) Coesel
Xanthidium antilopaeum var. *minneapoliense* Wolle
Xanthidium antilopaeum var.*planum* Roll
Xanthidium antilopaeum f. *polymazum* (Nordstedt) Petlovany)
Xanthidium antilopaeum cf. var. *subeurycerum* Scott & Gröblad
Xanthidium armatum var. *fissum* Nordstedt
Xanthidium bifidum (Brébisson) Deflandre
Xanthidium octocorne Ehrenberg ex Ralfs
(=*Staurodesmus octocornis* [Ehrenberg ex Ralfs] Šťastný, Škaloud & Neustupa)
Xanthidium scrobiculatum (Scott & Grönblad) Šťastný, Škaloud & Neustupa
Xanthidium subhastiferum West
Xanthidium tumidum (Ralfs) Šťastný, Škaloud & Neustupa
(=*Staurastrum tumidum* Brébisson ex Ralfs)
(=*Staurodesmus tumidus* [Brébisson ex Ralfs] Teiling)

Table 27.1: Key to *Xanthidium* Species

A	Cell length without spines >100 μm	
	A.1 Cells wall smooth, lacking spines; cell broadly triangular in cross-section, resembling *Staurodesmus*	*Xanthidium tumidum* (Figures 27.38–27.40)
	A.2 Cells with many long, forked or unforked marginal spines	*Xanthidium armatum* (Figures 27.23–27.27)
B	Cell length without spines ≤25 μm	
	B.1 Cells with long, open, neck-like sinus; outer semi-cell angles ending in long, stout spines	*Xanthidium octocorne* =*Staurodesmus octocornis* (Chapter 23, page 1107)
	B.2 Cells with short, V-shaped sinus; outer semi-cell angles ending in short, blunt teeth	*Xanthidium bifidum* (Figures 27.28–27.29)
C	Cell length without spines 40–90 μm	
	C.1 Semi-cell with 8 marginal spines arranged in 4 pairs	*Xanthidium antilopaeum* (including most varieties)
	C.1a Cell face smooth except for central raised area (may have fine pits or single pore); center usually orange-brown; spines straight or very gently curved	*Xanthidium antilopaeum* cf. var. *subeurycerum* (Figures 27.19–27.22)
	C.1b Cell face ornamented with oval ring of small pits; lower spine pairs (near isthmus) directed downward	*Xanthidium antilopaeum* var. *planum* (Figures 27.13–27.14)

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Table 27.1: Key to *Xanthidium* Species, continued

	C.1c Cell face ornamented with curving row of teeth upper spines nearly vertical; lower spines directed downward	*Xanthidium antilopaeum* f. *polymazum* (Figures 27.15–27.18)
	C.1d Cell face ornamented with curving row of teeth and one outwardly directed spine; upper spines nearly vertical; lower spines directed downward	*Xanthidium antilopaeum* var. *minneapoliense* (Figures 27.10– 27.12)
C.2	Semi-cell with marginal spines not arranged in 4 pairs	
	C.2a Semi-cells with 10 spines; solitary spines above sinus; paired spines along center and upper lateral margin; cell face with oval ring of large pits	*Xanthidium scrobiculatum* (Figures 27.30–27.34)
	C.2b Semi-cells with 8 spines; upper spines paired; lower spines one above the other; cell face with oval ring of small pits	*Xanthidium antilopaeum* f. *javanicum* (Figures 27.7–27.9)
	C.2c Semi-cells with 4 unpaired spines; cell face with large central pitted area (irregularly oval)	*Xanthidium subhastiferum* (Figures 27.35–27.37)
	C.2d Semi-cells with irregular number of short, unpaired or paired spines (typically 6–8); cell face with incomplete ring of deep pits; highly variable form - examine multiple specimens	*Xanthidium antilopaeum* var. *depauperatum* (Figures 27.4–27.6)

Table 27.2: *Xanthidium* Cell Measurements

		Cell Width	Cell Length	Isthmus Width	L/W Ratio
Xanthidium antilopaeum	min	43.4 μm	42.6 μm	13.8 μm	1.0
(without spines)	med	54.1 μm	61.6 μm	16.1 μm	1.0
	max	66.3 μm	67.8 μm	22.3 μm	1.2
Xanthidium antilopaeum	min	69.9 μm	59.8 μm	13.8 μm	0.9
(with spines)	med	96.2 μm	86.7 μm	16.1 μm	0.9
	max	113.7 μm	107.1 μm	22.3 μm	1.0
Xanthidium antilopaeum	min	54.4 μm	54.4 μm	14.8 μm	1.0
var. *depauperatum*	med	55.3 μm	56.4 μm	16.9 μm	1.0
(without spines)	max	56.7 μm	59.9 μm	19.8 μm	1.1
Xanthidium antilopaeum	min	78.7 μm	63.1 μm	14.8 μm	0.8
var. *depauperatum*	med	80.0 μm	66.2 μm	16.9 μm	0.8
(with spines)	max	85.5 μm	75.9 μm	19.8 μm	0.9
Xanthidium antilopaeum	min	52.3 μm	52.8 μm	18.3 μm	0.9
f. *javanicum*	med	59.8 μm	57.7 μm	18.8 μm	1.0
(without spines)	max	6..7 μm	59.8 μm	19.3 μm	1.0
Xanthidium antilopaeum	min	91.6 μm	64.9 μm	18.3 μm	0.6
f. *javanicum*	med	100.4 μm	74.6 μm	18.8 μm	0.8
(with spines)	max	109.1 μm	89.5 μm	19.3 μm	0.9
Xanthidium antilopaeum	min	52.1 μm	55.6 μm	14.4 μm	1.0
var. *minneapoliense*	med	57.7 μm	61.1 μm	17.2 μm	1.0
(without spines)	max	64.1 μm	66.8 μm	20.8 μm	1.2
Xanthidium antilopaeum	min	84.4 μm	78.7 μm	14.4 μm	0.9
var. *minneapoliense*	med	92.4 μm	87.6 μm	17.2 μm	0.9
(with spines)	max	101.2 μm	95.4 μm	20.8 μm	1.0

†*summary statistics based on <5 cells*

continued on next page

Table 27.2: *Xanthidium* Cell Measurements, continued

		Cell Width	Cell Length	Isthmus Width	L/W Ratio
Xanthidium antilopaeum	min	43.8 μm	44.8 μm	12.9 μm	1.0
var. *planum*	med	44.7 μm	45.7 μm	14.3 μm	1.0
(without spines)	max	48.7 μm	48.6 μm	16.1 μm	1.0
Xanthidium antilopaeum	min	70.4 μm	64.3 μm	12.9 μm	0.9
var. *planum*	med	73.5 μm	67.2 μm	14.3 μm	0.9
(with spines)	max	75.7 μm	70.4 μm	16.1 μm	1.0
Xanthidium antilopaeum	min	50.7 μm	54.7 μm	14.6 μm	1.0
f. *polymazum*	med	58.8 μm	61.6 μm	19.4 μm	1.1
(without spines)	max	65.0 μm	69.8 μm	22.2 μm	1.2
Xanthidium antilopaeum	min	72.8 μm	72.3 μm	14.6 μm	0.9
f. *polymazum*	med	87.5 μm	82.8 μm	19.4 μm	1.0
(with spines)	max	96.2 μm	89.7 μm	22.2 μm	1.0
Xanthidium antilopaeum	min	43.2 μm	44.8 μm	11.3 μm	0.9
cf. var. *subeurycerum*	med	48.7 μm	57.2 μm	14.0 μm	1.2
(without spines)	max	55.8 μm	62.9 μm	18.2 μm	1.3
Xanthidium antilopaeum	min	86.7 μm	76.4 μm	11.3 μm	0.7
cf. var. *subeurycerum*	med	96.2 μm	82.2 μm	14.0 μm	0.9
(with spines)	max	117.0 μm	90.0 μm	18.2 μm	1.0
Xanthidium armatum	min	66.1 μm	107.2 μm	28.5 μm	1.3
var. *fissum*	med	77.8 μm	112.7 μm	30.4 μm	1.5
(without spines)	max	86.8 μm	125.2 μm	35.5 μm	1.7
Xanthidium armatum	min	92.5 μm	130.4 μm	28.5 μm	1.2
var. *fissum*	med	105.7 μm	140.2 μm	30.4 μm	1.3
(with spines)	max	119.8 μm	150.4 μm	35.5 μm	1.4

†*summary statistics based on <5 cells*

continued on next page

Table 27.2: *Xanthidium* Cell Measurements, continued

		Cell Width	Cell Length	Isthmus Width	L/W Ratio
Xanthidium bifidum	min	11.8 μm	11.9 μm	5.6 μm	0.9
(without spines)	med	12.7 μm	12.3 μm	6.4 μm	1.0
	max	13.1 μm	13.4 μm	6.5 μm	1.1
Xanthidium bifidum	min	14.7 μm	14.3 μm	5.6 μm	0.9
(with spines)	med	15.3 μm	15.1 μm	6.4 μm	1.0
	max	15.8 μm	16.5 μm	6.5 μm	1.1
Xanthidium scrobiculatum	min	35.7 μm	49.9 μm	11.4 μm	1.3
(without spines)	med	43.7 μm	59.4 μm	13.6 μm	1.4
	max	50.4 μm	68.6 μm	16.7 μm	1.5
Xanthidium scrobiculatum	min	51.5 μm	65.6 μm	11.4 μm	1.2
(with spines)	med	67.5 μm	82.5 μm	13.6 μm	1.2
	max	78.1 μm	94.5 μm	16.7 μm	1.2
Xanthidium subhastiferum	min	45.7 μm	44.9 μm	11.9 μm	1.0
(without spines)	med	47.1 μm	48.9 μm	13.7 μm	1.0
	max	50.4 μm	52.1 μm	15.0 μm	1.1
Xanthidium subhastiferum	min	78.5 μm	49.1 μm	11.9 μm	0.6
(with spines)	med	81.6 μm	55.3 μm	13.7 μm	0.7
	max	94.1 μm	69.4 μm	15.0 μm	0.8
Xanthidium tumidum	min	98.7 μm	114.4 μm	48.0 μm	1.1
(without spines)	med	109.6 μm	118.6 μm	53.6 μm	1.1
	max	111.6 μm	126.9 μm	61.6 μm	1.2
Xanthidium tumidum	min	103.5 μm	114.0 μm	46.0 μm	1.0
(with spines)	med	114.0 μm	118.6 μm	53.6 μm	1.0
	max	125.0 μm	126.9 μm	61.6 μm	1.1

[†]*summary statistics based on <5 cells*

Description

Most *Xanthidium* cells are large, angular, oval or compressed in cross-section, with a deep sinus, and 1–2 axial chloroplasts with large, central pyrenoids. The outer angles of the cells usually extend into long spines. The cell wall may be smooth or ornamented with pits or teeth. The species and varieties of *Xanthidium* are mostly separated by differences in cell wall ornamentation and variations in the number, placement, and angle of spines. Several *Xanthidium* species do not fit the characteristics listed above (e.g., *Xanthidium bifidum*, Figure 27.28). In addition, most species are extremely polymorphic, so species identification can be difficult.

Xanthidium antilopaeum is a very common, highly polymorphic species with many named varieties and forms. Most of the varieties, including the nominate variety[66] have hexagonal or elliptical semi-cells that are moderately compressed, oval in cross-section, with four pairs of long, slightly curved marginal spines, resulting in eight spines per semi-cell (Figures 27.1–27.22) The sinus is usually deep, narrowly open or closed and linear near the isthmus, then widely flared near the lateral margin. The center of the semi-cell wall is thickened and contains one or more rings of small pits. The varieties of *Xanthidium antilopaeum* are distinguished by differences in cell wall ornamentation and spine features.

Xanthidium antilopaeum* var. *depauperatum semi-cells are broadly elliptical, with deep sinus that is closed and linear near the isthmus, then flared near the lateral margin (Figures 27.4 –27.6). The semi-cells usually have 6–8 short, widely spaced marginal spines on each semi-cell; the spines may be paired or unpaired. This irregular spine configuration is a characteristic of the variety. The semi-cell is ornamented with incomplete rings of large pits that form a central oval.

Xanthidium antilopaeum* f. *javanicum semi-cells are hexagonal, with an upper set of paired spines (similar to the nominate variety) and two additional unpaired lateral spines placed one above the other, for a total of eight spines per semi-cell (Figures 27.7–27.9). The sinus is narrowly open near the isthmus, then widely flared. The wall ornamentation consists of a central oval of small pits. *Xanthidium antilopaeum* f. *javanicum* resembles *Xanthidium hebridarum* (no image available), which has unpaired subapical spines (six spines per semi-cell). Coesel (2007) indicated that there were intermediate specimens often present in Dutch populations, so it is not clear whether *Xanthidium antilopaeum* f. *javanicum* is a morphological variation or a genetically distinct variety.

[66] *Xanthidium antilopaeum* var. *antilopaeum*

Xanthidium antilopaeum* var. *minneapoliense is characterized by compressed, hexagonal or elliptical semi-cells, with a deep sinus that is closed and linear near the isthmus, then flared near the lateral margin (Figures 27.10–27.12). The semi-cells have four sets of paired spines along the lateral margin (eight spines per semi-cell); the upper spines are nearly perpendicular to the apex and the lower spines are angled downward. The wall ornamentation consists of a curved horizontal row of large teeth on the face of each semi-cell, and one additional short, thin spine is located subapically just below a row of teeth.[67] *Xanthidium antilopaeum* var. *minneapoliense* closely resembles *Xanthidium antilopaeum* f. *polymazum*, which lacks the additional subapical spine below the row of teeth (Figure 27.16). Gerrath (1986) suggests merging these two taxa because he found intermediate forms in samples collected concurrently.

Xanthidium antilopaeum* var. *planum semi-cells are hexagonal, with a deep sinus that is closed and linear near the apex, then flared near the margin (Figures 27.13–27.14). The semi-cells have four pairs of long marginal spines (eight spines per semi-cell), with nearly vertical subapical spines and downwardly directed lateral spines. The center of the semi-cell wall is ornamented with an oval ring of pits, with a few additional pits inside the ring.

Xanthidium antilopaeum* f. *polymazum is characterized by compressed, hexagonal or elliptical semi-cells and a deep sinus that is closed and linear near the isthmus, then flared near the lateral margin (Figures 27.15–27.18). The semi-cells have four sets of paired spines; the upper spines are nearly perpendicular to the apex and the lower spines are angled downward. The wall ornamentation consists of a curved horizontal row large teeth on the face of each semi-cell. *Xanthidium antilopaeum* f. *polymazum* closely resembles *Xanthidium antilopaeum* var. *minneapoliense*, which has one additional spine that extends upward from just below the row of teeth (Figure 27.11). Gerrath (1986) suggests merging these two taxa because he found intermediate forms in samples collected concurrently.

Xanthidium antilopaeum* cf. var. *subeurycerum is characterized by elliptical or hexagonal semi-cells, with a deep sinus that is closed or narrowly open, then inflated at the margin (Figures 27.19–27.22). The semi-cells have four pairs of long, slender spines (eight spines per semi-cell). Cell ornamentation is reduced to a raised orange-brown central region that many be entirely smooth or have a large pore. The identification is uncertain because Prescott, et al. (1982) describe this variety as having walls ornamented with an arc of shallow pits on the apical margin

[67] Prescott, et al. (1982) states that the spine may be located above or below the row of teeth.

of the central raised area. This type of ornamentation was not clearly visible in any of the SEM images; however, one specimen from Bear Lake appeared to have a partial ring of fine pits above the central pore (Figure 27.21).

Xanthidium armatum cells are large and broadly oval in cross-section, with spiny octagonal semi-cells, and a deep, open sinus (Figures 27.23–27.27). Almost all of the northwest Washington specimens were ***Xanthidium armatum* var. *fissum***, which is characterized by long, forked (occasionally unforked) marginal and apical spines, with a tuft of spines on the face of the cell above the isthmus. An important characteristic of this variety is that the central spines above the isthmus resemble the marginal and apical spines, with the ends of most spines divided 2–4x. Approximately 30% of the specimens from Bear Lake exhibited an morphological variation where the lateral spines immediately adjacent to the sinus was intact rather than forked (Figure 27.26).

Xanthidium bifidum cells are small, approximately rectangular in outline, and strongly flattened (Figures 27.28–27.29). The semi-cells are cup-shaped, with a concave apex, and a widely open sinus. The outer angles of the semi-cell terminate in short, paired, marginal teeth (four teeth per semi-cell). ***Xanthidium bifidum*** does not resemble other species of *Xanthidium*, and is closer in appearance to *Staurodesmus octocornis* (Chapter 23, page 1107). Not surprisingly, both taxa have synonyms in other genera: *Xanthidium bifidum* was briefly renamed *Octacanthium bifidum*, but is currently listed as *Xanthidium bifidum* on AlgaeBase ((www.algaebase.org, Guiry and Guiry, 2023); *Staurodesmus octocornis* was, until recently, named *Xanthidium octocorne*, but was moved to the genus *Staurodesmus* based on genetic analyses.

Xanthidium scrobiculatum cells are broadly oval in outline, with hexagonal semi-cells (Figures 27.30–27.34). Each semi-cell has four pairs of short, stout spines on the upper angles of the cell margin and a single spine on either side of the sinus, resulting in a total of ten spines per semi-cell. The sinus is deep and almost closed near the center, then flared near the outer margin. The center face of each semi-cell has thickened, orange region containing a ring of pits. Some specimens may also have a raised knob inside the ring of pits (Figure 27.34).

