

University of Nebraska - Lincoln

DigitalCommons@University of Nebraska - Lincoln

Papers in Systematics & Biological Diversity

Papers in the Biological Sciences

5-1-1900

The Modern Conception of the Structure and Classification of Diatoms

Charles E. Bessey

University of Nebraska - Lincoln

Follow this and additional works at: <https://digitalcommons.unl.edu/bioscisystematics>



Part of the [Botany Commons](#)

Bessey, Charles E., "The Modern Conception of the Structure and Classification of Diatoms" (1900).
Papers in Systematics & Biological Diversity. 16.
<https://digitalcommons.unl.edu/bioscisystematics/16>

This Article is brought to you for free and open access by the Papers in the Biological Sciences at DigitalCommons@University of Nebraska - Lincoln. It has been accepted for inclusion in Papers in Systematics & Biological Diversity by an authorized administrator of DigitalCommons@University of Nebraska - Lincoln.

THE MODERN CONCEPTION OF THE STRUCTURE AND CLASSIFICATION OF DIATOMS.

WITH A REVISION OF THE TRIBES AND A REARRANGEMENT OF THE
NORTH AMERICAN GENERA.

By CHARLES E. BESSEY, PH. D.

WITH PLATE V.

In the revision of the Bacillariaceae for Engler and Prantl's "Pflanzenfamilien," Schütt has availed himself principally of the studies of Otto Müller and has given us the first clear conception of the meaning of the diatom cell, and its relation to the diatom filament. Starting with the filament, we regard it as the typical condition, from which the unicellular diatoms have been derived by the solution of the filament and the adaptation of the separate cells to an independent life. Diatoms are thus regarded as typically filamentous algae, and are no longer to be placed among unicellular plants. Accordingly their place in the system is readily determined, and there is no longer any excuse for trying to assign them to the Protophyta or Phaeophyceae, much less to place them outside the vegetable kingdom. Schütt asserts their near relationship to the Desmidiaceae, and Engler in his "Syllabus der Pflanzenfamilien" assigns them to the Euphyceae, with Desmidiaceae and Zygnemaceae as close relatives on the one hand, and the Peridinales on the other.

In a recent study of the diatoms in the light of these views as to their structure, I have accepted Schütt's interpretation with a slight modification, and have adopted the principal fea-

tures of his classification, introducing, however, some changes in both, which I fear he may not accept. What follows must then be understood as based upon Schütt's monograph, but with my own modifications so freely introduced that the responsibility for the views set forth must rest with the present writer rather than the eminent German monographer.

FAMILY BACILLARIACEAE.

Cells yellowish-brown (by the addition of phycoxanthin to the chlorophyll) in unbranched filaments, circular, angled or flattened in cross section (end view or valve view); or more commonly separated early into isolated individuals (sometimes, however, more or less associated together in gelatinous colonies) which are similarly shaped, or variously twisted or bent; cell wall at first composed of cellulose, early more or less completely silicified, in most tribes very finely porous, and often wholly or partly covered with a gelatinous layer; the walls of each cell constitute a closed box ("frustule" of older authors), consisting of two ends ("valves") and two overlapping rings, the "girdle," and in many cases of "interzones" (zwischenbänder), which lie between the girdle and the valves; the interzones are sometimes mere rings, but often they have more or less complete septa which transversely divide the cavity of the cell; chromatophores one or two, large and lamelliform, or numerous, small and granular; propagation (1) by the division of the cell (always at right angles to the axis of the filament) forming two similar cells, (2) by the escape of the protoplasm from its wall, its rapid growth into a larger cell and the formation of an entirely new wall (rejuvenescence), and (3) by contraction of the protoplasm of a cell and the formation of a new thick and armed wall (asexual resting spore); generation by the union of the escaped protoplasmic contents of the two cells, resulting in the formation of one or two new, usually much larger cells (several modifications of this process have been observed). Minute fresh water and marine plants, floating free or attached to various objects.

The family is readily separated into two sub-families:

A. SUB-FAMILY CENTRICAÆ.—Cells in transection circular, less commonly polygonal or elliptical, and rarely irregular; valves marked concentrically or radially by dots, areolations, lines or ribs; cells often with spines, processes or horns.

B. SUB-FAMILY PENNATAÆ.—Cells in transection narrowly elliptical to linear, less commonly broadly elliptical, lunate, cuneate or irregular; valves marked pinnately or transversely by dots, areolations, lines or ribs; cells without spines, processes or horns (spines very rarely present, e. g., *Dimerogramma* and *Cymatosira*).

Under the sub-family Centricæ are arranged nine tribes, the sequence being from those which are typically cylindrical filaments to those which are flattened filaments, in the former more commonly remaining as filaments, in the latter more commonly separating into individual cells. (Plate V.)

Under the sub-family Pennatæ are arranged six tribes, the sequence being from those typically filamentous to those typically separated into individual cells. (Plate V.)

In further interpretation of the diatom structure as indicating the relationship of these two sub-families I have regarded them as constituting two separate but somewhat parallel genetic lines, in which the Coscinodisceæ and Fragilarieæ are approximately primitive, the former having given rise to the Centricæ and the latter to the Pennatæ.

In comparing the two sub-families it is interesting to note that the species of Centricæ are largely marine and fossil, and those of Pennatæ are largely fresh-water and recent. The structure of the plants of the former is relatively simpler, but the superficial ornamentation is usually more marked, while in the Pennatæ the structure is increasingly more complex up to the Naviculeæ, Bacillarieæ and Surirelleæ, where the raphe is a characteristic structure, while in these the superficial ornamentation is less marked.

