FISHERIES RESEARCH BOARD OF CANADA

Translation Series No. 2779

The phytoplankton of fresh water, systematics and biology

by G. Huber-Pestalozzi

Original title: Das Phytoplankton des Subwassers, Systematik und Biologie

From: Die Binnengewasser; Einzeldarstellungen aus der Limnologie und ihren Nachbargebieter, 16(2) : 1942

Translation of selected taxonomic keys only. 372-377,392-395,408-409,415-418, 422-432,437-438,445,455-457,460-461,465-467,469-472,479-480,485-492,520-521, 524

Translated by the Translation Bureau(MV)
Multilingual Services Division
Department of the Secretary of State of Canada

Department of the Environment
Fisheries Research Board of Canada
Canada Centre for Inland Waters
Burlington, Ont.

1973

91 pages typescript

FRB 2779

DEPARTMENT OF THE SECRETARY OF STATE
TRANSLATION BUREAU

SECRÉTARIAT D'ÉTAT
BUREAU DES TRADUCTIONS

FOREIGN LANGUAGES DIVISION

DIVISION DES LANGUES ÉTRANGÈRES

CANADA

TRANSLATED FROM – TRADUCTION DE	INTO – EN
German	English

AUTHOR – AUTEUR

G. HUBER-PESTALOZZI

TITLE IN ENGLISH – TITRE ANGLAIS

The phytoplankton of fresh water; Pt. 2, 2d half: The diatoms. systematics and biology.

Title in foreign language (transliterate foreign characters)

Das Phytoplankton des Süßwassers; 2 Teil, 2 Hälfte: Diatomeen. Systematik und Biologie.

REFERENCE IN FOREIGN LANGUAGE (NAME OF BOOK OR PUBLICATION) IN FULL. TRANSLITERATE FOREIGN CHARACTERS.
RÉFÉRENCE EN LANGUE ÉTRANGÈRE (NOM DU LIVRE OU PUBLICATION), AU COMPLET. TRANSCRIRE EN CARACTÈRES PHONÉTIQUES.

Series: Die Binnengewässer; Einzeldarstellungen aus der Limnologie und ihren Nachbargebie v.16, pt.2, 2d half.

TRANSLATION OF SELECTED TAXONOMIC KEYS ONLY

REFERENCE IN ENGLISH – RÉFÉRENCE EN ANGLAIS

PUBLISHER – ÉDITEUR	DATE OF PUBLICATION / DATE DE PUBLICATION			PAGE NUMBERS IN ORIGINAL / NUMÉROS DES PAGES DANS L'ORIGINAL
E. Schweizerbart'sche Verlagsbuchhandlung	YEAR / ANNÉE	VOLUME	ISSUE NO. / NUMÉRO	372-377, 392-395, 408-409, 415-418, 422-432, 437-438, 445, 455-457, 460-461, 465-467, 469-472, 479-480, 485-492, 520-52[illegible], 524
PLACE OF PUBLICATION / LIEU DE PUBLICATION: Stuttgart, Germany	1942			NUMBER OF TYPED PAGES / NOMBRE DE PAGES DACTYLOGRAPHIÉES: 91

REQUESTING DEPARTMENT / MINISTÈRE-CLIENT: Canada Centre for Inland Waters

TRANSLATION BUREAU NO. / NOTRE DOSSIER Nº: 4517

BRANCH OR DIVISION / DIRECTION OU DIVISION: Burlington, Ont.

TRANSLATOR (INITIALS) / TRADUCTEUR (INITIALES): MV

PERSON REQUESTING / DEMANDÉ PAR: Mrs. E. Fosdick, Librarian

DATE COMPLETED / ACHEVÉ LE: 10.2.1970

YOUR NUMBER / VOTRE DOSSIER Nº: 2890

DATE OF REQUEST / DATE DE LA DEMANDE: 30.12.1969

UNEDITED DRAFT TRANSLATION
Only for information
TRADUCTION NON REVISÉE
Information seulement

FLD 69A

SOS-200-10-6 (REV. 2/68)

DEPARTMENT OF THE SECRETARY OF STATE
TRANSLATION BUREAU
FOREIGN LANGUAGES DIVISION

SECRÉTARIAT D'ÉTAT
BUREAU DES TRADUCTIONS
DIVISION DES LANGUES ÉTRANGÈRES

CANADA

CLIENT'S NO. Nº DU CLIENT	DEPARTMENT MINISTÈRE	DIVISION/BRANCH DIVISION/DIRECTION	CITY VILLE
2890	Canada Centre for Inland Waters	Library	Burlington, Ont.
BUREAU NO. Nº DU BUREAU	**LANGUAGE LANGUE**	**TRANSLATOR (INITIALS) TRADUCTEUR (INITIALES)**	**DATE**
4517	German	MV	14.1.1970

From

The phytoplankton of fresh water; systematics and biology

(Das Phytoplankton des Süßwassers; Systematik und Biologie

By

G. HUBER-PESTALOZZI

Part II, 2d half

The Diatoms

Pages 372-377, 392-395, 408-409, 415-418, 422-432, 437-438, 445, 455-457, 460-461, 465-467, 469-472, 479-480, 485-492, 520-521, 524.

(selected taxonomic keys only)

UNEDITED DRAFT TRANSLATION
Only for information
TRADUCTION NON REVISÉE
Information seulement

I. Order: Centricae (Centrales)

Cells ± cylindrical, flatly disk-, drum- to box-shaped, isolated, in chains or cords. Predominantly marine forms; only few fresh-water genera. Predominantly planktonic.

The order of Centricae comprises three sub-orders:

I. Discineae; II. Soleniiceae; III. Biddulphiineae.

Of these three groups, only the first one has a relatively large number of representatives in fresh water; of the other two, only one genus each occurs in fresh water.

I. Sub-order: Discineae. Cells mostly disk-shaped or shortly cylindrical, rarely with conspicuously elongated pervalvar axis. Valvar area usually circular; in most genera, frustule without horns or humps. Of this sub-order, only one family occurs in fresh water, namely .... Coscinodiscaceae (p.373) with its three sub-families Melosiroideae, Sceletonemoideae and Coscinodiscoideae.

a. Cells cylindrical or spherical, always forming ± long chains. Shell lining usually well developed, with peculiar structure

Sub-family .... Melosiroideae (p. 373)

With one genus: Melosira (p. 373).

b. Cells disk- to drum-shaped, isolated or, more rarely, forming mostly loose chains. Shell structure particularly well developed on discus area (= terminal area of shell, valvar area).

1. Cell walls very incompletely silicified; discus with one unpaired marginal thorn (in the only species we are concerned with here) ....

Sub-family .... Sceletonemoideae (p. 392)

with one genus: Thalassiosira (p. 392).

2. Cell walls more silicified; discus area without unpaired marginal thorn, but frequently with numerous large or small marginal thorns ....

Sub-family .... Coscinodiscoideae (p. 392)

with three genera: Cyclotella, Stephanodiscus, Coscinodiscus.

α. Shells with radially striated marginal parts and distinctly defined, differently structured central area

Cyclotella (p.393)

β. Margin of shell and central area not differentiated in this manner.

+ Shells with radial rows of dots which in the centre are single lines of dots, towards the margin multiple lines of dots, and are separated by hyaline interstices .... Stephanodiscus (p.408)

++ Shells differently structured .... Coscinodiscus (p.415)

II. Sub-order: Soleniineae. Cells rod-shaped, always much longer than wide, pervalvar axis conspicuously elongated on account of numerou intercalary bands; circular or oval cross-section, mostly isolated, rarely in chains.

Comprises one family .... Soleniaceae (p.417) with the sub-family Rhizosolenioideae, which is the only one that concerns us here, and one genus: Rhizosolenia (p.417)

III. Sub-order: Biddulphiineae. Cells cylindrical or box-shaped, with round cross-section; valvar area mostly elliptical. Poles of shells with humps or horns. Of the four families (Chaetoceraceae, Biddulphiaceae, Anaulaceae and Euodiaceae), which have many marine genera, we are concerned only with Chaetoceraceae and Biddulphiaceae.

a. Cells with very long bristles which are several times as long as the cell and form angles of varying sizes with the pervalvar axis. Family .... Chaetoceraceae (p.422) with the genus Chaetoceros (p.422).

b. Bristles hardly as long or shorter than cell, directed towards pervalvar axis: family .... Biddulphiaceae (p.424) with the sub-family Eucampioideae and one genus Attheya (p.424).

Family: Coscinodiscaceae

Sub-family: Melosiroideae

Melosira AGARDH 1824

(Outdated synonyms)

Cells almost always cylindrical, in some species very short, drum-shaped, in others long, cylindrical, almost spherical only in few species. Valvar area always circular. Terminal area of valva (= discus) flat or ± convex; accordingly, the chains are either tight or loose. In the forms with convex discus areas, the cells are connected with each other by gelatinous cushions, but in the species with flat shells the cells are attached to each other by the row of teeth at the margin of the discus, with the teeth of two neighbouri cells each interlocking. Shells irregularly or radially dotted or striated; marginal teeth differ in length according to species. As far as we know, the dots are pores which completely penetrate the cell wall. Chromatophores occur as numerous small roundish lobed platelets attached to the mantle.

Auxospores are formed asexually in different ways, but always 3
by strong swelling and rounding of one or several cells in the colony; one end of the filament may or may not be discarded (auxospore formati with or without fragmentation). The spore is flatly attached to the parent cell, or it lies in a depression with a navel; its axes may run parallel with the axes of the parent cell or may intersect with t

Morphologically and terminologically, Melosira has a few pecularities (see Fig.446). The terminal area of the shell, the so-called valvar area, is called discus, the (lateral) cylindrical area, mantle. Very often, the latter has a ring-shaped furrow (± deeply incised), the sulcus, shortly before its "open" margin; this sulcus usually projects into the interior as a ring-shaped ridge, the septum. The furrow formed by the ± strongly rounded cell ends at the point of attachment of two neighbouring cells is called pseudosulcus. Sulcus and pseudosulcus are always open grooves, "but often appear closed on account of long, overlapping girdle bands" (HUSTEDT). The narrow mantle portion between sulcus and the margin of the girdle band is called collum. Another structure, which occurs only in two species not living in fresh water, is the ring-shaped thin lamellar keel at the cell ends, at some distance from the top of the discus.

"Depending on the state of development of the girdle bands and on the overall growth, the length of the cells varies to such an extent that, contrary to common practice, it cannot serve as a characterizing feature of the various species. Instead, we are using a measure which is variable, too, but does not depend on the state of the girdle bands: the height, which we define as the measure of half the frustule, measured at the longitudinal axis of the cell from the centre of the discus to the insertion of the girdle band." (HUSTEDT, Fresh-water flora [Süßwasserflora]).

When determining *Melosira* specimens, special attention must be given to the following features: whether the filaments show peculiarly shaped terminal or border cells (e.g. ± long thorns or folds of one half of the cell, or a different structure); how the disci (valvar areas) are developed (whether they are flat or arched, whether the margins bear ± long thorns or fine teeth, or whether the margins are completely smooth); the structure of the mantle areas (coarse or fine; whether the rows of pores run parallel or 37
at an angle to each other). It is also very important to observe the course of the mantle line (not of the surrounding girdle band) in the optical cross-section.

Most species of the genus *Melosira* are euplanktonic organisms and in that capacity widely distributed in lakes. Some of them are most likely endemic species (e.g. in large East African lakes: *M. nyassensis*, or in Lake Baykal: *M. baicalensis*). Some species are littoral forms (from lakes and ponds) and occur frequently, for instance, also in ditches (*M. arenaria*, *M. varians*); other species prefer moss growing on wet cliffs (*M. Roeseana*) or live at the bottom of cold high-altitude pools (*M. distans*). Such forms may be found accidentally also in plankton.

The following list comprises 20 species.

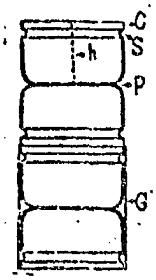

Fig.446

Melosira cell: G - old girdle band, S - sulcus, C - collum, P - pseudosulcus, h - height. According to HUSTEDT.

Key for determining Melosira species

(according to HUSTEDT)

A. Cell filaments with end or border cells; in the latter, one cell half bearing ± long thorns and folds, mostly also with different structure.