Xanthidium subhastiferum cells are oval in outline, with compressed, elliptical or trapezoidal semi-cells, and a deep, open sinus (Figures 27.35–27.37). Each semi-cell has four long, unpaired spines, with two located on opposite sides below the apex, and two more located half way up the lateral margins. The face of the cell is ornamented with a central oval of small pits.

Xanthidium tumidum is characterized by large, oval, smooth-walled cells that are broadly triangular in cross-section (Figures 27.38–27.40). The outer angles of the cells are slightly thickened, but lack the distinctive long spines that are present in other species of *Xanthidium*. The cell wall is smooth, lacking pitted surface ornamentation that is common in other species of *Xanthidium*. Morphologically, *Xanthidium tumidum* does not resemble other species of *Xanthidium*. This species was assigned to the genus *Xanthidium* by Šťastný et al. (2013) based on genetic analyses and is co-listed under *Staurodesmus* (Chapter 23, page 1107) and *Staurastrum* (Chapter 22, page 755) to match older taxonomic guides.

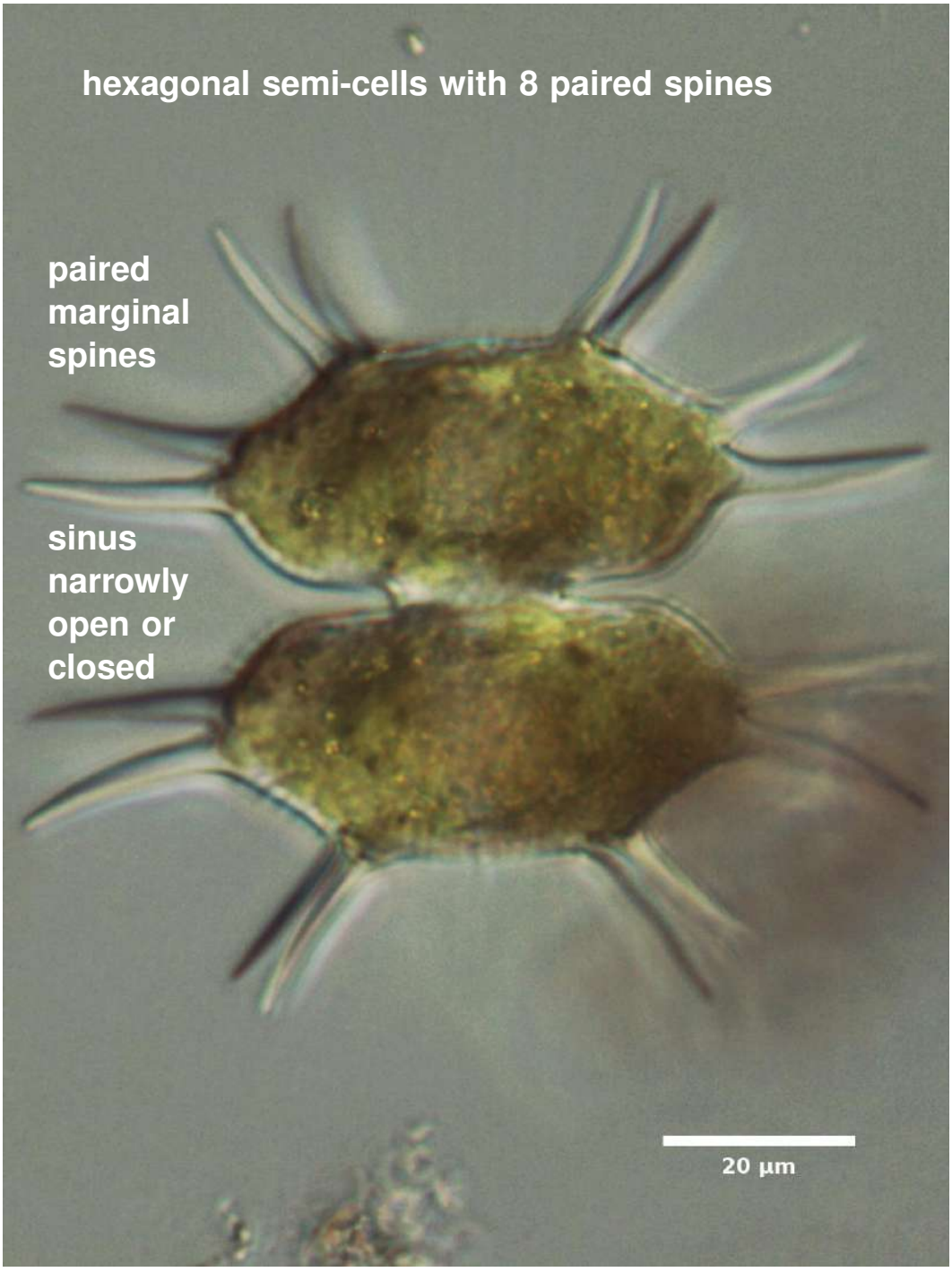
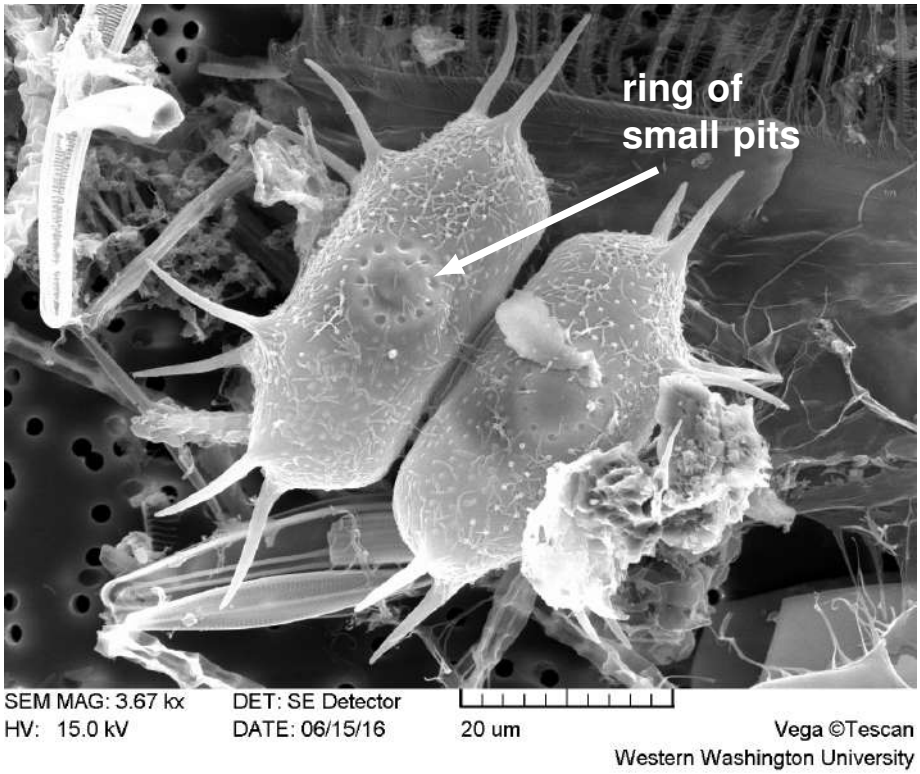


Figure 27.1: *Xanthidium antilopaeum* (DIC), Lake Evan, Mountain Loop Highway, Snohomish County.



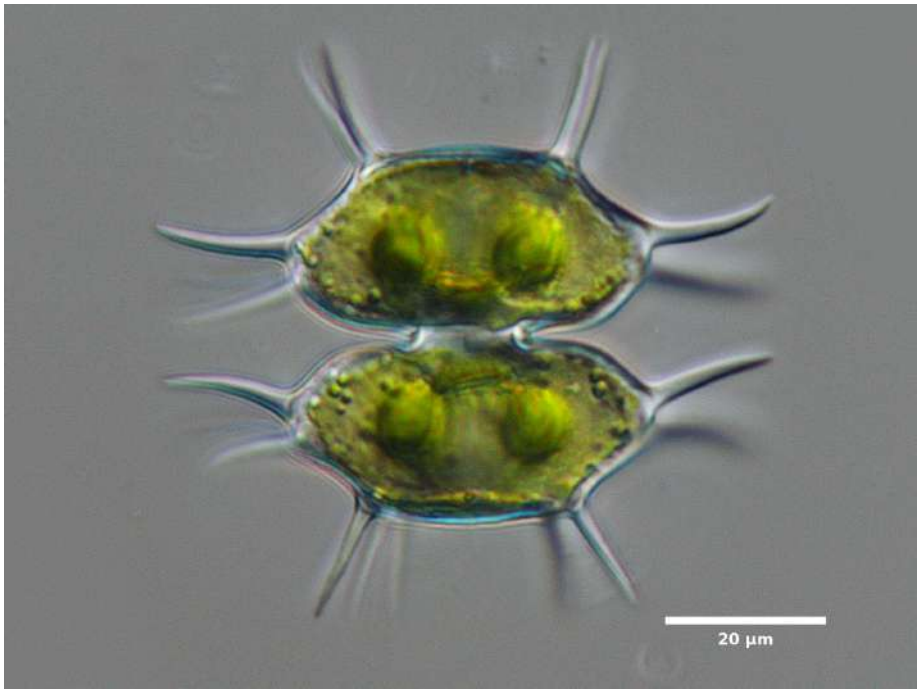


Figure 27.2: *Xanthidium antilopaeum* (SEM/DIC), Bear Lake, Mountain Loop Highway, Snohomish County (upper image); Lake Evan, Mountain Loop Highway, Snohomish County (lower image).

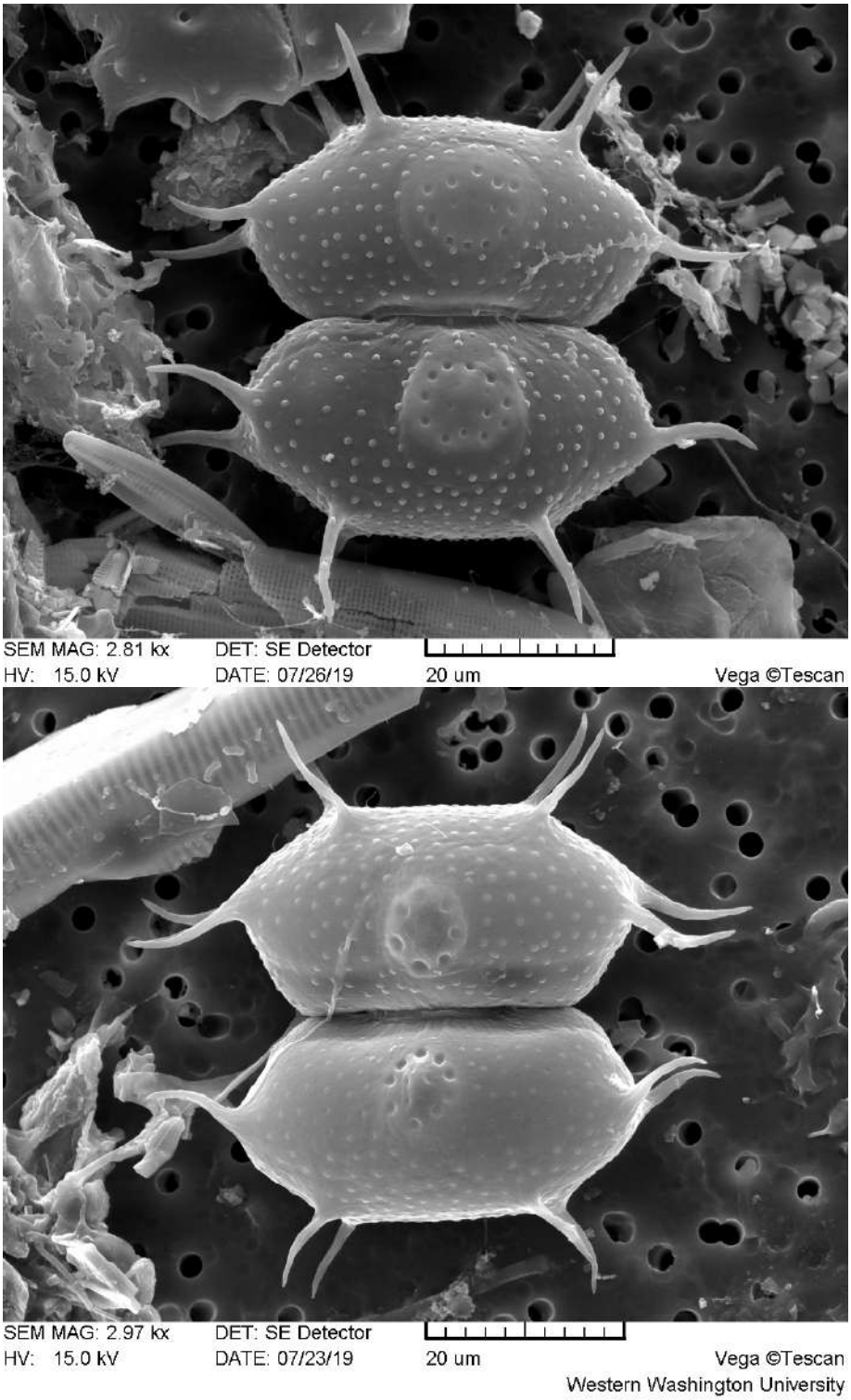


Figure 27.3: *Xanthidium antilopaeum* (SEM/SEM), side channel of Chain Lake, Gifford Pinchot National Forest, Skamania County (upper/lower images).



Figure 27.4: *Xanthidium antilopaeum* var. *depauperatum* (DIC), small boggy pond along Morris Valley Road near Harrison BC.

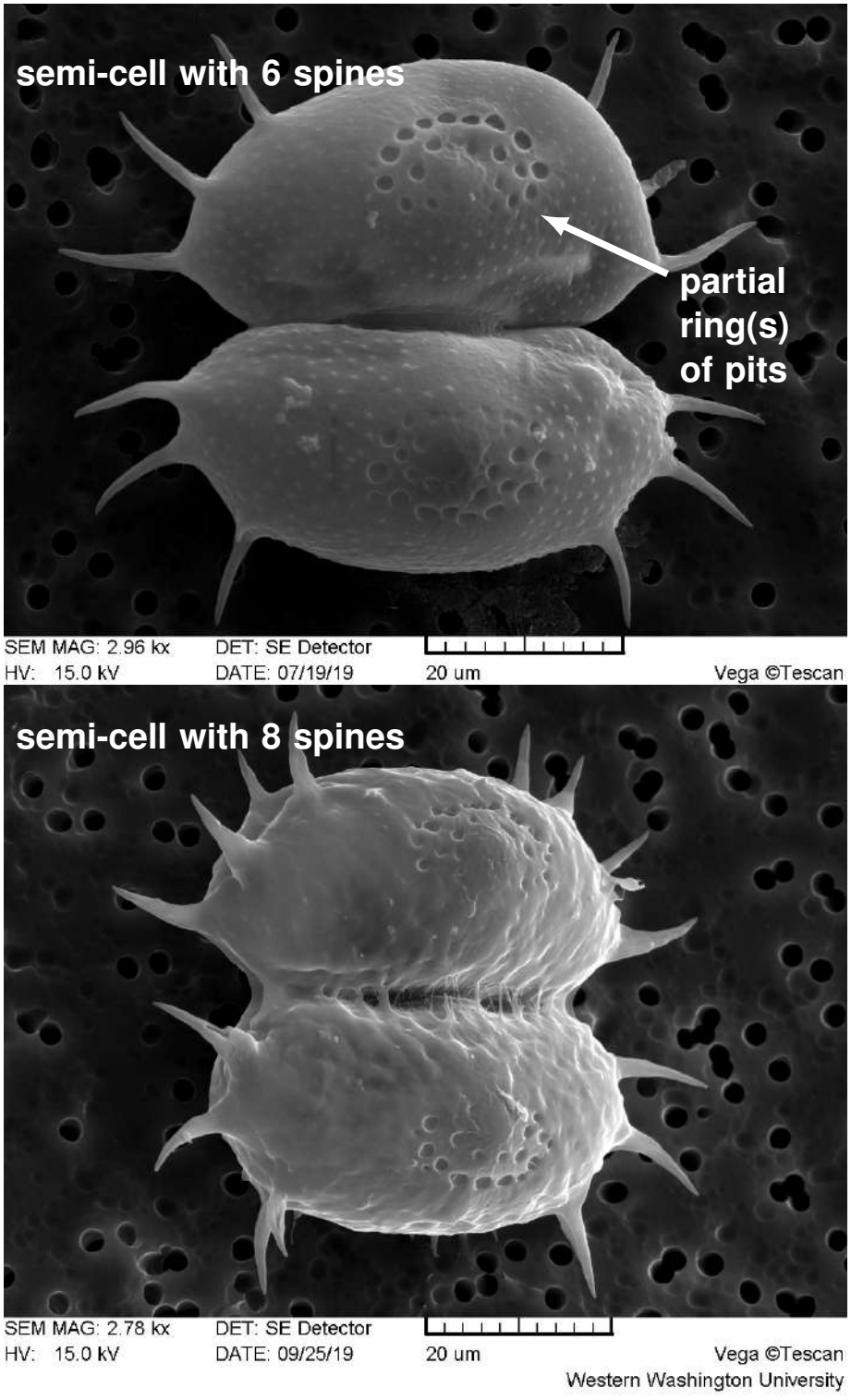


Figure 27.5: *Xanthidium antilopaeum* var. *depauperatum* (SEM/SEM), small boggy pond along Morris Valley Road near Harrison BC (upper/lower images).