I may say in passing that I have a similar conception of the structure of the Desmids, and that in the arrangement of the

families of the Conjugatae I regard the Zygnemaceae as more nearly primitive, with their filamentous, unbranched plant-body, and that the Desmids and Diatoms represent two similar and somewhat parallel genetic lines, in which the filaments tend to break up early into independent cells, the former with a less modified cell wall, the latter with its wall usually much modified by the deposition of silica.

KEY TO THE TRIBES.

- A. SUB-FAMILY CENTRICAÆ.—Cells in transection circular, less commonly polygonal or elliptical, and rarely irregular; valves marked concentrically or radially by dots, areolations, lines or ribs; cells often with spines, processes or horns.
- I. Cells short box-shaped or discoid, mostly circular in transection, usually without horns or projections,
 - a. Valves not divided into sectors by ribs, sometimes with radial rows of dots, without “eyes” (round or oval, definitely bounded, hyaline areas) or nipples,

Tribe 1. *Coscinodisceae*.
 - b. Valves divided into sectors by ribs, without “eyes” or nipples,

Tribe 2. *Actinodisceae*.
 - c. Valves with radial undulations, or dome-shaped projections, the latter with “eyes,” nipples or spines,

Tribe 3. *Eupodisceae*.
 - II. Cells two to many times as long as broad, circular, rarely round-elliptical in transection; girdle with numerous interzones,

Tribe 4. *Solenieae*.
 - III. Cells box-shaped, about as long as broad (rarely much longer), transection circular to elliptical, with two to many horns much longer than the cell; interzones rarely present,

Tribe 5. *Chaetocereae*.
 - IV. Cells box-shaped, shorter than broad or but little longer, transection circular, polygonal or commonly elliptical; valves with two (rarely one) to more poles, each pole with a projection or horn which is shorter

than the cell, or when about its length provided with claws; interzones rarely present,

Tribe 6. *Biddulphiaceae*.

- V. Cells box-shaped, as long as broad or shorter, elliptical, sometimes lunate in transection; valves without horns or projections; rarely with interzones,

- a. Valves lunate, without transverse septa,

Tribe 7. *Euodiaceae*.

- b. Valves not lunate,

1. Valves with transverse septa, without spines,

Tribe 8. *Ananuleae*.

2. Valves without transverse septa, with a marginal row of spines,

Tribe 9. *Rutilariaceae*.

- B. SUB-FAMILY PENNATAE.—Cells in transection narrowly elliptical to linear, less commonly broadly elliptical, lunate, cuneate or irregular; valves marked pinnately or transversely by dots, areolations, lines or ribs; cells without spines, processes or horns (spines very rarely present, e. g., *Dimerogramma* and *Cymatosira*).

- I. Rachis of the valves (i. e., the line between the divergent pinnate markings) evident as a narrow unmarked strip (pseudoraphe), rarely wanting; valve without a slit (raphe),

- a. Cells usually little shorter than broad or longer, with numerous interzones, mostly united into filaments,

Tribe 10. *Tabellariaceae*.

- b. Cells prevailingly much shorter than broad (“rod-shaped” of older authors, the longer axis of the rod representing one of the transverse axes of the cell), often united into filaments,

1. Cells cuneate in girdle view (i. e., valves not parallel), rachis median, interzones present,

Tribe 11. *Meridioneae*.

2. Cells rectangular in girdle view, or if cuneate the rachis not median, interzones present or absent,

Tribe 12. *Fragilariaceae*.

- II. Rachis containing an elongated slit (raphe) through the cell wall,
 - a. Rachis commonly median, often more or less lateral, not keeled or when keeled not punctate, interzones present or absent, Tribe 13. *Naviculeae*.
 - b. Rachis lateral, less often median, punctate-keeled, raphe not plainly visible, Tribe 14. *Bacillarieae*.
- III. Rachis evident as a narrow, unmarked strip, or keeled; valve with two lateral wing-keels, each enclosing a raphe, Tribe 15. *Surirelleae*.

A. SUB-FAMILY CENTRICAE.

TRIBE I. COSCINODISCEAE.

KEY TO THE GENERA.

- I. Cells forming filaments, girdle side marked,
 - a. Valves without spines,
 - 1. Entire valve uniformly marked, 1. *Lysigonium*.
 - 2. Margin and center of valve differently marked,
 - a. Marginal portion a narrow ring, 2. *Paralia*.
 - b. Marginal portion a very broad radially striate ring,
 - 1. Central portion finely punctate, 3. *Hyalodiscus*.
 - 2. Central portion areolated, 4. *Hyalodictya*.
 - b. Each valve with a circle of spines, 5. *Stephanopyxis*.
- II. Cells single, girdle side not marked,
 - a. Long box-shaped, central portion of valves coarsely areolated, 6. *Craspedodiscus*.
 - b. Cells disk-shaped,
 - 1. Valve markings not consisting of sinuate lines,
 - a. Valve with distinct central and marginal portions, without spines, 7. *Cyclotella*.
 - b. Central and marginal portions of valve grading into one another,
 - 1. Valve with a circle of spines, 8. *Stephanodiscus*.
 - 2. Valve without spines, 9. *Coscinodiscus*.
 - 2. Valve markings consisting of sinuate lines, 10. *Liradiscus*.

1. *Lysigonium* Link (*Melosira* Agardh). Cells cylindrical (or elliptical), closely joined together, not carinate, sometimes transversely furrowed, sometimes superficially denticulate in the plane of the fracture, valves simply punctate. Species numerous, in fresh and marine waters.

2. *Paralia* Heiberg. Cells cylindrical, valves furrowed parallel to the edge, valve markings of two kinds, at the center finely punctate, at the edge a circle of areolae. Species few, marine and fossil.

3. *Hyalodiscus* Ehrenberg. Cells solitary, geminate or several, valves orbicular, with radiating lines, and with a distinct central smooth umbilicus. Species few, marine and fossil.