I. Shell mantle with deeply incised, thin septum. Height of shells on an average much less than diameter (tropical form)
6. M. Agassizii

II. Shell mantle without septum. Height of shells mostly larger than diameter or differing only little from it.

a. Fine structure, 18-20 rows of pores in 10 µ, parallel to or only slightly inclined to pervalvar axis (tropical form) .... 7. M. kondeensis

b. Coarser structure, rows of pores on mantle area - apart from the border cells - more inclined (cosmopolitan form)
5. M. granulata

B. Without peculiarly developed end or border cells.

I. Mantle areas convex in an outward direction, cells therefore barrel-shaped .... 4. *M. Binderana*

II. Shell mantle cylindrical, cells in girdle view not barrel-shaped.

a. Margin of discus with several irregular rows of very small thorns .... 2. *M. Hustedti*

b. Margin of discus with only one row of regularly arranged small thorns, or apparently without teeth. 37

1. Shell mantle without septum or sulcus.

α. Shell mantle distinctly punctate.

* Very large, thick-walled form, inner mantle line strongly waved (tropical form) ..3. *M. undulata*

** Delicate small form, inner mantle line not waved

20. *M. distans var.*

β. Shell mantle apparently without structure.

* Margin of discus with very coarse teeth

19. *M. americana*

** Margin of discus with fine teeth or smooth

1. *M. varians*

2. Shell mantle with septum or, on the outside, with distinct groove.

α. Sulcus forming a strong septum, on the outside without groove or furrow.

* Cells thick-walled, inner mantle line convex towards interior of the cell ..13. M. baicalensis

** Inner mantle line straight ... 12. M. pyxis

β. Sulcus developed as outer groove or furrow.

* Sulcus forming a distinct groove.

Mantle structure very coarse, a maximum of 10 rows of areoles in 10 u (tropical form)

14. M. argus

Mantle structure much finer, 16-20 rows of areoles in 10 μ (cosmopolitan form)

15. M. ambigua

** Sulcus forming furrow incised at an acute angle, or merely a shallow groove.

Cells with highly arched disci and conspicuously long thorns, therefore filament looser

16. M. longispina

Disci almost or completely flat, thorns shorter and only very fine, filament mostly tight.

O Cells mostly very flat, shell mantle with more or less strongly developed, mostly deeply incised, flat septum, discus area coarsely areolate-punctate (Nordic-Alpine species)

20. M. distans

OO Cells generally more highly cylindrical, shell mantle without conspicuously developed septum or with ridge-like septum.

x Rows of pores on mantle area parallel or very slightly inclined to pervalvar axis.

v Height of shells mostly much larger than diameter (tropical form) ... 9. M. Goetzeana

vv Shells generally only slightly higher than diameter, but very often shorter

8. M. islandica

xx Rows of pores on mantle area in more or less strongly inclined spirals.

v Shell mantle with coarse structure, pervalvar rows of areoles up to approx. 15 in 10 u. 3

w Margin of discus with strong teeth (Nordic-Alpine form) .... 17. M. italica va

ww Margin of discus with very small teeth (tropical forms).

z Cell diameter 12-16 u, pervalvar rows with strong S-shaped curvature.

11. M. Magnusii.

zz Cell diameter 20 u and more, pervalvar rows less strongly curved.

10. M. nyassensis

vv More delicate structure.

w Rows of pores on mantle area strongly spirally inclined, teeth on margin of discus strong .... 17. _M._ _italica_

ww Rows of pores little inclined, small teeth on margin of discus more delicate (tropical form, living predominantly in acid waters) .... 18. _M._ _ikapoënsis_

Sub-family: Sceletonemoideae

Its only fresh-water genus is

Thalassiosira CLEVE 1873

with one species:

Thalassiosira fluviatilis HUSTEDT (Fig.478). - Cells living separately (in the marine species the cells, attached to each other by a central gelatinous filament, form loose chains, sometimes also shapeless gelatinous masses) . Cells drum-shaped or shortly cylindrical, diameter 15-23 u, shells slightly indented or convex in centre. Marginal thorns of shells very small, arranged in one row, approx. 10-13 in 10 u; unpaired larger thorn close to the margin. Shells with delicate radial punctate striae which form unbundled rows and leave the centre free. In the resultant central area several dispersed, larger dots. Cells with 2-4 intercalary bands; only slightly silicified, fairly thin-walled. As yet, no colonies have been observed.

Halophilic fresh-water species. In the summer of 1925 and 1926, it occurred in great numbers in the plankton of the upper Weser River and in the Werra River, below the places where potash waste products get into the river. Also observed in the lower Rhine, and on Kauai and Oahu in the Hawaiian Islands; presumably still more widely distributed (HUSTEDT).

It may also be mentioned that A. CLEVE, in 1911, established

Cyclotella KÜTZING 1834.

Cells disk- to drum-shaped, with circular, very rarely elliptical cross-section [Cyclotella austriaca (PERAGALLO) HUST.], mostly without intercalary bands. Shells rarely flat, almost always ± tangentially or concentrically waved, without peculiarly developed mantle portion, with radially striated marginal zone and distinctly defined, punctate, spotted or smooth central area. "Radial striae regular, or with short shadow lines at regular intervals or with similarly arranged humps on the interior of the shell." Shortened marginal striae are sometimes preceded by isolated ("flaming") dots. Chromatophores are small roundish platelets on the side of the shell. The girdle side appears rectangular, with straight, undulate, convex or concave lateral margins. Mucilage or bristles often present. Cells mostly living separately, more rarely forming loose or tight chains, predominantly planktonic, less frequently growing at the bottom (littoral) of various water bodies. "To obtain correct information on the formation of colonies, it is necessary to re-examine all Cyclotella material" (HUSTEDT). The auxospores develop from a single parent cell (MEISTER).

Of the 21 species listed here, at least one dozen are euplanktonic (Cycl. bodanica, catenata, chaetoceras, comensis, comta, glomerata, planctonica, quadrijuncta, socialis, etc.); other species occur mainly in littoral locations, more rarely in the plankton

(*C*. *Kützingiana*, *Meneghiniana*, *operculata*, *stelligera*); one species 39
(*C*. *striata*) is halophilic. It occurs (according to HUSTEDT) frequently in the plankton of all littoral regions, but also moves far upstream, into the interior, where it lives in almost purely fresh water.

Key for determining the species of *Cyclotella*
(according to HUSTEDT)

A. Cells living separately, forming short chains for short periods at best soon after division.

I. Shells in regularly striated marginal zone without humps or shadow lines.

a. Centre of shell with radially arranged striae (or dots).
4. *C*. *stelligera*

b. Central area with different markings or smooth.

1. Shells concentrically undulate, large form with diameter of approx. 40-90 u .... 11. *C*. *Fotti*

2. Shells tangentially undulate.

α. Central area apparently smooth or with few larger dots, sometimes very delicately, radially punctate-striated (visible only in highly refracting embedding media).

* Marginal zone with coarse club-shaped radial striae, approx. 8-9 in 10 u .... 1. *C*. *Meneghiniana*

** Marginal zone more delicately striated.

Central area with several (mostly 3) coarse papillae .... 7. *C. ocellata*

Central area smooth or with only disperse punctation .... 10. *C. Kützingiana*

β. Central area irregularly punctate-spotted.

* Very small fresh-water form with irregularly radially punctate-spotted central area, living predominantly in chains. Individual cells of .... 20. *C. comensis*

** Larger, halophilic species with densely spotted central area .... 3. *C. striata*

II. Marginal zone of shells with humps or shadow lines.

a. Shells tangentially undulate.

1. Marginal zone of shells with shadow lines or individually strengthened radial ribs.

α. Very large form with a diameter of approx. 100 u
12. *C. baicalensis*

β. Extremely small form with a diameter of hardly 5 u (tropical form) 6. *C. atomus*

2. Shells with marginal thorns or inner humps.

α. Shells with distantly arranged marginal thorns.

* Large central area, marginal striae of equal length 5. *C. pseudostelligera*

** Small central area, marginal striae of unequal length (tropical form) .... 9. C. *Woltereck*i

β. Marginal zone of shells with a ring of small humps at the inner side of the cell wall (at high magnifications, the humps appear as light dots)

8. C. *operculata*

b. Shells concentrically undulate. Central area radially punctate.

1. Marginal zone delicately striated, approx. 20 striae in 10 μ, shadow lines indistinct (hypolimnetic species with fairly large forms) .... 15. C. *styriaca*

2. Marginal zone more coarsely striated, conspicuous shadow lines.

α. Shell margin with inserted, shorter striae outside the ring formed by the shadow lines (particularly in edge view), shells strongly undulate, mostly large forms 14. C. *bodanica*

β. Shell margin without such inserted striae, individuals usually smaller 13. C. *comta*

B. Cells combined to - mostly chain-like - colonies.

I. Cells with bristles.

a. Colonies forming tight chains ,........... 2. C. *chaetoceras*

b. Cells forming irregularly shaped groups ... 18. C. *socialis*

II. Cells without bristles.

a. Chains loose, with wide spaces between cells.

1. Larger forms in straight or slightly curved chains.

α. Chains with wide, distinct gelatinous cover, marginal zone of shells without shadow lines

17. *C. planctonica*

β. Cells attached to each other by thin, hardly visible gelatinous threads, marginal zone of shells with shadow lines .... 16. *C. quadrijuncta*

2. Small form in very long chains which are curved several times and balled up .... 19. *C. glomerata*

b. Chains similar to those of *Melosira*, tight, without visible gelatinous cover.

1. Deep pseudosulcus, incised at an acute angle, between two cells each. Shells tangentially undulate

20. *C. comensis* (syn. *C. melosiroides*)

2. Pseudosulcus shaped like a channel, shells concentrically undulate .... 21. *C. catenata*

Stephanodiscus EHRB. 1845. 40

(Out-dated synonyms). - Cells separate or in tight chains, as a rule disk-shaped, more rarely drum-shaped, very rarely cylindrical; with intercalary bands. Valvar area circular. Shells in most cases more or less concentrically undulate, with a marginal ring of mostly thick thorns, sometimes also with thin long bristles. Discus area finely areolate-punctate, with radial rows of dots which in the centre are single, towards the margin bundled, and with more or less regular, intersecting striae. Radial bundles separated from each other by hyaline spaces; central areoles disaggregate, isolated, irregular. Chromatophores small platelets attached to the sides of the shells, or 1-2 large plates attached to the mantle areas. Auxospores spherical (in the smaller forms) or ellipsoidal (in the larger forms).

Euplanktonic species which occur mainly in fresh water, more rarely in brackish water; no marine species are known among the species presently existing. Main development in eutrophic lakes.

Key for determining the Stephanodiscus species
(according to HUSTEDT)

A. Only traces of shell structure on the small, tangentially undulate central area, for the rest the spaces between the ribs are apparently hyaline .... 8. St. luceus

B. Shells without such central area, either concentrically undulate or flat to evenly convex.

I. Marginal zone with distinct rib-like structure within which the individual dots can hardly be distinguished. Shells therefor similar to those of Cyclotella .... 1. St. dubius

II. Punctation visible as far as the margin, or very fine throughout

a. Shell area distinctly punctate, structure visible already with dry systems. Mostly large forms.

1. Marginal bundle of areoles, approx. 4-6 in 10 u.

α. 20-24 areoles in 10 u, delicate forms, diameter mostly less than 30 u. .... 3. St. tenuis

β. 12-14 areoles in 10 u, robust forms, diameter mostly much more than 30 u .... 4. St. Niagarae

2. Marginal bundle of areoles, approx. 9 or more in 10 u. 4

α. Marginal thorns present regularly in front of each hyaline radial stria, therefore remarkably dense. Shells delicate (hypolimnetic species) ...5. St. alpinu

β. Marginal thorns less dense. Shells always thicker (epilimnetic species) .... 2. St. astrae

b. Very fine structure, visible only with strong immersions.

1. Pervalvar axis not conspicuously elongated, cells therefore disk- to drum-shaped. Chromatophores numerous small granules .... 6. St. Hantzschii

2. Cells elongate cylindrical on account of greatly elongated pervalvar axis, very delicate. Chromatophores 1-2 large plates at mantle areas .... 7. St. subsalsus

Coscinodiscus EHRB. 1838 41

Numerous out-dated synonyms.

