Micscape Magazine - January 2022

Contents

Diatoms from an Ephemeral Lagoon
Bob Straub State Park, Oregon, US

Day of collection. Lagoon in foreground. Nestucca River mouth in background.

Illustrated here is a selection of diatoms found in a biofilm on the sand flat at the edge of a small, ephemeral, tidal lagoon in the sand tip of Bob Straub State Park on the west coast of Oregon, US, where the Nestucca River empties into the Pacific Ocean.

On the day of the collection, the sky was overcast with a thick layer of smoke from wildfires that were burning in the Western Cascades of Oregon 50 miles to the east. Unusual circumstances of fire and weather combined to rapidly spread the fires and blanket much of western Oregon with smoke. Large wildfires were burning in the Cascades of Oregon when a high pressure system in the Rocky Mountains fed east winds of up to 65 miles per hour into the fires, causing them to spread rapidly toward the west, overwhelming much forested land and several towns.

The hike along this beach to the collection point was windy from the northeast but the smoke was held aloft by local air inversions. The smoke colored the sunlight orange-brown. Judging by the bubbling biofilm the algae were happily metabolizing and producing oxygen despite the dim light. Also living in the lagoon were free floating seaweeds and animals buried in the sand flat sending short squirts of water into the air. This calm body of water contrasted sharply with the high energy of the coastal beach a short distance to the west. The wind from the northeast rather than from the south or west made this an excellent hiking and collecting day despite the smoke overhead.

Sand spit at mouth of Nestucca River [3]

Site of the lagoon seven weeks and two storms after the collection.

Seven weeks and two storms later the lagoon was completely filled with nearly a meter of sand and the area strewn with wood debris.

Live material contained many diatoms and some cyanobacteria. Cleaned material contained a profusion of diatom forms.

Diatoms are microscopic unicellular algae that make shells of transparent opal which is very similar to glass. [1] The shell consists of two valves that overlap like parts of a Petri dish. The surface features of the valves are used to identify diatoms. These organisms have been placed in the taxonomic group, Bacillariophyta. [2]

Materials and Methods

The collection site was a sand flat in a few millimeters of water in a small lagoon on the tip of the sand spit at mouth of the Nestucca River, Oregon, US (lat 45.159926, lon -123.970079, elevation sea level). On 8 September 2020 during a falling tide, about 5 ml (one teaspoon) of sand and bubbling biofilm was scooped from the sand flat using a small mussel shell found nearby. The sample was transported in a plastic bag.

Biofilm producing oxygen bubbles at collection site. Spots on right are the reflected sun colored by thick blanket of smoke overhead.

Cleaning used an acid-peroxide-permanganate procedure [8]. Muriatic acid (HCl) was used to dissolve calcareous material and to loosen mucilage. The sample was swirled and decanted twice with tapwater to remove sand (sedimentation following Sterrenburg, 2006) and the sand was discarded without checking for diatoms. The sample was heated in the acid for several hours then rinsed several times with tap water.

Hydrogen peroxide 35% was added and the mixture heated at less than boiling for several hours. The heat was reduced and a saturated solution of potassium permanganate was added by the drop until fizzing stopped. Hydrogen peroxide and then muriatic acid was added to remove the brown color. The sample was rinsed with distilled water several times.

Five strew slides were made by mounting coverslips in Zrax [9].

The images of diatoms were produced with a Canon T1i digital camera attached to a Nikon LaboPhot2 fitted with a Nikon 60x Plan 0.85NA objective and a Nikon 100x Plan-Apo 1.40NA objective. Image processing was done with Windows Explorer (tagging), PhotoScape X (enhancing, scale bars, stitching), GIMP (stitching, enhancing), and Microsoft ICE (stitching).

The text and figures were prepared by Rob Kimmich [4] in Microsoft Office365 Word and exported to PDF with PDF/A compliant and Optimize for image quality both set. First edition published on 8 November 2020, last revised on 11 Jan 2022.

Results

This cleaning method produced a clean, white sample. Only simple decanting was needed to remove sediment since it was mostly sand with very little silt, perhaps removed by tidal action.

Many of the images appear faint and show little detail while others show more detail. Perhaps the valves of the faint diatoms contain less silica.

Discussion

This sample contained a great diversity of diatoms. *Nitzschia closterium* seemed the most abundant with species of *Achnanthidium* next or equal in abundance. Many other forms were also quite numerous. Many forms appeared to be very lightly silicified judging by their faint details. Forms were selected for imaging because they were interesting or previously unknown to the author. Qualitatively, most of the genera on the slides appear to have been included in the images. Most surprising was the diversity of the genus A*mphora*.

The author was fairly confident about the identification of genera but much less confident about identification to species. Sources for identification were scarce and have been included in the References. A number of papers were provided on request.

Images are arranged by morphological group [28] and occasionally by family or genus within a group. Scale bars on the images represent a 10 µm length. When viewed electronically, more detail can be seen by expanding the view of an image.

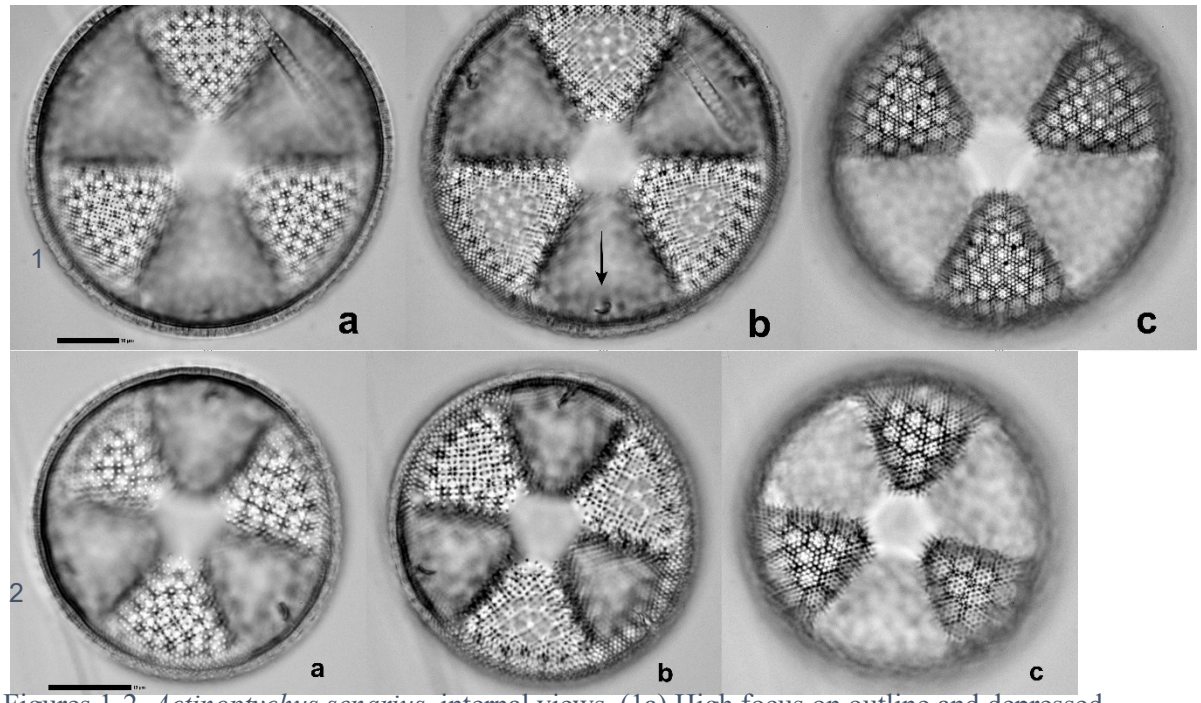
Definitions for many terms can be found in the Glossary on Diatoms of North America [29].

Illustrated Forms

Name	Figure	Group
Achnanthidium sp	11	monoraphid
Actinoptychus senarius	1, 2	centric
Amphora cinglua	37	asymmetric biraphid
Amphora obtusa	44-47	asymmetric biraphid
Amphora straub-01	35	asymmetric biraphid
Amphora straub-02	38-40	asymmetric biraphid
Amphora straub-03	41-43	asymmetric biraphid
Anorthoneis sp	12	monoraphid
Arcuatasigma closterioides	27-28	symmetric biraphid
Caloneis robusta subelliptica	13	symmetric biraphid
Cocconeiopsis sp.	17	symmetric biraphid
Coscinodiscus excentricus	6	centric
Coscinodiscus radiatus	4, 5	centric
Delphineis sp	10	araphid
Diploneis cf. *didyma*	18-19	symmetric biraphid
Diploneis interrupta	20	symmetric biraphid
Diploneis smithii	21	symmetric biraphid
Donkinia recta	29-30	symmetric biraphid
Entomoneis alata	49	surirelloid
Halamphora sp.	36	asymmetric biraphid
Lyrella sp.	15	symmetric biraphid
Navicula longa	23-24	symmetric biraphid
Navicula palpebralis	26	symmetric biraphid
Navicula sp.	25	symmetric biraphid
Nitzschia closterium	48	nitzschioid
Pleurosigma aestuarii	33-34	symmetric biraphid
Pleurosigma straub-01	31-32	symmetric biraphid
Proschkinia complanatoides	22	symmetric biraphid
Rhaphoneis amphiceros	7-9	araphid
Thalassiosira sp	3	centric
Stauroneis constricta	14	symmetric biraphid
Staurophora sp	16	symmetric biraphid
Surirella taeniata	50-52	surirelloid

Figure refers to the figure number of an image. Group refers to a morphological group [28]. A code such as straub-01 may be used for unidentified species in a genus. Thirty-three forms are presented.

Centric Diatoms



Figures 1-2. *Actinoptychus senarius*, internal views. (1a) High focus on outline and depressed sectors. (1b) Mid focus on inner lips of rimoportulae (arrow on one of the three rimoportulae). (1c) Low focus on raised sectors. (2a) High focus on outline and depressed sectors. (2b) Mid focus on inner lips of rimoportulae. (2c) Low focus on raised sectors.

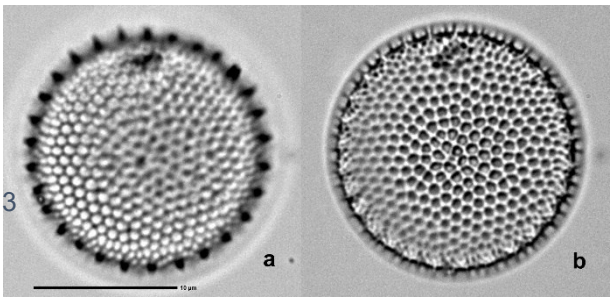


Figure 3. *Thalassiosira* sp. (a) focus on spines around margin. (b) focus on center showing foramina opening to outside. (By contrast, *Coscinodiscus* has no marginal spines and has foramina opening to the inside.)

Centric Diatoms

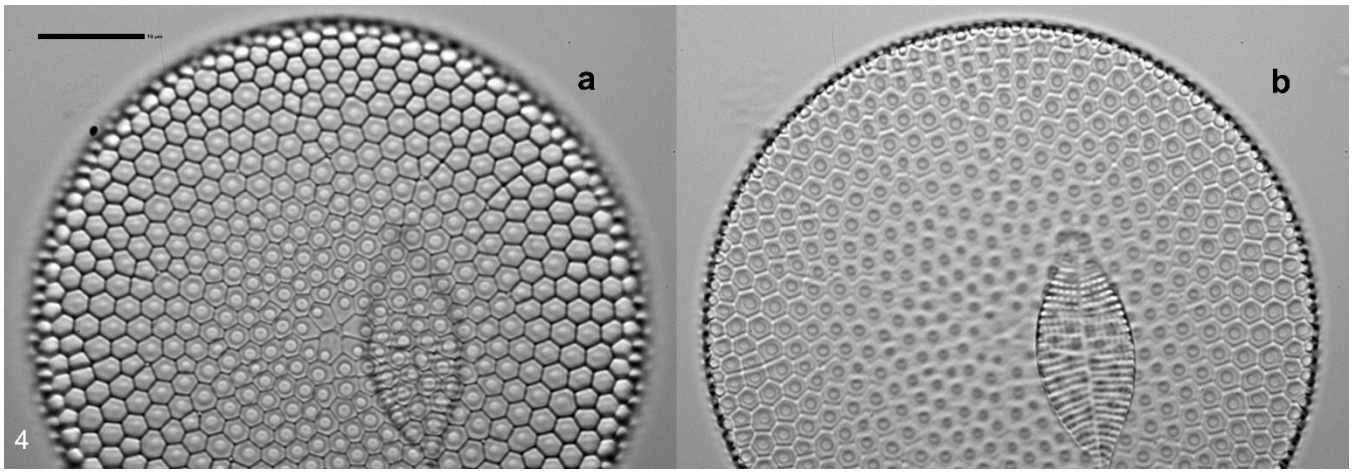


Figure 4. *Coscinodiscus radiatus*. Dia = 58 µm. Central areolae suggest a rosette and are slightly larger than other areolae. (a) High focus on center. (b) Low focus on outline. Foramina opening to inside. 100x objective.