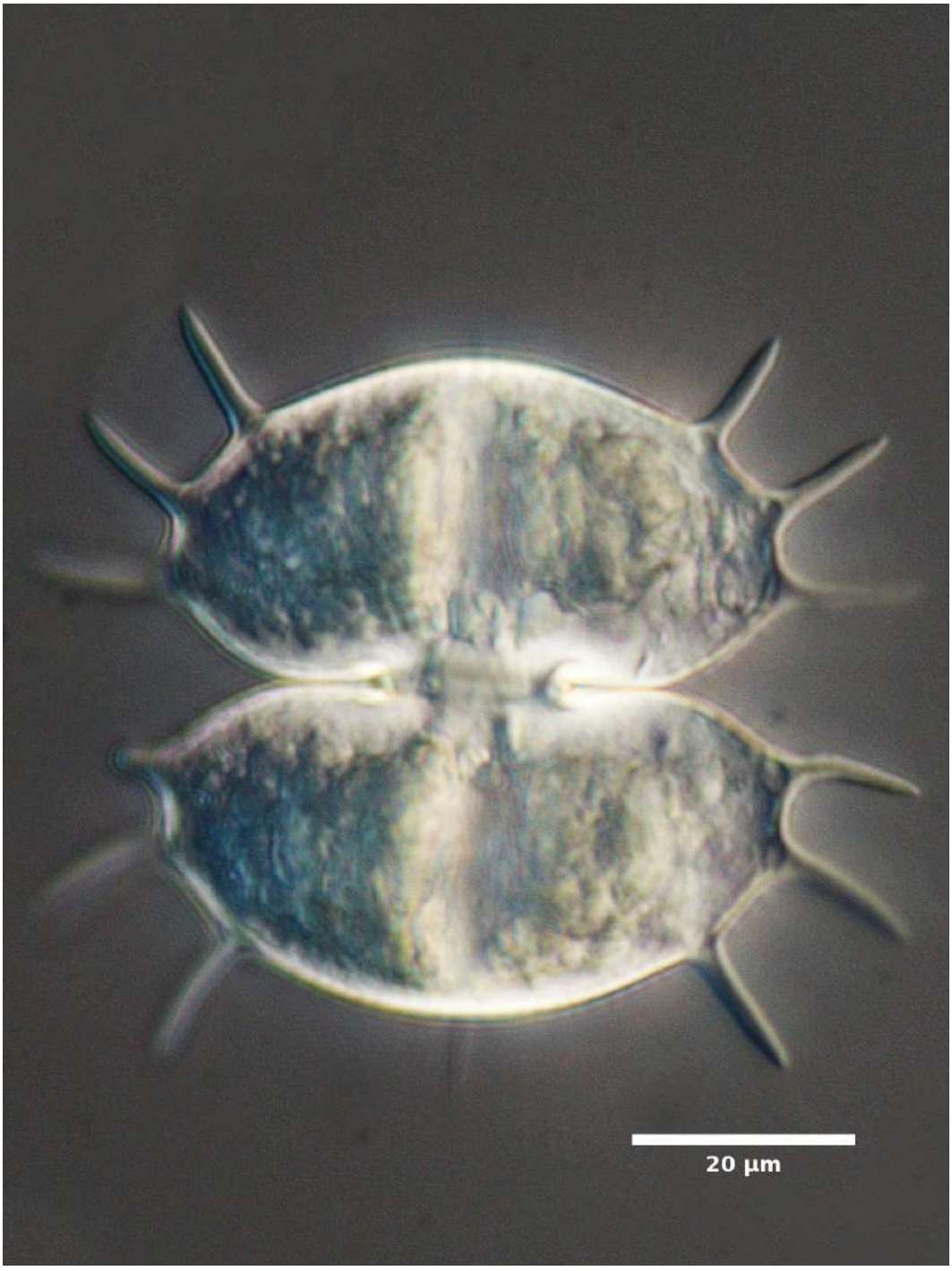


Figure 27.6: *Xanthidium antilopaeum* var. *depauperatum* (DIC), small boggy pond along Morris Valley Road near Harrison BC.

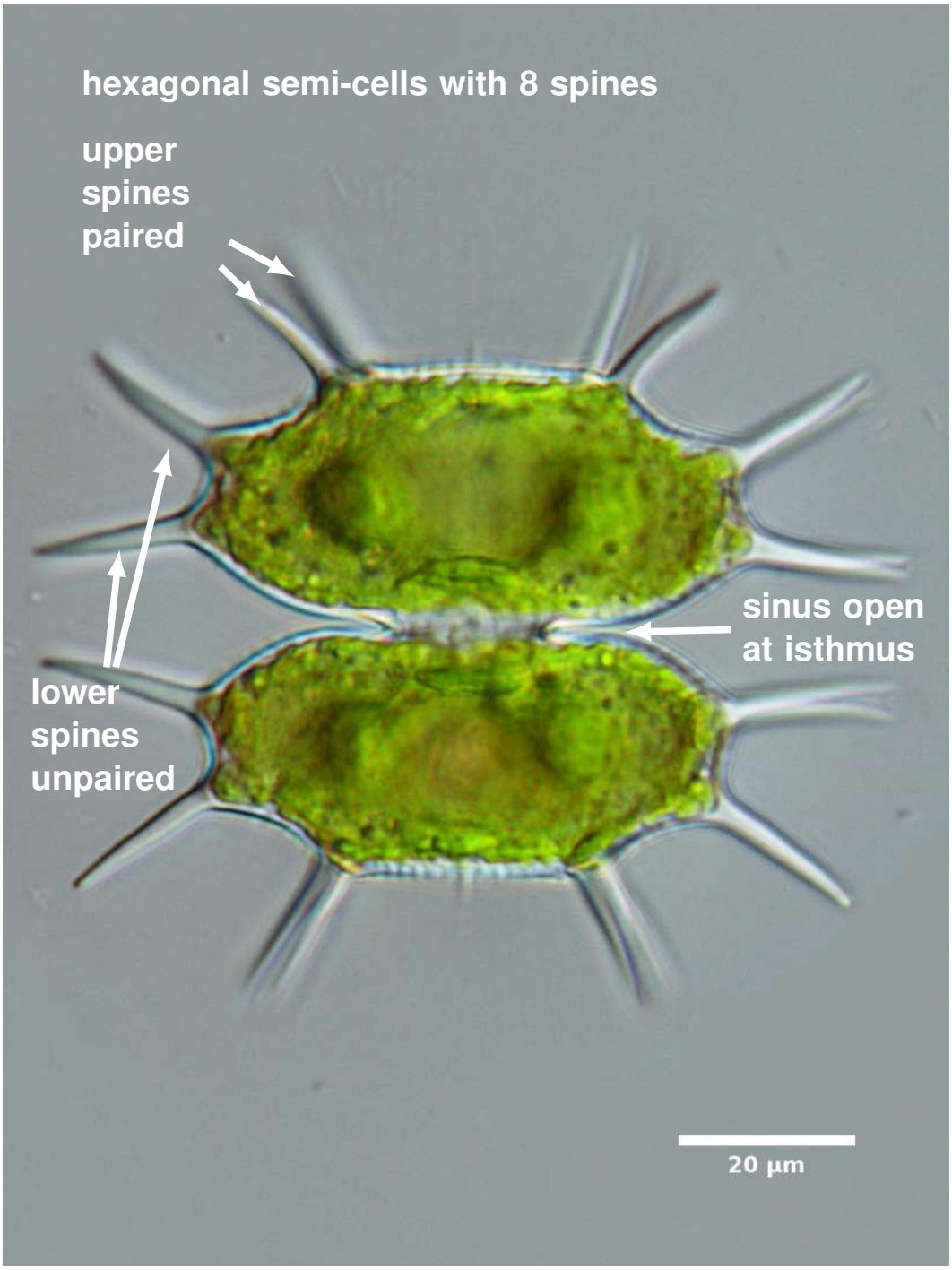


Figure 27.7: *Xanthidium antilopaeum* f. *javanicum* (DIC), small residential pond on Valley Circle Drive, Snohomish County.



Figure 27.8: *Xanthidium antilopaeum* f. *javanicum* (DIC/DIC), small residential pond on Valley Circle Drive, Snohomish County (upper/lower images).

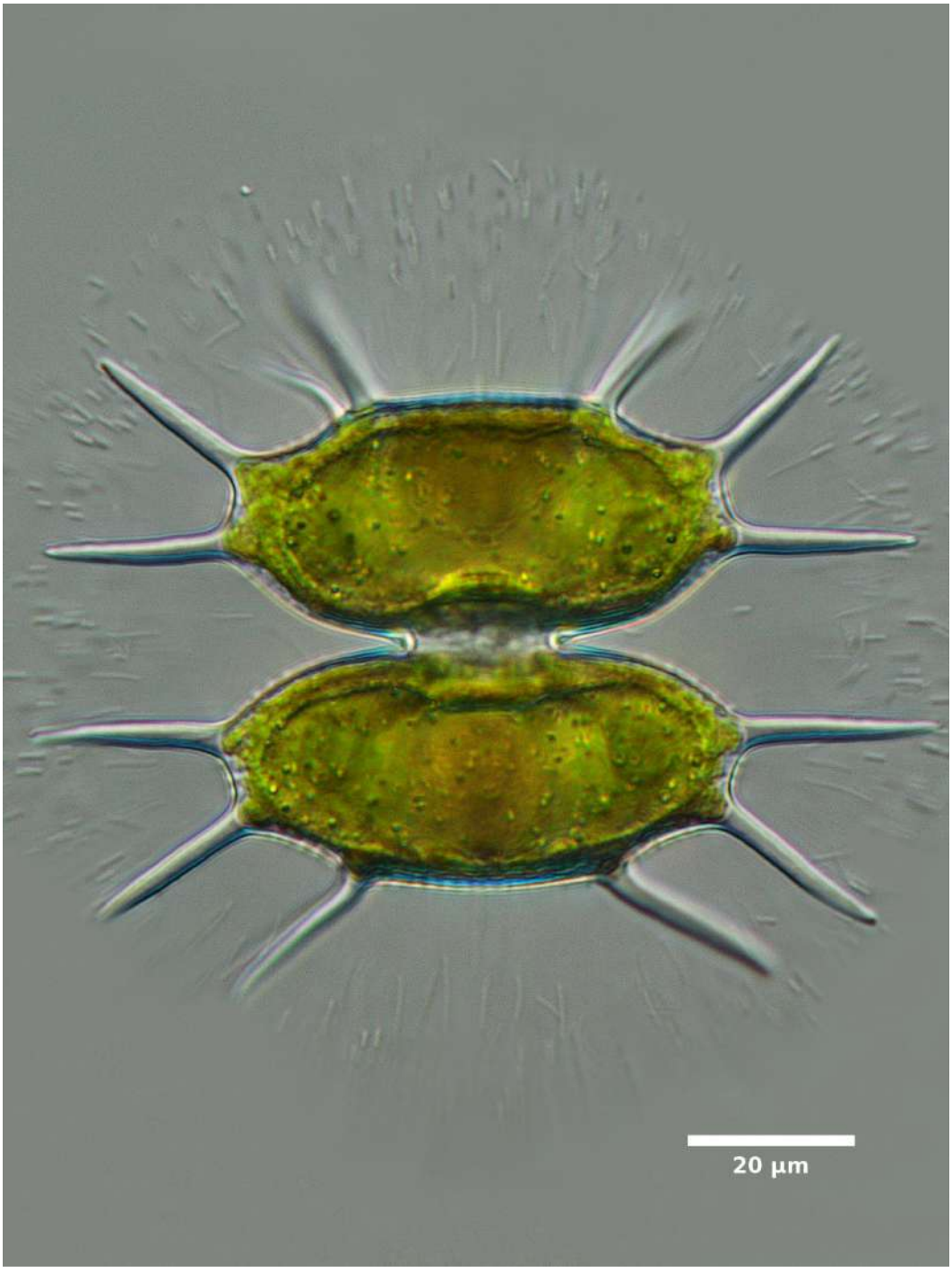


Figure 27.9: *Xanthidium antilopaeum* f. *javanicum* (DIC), small residential pond on Valley Circle Drive, Snohomish County.

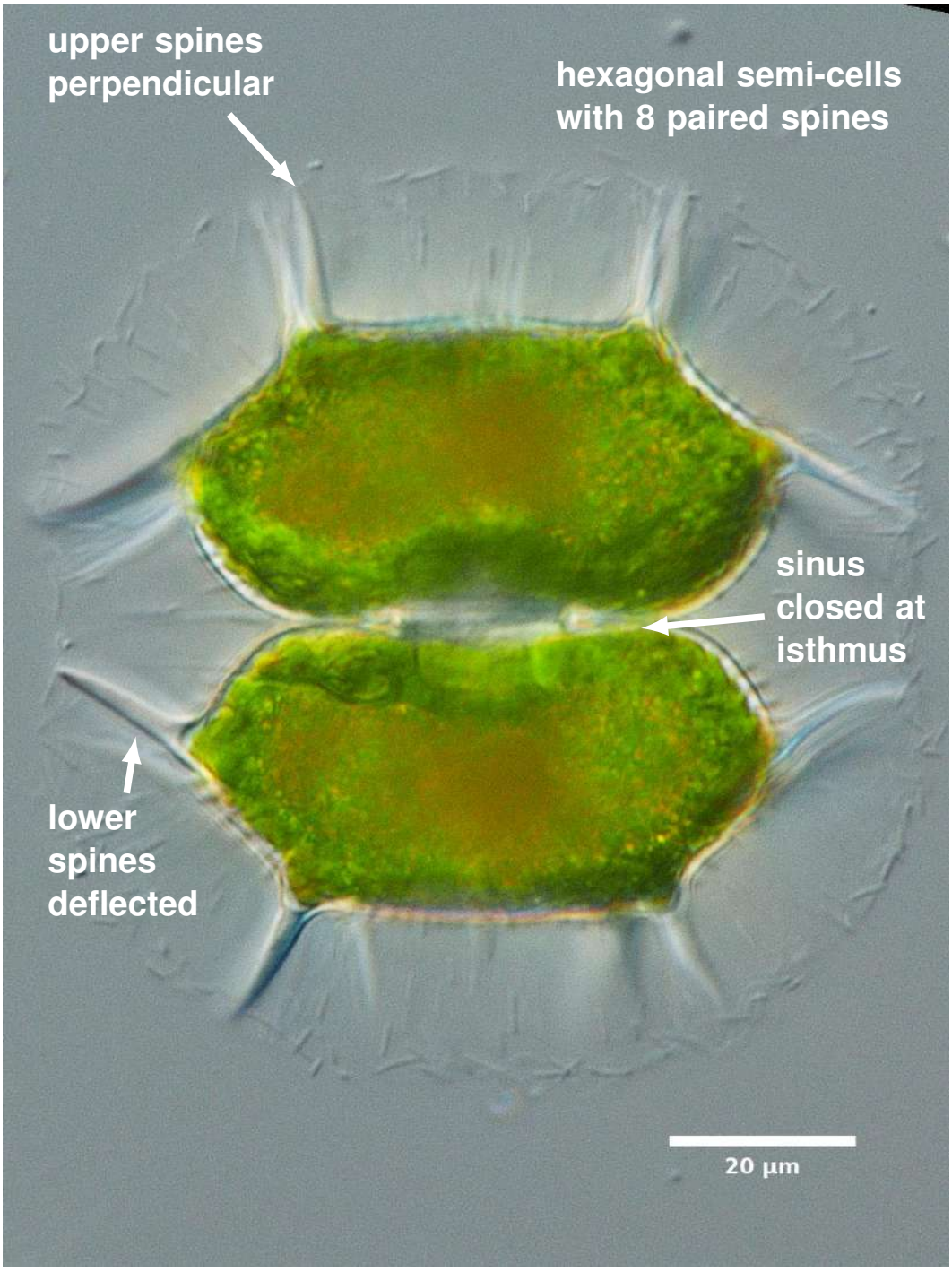


Figure 27.10: *Xanthidium antilopaeum* var. *minneapoliense* (DIC), Lake Geneva, Whatcom County.

