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by G. Huber-Pestalozzi

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Translator's note:

The signs used by the author (or better, by the printers) for the differently indented groups of comparable groups in the taxonomic keys include asterisks, daggers, paragraph-signs, numerals and letters (the former Arabic and Roman, the latter Roman and Greek) all with one or two apostrophies as well as without them.
Since some of the signs are not available on an ordinary typewriter, while the asterisk always refers to a footnote, the indentations have been marked as follows (and consistently in that order):

A. (B., C., etc.) [same as printers marks]
I. (II, III, etc.) " " " "
a) (b, c, d, etc.) " " " "
1. (2, 3, 4, 5, etc. " " " "
α) (β, γ, ϐ) " " " "
- (This position marked by printers as 1', 2', etc.)
— [marked by printers as α'), β'), γ'), etc.]
– [printers used (inconsistently) either asterisks e.g. *), **), up to *******), or daggers in var. numbers; in isolated instances, markings in this position were 1"), 2"), a"), α"), and so on.

The translator hopes that the 8 positions as marked in the work submitted are acceptable and less confusing.

Although footnotes by the author were never marked for translation, a few have been translated nevertheless, since they seemed important. Author's footnotes are marked by an asterisk only, while footnotes by the translator are marked "Translator's note."

On p.93 of the German text, two sentences were marked for translation which had just been translated before (see green paper affixed to p.93); these passages have not been repeated in the translation.

Fifty-two pages of the photostatic copy submitted for translation are barely legible; to point to just a couple: Cf. p.88, 91, or 23.....

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Class IV: Chrysophyceae

p.4

Cells oviform, ellipsoidal, or spherical, less frequently cuneiform or conical, with one or more golden-yellow to brownish chromatophores which may have a discoid, platelike, or reticular form. The characteristic coloration is attributed to a pigment that masks the color of the chlorophyll ("chrysochrome" after KLEBS, or "phycochrysine" after GAIDUKOV). The cells are either naked (without cellulose membrane), or provided with a gelatinous to characteristically sculptured envelope; they may be more or less changeable in form (metabolous) or ametabolous. Individual cells have either one flagellum, or two flagella of equal or unequal length at the anterior end, occasionally situated also somewhat lateral; sometimes an extra flagellum may be seen. In some species, pseudopodia of various forms may be present (in addition to flagella or in their absence) which serve mainly the purpose of food-intake. Lobopodia and rhizopodia serve, furthermore, as organs of motion for some species; few species may also have less flexible axopodia. While such amoeboid states are for many forms usually only a temporary phase, they represent a permanent state for a small group of indi-

p.5

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*) Translator's note: This translation consists of excerpts (taxonomic keys) only, as requested.

viduals (Rhizochrysidales). Contractile vacuoles (1-10) are usually situated at the anterior end. An eyespot may be present or absent. Typical pyrenoids are missing, but pyrenoidlike structures, whose function has as yet not been established with certainty, are found in some forms. The cells are of bilateral symmetry, sometimes oblate, often radial, without interruption by a lateral or elongated groove. They may be free-swimming or sessile, solitary or united in colonies of a more or less characteristic form.

Of special importance — morphologically as well as from the evolu- p. 8
tionary point of view — is the very peculiar, though rare, duplication of structures in some of the Chrysomonadales which, while having an external appearance of homogeneous organisms, reveal, upon close inspection, a duplication of some or even most of their protoplastic organelles; indeed, even the cell body as such may be duplicated. For example, in Didymochrysis PASCHER, duplication of the chromatophoral apparatus, the eyespot, the secretory apparatus (contractile vacuoles), and even the flagellar apparatus has been established despite the apparent homogeneity of the nucleus. In p. 9
another species (Amphichrysis KORSHIKOV), only the chromatophoral and secretory apparatus are duplicated, but not the cell body, flagellum and nucleus. As pointed out by PASCHER (1929), these forms are not without parallels in the domain of the Protista (e.g. the Distomata or Diplozoons, featuring flagellates and algal swarmers with many nuclei and flagella, or with a single nucleus and many flagella, all of which lend additional support to the view that, with great probability, a great number among the algae may be descendants of flagellates).

The development of such diploid organisms in varying degrees might, without doubt, be connected with the interruption or obstruction of the

process of cell division during various phases, resulting – at least for a number of organisms – in the genetic fixation of a certain state of inhibition.

The Chrysophyceae, as a class of great wealth of forms, pose a problem in systematics since opinions are presently still divided as to the importance to be attached to the various groups or morphological criteria. The author of the present synopsis has, in general, adopted the system designed by PASCHER which can truly be called "The" Chrysophyceae system because it is based on fundamental criteria common to all strains of algae. What makes classification at times so difficult are the many transitional forms for which to find a distinct place within the system often proves to be next to impossible. Appreciably, therefore, this system offers not a generally rigid framework but shows here and there a marked flexibility thus allowing for personal judgement in the systematic evaluation of a certain characteristic.

Before introducing the general outline of the Chrysophyceae system, we shall first take a look at its framework, that is, its principal categories.

The systematics of the Chrysophyceae is based on the following levels of organization:

I. Chrysomonadales: Flagellate state predominant, individuals motile. Level of organization: Flagellates. p. 10

II. Rhizochrysidales: Rhizopodial (amoeboid) state predominant. Level of organization: Rhizopodal.

III. Chrysocapsales: Immobile cells embedded in gelatinous colonial matrix in tetrasporoidal (palmelloid) formation; capable of reproduction and of returning (solely for this purpose) temporarily to a motile (flagellate) condition. Level of organization: Tetrasporales.

IV. Chrysosphaerales: Cells surrounded by solid membrane, vegetative life taking place within this enclosure. Solitary or in colonies. Level of organization: Protococcales

V. Chrysotrichales: Cells united to form simple or branched filaments. Uniseriate filamentous organization.

Following below, the author attempts to give a systematic outline of the entire class of Chrysophyceae. Many a limnologist may welcome finding here such a synopsis which takes the more recent research findings into consideration whenever possible. However, the outline offered cannot claim absolute completeness; this task is better left to the monographers specializing in this field. Nevertheless, the limnologist, especially the planktonologist, will probably find the list of species that are of major interest to him, to be fairly complete. Of course, here and there, different views may be taken with regard to the classification of certain forms; but then, any system is bound to be artificial. It can never be irrevocable but is, necessarily, subject to prevalent views. The author thought it important to observe the connectedness of this outline instead of (as is usually done) dispersing it in isolated steps throughout the text. The various aspects of this outline will of course have to be dealt with in greater detail wherever necessary in the text. One the other hand, those forms that are of no further importance to planktonology need not be discussed again later in the text. This synopsis has the advantage that it permits effortless determination of facts such as from which "parent soil" individual plankton organisms originate, in which environment they are usually found, whether the position of the planktonic forms is an intermediary or independent one, etc. For those investigators who prefer probing deeper into the biological interactions it will certainly be more stimulating to persue such relationships than being faced with yet another bare, noncommittal compilation or enumeration of plankton organisms. Especially in dealing with these primitive forms, whose levels of organization show progressing, that is, higher development from simple flagellar to definite algal forms, is it particularly interesting to study also the various degrees of planktonicity of organisms that have developed into planktonic forms.

Synopsis of the class of Chrysophyceae

A. Motile monadic state dominant, rhizopodial and palmella stages facultative ..... Series (subclass) of Chrysomonadales.

I. Monads with one apical flagellum ..... Order: Chromulinales.

a) Little differentiated chromatophore in form of a more or less distinctly developed network (reticulate chromatophore). p.11
Family: Chrysapsidaceae.
Only genus known: Chrysapsis.

b) Chromatophore well differentiated.

1. Protoplast with simple vacuolar system, without apical vesicle or sculptured cover; sometimes lying within a delicate open lorica or thick valves. ..... Family: Euchromulinaceae.

α) Cells naked (without lorica)
Cells not oblate ..... Subfamily: Chromulinoideae*
With the genera Chromulina, Pseudochromulina, Chrysamoeba, Wellheimia.
Cells oblate ..... Subfamily: Sphaleromantidoideae.
Only genus: Sphaleromantis.

β) Cells tightly enclosed in thick lorica, with a narrow opening at the anterior end through which the flagellum projects..... Subfamily: Kytochromulinoideae.
With the genera Chrysococcus, Porochrysis.

γ) Cells loosely fitted into delicate, open lorica; free-swimming and sessile forms without radial tentaculoids.
Subfamily: Lepochromulinoideae.
With the genera Kephyrion, Chrysococcocystis, Stenokalyx (free-swimming), Lepochromulina, Chrysopsis (sessile).

δ) Cells with radially arranged tentaculoids around anterior margin; sessile. ..... Subfamily: Cyrtophoroideae.
Pedinella, Cyrtophora, Palatinella; no euplanktonic forms, sometimes secondarily planktonic.

2. Protoplast with apical vesicle or pustulous system, and with tightly fitted, often intricately sculptured periplast (siliceous scales with or without siliceous setae, siliceous spines)
Family: Mallomonadaceae.

α) Unicellular forms .. Subfamily: Mallomonadoideae solitariae.
Chrysoglena, Microglena, Mallomonas, Conradiella.

β) Forms living in colonies
Subfamily: Mallomonadoideae aggregatae.
Chrysosphaerella.

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*) In accordance with internationally accepted rules of nomenclature, the author added the suffix "oideae" to those groups that he considers as subfamilies.

II. Monads with two apical flagella of equal length.
Order: Isochrysidales (Hymenomonadales).

a) Periplast of cells not particularly differentiated; cells without complex vacuolar system. Family: Syncryptaceae (Isochrysidaceae).

1. Cells without lorica, free-swimming, either solitary or in colonies. ..... Subfamily: Isochrysidoideae. p.1

α) Cells solitary ..... Tribe: Chrysidalideae.
1 genus only: Chrysidales.
β) Cells united in globose, gelatinous colonies.
Tribe: Isochrysideae.
Syncrypta, Pseudosyncrypta, Tessella.

2. Cells with delicate lorica attached to substratum by stipe.
Subfamily: Lepisochrysidoideae.
With the genera Stylochrysallis, Derepyxis (not planktonic but some of them are plankton epibionts).

b) Cells with firm periplast which is sculptured in various ways (siliceous scales, but no calcareous disks [coccoliths], and with apical system of vacuoles. ..... Family: Synuraceae (Euhymenomonadaceae).

1. Solitary forms presently unknown (the unicellular genus Hymenomonas, previously placed here, belongs to the Coccolithophoridaceae; see below).

2. Cells united in globose to filamentous colonies, each cell enclosed by firm periplast sculptured with setae, verrucae, or costae.

α) Colonies globose: Synura
β) Colonies filamentous: Chlorodesmus

c) Cells surrounded by gelatinous envelope covered with small calcareous disks of definite form, or by calcareous shell with or without coccoliths. ..... Family: Coccolithophoridae (Coccolithineae).

Mostly marine forms (5 subfamilies).
In fresh water represented only by ..... Syracosphaeroideae (Syracosphaeraceae).
With the genera Acanthoica and Pontosphaera and the Thoracosphaeroideae (Thoracosphaeraceae)
with one genus only: Hymenomonas.

III. Monads with two apical flagella of unequal length.
Order: Ochromonadales.

a) Cells with undifferentiated periplast, with or without lorica.
Family: Ochromonadaceae.

1. Cells naked, without distinctly differentiated periplast or lorica; solitary or in colonies. .. Subfamily: Ochromonadoideae.

α) Unicellular forms (Ochromonadeae solitariae) with the genus Ochromonas.

β) Cells united in colonies (Ochromonadeae aggregatae).
- Colonies spherical-ellipsoidal: Uroglena (Uroglenopsis), Volvochrysis, Synochromonas, Synuropsis.
- Colonies coronal: Cyclonexis.

2. Cells with delicate, usually open lorica of various shapes; solitary or in colonies, epiphytic or free-swimming.
Subfamily: Lepochromonadoideae.

α) Lorica appears homogeneous.
- Sessile (epiphytic) forms; solitary or in colonies: Stylopyxis, Poteriochromonas, Dinobryon (section Epipyxis).
- Free-swimming forms whose protoplast is attached (with or without stalk) to base of lorica (sometimes also slightly higher; solitary or in colonies: Pseudokephyrion, Kephyriopsis, Diceras, Dinobryon.

p. 13

β) Lorica made up of successive, laterally open, growth rings; Cells solitary or in dendroid colonies: Hyalobryon.

b) Cells with strongly differentiated periplast (siliceous platelets studded with spines), without lorica. Cells are colorless (no chromatophores), and live holozoic [heterotrophic], free-swimming or sessile on stipe. .....Family: Physomonadaceae.
With the genus Physomonas (to be dealt with under "colorless flagellates", p.101).

B. Cells of some species known only in rhizopodial form, solitary or united in spherical, linear, or amorphous colonies. In several other species, to be looked upon as transitional forms, the flagellated phase is still observed as a temporary phase in the life cycle (Chrysamoeba, placed among the Euchromulinaceae, and Brehmiella, see p.8).
Series (subclass) of Rhizochrysidinae.
One order: Rhizochrysidales.

I. Forms without lorica ..... Family: Rhizochrysidaceae.

a) Solitary, or united in chrysamoebic clusters. Protoplast with long rhizopodia [acicular pseudopodia]: Rhizochrysis.

b) Several of the amoeboid cells joined to one another to form chains: Chrysidiastrum.

c) Cells usually in doughnut-shaped colonies, with numerous excretory globules: Chrysostephanosphaera.

d) Cells forming reticulate colonies: Chrysarachnion.

e) Cells solitary, firmly attached to substratum by a pseudopodium, with Hydra-like tentaculoids, sometimes with flagellla reminiscent of Ochromonas: Brehmiella.

f) Mature cells forming dendroid colonies with fine, elastic, cytoplasmic stalk. Flagella (reminiscent of Ochromonas) are preserved despite rhizopodia formation: Chrysodendron.

II. Forms with lorica.

a) Lorica stipitate ..... Family: Stylococcaceae.

1. Lorica spindle-shaped; anterior end of cell has one long, rigid, rhizopodial prolongation (sessile): Stylococcus.

2. Lorica cyathiform; cells with 6-8 long rhizopodia in wheel-spoke formation: Rhizaster.

b) Lorica with broad base (without transversal projection), sessile; flask-, bell-, or cone-shaped (not planktonic): Lagynion, Heterolagynion, Chrysocrinus. ..... Family: Lagynionaceae.

C. Immobile stages in palmelloid (tetrasporoidal) gelatinous envelope predominant, motile monadic phase facultative. p.14

Series (subclass) of Chrysocapsinae
One order only: Chrysocapsales.

I. Gelatinous thalli without apical growth, palmella stages more or less amorphous. .....Family: Chrysocapsaceae.

a) Gelatinous colonies forming small globose lumps, in most cases free-floating: Chrysocapsa.

b) Gelatinous colonies more saccate-tubular, frequently branched: Phaeosphaera.