Cells disk-shaped and (in the species found in fresh water) with circular valvar area; living separately. Shells flat or undulate, mantle zone not particularly well developed; discus area more or less finely punctate to areolate. Structural elements arranged irregularly or in oriented, tangential or radial rows; radial rows sometimes bundles, individual rows of the central row or of one lateral row of the bundles parallel. Marginal thorns more or less distinct. In larger forms, the membrane has been found to be two-layered, the areoles constitute chambers communicating with the interior of the cell, partly also with the surrounding water. Chromatophores mostly small platelets at sides of shells. (Diagnosis according to HUSTEDT, Süßwasserflora [Fresh-water flora], 1930).

A very large genus (comprising about 500 species), predominantly marine, with only a few fresh-water forms which are still halophilic.

A. Shells coarsely areolate; areoles in ± regular radial bundles.
C. Rothii var. 1

B. Shells punctate; rows of dots radial, ± distinctly ramified in a dichotomic manner. Shells tangentially undulate... C. lacustris 2

1. Coscinodiscus Rothii (E.) GRUN. - Of this marine species we have found only 4

var. subsalsa (JUHLIN-DANNFELT) HUSTEDT (Fig.511). - "Cells drum-shaped, shells concentrically undulate or with one indentation, with a diameter of 25-40 u. In the species, the areoles form regular, bundled radial rows, parallel to the central row within the bundle. In the variety, much less bundling, sometimes even fewer rows, areoles becoming more or less irregular. The most central areoles are sometimes smaller than the adjoining ones: for the rest, the size of the areoles at first does not decrease at all or only a little in an outward direction, but in a broad marginal zone it suddenly decreases substantially, to about 15 areoles in 10 u; also in the marginal zone, the areoles are arranged in intersecting line systems. Marginal thorns at the inner margin of the marginal zone, in regularly structured shells one each before centre of bundle. They are lamellar processes with a pore canal, penetrating into the interior.

Occurs in the littoral regions (river mouths) of the North and Baltic Seas; has also been found in inland lakes and rivers: Havel, Spree, Müggel Lake, Dümmer Lake, Zwischenahner Meer." (HUSTEDT, Süßwasserflora [Fresh-water flora]).

Compare also the note at the end of the chapter on Thalassiosira.

2. Coscinodiscus lacustris GRUN. (Fig.512) (Syn. Cyclotella punctata W. SMITH, Stephanodiscus punctatus GRUN). - "Cells disk-shaped, with tangentially undulate shells, diameter 20-75 µ. Discus area distinctly punctate, areole network becomes visible only at high magnifications with immersions. Approx. 10-12 dots in 10 µ, arranged in radial rows ramified dichotomically in an outward direction. Dots in marginal zone usually smaller and finer. Marginal thorns thick, 5-7 in 10 µ, several larger thorns form a second ring slightly more inward from the first ring.

Halophilic littoral form, very common in river mouths on our coasts, but also in salt mines, mildly salty pools and ditches, even in fairly pure fresh water of inland water bodies." (HUSTEDT). - Germany. - In his plankton synopsis (1935), REDEKE lists numerous locations of Cosc. lacustris in fresh and (oligohaline) brackish water in Holland. - England.

var. septentrionalis GRUN. (Syn. Cosc. septentrionalis GRUN.) 4
(Fig.512A). - Differs from the species by larger dots which, being more densely arranged, resemble areoles. Approx. 8-9 dots in 10 µ.

This (Arctic) form found by GRUNOW (1884) in Franz-Josef-Land was discovered by WISLOUGH (1923) also in Lake Balkhash, a vast undrained fresh-water lake where the above variety occurs euplanktonically as a "characteristic form".

var. hyperborea GRUN. (Fig.512B) is characterized by an even coarser structure and by pronounced areolation of the shells.

This Arctic variety, too, was found in Lake Balkhash (whose fresh-water character is specially emphasized by WISLOUCH), namely in the plankton, together with the preceding variety.

Uncertain species:

Coscinodiscus Rudolfi BACHM. - Cells with flat shells, circular, diameter 16-40 u. Areoles arranged in distinct radial rows which extend as far as the margin; the latter itself bears short radial marginal rays, 7 in 10 u.

Plankter in Lake Rudolf, East Africa. Unfortunately, the photograms added by BACHMANN (1938) to his very brief description do not show the nature of areolation distinctly enough, so that the form cannot be definitely identified. Since that region has salt lakes where Coscinodisci live, it would be very interesting to identify this species beyond any doubt.

II. Sub-order: Soleniineae.

Its only fresh-water family is the following:

Family: Soleniaceae

Rhizosolenia EHRB. 1841 (1843).

Cells elongate, cylindrical, rod-shaped, with greatly elongated

pervalvar axis and numerous scale- or ring-shaped intercalary bands; living separately or forming chains. Circular or elliptical cross-section; end of shell (= "calyptra") with more or less long horn or thorn which is excentrically attached, cone- or cap-shaped, and mostly hollow. Shells and intercalary bands finely punctate-striate, often even without visible structure; mostly with very slight silification. Nucleus mostly centrally attached to girdle side. Chromatophores numerous small, roundish or elongate platelets. Auxospore formation asexual. Resting spores known of only a few species; formed in pairs or singly in parent cell, "grenade-shaped", with conical tips facing each other. Main axis of auxospores in some species parallel, in 41
others (exclusively marine) species perpendicular to the main axis of the parent cell.

The genus is almost exclusively marine; its species are euplankters. Only 5 species have been found in fresh water (actually, only two of them with certainty). Rh. minima LEVANDER occurs in brackish water.

Key for determining the species.

I. Cells very small, only 8-20 μ long.

a. Cells 8-17 u long, 3-4 u wide, forming chains (4-9 cells) Rh. Guldbergiana 5.

b. Cells 15-20 μ long, 5-7 u wide, not forming chains Rh. eriensis var. pusilla 2.

II. Cells larger, 40-200 u long without bristles, isolated or in chains.

a. Calyptra narrow, lanceolately produced. Bristles long, hair-like. .... _Rh. longiseta_ 1.

b. Calyptra broader and ± shortened.

1. Bristles extending in the longitudinal direction of the cell, i.e. in the direction of the pervalvar axis.

α. Calyptra obliquely conical, bristle originating in the proximity of the dorsal margin of the cell, fairly straight .... _Rh. eriensis_ 2.

β. Calyptra with bump-like ridge, bristle originating (in lateral position of cell) more towards the centre of the calyptra, then curves abruptly, and in the distal portion extends in the direction of the lateral margins of the cell .... _Rh. Victoriae_ 3.

2. Bristles not extending in the direction of the pervalvar axis, but at an acute angle, sometimes even at a right angle, with that axis. Bristles very strongly excentrically inserted .... _Rh. curviseta_ 4.

III. Sub-order: Biddulphiineae.

Family: Chaetoceraceae.

Cells box-shaped, with elliptical or circular cross-section (valvar area). Intercalary bands rare, septa absent. "Shells with two or several poles, poles with very long bristles. Cells living separately or in chains, in the latter case the bristles at the base or in its proximity intersecting with each other and firmly connected with each other by cementing substance. Ends of bristles free. Chromatophores small granules in differing numbers, or 1-2 larger plates. Resting spores have been found particularly frequently in this family." Almost exclusively marine; only one inland genus (according to HUSTEDT).

Chaetoceros EHRENBG. 1844

"Cells with elliptical valvar area, intercalary bands sometimes present, but without septa. Each shell with two fully developed bristles, sometimes also with rudiments of other bristles. Cells separate or in chains, often with gelatinous cover" (HUSTEDT).

Chaetoceros Muelleri LEMM. (Fig.517B). (Syn. Chaet. Muelleri var. duplex LEMM.; Chaet. subsalsus LEMM.; Chaet. Borgei LEMM.; Chaet. Zachariasi HONIGM., and all the varieties of this species found by that author, also his other species; Chaet. diversicurvatus VAN GOOR; Chaet. Thienemanni HUST.). - Cells mostly separate, but sometimes forming short straight chains, with elliptical to almost circular valvar area and apical axis approx. 5-30 u long. Shells flat or concave, often also convex or with small distention in the centre. Shell mantle moderately thick, hardly 1/3 of pervalvar axis, only trace of constriction at the margin of the girdle band. Bristles thin and long, originating at the poles of the apical axis, diverging outward at an acute angle, straight or curved in various manners. Chromatophores a plate on the girdle. Single resting spores in cells, with smooth membrane. Primary shell uniformly arched, secondary shell ± strongly constricted at base, then truncate- conical, flatly truncate at the end. In flatter cells the shape of the secondary shell becomes more similar to that of the primary shell" (HUSTEDT, RABENHORST).

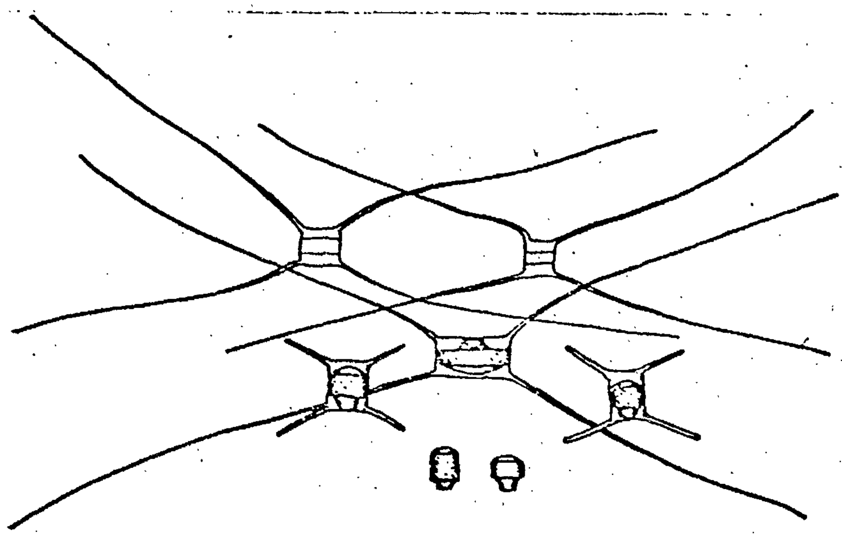

Fig.517B. Chaetoceros Muelleri LEMM. - x 600 (acc. to HUSTEDT)

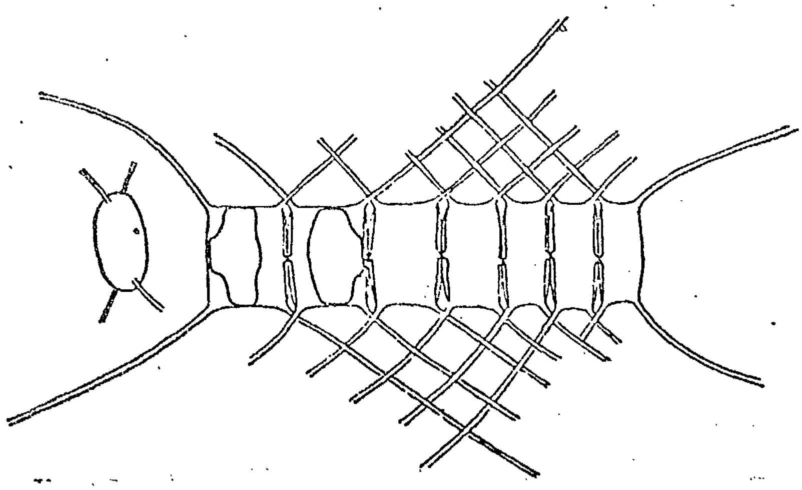

Fig. 517C.

Chaetoceros Elmorei BOYER.

x 600 (acc. to BOYER)

Very common in brackish waters of European littoral and inland regions, in some locations occurring in large numbers. In mildly salty water, it has been found in the following locations: Lake Prest near Magdeburg, salt-mining district of Sperenberg, Oldesloe in Holstein, upper Weichsel River, Lake Waterneverstorf.

Chaetoceros Elmorei BOYER (Fig.517C) (Fig. in "The Freshwater Algae of the United States" by G.M. SMITH, p.224 [1937]). - A chain-forming species, has been reported from the plankton of Devil's Lake, North Dakota (BOYER, 1914; ELMORE, 1922) which also contains mildly brackish water, but whose algal flora is reported to have the character of a fresh-water flora. According to G.M. SMITH, BOYER found this species also in a Canadian lake.