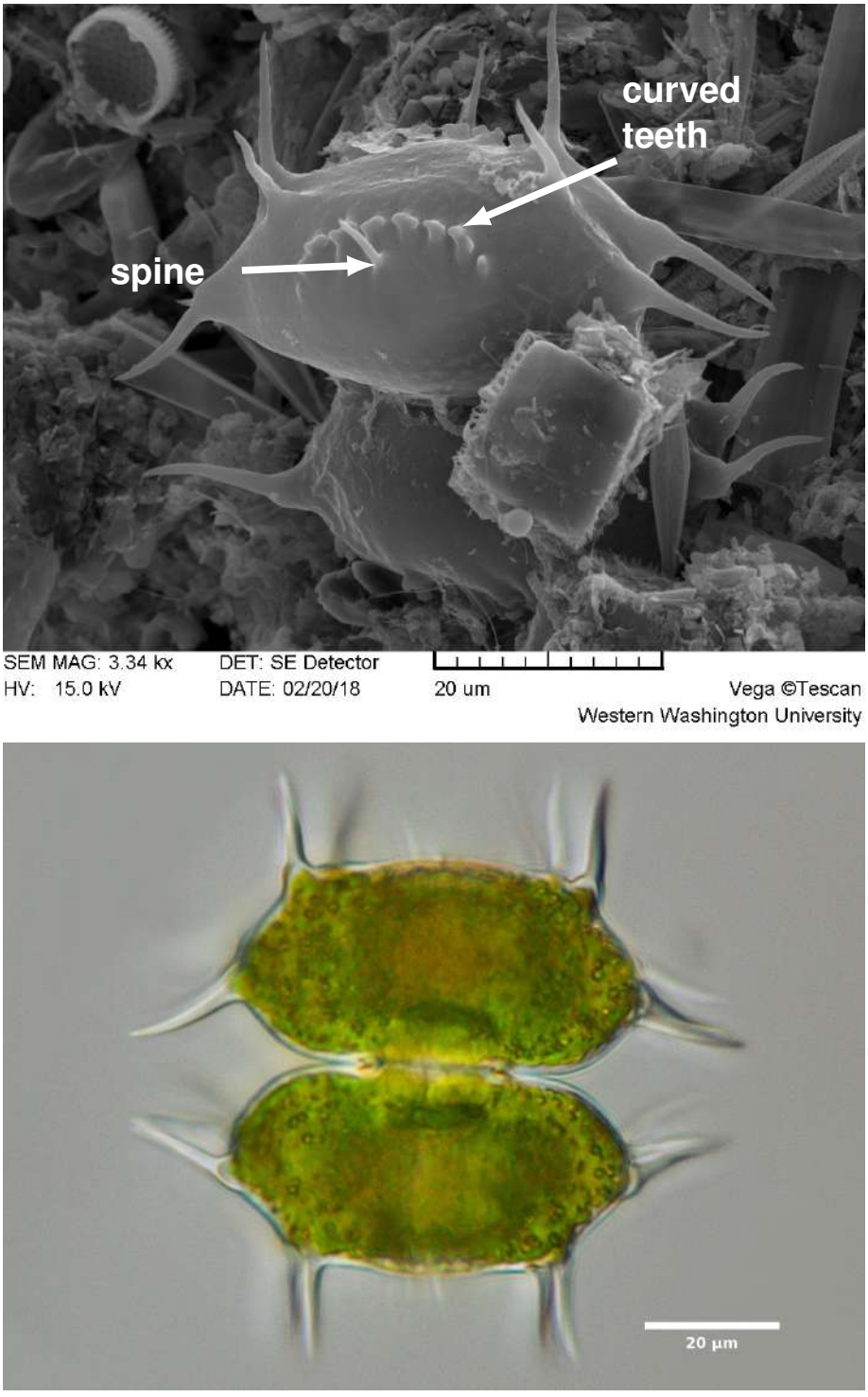


Figure 27.11: *Xanthidium antilopaeum* var. *minneapoliense* (SEM/DIC), Lake Twenty-two, Mountain Loop Highway, Snohomish County (upper/lower images).



Figure 27.12: *Xanthidium antilopaeum* var. *minneapoliense* (DIC/DIC), Lake Geneva, Whatcom County (upper/lower images).

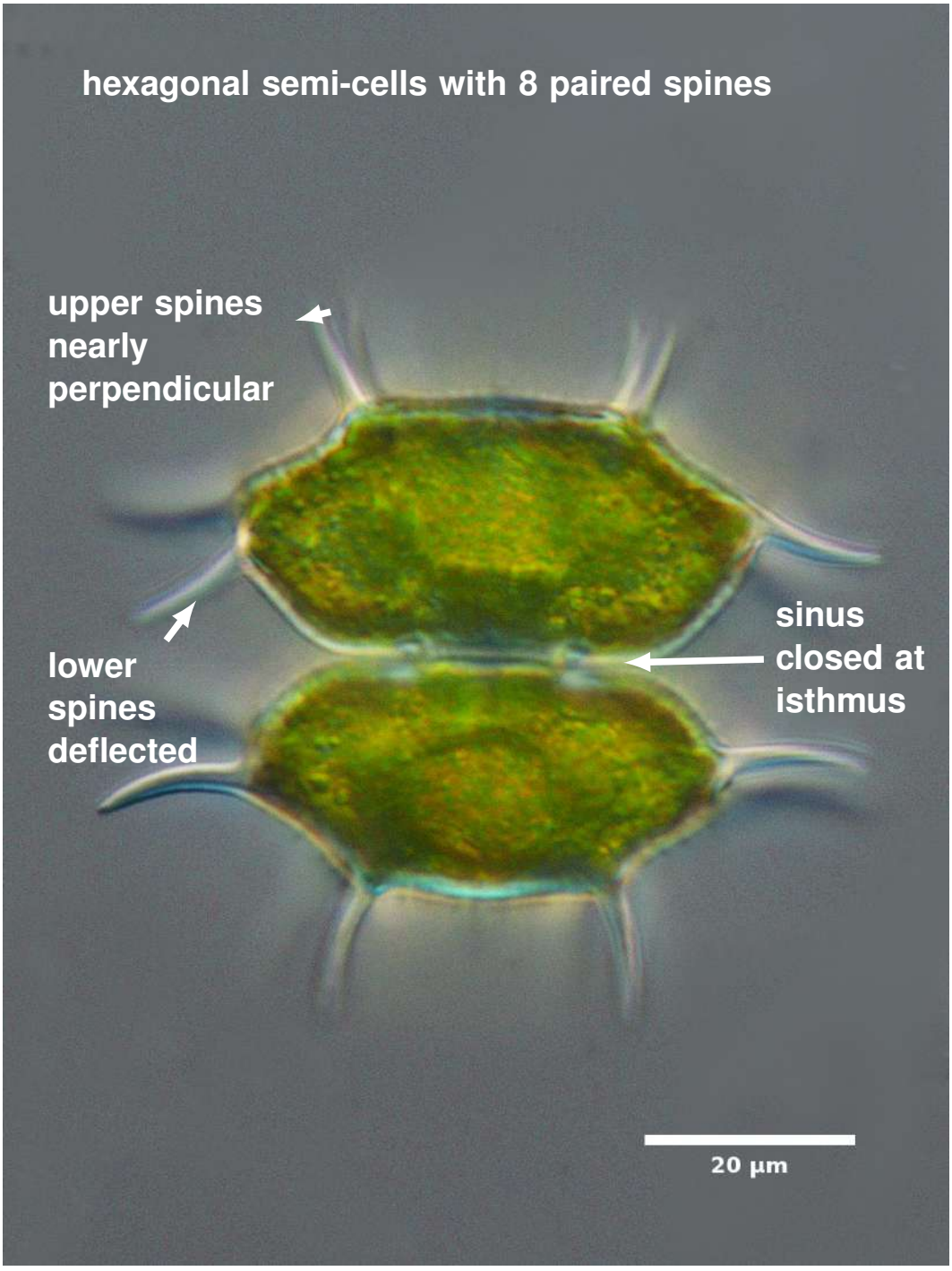


Figure 27.13: *Xanthidium antilopaeum* var. *planum* (DIC), Lake Evan, Mountain Loop Highway, Snohomish County.



Figure 27.14: *Xanthidium antilopaeum* var. *planum* (SEM/DIC), Lake Evan, Mountain Loop Highway, Snohomish County (upper/lower images).

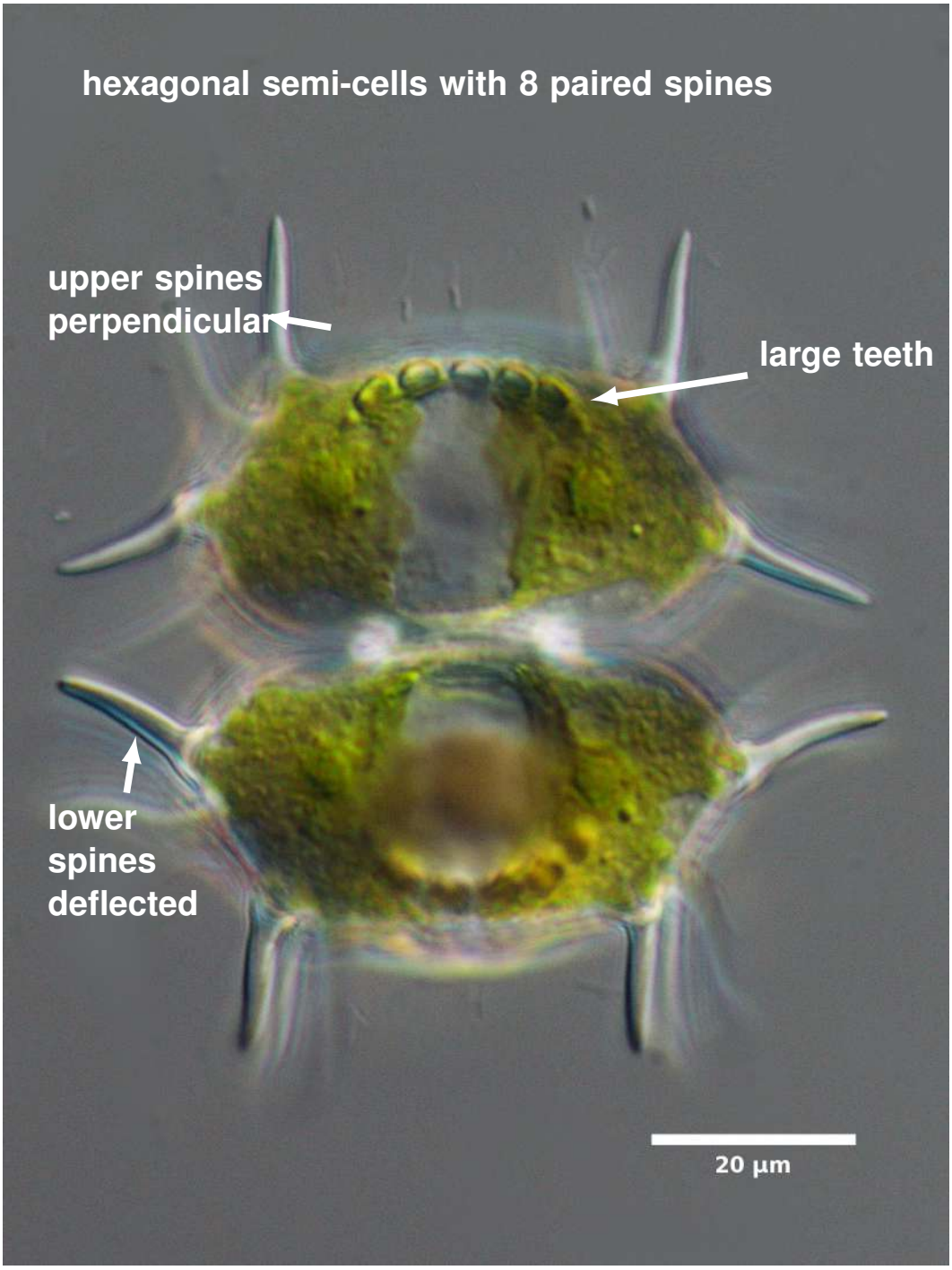
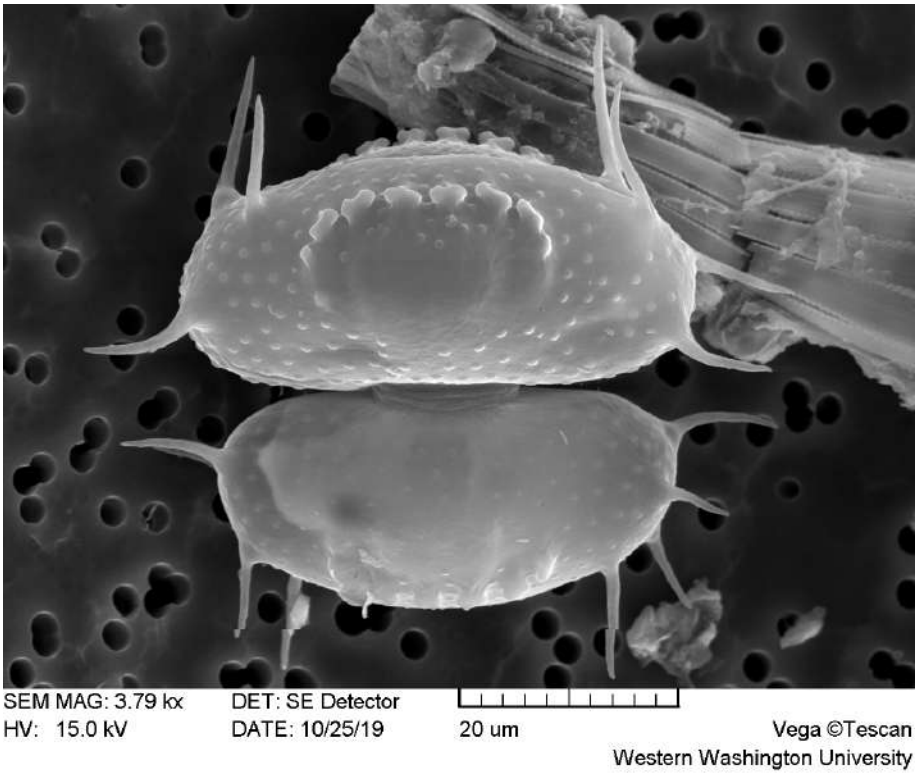


Figure 27.15: *Xanthidium antilopaeum* f. *polymazum* (DIC), Highwood Lake, Mt. Baker area, Whatcom County.



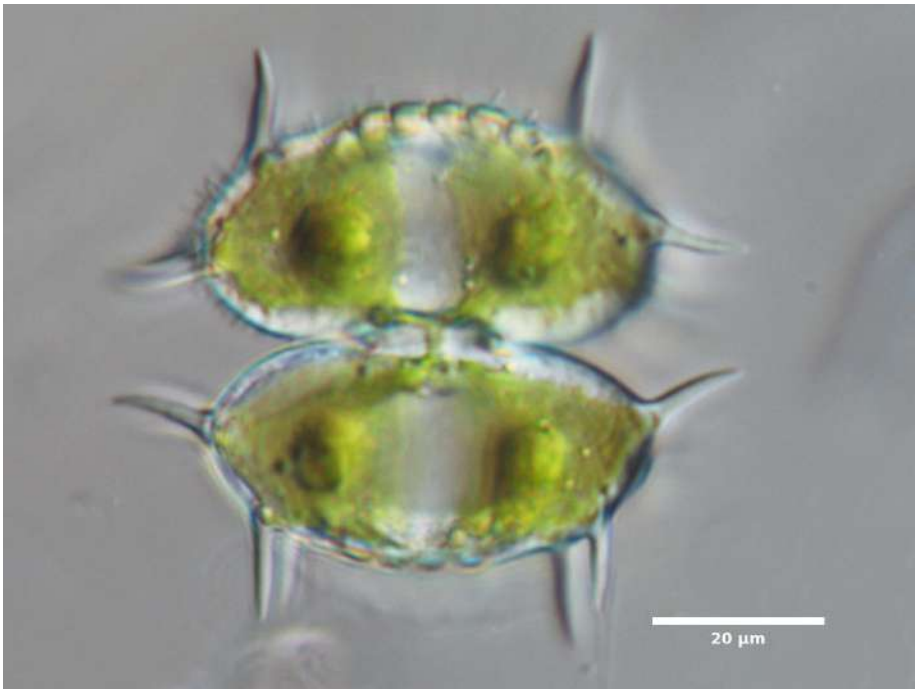


Figure 27.16: *Xanthidium antilopaeum* f. *polymazum* (SEM/DIC), Clear Lake, Skagit County (upper/lower images).