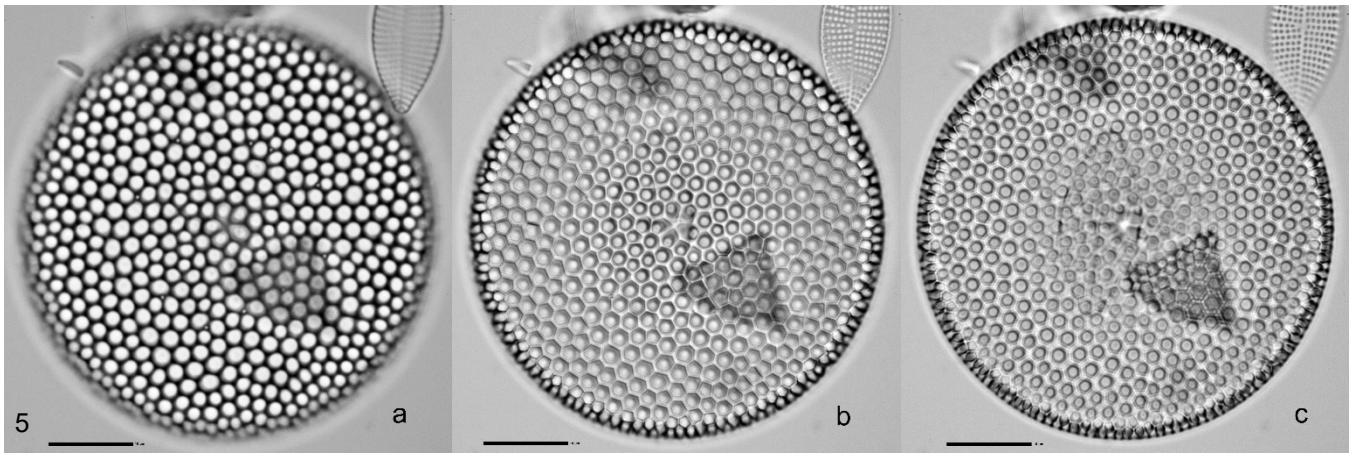


Figure 5. *Coscinodiscus radiatus*. Dia = 49 µm. (a) High focus on valve face. (b) Middle focus. (c) Low focus on outline. 100x objective. [5]

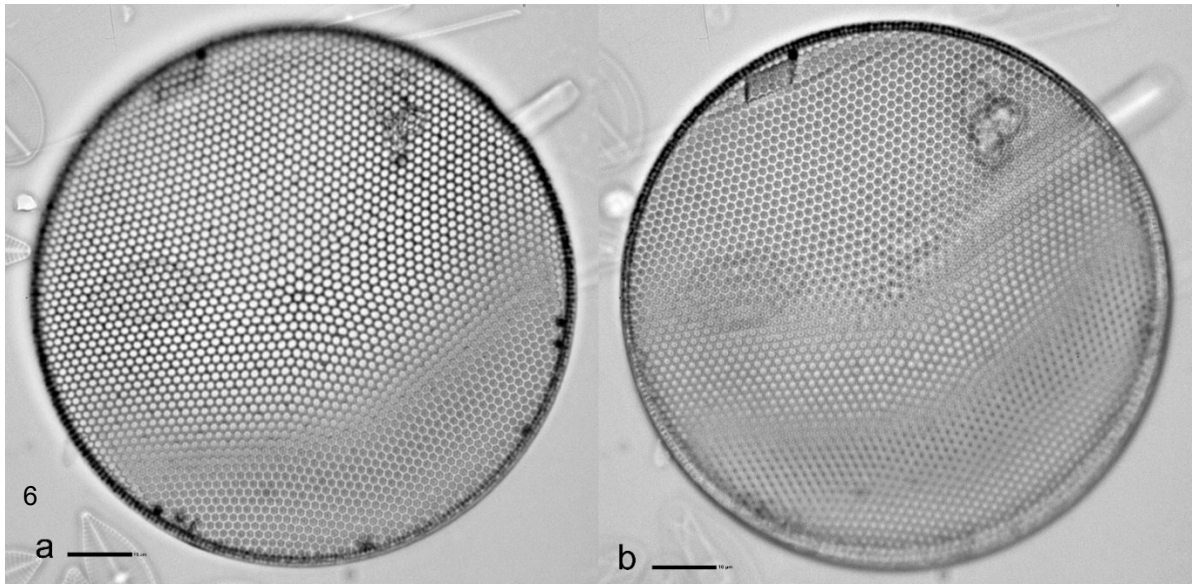
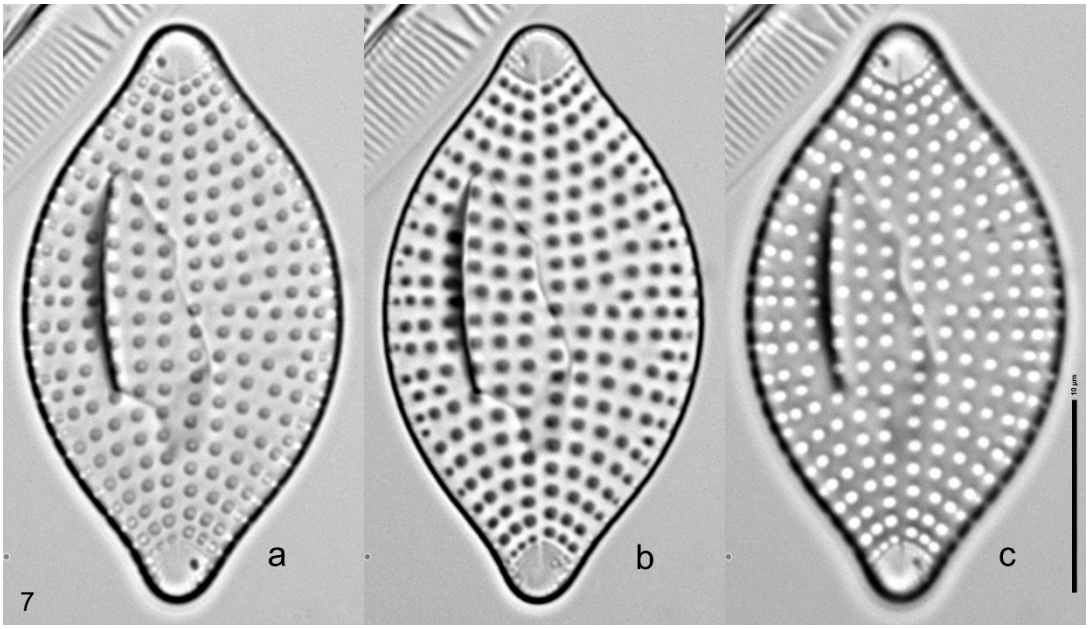
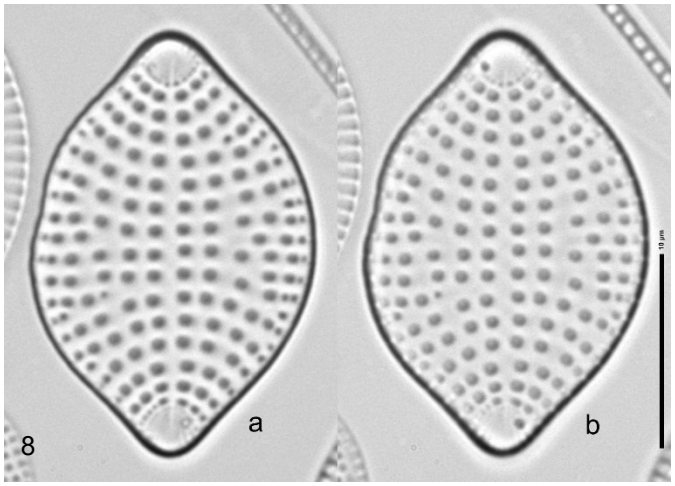


Figure 6. *Coscinodiscus excentricus* [5]. Dia = 85 µm. Foramina of loculae on inside of areolae. Seven areolae grouped around a central areola. (a) High focus on center. (b) Low focus on areola foramina. 60x objective.

Araphid Diatoms





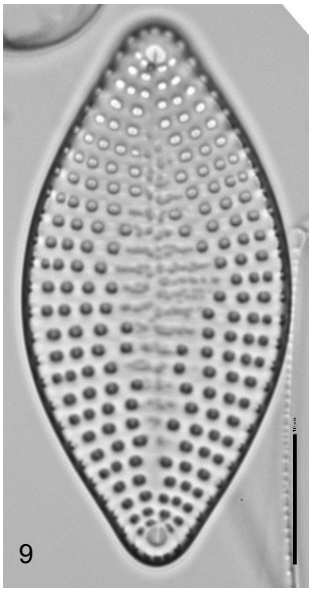


Figure 7-9. *Rhaphoneis amphiceros.* (7a, b, c) Various focal planes to accentuate the apical pore fields and the rimoportulae near the apices on opposite sides of the apices. (8a) High focus on valve face. (8b) Low focus on rimoportulae near apices. (9) A variation with small apical pore fields, hyaline central area, and lines through the pore fields. Round et al. (1990) and Stidolph (2012, plate 1, fig 16) show this form.

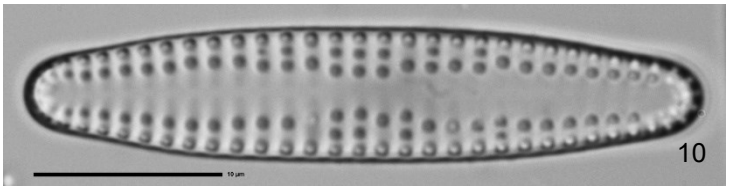


Figure 10. *Delphineis* sp. The diagnostic pair of pores near each apex are not visible here.

Monoraphid Diatoms

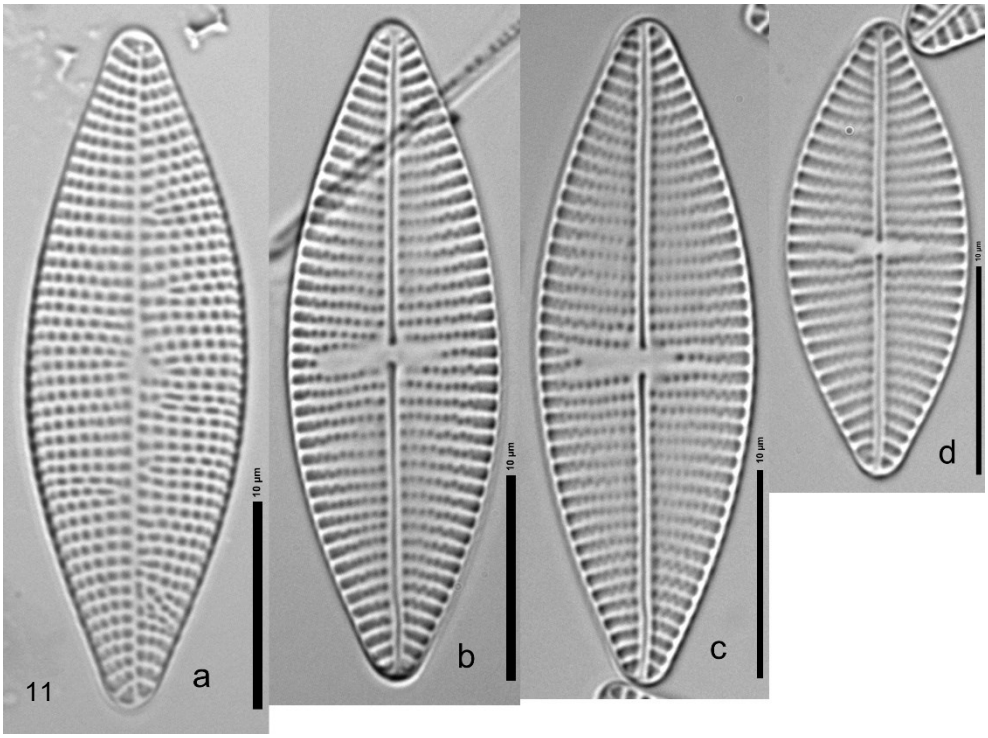


Figure 11. *Achnanthidium* sp. Abundant in the sample. Resembled rice grains. Several forms were present, suggesting several species. This image shows the most common form. (a) Rapheless valve with uniseriate striae. (b-d) Raphe valves with striae uniseriate and biseriate.