(For the diagnosis of Chaetoc. Elmorei BOYER, see Proc.Acad.Nat. Sci.Philadelphia, 66, pp.219-221, 1914; BOYER, C.S., A new Diatom).

Family: Biddulphiaceae.

"Cells mostly shortly box-shaped, more rarely elongate-cylindrical in the direction of the pervalvar axis; intercalary bands present or absent. Cross-section of cells elliptical to circular, but poles of shells with humps, horns or processes, shells therefore deviating from circular form. Chromatophores as a rule numerous small granules. This family, which is extraordinarily common and has many species in sea water, has only one fresh-water species in the group of Eucampioideae." (HUSTEDT)

Sub-family: Eucampioideae.

"Cells with elliptical cross-section, mostly cylindrical on account of numerous intercalary bands. Shells with two poles, with short humps or longer processes. Membrane always very incompletely silicified" (HUSTEDT).

Attheya TUFFEN WEST 1860. - (Syn. Acanthoceras HONIGMANN.)

"Cells flat-cylindrical, with numerous intercalary bands. Shells narrowly elliptical, poles with ± long bristles. Cell walls very incompletely silicified, cells can therefore be easily overlooked (dry preparations!). Resting spores known" (HUSTED).

Attheya Zachariasi J. BRUN. (Fig.518) (Syn. Acanthoceras magdeburgense HONIGM., also var. lata HONIGM.). - Cells cylindrical, with narrowly

elliptical cross-section; numerous ring-shaped intercalary bands which interlock like teeth at the ends; this results in a frequently, mostly regularly interrupted central line in broad girdle view. Shells very narrowly elliptical; poles with two long thin bristles each ("horns"), which extend parallel to the longitudinal (pervalvar) axis, but diverge slightly in an outward direction. Chromatophores mostly four small, centrally located platelets. Single thick-walled 4
resting spores in the centre (girdle band zone) of the cells, with one concave and one convex valva each, ± regularly grooved.

Length of cells (or apical axis) 12-40 u (according to HUSTEDT) or 35-100 u (according to MEISTER), width of cells 15-25 u (according to MEISTER). Length of bristles 40-60 μ (according to HUSTEDT) or 40-70 μ (according to MEISTER), 3.4-4 striae in 10 μ (according to MEISTER).

Euplankters, in mostly eutrophic lakes and ponds, also in rivers; very common and sometimes occurring in large numbers, but often overlooked. Sometimes occurring also in larger lakes that show little pollution (Lake Biel and Lake of Morat, Switzerland); found in many north German lakes, but apparently not developing any great maxima; in Lake Dobersdorf (on 28.7.1922 60 cells per cubic centimetre, according to UTERMÖHL). The species seems to occur mainly in warm water. In the Havel River, according to KRIEGER, it occurs only in summer, sometimes in large numbers: 600 individuals in 1 cu.cm.

(Teltow Canal, 23.7.1923). - The maximum generally occurs in July and August. According to HUSTEDT, resting spores occur in north Germany mainly in September-October, while in the Danish lakes, according to WESENBERG-LUND, they are formed in October-November. KRIEGER observed resting spores mainly in winter. The living conditions of Attheya seem to be very similar to those of Rhizosolenia longiseta, for the two plankters are often found together.

Sometimes found also in Holland (REDEKE, synopsis 1935); common, both in standing fresh eutrophic water bodies and in large rivers (Rhine, Waal, Nieuwe Maas, etc.), June-September. - Numerous locations also in France, England, Scotland and Ireland.

Reported not only from Europe, but also from Java, e.g. frequently in the plankton of the Tjigombong, West Java (HUSTEDT), also in Tjibodas (WOLOSZYNSKA).

II. Order: Pennatae (Pennales)

Shells zygomorphic, always with raphe (which is difficult to see) or pseudoraphe. Structure in relation to raphe or pseudoraphe mostly regularly pennate (hence the name). Basic shape of cross-section mostly boat- or rod-shaped, but only very rarely circular; cells therefore always line symmetrical. Shells always without long processes (horns, humps, bristles). Chromatophores numerous small platelets or mostly larger plates. Reproduction by division and auxospores.

This order comprises the majority of all Diatoms living in the littoral and profundal regions of our inland water bodies. A smaller number of the forms belonging to Pennatae are typical planktonic forms.

Overview over the order of Pennatae (according to HUSTEDT) 42

I. Shells without true raphe, at the most with pseudoraphe (which is almost always present) in the direction of the apical axis

1st sub-order: Araphidineae.

It comprises one family, the Fragilariaceae.

Cells living separately, or forming cord-shaped, sometimes star-shaped colonies. Valvar area mostly rod-shaped, rarely broadly elliptical, sometimes club-shaped or with undulate margin. Axes as a rule straight and mostly isopolar. Intercalary bands and septa often present; when they are present, the cells, in girdle band position, often broadened into tabular shape. Shells with mostly distinct pseudoraphe and as a rule with ± finely transapically punctate-striate pattern, sometimes also with transapical ribs. Species living predominantly in littoral regions, some also in plankton; usually attached to a substrate; when freed, able to live without substrate.

3 sub-families:

a. Cells with strong septa parallel to valvar area

Sub-family: Tabellarioideae

with the genus *Tabellaria*.

b. Cells without such conspicuous septa

1. Shells with strong transapical ribs, also transapically striated .... Sub-family: Diatomoideae with the genera *Diatoma* (and *Meridion*).

2. Shells without ribs, only with coarser or finer transapical dotted striae .... Sub-family: Fragilarioideae with the genera *Centronella*, *Fragilaria*, *Asterionella*, *Synedra* (*Opephora*, *Ceratoneis*, *Amphicampa*).

II. Shells with true raphe (although it may be difficult to see).

a. Raphe rudimentary and as a rule developed only at the poles of the shells; also with pseudoraphe which as a rule is displaced transapicad .... 2nd sub-order: Raphidineae with one family: Eunotiaceae.

b. Raphe developed at least on one shell of each cell

1. Raphe developed only on one shell; the other shell with rudimentary raphe or with pseudoraphe

3rd sub-order: Monoraphidineae.

with one family: Achnanthaceaeae (which comprises the two sub-families of Cocconeioideae and Achnanthoideae).

2. Both shells with developed raphe

4th sub-order: Biraphidineae

comprising 4 families: Naviculaceae, Epithemiaceae, Nitzschiaceae, Surirellaceae.

α. Raphe like that of Navicula; outer and inner fissures not separated by channel-like dilatation; mostly located in the central line of the shell, more rarely displaced or shifted to a keel, without keel dots, cells generally with boat-shaped shell ..... 1st family: Naviculaceae with 3 sub-families

α'. Apical or transapical axis or both heteropolar

Sub-family: Gomphocymbelloide

with the genera Didymosphenia, Gomphonema, Gomphocymbella, Cymbella and Amphora. 4

β' Axes isopolar

\+ Raphe displaced to a keel located in the central line of the shell. Cells often twisted around apical axes

Sub-family: Amphiproroideae

with the genus Amphiprora (predominantly marine form).

++ Shells not distinctly keeled. Raphe located in valvar area .... Sub-family: Naviculoideae with the genera Diatomella, Mastogloia, Amphipleura, Frustulia, Gyrosigma, Pleurosigma, Caloneis, Neidium, Diploneis, Stauroneis, Anomoeoneis, Navicula, Pinnularia.

β. Raphe developed as canal raphe, mostly displaced on to a keel.

\+ Shells keeled indistinctly or not at all; keel dots or wing canals absent or developed only in the form of delicate pitted pores .... 2nd family: Epithemiaceae (cells with boat-shaped or ± clamp-shaped shells. Cells as a rule with transapical rings, the membranes between the rings areolate and with ventricles).

o Raphe not distinctly keeled, with pits at inner wall of canal. Shells boat-shaped or curved into an arc, not clamp-shaped

Sub-family: Epithemioideae

with the genera Denticula and Epithemia.

oo Raphe keeled, without distinct pits; shells mostly curved like clamps .. Sub-family: Rhopalodioideae with the genus Rhopalodia.

++ Keel dots or wing canals distinct, raphe always ± raised in the shape of a keel.

o Keeled canal raphe located in valvar area (central or laterally displaced), or only one shell margin

with keel .... 3rd family: Nitzschiaceae
Each shell with canal raphe which is displaced to a ± raised keel; canal raphe connected with cell interior through numerous tubules [keel dots]. Central pores present, but mostly poorly visible, or altogether absent. One sub-family

Sub-family: Nitzschioideae

Cells mostly elongated in the direction of the apical axis, more rarely elliptical, mostly without intercalary bands and septa. Sometimes twisted around an axis, keel with raphe in the central line of the shell or displaced transapicad, but never extending around the entire shell, shells only with one keeled edge. With the genera <u>Cylindrotheca</u>, <u>Bacillaria</u>, <u>Hantzschia</u> and <u>Nitzschia</u>.

oo Keel with canal raphe extending around the entire shell at the valvar edge... 4th family: Surirellaceae 4
Shell with thin keel to strong wing on valvar edge. Keel or wing extending around the entire shell, each shell therefore appearing to have two canal raphes. Raphe canal communicating with cell interior through wing canals. The membranes between the tubules are called "windows". - With two sub-families

\# Cells arched like saddles, apical axes of the two shells (the so-called "parapical axes") intersecting at a right angle

Sub-family: Campylodiscoideae

with one genus: Campylodiscus.

\## Parapical axes of shell not intersecting

Sub-family: Surirelloideae.

Parapical axes of the two shells running parallel to each other. Cells frequently twisted around axis; shells sometimes undulate.

With 3 genera:

* Shells with undulate parapical axis: Cymatopleura

** Parapical axis straight or curved, not regularly undulate.

x Shells with indistinct wing, elongate-linear outline, curved like an S ..... Stenopterobia

xx Shells with distinct wing, or of different shape .... Surirella

Sub-order: Araphidineae

Family: Fragilariaceae

Sub-family: Tabellarioideae

Tabellaria EHRENBG. 1839

(Syn. Conferva e.p., Diatoma e.p., Tetracyclus e.p.)

Cells forming zigzag-shaped or tight cords, sometimes also star-shaped colonies; in the latter case the cells are connected with each other by small gelatinous cushions ("gelatinous intercalary elements" according to SCHRÖDER). When fully developed, cells with four to numerous intercalary bands with more or less deeply penetrating septa. Intercalary bands ring-shaped, open at one pole, septa flat, more or less thickened in the manner of a wall at the free margin; septa of adjacent intercalary bands alternately attached. Outline of valvar area linear, usually more or less inflated in the centre and at the poles (constricted in one non-planktonic species, Tabellaria binalis (E.) GRUN.). Shells without ribs, with delicate transapical striae and distinct narrow pseudoraphe. Chromatophores more or less numerous, dispersed granules. 42

In the preparations, the position of the zigzag cords or stars, and mostly also of isolated cells, is such that the observer sees their rectangular girdle band side.

A small genus (with only three species, of which one is common in the euplankton of large and small lakes, and two of which occur mainly in littoral regions). Fresh-water forms which rarely occur in mildly brackish water. We shall concern ourselves only with the two following species:

A. Normal resting cell with 4 or more intercalary bands and as many septa; apical axis very long, central distension of shell slightly wider than polar ones .... T. fenestrata 1.
B. Normal resting cell with numerous intercalary bands and septa; apical axis relatively shorter. Shells in centre often considerably wider than at the poles........................ T. flocculosa 2.

1. Tabellaria fenestrata (LYNGB.) KG. (Fig.519). (Syn. Diatoma fenestratum LYNGBYE; Tabellaria trinodis E.; T. fenestrata var. gracilis MEIST.; T. fenestrata var. intermedia GRUN.). - Cells mostly forming flat zigzag cords, in girdle band view rectangular, with rounded corners, very flat, strongly developed in the direction of the apical axis. In the resting cell, four (two in each half of the cell) intercalary bands or more (5-8), septa extending almost as far as the centre. Shells linear, distended transapically in the centre and at the poles; centre as wide as or only slightly wider than the poles, 30-140 u long, 3-9 u wide. Transapical striae delicate, distinct, punctate-striate, striae parallel, perpendicular to apical axis, 18-20 in 10 u, at the

ends slightly radial. Pseudoraphe narrow, slightly broader at the poles, sometimes also at the centre. Near the centre, slightly to the side of the central line, shell area with one small pore; a second pore, which is difficult to see, at the margin of the apical shell mantle (polar point of curvature of valva).