4. *Hyalodictya* Ehrenberg. Like the preceding, but with the umbilicus closely areolate. Species one, in fresh waters.

5. *Stephanopyxis* Ehrenberg. Cells cylindrical or discoid (occasionally elliptical in transection), mostly united in chains, valves tumid convex, hexagonally alveolate, spines usually coronal, sometimes wanting. Species many, marine and fossil.

6. *Craspedodiscus* Ehrenberg. Cells solitary, long box-shaped, valves diversely areolate, central portion sharply defined from the surrounding border by a spiny line. Species few, marine and fossil.

7. *Cyclotella* Kützing. Cells mostly single or in twos, short cylindrical, discoid, valves saucer-shaped, diversely marked, central portion inflated, smooth or granulate, surrounded by a circular border marked by fine radiating lines. Species numerous, mostly in fresh waters.

8. *Stephanodiscus* Ehrenberg. Cells single, short cylindrical, discoid, valves circular, slightly convex, not hexagonally areolate, radially granulate with hyaline spaces between the radii, center hyaline or granulate, edge with a simple crown of spines. Species many, mostly in fresh waters, some fossil.

9. *Coscinodiscus* Ehrenberg. Cells single, discoid, valves circular, rarely elliptical or rhomboid, flat or centrally depressed, sometimes undulate or plicate, often with a central hyaline circular or irregular area, which may contain an areolate rosette;

markings areolate or granulate, margin narrow or broad, mostly with marginal spines. Species very many, marine and fossil.

10. *Liradiscus* Greville. Cells single, discoid, with a narrow girdle band, valves circular to elliptical, somewhat convex, flattened towards the edge, surface sinuate-reticulate, more or less rough, sometimes with small spines, no central area, margin narrow and hyaline, or broad and radially lined. Species few, marine and fossil.

TRIBE II. ACTINODISCEAE.

KEY TO THE GENERA.

- I. Ribs or sectors without claws,
 - a. No sharp separation of central and marginal portions,
 - 1. Radial ribs not transversely connected,
 - 11. *Stictodiscus*.
 - 2. Radial ribs connected by transverse lines or rows of granules,
 - 12. *Hemiptychus*.
 - b. Center areolated and surrounded by a hollow, radially chambered border,
 - 13. *Planktoniella*.
- II. Ribs or sectors with claws,
 - a. Valve radially undulate, the alternate sectors dissimilar,
 - 14. *Actinoptychus*.
 - b. Valve not undulate,
 - 1. Rays all alike,
 - 15. *Asterolampra*.
 - 2. One of the rays dissimilar,
 - 16. *Asteromphalus*.

11. *Stictodiscus* Greville. Cells single, discoid, valves circular or angled, more or less convex (often unequal), with radial ribs usually not reaching to the center, central area usually granulate. Species many, mostly marine and fossil.

12. *Hemiptychus* Ehrenberg (*Arachnoidiscus* Ehrenberg). Cells single, discoid, valves circular, with numerous stout radiating ribs (often alternately longer and shorter), which are connected by transverse lines or rows of granules, center hyaline. Species few, marine and fossil.

13. *Planktoniella* Schütt. Cells single, discoid, flat; valves circular, consisting of a sharply defined, slightly areolated center,

surrounded by a broad, hyaline, hollow, radially chambered and ribbed border. Species one, marine.

14. *Actinoptychus* Ehrenberg. Cells single, discoid, valves circular to hexagonal, with radial more or less dissimilar undulations, the surface mostly hexagonally areolate; sectors provided with marginal claws; umbilicus central, often hyaline and mostly stellate. Species many, marine and fossil.

15. *Asterolampira* Ehrenberg. Cells single, discoid, flat; valves circular or obtusely angled, with similar hyaline, radial rays, all reaching the margin and there provided with marginal claws; center sometimes areolate, margins always areolate, with a middle non-areolated band between the marginal band and the center. Species many, marine and fossil.

16. *Asteromphalus* Ehrenberg. Cells single, discoid; valves circular or elliptical to oval, with sub-similar, hyaline, radiating rays, all reaching the margin and there provided with marginal claws; center hyaline, crossed by radial zigzag lines, and surrounded by a broad areolated field divided by the rays. Species many, marine and fossil.

TRIBE III. EUPODISCEAE.

KEY TO THE GENERA.

I. Valves with nipples, no "eyes," 17. *Tripodiscus*.

II. Valves without nipples, with "eyes,"

a. "Eyes" sub-marginal, small,

1. Valve surface granulate in radiating lines, one "eye," 18. *Actinocyclus*.

2. Valve surface mostly areolate, one to four "eyes," 19. *Eupodiscus*.

b. "Eyes" not marginal, usually large, 20. *Auliscus*.

17. *Tripodiscus* Ehrenberg (*Aulacodiscus* Ehrenberg). Cells single, discoid or box-shaped; valves circular (rarely polygonal), bearing one to forty-five sub-marginal nipple-like processes, flat, crateriform, or with an elevated zone; markings granular, in straight or crooked lines. Species many, marine and fossil.

18. *Actinocyclus* Ehrenberg. Cells single, discoid, or short box-shaped; valves circular to elliptical or rounded rhomboid, flat (rarely convex), granulate, the granules usually round, and arranged radially; central area usually round; one round, sub-marginal "eye." Species many, marine and fossil.

19. *Eupodiscus* Ehrenberg. Cells single, discoid; valves circular, flat or slightly convex, center often depressed; markings mostly areolate, without a central area, "eyes" one to four, small, near the margin; spines small, few to many, sub-marginal. Species few, marine and fossil.