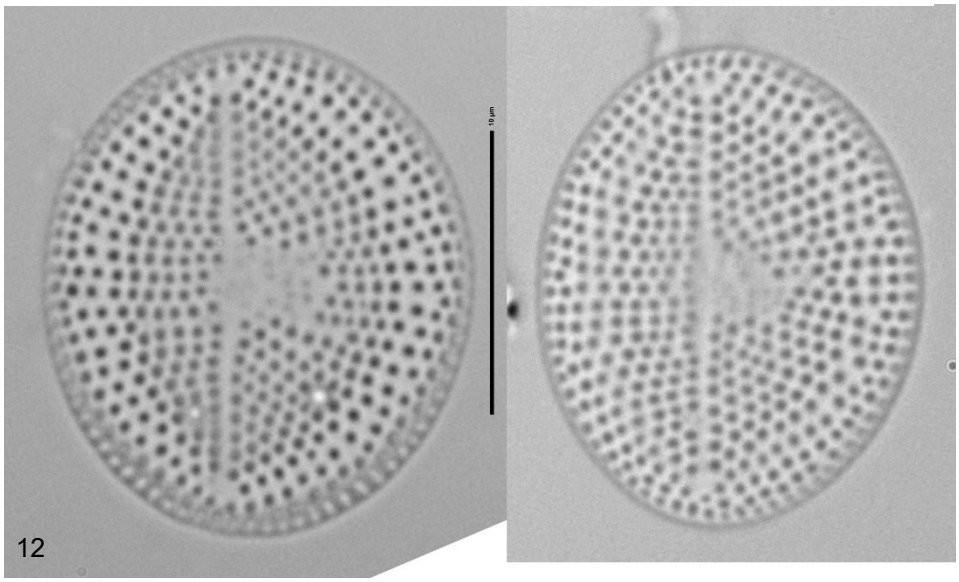


Figure 12. *Anorthoneis* sp. Two rapheless valves. Related to *Cocconeis*.

Symmetric Biraphid Diatoms

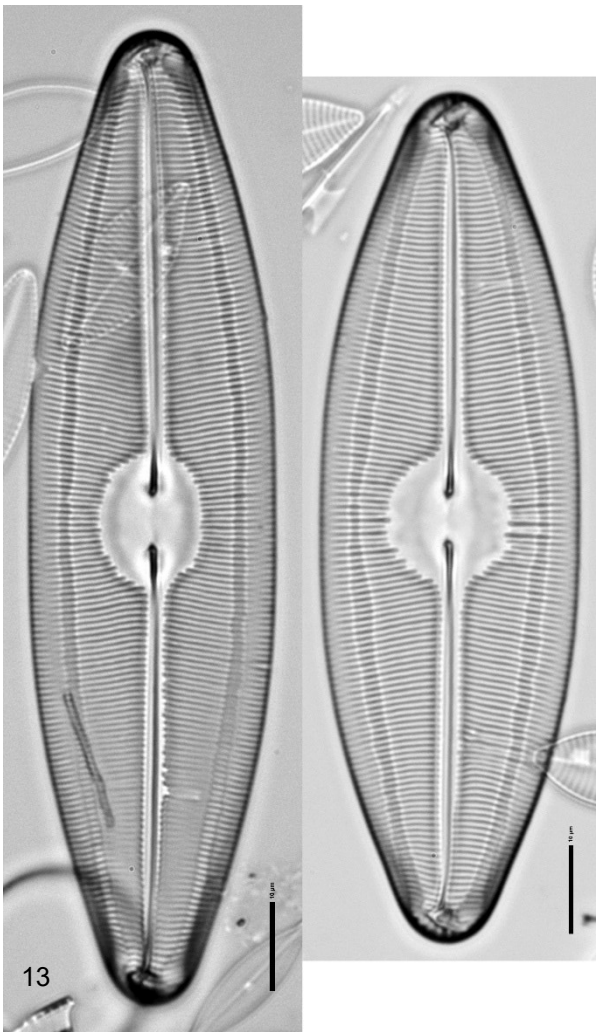


Figure 13. *Caloneis robusta subelliptica* [6].

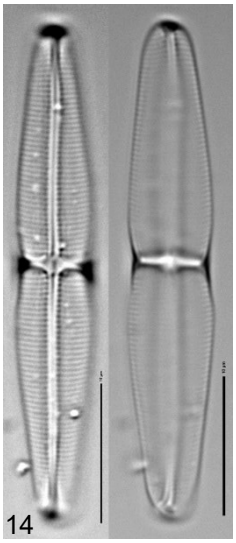


Figure 14. *Stauroneis constricta* [10].

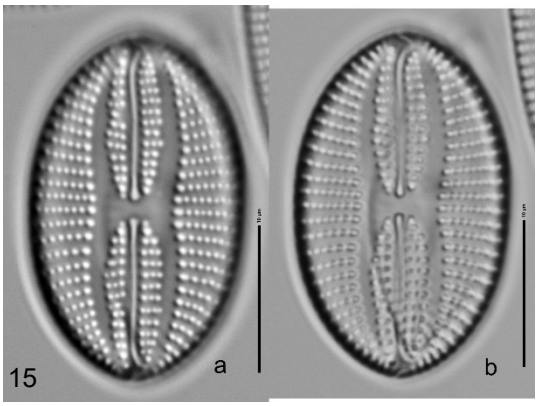


Figure 15. *Lyrella* sp. [7].

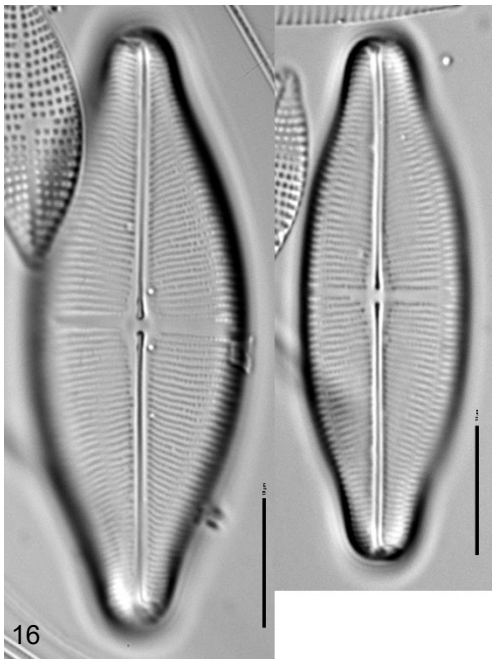


Figure 16. *Staurophora sp*. [2]. Distal raphe ends are deflected to opposite sides of valve.

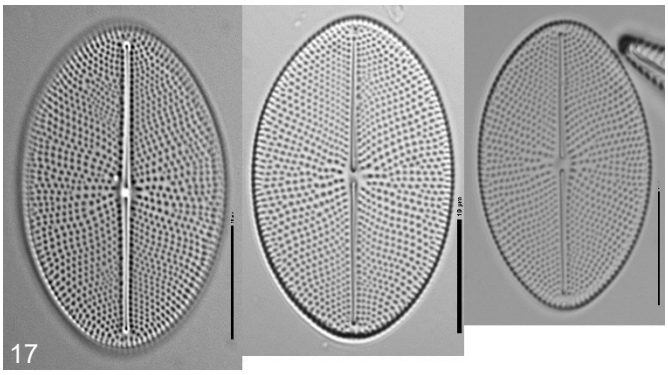
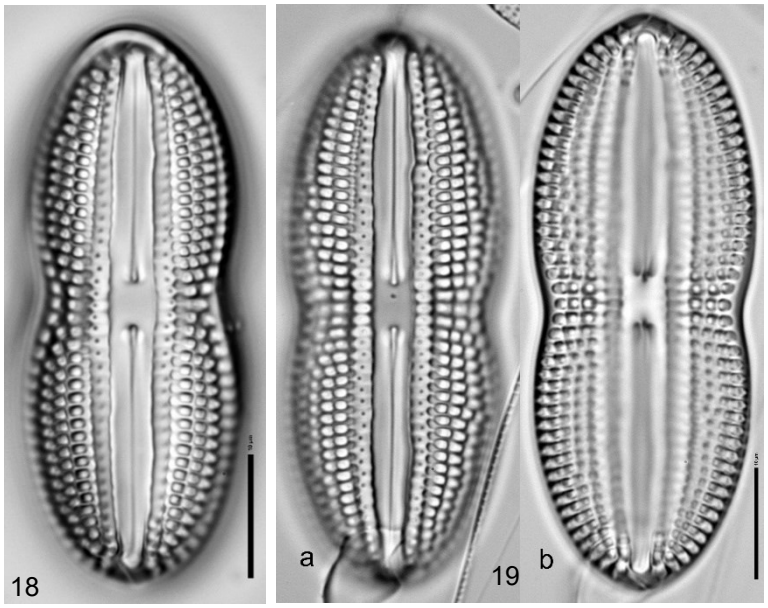


Figure 17. *Cocconeiopsis* sp. A biraphid that appears superficially like the raphe valve of *Cocconeis* [11].

Symmetric Biraphid Diatoms - Diploneis



Figures 18-19. *Diploneis* cf. *didyma.* One end of valve is wider than the other end [12]. (18) Focus on central area of longitudinal canals. (19a) High focus on proximal raphe ends. (19b) Low focus on outline.

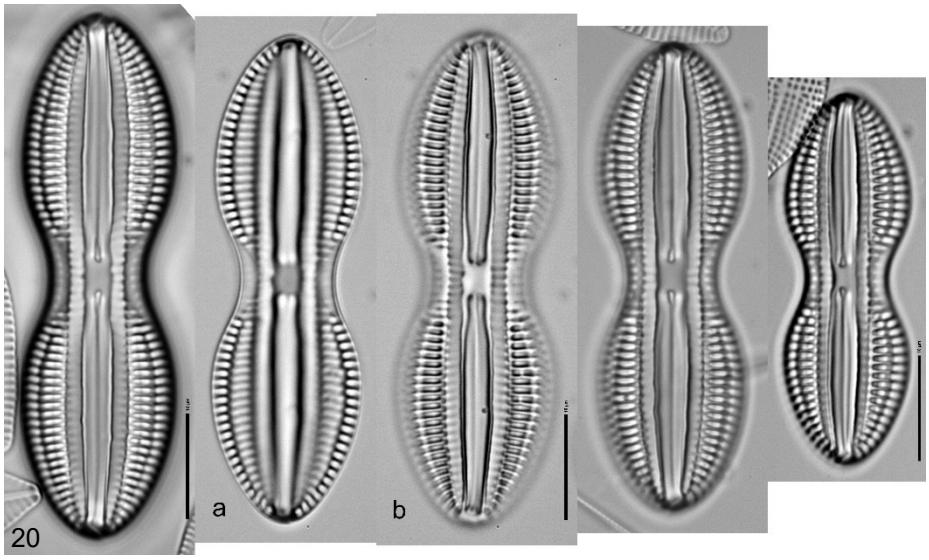


Figure 20. *Diploneis interrupta* [13]. Four valves. (a,b) Internal view of a valve. (a) High focus on outline. (b) Low focus on raphe.

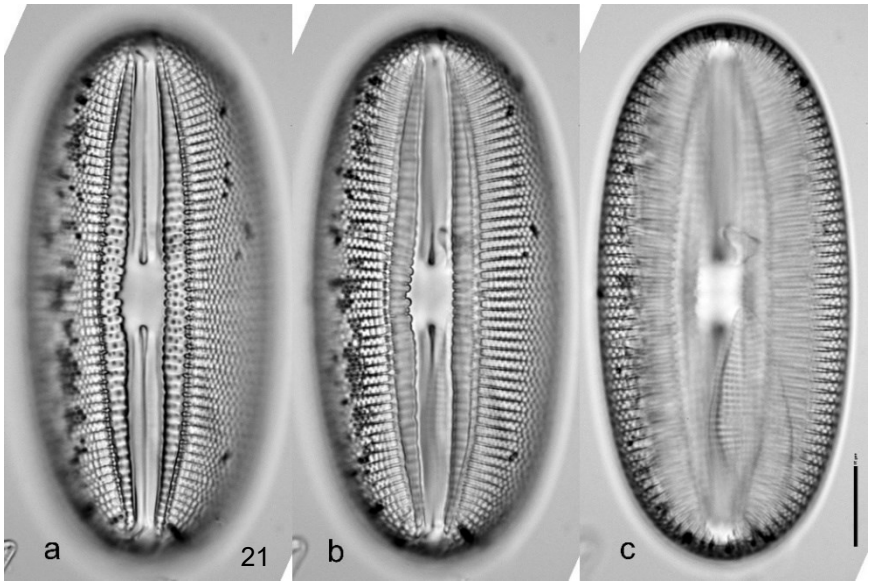


Figure 21 *Diploneis smithii* [14]. Single valve. (a) High focus on longitudinal canals. (b) Middle focus on biseriate striae. (c) Low focus on outline.