II. Cells form mono- or multistromatic colonies surrounded by gelatinous envelope bearing a single cluster of apical gelatinous setae.
Family: Naegeliellaceae
With one genus: Naegeliella (sessile).*

III. Cells in sessile colonies of the Hydrurus type but without apical cell; apical growth is taken care of by a group of cells (apical meristem). Single cells occasionally capable of swarming (Chromulina-type swarmers, also amoeboid motility of single cells without flagellum, cyst formation). ..... Family: Celloniellaceae.
One genus: Celloniella.

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*) Translator's note: G.M.SMITH (1950) includes in this family also the genus Chrysostephanosphaera which is (in contrast to Naegeliella) free-floating.

IV. Cells forming more or less long thalli (in cold mountain streams) by way of apical growth (apical cell). ..... Family: Hydruraceae
With the genera Hydrurus, Nanurus.

D. Cells more or less firm and thick-walled (protococcoid habitus); immobile, solitary or in nonfilamentous colonies. Parallel to normal cell formation there are also motile swarmers, rhizopodial or palmella stages as well as gloeocysts. Mostly sessile forms.
Series (subclass): Chrysosphaerinae
One order: Chrysosphaerales
with the family: Chrysosphaeraceae
Chrysosphaera, Chrysobotris, Epichrysis.

E. Cells united in filamentous, unbranched or genuinely branched, thalli. Sessile forms. ..... Order: Chrysotrichales.

I. Unbranched filaments ..... Family: Nematochrysidaceae
Genus: Nematochrysis (marine).

II. Branched filaments without parenchymatous growth.
Family: Phaeothamnoniaceae
Genera: Phaethamnion, Chrysoclonium.

III. Branched filaments forming parenchymatous thalli.
Family: Thallochrysidaceae
Genera: Phaeodermatium (in cold mountain streams),
Thallochrysis (in brackish water).

F. Cells uniseriately arranged in discoid, vaulted thalli of nonfilamentous character ("blastoparenchyme" after GEITLER) with regular sequence of cell division; sessile. ..... Order: Chrysothallales
Family: Chrysothallaceae
With the genus Chrysothallus K.J.MEYER, 1930 (epiphytic on Gomphonema geminatum, Lake Baikal).

Subclass 1: Chrysomonadae

p.15

(Euchrysomonadinae, Chrysomonadales)

Monads with 1-2 apically inserted flagella; in general, motile stages predominant. Rhizopodial and palmella stages temporary and known only of some species. Cyst formation has been investigated for a number of forms, and also the germination of such cysts. There are distinct developmental trends toward the Chrysocapsales.

Outline of the orders that make up the Chrysomonadae:

A. Monads with one flagellum ..... Chromulinales (below)
B. Monads with 2 flagella of equal length..... Isochrysidales (p. 41)
C. Monads with 2 flagella of unequal length ..... Ochromonadales (p. 50)

Order 1: Chromulinales

Free-swimming or sessile chrysomonads with a single apical flagellum. Consist almost exclusicely of solitary forms (the only exception being the colony-forming Mallomonadacea Chrysosphaerella). Flagellum sometimes reduced (even within one and the same genus, e.g., Chrysopyxis) and replaced by unbranched or branched rhizopodia [pseudopodia]. In some forms, that is, among the nonplanktonic Cyrtophorea, a tentaculoid ring is formed around the flagellum. Developmental trends toward the Chrysocapsales. This series is the richest in forms among the chrysomonads.

Outline of the families belonging to the Chromulinales:

A. Little differentiated chromatophore, "in form of a network that is undecided about its formation" (reticulate chromatophore).
Chrysapsidaceae (below)

B. Chromatophore well differentiated
1. With simple vacuolar system, without apical vesicle and without sculptured lorica. ..... Euchromulinaceae (p. 11).
2. With apical vesicle or pustulous system, and with firm, intricately sculptured periplast (siliceous scales with or without setae, siliceous spines)
Mallomonadaceae (p.30).

Family: Chrysapsidaceae

Chromulina-type cells, solitary, with undifferentiated chromatophore which varies greatly in form in that it is sometimes only slightly indicated as a fine meshwork, while, at other times, it consists of wide strands which are frequently combined to form one apparently homogeneous chromatophore. Reproduction by way of longitudinal cell division. Spine-studded cysts have been recorded for some species. Only genus known: p.16

Chrysapsis PASCHER

Cells solitary or held together, for a short time after division, by a gelatinous matrix; metabolous or almost ametabolous, without differentiated periplast. Chromatophore not sharply delimited and consisting of a meshwork which greatly varies in its quantitative development. Eyespot may be present. Vacuoles in most cases distinct. Cysts with acicular verrucae or setae (one brackish species). Nutrition holophytic or heterotrophic.

Almost exclusively consisting of fresh-water forms, free-swimming on the surface of pondlike bodies of water. So far, only one species (Chrysapsis yserensis CONRAD) is known to live in brackish water. CONRAD also observed Chrysapsis sphaguorum in the "pore cells" of decaying Sphagnum plants.

A. Flagellum same length as cell body, or slightly longer. Cells slightly metabolous, chromatophore more or less in lateral position.
   1. Cells 12-14 μ long, 9 μ wide ..... Chrysapsis fenestrata 1.
   2. Cells 50 μ long, 20-30 μ wide ..... Chrysapsis gigantea 2.

B. Flagellum much longer than protoplast. Cells very metabolous.
   1. Cells 7-13 μ long, flagellum three times longer than protoplast. Chrysapsis sagene 3.
   2. Size of cells 3-5 μ, flagellum up to five times longer than protoplast ..... Chrysapsis agilis 4.

Family: Euchromulinaceae

p. 17

Cells naked, without differentiated cover, occasionally seen in loose, open lorica or in more or less thick valves; periplast sometimes more distinct. One apical flagellum. Without anterior pustulous system or apical vesicle. 1-2 very distinct chromatophores of various shapes. — Comprising a very large number of free-swimming and sessile forms.

[illegible] with definite rhiz[illegible]

Outline of the subfamilies:

A. Cells without tentaculoid ring.

I. Cells naked (without casing or lorica)

a) Cells not oblate .... Chromulinoideae (below)

b) Cells strongly oblate ..... Sphaleromantodoideae (p. 23)

II. Cells tightly surrounded by thick lorica which only leaves a narrow opening at the anterior end through which the flagellum projects (very rarely, a fine porus can also be seen at the posterior end). Cells may also be surrounded by a calcareous lorica with an anterior opening for the flagellum while the posterior portion shows a sievelike perforation through which pseudopodia are projected.

Kytochromulinoideae (p. 23)

III. Cells with delicate, usually somewhat loose, open lorica. p.18

Lepochromulinoideae (p. 26)

B. Cells with tentaculoid ring at anterior end .. Cyrtophoroideae (p. 29)

Subfamily: Chromulinoideae

Cells naked, motile, round in cross-section, rarely angular, never flat; solitary, sometimes temporary tendency to form colonies. Developmental trend toward the Chrysocapsales and Rhizochrysidales are sometimes observed.

Key for the genera of the Chromulinoideae:

A. Organisms without definite rhizopodial stage.

I. One or two chromatophores

a) Cells ellipsoidal, ovi- or pyriform, spindle- or cone-shaped, sometimes spherical. In optical cross-section circular or square. More or less metabolous, but also ametabolous. Cysts spherical, radially symmetrical. ..... Chromulina (p. 13)

b) Cells spherical, asymmetrical cysts which are oviform in lateral view ..... Pseudochromulina (p.20)

c) Cells oviform, triangular with 3 slightly coiled longitudinal ridges. Cysts spherical with thick verrucose membrane.

Pyramidochrysis (p.21)

d) Cells cylindrical without longitudinal ridges, anterior end with unilateral slit from which a stout axopodium can be extended.

Wellheimia (p.21)

II. Four chromatophores (diploid organism) ..... Amphicrysis (p.20)

B. Organisms with definite rhizopodial phase ..... Chrysamoeba (p.21)

Chromulina CIENKOWSKY, 1870

Cells ovi- to pyriform, ellipsoidal, conical or cuneiform, sometimes fusiform, cylindrical or globose; frequently very metabolous (particularly at the posterior end), but often only slightly metabolous, amoeboid or rigid, solitary or showing tendency to form colonies. Protoplast "naked," in most cases with a distinctly differentiated membrane (periplast) which may be smooth, granular, or more or less densely covered with verrucae; only one species is known whose cells are, in addition, surrounded by a definite, firm, gelatinous envelope. Cross-section of cell may appear circular, rarely somewhat compressed (broadly oval) or square. One apical flagellum. 1-2 chromatophores (sometimes more, due to division), sharply demarcated either in the form of a soup-plate or cup, sometimes also tunic-, band-, or ring-shaped, in the latter case often spirally twisted; with straight, smooth, or more or less strongly lobed edges and frequently with very distinct, more or less broad, hemlike folds. If two chromatophores are present (rare case) they lie on opposite sides of the cell. In a few species, p. 19 a pyrenoid has been observed for each chromatophore, that is, within each chloroplast. Some species have an eyespot. One, two, or more contractile vacuoles are found in the anterior cell portion. The position of the nucleus (evident only upon staining) varies from species to species: It may be situated in the extreme anterior part at the base of the flagellum, in the median, or closer to the posterior portion of a cell. Leucosin usually accumulates in a more or less large granule at the posterior end of a cell; in addition, smaller droplets of fat may be seen. Cysts [statospores] are known for a great number of species. Their endogenous formation (that is, within the plasma substance) has been subject to detailed investigations for several species (DOFLEIN 1923). They are spherical and have a smooth or spine-studded enclosing wall, a pore with or without collar and are closed by

a plug. Germination takes place as follows: The protoplast within a statospore develops again into flagellated monads whereupon the contents are liberated by dissolution of the plug and migrate through the porus to the outside.

Taxonomic key for the Chromulina species: p. 22

A. Flagellated cells naked, without gelatinous envelope.

I. Cells with smooth (or almost smooth) periplast.

a) With one chromatophore.

1. Chromatophore homogeneous, not reticulate, but sometimes with undulate, more or less lobed margins; in the case of two large lateral lobes with connecting bridge.

α) Chromatophore soup-plate or cup-shaped, not tunic- or ring-shaped.

- With eyespot.

— Cells very minute; spherical, 3 μ in diameter. Chromatophore in lateral position, occupying half a hemisphere. Chromulina parvula 1.

— Cells larger

— Cells more or less ellipsoidal with strongly metabolous base, posterior end round or pointed, anterior end marginate; size = 9-14 X 6-7 μ, flagellum 1 1/2 times longer than cell body...(1) Chromulina ovalis 2.

— Cells oviform, anterior end pointed and almost rigid; size = 13-15 X 6-8 μ, flagellum 1 1/2 times longer than cell body. Solitary, or temporarily forming small colonies. .....(2) Chromulina hokeana 3.

— Cells ovi- to cuneiform, anterior end obliquely truncate and broadened, posterior end pointed, with 1 (?) chromatophore; size 7 X 4 μ. (3) Chromulina obconica 4. p. 23

— Cells cuneiform, anterior end marginate, one corner slightly projecting; posterior end pointed, sides mildly convex (uneven). Length of flagellum = 3/4 of cell body which measures 12 X 3.5-4 μ. (4) Chromulina cuneata 5.

— Cells pyriform, 16-18 μ long; both ends round, the anterior one narrower than the posterior end. Chromatophore saucer-shaped, front lobed, with narrow hem around edges. ..... (5) Chromulina grandis DOFLEIN 6.

- Cells reversed cuneiform, anterior end rounded off, posterior end tapered to a point. Flagellum not quite the length of cell body which measures 11-12 X 5.5 μ.
(6) Chromulina pyriformis PLAYFAIR 7.

- Cells spherical, 16 μ in diameter. — Chromatophore "in center of cell," margins with distinct hem; flagellum about 1 1/2 times longer than cell body.
(7) Chromulina sphaerica BACHMANN* 8.

- Without eyespot**
  - Cells predominantly oviform.
    - Cells very minute (2-4 μ)
      - Chromatophore occupies about 4/5 of the length of the cell body which measures 2-3 μ; anterior end slightly notched. Flagellum somewhat longer than cell body..... (1) Chromulina minima 9.

      - Chromatophore in the form of a mildly saucer-shaped platelet. Size of cells 2-3 μ, cells strongly metabolous. Flagellum 5-7 times longer than cell body.
(2) Chromulina microplankton 10.

    - Cells larger.
      - Cells 6-10 μ long, anterior end broadened and bulging, posterior end pointed or roundish. Chromatophore somewhat spirally twisted and running along more than half of the cell wall. Flagellum 1 1/2 times longer than cell body.
(1) Chromulina zartensis 11.

      - Cells measuring 8-9 X 4-6 μ, more or less oviform, metabolous to a limited degree. Cysts with distinctly flange-like collar; frequent among neuston ("golden luster"). .... (2) Chromulina rosanoffii 12. p.24

      - Majority of cells oviform, rarely globose-ellipsoidal, strongly metabolous; size: 6-9 X 5-7 μ. Flagellum slightly longer than cell body. Cysts without flange-like neck..... (3) Chromulina woroniniana 13.

      - Cells broadly oviform, basal chromatophore saucer-shaped; flagellum barely as long as the cell body which measures 18 X 15 μ....(4) Chromulina crassa 14.

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*) Cf. also Chromulina sphaerica DOFLEIN which is about 4 times smaller and has a much shorter flagellum, furthermore 2 chromatophores and 2 pyrenoids (p.18).

**) Whether the eyespot is really always absent has not been confirmed for all the species listed here. Some diagnoses only state carefully: "Eyespot not observed." Forms for which ocelli have not been mentioned, have here been listed among species "without eyespot."

— Cells in most cases ellipsoidal, less frequently also spherical or oblong.

— Anterior end of cell slightly bulging; size 5-7 X 4-5 µ. Flagellum not quite as long as cell body. Chromatophore with definite hem around margins and situated in anterior portion of cell.
(1) Chromulina ovaloides 15.

— Anterior part of cell broad, obliquely truncate and notched; slightly compressed: 15-18 X 8-10 µ. Flagellum slightly longer than cell body.
(2) Chromulina magna 16.

— Cells in most cases ellipsoidal, anterior end without notch; often elongated but sometimes also rounded off considerably. Size 9-15 X 6-9 µ. Chromatophore with 2 large lateral lobes connected by a more or less wide bridge. (3) Chromulina freiburgensis 17.

— Cells spherical.

— Cells very minute (3-4 µ), spherical to oval, quite metabolous. Chromatophore occupies nearly the entire inner cell. ..... (1) Chromulina elegans 18.

— Cells larger, front broadly truncate and slightly indented. Flagellum 1 1/2 times longer than cell body. Chromatophore very large, occupies nearly the entire interior of the cell, leaving only a narrow, often more or less triangular slit open. Size: 25 µ.
(2) Chromulina truncata 19.

— Cells pyriform.

— Cells measure 13-18 X 13 µ; pyriform to spheroidal, metabolous. Chromatophore saucer-shaped, flagellum about twice the length of the cell body.
(1) Chromulina danubiensis 20.