20. *Auliscus* Ehrenberg. Cells single, discoid; valves circular, round to elliptical (rarely bluntly angled), flat, with usually two (rarely one, three or four) truncate, conical processes, each terminating in a large "eye;" central area usually present; markings of the surface variable, granulate, pruinose, to areolate. Species many, marine and fossil.

TRIBE IV. SOLENIEAE.

[We have but one genus.]

21. *Rhizosolenia* Ehrenberg. Cells long cylindrical, forming chains; girdle composed of numerous scale-like, almost ringed segments; valves unsymmetrical, oblique to the long axis of the cell; cell-wall but little silicified. Species many, mostly marine, rarely in fresh waters.

TRIBE V. CHAETOCERAE.

KEY TO THE GENERA.

- I. Valves circular, with many horns, 22. *Bacteriastrum*.
- II. Valves elliptical, each with two horns, 23. *Chaetoceros*.
- 22. *Bacteriastrum* Shadbolt. Cells short cylindrical, usually shorter than broad, forming chains, with numerous horns arising at the margins of the valves. Species few, marine.
- 23. *Chaetoceros* Ehrenberg. Cells short elliptical, shorter or longer than broad, forming chains; valves elliptical, each bearing two long horns, girdle bands but little silicified. Species many, marine.

TRIBE VI. BIDDULPHIEAE.

KEY TO THE GENERA.

- I. Projections or horns without claws,
 - a. Valves alike,
 - 1. Valves tri- to multipolar, with a projection at each angle,
 - a. Strongly silicified, without spines or claws, 24. *Triceratium*.
 - b. Weakly silicified, a stout spine at each pole, 25. *Lithodesmium*.
 - 2. Valves bipolar,
 - a. With spines, strongly silicified,
 - 1. Projections strongly developed, 26. *Biddulphia*.
 - 2. Projections reduced, each bearing a slender spine, 27. *Zygoceros*.
 - b. Without spines, weakly silicified, 28. *Eucampia*.
 - b. Valves unlike, 29. *Isthmia*.
 - II. Projections or claws with terminal claws, 30. *Hemiaulus*.

24. *Triceratium* Ehrenberg. Cells prismatic, box-shaped, free or connected in chains; valves three to many angled, angles more or less prolonged into protuberances, without spines or claws. Species many, nearly all marine and fossil.

25. *Lithodesmium* Ehrenberg. Cells prismatic, box-shaped, united into long chains; valves three angled, each angle with a stout terminal spine; girdle band of many scale-like segments; cell walls incompletely silicified. Species few, marine and fossil.

26. *Biddulphia* Gray. Cells box-shaped, elliptical to sub-circular in transection, free or connected in chains; valves usually strongly convex, bipolar, each pole with a short protuberance or stout horn, which is rounded or truncate; valves frequently with stout spines. Species many, marine and fossil.

27. *Zygoceros* Ehrenberg. Like *Biddulphia*, but with the protuberances of the valves reduced, and bearing a slender spine-like or thread-like horn. Species few, marine and fossil.

28. *Eucampia* Ehrenberg. Cells short, slightly curved, forming spiral chains; valves elliptical, flat or with two protuberances; girdle band mostly with many cross-lines; cell walls weakly silicified. Species few, marine and fossil.

29. *Isthmia* Agardh. Cells box-shaped, mostly longer than thick, and broad, trapezoidal, free or united into tree-like colonies; valves elliptical, dissimilar, each with a protuberance; girdle band distinct. Species few, marine and fossil.

30. *Hemiaulus* Ehrenberg. Cells mostly box-shaped, transverse section elliptical to multiangular, with relatively long protuberances, united into chains; valves bi- to multipolar, each pole extended into a short or long horn, terminating in one or more claws. Species many, marine and fossil.

TRIBE VII. EUODIEAE.

[We have but one genus.]

31. *Hemidiscus* Wallich (*Euodia* Bailey). Cells box-shaped, single; valves lunate, markings areolate or granulate. Species few, marine and fossil.

TRIBE VIII. ANAULEAE.

KEY TO THE GENERA.

- I. Valves with transverse septa appearing in girdle view as straight, incomplete partitions,
 - a. Valves straight, 32. *Anaulus*.
 - b. Valves slightly curved, 33. *Eunotogramma*.
- II. Valves with transverse septa appearing in girdle view as bent, incomplete partitions,
 - a. Incomplete partitions bent-capitate, 34. *Terpsinoe*.
 - b. Incomplete partitions, after bending, elongated parallel to the valve-face, 35. *Porpeia*.

32. *Anaulus* Ehrenberg. Cells box-shaped, single; valves elliptical, straight, with two transverse septa, which appear as straight, short, incomplete partitions in the girdle view; valve markings punctate. Species few, marine and fossil.

33. *Eunotogramma* Weisse. Cells as in *Anaulus*, but the valves slightly curved, and with two to many transverse septa. Species few, marine and fossil.

34. *Terpsinoe* Ehrenberg. Cells box-shaped, single or united into chains by their angles or valve-faces; valves symmetrical, oblong-elliptical, with lateral undulations, and with two to many transverse septa which in girdle view appear as short, incomplete partitions with thickened curved ends (resembling "notes" of written music). Species few, fresh-water, marine and fossil.

35. *Porpeia* Bailey. Cells box-shaped, single; valves oblong-elliptical, the middle and ends swollen, with two transverse septa which in girdle view appear as incomplete partitions, which soon bend axially parallel to the valve-face. Species few, marine and fossil.

TRIBE IX. RUTILARIEAE.

[We have but one genus.]

36. *Rutilaria* Greville. Cells much broader than long, in valve view oblong-elliptical, united into short chains; valves boat-shaped, somewhat elevated at the ends, surrounded by tooth-like spines. Species few, marine and fossil.