The variety *intermedia* GRUN. (cells with more than 4 intercalary bands) has here been combined with the type.

var. *asterionelloides* GRUN. (Fig.520). (Syn. *Tab*. *fenestrata* var. *Willei* HUITF.-KAAS; *Tab*. *fenestrata* var. *lacustris* MEISTER; *T*. *flocculosa* var. *pelagica* HOLMB.). - Cells mostly forming star-shaped colonies, which frequently break up into zigzag cords, however, thus forming transitions to the species.

var. *geniculata* A. CLEVE (Fig.521). - Cells bent in centre (girdle 4
band side with strongly angular bend), mostly forming star-shaped colonies. (This "variety" strikes me as being the result of a malformation which has become heritable, HUBER-PEST.)

Euplanktonic species, very common and frequent; inhabits mainly mesotrophic and eutrophic lakes; tolerates mildly brackish water where as a rule it occurs only in small numbers. In most water bodies in plains, *Tabellaria fenestrata* reaches pronounced maxima, mainly in the summer months; during the colder season, the number of *Tabellaria* decreases. Small numbers may survive the winter in the plankton; a substantial increase in numbers starts in March-April. Mass development as early as February (as observed by HUSTEDT, 1919, in Lake Schöh) is an exception. A rapid decrease in numbers usually begins in late autumn.

In the form of its colonies, Tabellaria shows a pronounced seasonal difference: "in the colder season the chain-shaped colonies were by far predominant: they occurred from January to June, and again in September; during the months of June to September, almost only stars and spirals were found" (observation by C. SCHRÖTER in the Lake of Zurich [1896]). The "explosive" development of Tabellaria in the Lake of Zurich in 1896 was a remarkable phenomenon. In the preceding years, none of the researchers who regularly studied the lake (HEUSCHER, SCHRÖTER, etc.) had noticed the alga (this, of course, does not mean that it had not occurred there, but in any case it had not formed a conspicuous part of the plankton). From 1896 onwards, Tabellaria has occurred in the Lake of Zurich as a regular planktonic organism, with high maxima in summer. In 1896, then, conditions in the Lake of Zurich had, obviously for the first time, reached that level of eutrophy which made the mass development of Tabellaria possible.

Sometimes the species occurs also in high mountain regions; I found it, although in very small numbers, in a lake in Corsica, at an altitude of 2,000 m.

The strange variety geniculata has been observed as euplanktonic organism in North European lakes, from northern Finland to Norway.

In the Lake of Zurich, in winter, C. SCHROETER found that a fungal parasite of the family of Chytridiaceae, which he called Phlyctidium Tabellariae C. SCHROET., occurred fairly frequently on T. fenestrata. (SCHERFFEL found a very similar fungus [1926, p. 188], but on Amphora ovalis [also in winter]; he described it as Physorhizophidium pachydermum SCHERFF., and he felt it was not impossible that his and SCHROETER's form were identical; in any case, they are very closely related.)

Salpingoeca (Diplosigopsis) frequentissima (ZACH.) LEMM., a "flagellate" of the family of Craspedomonadaceae, may occasionall be found parasitizing T. fenestrata. The same organism is found on Asterionella and occasionally also on planktonic blue algae.

2. Tabellaria flocculosa (ROTH) KG. (Fig.522). (Numerous old synonyms, also T. flocculosa var. ventricosa GRUN., T. flocculosa var. amphicephala GRUN., T. flocculosa var. genuina KIRCHN.). - Cells 4 forming zigzag cords, star-shaped colonies unknown. In girdle view (usual position in preparations) tabular, width predominant dimension (emphasis on pervalvar axis). Numerous intercalary bands, with deeply penetrating, flat septa. Shells with ± inflated

centre, at the poles rounded into the shape of a head or broadly and flatly truncate; centre as a rule distinctly broader than poles. Length 12-50 u, width 5-16 u. (The length of the girdle band side is often a multiple of the shell length.) Transapical striae (or rows of dots) delicate, approx. 18 in 10 u, perpendicula to centre line, slightly radial at the ends. Pseudoraphe narrow, often slightly widened in centre, more rarely at poles. Gelatinous pores as in T. fenestrata.

Shell anomalies (or asymmetries) not rare. Fairly strong variations in the species, therefore according to HUSTEDT the establishment of separate forms based on the variations in the outer appearance of the shell not justified. Frequent transitions in almost all materials.

In agreement with HUSTEDT, and "in spite of the apparent transition forms", I cannot share BACHMANN's view that T. fenestrat and T. flocculosa are the extreme forms of one single species; I, too, think that the two forms are "sufficiently differentiated from morphological and ecological viewpoints" to maintain their independence as separate species.

Very common and frequent form; very often tychoplanktonic, sometimes also facultative plankter. In contrast to T. fenestrata, particularly common in marshy waters. "From the plains it rises to the highest basins where it is almost always found, both in the littoral region and in the open water (facultative plankter) (e.g. the lakes of the Bernina Alps, the lakes of Aela, and the high-altitude lakes of the Glarus Alps, etc.). I have also found it frequently in high-altitude Corsican lakes (above 2,000 m), and it has been reported often from nordic lakes at fairly high altitudes (HUITFELDT-KAAS, STRÖM)." (HUBER-PESTALOZZI, 1926).

Although ecologically *T. flocculosa* differs essentially from *T. fenestrata*, both species are sometimes found together in plankton, occasionally even in oligotrophic lakes (author's own observation in the plankton of the Lake of Wallenstadt, Switzerland).

Sub-family: Diatomoideae

Diatoma DE CANDOLLE 1805 (em. HEIBERG 1863)

Several obsolete synonyms.

Cells forming tight or zigzag cords, in girdle view rectangular-tabular, in shell view linear to elliptical, sometimes with produced or head-shaped poles. Intercalary bands sometimes present, septa absent. Shells with strong transapical ribs and delicate dotted striae. Gelatinous pores on shell side near the pole mostly distinctly visible.

In preparations, the girdle side of the bands faces the observer. 1. Cells connected with each other by small gelatinous cushions at the corners close to which lies a pore excreting gelatinous matter (particularly distinct in zigzag cords).

Exclusive fresh-water genus. Only one planktonic species: D. elongatum. The other species are attached to the bottom of water bodies and occur in slowly running water, at river banks, in streams, wells and small channels, also in the littoral zone of lakes, etc.; therefore sometimes tycholimnetic.

Key for determining its species

A. Cells forming tight cords; shells with distant ribs, usually fewer than 5 in 10 µ .... (Sub-genus: Odontidium)
   I. Shells narrowly linear, with ends constricted into the shape of a head or at least produced distinctly, smaller forms (D. anceps)
   II. Shells elliptical-lanceolate, with blunt or hardly produced ends, larger forms .... (D. hiemale)

B. Cells forming zigzag cords; shells with close ribs, usually more than 7 in 10 µ .... (sub-genus: Diatoma)
   I. Cells in girdle and shell views narrow, elongate, always fairly delicate .... D. elongatum 1.
   II. Cells in girdle view broadly linear, shells linear to elliptical lanceolate, also relatively broad; strong forms ...D. vulgare 2.

Fragilaria LYNGBYE 1819, emend. RABENH. 1864 437

Cells at shell side connected with each other, forming more or less long, tight cords which sometimes show regular gaps between individual cells (so-called "fenestrated" cords). Connection between cells frequently strengthened by tiny thorns at the shell margin. Outline of shells narrowly linear to elliptical, sometimes transversely inflated or constricted in centre. Intercalary bands and septa absent. Striation of shell transapical (transverse); pseudoraphe narrow to very wide, without continuous transapical ribs. Chromatophores a few isolated large plates or numerous small granules. Special resting spores known only in a few marine species.

In preparations, the girdle band of the cells forming the cords faces the observer.

Predominantly fresh-water forms; several marine species. Among the first-mentioned group, actually only Fr. crotonensis is euplanktonic, the other species are mostly attached to the bottom and are sometimes swept into the open water. Some of the latter will be included in the following key.

Key for determining the species
(according to HUSTEDT)

A. Cells in cords connected with each other only by shell centres, sometimes also at inflated ends; lanceolate gaps ("windows") between centre and ends; cords therefore "loose"; common planktonic form .... Fr. *crotonensis* 1.

B. Cells forming cords without gaps.

I. Shells narrow and elongately linear, rarely lanceolate or (variety) slightly constricted in centre. Pseudoraphe very narrow; often with central area, although the latter is sometimes indistinctly defined. Length 25-100 µ; width 2-5 µ Fr. *capucina* 2.

II. Shells mostly somewhat broader, predominantly linear or linear-elliptical (here, too, one variety with constricted centre); in front of the ends tapering abruptly, but mostly only slightly. Poles not pronouncedly head-shaped (distinctly head-shaped only in the variety *capitata*). Central area absent. In addition to the shell, the girdle band side, too, mostly slightly broader than in the preceding species. — Length 12-120 µ; width 5-10 µ .... Fr. *virescens* 3.

III. Shells abruptly and strongly transapically inflated in centre, or with rhombic outline and strongly tapering from centre to ends. Small forms: length 7-25 µ, width 5-12 µ; transapical striae very delicate, 14-17 in 10 µ .... Fr. *construens* 4.

IV. Shells elliptical or lanceolate; (rarely with three poles); small forms: length 3-30 µ, width 2-6 µ; striae strong, 4 rib-like, approx. 11 in 10 μ .... *Fr. pinnata* 5.

C. Cells forming irregular zigzag cords .... *Fr. zasuminensis* 6.

Asterionella HASSALL 1855

Cells rod-shaped, narrowly linear, with unequally thickened poles, at one shell pole (foot pole) connected with other cells, forming star-shaped, more rarely chain-like colonies; without intercalary bands and septa. Girdle band side of cells linear, usually broadened at the ends, sometimes with pervalvar constriction. Valvar area linear, with head-shaped ends. Shells with delicate transapical striation, without central area, with narrow pseudoraphe which broadens at the poles, without transapical ribs. Chromatophores: several small,round, ± lobed platelets. - Occasionally asymmetrical forms with ± strongly curved cells.

Very common euplankter, occurring in large numbers. In the colonie which lie flat on the slide, girdle band side faces the observer. For determination, individual cells must be found and placed on the slide with the shell side facing upwards (valvar view).

In general, we distinguish between two fresh-water species:

A. In valvar view, foot pole of shell broader than head pole
A. formosa 1.

B. Foot pole hardly broader than head pole .... *A. gracillima* 2.

Another author (A. MAYER) uses the girdle band sides for determination:

A. At the foot pole, cells are joined with areas

A. formosa 1.

B. Cells are joined with acutely rounded edges. *A. gracillima* 2.

However, the forms determined according to the latter method do not correspond exactly to the forms determined according to the first method. (See pertinent discussion on p.447).

Synedra EHRENBERG 1830 4

Several obsolete synonyms.

Cells isolated or forming fan-shaped to bushily star-shaped
colonies, rarely forming short cords; generally rod-shaped, prismatic
on account of greatly elongated apical axis, sometimes curved in 4
the direction of the apical axis, but varying greatly in habit.
Intercalary bands and septa absent, thus girdle band side as a rule
narrowly linear. Valvar area linear to very narrowly lanceolate,
sometimes with waved margins, often with belly-shaped dilation at
centre or at the ends. Valvar area as a rule with transapical rows
of delicate dots (pores or poroids?) and narrow pseudoraphe, or
with broader, lanceolate, hyaline central field which is sometimes
dispersely dotted. Central area present or absent. One shell end
usually bears a gelatinous pore. Chromatophores: numerous small
granules to two large plates. (According to HUSTEDT.)

Genus with numerous species; mostly cosmopolitan species in fresh water (and in the sea), living predominantly in littoral regions as plants growing upwards; several species and varieties typical plankters. One species (Synedra cyclopum BRUTSCHY) lives epibiotically on planktonic crustaceans and Rotifera.

Key for determining the species

A. Cells forming bushily star-shaped, free-swimming colonies
(Sub-genus Belonastrum)

I. Shells linear, tapering little or not at all towards poles; approx. 15 transapical striae in 10 u ..... S. berolinensis 1.