— Cells 28 µ long, anterior end pointed, posterior end broad; posterior portion metabolous. Chromatophore in median position, slightly towards anterior end. p. 25
Flagellum 1 1/2 times longer than cell body.
(2) Chromulina pyriformis BACHMANN 21.

— Cells up to 30 µ long, posterior portion metabolous. Chromatophore platelike, in median or pronounced anterior position. Flagellum about same length as cell body (perhaps identical with preceding species ?).
(3) Chromulina gigantea 22.

β) Chromatophore tunic- or band-shaped, cylindrical, straight, or more or less spirally twisted.

- Chromatophore in the form of a wide band.

— Cells metabolous.

— Anterior end of cell rounded off, but not bulging; cylindrical. Strongly metabolous, particularly the basal portion (often tapered to a point). Flagellum up to 4 times the length of the cell body.
(1) Chromulina pseudonebulosa 23.

— Anterior end of cells slanted and rimmed, not broadened. Flagellum barely as long as cell body.
(2) Chromulina nebulosa 24.

— Cells strongly metabolous, oviform to about spherical when at rest, ellipsoidal, ovi- or pyriform when motile. Flagellum 3/4 the length of cell body. Spine-studded cysts. ..... (3) Chromulina echinocystus 25.

— Cells metabolous to a limited degree, or ametabolous.

— Cells slightly metabolous; oblong, ellipsoidal to cylindrical. Chromatophore forming a wide band, its ends almost touching one another. 12-14 X 5-6 μ.
(1) Chromulina vagans 26.

— Cells more or less cylindrical, ametabolous. Chromatophore tunic-shaped, covering almost the entire side of the cell lengthwise. 5-7 X 1-2 μ.
(2) Chromulina naunos 27.

— Cells ametabolous; slightly conical. Chromatophore forms a longitudinally fissured cylinder. Cells measure 13 X 5-6 μ. ..... (3) Chromulina gyrans 28.

- Chromatophore forms strongly spiralling narrow band.

— Cells reversed oviform, metabolous; anterior end slanted and rimmed. ..... Chromulina commutata 29.

— Cells fusiform, rigid. Chromatophore rather long and spiralling, but also X- or H-shaped. Flagellum 50% longer than cell body. Spine-studded cysts.
Chromulina fusiformis 30.

γ) Chromatophore distinctly annular, describing 1/2 to 3/4 of a circle, more or less equatorial. Cells oviform, almost ametabolous, very minute (3-4 X 2-3 μ).
Chromulina annulata 31.

b) Chromatophore situated in anterior portion of cell.

- Cells embedded in gelatinous flakes; chromatophore has striped appearance due to its folds. Chromulina mucicola 32.

- Resting cells not embedded in gelatinous flakes; see Chromulina grandis DOFLEIN [p. 14], Chr. pyriformis [p. 15], Chr. gigantea [p. 16], Chr. echinocystus [p. 17]. p. 26

2. Chromatophore urn-shaped, split nearly all the way to the bottom into several slightly spiralling bands. Eyespot present. Chromulina polyteniata 33.

b) Two chromatophores (see also Chromulina stellata, pyrum, and conica [p. 19]).

1. Cells in cross section roundish (circular to broadly oval).

α) Periplast coarsely granular, protoplast metabolous, chromatophore saucer-shaped. 14-19 X 6-12 μ. Chromulina flavicans 34.

β) Periplast smooth.

- Cells cylindrical, actively metabolous; 7-11 X 4-9 μ. Chromulina minor 35.

- Cells spherical.

— Diameter of cell 4-5 μ. Number of chromatophores uncertain. Flagellum not quite 3/4 the length of cell body (see also Chr. sphaerica BACHMANN, which is about 4 times larger; p. 15)... Chromulina sphaerica DOFLEIN 36.

— Cells 8-10 μ, barely metabolous. Flagellum almost 2 1/2 times longer than cell body. .. Chromulina sphaeridia 37.

- Cells ellipsoidal, ametabolous.

— Cells very minute, about 3 μ long. Number of chromatophores not quite certain (2 or 1 ?). Flagellum at least as long as cell body, 2 pyrenoids.. Chromulina minuta 38.

— Cells larger (15 X 10 μ). Chromatophores with irregularly undulate margins. ..... Chromulina batalinii 39.

- Cells more cuneiform, pointed at posterior end. Eyespot present. Flagellum 1 1/2 times longer than cell body; 2 (?) chromatophores. Anterior end obliquely truncate. Chromulina obconica 4*

2. Cells in cross section more or less square, 25-36 μ long. Chromulina spectabilis 40.

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*) p. 14

3. Cells in cross section quite distinctly oblate. Size = 10-12 μ. Contour in lateral position circular). ... Chromulina rotunda 41.

II. Cells with verrucose periplast.

a) Verrucae solid.

1. Cells globose to transversely spheroidal; only one chromatophore.

α) Cells of medium size (15-20 μ).

- Anterior end of cell weakly rimmed. Broad beltlike chromatophore. Periplast sometimes also not verrucose). Cell size 15-20 X 15 X 19 μ. ..... Chromulina globosa 42.

- Anterior end of cell obliquely truncate. Chromatophores trough-shaped to (nearly) broad semicircular. Chromulina pascherii 43.

β) Cells relatively large (27-35 μ); few minute verrucae. Chromulina grandis SCHILLER 44.

2. Cells ellipsoidal.

α) Cells with 1 chromatophore which is deeply rimmed, with lobed margins. 20-24 X 13-5 μ. ..... Chromulina scherffelii 45.

β) Cells with 2 chromatophores in lateral position; margins undulate, notched. 13 X 9 μ. ..... Chromulina stellata 46.

3. Cells more or less pyriform, p. 27

α) Anterior end truncate; verrucae sparse. Chromulina verrucosa 47.

β) Anterior end rounded off; verrucae joined by delicate costae. Chromulina pyrum 48.

4. Cells conical; anterior end broad, not rimmed. Two lateral chromatophores. ..... Chromulina conica 48.

b) Verrucae hollow due to a layer of vacuoles in the ectoplasm, filled with fluid and dissolved during conservation process. Cells form a short oval and have 2 pyrenoids. Chromatophore very large with wide marginal folds. Size of cells 4-6 μ. Chromulina dubia 50.

B. Flagellated cells enclosed in a firm, well-defined, gelatinous matrix (periplast smooth). ..... Chromulina vestita 51.

Of course, the key just presented can only be provisional. It is very likely that the systematics of the collective genus Chromulina will, at some future time, be rearranged on the basis of entirely different cri-

teria, namely on the structural characteristics of the cyst. A first attempt in this direction has already been made by CONRAD (1931). For the time being, the main difficulty of consequently building up on this lies merely in the fact that the cysts have been studied only for a limited number (about one third) of Chromulina species.

Amphichrysis KORSHIKOV, 1929 p. 49

Cells solitary, free-swimming, without differentiated periplast, metabolous. Four chromatophores and two contractile vacuoles, symmetrically facing one another, at the anterior end. A single apical flagellum. Chromatophores flanked by leucosin deposits; leucosin granules also between the chromatophores at the posterior end of the cell. Reproduction by longitu- p. 50
dinal cell division. Endogenous formation of cysts of the usual chrysomonadal type which is preceded, however, by temporary formation of a mucuous protective sheath around the cell body. Holophytic nutrition. Only one species known: Amphichrysis compressa KORSHIKOV.

Pseudochromulina DOFLEIN, 1923 p. 51

Cells globose, fairly amoeboid, with finely granular protoplasm. One flagellum of about the same length as that of cell body. Yellow chromatophore with strong, hemlike rims; without pyrenoid, and without eyespot. Two vacuoles at the anterior end. Karyosome in the median portion of cell body, or closer to the root of the flagellum. Cyst of asymmetrical structure. Contour ovoid; at one end, margin of porus elevated into a flange-like collar in the shape of a truncate cone; silicified. Only one species known so far: Pseudochromulina asymmetrica DOFLEIN.

Pyramidochrysis PASCHER, 1929

Cells ametabololous, rigid, oviform (more or less pyramid-shaped); two of the three edges are closer together (hence, monosymmetric). All three edges show slight helical windings, and have the form of a torus or wing-shaped projection, tapering off towards the apex. One large, bowl-shaped chromatophore in either lateral or basal position. Two contractile vacuoles, one relatively strong, apical flagellum performing spiralling motions. Reproduction by division while the cell is motile; the daughter cells are temporarily kept together by a gelatinous matrix. Cysts, which are, so far, known of one species only, are spherical, have a thick verrucose wall from which the contents (protoplast) are liberated. Holophytic nutrition. Two species: p.52

A. Longitudinal ridges winglike projected, smooth.
Pyramidochrysis splendens 1.
B. Longitudinal ridges toroidal, granular ..... Pyramidochrysis modesta 2.

Wellheimia PASCHER

Cells naked, without siliceous plates or lorica, of a saccate-tubular form, without longitudinal tori, smooth. Anterior end truncate, posterior end pointed. Anterior end with lateral fissure from which a sturdy rhizopodium (= axopodium) can be extended which, apparently, takes place only in response to certain stimuli. One species:

> Wellheimia pfeifferii PASCHER, with the characteristics of this genus. Found in polluted, bacteria-infested waters; not a planktonic form.

Chrysamoeba KLEBS, 1893

So far, only two species of this genus are known in greater detail. However, it is very likely that still other forms may be detected. The two known species differ in some essential aspects (to be discussed in detail later*)

*) Translator's note: The detailed description of the 2 species involved (pp.53-55 of original) is not marked for translation and is, therefore, not included here.

thus giving the impression that they are not that closely related.

The feature common to both these species is that their life cycle consists of two, more or less distinctly different, phases: One monadoid, flagellated state, the other rhizopodial. However, intermediate phases have also been observed, that is, pseudopodia-bearing flagellate forms. p. 53

The motile form (flagellated state) shows Chromulina-type characteristics: Spherical to ellipsoidal in shape, with one apical flagellum and several minute contractile vacuoles which are usually situated in the anterior end of the cell. An eyespot is present in one species, but lacking in the other. There are 1-2 yellow, distinct, chromatophores; leucosin, oil droplets. — The rhizopodial form has either thick and short or long and delicate pseudopodia, frequently both at the same time in varying numbers. Occasionally, pseudopodia are observed also in the presence of the flagellum ("mastigamoeboid state"). While the two phases are often distinctly different (even in their duration) in one of these species (Chrysamoeba radians), such a division is, apparently, less pronounced among the second form (Chrysamoeba helvetica).

The genus Chrysamoeba may be considered as the connecting link between the Chromulinales and the Rhizochrysidales, the flagellated state being completely suppressed among the latter.

The two species differ as follows:

A. Flagellate cells oviform, 12-15 μ long, 8-10 μ wide. Flagellum longer than cell body; 1-2 chromatophores, without eyespot. Cysts globose, smooth-rimmed. (Amoeboid state not characteristic)
Chrysamoeba radians.

B. Flagellate cells more or less spherical, 11-13 μ in diameter. Flagellum only 3/4 the length of the cell body, with eyespot and 1 chromatophore. Cysts unknown. (Amoeboid state not characteristic)
Chrysamoeba helvetica.

Subfamily: Sphaleromantidoideae p.55

Cells in optical section always compressed, never circular. One apical flagellum, 2 chromatophores. Eyespot present.

Sphaleromantis PASCHER, 1913

Cells discoid, narrow ellipsoidal in cross section, almost cookie-shaped, also rod-shaped or sigmoid. Contour broad oviform-triangular, with rounded corners, sometimes almost heart-shaped; also rectangular to trapezoid, or evenly oviform, even spherical. Protoplast slightly metabolous or rigidly fixed. Two platelike chromatophores, often slightly overlapping, one on each side. Two pulsating vacuoles. One apical flagellum, 2-4 times the length of the cell body. Large linear stigma. Cell division undetermined, cysts unknown. Motions consisting of a fast, flickering, irregular staggering and rocking. p.56

List of Sphaleromantis species:

A. Basic form of cells triangular, with broadly rounded corners, or heart-shaped. In cross section oblate. Found in fresh and brackish waters. Sphaleromantis ochracea.

B. Cells oviform, posterior end broadly rounded with narrow, sharp, winged blade running ventrally and dorsally from apex to base. Cross-section rod-shaped. In brackish water. ..... Sphaleromantis alata CONRAD.

C. Cells circular (without winged costae: surface undulate, in cross section sigmoid. In brackish water. ..... Sphaleromantis subsalsa CONRAD.

D. Cells rectangular or trapezoid. In fresh water. Sphaleromantis tetragona.

Subfamily: Kytochromulinoideae p.57

Cells tightly surrounded by relatively thick, sometimes lamellated lorica whose surface is often sculptured, leaving a fine opening for the flagellum at the anterior end (there are only 3 species that show a fine porus also at the posterior end); lorica may also be calcareous with anterior opening for the flagellum, the posterior portion with sievelike per-

forations through which pseudopodia can be extended. Comprising two genera, p.58
to be distinguished as follows:

A. Cell body tightly surrounded by thick-walled lorica having an apical porus for the flagellum (3 species also with a fine basal pore). Chrysococcus (below).

B. Cell body not tightly surrounded by calcareous lorica, with one anterior opening for flagellum, posterior portion with sievelike perforation to allow for projection of delicate axopodia. ..... Porochrysis.

Chrysococcus KLEBS, 1892

Protoplast surrounded by more or less thick, firm, frequently tight but often open lorica which is apparently homogeneous, sometimes (partially or entirely) lamellated, spherical to oviform, smooth or sculptured, with anterior opening for the flagellum. The opening may consist of a very narrow or broad circular porus, or of a tubular projection as the orifice. Very rarely, a second opening is seen at the basal end of the lorica. The lorica may be hyaline, but is often brown, sometimes to the point of being opaque (iron impregnation). One or two chromatophores, in one species 1-5. An eyespot has been observed in some (not in all) species. 1-2 contractile vacuoles at the anterior end. One flagellum, 1-7 times longer than cell body. Reproduction by division of protoplast within the lorica, thus forming two daughter protoplasts, one of which escapes through the opening for the flagellum (Chromulina-type swarmers) and secretes a new lorica. Cysts have not been observed.

Key for the classification of Chrysococcus species: p.59

A. Lorica smooth.

I. Lorica in most cases of even thickness throughout, perfectly spherical or ellipsoidal.

a) Lorica with only one opening (for the flagellum).

1. Chromatophore relatively large. Periplast without sectional markings of anterior portion.

α) Size of lorica 2-3 μ. One chromatophore. Flagellum 6-7 times longer than cell body. .... Chrysococcus punctiformis 1.

β) Size of lorica 8-11 μ. Two chromatophores. Flagellum 2-3 times longer than cell body. ..... Chrysococcus rufescens 2.

2. Chromatophores small. Anterior portion of periplast with sectional markings. Diameter of lorica about 14 μ. Flagellum twice as long as cell body. ..... Chrysococcus tesselatus 3.

b) Lorica with a second opening in form of a minute porus at the antapical pole.