B. SUB-FAMILY PENNATAE.

TRIBE X. TABELLARIEAE.

KEY TO THE GENERA.

- I. Transverse ribs of the valves, when present, not extending into the cell cavity,
 - a. Valves with a few prominent transverse ribs,
 - 37 *Tetracyclus*.
 - b. Valves transversely striate only,
 1. Interzones two to many, septa not undulate,
 - a. Valves coarsely striate, pseudoraphe present,
 38. *Rhabdonema*.
 - b. Valves finely striate, pseudoraphe absent,
 39. *Striatella*.
 2. Interzones two, septa undulate, 40. *Grammatophora*.
- II. Transverse ribs of the valves extending deeply into the cell cavity,
 41. *Denticula*.

37. *Tetracyclus* Ralfs. Cells united into flat filaments, shorter or longer than broad, with many interzones, and centrally perforated transverse septa; valves elliptical to oblong, swollen in the middle, without prominent median line, no nodules, and sparingly transverse ribbed. Species few, fresh-water and fossil.

38. *Rhabdonema* Kützing. Cells united into flat filaments, shorter or longer than broad, the filaments basally attached by a gelatinous cushion on one corner of the end cell; interzones many, externally cross-marked, their transverse septa variously perforated; valves elliptical or linear-lanceolate, with a pseudoraphe, and transverse-beaded lines and no nodules. Species few, marine and fossil.

39. *Striatella* Agardh (*Tabellaria* Ehrenberg). Cells shorter or longer than broad, united into flat filaments which may partly separate into zigzag chains, basally attached by one corner; interzones few to many, each with an alternately perforated septum; valves linear to elliptical-oblong, more or less swollen centrally and at the ends; without pseudoraphe or nodules; surface transversely striate, not ribbed. Species many, fresh-water, marine and fossil.

40. *Grammatophora* Ehrenberg. Cells shorter than broad, united into flat, zigzag chains, basally attached; interzones two, each with an undulate, centrally perforated transverse septum; valves linear to elliptical, sometimes swollen in the middle and sometimes at the ends also, with a faint pseudoraphe, and polar but no central nodules, mostly finely cross striate. Species many, marine and fossil.

41. *Denticula* Kützing. Cells free, single or united into very short, flat filaments; interzones two, each with a transverse septum with a row of perforations; valves lanceolate, without raphe, with transverse ribs and striae. Species few, fresh-water, brackish water, and fossil.

TRIBE XI. MERIDIONEAE.

KEY TO THE GENERA.

- I. Valves punctate or variously punctate-striate, without transverse ribs,
 - a. Not stalked, 42. *Sceptroneis*.
 - b. Cells stalked,
 - 1. Each interzone with a septum only at its broader end, 43. *Licmophora*.
 - 2. Each interzone with a scalariform-fenestrate septum, 44. *Climacosphenia*.
 - II. Valves finely transverse-striate and with transverse ribs, 45. *Meridion*.
42. *Sceptroneis* Ehrenberg. Cells free, mostly single, cuneate in valve and girdle view; interzones wanting; valves transversely moniliform-striate, with pseudoraphe which is sometimes very broad; polar nodules sometimes recognizable. Species few, fresh-water, marine and fossil.
43. *Licmophora* Agardh. Cells stalked, single or forming fan-like chains, cuneate in valve and girdle view; interzones two, open at the narrower end and with a septum at the broader end; valves very finely transversely striate, and with a pseudoraphe; nodules wanting. Species many, marine.
44. *Climacosphenia* Ehrenberg. Like *Licmophora*, but the interzones with scalariform-fenestrate septa. Species few, marine and fossil.
45. *Meridion* Agardh. Cells free, united into fan-shaped or spiral chains, cuneate in valve and girdle view; interzones wanting; valves cuneate, rounded at the ends, with transverse ribs, and fine, transverse, centrally interrupted striae, this interruption forming a pseudoraphe. Species few, in fresh waters.

TRIBE XII. FRAGILARIEAE.

KEY TO THE GENERA.

- I. Rachis median,
 - a. Valves with transverse ribs, or if not ribbed, with a central "eye,"

1. Without a central "eye," 46. *Odontidium*.
2. With a central "eye," 47. *Plagiogramma*.
- b. Valves without transverse ribs, without a central "eye,"
 1. Ends of valves alike,
 - a. Cells in filaments, or zigzag chains,
 1. Valves flat, without polar nodules, 48. *Fragilaria*.
 2. Valves raised at the ends, and often in the middle, with polar nodules. 49. *Dimerogramma*.
 - b. Cells single, or forming fan-like, stalked clusters, 50. *Synedra*.
 2. Ends of valves unequally swollen, 51. *Asterionella*.
- II. Rachis near one margin,
 - a. Ends of valves alike,
 1. Pseudoraphe and central nodule evident, 52. *Ceratoneis*.
 2. Pseudoraphe and central nodule not evident, 53. *Eunotia*.
 - b. Ends of valves unlike, 54. *Tibiella*.

46. *Odontidium* Kützing (*Diatoma* DC.). Cells united into short bands or zigzag chains, which are attached at the base, not cuneate, girdle view oblong-rectangular; valves lanceolate to linear with transverse ribs, and fine transverse striae, the latter interrupted centrally by the indistinct pseudoraphe; no central nodule. Species few, in fresh waters.

47. *Plagiogramma* Greville. Cells often united into chains, free, not cuneate, girdle view oblong-rectangular; valves linear or elliptical, transversely punctate striate and sometimes ribbed, with a central "eye;" pseudoraphe often present; terminal nodule present. Species many, marine and fossil.