II. Shells lanceolate, approx. 24 transapical striae in 10 u
S. Utermöhli 2.

B. Cells not forming such colonies. Cells attached to substrate either singly or in bushy or fan-shaped cushions (when occurring tycholimnetically), or free-living and isolated, not forming free-swimming clusters (in the latter case frequently planktonic)
(Sub-genus Eusynedra)

I. Apical axis curved (epiplanktonically attached form)
S. cyclopum 9.

II. Apical axis straight.

a. Transapical striae very delicate, often hardly visible. Nordic-Alpine planktonic form .... S. nana 3.

b. Coarser structure.

1. Shells fairly broadly linear, not tapering towards ends, at poles widened in the typical head shape and shortly rostrate .... S. capitata 7.

2. Shells shaped differently (small to very large forms).

α. Shells strong, linear to lanceolate, tapering towards the ends only little and gradually or not at all, or strong also at the ends; usually only approx. 10 striae in 10 µ .... S. ulna 6.

β. Shells delicate.

* Small forms, hardly longer than 70 µ; at the ends produced only little or not at all and only slightly capitate. Central area often particularly pronounced on account of the shells on either side being slightly constricted. Transapical striae very delicate, approx. 20 in 10 µ ... S. rumpens 5. 4!

** Longer forms (over 80 µ, mostly considerably longer).

\+ Shells with narrowly linear central portion from where they taper rapidly towards the ends, or entire shells very narrowly needle-shaped. Mostly 12 or more striae in 10 µ ...... S. acus 4.

++ Shells with double inflation in centre S. Cunningtonii 3.

1. Synedra berolinensis LEMM. (Fig.533) (Syn. S. limnetica LEMM.; S. victoriae WCL.; S. berolinensis var. gracilis LEMM.). - Cells forming free-floating, bushily star-shaped colonies. Shells linear, with ± transapical belly-shaped distention at centre and ends, but in smallest individuals completely elliptical (and bearing a deceptively close resemblance to the shells of Fragilaria pinnata

at the poles bluntly rounded, 5-40 u long, 1.3-3 u wide. 14-16 transapical striae in 10 u. Pseudoraphe narrow, linear. Central area absent.

Euplankter in standing and slowly flowing water; so far rarely found. Germany (Lake Grunewald, Lake Summt, Lake Colpin, Lake Petersdorf, near Danzig, from the Havel River region [Lake Woblitz], in the Wümme River near Bremen, Kleiner Eutiner See [smaller one of two lakes near Eutin in Schleswig-Holstein], Lake Molf, Lake Schulen).

2. Synedra Utermöhli HUST. (Fig.534). - Cells forming free-floating, bushily star-shaped colonies. Shells lanceolate, evenly and gradually tapering from centre towards moderately acutely rounded ends, 25-35 u long, 2.5-3 u wide. Transapical striae delicate, 22-24 in 10 u. Pseudoraphe narrow, linear. Central area absent.

Euplankter. So far found in only one locality: Lake Dobersdorf in Holstein.

Key for determining the varieties 46

(according to HUSTEDT)

A. Transapical striae close, approx. 15 in 10 u

S. ulna var. *oxyrhynchus*

B. 8-12 transapical striae in 10 u.

I. Shells transapically constricted.

a. Ends bluntly-cuneately rounded .... var. *impressa*

b. Ends produced-rostrate .... var. *contracta*

II. Shells not constricted.

a. Shells linear, not tapering towards broadly rounded ends; ends not capitate .... var. *aequalis*

b. Shells linear to lanceolate, with ± capitate ends 4

1. Shells linear, widened at ends, and with ± rostrate poles .... var. *spathulifera*

2. Shells with bluntly rounded, capitate poles

α. Shells almost linear, hardly tapering towards the ends; ends broadly capitate .... var. *biceps*

β. Shells lanceolate, with narrow, capitate ends.

* Shells mostly wider than 5 u, tapering fairly abruptly in front of ends, thus with capitately constricted poles .... var. *amphirhynchus*

** Shells mostly less wide than 5 u, narrow, needle-shaped, not much constricted in front of slightly capitate ends .... var. *danica*

Suborder: Biraphidineae

In this sub-order both shells have a true raphe which either lies in the centre line of the shell or is displaced transapicad, sometimes also transferred to a keel. The sub-order comprises four families: Naviculaceae (with the typical "Navicula raphe" which mostly extends in the centre line of the shell, but is rarely displaced or transferred to a keel); Epithemiaceae, Nitzschiaceae and Surirellaceae. In the last three families the raphe is developed as a "canal raphe" and is mostly transferred to a keel. The latter lies either on the valvar area (medial, or laterally displaced) or on one margin of the shell (Nitzschiaceae), or extends around the shell (on the valvar edge) (Surirellaceae).

Family: Naviculaceae

Sub-family: Naviculoideae

Cells always symmetrical, shell view never club- or crescent-shaped. Raphe on valvar area. Intercalary bands and septa often present, but in most cases absent. Cells usually isolated, rarely in gelatinous tubes or on gelatinous stalks also rarely forming cords, in which case it is difficult to distinguish them from Fragilaria (according to HUSTEDT).

The sub-family of Naviculoideae comprises many genera; some species frequently occur tychoplanktonically, and have been erroneously called euplanktonic. Among these species are, in particular, species belonging to *Navicula*, *Pinnularia*, *Frustulia*, *Stauroneis*, *Gyrosigma*, more rarely also to *Diploneis*, *Caloneis*, *Anomoeoneis*, *Neidium*, etc. It is not permissible to include here the very large number of species, especially of the first two genera, which fairly often are found on lists of "plankters". Reference may be made to the main publications, already quoted repeatedly. As yet, no euplanktonic forms have been reported for this sub-family whose taxonomy is very complicated.

Sub-family: Gomphocymbelloideae

Cell body asymmetrical in relation to at least one main section. Either apical axis or transapical axis, or both axes heteropolar, pervalvar axis isopolar. Intercalary bands frequently present, septa absent. Raphe of the *Navicula* type, with ± developed nodules, frequently displaced from the centre line of the shell, but not distinctly keeled, no keel dots (according to HUSTEDT).

This sub-family comprises several very common genera: *Gomphonema*, with mostly club-shaped, attached cells which, however, once torn from their gelatinous stalk, can also live freely, in which latter case they often float around tychoplanktonically. - *Amphora*, whose 4
cells, in girdle view, are elliptical with flattened ends, but in

shell view are ± crescent-shaped, with bluntly rounded or produced, often capitate ends. Cells mostly isolated, either attached to a substrate or free-living in the mud of the water body. Often found tychoplanktonically (e.g. Amph. ovalis and its variety pediculus, which often attaches in large numbers to larger diatoms, such as Nitzschia, Surirella and other algae, or also occurs free-living). - Another genus with numerous species is Cymbella, which will be discussed in greater detail below.

Cymbella AGARDH 1830.

Cells isolated and free-living, or attached to substrate on gelatinous stalks, or living in gelatinous tubes. Without intercalary bands and septa. Shells mostly boat-shaped, dorsiventral, rarely almost symmetrical about the centre line (in which case they resemble the shells of some species of Navicula). Raphe mostly close to ventral margin of shell; axial and central areas usually distinctly developed. Structure: transapical rows of dots, the central rows on the ventral side often terminate in isolated dots separated from the rest of the dots by a furrow. In some species a conspicuous pore (stigma) in the vicinity of the central nodule, usually on the ventral side. (According to HUSTEDT.)

Predominantly fresh-water forms, mostly of general distribution; no euplanktonic forms are known, but frequently occurring tychoplanktonically, both in lakes and in ponds. The following species merits attention:

Cymbella Ruttneri HUSTEDT (Fig.554). -"Shells naviculoid, narrowly and asymmetrically lanceolate, with flatly arched ventral margin and slightly more arched dorsal margin; very slightly produced at the fairly acutely rounded corners, 15-30 u long, 3-4.5 u wide. Axial area narrow, very narrowly lanceolate, not widened around central nodule. Raphe almost straight, slightly curved dorsad in front of central pores. Transapical striae slightly radial to perpendicular to centre line, 20-24 in 10 u, usually slightly wider at ventral side than at dorsal side.

General distribution! Very common in the lakes of the Sunda Islands, frequently also in the plankton, so that with great likelihood it is a form which occurs, at least temporarily, as a true planktonic form" (HUSTEDT).

Family: Epitheniaceae 4

Cells with boat- to ± clamp-shaped shells. Raphe developed as canal raphe, transferred to a keel or lying on valvar area, often with pitted pores in the inner canal wall, but always without actual keel dots, sometimes angulated on the valvar area and displaced transapicad. Nodules poorly developed or altogether absent.

Cell wall as a rule with transapical ribs, the membrane portions between the ribs areolate-chambered. Chromatophore as a rule a plate on the girdle extending to the other walls. - Two sub-families:

I. Raphe not distinctly keeled, pits on inner canal wall. Shells boat-shaped or curved like a bow, not clamp-like. Epithemioideae.

II. Raphe keeled, without distinct pits, shells mostly curved like a clamp. (No known planktonic forms) .. Rhopalodioideae.

Sub-family: Epithemioideae

In girdle view, cells rectangular or elliptical. Shells boat-shaped or evenly curved, in the latter case with dorsiventral structure. Raphe lying on valvar area, mostly ± displaced transapicad, often extending almost in its entirety on the valvar edge, but hardly pedicellate. Inner canal wall pitted; raphe often angulated in centre. Cells with intercalary bands and septa of peculiar structure. Two genera:

I. Apical axis straight, raphe on valvar area not angulated. Only one known planktonic species .... Denticula (p.467)

II. Apical axis curved, shells dorsiventral, raphe on valvar area angulated (no known planktonic species) .... Epithemia

Family: Nitzschiaceae

Both shells of each cell with canal raphe transferred to a ± protruding keel; canal raphe connected with cell interior through numerous tubules (keel dots). Central pores present, in which case they are mostly difficult to see, or altogether absent.

Sub-family: Nitzschioideae

Cells elongate (predominantly in the direction of the apical axis); mostly without intercalary bands and septa. Keel with raphe either in centre line of shell or displaced transapicad. Shells with only one keeled edge.

I. Cells forming tabular colonies inside which individuals perform independent gliding motions .... Bacillaria (p.469)

II. Cells not forming such colonies.

a. Apical axis bent into a curve in centre, cells therefore dorsiventral. Raphe of both shells on concave margin (Hantzschia)

b. Cells linear-rod-shaped, broadly elliptical or curved like an S .... Nitzschia (p.470)

Bacillaria GMELIN 1788

Cells forming tabular cords, but in a manner which allows gliding motions to be performed by individuals inside the cords; shape of cords thus changing frequently. Cells rod-shaped. Keel central.

Bacillaria paradoxa GMEL. (Fig.558). - In girdle view the cells are linear-rectangular, shells connected with each other to form multicellular plates. Shells linearly spindle-shaped, ends 470
sometimes slightly rostrate, 60-150 u long, 4-8 μ wide. 6-8 keel dots in 10 μ. Cell wall transapically punctate-striate, 20-25 striae in 10 u.

var. tumidula GRUN. (Fig.559). - Cells inflated in centre, in all other respects like those of the species.

This species, which in general is euryhaline, sometimes occurs in almost purely fresh water, and is very common in inland waters. According to observations by G. KARSTEN, Bacillaria paradoxa sometimes rises from its usual location, the muddy bottom, and after extensive reproduction appears in the plankton in huge numbers.

Nitzschia HASSALL 1845

(Homoeocladia AGARDH, 1830)

Cells isolated or forming colonies, differing greatly in habit; mostly linearly rod-shaped, or curved like an S, or, more rarely, with broadly elliptical shells. Keel central or displaced ± transapica in the latter case cells diagonally symmetrical. Keel dots sometimes extending like ribs across the shell area. Canal raphe with or without central pores. Shell area sometimes with apically oriented fold on which the structure is less distinct or often altogether absent.

Genus with large number of species (more than 180 species in fresh, sea and brackish water, mostly marine and fossil); sometimes forms difficult to distinguish from each other. "With regard to identification, it must be remembered above all that the appearance of the shells differs with their position. As a rule they rest on one side of the keel, thus occupying a "half-turned" position, while their true shape is revealed only in the "keel position", i.e. when the crest of the keel faces the observer; this position, however, can be achieved for most species only by time-consuming searching and trying" (HUSTEDT).