1. Margin of the porus for the flagellum annular; smooth, without verrucae. ..... Chrysococcus porifer 4.

2. Margin of the porus for the flagellum with two minute verrucae. Chrysococcus minutus 5.

3. Lorica slightly thicker at the flagellated pole, including the porus which is also slightly elevated. . Chrysococcus hiporus 6.

II. Lorica basically globose, but with a wartlike protuberance at the apical pole. ..... Chrysococcus umbonatus 7.

B. Lorica sculptured (verrucae, costae, rods or thorns).

I. Lorica globose, of even thickness.

a) Surface of lorica covered with minute roundish verrucae which are connected by a network of fine costae. . Chrysococcus klebsianus 8.

b) Surface of lorica with short, transversal, "sausage-shaped," costae. ..... Chrysococcus heverlensis 9.

c) Surface of lorica with short, "radially" projected rodlets.

1. Three to five chromatophores; diameter of lorica 6-8 μ. (Very doubtful whether this species belongs to Chrysococcus.) Chrysococcus dokidophorus

2. One chromatophore; diameter of lorica 7-15 μ. Chrysococcus radians

d) Basal end of lorica with two very long, thin setae. Opening for the flagellum (in contrast to the other species) elevated into collar. ..... Chrysococcus bisetus 10.

II. Lorica oviform, of uneven thickness (basal portion thickest); visibly stratified, surface covered with numerous minute verrucae. Chrysococcus ornatus 11.

Subfamily: Lepochromulinoideae

p. 66

Cells solitary, free-swimming or sessile, with delicate, loose, open lorica. One flagellum, but sometimes also a rhizopodium, extended through the more or less broad opening of the lorica. With or without eyespot. Colonies are not formed. Reproduction by longitudinal division, whereby one daughter cell remains within the mother lorica, while the other escapes (swarmer) and secretes a new lorica, or by budding, in which case the base of the daughter cell is attached to the mouth of the mother lorica, but becomes detached soon afterwards.

Key for the determination of the genera: p. 67

A. Free-swimming forms.

I. Lorica smooth, hyaline, without flangelike collar or annular inspissation lines.

a) Lorica ovi- or fusiform, or truncate cone-shaped. Protoplast fills only the lower half of the lorica. ..... Kephyrion (below)

b) Lorica flask-shaped or saccate. Protoplast attached centrally by a minute stipe. ..... Chrysococcocystis (p.27)

II. Lorica with 1-2 flangelike collars or annular inspissation lines; oval or cap-shaped, yellow or brownish, frequently almost colorless. Protoplast fills the lorica almost completely. .. Stenokalyx (p.28)

B. Sessile forms (not planktonic).

I. Lorica stipitate or without stipe, and without two basal, pronglike projections holding on to the substratum (filamentous algae). Occasionally tychopotamic. ..... Lepochromulina.

II. Lorica without stipe, with two pronglike-closing projections riding on the substratum (filamentous algae). ..... Chrysonyxis.

Kephyrion PASCHER, 1913

Protoplast sitting in the bottom half of a delicate, ovoid to spindle-shaped lorica which is only slightly tapered and broadly truncate at the anterior end; the protoplast completely fills only the lower half of the lorica. One chromatophore, usually parietal, equatorial, ring-shaped. One

terminal flagellum, as long as the lorica or longer. At the time of reproduction, the daughter cells slowly slip out of the lorica and secrete, free-swimming, their own lorica. Cysts?

Very minute, planktonic chrysomonads obtainable only by centrifugation; extremely fragile nannoplankters. One species has been newly discovered only recently also in brackish water: Kephyrion petasatum CONRAD (Belgium).

Key for the classification of Kephyrion species:

o Lorica smooth, without costae or tori.

A. Lorica spindle-shaped, optical section circular, anterior end straight truncate. ..... Kephyrion sitta 1.

B. Lorica oviform, circular in cross section.

I. Anterior end truncate (straight).

a) Flagellum same length as lorica ..... Kephyrion doliolum 2.
b) Flagellum 2-2 1/2 times longer than lorica. Kephyrion mastigophorum 3.

II. Anterior end obliquely truncate, flagellum as long as lorica. Kephyrion ovum 4.

C. Lorica truncate conical, abruptly narrowing in anterior quarter; cross section ellipsoidal. ..... Kephyrion cupuliforme 5.

oo Lorica with costae, tori, etc.

A. One horizontal torus along border between basal and apical portion of lorica. ..... Kephyrion rubri-claustri 6. p. 68

B. Lorica with helical markings, describing 1-2 turns.

I. Helical markings thickly elevated; surface of lorica between these elevations quite strongly concave ..... Kephyrion spirale 7.

II. Helical markings flat, bandlike, not or only slightly elevated. Surface of lorica between markings little or not concave. Kephyrion mosquense 8.

Chrysococcocystis DOFLEIN, 1923 p. 72

Protoplast globose or roughly oviform (Chromulina-type), surrounded by delicate, hyaline, flask-shaped or saccate lorica which it does not fill completely; with more or less distinct basal stipe, inserted at bottom of lorica (always ?); cell occupies approximately the center portion of the

lorica. With one apical flagellum; in one species only, this is replaced by a slender pseudopodium capable of ingesting minute particles of solid food. One chromatophore, 1-2 apical vacuoles have been observed. No eye-spot.

One species lives epiphytic on Dinobryon, all other species are free-swimming.

Key for the classification of Chrysococcocystis species:

A. With one flagellum.

I. Lorica sessile; opening for the flagellum strongly oblique. Chrysococcocystis dinobryonis 4.

II. Lorica free; opening for the flagellum straight.

a) Lorica oviform, without collar ..... Chrysococcocystis ovoides 1.

b) Lorica globose, opening elevated into truncate-conical collar. Chrysococcocystis elegans 2.

B. Filamentous pseudopodium (instead of flagellum); lorica nearly globose, with oblique opening. ..... Chrysococcocystis rhizopodica 3.

Key for the classification of Stenokalyx species:* p.75

A. Lorica with one distinctly elevated collar.

I. With definite neck between mouth of lorica and edge of collar. Stenokalyx monilifera 1.

II. Collar directly adjacent to mouth of lorica ... Stenokalyx parvula 2.

B. Lorica with two flangelike or winged costae.

I. Colorless cylinder sitting on top of the lorica, the two flangelike costae forming a ventral groove. ..... Stenokalyx circumvallata 3.

II. Lorica gradually tapered toward anterior end; both collars of very irregular structure, with 1-3 interruptions, not forming longitudinal groove. ..... Stenokalyx inconstans 4.

C. Without collar, only with one ring-shaped thick rim.

I. Lorica with distinctly demarcated colorless cylinder. Stenokalyx cylindrica 5.

II. Lorica gradually tapered toward anterior end. . Stenokalyx densata 6.

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*) After Gerlind SCHMID, 1934.

Translator's note: On p.77 of the original, the author added (just before completion of this volume) one more species (Stenokalyx laticollis) which is characterized by a particularly long and broad neck. (Not marked for translation.)

Subfamily: Cyrtophoroideae

p.77

Members of this subfamily are normally always sessile. However, it is with good reason that this group is taken into consideration here, namely because individuals having become detached from their stipe, are occasionally found free-swimming in the water, an observation already reported by several investigators.

p.78

Key for the determination of the genera:

A. Sessile on contractile stipe.

I. Protoplast forms hexagonal prism, flagellum 3 times longer than cell. With 3-6 peripheral, rather thin, stiff tentaculoids, barely as long as cell body. Brackish form. ..... Pedinella.

II. Protoplast reversed trilaterally pyramidal. Tentaculoids 5-7 times longer than the flagellum. ..... Cyrtophora.

B. Protoplast firmly attached to anterior third of cone-shaped lorica. Tentaculoid up to 20 times longer than the very short flagellum. Palatinella.

Cyrtophora PASCHER, 1913

Protoplast reversed pyramidal, with three blunt edges; sessile on contractile stipe. 6-8 tentaculoids arranged in basket fashion, more or less leaning together, 1 1/2 to 3 times longer than cell body. The flagellum has about the same length as the tentaculoids. One cup-shaped chromatophore with 2-3 sturdy, parietal lobes extended toward anterior portion of cell and enclosing a large cupuliform leucosin globule. Nutrition holophytic and heterotrophic. Reproduction by longitudinal division during detached, free-swimming state.

Cyrtophora pedicellata PASCHER. — Protoplast 18-22 µ long, as well as wide. Tentaculoids 40-60 µ, stipe 50-80 µ long. (Bohemia, in swamps).

Palatinella LAUTERBORN, 1906

Protoplast hemispherical to prismatic, attached with fine threads within anterior portion of stipitate, saccate, transversally slightly un-

dulate lorica. 16-20 tentaculoids projecting from the edge of the anterior cell portion evenly in basketlike fashion, retaining their shape which encloses a flask-shaped hollow space 2-3 times the length of the protoplast; ends capilliform. Flagellum strikingly short, only 1/3 of the length of the cell body. One cup-shaped chromatophore with large lobes. Several contractile vacuoles in equatorial position. Reproduction by budding within the space enclosed by the tentaculoids. Nutrition holophytic and heterotrophic.

Family: Mallomonadaceae p. 80

Solitary or colony-forming, mostly planktonic chrysomonads (Chromulinales). Cells tightly surrounded by elastic, or more or less firm, periplast showing verrucose elevations, or siliceous intercalations, or external ornamentation of varying nature; more or less metabolous, or ametabolous. Protoplast uniflagellate, with 1-2 vacuoles, or with a more or less complicatedly structured vacuolar system: One apical vacuole which is noncontractile (aggregate pustule, aggregate vacuole) and, connected with the latter, several peripheral contractile vacuoles. 1-2 parietal chromatophores; photosynthetic reserves in the form of leucosin and oil droplets. Reproduction is by longitudinal division. Cysts have been noted for many species.

The family consists of two groups (subfamilies):

A. Solitary forms (Mallomonadoideae solitariae):

I. Periplast thick, firm, but easily deformable, tightly surrounding the protoplast.

a) Periplast covered with minute verrucae which are a definite part of the membrane and are neither calcified nor silicified. 1-2 pulsating vacuoles at anterior end. ..... Chrysoglena (p. 31).

b) Periplast ornamented with minute insertions in the form of lenticular plates of silica. Anterior end of cell with complex vacuolar system (consisting of one nonpulsating aggregate vacuole and 4-8 contractile vacuoles which discharge their contents into the former). ..... Microglena (p.32)

II. Periplast more or less rigid and quite resistant to deformation, protoplast easily detachable. Periplast covered with minute, imbricate, siliceous scales, many of which bear more or less long siliceous spines. ..... Mallomonas (p.33)

III. Protoplast surrounded by a shield of closely-set, transversally arranged, siliceous rings, with or without siliceous spines. Conradiella (p.39)

B. Colony-forming types (Mallomonadoideae aggregatae):

Colonies spherical, cells hanging radially together, covered by gelatinous matrix. Each cell bears at its anterior end two lateral minute funnels; long siliceous rods are inserted in each of these projections. Chrysosphaerella (p.40)

Subfamily 1: Mallomonoideae solitariae

p.81

Solitary forms.

Chrysoglena WISLOUCH, 1914

Cells more or less cylindrical, or oblong oviform, solitary, relatively large, apparently somewhat metabolous. Slightly broadening toward anterior end, anterior margin straight truncate and slightly rimmed. Tapered toward posterior end with short taillike extension, end slightly rounded. Periplast firm, wall showing verrucuse elevations (no coccoliths or siliceous plates). A single flagellum which is shorter than the cell body. Two chromatophores, large, parietal, almost completely covering the wall laterally, except for two hyaline bands. Distinct eyespot in anterior portion of cell. One apical contractile vacuole. One large leucosin granule in basal position. — Reproduction is by longitudinal division. Cyst formation has been observed, taking place within wide gelatinous envelope; thereby, the eyespot and often also parts of the chromatophores are discarded and gradually disintegrate external to the cyst. Cysts are spherical,

with thick, smooth wall and conspicuous, broadened plug. One species:

Chrysoglena verrucosa WISLOUCH. — Cells 30-32 μ long, 20-25 μ thick. Diameter of cyst 28-38 μ. (Russia; spring form; probably oligo- and stenothermal.)

Microglena EHRENBERG, 1838

Cells tightly surrounded by a tough, but elastic, rather thick envelope consisting mainly of pectinous substances; its surface is ornamented with numerous lenticular platelets of silica, so that the cells appear finely dotted. The cell body is approximately cylindrical, ellipsoidal or ovoid, front often slightly bulging, base more or less rounded, in cross section slightly compressed; metabolous to a limited degree. Anterior end occasionally with short, broad collar. One or two chromatophores, large, parietal, saucer-shaped or forming a simple plate, yellowish-brown, often with a tinge of green. One or more eyespots at the anterior end, sometimes dissolved into minute granuli. The anterior end holds, furthermore, 4-8 pulsating peripheral vacuoles whose contents are emptied through a very narrow canal into the neighboring, terminal, noncontractile, pyriform vacuole (aggregate pustule). One strong flagellum, tapered toward end, of same length as cell body. Nucleus distinct, large, broad ellipsoidal or spherical, in central position. Most cells have a very massive basal leucosin granule in addition to minute oil droplets dispersed throughout the protoplasm. Reproduction is by longitudinal division; amoeboid and palmella stages unknown. Cysts p. 82 with thick brown wall, sometimes (two species) studded with minute apiculi or beads. Nutrition holophytic.

Very fragile forms, usually rare and occurring in limited numbers among other chrysomonads in still, clear, unpolluted water. Rather slow swimmers, moving in undulate fashion and turning now and then about their longitudinal axis. Seven species are know so far.

Key for the classification of the Microglena species:

(after W. CONRAD)

A. Anterior end of cells without collar.....Section 1: Eumicroglena

I. Cells bulging along anterior margin.

a) Only slightly bulging, not "heart-shaped;" one chromatophore.
Microglena punctifera 1.

b) Marked bulge, "heart-shaped;" two chromatophores.
Microglena cordiformis 2.

II. Cells not bulging at anterior margin.

a) Cell body ellipsoidal.

1. Two chromatophores; (cell not compressed ?)
Microglena australica 3.

2. One chromatophore; cell slightly compressed.
Microglena elliptica 4.

b) Cell body oviform.

1. Posterior end broader than anterior end (without compression ?); two chromatophores. ..... Microglena subglobosa 5.
2. Anterior end broader than posterior end (strongly compressed); one chromatophore. ..... Microglena ovum 6.

B. Cells with collar at anterior end.....Section 2: Pseudomicroglena

Cell body cylindrical, rounded at the ends. ... Microglena gracillima 7.

Mallomonas PERTY, 1852

p. 84

In most cases relatively large (rarely small) monads of various shapes. Cells in general longer than broad, that is, more or less oblong-ellipsoidal, cylindrical, fusiform, ovi- or pyriform; rarely club- or flask- p. 85 shaped; spherical or even transversally elliptical forms have also been observed. In a few species, the posterior end is taillike extended.