48. *Fragilaria* Lyngby. Cells united into mostly ribbon-shaped, rarely zigzag, chains, not cuneate, girdle view rectangular, mostly narrowly linear; valves linear-lanceolate or fusiform, flat, transversely striate or with transverse rib-like, beaded markings but no true ribs; pseudoraphe present; no nodules. Species many, fresh-water, marine and fossil.

49. *Dimerogramma* Ralfs. Cells united into ribbon-like chains, not cuneate, girdle view rectangular; valves lanceolate to linear-lanceolate, sometimes broader or narrower in the middle, not flat, raised at the ends, and often in the middle, with coarse or fine transverse-punctate striations, interrupted by the pseudoraphe; with polar and often central nodules. Species few, marine and fossil.

50. *Synedra* Ehrenberg. Cells free or attached, single or in fan-shaped clusters, not cuneate, girdle view linear; valves linear or lanceolate-linear, sometimes somewhat crinkled, transversely striate, mostly with a pseudoraphe; sometimes with false central and polar nodules. Species many, fresh-water, marine and fossil.

51. *Asterionella* Hassall. Cells attached into a star-shaped cluster, not cuneate, girdle view narrowly linear, with unequally thickened ends; valves narrowly linear with unequally swollen ends, very finely transverse striate, with a pseudoraphe; no nodules. Species few, fresh-water and marine.

52. *Ceratoneis* Ehrenberg. Cells free, single, not cuneate, girdle view linear; valves crescentic, faintly or not at all transversely striate; pseudoraphe present close to the concave edge; polar and central nodules present. Species few, fresh-water and fossil.

53. *Eunotia* Ehrenberg. Cells free or united into chains, or attached, not cuneate, girdle view rectangular-oblong; valves crescentic, often undulate on the convex margin, transverse striae uninterrupted; pseudoraphe not evident; polar nodules present; central nodule wanting. Species many, fresh-water and fossil.

54. *Tibiella* Bessey (*Actinella* Lewis*). Cells attached into fan-shaped colonies, cuneate in girdle view; valves curved, with the ends unequally swollen, finely transverse-punctate-striate, with marginal beads or spines; pseudoraphe indistinct; polar

* *Actinella* Lewis (1865) is antedated by *Actinella* Persoon (1807), as well as by *Actinella* Nuttall (1818), and must therefore be suppressed. The name *Tibiella* is suggested by the resemblance of the cells in valve view to the human tibia.

nodules present; central nodule wanting. Species few, fresh-water and fossil.

TRIBE XIII. NAVICULEAE.

KEY TO THE GENERA.

- I. Valves parallel,
 - a. Rachis of valves not keeled,
 - 1. Raphe almost straight,
 - a. Raphe with a simple border,
 - 1. Septa of interzones (when present) not fenestrate,
 - †. Cells straight in girdle view, 55. *Navicula*.
 - ††. Cells curved,
 - §. Both valves with a raphe, 56. *Rhoiconeis*.
 - §§. Only one valve with a raphe,
 - 57. *Achnanthes*.
 - 2. Septa of interzones fenestrated,
 - †. Both valves with a raphe, 58. *Mastogloia*.
 - ††. Only one valve with a raphe,
 - §. Interzonal septa narrow, marginal, fenestrated, 59. *Cocconeis*.
 - §§. Interzonal septa complete, fenestrated,
 - 60. *Campyloneis*.
 - b. Raphe bordered by two ridges,
 - 1. Central nodule small or only slightly elongated,
 - 61. *Brebissonia*.
 - 2. Central nodule much elongated, rib-like,
 - 62. *Amphipleura*.
 - 2. Raphe strongly sigmoid or arcuate,
 - a. Raphe sigmoid,
 - 1. Cell not twisted, 63. *Gyrosigma*.
 - 2. Cell twisted, 64. *Scoliopleura*.
 - b. Raphe arcuate, 65. *Toxonidea*.
 - b. Rachis of valves with a keel,
 - 1. Keel (including the raphe) sigmoid, median,
 - 66. *Amphiprora*.
 - 2. Keel (including the raphe) arcuate, excentric,
 - 67. *Amphitrite*.

- II. Valves not parallel, ends approximating,
 - a. Cells straight in girdle view, 68. *Gomphonema*.
 - b. Cells curved in girdle view, 69. *Rhoicosphenia*.
- III. Valves not parallel, edges approximating,
 - a. Valves without transverse ribs,
 - 1. Girdle narrow, not striate, 70. *Cymbella*.
 - 2. Girdle broad, striate, 71. *Amphora*.
 - b. Valves with transverse ribs, raphe not evident, 72. *Cystopleura*.

55. *Navicula* Bory. Cells single, free or enclosed in gelatinous tubes, or rarely united in chains, not cuneate, elliptical to linear-lanceolate in valve view, rectangular and straight in girdle view; with or without interzones, interzonal septa not marginally chambered; valves bilaterally symmetrical, with a straight raphe (or nearly so), no keel, and round polar and central nodules, the latter sometimes elongated (stauros); surface transversely punctate-striate or ribbed. Species very many, fresh-water, marine and fossil.

56. *Rhoiconeis* Grunow. Cells single, free, not cuneate, curved in girdle view, interzones several; valves elliptical-lanceolate, symmetrical, with a straight median raphe and central and terminal nodules; surface transversely striate. Species few, fresh-water, marine and fossil.

57. *Achnanthes* Bory. Cells single or forming short chains attached by the basal cell, cells curved only in girdle view; valves elliptical to lanceolate, often narrower or broader in the middle; valves dissimilar, the one concave with a true raphe and central and polar nodules, the other convex with a pseudo-raphe, both striate with transverse rows of dots, sometimes ribbed. Species many, fresh-water, marine and fossil.