Symmetric Biraphid Diatoms

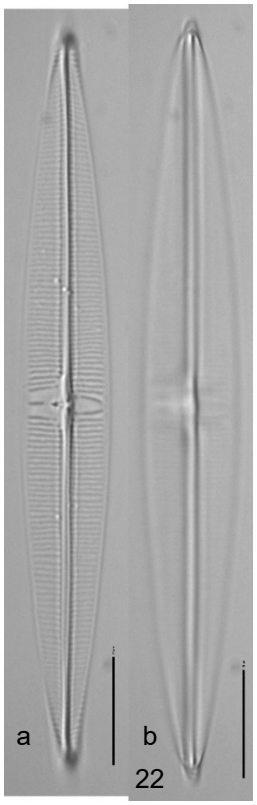
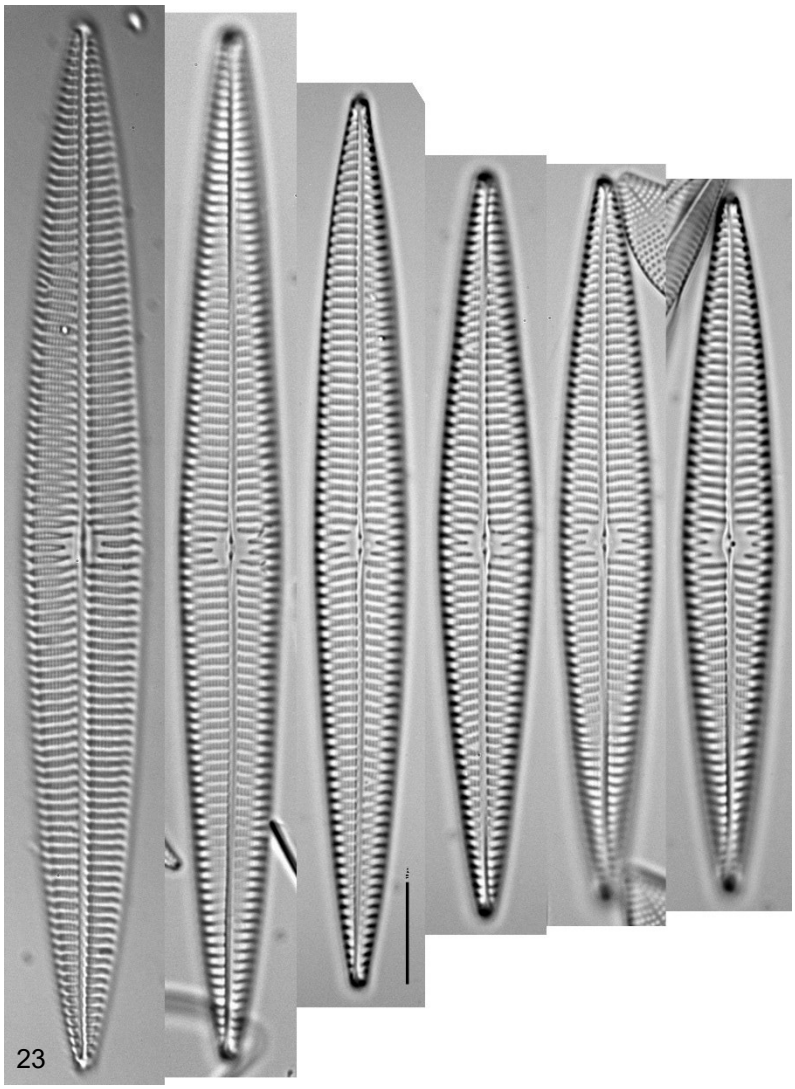


Figure 22. *Proschkinia complanatoides* [15]. (a) High focus on striae. (b) Low focus on outline.



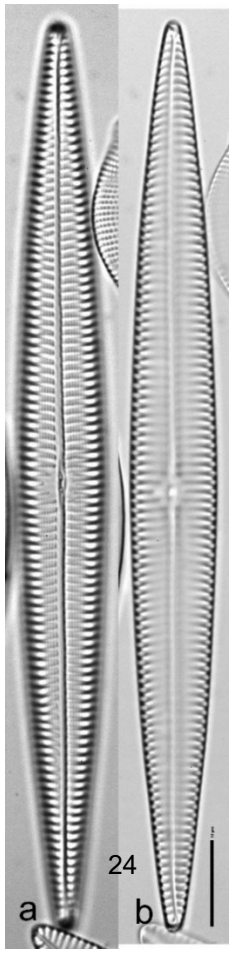


Figure 23-24. *Navicula longa.* [16]. (23) A size series showing the parallel striae along the length of the valve and the lineolate areolae. (24a) High focus on central area and lineolate striae. (24b) Low focus on valve outline.

Symmetric Biraphid Diatoms

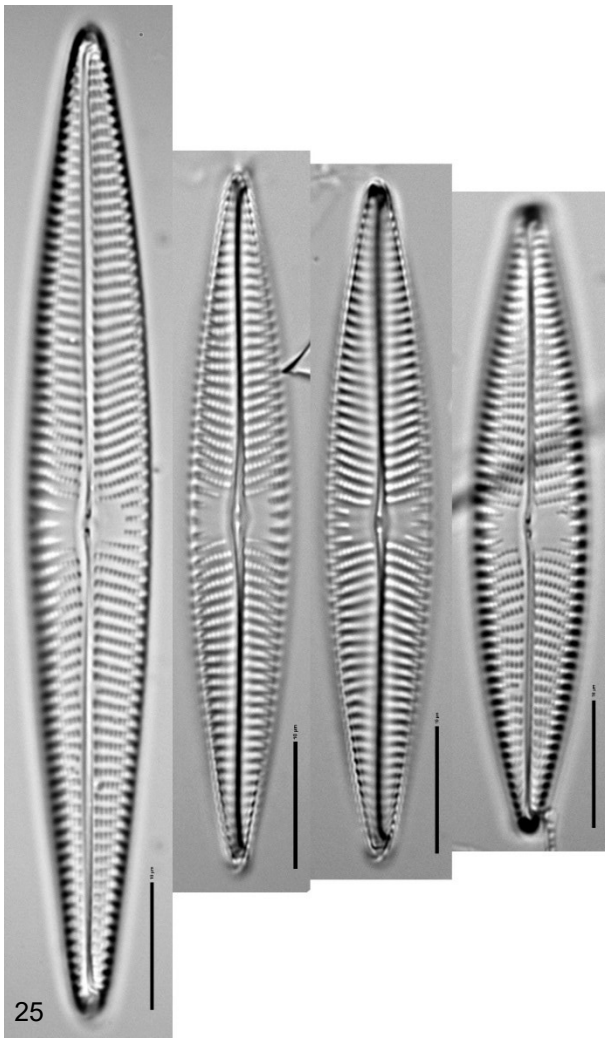


Figure 25. *Navicula* sp. [17]. Similar to fig. 23 except for the radiate striae in the central area and for the smaller aspect ratio.

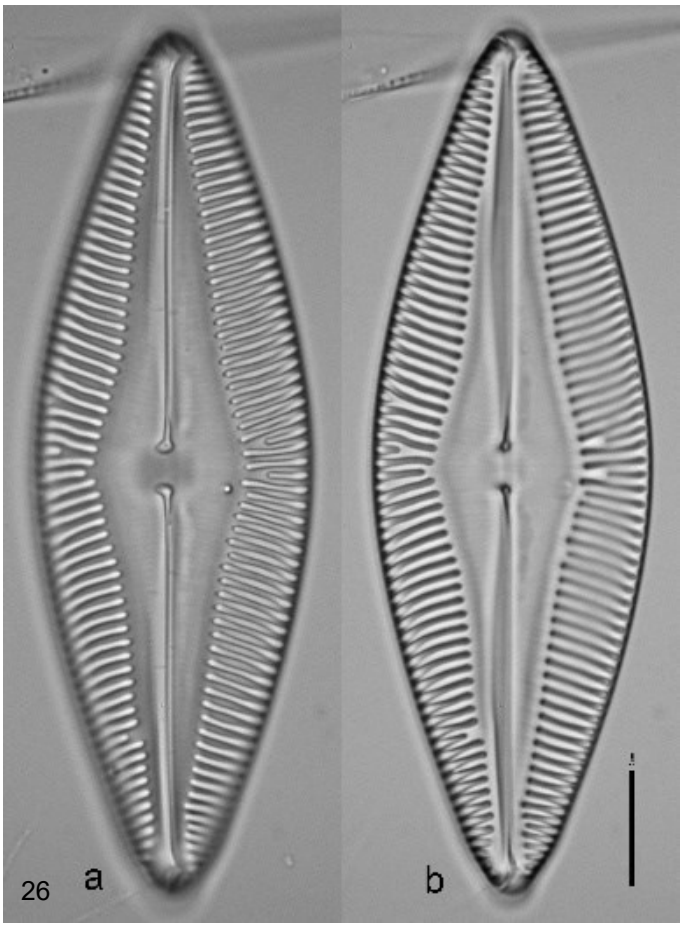
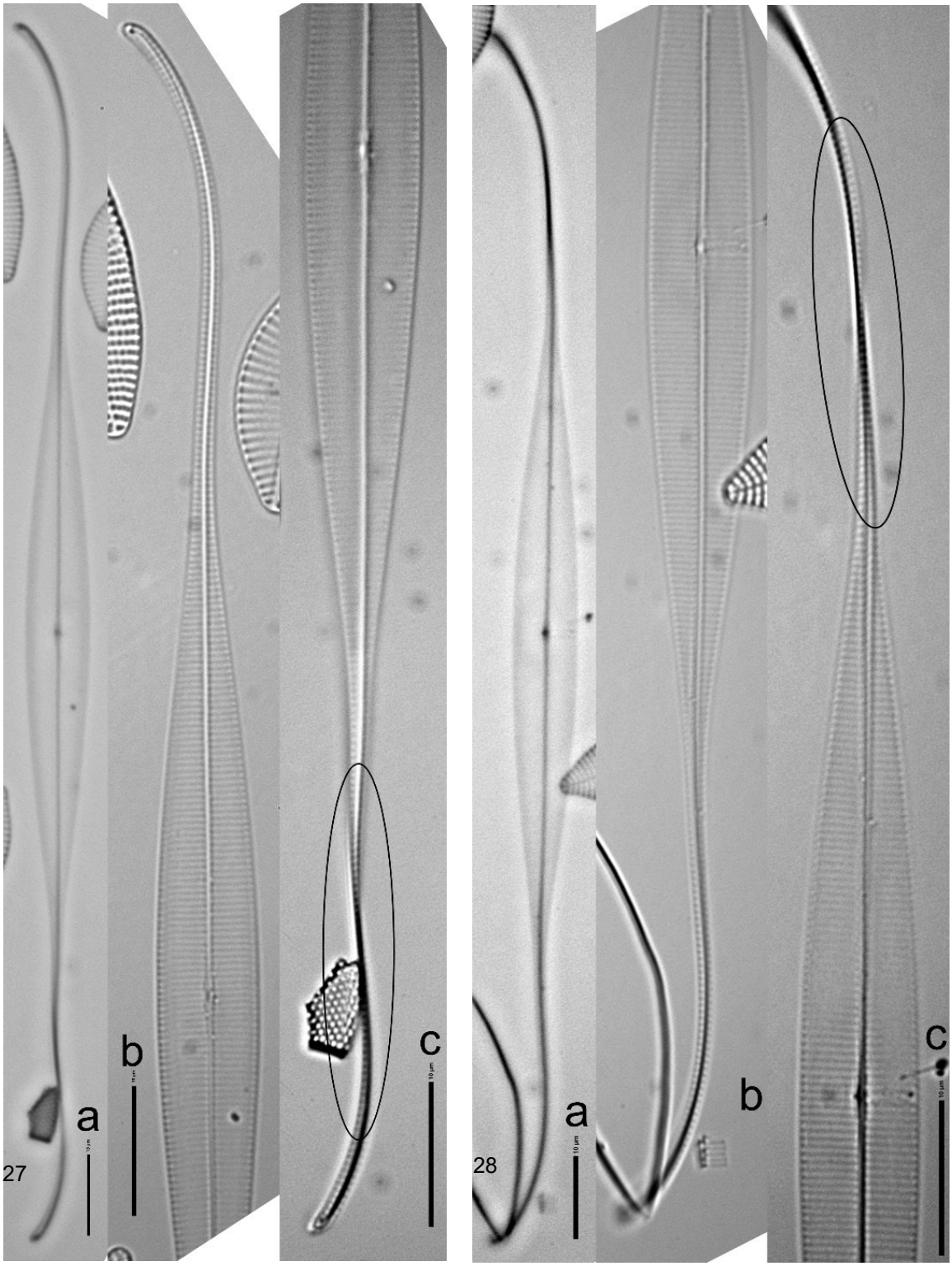


Figure 26. *Navicula palpebralis* [18].