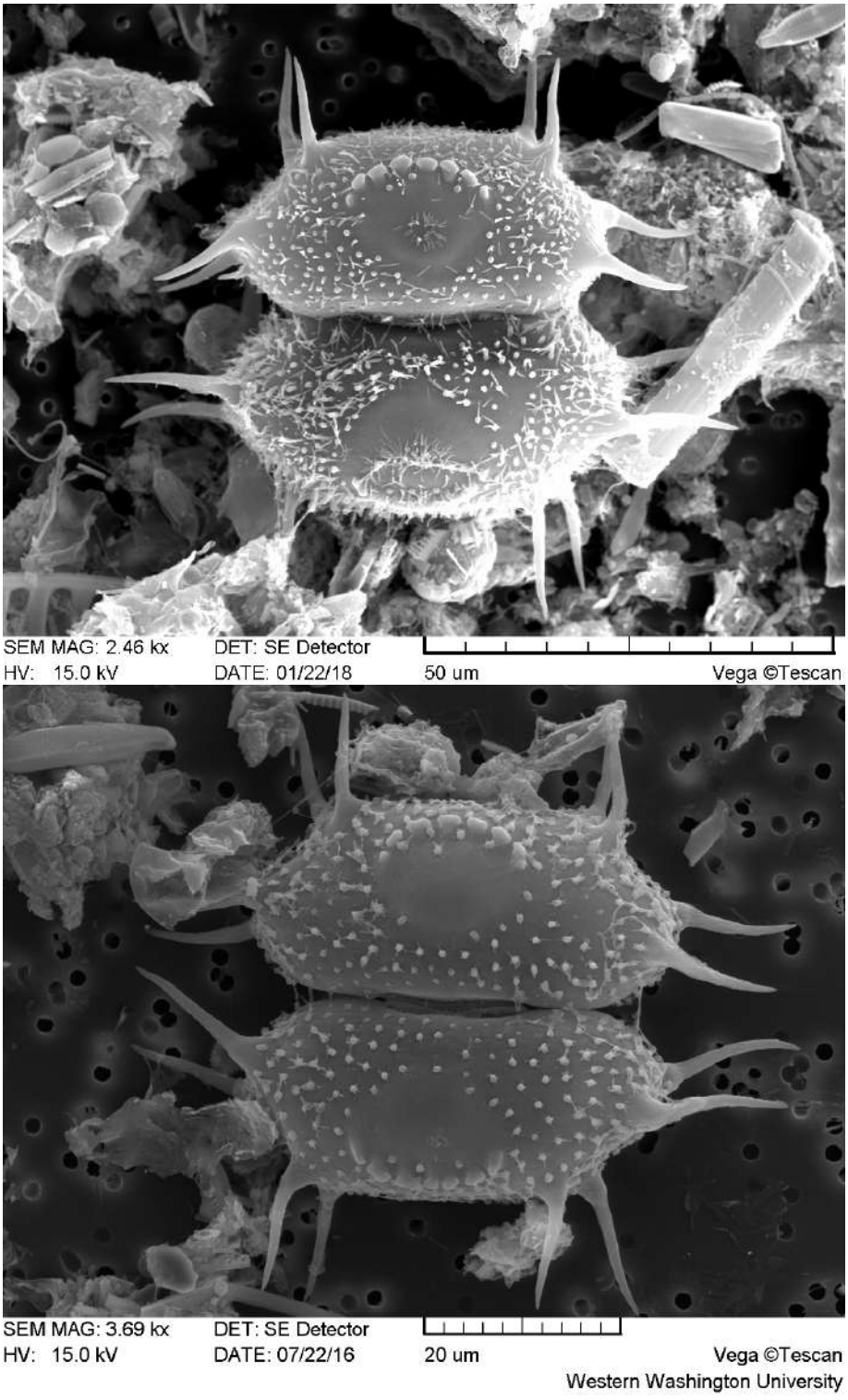


Figure 27.17: *Xanthidium antilopaeum* f. *polymazum* (SEM/SEM), Lake Evan, Mountain Loop Highway, Snohomish County (upper/lower images).



Figure 27.18: *Xanthidium antilopaeum* f. *polymazum* (DIC/DIC), Myrtle Lake, Mountain Loop Highway, Snohomish County (upper/lower images).

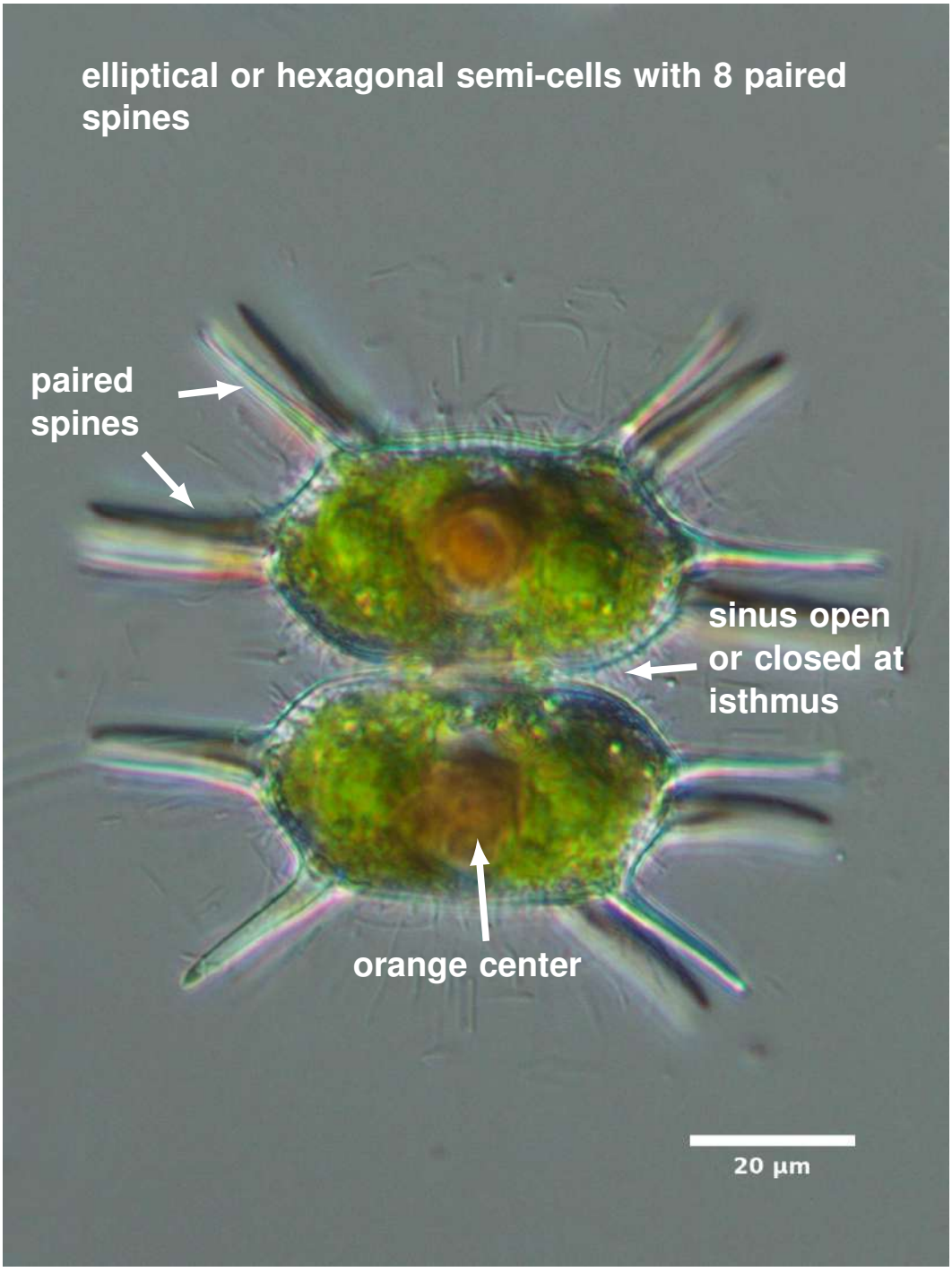


Figure 27.19: *Xanthidium antilopaeum* cf. var. *subeurycerum* (DIC), Bear Lake, Mountain Loop Highway, Snohomish County.

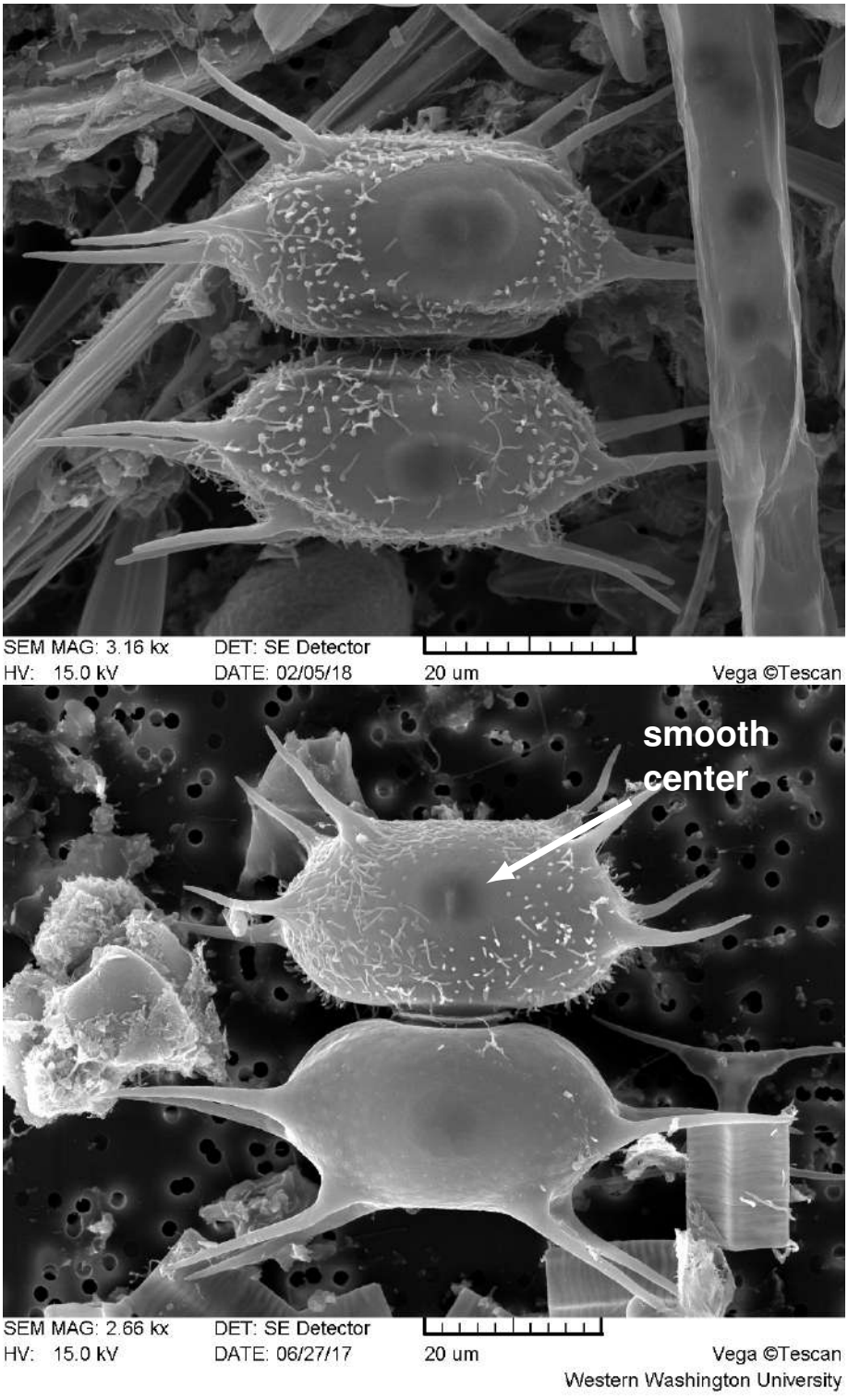


Figure 27.20: *Xanthidium antilopaeum* cf. var. *subeurycerum* (SEM/SEM), Bear Lake, Mountain Loop Highway, Snohomish County (upper image); Boardman Lake, Mountain Loop Highway, Snohomish County (lower image).

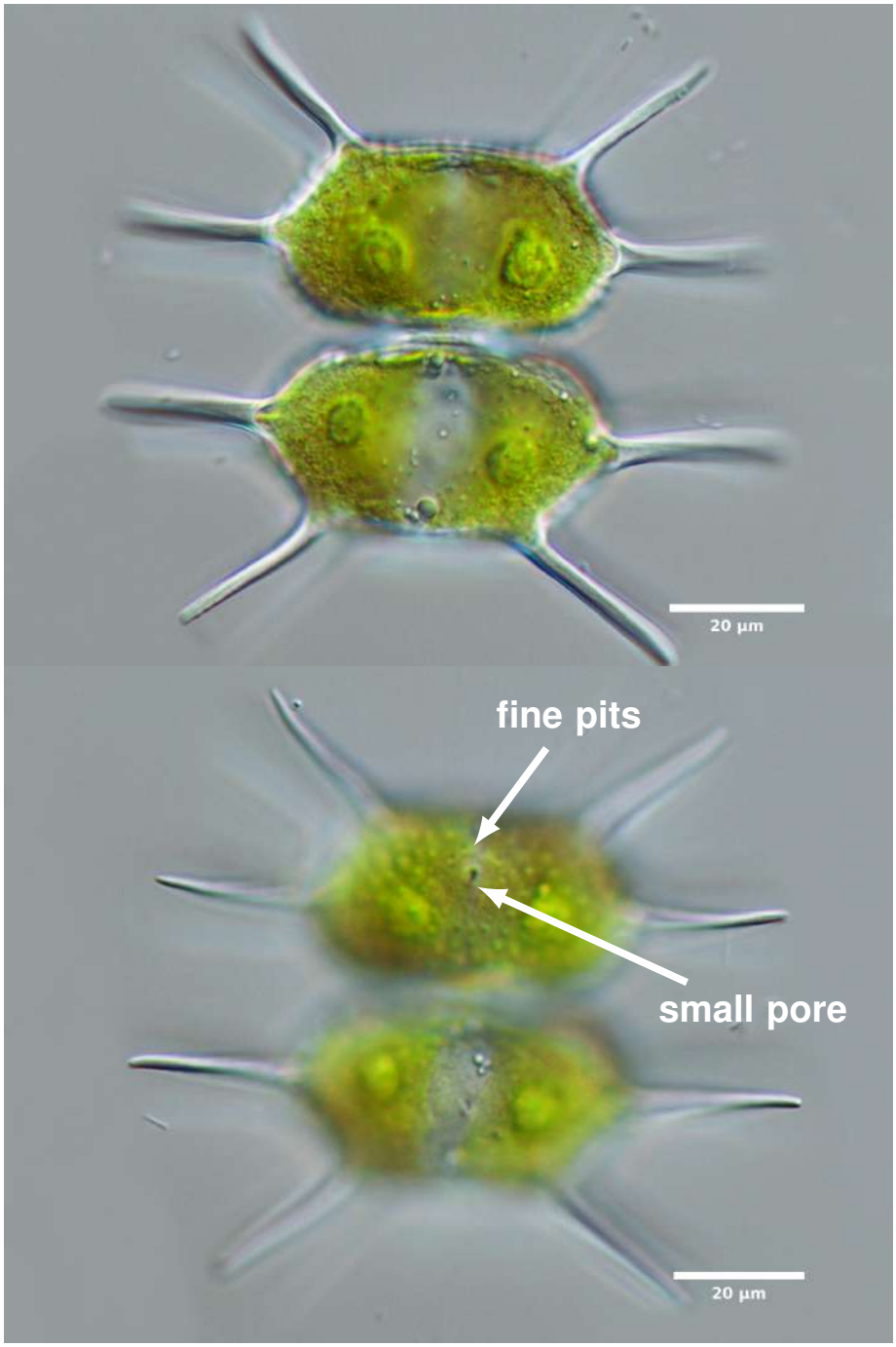


Figure 27.21: *Xanthidium antilopaeum* cf. var. *subeurycerum* (DIC/DIC), Bear Lake, Mountain Loop Highway, Snohomish County (upper/lower images).



Figure 27.22: *Xanthidium antilopaeum* cf. var. *subeurycerum* (DIC), Bear Lake, Mountain Loop Highway, Snohomish County.