Outline of the genus Mallomonas, and division into groups and subgroups (after CONRAD):

p. 88

Group I: Calyptroideae.
Scales conical, circular, with one spine extending from the tip of the cone.

Group II: Scutellatae.

Scales platelike, flat or saucer-shaped; spines excentrically affixed to outer surface of scale.

Subgroup 1: Triangulares = scales triangular.
Subgroup 2: Quadratae = scales quadrangular.
Subgroup 3: Ellipticae = scales ellipsoidal or oviform.
Subgroup 4: Discoideae = scales circular, discoid.

Key for the classification of Mallomonas species (after CONRAD): p. 89

I. Scales conical, circular, with one spine extending from the tip of the cone ..... Calyptroideae (Group I)

Cells spherical, with 2 chromatophores ..... Mallomonas globosa 1.

II. Scales platelike, flat or slightly indented like a watch glass. Scutellatae (Group II)

A. Scales triangular ..... Triangulares (subgroup 1)

Scales minute, interspaced, with 6-8 spines at anterior end; cells fusiform, with 2 chromatophores ..... Mallomonas akrokomos 2.

B. Scales quadrangular..... Quadratae (subgroup 2)
- Cells with only one kind of scales.
1. Scales exactly rhombic (occasionally very broad).

a) Scales firm, strong, concave/convex, often with rounded corners and slightly curved crests. Cells ellipsoidal, without spines or thorns.
- Cells without collar, scales shaped like arrowhead. Mallomonas allorgei 3.
- Cells with collar formed by modified scales; rest of scales kitelike rhomboid. Cells 30-38 X 16-18 µ. ... Mallomonas lychenensis 3a.
- Cells with collar; shape of scales unknown. Mallomonas majorensis 3b.

b) Scales different.
- Without thorns or spines.
α) Cells ellipsoidal, very broadly rounded at both ends. Scales only slightly projecting. Opening for flagellum drawn out to form simple collar, rather wide. One chromatophore. Mallomonas playfairii 4.

β) Cells ellipsoidal to subovoid, anterior end only very little tapered, collar not very distinct. Free edges of scales projecting; 2 chromatophores. ..... Mallomonas elliptica 5.

γ) Cells fusiform to oblong oviform, without collar; one chromatophore. ..... Mallomonas tenuis 5a.

- With thorns only.

α) Thorns at both ends.

- Cells fusiform, 2 chromatophores. Mallomonas pulcherrima 6.
- Cells ellipsoidal, 1 chromatophore. Mallomonas genevensis 7.

β) Thorns only at posterior end.

- Cells cylindrical to cone-shaped; 2 chromatophores. Mallomonas nannoplankton 8.
- Cells ellipsoidal, 1 chromatophore... Mallomonas dentata 9.

γ) Thorns only at anterior end.

- Cells ellipsoidal, with a ring of thorns around the opening for the flagellum..... Mallomonas gracillima 10.

- With spines only.

α) Cells broader than long, ellipsoidal..... Mallomonas lata 11.

β) Cells longer than broad.

- Spines distributed over the entire cell
  - — Spines irregularly bent (undulate or zigzagging). Cells fusiform, with 2 chromatophores... Mallomonas hirsuta 12. p.90
  - — Spines formed differently.
    - – Chromatophore greatly reduced, discoid; cells ellipsoidal. ..... Mallomonas pallida 13.
    - – Chromatophore normal [not reduced]; cells ellipsoidal. ..... Mallomonas fresenii 14.
- Spines only at both ends, forming a circle; with nodular thickenings at their base. Cells approximately cylindrical. ..... Mallomonas splendens 15.
- Spines only at posterior end, or on the posterior portion of the cell. Cells cylindrical, with 2 chromatophores.
  - — Spines forked or denticulate. Cells 24 μ long. Mallomonas spinifera 16.
  - — Spines plain, cells 11-16 μ long. Mallomonas bacterium 17.

- In addition to spines, thorns also present.

Thorns at both ends, spines distributed over the entire surface of the cell. ..... Mallomonas aculeata 18.

2. Scales in the form of a kitelike rhomboid (2 isosceles triangles with common base but of unequal height).

a) Spines on posterior half of cell; cells cylindrical-ellipsoidal, with 2 chromatophores. ..... Mallomonas producta 19.

b) Spines only at posterior pole, cells oviform, broadening at anterior end, 1 chromatophore. ..... Mallomonas lillolnsis 20.

- Cells bear two kinds of scales (rhomboid as well as roughly circular). Mallomonas mesolepis 21.

- Cells with two kinds of scales (broadly rhomboid as well penta- to hexagonal, the latter especially at the posterior end of the cell. Mallomonas anglica 21a.

C. Scales elliptic or oviform ..... Ellipticae (subgroup 3)

1. Scales in the form of a watch glass (concave toward outside). Cells considerably lengthened, ending in a long denticulate tail. Two chromatophores. ..... Mallomonas insignis 22.

2. Scales formed differently.

a) Without thorns or spines.

- Scales with thornlike hump; cells almost cylindrical, without collar. ..... Mallomonas spinulosa 23.

- Scales different; cells with collar.

α) Collar high and broad; cells broad ellipsoidal. Mallomonas valkanoviana 24.

β) Collar short and narrow; cells fusiform. Mallomonas heverlensis 25.

b) With thorns only (at anterior end). Two chromatophores with pyrenoids; cells oviform, posterior end extended. Mallomonas pyriformis 26.

c) With spines only.

- Spines denticulate (1-3 teeth near tip, or several teeth in a row).

α) Two chromatophores. p.91

- Scales elliptic, without markings.

— Cells ellipsoidal..... Mallomonas longiseta 27.

— Cells oviform, tapered toward posterior end or extended. ..... Mallomonas caudata 28.

- Scales oviform, dotted markings V-shaped. Cells more or less ellipsoidal. ..... Mallomonas acaroides 29.

β) One chromatophore.

Scales platelike with V-shaped markings. Cells more or less ellipsoidal. ..... Mallomonas intermedia 30.

- Spines plain (not denticulate; M.acaroides [29] occasionally has spines without teeth).

α) Spines at the posterior end.

- One chromatophore. Cells oviform, tapered toward anterior end. ..... Mallomonas taxandriae 31.

- One chromatophore, with deep longitudinal fissure. Cells reversed oviform; posterior end with 1-3 rather short straight spines, in the direction of the longitudinal axis. Eyespot. ..... Mallomonas umbrina 32a.

- Without chromatophore. Cells subcylindrical. Mallomonas apochromatica 32.

β) Spines at anterior end or on anterior half of cell; 2 chromatophores.

- Scales greatly standig up from anterior portion of cell body. Cells narrow oviform. ..... Mallomonas tonsurata 33.

- All scales lying evenly flat on cell body; Cells broad ellipsoidal. ..... Mallomonas pulchra 34.

γ) Spines at both ends only.

- Cells 6-8 times longer than broad, cylindrical; scales polygonal-elliptic or polygonal-oviform. Spines slightly bent and obliquely raised. ..... Mallomonas cylindracea 35.

- Cells twice as long as wide, approximately ellipsoidal; scales elliptic. Spines solid, straight, pointed exactly in the direction of the longitudinal axis. Mallomonas salina 36.

δ) Spines distributed over the entire cell, in some cases with the exception of the basal calotte.

- Opening for the flagellum surrounded by a collar formed by modified scales, standing upright, and having dotted markings. Cells broad ellipsoidal. Mallomonas coronata 37.

- Without collar.

— Cells very narrow ellipsoidal. Nearly all spines pointing obliquely to front; scales (missing from the posterior quarter of the cell) elliptic, not dotted, with V-shaped markings. ..... Mallomonas elongata 38.

— Cells oviform. Scales oviform, projecting, dotted at anterior end which bears the spine.

— [p.t.o.]

- Basal calotte without spines and scales. Cells short, posterior end broadly rounded, then conical and tapered to a point at anterior end. ..... Mallomonas ovum 39. p.92

- Basal calotte with spines and scales. Cells elongated, anterior end not pointed. ..... Mallomonas horrida 40.

D. Scales discoid, circular.....Discoideae (subgroup 4)

1. Without spines or thorns. A broad apical collar of upright platelets. Scales large (very broad elliptic). Cells broad elliptic. Two chromatophores. ..... Mallomonas sphagnalis 41.

2. Thorns only (at anterior end). Cells fusiform, extended so as to form fine, acicular tail. 2 chromatophores. Mallomonas paucispinosa 42.

3. With spines only.

a) Scales not imbricated. Spines at the anterior end, smooth, not very numerous, pointing in all directions, Cells oviform, anterior end pointed.

- Cells 26-40 X 15-25 µ. ..... Mallomonas pascherii 43.

- Cells 14-20 X 7-12 µ. ..... Mallomonas minima 44.

b) Scales imbricated.

- Spines at the very beginning or on the anterior portion of the cell only.

α) Apical hump; with several radially arranged spines (reminiscent of the ribs of an umbrella). ..... Mallomonas curta 45.

β) Without apical hump. Spines radially arranged around anterior half of cell body. ..... Mallomonas helvetica 46.

- Spines at the very end or on the posterior half of cell only.

α) Spines forked. Cells flask-shaped; 2 chromatophores. Mallomonas clavata 47.

β) Spines with 2-3 triangular teeth (at their ends), facing in two directions; cover basal half of cell only. Cells ellipsoidal; one chromatophore. .....Mallomonas reeuwykiana 48.

- Spines at both ends. Two chromatophores.

α) Spines at anterior end radially arranged (like umbrella ribs), at posterior end more or less obliquely pointing backwards. Cells narrow, approximately cylindrical. Mallomonas litomesa 49.

β) Spines at anterior end in different position. Depending upon their position, spines pointing either forward or backward. Cells broad fusiform. ..... Mallomonas teilingii 50.

- Spines distributed over entire cell.

α) Spines denticulate at their ends.

- Scales arranged in transversal rows; cells oviform, tapared toward anterior end. ..... Mallomonas dubia 51.

- Scales in spirals; cells club-shaped. Mallomonas fastigata 52.

β) Spines plain, pointing backwards.

- Contour of cell reminiscent of tennis racket. Mallomonas rhopaloides 53.

- Cells ellipsoidal, posterior end sometimes extended. Mallomonas mirabilis 54.

4. In addition to spines also thorns, the former distributed over the entire cell, the latter around opening for the flagellum. p.93

a) Cells narrow ellipsoidal; spines pointing in all directions, and slightly curved backwards. ..... Mallomonas elegans 55.

b) Cells broader; spines rather short, pointing in all directions. Mallomonas radiata 56.

Conradiella PASCHER, 1925 p.120

(Syn. Mallomonas etc.)

Cells medium to large, more or less cylindrical to slightly elongated oviform, both ends rounded off, or occasionally drawn out to a basal point; dorsoventrally slightly compressed, with an armor of transversally arranged annuli. The latter are more or less equally wide, completely closed, delicate and flexible; those surrounding the median portion of the cell are cylindrical, those at the poles are correspondingly curved, not directly covering the protoplast, but lying on a thin gelatinous film surrounding the protoplast. A narrow porus from which the flagellum projects at the anterior end. Armor consists of silica. Numerous short setae are sitting on the annuli (with the exception of the first and last polar annuli; sometimes also few setae either at the anterior or the posterior end, or completely absent. One flagellum of about the same length as the cell body,

two large parietal chromatophores, a large nucleus. Larger leucosin granules in the basal portion of the cell, accompanied by smaller leucosin granules, and often also by fat or oil droplets showing just a tinge of yellow. Numerous contractile vacuoles, some in basal, others more in anterior position, together perhaps forming a system. An eyespot has been reported for one species. Cyst fomation observed in one species.

There exists a close relationship with Mallomonas, the difference being that the rows of scales are, here, replaced by annuli; conceivably, the annuli may have been formed by fusion of formerly separated scales. So far, four species are known of this genus, forming, in a sense, a series.

Found in fresh and brackish waters.

I. All annuli with numerous short, slightly raised setae, pointing backwards. Anterior calotte large, quite broad, "bare;" posterior calotte short, pointed, also "bare."..... Conradiella calva 1. p. 121

II. Setae only in limited numbers, not formed on all annuli.

a) Setae (3-5) at the anterior end only, annuli (about 15) narrow. Conradiella gracilis 2.

b) Setae at posterior end only, annuli (about 6-8) wide. Conradiella pascherii 3.

III. Setae missing completely: Armor bare and smooth. Conradiella circulata 4.

Subfamily 2: Mallomonoideae aggregata p. 122

Colony-forming mallomonads. — Only one genus:

Chrysosphaerella LAUTERBORN, 1896

Cells with their narrower basal ends radially united in spherical colonies kept together by a gelatinous matrix containing numerous, minute plates of silica. Cells ovi- to pyriform, each with a well differentiated periplast which bears at the anterior end of the cell two symmetrically placed, vase-shaped projections; a long, straight, cylindrical siliceous rod

with bidentate ends is movably inserted in each of the projections, thus radially surrounding the colony. Two chromatophores, in lateral and parietal position. Two (?) eyespots (G.M.SMITH, 1933, mentions only one). Several vacuoles; nucleus in central position. Nutrition holophytic. Cell division and cyst formation not observed. One species:

Chrysosphaerella longispina LAUTERBORN. — Cells up to 15 µ long, and up to 9 µ wide. Diameter of colony = up to 250 µ. Flagellum about 1 1/2 times as long as cell body. — In stagnant waters (ponds, dead tributaries) with rich plant life; also as plankters in Europe and North America.

Order 2: Isochrysidales

p.123

Chrysomonads with two apical flagella of equal length, and in most cases with 2 (rarely only 1, or 8 and more) yellowish-brown chromatophores. Periplast undifferentiated, or with a more or less high degree of differentiation. A relatively small group of free-living or sessile organisms. The free-living species are either unicellular, naked, or surrounded by a cellular envelope (with siliceous scales, or calcareous platelets), but they may also be united in colonies. The sessile forms are enclosed by a lorica with or without stipe.

The parallel series to the Isochrysidales consists of the similarly flagellated Volvocales among the Chlamydomonas (green algae). However, in contrast to the latter group, the Isochrysidales consist of fewer families.

The order of the Isochrysidales consists of three families according to the structure of the cellular envelope (periplast).

Outline of the families belonging to the Isochrysidales:

A. Cells without differentiated periplast.

Family 1: Syncryptaceae (Isochrysidaceae).
Cells naked or within lorica, with simple system of vacuoles. Solitary or in colonies, free-swimming or sessile.

B. Cells with differentiated periplast.

Family 2: Synuraceae (Euhymenomonadaceae).
The cellular envelope consists (investigated so far: Synura) of siliceous scales with or without bristles. If such scales

are not known (as in Chlorodesmus), differentiation of the periplast is seen in the form of minute horns. Cells united in colonies.

Family 3: Coccolithophoridae (Coccolithineae).