Symmetric Biraphid Diatoms - Pleurosigmataceae



Figures 27-28. *Arcuatasigma closterioides* [18]. Valve view of two valves. This genus is distinguished partly by the twist in one end of the valve. (a) Full views of valves. (b) Details of central areas and straight ends. (c) Details of twisted ends with 180° twists circled. (27) Length = 150 µm. (28) Length = 146 µm. Rare on these slides.

Symmetric Biraphid Diatoms - Pleurosigmataceae

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Figure 29-30. *Donkinia recta* [19]. Similar to *Gyrosigma* but with a more sigmoid raphe. (29a) High focus on arch of the raphe. (29b) Middle focus on central nodule. (29c) Low focus on outline. (30 left) Valve outline. (30 right) Focus on central nodule.

Symmetric Biraphid Diatoms - Pleurosigmataceae

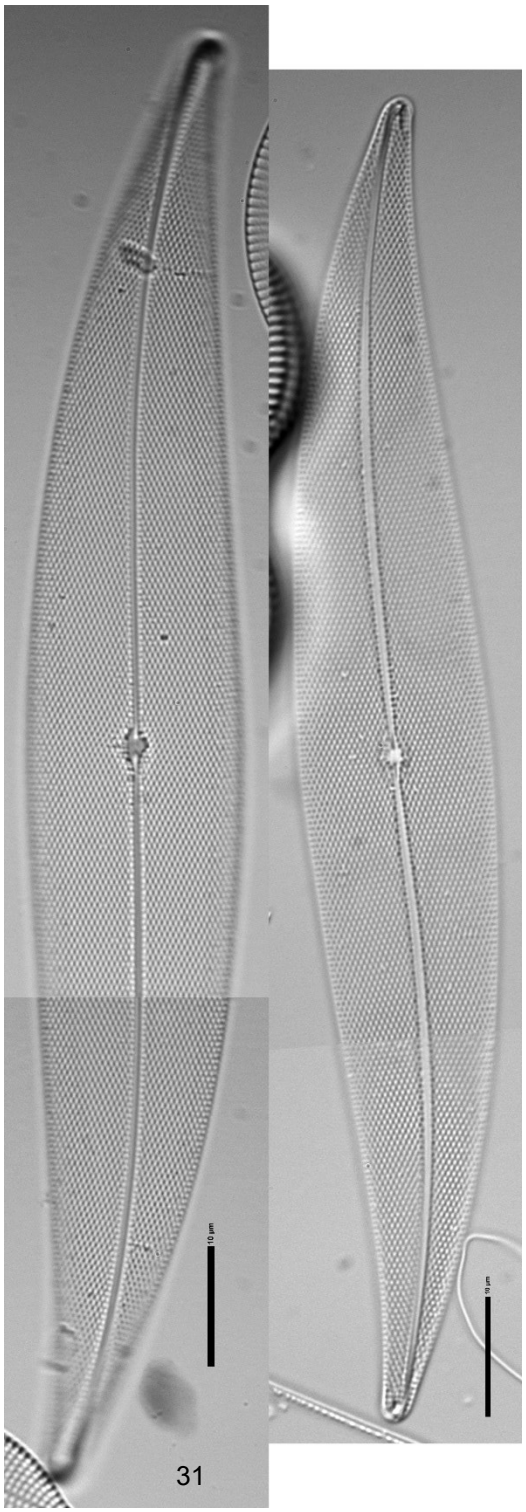


Figure 31. *Pleurosigma* straub-01 [20]. Size series.

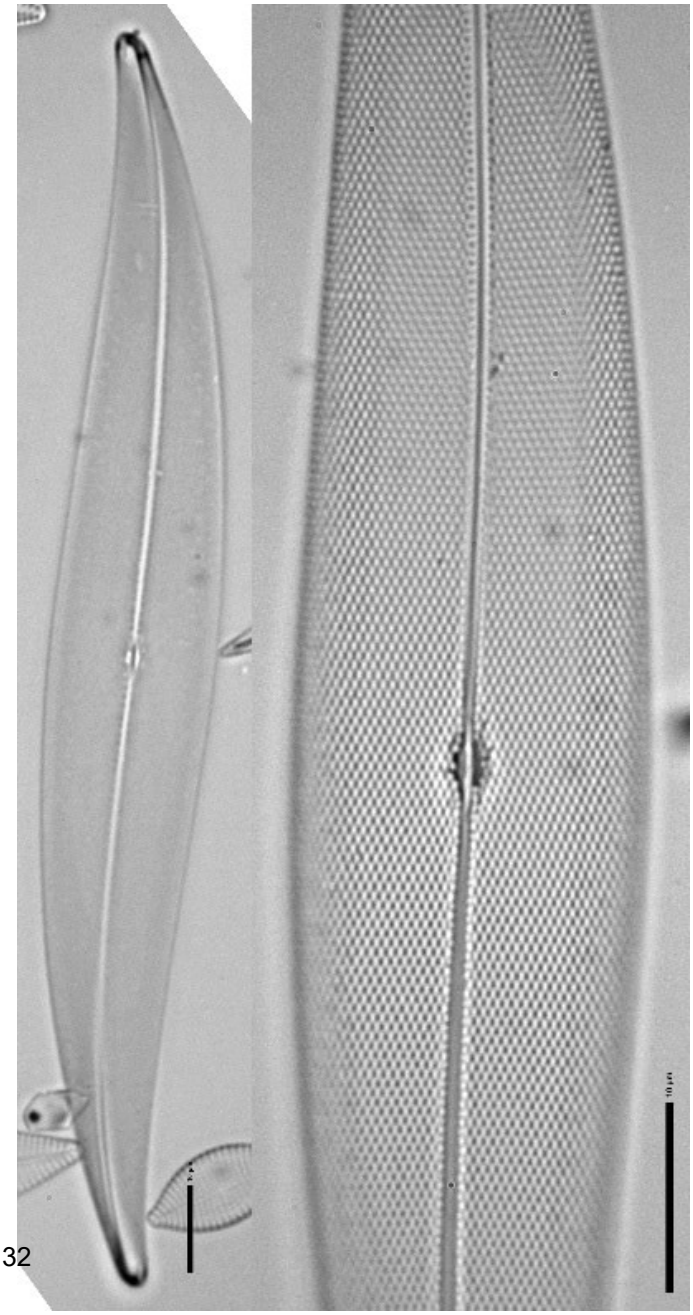
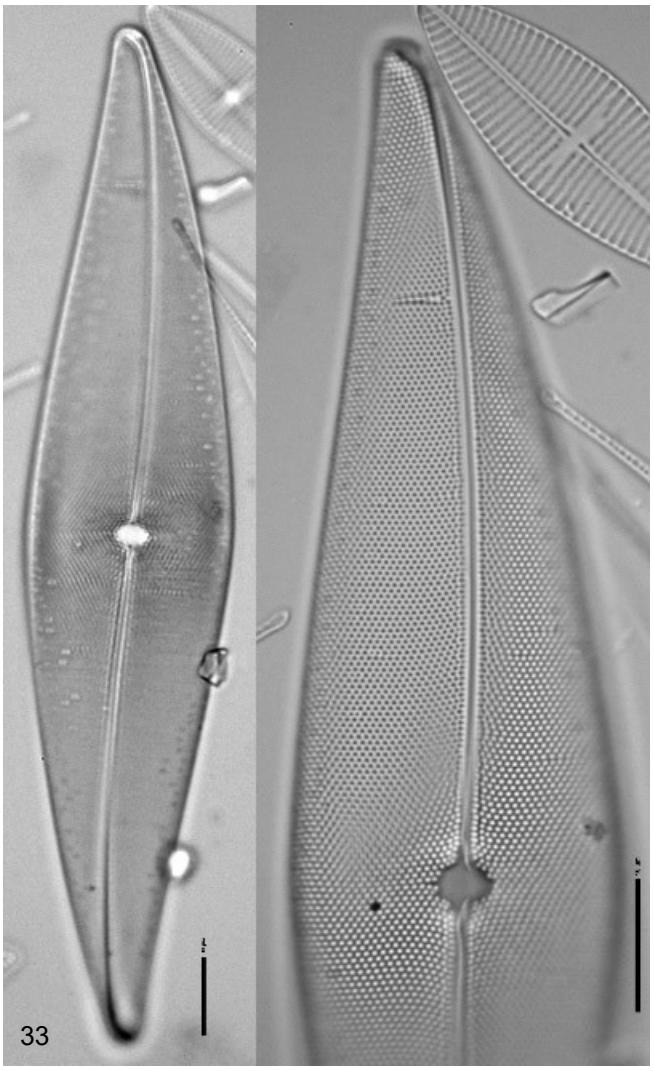
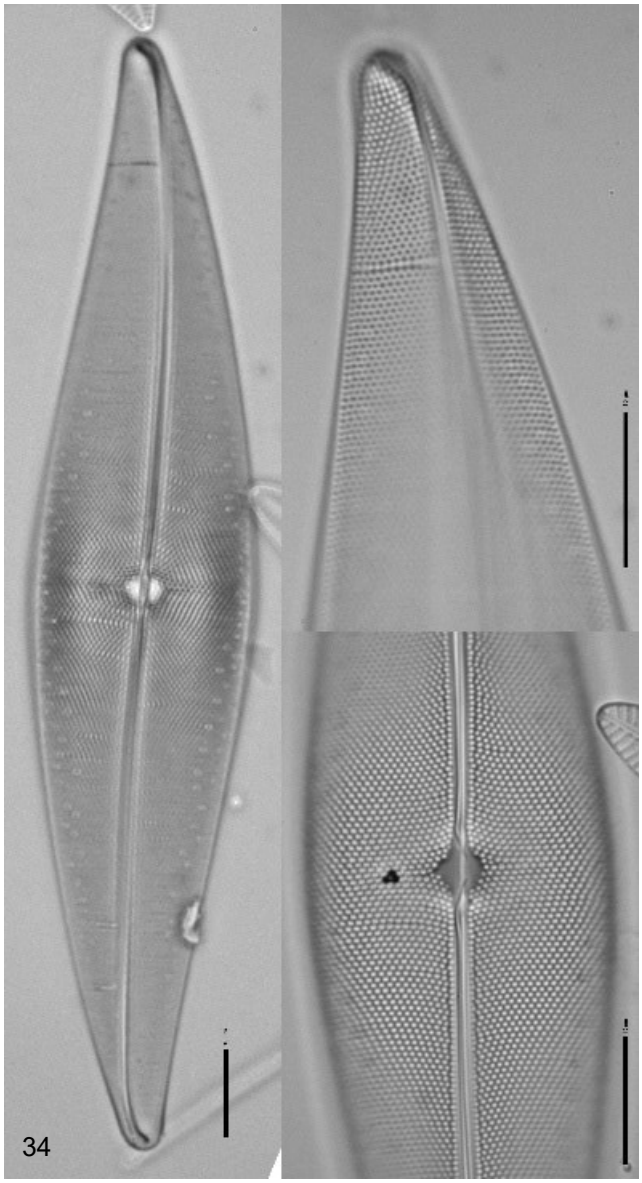


Figure 32. *Pleurosigma* straub-01 [20]. (left) Full valve with 60x objective. (right) Detail of central area with 100x objective.

Symmetric Biraphid Diatoms - Pleurosigmataceae





Figures 33-34. *Pleurosigma aestuarii* [21]. The species is distinguished by the striae in straight rows at the apices. Full valves with 60x objective. Details with 100x objective. These valves have a smaller aspect ratio (L/W) than those in figures 31-32.