HUSTEDT has divided the genus into 12 groups, of which we are interested only in those three groups to which the 25 species mentioned below belong, namely

1. Lanceolatae GRUN.: Nitzschia species with lanceolate shells which are ± distinctly striated transapically and have a strongly eccentric keel. Comprises the majority of the forms mentioned below.
2. Sigmoideae (GRUN.) HUST.: Species with cells which are curved in the shape of an S and whose keel is ± eccentric to almost central.

3. Nitzschiellae (RBH.) GRUN.: Species with spindle-shaped central portion of shells and long, beak-like produced shell ends; keel ± eccentric.

Only few forms seem to be euplanktonic (*N. actinastroides* (LEMM.) VAN GOOR, *N. asterionelloides* O.M., *N. fonticola* GRUN. var. *pelagica* HUST., *N. holsatica* HUST., *N. striolata* HUST., *N. pelagica* O.M., *N. baccata* HUST., *N. nyassensis* O.M., *N. lacustris* HUST.). The majority of *Nitzschia* species grow on the bottom or upwards, but 47
some of them occur very frequently in the plankton (tychoplanktonic). *N. epiphytica* O.M. and *N. Kützingiana* HILSE have been found to occur epiplanktonically.

Key for determining the species of Nitzschia

(HUSTEDT)

A. Cells with spindle-shaped central portion and longly rostrate, thin ends .... *Nitzschiellae* c.

B. Cells not conspicuously long and rostrate

I. Cells with S-shaped apical axis .... *Sigmoideae* b.

II. Apical axis straight .... *Lanceolatae* a.

a. Lanceolatae

A. Cells forming bushily star-shaped colonies.

I. Shells 2.5 u wide or wider .... *N. actinastroides* 1.

II. Maximum width of shells 2 u.

a. Width:length approx. 1:13-28, 14-17 keel dots in 10 u
N. holsatica 2.

b. Width:length approx. 1:32-72, 16-18 keel dots in 10 μ
(tropical form) .... N. asterionelloides 3.

B. Cells not forming such colonies.

I. Structure fairly coarse, hardly more than 16 transapical striae in 10 μ.

a. Shells broadly lanceolate, with strongly and fairly acutely rostrate poles (tropical form) .... N. lancettula 4.

b. Shells narrowly lanceolate to linear (cosmopolitan form) .... N. amphibia 5.

II. Structure more delicate.

a. Cells more than 150 u long (tropical form)... N. lacustris 21.

b. Cells much smaller, mostly shorter than 100 u.

1. Structure very delicate, hardly resolvable, approx. 35 or more transapical striae in 10 μ.

α. Shells linear, with parallel sides and shortly rostrate poles, 18-20 keel dots in 10 u .. N. pelagica 1

β. Shells more or less lanceolate, or the keel dots more distant.

* Shells with longly acute poles which are capitately rounded at the ends, shell outline thus narrowly spindle-shaped .... N. gracilis 19

** Shells with shorter ends or ends that are not produced at all.

Shells very narrowly linear-lanceolate, width:length approx. 1:20-40, structure as yet unresolved (tropical form) .... N. baccata 20.

Shells relatively broader.

aa Shells linear to linear-lanceolate, 10-15 keel dots in 10 u .... N. palea 11.

bb Shells lanceolate, mostly 14-18 keel dots in 10 u .... N. Kützingiana 12.

2. Structure always distinctly visible, mostly only up to 30 transapical striae in 10 u.

α. Shells linear with bluntly rounded, not produced ends (tropical form) .... N. epiphytica 17.

β. Shells more or less lanceolate, with pointed poles. 4

* Approx. 30 transapical striae in 10 u.

Shells broadly lanceolate, with strongly convex sides (tropical form) .... N. towutensis 15 (see also N. frustulum var.)

Shells narrowly lanceolate, with hardly convex sides.

\+ Shells up to approx. 35 u long, 12-16 keel dots in 10 u

O Shells 2.5-4 μ wide .... *N. fonticola* 10.

(see also *N. frustulum* var.)

OO Shells 1.5-2 μ wide (tropical form)

N. striolata 16.

++ Shells longer than 35 μ; keel dots mostly coarser (tropical forms).

O Shells with acutely rostrate ends, up to 3 μ wide .... *N. subrostrata* 9.

OO Shells 3.5-4.5 μ wide, tapering conically towards ends .... *N. philippinarum* 13.

** Structure coarser.

Central keel dots more distant (tropical forms).

\+ Shells 4-5 μ wide, with rostrate ends

N. pseudoamphioxys 6.

++ Shells narrower, ends not produced.

O Shells narrowly lanceolate, keel dots small .... *N. luzonensis* 14.

OO Shells wider, linear-lanceolate, keel dots coarse .... *N. invisitata* 8.

Distance between central keel dots and between other keel dots not conspicuously different (cosmopolitan form) .... *N. frustulum* 7.

b. Sigmoideae

A. Transapical striae distinct, up to approx. 26 in 10 u
N. *sigmoidea* 22.

B. Structure much more delicate, 30-36 striae in 10 u
N. *vermicularis* 23.

c. Nitzschiellae

A. Very long tropical form, shells 150-almost 500 u long, central portion only slightly wider .... N. *nyassensis* 21.

B. Shells with wider, spindle-shaped central portion, mostly shorter than 150 u (cosmopolitan form) .... N. *acicularis* 25.

Family: Surirellaceae

Shells with slightly keeled to strongly winged valvar edge; keel or wing extending around the entire shell, thus each shell appearing to have two canal raphes which biogenetically, however, must be considered as two branches of one raphe (HUSTEDT, Bau d.Diat. [The forms of the Diatoms], VIII. 1929). Canal of raphe communicating with cell interior through wing canals; the membranes between the tubules are called windows (HUSTEDT). Two sub-families:

I. Surirelloideae: Apical axes of the two shells of one cell running parallel to each other (not intersecting). Cells rarely with saddle-shaped arch.

II. Campylodiscoideae: Cells arched in the shape of a saddle, apical axes of the two shells ("parapical axes") intersecting at a right angle.

Sub-family: Surirelloideae

Review of its genera.

a. Shells with waved parapical axis .... Cymatopleura (p.480)

b. Parapical axis straight or curved, not regularly waved.

1. Shells with indistinct wings, elongate-linear outline, curved like an S .... Stenopterobia (p.484)

2. Shells with distinct wings, differently shaped Surirella (p.4?5)

Cymatopleura W. SMITH 1851 480

In shell view, cells elliptical, linear, or sole-shaped. Surface of shell transversely undulated, i.e. crossed by a small number of transverse waves with distinct profile at the shell margins, but becoming flatter towards centre of shell. Shell area with delicate transverse striation (transapical striae). Pseudoraphe thin, mostly difficult to see. Margins of shell side with short, strong marginal ribs which in some species are so short that they appear as "pearls". Cells without intercalary bands and septa, in girdle view mostly rectangular, rod-shaped; waves of shell lid in girdle view clearly visible. Canal raphe at each longitudinal edge. - Auxospores: two apogamous spores from two cells (G. KARSTEN).

This genus includes several very characteristic species which occur in lake plankton.

Key for determining the species
(according to HUSTEDT)

A. Shells with one strong, curved thorn each at centre line, at some distance from each pole .... C. calcarata 1.

B. Shells without such thorns.

I. Wing canals extended into delicate but distinctly recognizable transapical ribs which extend as far as the centre line of the shell .... C. solea 2.

II. Shells without such ribs.

a. Shells sole-shaped, with elongate, considerably constricted central portion, almost circular before the ends

C. nyansae 3.

b. Shells shaped differently.

1. Striation on wave crests in apical direction, outline of shells linear, conical towards the ends ..*C. angulata* 4
2. Striation on wave crests forming an acute angle with apical axis.

α. Transapical striae on shell areas delicate but distinctly visible. Shells elliptical, rhombic-elliptical to broadly linear, sometimes slightly constricted in centre .... *C. elliptica* 5.

β. Very delicate and irregular, small-meshed network of hyaline striae dissolving structure into an intricate system of short, finely dotted striae. Transapical striae visible only in a narrow marginal zone .... *C. Brunii* 6.

Surirella TURPIN 1827.

Cells very different in appearance. In girdle view rectangular to trapeziform, sometimes twisted around an axis. Shells with lineal, elliptical, oval or ovoid outline*, margin with more or less distinct wings. Wing canals usually extending into valvar area as narrow wave crests (called "ribs" because of their shortness and appearance, but not representing membranous thickenings [or only in exceptional cases]). "Depending on the location and development of the wing, the wing canals and windows, in shell view, are distinctly visible or hardly recognizable, so that we can speak of "distinct or indistinct wing projection". The waved boundary line between valvar area and wing is called "loop". If the differences between wave crests and wave troughs are very great, long loops are formed, usually in connection with indistinct wing projection; if the differences are small, short loops are formed, mostly in connection with distinct wing projection. The distinctiveness of wing projection, which is an essential distinguishing feature of several species, depends even more on the location of the wings. If the wings lie perpendicular to the valvar area, wing projection is of course completely absent; its distinctiveness increases with decreasing 4
angles of inclination between wing and valvar area. The chromatophores

---

* With lineal, elliptical, or oval shell outlines (with exactly identical poles) the apical axis is isopolar, with ovoid shells, heteropolar.

to the extent they are known, are two more or less divided plates, attached to the shells." Pseudoraphe linear or lanceolate; pseudoraphes of both shells parallel to each other.

Large genus with many more than 200 species in fresh, brackish and sea water; free-swimming or attached (marine). Mostly very attractive forms. So far, no typical plankters have been found in freshwater bodies of Europe and North America. (But some species are found fairly regularly in the tychoplankton.) On the other hand, it seems that a number of tropical and subtropical species must be regarded as euplanktonic. The genus, at least in tropical and subtropical waters, shows a strong tendency towards endemic forms; this, HUSTEDT (in litt.) thinks, is due to the "phylogenetic youth of this genus".

The following list includes 66 species (with numerous varieties and forms). A considerably number of these species have been taken from the publications by O. MÜLLER, OSTENFELD, G.S. WEST and WOLOSZYNSKA, but in particular from those by HUSTEDT (from SCHMIDT's atlas [material from Tanganyika], from Aokiko, Japan, and Lake Toba, Sumatra, and from his description, to be published shortly, of the material collected by the Wallacea expedition). Furthermore, Dr. HUSTEDT was so kind as to put at my disposal a large number of new forms with their diagnoses and pictures, and to draw my attention to several forms to be included in my list. The key for determining the species of Surirella, given below, has also been kindly supplied by Dr. HUSTEDT.

The new species from Lake Baykal described by SKVORTZOW have been included only to the extent to which they had been found by HUSTEDT in the material at his disposal; the pictures and diagnoses of these forms, too, were revised by HUSTEDT. Isolated finds of doubtful species, which require further observation, have not been included.

Some forms have been included which were found in mud samples from the bottom at depths of 75 m, 100 m and more; the reason for this is that we had to assume that these forms got into the sediments from the open water. It was not certain, however, whether they were tychoplanktonic or euplanktonic forms. In any case, the depths mentioned could not have been the usual habitat of these Surirella species. And it was indeed possible to prove that some of the species had come from the open water.

When determining the Surirella species, the following factors must be taken into account: 1. A definite division into heteropolar and isopolar forms, introduced by Otto MÜLLER, is hardly ever possible. Many isopolar species have heteropolar varieties or anomalies, and in some heteropolar forms the differences between the two shell poles are hardly recognizable. A definite distinction usually requires entire cells, which must be examined both in shell view and in girdle view. The true heteropolar forms have wedge-shaped girdle band sides, and the shell mantles are wider at the head pole than at the foot pole. 487

2. In some species torsion occurs, which is not always easily recognizable. Mild torsion about the apical axis manifests itself by the fact that the wing margins, when viewed from the shell side, do not lie at the same level, but appear to descend towards the foot pole at one longitudinal side, towards the head pole at the other. On the other hand, those parts of the wings which face each other diametrically, lie at the same level.

Key for determining the species of Surirella

(HUSTEDT)

a. Forms with isopolar apical axis.