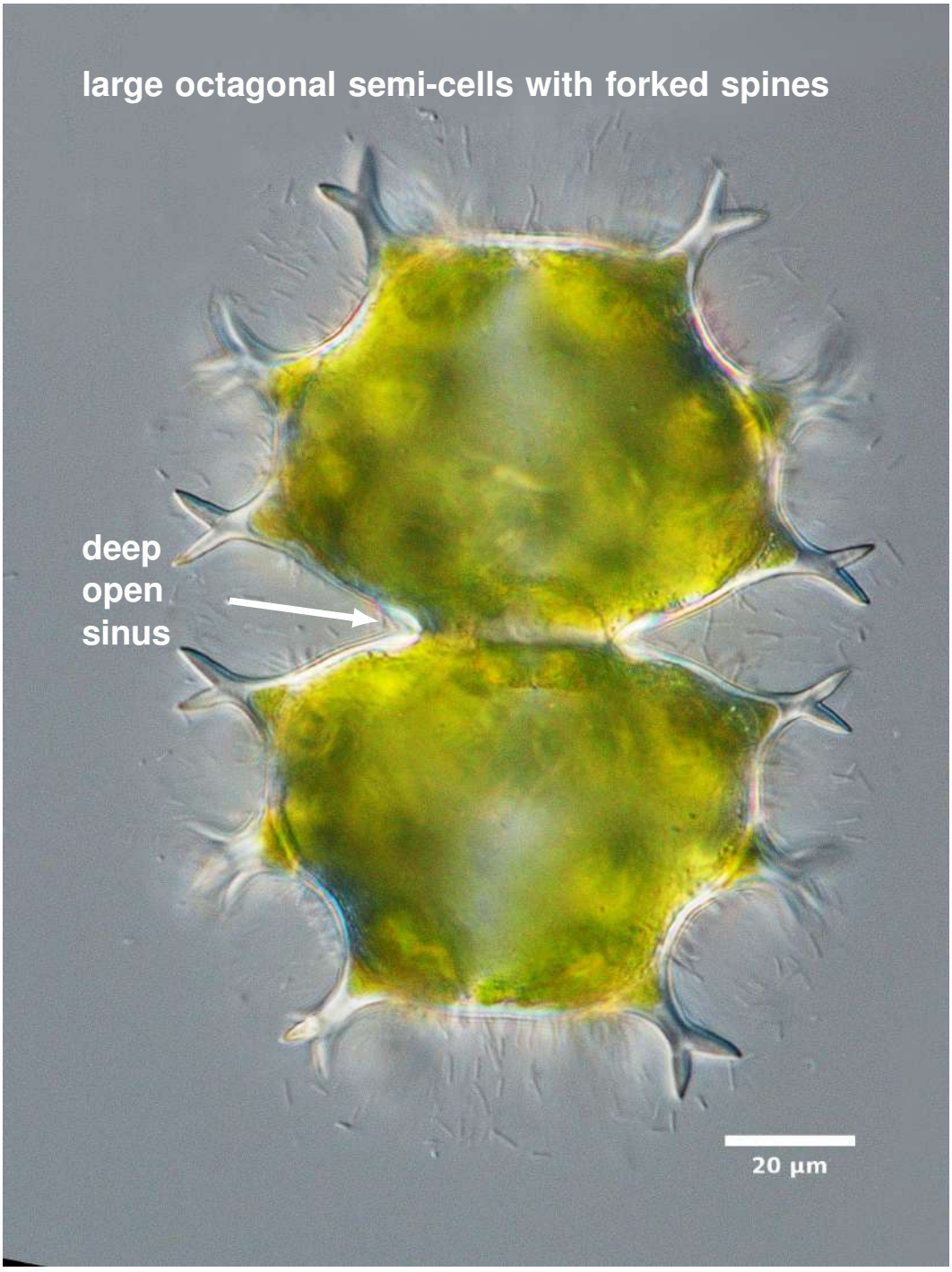
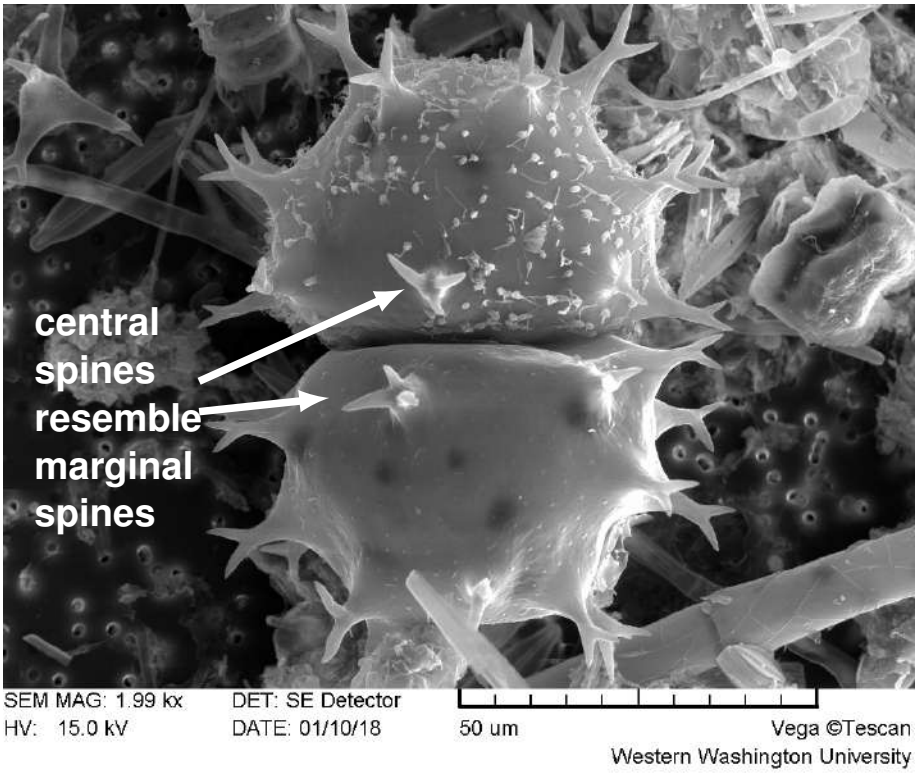


Figure 27.23: *Xanthidium armatum* var. *fissum* (DIC), Chain Lake, Gifford Pinchot National Forest, Skamania County.



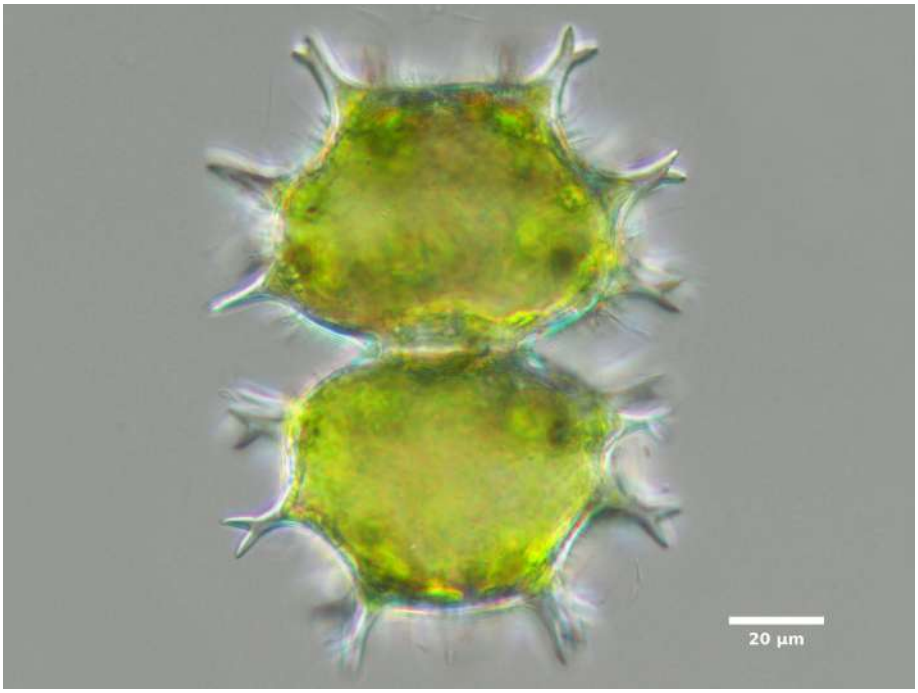
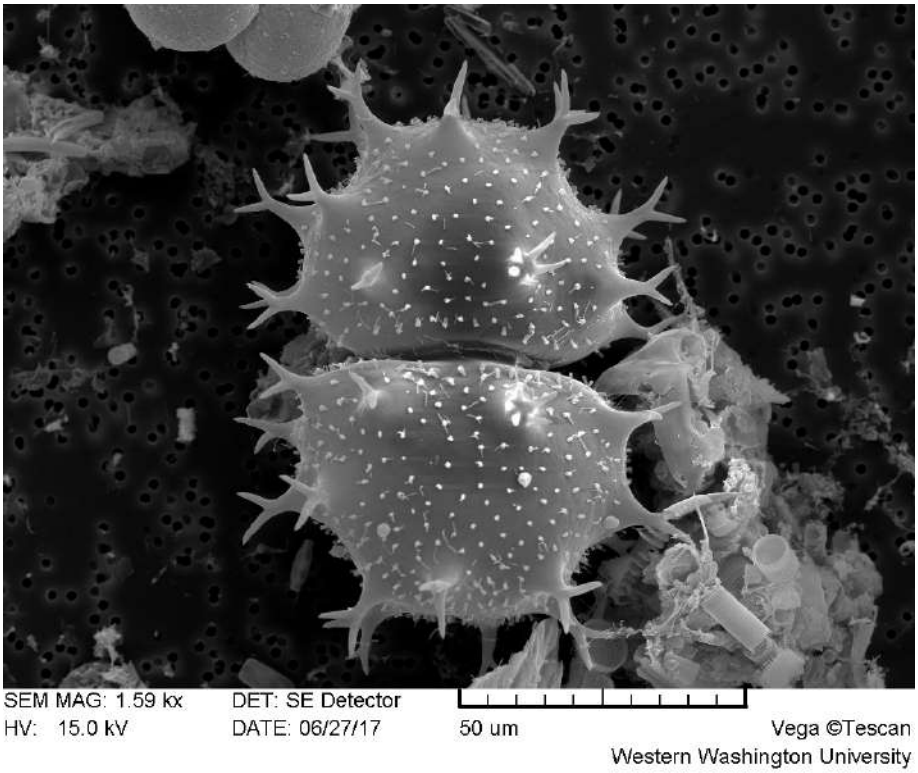


Figure 27.24: *Xanthidium armatum* var. *fissum* (SEM/DIC), Bear Lake, Mountain Loop Highway, Snohomish County (upper/lower images).



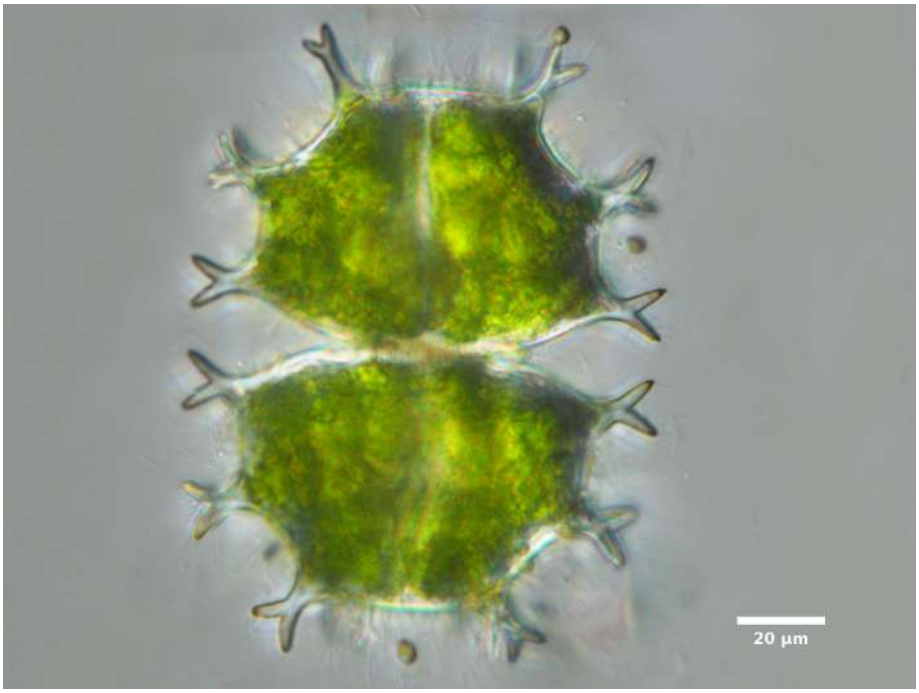


Figure 27.25: *Xanthidium armatum* var. *fissum* (SEM/DIC), Island Lake, Mountain Loop Highway, Snohomish County (upper/lower images).

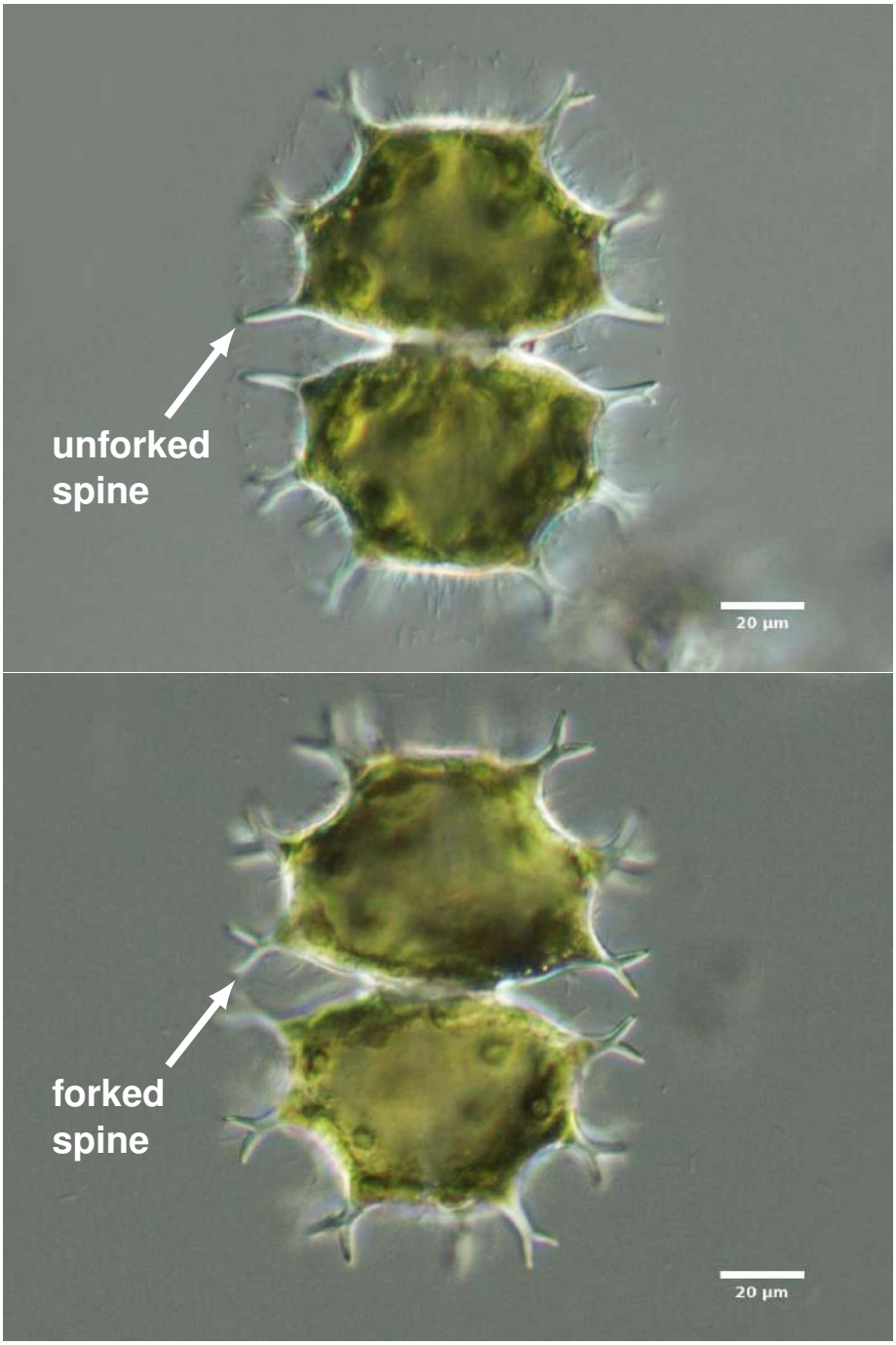


Figure 27.26: *Xanthidium armatum* var. *fissum* (DIC/DIC), semi-cells with solitary lower spines (upper image) and forked lower spines (lower image) collected on same date in Bear Lake, Mountain Loop Highway, Snohomish County.



Figure 27.27: *Xanthidium armatum* var. *fissum* (DIC), Lower Ashland Lake, Mountain Loop Highway, Snohomish County.

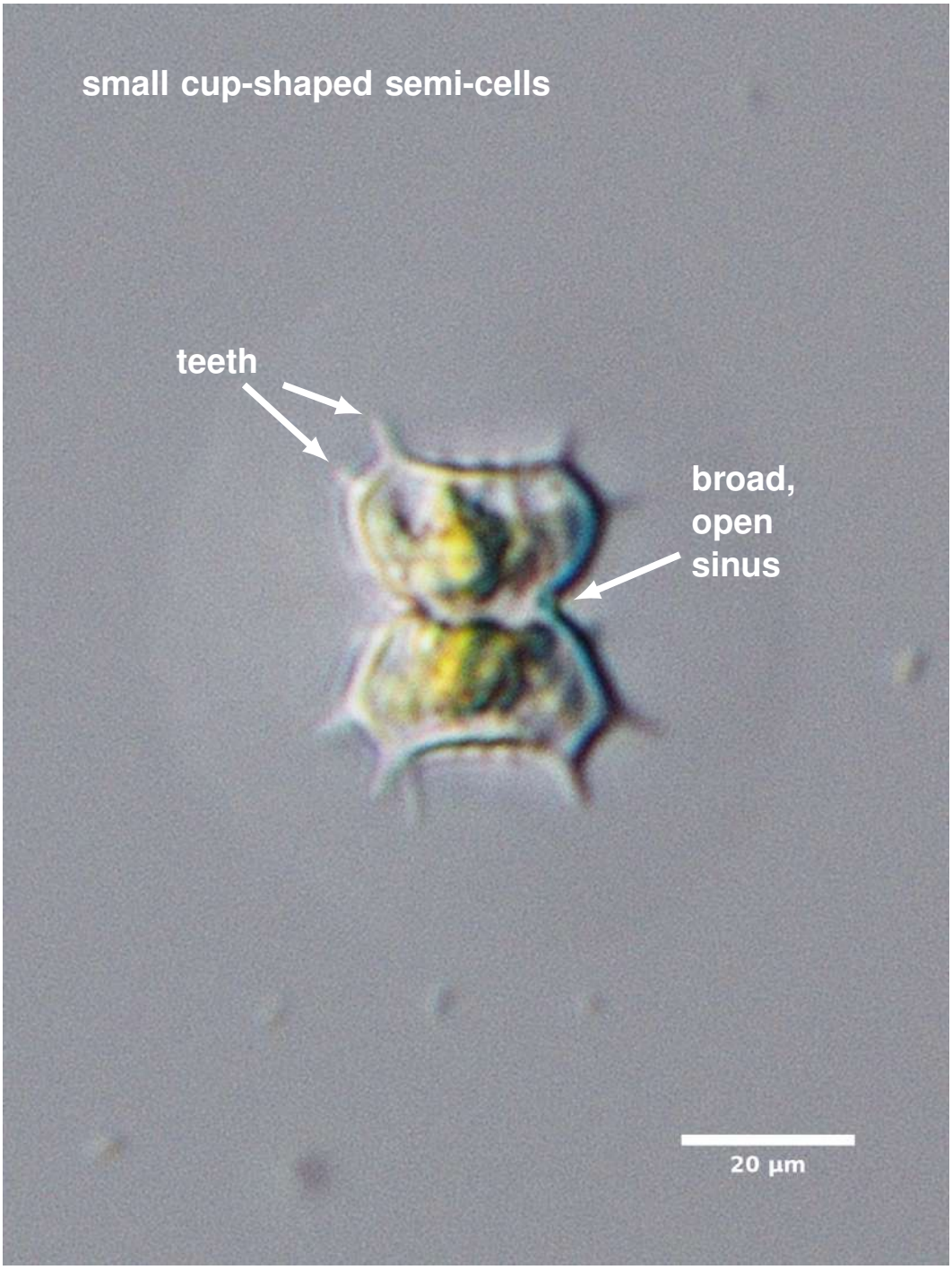


Figure 27.28: *Xanthidium bifidum* (DIC), small boggy pond along Morris Valley Road near Harrison BC.