The cellular envelope consists of a gelatinous matrix which is covered with calcareous platelets, or of a calcareous shell with or without coccoliths. Solitary forms.

Family: Syncryptaceae (Isochrysidaceae)

Cells naked or within lorica, with simple system of vacuoles; solitary or in colonies, free-swimming or sessile.

The family of the Syncryptaceae consists of the following subfamilies, tribes, and genera:

Subfamily 1: Cells without lorica ..... Isochrysidoideae. p. 124

a) Solitary forms, free-swimming. .... Tribe: Chrysidalideae.
1 genus: Chrysidalis (p. 43).

b) Cells united in colonies, free-swimming.
Tribe: Isochrysideae.

1. Cells reversed oviform; radially united in solidly packed colonies which are surrounded by a gelatinous envelope; rodlets of silica are embedded in the latter.

   α) Cells with 2 chromatophores; basal ends of cells not elongated. Spherical colony measures 20-70 μ.
   Genus: Syncrypta

   β) Cells with numerous (8 or more) chromatophores; basal ends of cells extensively elongated. Spherical colony measures 100-140 μ.
   Genus: Pseudosyncrypta

2. Pillow-shaped cells arranged in a peripheral layer, thus forming a globose (allegedly hollow) colony measuring 30-70 μ. (1 or 2 chromatophores ?)
Genus: Tessella

Subfamily 2: Cells with delicate, usually stipitate lorica attached to substratum; not planktonic. ..... Lepisochrysidoideae.

With the genera: Derepyxis, Stylochrysallis (p. 44), Stylotheca (the latter epiplanktonic).

Subfamily: Isochrysidoideae

Cells naked, without lorica.

Tribe: Chrysidalideae

Solitary unicellular forms, never in colonies. So far, one genus is known: Chrysidalis SCHILLER, 1929.

Cells solitary, planktonic, naked; in lateral view broad oval, in cross section circular or roundish oval. The median line of the anterior and posterior poles, across the flagellar base, more or less grooved or rimmed. Periplast thin, two slender flagella of equal length (twice the length of the cell body). Two chromatophores, yellow, saucer-shaped, always opposite one another, not touching, so that a lighter-colored plasmatic zone remains between them, including the shallow indentations. Eyespot absent. Reproduction is by longitudinal division.

The number of the naked Isochrysidales seems to be limited.

Pseudosyncrypta KISSELEW, 1931. p. 126

Free-swimming colonies similar in structure as those described for Syncrypta but much larger; spherical, with minute rodlets embedded in the apparently unstructured gelatinous envelope. Individual cells reversed oviform, broad, anterior end rounded; the attenuated basal ends are elongated and point to the colonial center where they are all united. Chromatophores numerous (8 or more), discoid, yellowish-brown. An eyespot is lacking. Two apical flagella of equal length. Two or more contractile vacuoles in the posterior end of the protoplast. Only species: Pseudosyncrypta volvox KISSELEW.

Epiplanktonic forms: p. 127

Stylochrysallis STEIN, 1878

Protoplast tightly surrounded by a very delicate lorica with a long gelatinous stalk which broadens at its base into a diffuse discoid pedicle. The cells are elliptic to almost spherical, two parietal trough-shaped chromatophores; an eyespot is lacking. One contractile vacuole in basal position. The flagella are twice as long as the cell body. Nutrition is holophytic. p. 128

Stylochrysallis parasitica STEIN. — Lorica (without the gelatinous stipe) 9-11 μ long.

*) Translator's note: Due to the fact that pp. 123 and 126 of the original German text had been added to the end (which could not have been anticipated since many pages were not submitted for translation), the translation for the pages mentioned had to be inserted later (pp. 41-44) and pagination from here to the end of the translation had to be changed. Unfortunately, this page (44) could not be filled completely.

Family: Synuraceae

(Euhymenomonadaceae)

p. 129

So far, only colony-forming genera are known*. The colonies are free-floating, spherical or oblong-ovoid; the cells of one genus are united in unbranched filaments. Periplast differentiated, covered (presently confirmed only for Synura) with scales which may or may not bear bristles.

A. Colonies mostly spherical (less frequently oblong-ovoid).

I. Cells without eyespot, with 2 chromatophores. Periplast covered with scales which may or may not bear longer or shorter bristles. Synura (below)

II. Cells with eyespot, one curved chromatophore (?); surface smooth. Pseudosynura (p. 46)

B. Colonies filamentous. Cells approximately triangulat with broad, indented base. With bristles. ..... Chlorodesmus (p. 47)

Key for the classification of Synura species:

p. 133

A. Cells oblong club-shaped, anterior end rounded, strongly tapered toward posterior pole. 42-47 X 6.5-10 µ. Colonies not dense. Anterior end bearing a few short thorns. Structure of scales unknown. Synura adamsii (8)

B. Cells fusi- or cuneiform, very slender, anterior pole truncate. Cells absolutely smooth. Length of cells 45 µ, greatest width 5-8 µ, at apex 2.5-3 µ. Diameter of colonies 70-140 µ. Structure of scales unknown. ..... Synura australiensis (9)

C. Cells reversed oviform, with more or less elongated posterior end, anterior pole broadly rounded. 20-40 X 8-17 µ, or more or less spherical. Colonies more or less dense. Periplast covered with scales, structure of latter known; with or without thorns. .... Synura uvella (1)
sphagnicola (2)
spinosa (3)
echinulata (4)
bioretii (5)
petersenii (6)
glabra (7)

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*) The genus Hymenomonas (for a long time considered as the prototype for the Hymenomonadaceae) has meanwhile been identified as a member of the Coccolithophoridales; hence, it no longer belongs to the family of "Euhymenomonadaceae" so that, perhaps, this name should also be eliminated from the nomenclature to avoid errors.

1. Scales all with one thorn in anterior position; without median dorsal fold. ..... 2.
   - Scales without (rarely with) thorn; with dorsal fold (median, elliptic. ..... 6.

2. Scales evenly elliptic or slightly ovoid..... 3.
   - Scales shaped differently ..... 4.

3. Scales elliptic, margin evenly thickened to form annular rim; attached to periplast with their basal ends only.
   Synura (skadovskiella) sphagnicola (2)
   - Scales elliptic to ovoid, entirely homogeneous ... Synura bioretii (5)

4. Scales at anterior end very sturdily constructed, hocklike, with very thick transversally striped margin, and with a usually short, hollow, sturdy, subterminal thorn bending up from the surface of the scale.
   Synura uvella (1)
   - Scales of different shape, thorn solid. ..... 5.

5. Scales at anterior end with large roundish frontal lobe; thicker rim only at posterior, not at anterior, margin of scale; long thorn running straight along surface of scale. ..... Synura spinosa (3)
   - Scales at anterior end rather small, with poorly developed, obtuse-angled, frontal lobe. Thorn short, rod-shaped, bent sideways.
   Synura echinulata (4)

6. Scales elliptic, about twice as long as wide, with distinct marginal rims, and with a pronounced narrow-elliptic dorsal fold.
   Synura petersenii (6)
   (S. uvella auct.)
   - Scales irregular elliptic, broad elliptic, anterior end obliquely rounded. Marginal rim and median dorsal fold less pronounced.
   Synura glabra (7)

Pseudosynura KISSELEW, 1931

p. 146

Colonies free-floating (of the Synura-type); cells with smooth periplast, reversed ovi- or pyriform, markedly prolonged. Two flagella of p. 147 equal length. One curved chromatophore (sometimes giving the impression that two chromatophores exist). One distinct eyespot at anterior end. One species:

Pseudosynura urogleniformis KISSELEW. — With the characteristics just described. The markedly prolonged cells are up to 45 µ long. The flagella are apparently about half as long as the cell body.

Euplanktonic form (Russia, Old-Peterhof, among plankton of the so-called "Cristatella-Pond," June 1928).

The species (that is, the genus) differs from Synura mainly in having an eyespot and one curved chromatophore. Unfortunately, a detailed description of the structure of the periplast is not available; it remains to be seen whether it is also covered with scales, as in Synura (see also Synuropsis danub. SCHILL.).

Chlorodesmus PHILIPPS, 1882

Cells united in unbranched filaments, one end attached to substratum; cells are triangular-conical; sides, base and front rimmed (the base more, the sides slightly). 1 1/2 - 2 times higher than wide, the cells are adjoined to one another at their broad bases so that a biseriate filament is formed. The tightly-fitted wall is covered with short bristles. The two chromatophores are in lateral and parietal position. No eyespot. Pulsating vacuoles at basal end. At the anterior end one apical "triangular" vacuole, communicating to the outside. Two flagella of the same length as the cell body. The only species:

Chlorodesmus hispidus PHILLIPS (syn. Phillipsiella hispida PHIL., LEMM.). — Dimensions not reported. England; Black Forest, Germany.

Family: Coccolithophoridae (LOHMANN) p. 148
(Coccolithineae KÄMPTNER)

"Unicellular and solitary chrysomonads, primarily with radially symmetric cell body. Protoplast surrounded either by gelatinous envelope in which numerous calcareous platelets are embedded, or by a calcareous lorica with or without coccoliths. Normally with two flagella of equal length, but there are also a few forms which, probably, are without flagellum. Two yellowish-brown, saucer-shaped, large chromatophores without pyrenoids. Colorless cells doubtful. Food reserves accumulate as fat (oil)

and leucosin. Nutrition holophytic. Only asexual reproduction known, either by ordinary cell division during motile or resting stages, or by division of the protoplast inside the wall, certainly forming 2, but probably also 4, 8, or 16 daughter cells (spores) which are then liberated by fragmentation of the wall, or escape through the circular pore-opening at the flagellar pole. Palmella stages and cysts have not been reported." (SCHILLER, 1930).

The only freshwater forms, so far reliably identified as members p. 149
of this family, are the two genera Acanthoica and Hymenomonas (together with 3 species); Pontosphaera must be considered as doubtful. These belong to two different groups of coccolithophores:

Group 1: Coccoliths not perforated (= discoliths), or a homogeneous lorica may take their place. Cellular envelope covered with hump-, disk-, bowl-, or cup-shaped coccoliths; with or without pore-opening. With the genera Acanthoica and Pontosphaera.

Group 2: Coccoliths perforated (= tremaliths), annular or discoid. With the genus Hymenomonas.

The exact systematic classification of the species concerned — based on the system designed by KAMPTNER & SCHILLER, nomenclaturally adjusted in accordance with our way of grouping — is as follows:

Family: Coccolithophoridae LOHMANN

Subfamily: Syracosphaeroideae (in the sense of KAMPTNER's "fam. Syracosphaeraceae" but not his subfamily by the same name).

Tribe: Acanthoiceae p. 150
Genus: Acanthoica

Tribe: Pontosphaereae
Genus: Pontosphaera

Subfamily: Thoracosphaeroideae (in the sense of SCHILLER's "fam. Thoracosphaeraceae" but not of KAMPTNER's subfamily by the same name).

Tribe: Hymenomonadeae
Genus: Hymenomonas.

Acanthoica LOHMANN, 1912

Cell body approximately spherical or oval; coccoliths form more or less flat to hemispherical protuberances which are crowned either with another smaller hump, or a rodlet, or a long calcareous spine. The coccoliths are loosely or densely arranged, and sometimes even intergrown with one another. Two chromatophores. If observed, two flagella of conspicuous length. Mode of reproduction unknown. Two freshwater species.

I. All coccoliths with a small, blunt, cylindrical protuberance. Acanthoica ornata 1.

II. The coccoliths around the flagellar porus (6-8) each bear a calcareous spine instead of the protuberance ..... Acanthoica schillerii 2.

Hymenomonas STEIN, 1878

P. 152

The solitary free-swimming cells vary greatly in form: Ellipsoidal to cylindrical, more or less rounded off; anterior end usually slightly indented, heart-shaped; tightly surrounded by thick, soft, pliable, more or less reddish-brown envelope. Protoplast within envelope more or less metabolous. Numerous annular coccoliths are embedded in the gelatinous cellular envelope. Two flagella of equal length, two chromatophores, one or more contractile vacuoles at the anterior end. Cell division during motile as well as during immobile (after the flagella have disappeared) stage. Reproduction by formation of 4 statospores per cell. Resting stages in the form of cysts without porus.

One species (Hymenomonas roseola STEIN), the only one thoroughly known so far.

Appendix (re. Coccolithophoridae):

p. 153

SCHILLER (1930) placed the following two forms among the doubtful freshwater species:

Pontosphaera (?) stagnicola CHODAT & ROSILLO. — Cells vary greatly in shape (spherical, oviform, ellipsoidal, or irregular with protruding humps); size = 14-20 μ. Coccoliths allegedly always lying on the gelatinous envelope, narrow, oval (2.5 X 1 μ), with distinctly indented center, but indentation broader than deep. Two or one (?) yellow chromatophore(s). "The authors observed one flagellum," which is doubtful since the coccolithic forms (except for those without flagella) always have 2 flagella of equal length; however, these are very fragile. Reproduction reportedly by total cell division.

Order 3: Ochromonadales p.154

Chrysomonads with two apical flagella of unequal length, the longer one being referred to as the primary, the shorter one as the secondary, flagellum*. The forms may be solitary or colonial, free-swimming or ses- p.155 sile, naked or surrounded by a delicate lorica. Cells of species with chromatophores have an undifferentiated periplast. Chromatophores 1-2, development varying; with or without eyespot. Few contractile vacuoles in the anterior, median, or posterior portion of a cell.

The Ochromonadales are, in their development, definitely equal to the levels of organization observed among the other two groups of chrysomonads (Chromulinales and Isochrysidales), that is, they consist of more primitive forms without differentiated periplast and with a simple system of vacuoles, as well as (taking Physomonas also into consideration here) "higher" forms, namely those with differentiated periplast and a complex system of vacuoles.

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*) Anomalies are sometimes observed, e.g., forms with 3 flagella (one primary and two secondary flagella), or with 1 flagellum only (primary). In the latter case, these may be individuals immediately after division so that the secondary flagellum has not yet been developed (the primary flagellum grows faster anyway), or genuine anomalies, perhaps even variations for some reason.

Within the order of the Ochromonadales, the free-swimming unicellular forms are represented mainly by one genus (Ochromonas) consisting, however, of numerous species, but, to a greater part, the forms are unicellular and sessile, or form colonies which may be free-floating or sessile.

Special mention among the free-swimming unicellular forms deserves, furthermore, the peculiar and apparently very rare genus Didymochrysis PASCHER, a diploid Ochromonas variance.

Among the Ochromonadales there are also some parallel forms to the Chromulinales and, in part, also to the Isochrysidales, e.g., Ochromonas—Chromulina—Chrysidalis, Pseudokephyrion—Kephyrion.

The free-swimming forms of the Ochromonadales include also some very important euplanktonic inhabitants of large and small lakes (e.g., Uroglena, Dinobryon), as well as of ponds, swamps, marshes, and also of brackish waters. Accidental plankters are a frequent occurrence because the sessile organisms of this order are quite numerous in small bodies of water, e.g. among potamoplankton.