Asymmetric Biraphid Diatoms – Genus Amphora

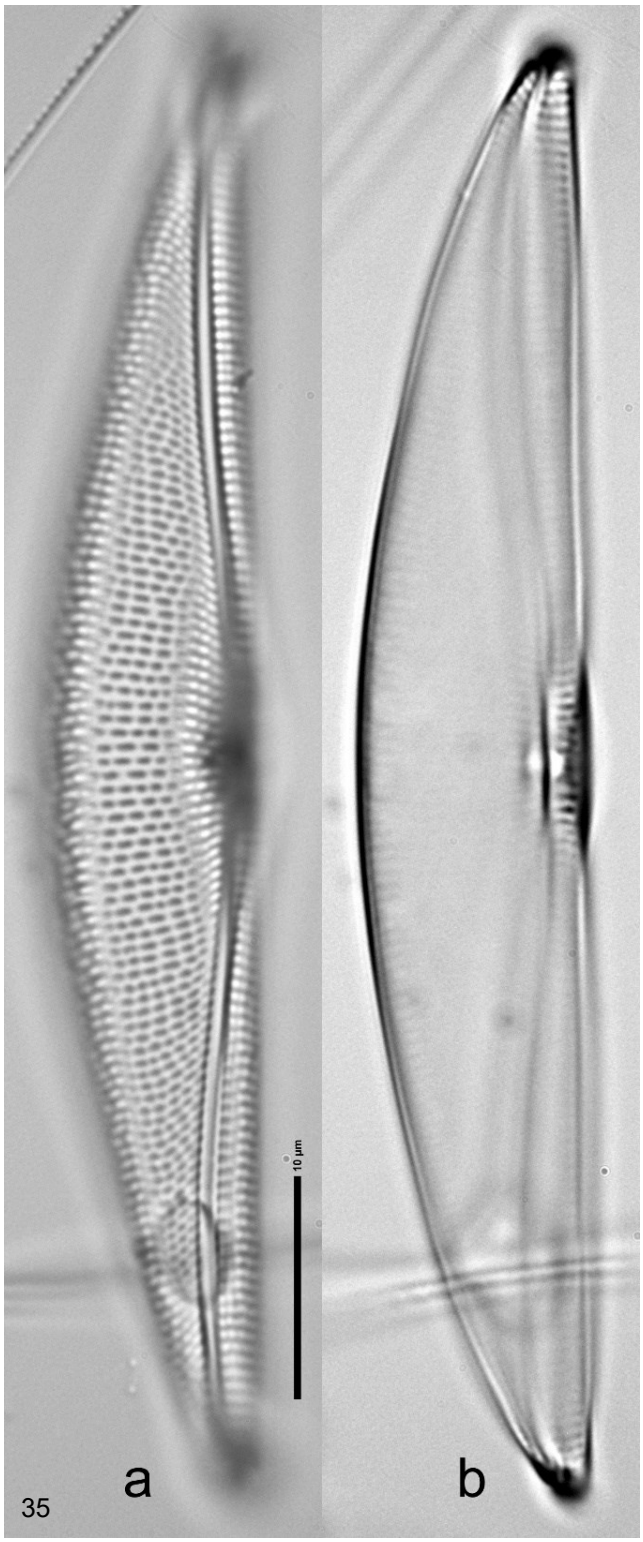


Figure 35. *Amphora* straub-01 [20]. (a) High focus on valve face. (b) Low focus on outline.

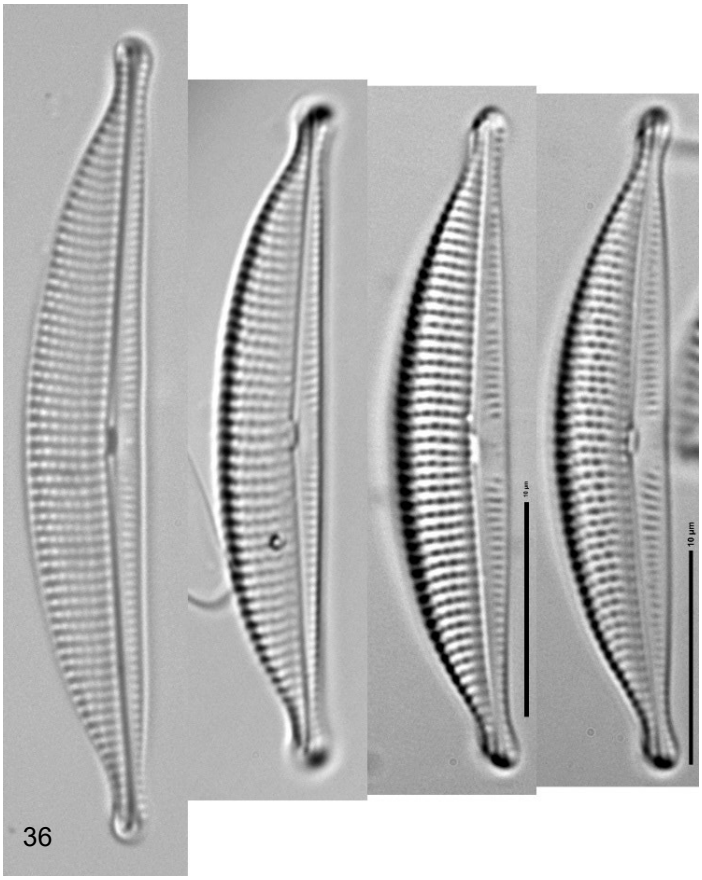
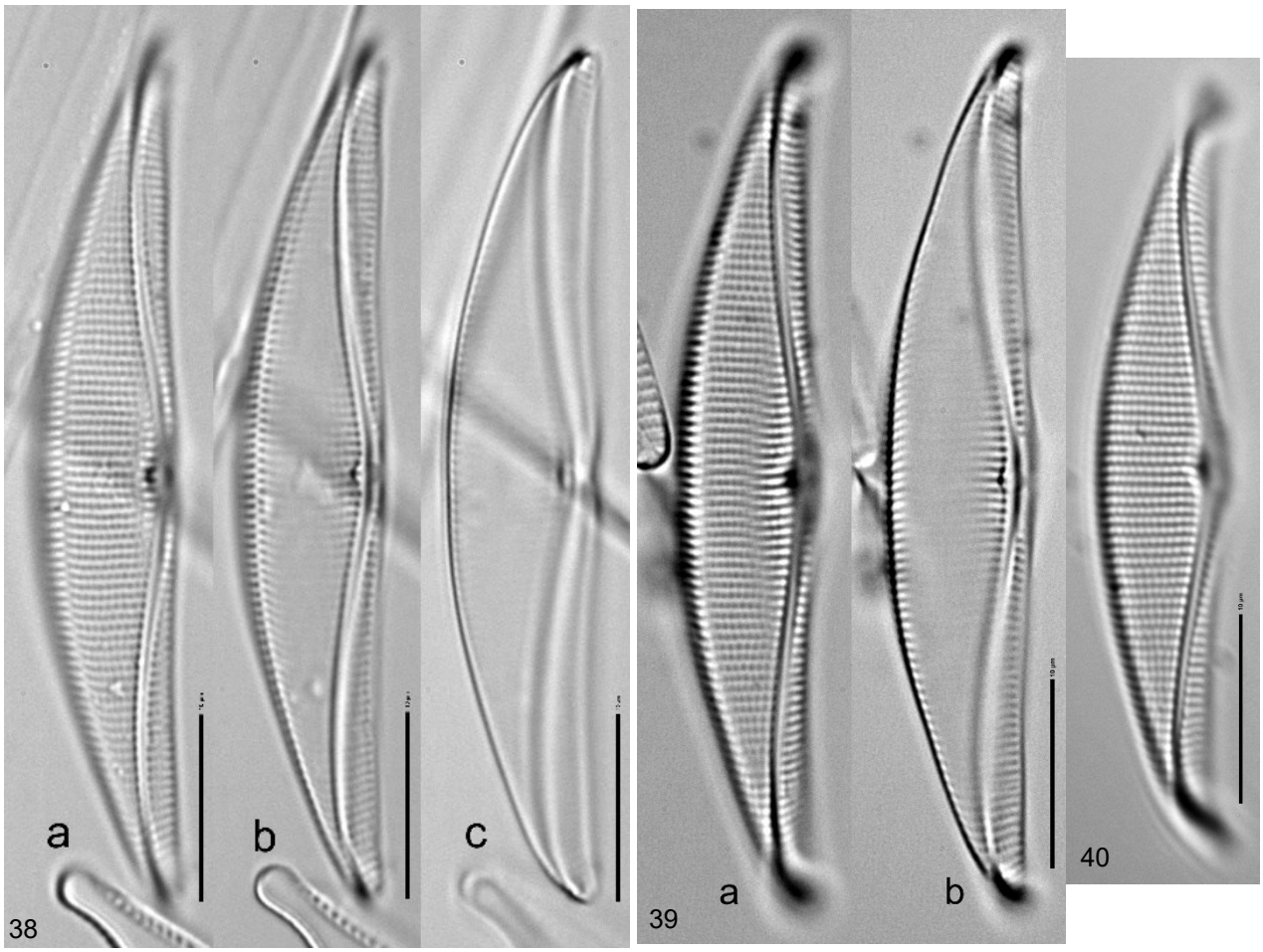


Figure 36. *Halamphora* sp [22]. A size series.

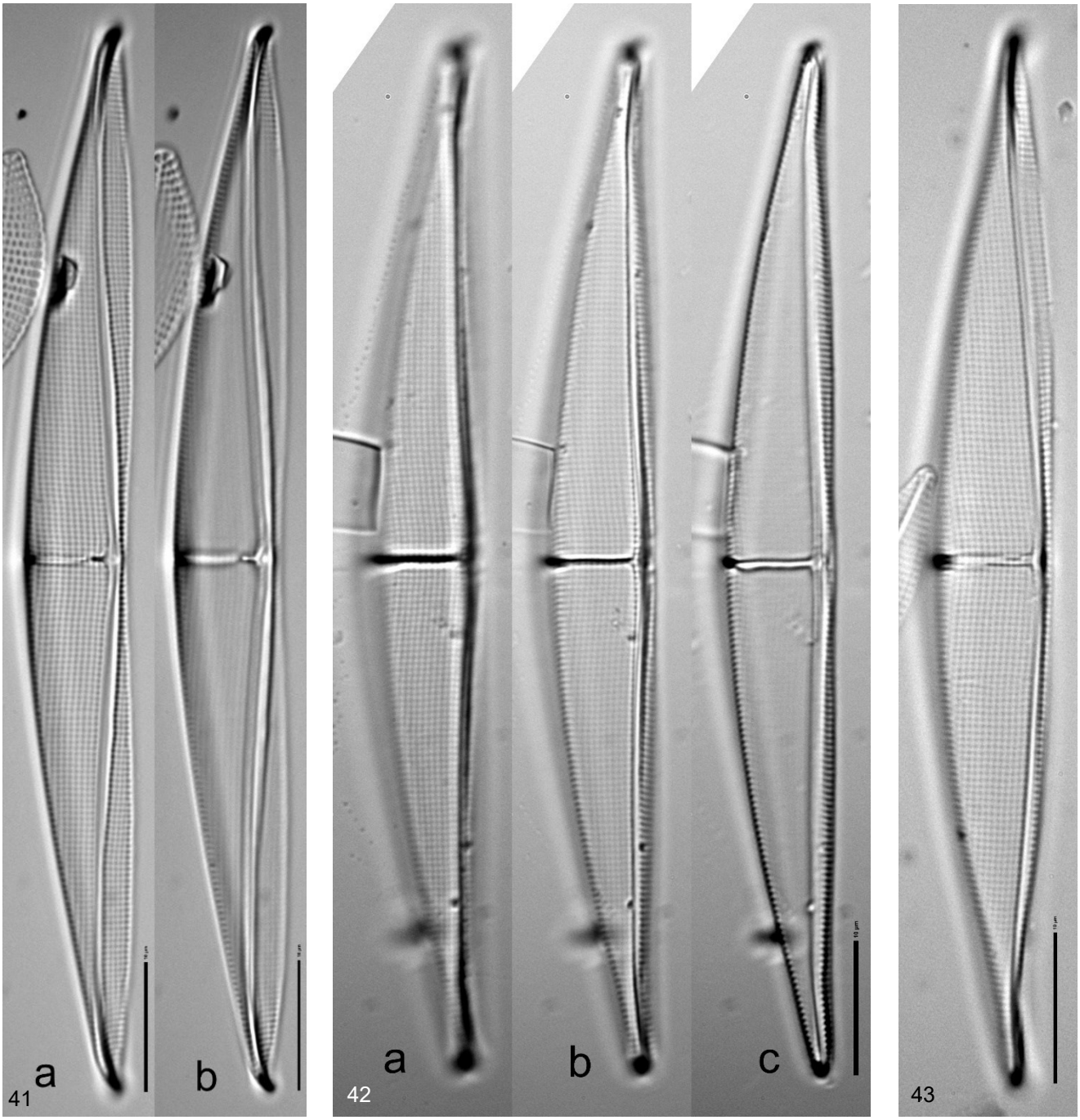
Figure 37.
Amphora cingula [23].