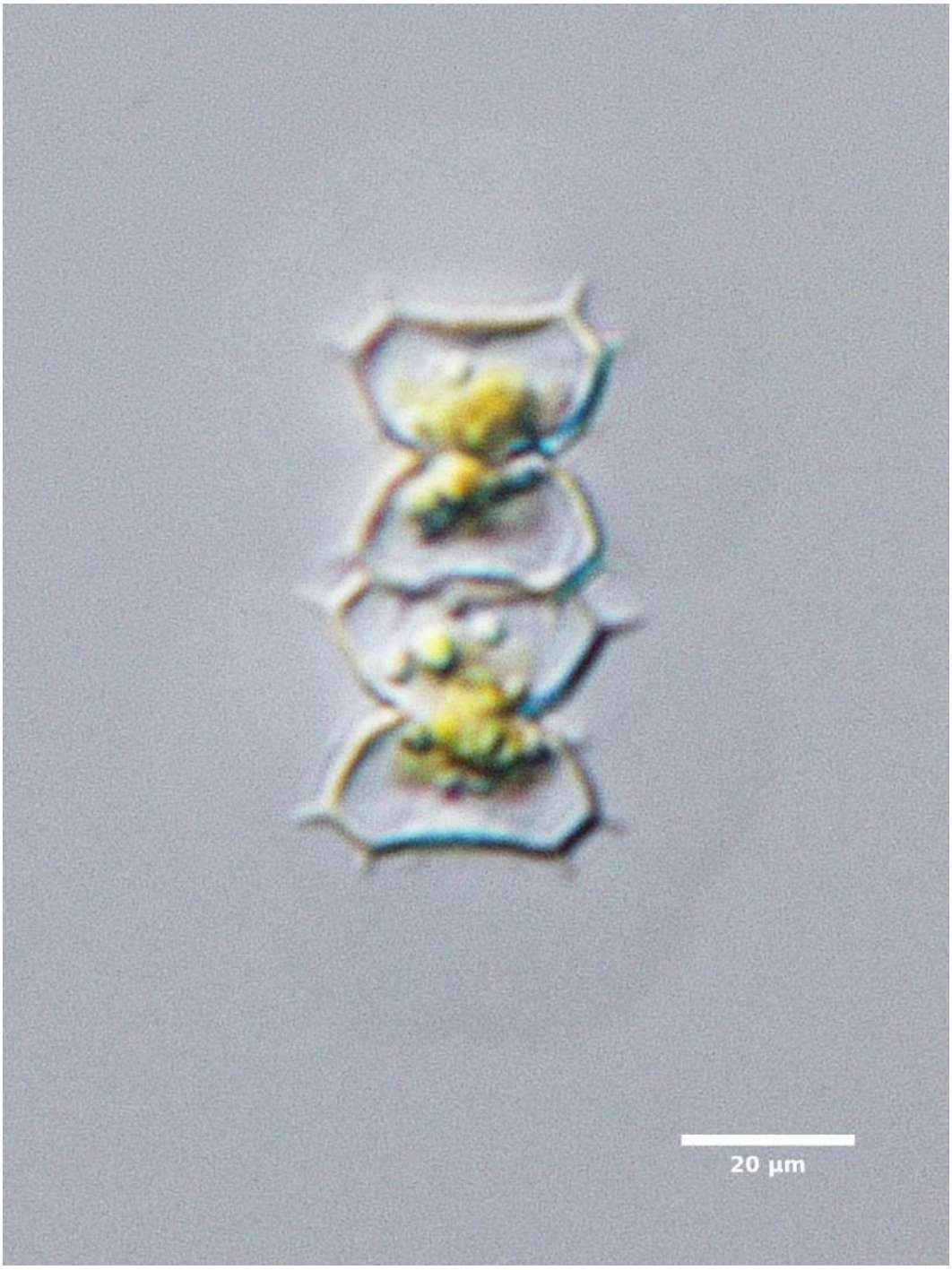


Figure 27.29: *Xanthidium bifidum* (DIC), small boggy pond along Morris Valley Road near Harrison BC.

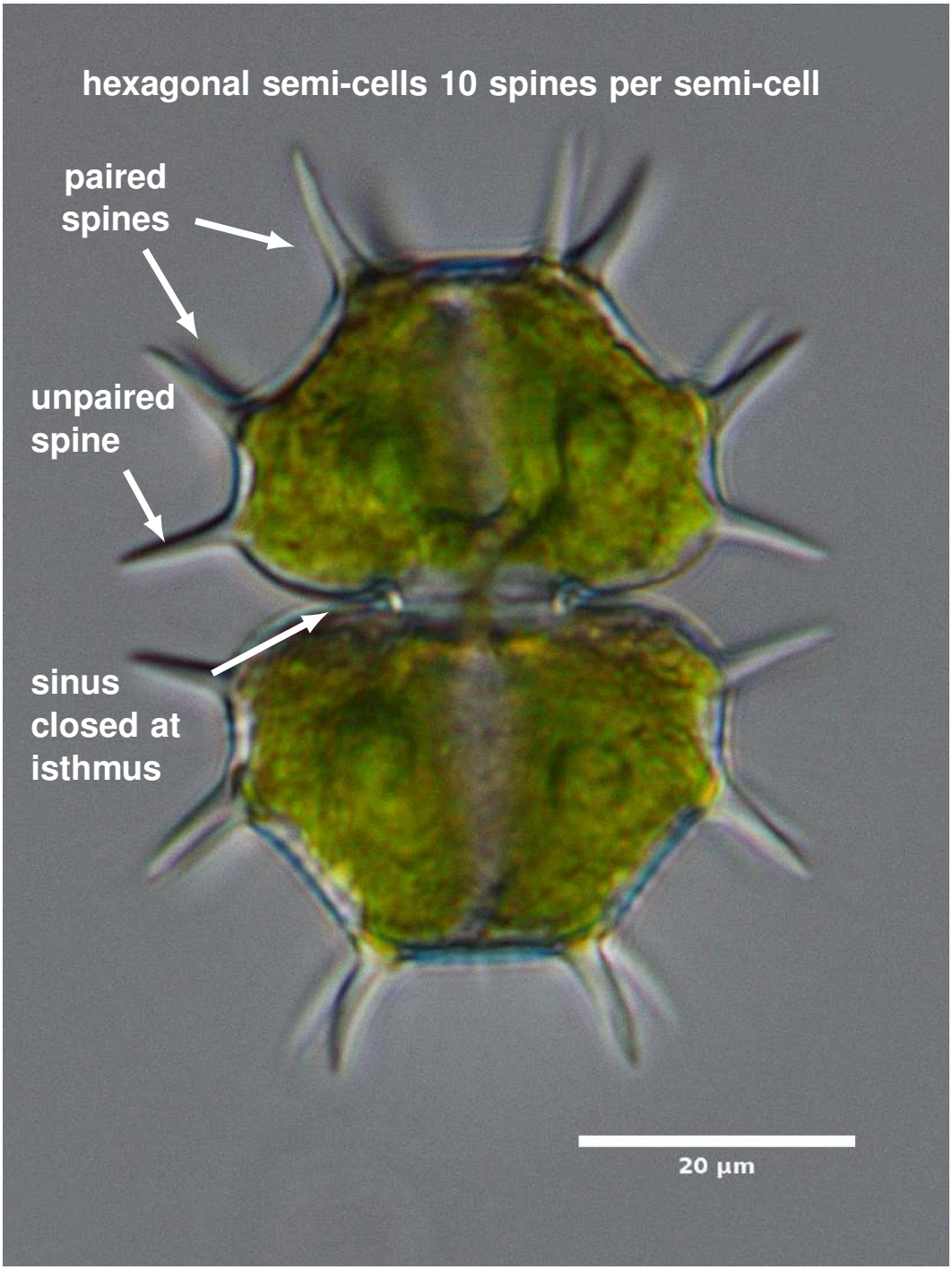


Figure 27.30: *Xanthidium scrobiculatum* (DIC), Myrtle Lake, Mountain Loop Highway, Snohomish County.

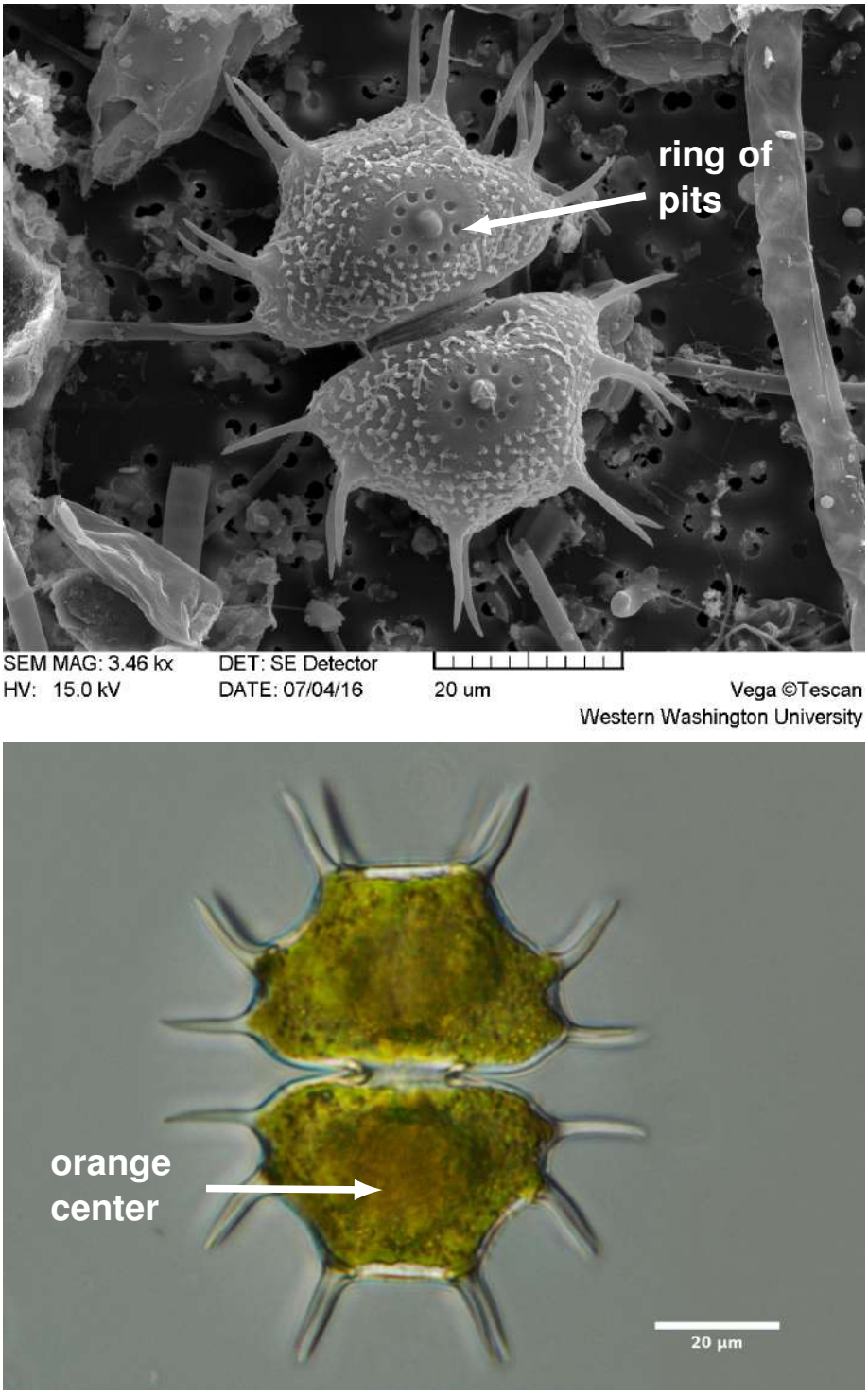


Figure 27.31: *Xanthidium scrobiculatum* (SEM/DIC), Boardman Lake, Mountain Loop Highway, Snohomish County (upper/lower images).



Figure 27.32: *Xanthidium scrobiculatum* atypical semi-cells (DIC/DIC), Myrtle Lake, Mountain Loop Highway, Snohomish County (upper/lower images).



Figure 27.33: *Xanthidium scrobiculatum* atypical semi-cells (DIC/DIC), Beaver Lake, Mountain Loop Highway, Snohomish County (upper/lower images).

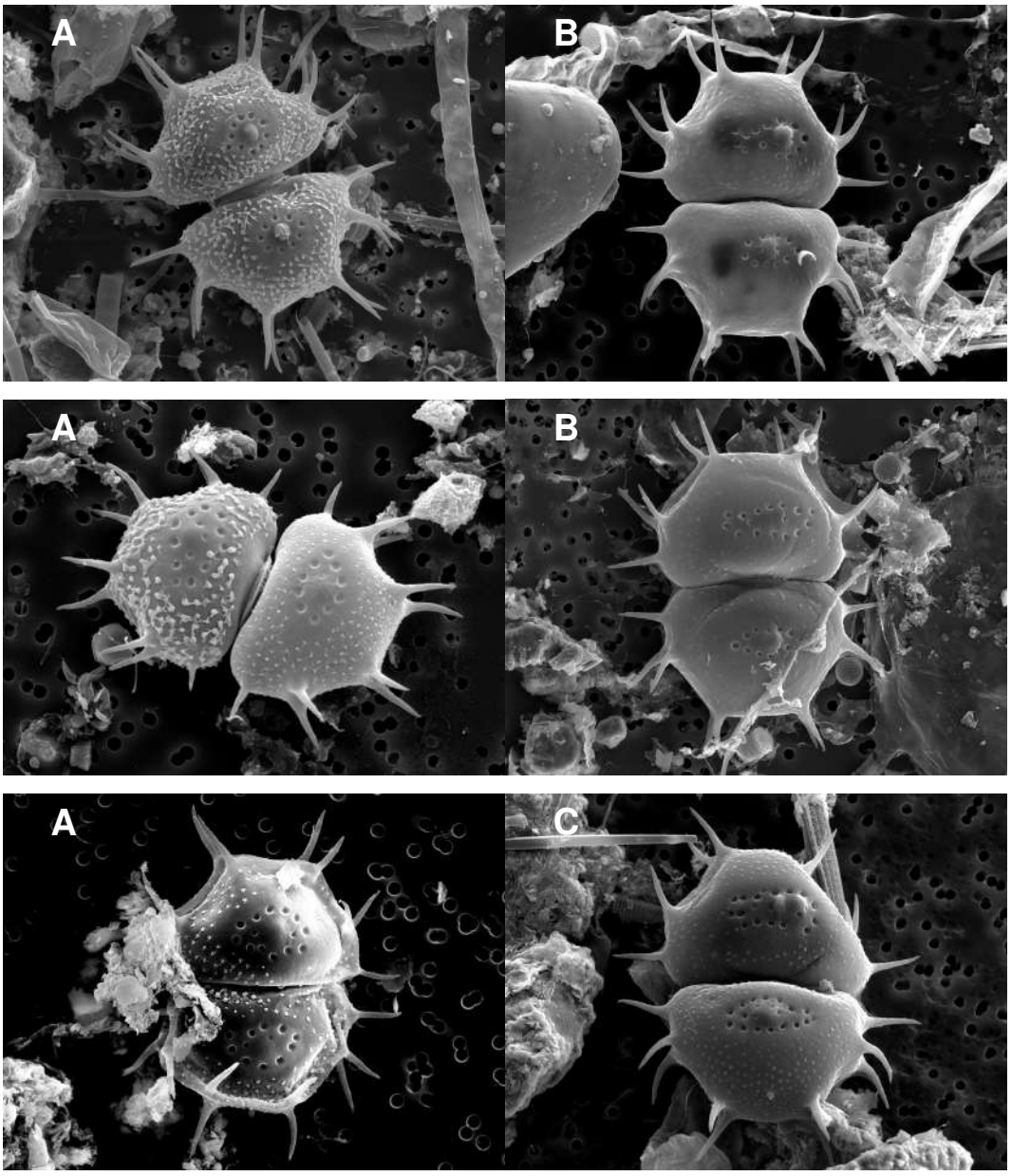


Figure 27.34: *Xanthidium scrobiculatum* variations in center wall ornamentation (SEM); images on left (A) are from Myrtle and Boardman Lakes, Mountain Loop Highway, Snohomish County; images on right (B) are from a small floating bog along Morris Valley Road near Harrison, BC.