Just as in the group of the Chromulinales achromatic forms may develop and, in fact, have developed due to reduction and, finally, loss of the chromatophores as well as due to the conversion to a totally heterotrophic nutrition, so may the same process have taken place also among certain members of the Ochromonadales. When discussing the Ochromonas, it will be pointed out especially* that the Monas species are to be looked upon as Ochromonas that have become achromatic because they no longer have chroma- p. 156
tophores; but it can be taken for granted that the other members of the Monadaceae are also descendants of the chrysomonads. KORSHIKOV has estab-

*) Translator's note: The paragraph referred to (original p. 158, top) has not been marked for translation.

lished that Physomonas STOKES, not featuring chromatophores and being, therefore, colorless, must also be considered as an apochromatic and apoplastid ochromonad, all the more so as it has the same type of flagella. Accordingly, G.M. SMITH (1933) in his treatise "The fresh-water algae of the United States" places a Physomonadaceae family (with the genus Physomonas) as equivalent besides the family of Ochromonadaceae. In other words, the American author divides the order (that is, his "suborder: Ochromonadineae") into two families: 1. Ochromonadaceae (cells with undifferentiated periplast), and 2. Physomonadaceae (cells with differentiated periplast).

Since, in this chapter, we are dealing exclusively with the pigmented chrysomonads, we shall discuss the Physomonas in the appendix to the chrysomonads along with other achromatic forms.

Family: Ochromonadaceae (Euochromonadaceae)

Cells naked, periplast undifferentiated; with or without lorica, solitary or in colonies. Two subfamilies:

I. Ochromonadoideae: Cells naked, periplast undifferentiated; without lorica, solitary or colonial.

II. Lepochromonadoideae: Cells with delicate lorica (in a variety of shapes). Solitary or in colonies.

Subfamily: Ochromonadoideae

Cells naked, periplast undifferentiated, without lorica; solitary or in colonies. This little specialized group consists of two tribes, one comprising unicellular, the other colonial, genera.

1. Unicellular forms ..... Ochromonadeae solitariae with the genera Ochromonas, Chlorochromonas, and Didymochrysis.
2. Colonial forms ..... Ochromonadeae aggregatae with the genera Uroglena (Uroglenopsis), Volvochrysis, Synochromonas, Synoropsis, and Cyclonexis.

Ochromonadeae solitariae p.157

Solitary forms.

a) Cell structure of the type described; 1-2 chromatophores and 2 flagella of unequal length (= 1 pair)...Ochromonas (below) Chlorochromonas (p.57)

b) Cells with 2 pairs of flagella of the Ochromonas-type, two chromatophores; other organelles (eyespot, vacuoles) also in duplicate. Diploid organism. ..... Didymochrysis (p.58)

Ochromonas WYSSOTZKI, 1887

Cells solitary (sometimes forming small, loose, temporary [palmelloid] colonies), free-swimming, or attached to substratum with the often stipelike extended posterior pole. Protoplast mildly to very strongly metabolous, naked, without lorica; some species are rigid, others may sometimes show an amoeboid plasticity. Periplast in most cases very delicate, smooth, less frequently robust and studded with verrucae. Two flagella of unequal length, the longer being the primary, the considerably shorter one the secondary flagellum (sometimes flagellar anomalies [see footnote p.48]). Some species easily shed their flagella upon external stimulation. One or two chromatophores, showing here and there definite signs of developmental reduction. One contractile vacuole at the base of the flagella, with or without eyespot. Division may take place while a cell is actively motile, or after it becomes immobile and invested with a gelatinous envelope. Palmella stages have been observed. Cysts have been reported for some species, their wall being either smooth or ornamented with spines.

Grouping of Ochromonas species according to size: p.158

1. Very minute forms (2-5-8 µ); all measurements represent mean (µ) values:

Ochromonas nana DOFLEIN = 2-3
sphagnalis CONRAD = 3-4
minuscula CONRAD = 4-6
gracilis DOFLEIN = 5 X 3
pallida KORSHIKOV = 5-6

Ochromonas vagans DOFLEIN = 6
silvarum DOFLEIN = 6-8
ovalis DOFLEIN = 6-8 X 3-4
variabilis MEYER = 6-9 X 5-8
nannos SKUJA = 5-9.5 X 3-6

2. Small to medium-sized forms (means of about 8-16 μ):

Ochromonas granulosa DOFLEIN = 5-12
scintillans CONRAD = 7-10
aspera PLAYFAIR = 8-10
tenera MAYER = 8-12 X 5
vallesiaca CHODAT = 9 X 6
chromata MEYER = 9-12 X 6-9
fragilis DOFLEIN = 9-16 X 10-12
pigmentata DOFLEIN = 10-12 X 6-8
pinguis CONRAD = 10-12 X 7-9
stellaris DOFLEIN = 10-15 X 5-7 p. 159
wislouchii SKVORTZOW = 11-12 X 8
sociata PASCHER = 11-13 X 6-8
hinterzartensis DOFLEIN = 12 X 6-7
nasuta SKVORTZOW = 12-14
ludibunda PASCHER = 12-17 X 6-12
crenata KLEBS = 12-20
granulosa MEYER = 12-20 X 6-15

3. Larger forms (means of about 16-30 μ):

Ochromonas simplex PASCHER = 15-20 X 12-14
mutabilis KLEBS = 15-30 X 8-22
reptans CONRAD = 18-24
perlata DOFLEIN = 25 X 15
verrucosa SKUJA = 19-27 X 12-18

Key for the classification of Ochromonas species:

A. One chromatophore.

I. Cells with smooth surface.

a) Chromatophore cup-shaped (hollowed, rims usually somewhat unevenly extended), in basal position.

1. Chromatophore not (or very little) excentric. p. 160

α) Cells rigid, ellipsoidal, without eyespot. Primary flagellum as long as cell body, which measures 15-20 X 12-14 μ. Ochromonas simplex 1.

β) Cells metabolous, reversed ovi- to pyriform, with eyespot; 11-12 X 8 μ. ..... Ochromonas wislouchii 2.

2. Chromatophore excentric, cell body rigid, oviform, 4-6 μ long. With eyespot. Primary flagellum 2-2 1/2 times longer than cell body. ..... Ochromonas minuscula 3.

b) Chromatophore not cup-shaped and not in basal position.

1. Chromatophore band-shaped, spirally twisted.

α) Cells 9 X 6 μ, with eyespot, metabolous. Ochromonas vallesiaca 4.

β) Cells 28 X 17 μ, with eyespot, only slightly metabolous. Ochromonas dofleinii 4a.

2. Chromatophore discoid or platelike, slightly curved into the shape of a shallow bowl; relatively large.

α) Chromatophore in anterior portion of cell.

- Cells pronounced metabolous, 5-12 μ long. Without eyespot. One apical vacuole. Primary flagellum about the same length as cell body. Cysts smooth, 7 μ in diameter.
Ochromonas granularis 5.

- Cells pronounced metabolous, 7-10 μ long. With eyespot. Two apical contractile vacuoles. Primary flagellum up to 3 times longer than cell body. Cysts smooth, 6-9 μ in diameter. Enormous leucosin granules.
Ochromonas scintillans 6.

- Cells metabolous (occasionally amoeboid, without flagella), oblong oval (10-15 X 5-7 μ). Without eyespot. Primary flagellum same length as cell body. A great number of oil droplets in peripheral position. Cysts with long spines and large, elevated (funnel-shaped) pore; 10-12 μ in diameter. ..... Ochromonas stellaris 7.

β) Chromatophore in lateral position.

- Cells without brownish pigment granules or accumulation of oil droplets in the periplast.

— Cells very minute (just 2-3 μ), ellipsoidal, strongly amoeboid, without eyespot. ..... (1) Ochromonas nana 8.

— Cells somewhat larger (6 μ), oviform, without eyespot; prone to be rendered amoeboid due to loss of flagella.
(2) Ochromonas vagans 9.

— Chromatophore platelike, often distinctly oblong oval. Cells pyriform, sometimes with long pointed posterior pole; markedly changing in form, even to amoeboid creeping. Length about 7-8 μ (?). Without eyespot.
(3) Ochromonas elegans 10.

— Chromatophore of medium size, in central position. Cells oval, 6-8 X 3-4 μ; strongly metabolous (amoeboid), especially the posterior portion of the cell body. Both flagella are conspicuously thick and projecting from a little pit. Primary flagellum almost twice as long as cell body. No eyespot..... (4) Ochromonas ovalis 11.

— Cells strongly metabolous, oblong-oval to spherical. Globose cells 9-16 X 10-12 μ. Extremely sensitive to irritations (shedding of flagella, bursting of cell wall). Flagella sitting in a groove, primary flagellum somewhat longer than cell body. Protoplasm contains a great number of oil droplets as well as large leucosin granules. No eyespot. Cysts with forked spines, 12-15 μ in diameter and with broadly elevated (funnel-shaped) pore. p.161
(5) Ochromonas fragilis 12.

γ) Chromatophore usually in dorsal position, saucer-shaped, with pyrenoid. Cells minute (5-9.5 X 3-6 μ), asymmetric. Ochromonas nannos 12a.

- Cells with delicate brown pigment granules peripherally embedded in periplast.

  — Cells 6-8 μ, globose; chromatophore with large flange-like margins. .....(1) Ochromonas silvarum 13.

  — Cells 10-12 X 6-8 μ, oviform; also with oil droplets, mainly all around the chromatophore. (2) Ochromonas pigmentata 14.

  — Pigment granules within a broad "ectoplasmic seam." Cells very minute (5 X 3 μ), oviform. (3) Ochromonas gracilis 15.

- Cells with numerous fat-granules usually quite regularly arranged throughout periphery of periplast.

  — Cells barely metabolous, oviform (about 5-7 μ), without eyespot. Cysts very characteristic: Spherical, with smooth wall and large hemispherical pore-funnel. (1) Ochromonas vasocystis 16.

  — Cells strongly metabolous, oval, spherical, or elongated with pointed posterior pole. Without eyespot. With an abundance of even-sized peripheral fat-granules. The chromatophore embraces, as a rule, a large leucosin granule. Anterior end slanted. 25 X 15 μ. (2) Ochromonas perlata 17.

  — Cells not metabolous, 12 X 6-7 μ; without eyespot. Perifery with smaller and larger oil droplets; several relatively large leucosin granules within. (3) Ochromonas hinterzartensis 18.

II. Cell wall vesicular-verrucose or verrucose-bumpy.

a) Chromatophore in the shape of a folded band; cells 12-20 μ, with eyespot, strongly metabolous. .....Ochromonas crenata 19.

b) Chromatophore platelike with notched rim, curved lengthwise (sometimes the curvature is more centrally concentrated). Cells 19-27 X 12-18 μ. With eyespot. Flagella relatively shorter than those of preceding species [O. crenata]. ..... Ochromonas verrucosa 19a.

c) Chromatophore saucer-shaped, in lateral position, occupying half the cell body. Cells 10-12 X 7-9 μ, barely metabolous. Without eyespot. Cysts ornamented with spines; broad vasiform pore. Ochromonas pinguis 20.

d) Chromatophore platelike, positioned slightly toward anterior portion of the cell. Outside irregularly covered with smaller and larger, often dentate, verrucae (in part foreign bodies ?). One (or two ?) chromatophore(s), no eyespot. ..... Ochromonas aspera 21.

B. Two chromatophores.

I. Chromatophores poorly developed, in anterior position.

a) Vacuole at anterior end; eyespot. 12-20 X 6-15 µ. p.162
Ochromonas granulosa 22.

b) Vacuole in about median position; eyespot. Cells 5-6 µ, strongly metabolous. ..... Ochromonas pallida 23.

c) Vacuole in basal position; eyespot. 8-12 X 5 µ.. Ochromonas tenera 24.

II. Chromatophores large and distinct.

a) Periplast smooth.

1. Chromatophores at anterior end. ..... Ochromonas ludibunda 25.

2. Chromatophores in lateral position.

α) Without eyespot.

- Cells very minute (3-4 µ), broad oviform to spherical.
Ochromonas sphagnalis 26.

- Cells larger.

— Cells rigid, ellipsoidal, 11-13 X 6-8 µ; sometimes in small filamentous colonies. ... (1) Ochromonas sociata 27.

— Cells metabolous, more globose (6-9 X 5-8 µ).
(2) Ochromonas variabilis 28.

— Cells extremely metabolous, in most cases creeping; 18-24 µ. Cysts smooth, 17 µ in diameter.
(3) Ochromonas reptans 29.

β) With eyespot.

- Cells strongly metabolous, particularly the basal portion; ellipsoidal, oviform to spherical. 15-30 X 18-22 µ.
Ochromonas mutabilis 30.

b) Periplast verrucose-granular. Chromatophores large, in lateral position.

1. One contractile vacuole, primary flagellum same length as cell body. Anterior end not labiate. ..... Ochromonas chromata 31.

2. Two contractile vacuoles, primary flagellum 1 1/2 times the length of the cell. Anterior end unilaterally labiate.
Ochromonas nasuta 32.

Chlorochromonas LEWIS, 1913 p.176

Cells cylindrical, pyriform to spherical, anterior end lopsided, periplast very delicate. Individual cells usually free-swimming, sometimes amoeboid, or sessile on pseudopodiumlike projection of the posterior pole.

Two chromatophores, in the form of often very unevenly elongated plates. With or without ocellus. A single contractile vacuole in anterior cell portion. Nucleus vesicular. Primary flagellum about twice as long as cell body, secondary flagellum barely 1/3 of the length of the cell body. Multiplication is by longitudinal division while the cells are actively motile. Cysts not observed.

There are two species which are difficult to distinguish on account of their pronounced changeability; Chlorochromonas minuta is, furthermore, not that well known.

I. Minute forms (4.5-9.5 μ long), shape pyri- to oviform; indentation at anterior end apparently rather shallow. ..... Chlorochromonas minuta 1.

II. Larger forms (between 5 and 25 μ), on the average 9-22 X 3-9.5 μ; indentation at anterior end generally more pronounced. Changeability of form apparently greater. ..... Chlorochromonas polymorpha 2.

Didymochrysis PASCHER, 1929 p. 177

Here, we are dealing with a diploid chrysomonad which, "morphologically, corresponds to Ochromonas cells, intergrown longitudinally on one side, slightly leaning towards one another, and diagnosed by PASCHER as follows:

"Protoplast distinctly dorsiventral, reversed oviform if viewed from its broad side, anterior end slightly indented with somewhat elongated sides; if viewed from its narrow side, dorsal contour arched and ventral contour flat. In optical cross section somewhat reniform. Periplast very delicate. Two pairs of flagella, each consisting of one long and one shorter flagellum. Both pairs are set slightly apart and project from the anterior end in such a manner that each of the shorter flagella is turned to one of the elongated sides. Two chromatophores in lateral position, approximately

median-symmetrical to one another; slightly curved and platelike toward the end. Each chromatophore with one eyespot. With two pairs of contractile vacuoles in anterior and lateral position. Nucleus in anterior portion of cell. Longitudinal cell division along the median of the protoplast. Cysts spherical, smooth, with slightly elevated pore."