Asymmetric Biraphid Diatoms – Genus Amphora



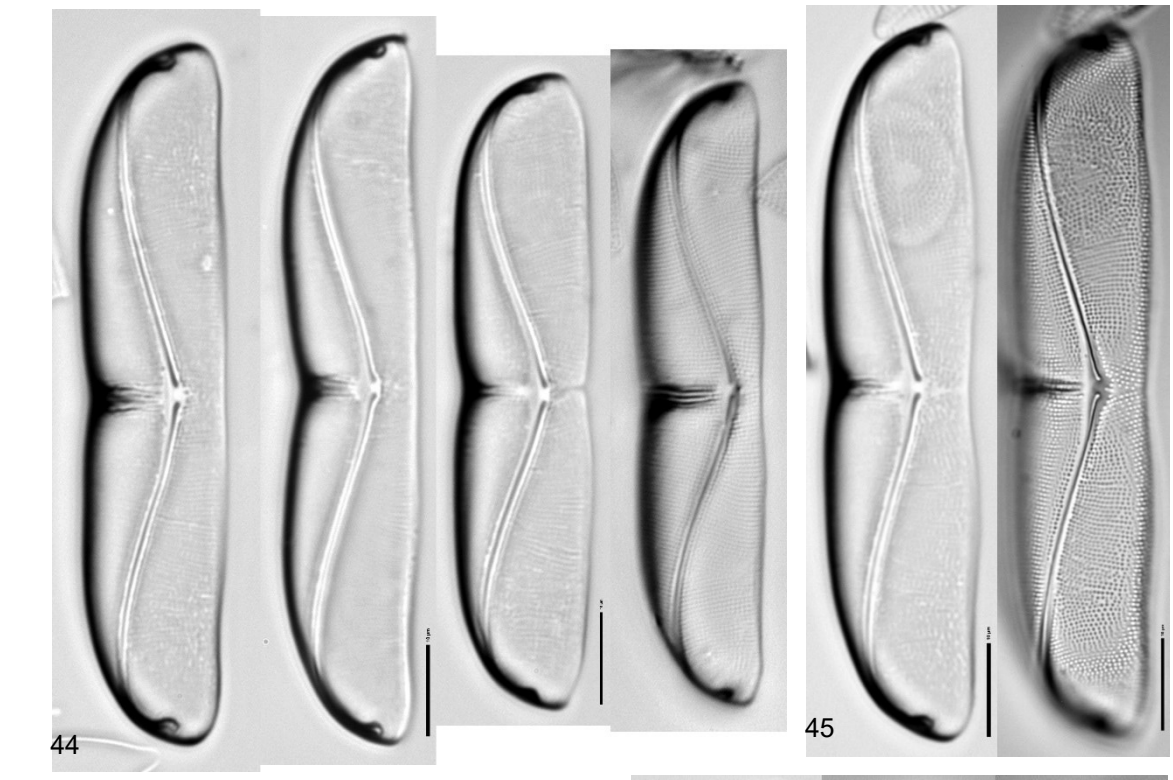
Figures 38-40. *Amphora* straub-02 [20]. Three valves. (38a-c) High focus on striae, middle focus on proximal raphe ends, and low focus on outline. (39a-b) High focus on striae and low focus on proximal raphe ends. (40) Focus on striae.

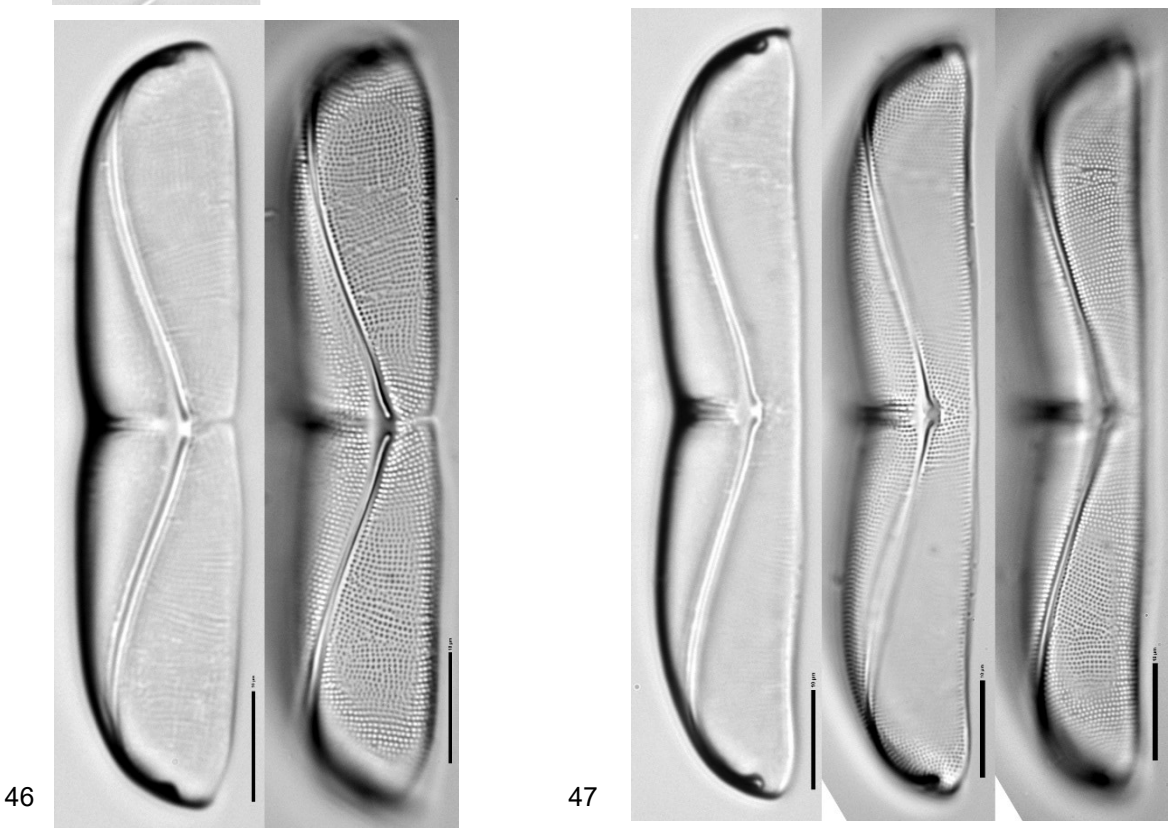
Asymmetric Biraphid Diatoms – Genus Amphora



Figures 41-43. *Amphora* straub-03 [20]. Distinguished by areolae arranged in longitudinal and transverse rows. Three valves. (41a-b) Focus on valve face and on outline. (42a-c) High focus on valve face, middle focus on central area, low focus on outline. (43) Focus on valve face and central area.

Asymmetric Biraphid Diatoms – Genus Amphora





Figures 44-47. *Amphora obtusa* [24]. (44) A size series. (45-47 left) Focus on proximal raphe ends under 60x objective. (45-47 right) Focus on valve face ventral to the raphe under 100x objective. (47 middle) focus on central area under 100x objective.

Ephemeral Lagoon

Nitzschioid Diatoms - Nitzschia

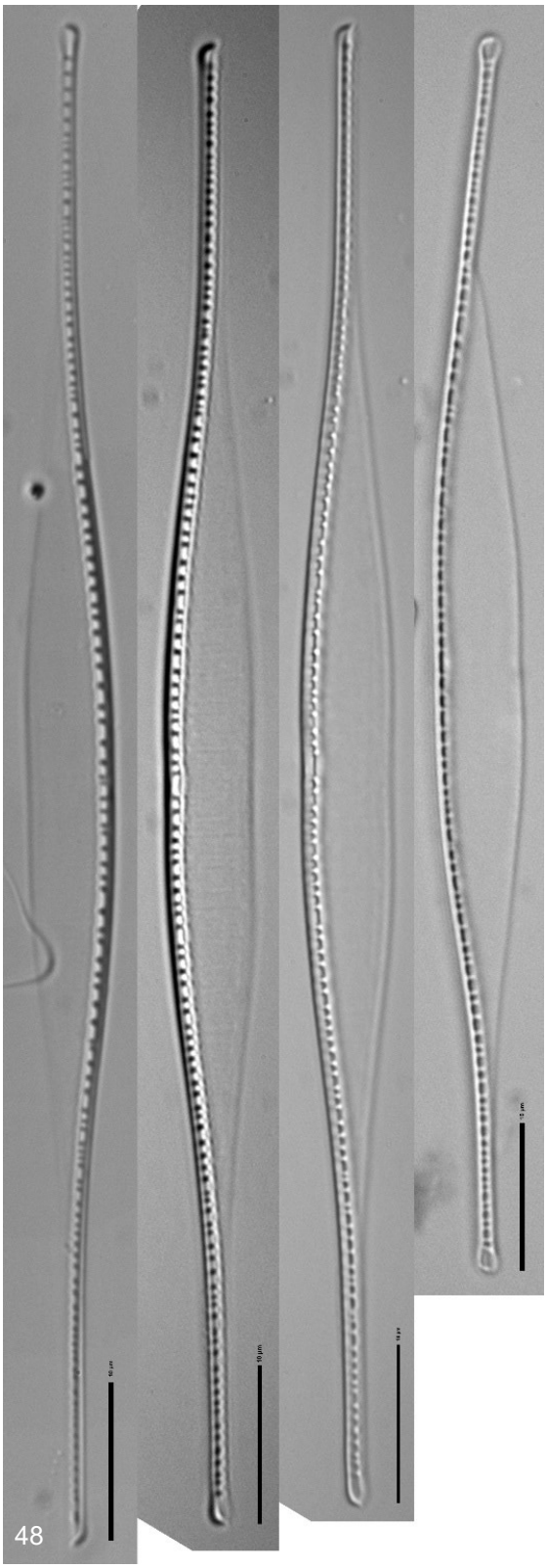


Figure 48. *Nitzschia closterium* [25]. Appeared to be lightly silicified. No striae visible in these images using a 100x objective. This was the most abundant form in the sample.

Surirelloid Diatoms - Entomoneis

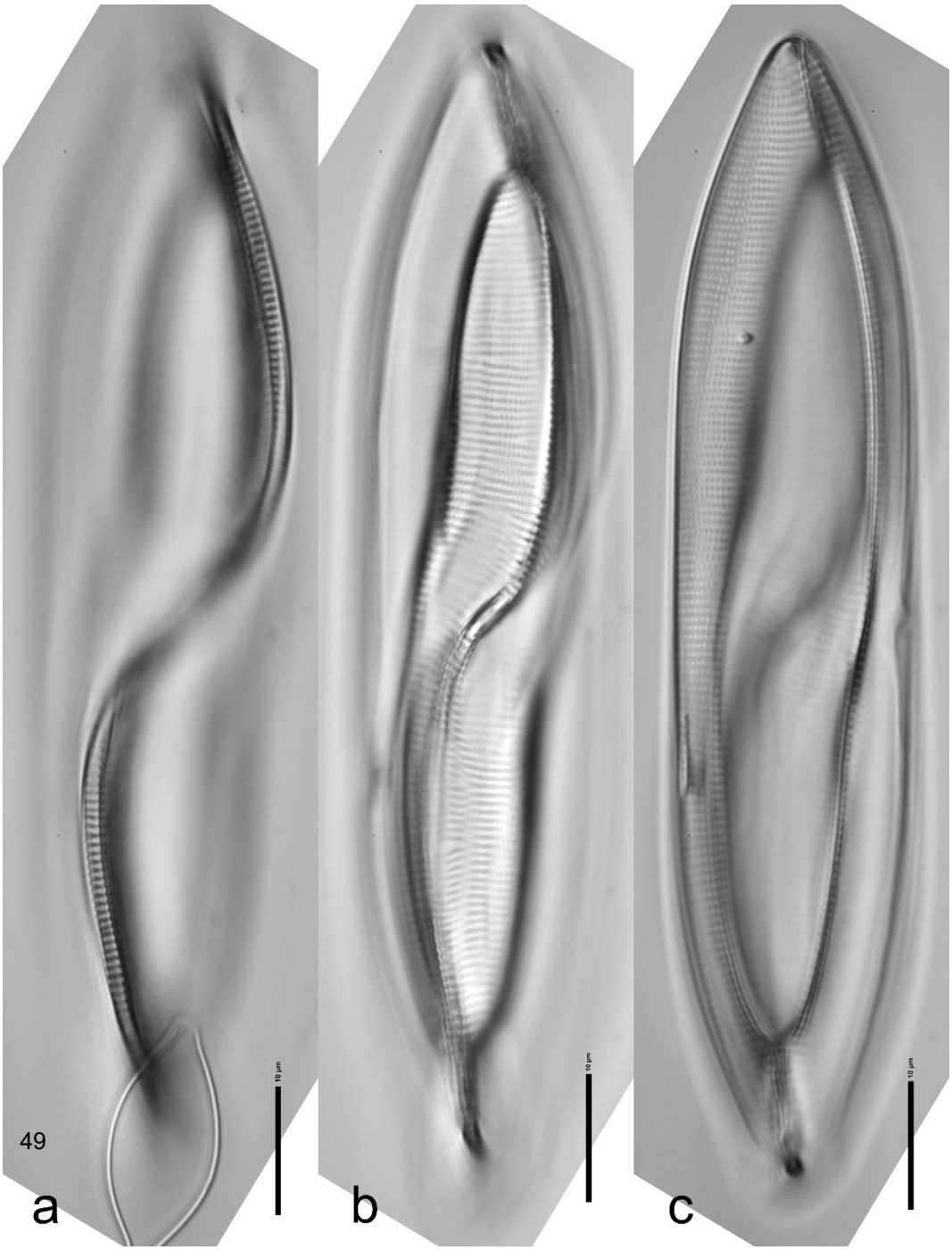


Figure 49. *Entomoneis alata* [26]. Single valve. (a) High focus on crests of the raphe. (b) Middle focus on central nodule and proximal raphe ends. (c) Low focus on outline.