58. *Mastogloia* Thwaites. Cells mostly enclosed in a gelatinous mass, not cuneate, lanceolate in valve view, and oblong in girdle view; valves like those of *Navicula*; two interzones present, each having a septum with a central opening surrounded by a row of rectangular chambers. Species many, fresh-water and marine.

59. *Cocconeis* Ehrenberg. Cells single, free, straight or curved in girdle view, and the plane of the upper valve with its margins curved downwards; valves round-elliptical to circular, dissimilar, the lower concave with a true raphe and nodules, the upper with a pseudoraphe and without nodules, both transversely punctate-striate; interzone one with a narrow marginal fenestrated septum, or none. Species many, fresh-water, marine and fossil.

60. *Campyloneis* Grunow. Cells single, free, curved in girdle view, and the plane of the upper valve with the margins curved downwards; valves scutelliform, dissimilar, the lower concave, transversely punctate-striate, with a straight raphe and central nodules, the upper convex, cribose-punctate, with a pseudoraphe and without nodules; interzone one, between the lower valve and the girdle, its septum complete, fenestrated. Species few, marine and fossil.

61. *Brebissonia* Grunow. Cells single, free or enclosed in gelatinous tubes, or sometimes stalked, not cuneate, elliptical to linear-lanceolate in valve view, rectangular and straight in girdle view; without interzones; valves bilaterally symmetrical, with a straight raphe (or nearly so) which is enclosed between two parallel ridges; central nodule small, usually slightly elongated; surface transversely punctate-striate or ribbed. Species few, fresh-water and marine.

62. *Amphipleura* Kützing. Cells single, free, or enclosed in gelatinous masses or tubes, not cuneate, narrowly lanceolate in valve view, narrowly oblong in girdle view; valves bilaterally symmetrical; raphe straight, bordered by two parallel ridges, and separated by the long, narrow, longitudinal, rib-like central nodule; polar nodules small; surface transversely striate. Species many, fresh-water, marine, and fossil.

63. *Gyrosigma* Hassall (*Pleurosigma* W. Smith). Cells single, free or rarely enclosed in gelatinous tubes, not cuneate, straight and oblong-elliptical in girdle view, sigmoid in valve view; valves bilaterally symmetrical, sigmoid-lanceolate; raphe median, sigmoid; central nodule small; striations crossed, ob-

liquely (decussate) or at right angles (rectangular), reaching almost to the raphe. Species many, mostly marine, some in fresh waters, also fossil.

64. *Scoliopleura* Grunow. Cells single, free, twisted, not cuneate, girdle view oblong, the girdle oblique; valves elliptical, strongly convex, the raphe sigmoid, excentric; central nodule small; surface transversely striate, sometimes obliquely striate-pearled. Species few, fresh water, marine, and fossil.

65. *Toxonidea* Donkin. Cells single, free, not cuneate, twisted, lunate or arcuate in valve view, the girdle oblique; valves unsymmetrical, with an arcuate excentric raphe, and central and polar nodules; striations decussate. Species few, marine.

66. *Amphiprora* Ehrenberg. Cells single, free, not cuneate, twisted, lanceolate in valve view and oblong in girdle view but with a sigmoid girdle; interzones present; valves convex, with the raphe concealed in a sigmoid emarginate keel; central and polar nodules present; valves transversely striate, rarely scattered punctate. Species few, fresh water and marine.

67. *Amphitrite* Cleve (*Auricula* Castracane). Cells single, free, not cuneate, quite unsymmetrical; valves reniform, with an arcuate, emarginate, oblique keel at the convex margin including the raphe, central and polar nodules present; interzones present; striations of valves transverse or irregular. Species few, marine.

68. *Gomphonema* Agardh. Cells single, mostly stalked or in gelatinous masses, cuneate in both girdle and valve views; interzones present; valves bilaterally symmetrical, often laterally twice indented; raphe straight, with central and polar nodules, the former sometimes transversely elongated (stauros); surface transversely punctate-striate. Species many, fresh water, marine, and fossil.

69. *Rhoicosphenia* Grunow. Cells mostly stalked, cuneate in both girdle and valve views, curved in girdle view; interzones present; valves straight, bilaterally symmetrical, transversely striate, unlike; the concave valve with raphe and central

and polar nodules, the other without nodules, and with a pseudo-raphe. Species few, fresh water and marine.

70. *Cymbella* Agardh. Cells single, stalked, (often becoming free) or enclosed in gelatinous tubes, oblong and straight in girdle view; no interzones; valves lunate, not symmetrical; raphe somewhat excentric, arcuate, rarely straight; central and polar nodules present; surface transversely striate, without ribs. Species many, fresh and brackish waters, and fossil.

71. *Amphora* Ehrenberg. Cells single, mostly free, elliptical to rectangular in girdle view; sometimes with cuneate interzones; valves lunate, not symmetrical; raphe excentric, near the concave margin, doubly arcuate; central nodule rounded or transversely elongated; surface transversely punctate-striate. Species very many, fresh water, marine, and fossil.

72. *Cystopleura* Brebisson (*Epithemia* Brebisson). Cells single, rarely in short chains, attached ventrally to other plants, girdle view oblong to doliiform; interzones present or absent; valves lunate, internally transversely ribbed, transversely beaded externally; raphe excentric near the concave margin (by some considered to be a pseudoraphe). Species many, fresh and brackish waters.

TRIBE XIV. BACILLARIEAE.

KEY TO THE GENERA.

- | | |
|-----------------------|---------------------------|
| I. Keel median, | 73. <i>Bacillaria</i> . |
| II. Keel at one edge, | 74. <i>Homoeocladia</i> . |

73. *Bacillaria* Gmelin. Cells parallel, in free chains, gliding upon one another in the chains, rod-shaped, straight, rhombic in cross section; valves linear, pointed, with a median, beaded keel in which is concealed the raphe; transversely striate. Species few, fresh water and marine.