A. Cells twisted around the apical axis.

I. Cells strongly twisted.

a. Shells elliptical, with broadly rounded ends.

1. Shells elongate-elliptical, less than 50 u wide

S. conversa 35.

2. Shells broadly elliptical, wider than 80 u

S. uninodes 36.

b. Shells linear, with conical ends ... *S. spiraloides* 37.

II. Cells slightly twisted.

a. Shells linear-elliptical, sometimes constricted, up to 50 μ wide, bearing large number of small thorns *S. horrida* 33.

b. Shells broadly elliptical, approx. 75 μ wide *S. prehensilis* 34.

B. Cells not twisted around apical axis.

I. Shells very elongate, narrowly linear, approx. 12 times longer than wide, or even longer.

a. Approx. 17 wing canals in 100 μ, girdle band sides very broadly linear .... *S. effusa* 32.

b. Approx. 30-40 wing canals in 100 μ, girdle band side not conspicuously wide......................... *S. cuspidata* 31.

II. Shells relatively wider.

a. Transapical waves very short, developed only in narrow marginal zone, broad central field with irregularly reticulate structure.,...................*S. brevicostata* 30.

b. Waves longer or shorter, but central field with different structure, or absent.

1. Central field surrounded by a row of more or less numerous strong thorns .... *S. asperrima* 9.

2. Shells with different structure.

α. Wave crests and troughs on shell area of remarkably different widths, therefore wave crests or troughs appearing like ribs.

* Wave troughs rib-like, shells lanceolate

S. lancettula 29.

** Wave crests rib-like, shells linear.

O More than 100 μ long, approx. 25 wing canals in 100 μ .... S. gradifera 17.

OO Less than 100 μ long, approx. 34-40 wing canals in 100 μ ....S. angustiformis 15. 4

β. Wave crests and troughs on shell area not differing so conspicuously.

* Where wing canals open into wing margin canal, tongue-shaped processes running parallel to valvar area .... S. papillifera 6.

** Wings without such processes.

O Shell outline elliptical to linear-elliptical, with bluntly rounded ends, sometimes with concave margins.

\# Distinct wing projection.

aa Cells in girdle view constricted, shells dumbbell-shaped .... S. halteriformis 2

bb Girdle band side not constricted.

αα Cell wall dispersly but coarsely
punctate .... *S. granulata* 10.
(see also *S. linearis* v. *helvetica* 11)

ββ Cell wall not conspicuously punctate.
x Wing canals very distant, approx. 16
in 100 μ .... *S. alata* 13.
xx Wing canals closer, 20-30 in 100 μ
S. linearis 11.

Wing projection indistinct or absent.
aa Shell area dispersely covered with small
thorns or coarse dots
αα Shells elliptical, transapical striae
distinctly punctate .. *S. margaritifera* 23.
ββ Shells linear, often constricted in
centre
x Wave crests at margin with flat
loop heads .... *S. aculeata* 22.
xx Loop heads strongly developed
S. Heideni 21.

aa Shell area without such thorns
αα Shells elliptical-lanceolate
S. latecostata 26.
ββ Shells linear to linear-elliptical,
sometimes constricted in centre

x Approx. 16 wing canals in 100 u

S. vasta 25.

xx 25 or more wing canals in 100 u

\+ Girdle band sides linear..S. sublinearis 1

++ Girdle band sides constricted in centre .... S. obtusiuscula 14.

OO Shells linear to lanceolate, with more or less conical ends.

Shells with distinct wing projection

aa Central portion of centre line raised conspicuously like a ridge, this ridge terminating in strong, laterally compressed teeth some distance from the poles

S. Reichelti 19.

bb Centre line without such teeth, but sometimes irregularly covered with small teeth along its entire length

αα Shells broadly rhombic-lanceolate

S. turgida 8.

ββ Shells linear to elliptical-lanceolate, sometimes constricted in centre

x 20-30 wave crests in 100 u

\+ Shells less than 40 u wide..S. lineari

++ Shells wider than 50 u..S. paucidens 2 xx 10-20 wave crests in 100 u

+ Shells elongate, abruptly widening in front of poles, short forms very broadly linear; ends typicallyconical (tropical form) .... S. Nyassae 1.

++ Shell ends not so conspicuously characteristic, shells linear with evenly tapering ends (cosmopolitan form) .... S. biseriata 7.

Shells with indistinct wing projection

aa Shells broadly lanceolate, 100 u and more wide .... S. lacus Baicali 28.

bb Shells considerably narrower

αα Central third of centre line raised from the level of the shell, centre line terminating in teeth at both ends of this ridge .... S. bidentula 20

ββ Centre field and centre line not characterized in this manner

x Wave crests on shell area distinctly wider than wave troughs

+ Shells linear .... S. Muelleri 5.

++ Shells constricted in centre S. Feuerborni 4.

xx Wave crests and troughs on shell area of approximately the same width, or wave crests narrower

+ Wave crests in centre between pseudoraphe and shell margin suddenly becoming narrower and lower, shell area thus with semi-lanceolate depressions on eithe side of the centre line

S. acuminata 18.

++ Wave crests extending evenly in relation to pseudoraphe

Y Shell area weakly and indistinctly waved, only small difference between wave crests and troughs

S. Engleri 2.

YY Shell area distinctly waved.

δ Shells up to approx. 30 u 49
wide .... S. Thienemanni 16.

δδ Shells 40 u wide or wider

S. Fülleborni 3.

b. Forms with heteropolar apical axis

A. Cells more or less twisted around apical axis, sometimes only at foot pole.

I. Shells with strong wings.

a. Cells twisted only at foot pole, shells elongate-oval (Nordic form) .... S. Astridae 41.

b. Cells strongly twisted, shells broadly oval, very little heteropolar (tropical form) .... S. Woltereckí 40.

II. Shells with weak or indistinct wings.

a. Shells very broadly oval, membrane strongly punctate-striate, waves very short, marginal .... S. striolata 55.

b. Shells more slender, more delicate structure.

1. Wave troughs very narrow. Large, oval form S. subcontorta 60.

2. Wave troughs wider. Smaller form with acutely egg-shaped shells .... S. pseudovalis 64.

B. Cells not twisted.

I. Centre line with one subulate or lamellar thorn each in front of head pole, mostly also in front of foot pole; rarely with two thorns in front of head pole.

a. Shells with two thorns at head pole .... S. bidens 52.

b. Shells with one thorn each at head pole, sometimes also at foot pole.

1. Wings strongly developed, distinct wing projection (cosmopolitan forms).

   α. Thorns on centre line strong, subulate

   S. Capronii 50.

   β. Thorns more delicate, laterally compressed, lamellar.

   S. tenera 44.

2. Wings less developed, indistinct wing projection (tropical forms)

   α. Shells narrowly oval, shell area strongly waved

   S. spinifera 51.

   β. Shells broadly oval, shell area slightly waved

   S. Debesi 59.

II. Centre line without terminal thorns, or irregularly serrate along its entire length.

   a. Wings separated from each other at head pole of shell by a wide gap, wave troughs rib-like, short .. *S. guatimalensis* 5

   b. Wings joining at head pole

   1. Shell area in inner part of shell not waved, waves short, marginal

      α. Shell area strongly punctate-striate (cells very slightl twisted) .... *S. striolata* 55.

      β. Shell area only dispersely punctate, or apparently smooth .... *S. sparsipunctata* 56.

2. Waves extending farther towards pseudoraphe, more or less reaching it, or leaving only a narrow central field free 491

α. Margin of shells without distinct loop heads (doubtful species from East Africa) .... S. fasciculata 65.

β. Margin of shells with distinct loop heads

* Wave troughs very narrow, rib-like (cosmopolitan form) .... S. elegans 53

** Wave troughs not conspicuously narrow.

\# Shells with distinct wing projection.

O Mostly fewer than 20 wing canals in 100 u, cell wall strong, strongly waved.

aa Centre field raised conspicously and strongly like a ridge, shells with deep depression between centre field and margin ...S. excellens

bb Centre field not so sharply defined S. robusta 42

OO Mostly 25 or more wing canals in 100 u, cell wall thinner, transapical striae more delicate.

aa 20-30 wing canals in 100 u, larger forms S. tenera 44.

bb 40-70 wing canals in 100 u, small forms S. tenuissima 45.

\#\# Indistinct wing projection

O Wider wave crests repeatedly divided at margin by small inserted windows ....S. rorata 49.

00 Wave crests undivided at margin

aa Shells with acutely rostrate foot pole, wave crests before centre field with small humps .... *S. pediculata* 47.

bb Foot pole not produced

αα Wave troughs deeply depressed like grooves, particularly towards the centre field, therefore centre field sharply defined and raised..*S. sulcata* 4

ββ Wave troughs less pronounced.

x Shells with distant wing canals, centre line strongly serrate

S. elegantula 46

xx Wing canals not conspicuously distant centre line not serrate.

\+ Shells oblong-elliptical, with almost straight or concave sides, slightly heteropolar

γ Fewer than 20 wing canals in 100 u .... *S. rudis* 63 (see also *S. celebesiana* var. 39.

γγ More than 20 wing canals in 100 u.

δ Shell margins slightly convex,

transapical striae distinctly
punctate .....S. celebesiana 39.

δδ Shell margins concave, striae not distinctly punctate .... S. decipiens 3?

++ Shells more broadly elliptical, with more strongly convex margins.

v Shell area with transapical rows of pearls ..... S. margaritacea 6?

vv Cell wall built differently.

δ 6-20 wing canals in 100 u

τ Shells elliptical-circular
S. Skvortzowi 57.

ττ Shells ovoid-lanceolate
S. conifera 58.

δδ Approx. 30 or more wing canals in 100 u

τ Shells with raised, lanceolat centre field ... S. ovulum 66

ττ Shells without such a centre field .... S. plana 61

Sub-family: Campylodiscoideae

Cells arched like a saddle; parapical axes (apical axes of both shells) intersecting at a right angle. Only one genus.

Campylodiscus EHRENB. 1841

Cells curved like a saddle, in shell view mostly circular. Canal raphe extending around the shells on the ridge of one more or less strongly developed wing; wing interrupted at the poles of the parapica axis. One shell turned by 90°C (about the pervalvar axis) in relation to the other shell of the same cell, so that the apical level of one cell half becomes the transapical level of the other. Pervalvar axis straight, the two other axes curved; all 3 axes isopolar. Apart from the torsion, cell halves symmetrical (HUSTEDT).

Genus with large number of species, predominantly marine or seawater forms. For our purposes, only the species listed below are of importance; they are forms living at the bottom, but they are not infrequently found tychoplanktonically, in the open water, particularly in smaller lakes, even at higher altitudes.

Key for determining the species (HUSTEDT)

A. Shells bearing coarse papillae, marginal zone strongly waved (tropical form) .... C. papillosus 5.

B. Shells with ± thick, small thorns.

I. 10 wing canals in 100 μ, shells with linear-elliptical, sharply defined centre field .... C. rutilus 3.

II. More than 10 wing canals in 100 μ, centre field absent or formed differently.

a. Shells divided into four distinctly recognizable structural sectors by two intersecting pseudoraphes .... C. noricus 1.

b. Shells with different structure.

1. 20 or more wing canals in 100 μ .... C. fragilis 2.

2. Fewer than 20 wing canals in 100 μ 521

α. Shells with more or less extensive centre field, the rest of the shell area strongly waved (cosmopolitan form) .... C. noricus var. 1.

β. Shells without centre field, hardly waved (tropical form) .... C. tanganicae 4.

List of diatoms capable of producing large maxima 52a

Melosira granulata (E.) RALFS.
" " var. angustissima MÜLL.
" " var. muzzanensis (MEISTER)
" islandica O. MÜLL., subspec. helvetica O. MÜLL.
Stephanodiscus astraea (E.) GRUN.
" Hantzschii GRUN.
Fragilaria crotonensis KITTON.
Asterionella formosa HASS.
" gracillima (HANTZSCH) HEIB.
Diatoma elongatum AG.
" " var. tenue (AG.) KG.
" " var. actinastroides KRIEG.
Tabellaria fenestrata (LYNGB.) KG., with var. asterionelloides GRUN.
Synedra acus KG.
Nitzschia nyassensis O. MÜLL.
Stenopterobia pelagica HUST.