Surirelloid Diatoms - Surirella

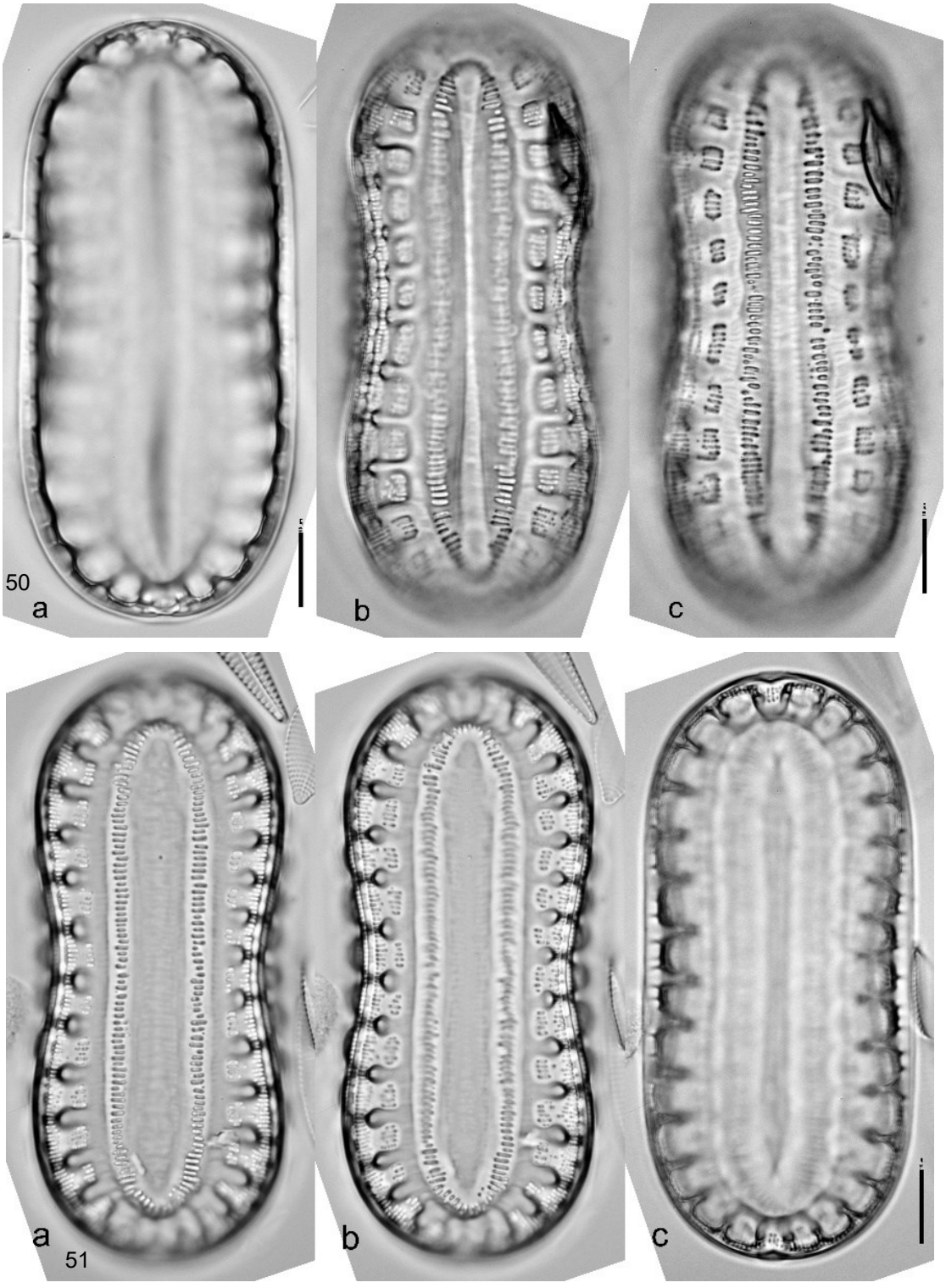


Figure 50-51. *Surirella taeniata* [27]. Two valves under 60x objective. Species has interrupted striae on the ridges leading from the peripheral raphe canal, which distinguishes this form from *S. fastuosa.* (50) Internal view. (a) High focus on outline. (b) Middle focus on striae near apices. (c) Low focus on short, central striae. (51) External view. (a) High focus on short, central striae. (b) Middle focus on raphe canal at middle of valve. (c) Low focus on outline.

Surirelloid Diatoms – Surirella

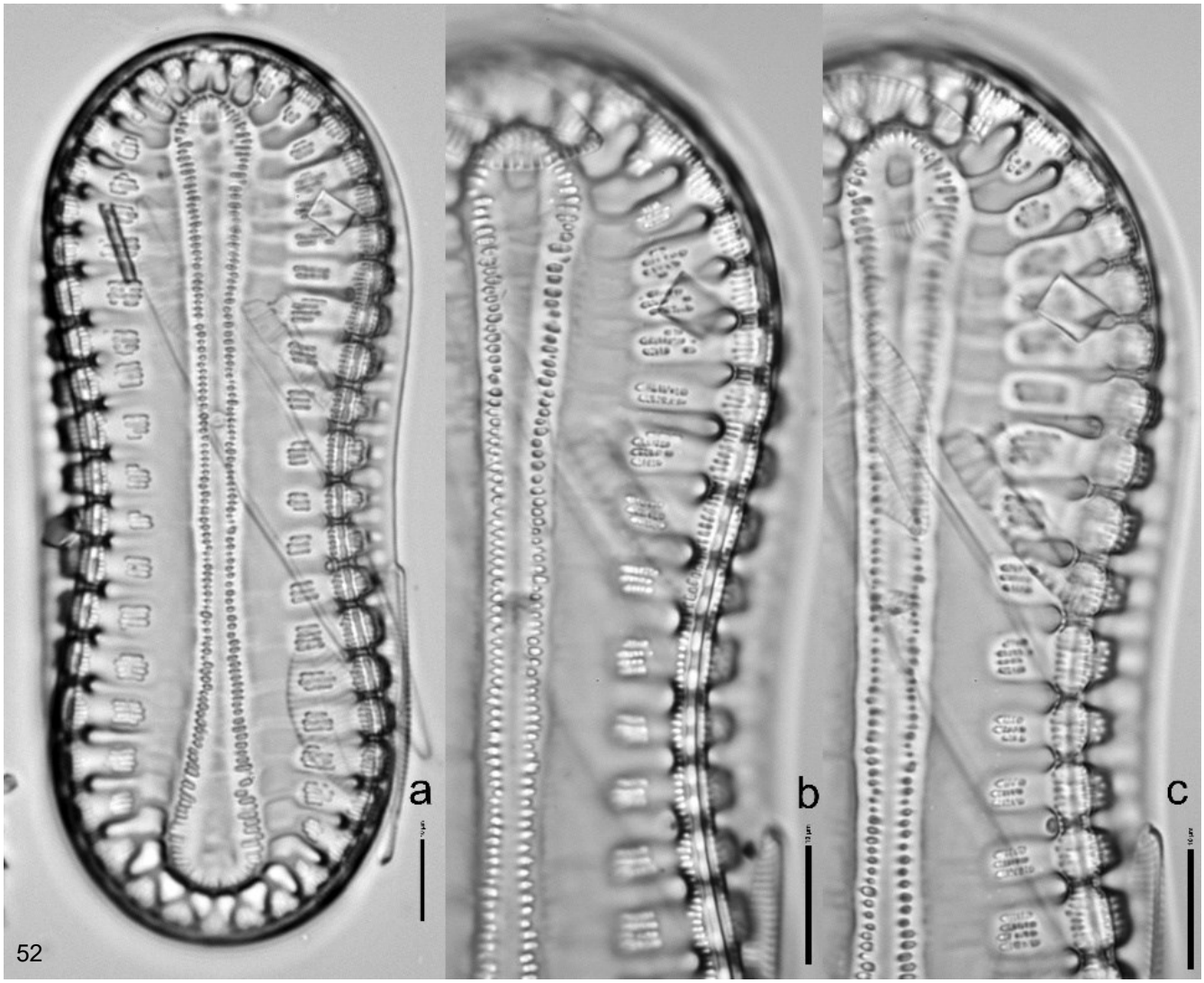


Figure 52. *Surirella taeniata* [27]. (a) Whole valve viewed under 60x objective. (b-c) Details under 100x objective. (b) Focus on peripheral raphe canal. (c) Focus on an infundibulum (structure shaped like a funnel) near the apex connecting to the central area and having the short, interrupted striae characteristic of this species.

Conclusion

The diversity of diatoms in one teaspoon of biofilm on this quiet sand flat was truly amazing.

Acknowledgements

My wife Mady joined me on the hikes to the end of the sand spit for this collection and the later visit to the site.

Notes

1. DONA (2020). https://diatoms.org/what-are-diatoms
2. (a) Round et al. (1990), p 125. (b) Retrieved from https://www.algaebase.org/browse/taxonomy/?id=86704 on 5 Nov 2020. AlgaeBase uses a hierarchy of Eucaryota / Chromista / Bacillariophyta.
3. Google Maps. Satellite image retrieved in October 2020.
4. Author email: rkimmich12@gmail.com
5. Cupp (1943) was used to distinguish among the species of *Coscinodiscus.*
6. Schmidt, A. (1959), Tafel 50 fig. 5. Best guess based on outline, apices, aspect ratio, and central area. The striae are each an alveola as found in *Pinnularia*, showing one way that *Caloneis* and *Pinnularia* are closely related. Here *Caloneis* is separated from *Pinnularia* by the more narrow alveolae in *Caloneis.*
7. *Lyrella* was chosen based on the hyaline branches (shaped like a lyre) separating at the distal ends as opposed to the joining ends found in many *Fallacia*. More characters would be needed to fully separate this from *Fallacia* or the smaller lyrate *Navicula* (Round et al., 1990).
8. For the basic procedure from Raymond, see (https://groups.io/g/diatom-forum/message/1784). Details for this sample can be obtained from Rob Kimmich.
9. Zrax resin produced by Bill Dailey.
10. Sims (1996, plate 257 fig 2).
11. (a) Stidolph (2012), Plate 1 fig 8. These valves also resemble the *Mastogloia notata* valve on the same plate but no valvocopulae, often seen in *Mastogloia*, were noted. (b) Description in AlgaeBase at https://www.algaebase.org/search/genus/detail/?genus_id=47241&-session=abv4:AC1F22891afb82C1F7lYB3583260
12. Sims (1996), plate 90 fig 1.
13. Sims (1996), plate 83 fig 4.
14. Sims (1996), plates 86-87, which show a great amount of variability.
15. (a) Sims (1996), plate 135 fig 3 for a clear illustration. (b) Round et al. (1990) explains the genus and provides excellent electron micrographs. (c) AlgaeBase (retrieved on 7 Nov 2020 from https://www.algaebase.org/search/species/detail/?species_id=63129) explains the name shift from *Navicula* to *Proschkinia.*
16. Stidolph (2012), plate 3 fig 86-87. The aspect ratio (L/W) of fig 23 is 10.6.
17. Aspect ratio was 7.6, smaller than that of figures 23-24.
18. (a) Lobban and Reid (2018). *A. closterioides* was chosen by the length, center width, and apical width. The stria count was close but not quite in the range given in Table 1. The genus identification was given by Lobban answering a request on diatom-L listserv in October 2020. (b) AlgaeBase (Oct 2020) has a full description but no illustrations.
19. (a) Round et al. (1990, p 584) for discussion of the genus. (b) Sims (1996, plate 114 fig 6). *D. recta* was chosen for its very pronounced sigmoid raphe.
20. Round et al. (1990) for genus description.
21. Sims (1996, plate 245 fig 1).

22. DONA (2020). Retrieved from https://diatoms.org/genera/halamphora/guide on 7 Nov 2020.
23. Sims (1996, plate 16 fig 5).
24. (a) Sims (1996, plate 20 fig 12). (b) Stidolph (2012, plate 12 fig 40-42).
25. Sims (1996, plate 290 fig 3).
26. Sims (1996, plate 12 fig 3).
27. (a) Schmidt, A. (1959) Band IV, Tafel 359, Fig. 8-9. (b) AlgaeBase. Retrieved on 8 Nov 2020 from https://www.algaebase.org/search/species/detail/?species_id=123157.
28. DONA (2020). https://diatoms.org/morphology
29. DONA (2020). https://diatoms.org/glossary

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