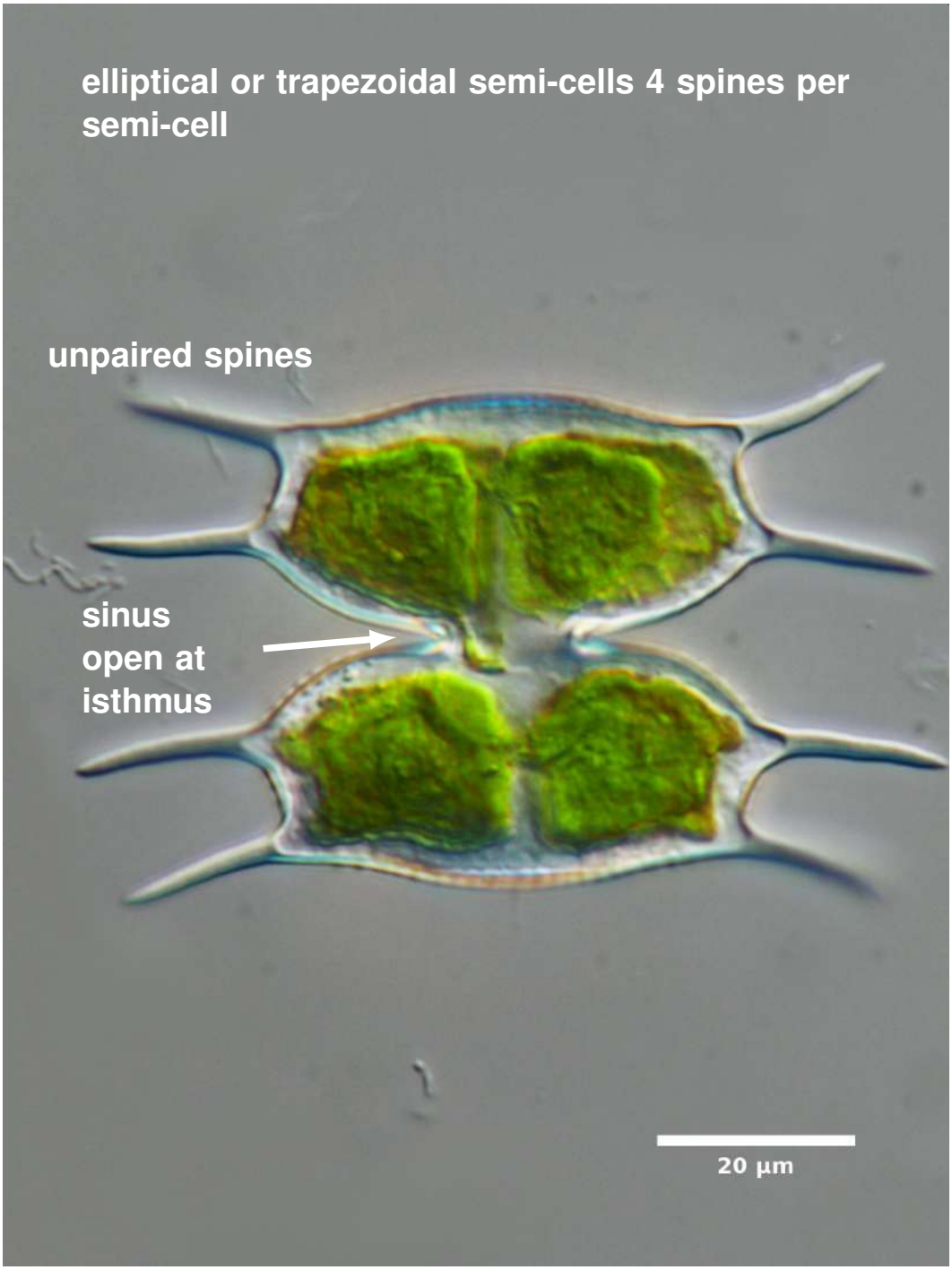
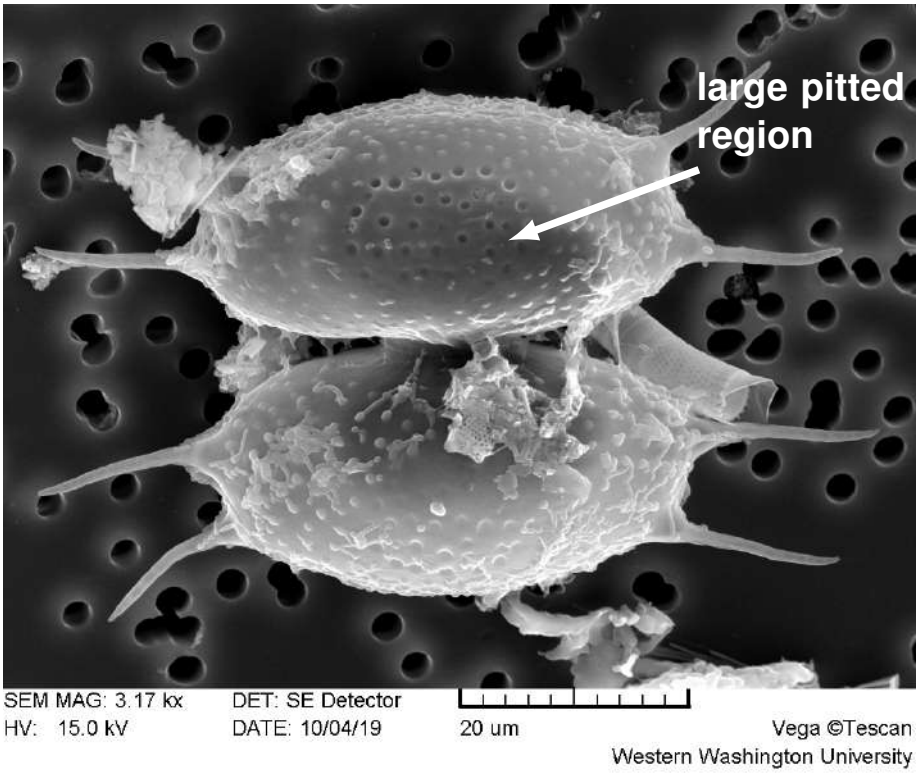


Figure 27.35: *Xanthidium subhastiferum* (DIC), Big Lake, Skagit County.



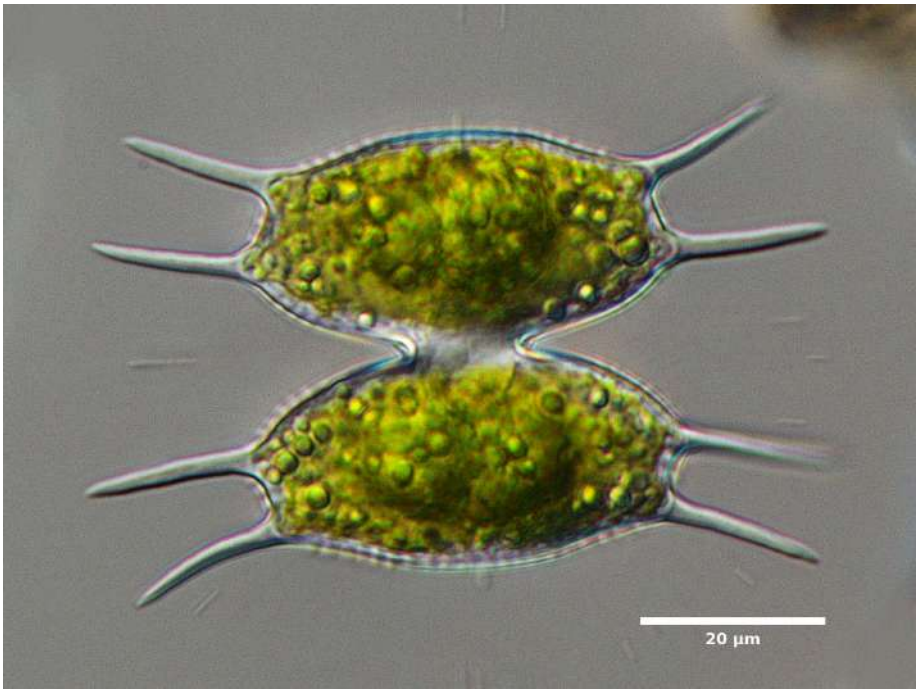


Figure 27.36: *Xanthidium subhastiferum* (SEM/DIC), Big Lake, Skagit County (upper/lower images).



Figure 27.37: *Xanthidium subhastiferum* (DIC/DIC), Lake Stevens, Snohomish County (upper/lower images).

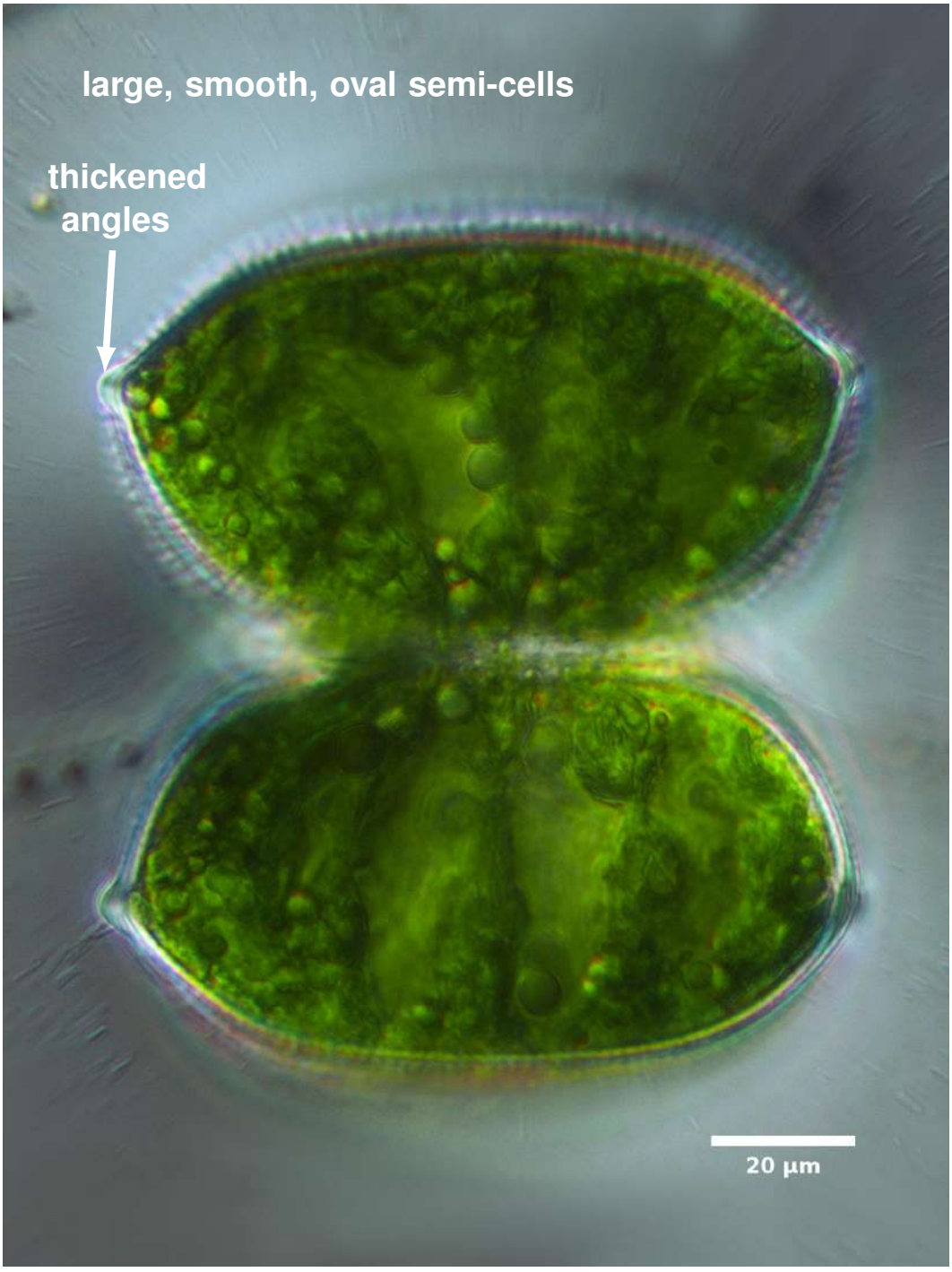
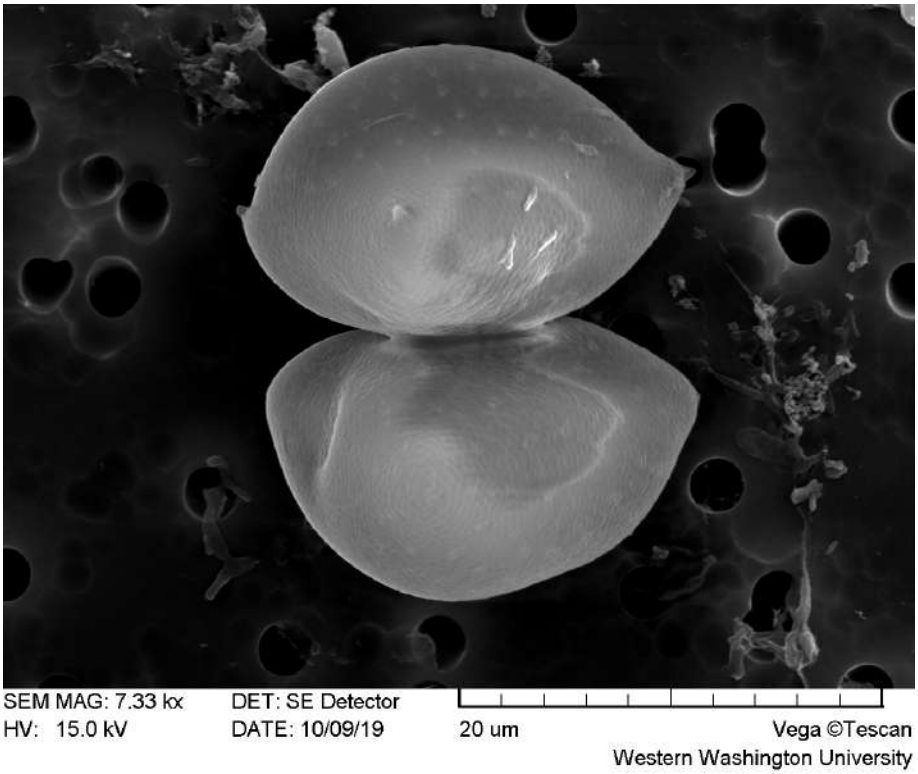


Figure 27.38: *Xanthidium tumidum* (DIC), Lake Twenty-two, Mountain Loop Highway, Snohomish County.



Figure 27.39: *Xanthidium tumidum* (DIC/DIC), Lake Twenty-two, Mountain Loop Highway, Snohomish County (upper/lower images).



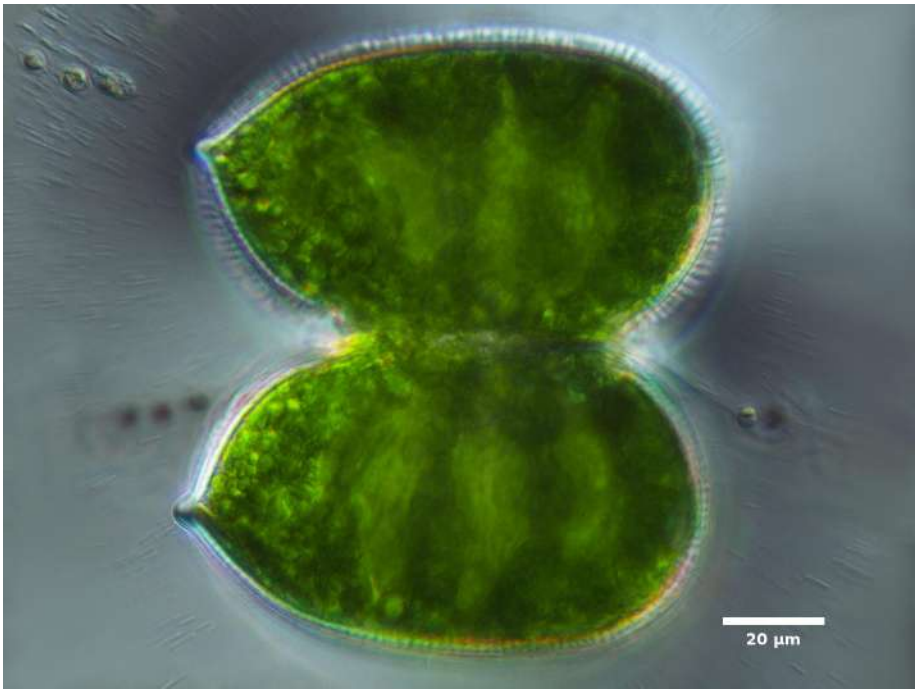


Figure 27.40: *Xanthidium tumidum* (SEM/DIC), small pond on trail to Lake Ann, Mt. Baker area, Whatcom County (upper image); Lake Twenty-two, Mountain Loop Highway, Snohomish County (lower image).

Appendix A

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