74. *Homoeocladia* Agardh (*Nitzschia* Hassall). Cells mostly free, rarely in tubes or chains, sometimes stalked, elongated or linear, rarely cuneate, rhombic in cross section; valves linear to lanceolate, pointed, with the oblique, bordered keel at one edge enclosing the raphe; surface punctate or transversely or decussately striate. Species many, fresh water, marine, and fossil.

TRIBE XV. SURIRELLEAE.

KEY TO THE GENERA.

- I. Valve surface undulate, 75. *Sphinctocystis*.
- II. Valve surface not undulate,
 - a. Valves cuneate, reniform, elliptical or linear,

76. *Surirella*.

- b. Valves sub-circular, saddle-shaped, 77. *Campylodiscus*.

75. *Sphinctocystis* Hassall (*Cymatopleura* W. Smith). Cells free, oblong to linear, straight; valve surface undulate and transversely striate, with a beaded keel on each margin, containing the raphe; along the center of the valve extends a straight pseudoraphe. Species few, in fresh and brackish waters.

76. *Surirella* Turpin. Cells free or stalked, straight or twisted, in valve view cuneate, reniform elliptical or linear, girdle view cuneate, elliptical, oblong or sigmoid; valves with a beaded or ribbed keel on each margin containing the raphe; surface with ribs extending from the margin towards or to the median linear or lanceolate pseudoraphe. Species many, fresh water and marine.

77. *Campylodiscus* Ehrenberg. Cells solitary, free, disk-shaped, disk twisted or saddle-shaped, round elliptic; valves round elliptic, with short mostly radiate ribs, and a marginal keel concealing the raphe; pseudoraphe median, but at right angles in the two valves. Species many, mostly marine, a few in fresh waters.

PLATE V.

EXPLANATION OF PLATE.*

The family Bacillariaceae consists of two quite sharply separated sub-families, which probably originated by divergent development from a common ancestral filamentous type.

SUB-FAMILY CENTRICAÆ.

TRIBE I. COSCINODISCEAE, represented by *Stephanopyxis*, a short filament in girdle view, and one cell in valve view; *Coscinodiscus*, in valve view; *Lysigonium*, a short filament in girdle view, and a cell in valve view.

TRIBE II. ACTINODISCEAE, represented by *Stictodiscus*, in girdle view (above) and valve view (below); *Asteromphalus* in valve view; *Asteroptychus*, in girdle and valve views.

TRIBE III. EUPODISCEAE, represented by *Eupodiscus*, valve view (fragment); *Actinocyclus*, valve view; *Tripodiscus*, girdle view; *Auliscus*, valve (fragment) and girdle views.

TRIBE IV. SOLENIAE, represented by *Corethron*, one cell in girdle view; *Lauderia*, a short filament in girdle view; *Rhizosolenia*, one cell and part of a second, in girdle view.

TRIBE V. CHAETOCERAE, represented by *Bacteriastrum*, a short filament in girdle view; *Chaetoceros*, a filament in girdle view, and another in end (valve) view.

TRIBE VI. BIDDULPHIAE, represented by a filament of *Eucampia*, a chain of *Triceratium* in both valve and girdle views, and cells and chains of *Isthmia* in girdle view, one above in valve view.

TRIBE VII. EUODIAE, represented by fragments of *Hemidiscus* in girdle view, with a smaller fragment in valve view at the left.

TRIBE VIII. ANAULEAE, represented by *Terpsinoe*, in girdle and valve views, and *Anaulus* in two girdle views, and valve view (at the right).

TRIBE IX. RUTILARIAE, represented by *Rutilaria*, two cells in girdle view, and one cell in valve view; *Pseudorutilaria*, girdle view of two contiguous half-cells (below), and valve or sectional view (above).

SUB-FAMILY PENNATAE.

TRIBE X. TABELLARIAE, represented by a filament of *Rhabdonema* and enlarged valve view, a chain of *Grammatophora* (girdle view) and enlarged valve view, *Tetracyclus* in girdle and valve views, and a broken filament of *Striatella*.

* The drawings for this plate were made upon a chart about 1×2 meters, by Miss Edna L. Hyatt, Artist for the Botanical Department of the University of Nebraska, and then photographically reduced to the present dimensions.

TRIBE XI. MERIDIONEAE, represented by several fan-shaped filaments of *Licmophora*, borne on gelatinous stalks.

TRIBE XII. FRAGILARIEAE, represented by broken filaments of *Fragilaria*, and one cell (at the right) in valve view; two cells of *Synedra*, the right in girdle, and the left in valve view; two cells of *Eunotia* in girdle view, and one (above) in valve view, and a broken filament of *Odontidium*, in girdle view.

TRIBE XIII. NAVICULEAE, represented typically by cells of *Navicula* (valve view on the right, girdle view on the left), *Gyrosigma* (girdle view below, valve above), *Gomphonema* (girdle view below, valve above), *Cystopleura* (valve view at left, girdle at right), and *Cymbella* (valve view below, girdle above), and somewhat aberrantly by *Achnanthes* (a short, attached filament at the right and two valve views at the left), and two valve views of *Cocconeis* (lower at left and upper at right).

TRIBE XIV. BACILLARIEAE, represented by a filament of *Bacillaria* (at the left) and two cells (at the right, the upper in girdle view, the lower in valve view); and three cells of *Hemoeocladia*, the lower in girdle view, the other two in valve view.

TRIBE XV. SURIRELLEAE, represented by two cells of *Surirella* (valve view at left, girdle view at right), and *Sphinctocystis* (girdle view below, valve view above).

PLATE V