One species: Didymochrysis paradoxa PASCHER. — With the characteristics described for this genus. Primary flagellum nearly as long as cell body. Cells measure 18-25 X 12-16 μ, up to 8 μ thick. p.178

Ochromonadeae aggregatae

Colonial forms. According to the shape of the colonies, two types can be distinguished: One gelatinous, globose, the other nongelatinous and ring-shaped. Unfortunately, much has still to be clarified in regard to the first group which embraces the genera Uroglena, Volvochrysis, Synochromonas, and Synoropsis, particularly as far as the structure of the colonies or the definement of the genera, and of some species, is concerned, so that the author was facing considerable difficulties. There exists an urgent need to concentrate attention on these difficult-to-investigate forms in the near future.

Key for the determination of the genera:

I. Cells united in spherical or ellipsoidal colonies.

a) Cells radially arranged at the periphery of a gelatinous matrix or a system of gelatinous threads.

1. Most colonies multicellular. Cells reversed ovi- or pyriform, their usually pointed base attached to dichotomously branched gelatinous threads or rodlets which radiate from the center.
Uroglena (p.60)
(incl. Uroglenopsis)

2. Most colonies consist of a few cells only; rarely multicellular. Cells spherical or oviform, touching one another with their blunt posterior pole which is inserted in a central, apparently homogeneous (?) gelatinous matrix from which the anterior half of the cell projects
Volvochrysis (p.61)

b) Basal poles of cells more or less firmly united in the center of the colony, cells from there radially projecting.

1. Cells surrounded by a gelatinous sheath, dorsiventral, oblong pyriform; two chromatophores. ..... Synochromonas (p.62)

2. Cells not surrounded by gelatinous sheath, only their elongated base is anchored in a spherical consistent gelatinous matrix, whereby the cells are kept united; two chromatophores. Synuropsis (p.62)

II. Cells united in coronal or ringlike colonies. ..... Cyclonexis (p.63)

Uroglena EHRENBERG, 1838

p.179

(incl. Uroglenopsis LEMMERMANN)

Cells may be oviform, ellipsoidal, also reversed oviform, basal end tapered, anterior pole rounded, occasionally pyriform, naked, their form very vulnerable. United in spherical to ellipsoidal colonies, radially arranged at the periphery of an — often seemingly homogeneous — gelatinous matrix and attached to a dense system of gelatinous threads or tubes (demonstrable by the use of appropriate stains) radiating from the center of the colony and, depending upon the division of the cells, more or less regularly dichotomously branched. (Such gelatinous strands can be observed mainly in young colonies, frequently even without artificial staining; they are no longer detectable by staining in older colonies, but become visible with India ink). With one chromatophore, in rare instances two (Uroglena europaea), parietal, saucer- or band-shaped, sometimes spirally twisted. Eyespot always present. Two contractile vacuoles of different size within the anterior end. Primary flagellum 2-5 times the length of the cell body. — Reproduction is by longitudinal cell division; formation of minute, spherical swarmers has also been observed (SCHILLER). Multiplication of a colony is allegedly by constriction into two daughter colonies. According to SCHILLER are new colonies formed by the migration of cell com-

plexes of 10-20 cells. Cysts have been reported for 3-4 species: Spherical, either with smooth, denticulate, or spine-studded wall and with a species-specific structure of the neck region. — Nutrition is holophytic.

Key for the classification of the Uroglena species (incl. Uroglenopsis) p.180

A. Gelatinous strands to which the cells are attached are detectable even without staining, particularly in young colonies; more difficult (often impossible) in older colonies.

I. Primary flagellum about twice as long as cell body. Chromatophore in the form of a spirally twisted band. Colonies multicellular. Cells measure 12-20 X 8-13 µ. ..... Uroglena volvox 1.

II. Primary flagellum about 2 1/2 to 3 times longer than cell body. Chromatophore saucer-shaped. Colonies somewhat irregular, with relative few cells. Length of cells 15-17 µ. ..... Uroglena conradii 2.

B. Gelatinous strands to which the cells are attached become visible only after preparation (India ink or appropriate stains).

I. Two chromatophores; primary flagellum 3-5 times the length of the cell body. Cells up to 7 µ wide. ..... Uroglena europaea 3.

II. One chromatophore.

a) Primary flagellum 4-5 times the length of the cell body.

1. Chromatophore in the shape of a watch glass, ribbonlike, or stellate. Cells 12-17 X 8-11 µ. Cysts spherical, with verrucose wall, flange-like collar and "handle."..... Uroglena soniaca 4.

2. Primary flagellum up to 4 times the length of the cell body. Chromatophore saucer-shaped; cells 5-12 X 3-7 µ. Cysts unknown. ..... Uroglena americana 5.

b) Primary flagellum only slightly longer than cell body. Chromatophore lamelliform. Cells 8-10 X 4-6 µ. ..... Uroglena botrys 6.

Volvochrysis SCHILLER, 1929 p.186

"Cells united in spherical colonies by being radially embedded at the periphery of a gelatinous matrix that keeps the cells, touching one another, firmly and rigidly together. The center of the colony is filled with a hyaline, rather consistent gelatinous mass which covers the basal

half of each cell. Cells globose or elongated oviform, with a long primary and a secondary flagellum, two chromatophores, with or without eyespot, all characteristics varying from species to species. Multiplication by division of the cells either within the colony or, after escape from the latter, in a solitary state. Two vacuoles; cysts unlnown. — Three species are known so far." (SCHILLER)

Key for the classification of Volvochrysis species: p.187

I. Cells with eyespot, oviform, 13-15 X 7-8 μ. ..... Volvochrysis xantha 1.

II. Cells without eyespot.

a) Small colonies with few (usually 8) cells. Cells spherical, 8-10 μ in diameter. ..... Volvochrysis globosa 2.

b) Multicellular colonies; cells oviform, 10-12 X 5-6 μ. Volvochrysis polyochla 3.

Synochromonas KORSHIKOV, 1929 p.188

Free-swimming, spherical colonies consisting of a varying number of cells which are radially arranged, their basal ends connected to one another; covered by gelatinous sheath. Cells are of the Ochromonas-type, dorsiventral, without differentiated periplast or lorica. With 2 flagella of unequal length, two chromatophores, one contractile vacuole, one nucleus. Food reserves accumulate as leucosin, fat, and volutin granules. One species: Synochromonas pallida KORSHIKOV.

Synuropsis SCHILLER, 1929 p.190

Cells united in mobile, spherical, less frequently oviform, colonies, but solitary (planktonic) cells have also been reported. Cells pyriform. Basal end metabolous, stretching lengthwise in reaction to external irritation (pressure, temperature). Periplast well developed (but lower portion of cell very delicate); smooth and without apiculi, but if the

latter exist, they are very fine. The two chromatophores directly adjacent to membrane, oblong through-shaped, reddish-brown. One eyespot, situated at the tip of one of the chromatophores, pale-red and, therefore, not very distinct, often apparently lacking. Two flagella of uneven length, one slightly longer than the cell, the other only half that length, the former radially stretched and also moving in the direction of the radius of the colony, the shorter one whipping more sideways (tangential direction). — Multiplication of individual cells within the actively motile colony by longitudinal division; multiplication of a colony by way of constriction into two daughter colonies of about equal size, as observed for Synura. The colonial cells excrete, from their basal ends, tough gelatinous material in which the cells are anchored and, hence, kept closely together.

Key for the classification of Synuropsis species: p. 191

I. Cells pyriform, basal portion short and pointed, or blunt, often filiform; with eyespot. 18-20 X 6-8 µ. ..... Synuropsis danubiensis 1.

II. Cells spherical to broad oviform, sparsely ornamented with short, barely visible bristles. Without eyespot. Size = 9-15 µ. Synuropsis globosa 2.

Cyclonexis STOKES, 1886 p. 192

Cells laterally joined to one another to form a flat discoid, free-floating, colony with a circular open space at the center. Cells obovate, not surrounded by lorica, anterior end broadened, cells about twice as long as broad. Anterior end also more or less pointedly protruding; colonies are initially infundibular, later definitely ring-shaped, aged colonies also bent down at the sides in about saddlelike fashion. With two yellow, ribbonlike chromatophores in lateral position (according to STOKES), or only a single pigment-bearing body (according to HÜZEL); without eyespot. Two

contractile vacuoles within the anterior end of the cell. Two flagella of unequal length: Primary flagellum as long as cell, more or less straight; secondary flagellum about half as long, sometimes somewhat spirally twisted. Nutrition is holophytic. Reproduction probably by way of longitudinal division. Cyst formation doubtful (HUZEL, 1936, may probably have seen some). The only species: Cyclonexis annularis STOKES.

Subfamily: Lepochromonadoideae p. 194

Cells with delicate loricas of various shapes, solitary or in colonies, free-swimming or sessile (from the Greek "lepos" = rind, shell).

I. Lorica homogeneous.

a) Sessile (mostly epiphytic) forms, solitary or in colonies. Of the genera here concerned (Stylopyxis, Poteriochromonas, Dinobryon = sect. Epipyxis) only the latter shall be described later* since it includes members that now and then occur as epiplankters and, hence, are most closely related to planktonic forms.

b) Free-swimming forms whose protoplast is attached to the base of the lorica by a contractile or noncontractile stalk or, without a stalk, laterally to the inner wall of the lorica. Solitary or in colonies.

1. Solitary forms.

α) Protoplast without basal stalk.

- Lorica ovi- or fusiform, conical, reminiscent of a small pot, barrel, or bottle gourd; with or without transverse ridges.

— Protoplast oblong fusiform, ovoid or ellipsoidal, orientated along the longitudinal axis inside the lorica without, or barely, touching the sides of the wall. Flagella apical, two lateral chromatophores, with eyespot.
Pseudokephyrion (p.65)

— Protoplast more massive, broad, occupying the entire base and partly also the sides of the wall, completely filling the lower half of the lorica in such a slanted position that the flagella seem to project laterally. One chromatophore, unilaterally shifted. ..... Kephyriopsis (p.67)

- Lorica oviform or spherical, with 2-3 long, strong, spines.
Diceras (p. 68)

- Lorica long, rod-shaped, median portion slightly bulging where the fusiform protoplast with stalk is situated; one chromatophore and eyespot. (Flagella not observed; genus doubtful, systematic position provisional.) ..... Stylocoras

*) Translator's note: The description of the genus referred to in this paragraph is on p. 231 of the original which has not been submitted for translation.

β) Protoplast with short contractile stalk. Lorica smooth (that is, without transverse ridges), cup-shaped, lateral end tapered to a point. ..... Dinobryon (sect. Dinobryopsis) (p.69)

2. Colonial forms. Lorica cup-shaped, anterior end tapered to a point. Dinobryon (sect. Eudinobryon) (p.71)

II. Lorica with more or less numerous successive growth rings sticking out sideways. Cells solitary or in colonies, in most cases sessile, rarely free-swimming and then only secondarily. ..... Hyalobryon (p.71)

Pseudokephyrion PASCHER, 1913 p.195

(Dinobryon, autt. pro parte; Dinobryopsis LEMMERMANN, pro parte)

Cells with lorica, free-swimming. The lorica may be barrel- or cup-shaped, yellowish to brownish in color, with 2-3 transversal or helically winding ridges so that, in optical cross section, the lorica appears undulate. The broad mouth of the lorica is straight truncate, sometimes slightly elongated. Protoplast ellipsoidal, without basal stalk attached to the base of the lorica, without contractibility, its delicate, smooth periplast not filling the lorica completely, and not touching the side-walls. Anterior end without peristomelike process. Two flagella of unequal length, the longer one 1 1/2 to 2 times the length of the lorica, the shorter one half as long as the cell body and sometimes projecting only slightly through the opening of the lorica. Two vacuoles, two lateral chromatophores which are mildly curved. One rod-shaped eyespot. Reproduction by division and budding. Cysts unknown.

Key for the classification of the Pseudokephyrion species:

A. Base of lorica broadly rounded, that is, not pointed, and without mastoid protuberance.

I. Surface of lorica without winged ridges, showing helical windings.

a) Lorica approximately conical, evenly rounded at base.

1. Mouth of lorica vaselike widened so that it becomes the broadest spot of the lorica; the latter with 6-7 broad transversal rings. Pseudokephyrion pilidium 1.

2. Mouth of lorica narrowing, broadest spot is just beneath so that, from there, the lorica is conelike attenuated towards either end. Base flatly rounded, lorica with one transverse ring.
Pseudokephyrion depressum 2.

b) Lorica approximately cylindrical or oviform. p. 196

1. Ridges form horizontal rings.

α) Mouth of lorica not narrowing, lorica 13 X 10 μ. Protoplast long and slender. ..... Pseudokephyrion uraula 3.

β) Mouth of lorica narrowed, lorica 8 X 7-7.5 μ. Protoplast massive. ..... Pseudokephyrion obtusum 4.

2. Annular ridges (2-4) spirally winding. Pseudokephyrion spirale 5.

c) Lorica ellipsoidal with broad, equatorial, shallow, annular groove.
Pseudokephyrion ruttnerii 6.

II. Surface of lorica with winged ridges, showing helical windings.
Pseudokephyrion formosissimum 7.

B. Base of lorica with mastoid protuberance, a pointed knob, or a sharp point.

I. Lorica resembles a tiny barrel; base with a broad, roundish, mastoid protuberance.

a) Protoplast oblong, attached at the bottom of the basal recess.
Pseudokephyrion undulatum 8.

b) Protoplast more roundish, attached at the edge of the basal recess without entering the latter. the recessed cavity is finely coiled. Lorica ornamented with 4-7 annular ridges.
Pseudokephyrion undulatissimum 9.

II. Lorica not barrel-shaped.

a) Lorica cone-shaped, just as long as it is wide, with numerous narrow, transverse tori, the base with a more or less pointed knob.
Pseudokephyrion conicum 10.

b) Lorica not conical.

1. Lorica shaped like a bottle gourd, equally long as wide, with 2 ampullae, the lower one at least twice as broad as the upper ampulla. Posterior end with with a short, broad-based point.
Pseudokephyrion ampullaceum 11.

2. Lorica approximately fusiform, at least twice as long as broad, base with a strong lanceolate point, anterior end truncate.

α) With 3 nearly equal transversal tori (at least the two lower tori are almost similar)... Pseudokephyrion acutum 12.

β) With 4 transversal tori, the uppermost having the smallest diameter, each of the following tori describing a proportionally larger circle; the lowermost, largest ring is followed immediately by the pointed end.
Pseudokephyrion pulcherrimum 13.

Kephyriopsis PASCHER & RUTTNER, 1913 p.203

Unicellular form with oviform or ellipsoidal lorica, anterior end broad, base truncate, frequently with a sharply delimited thick ring just below the mouth, and with reticular markings on the outside. Often, p.204 the lorica may be of a brownish color. The protoplast completely fills at least the lower portion of the lorica, a contractile stalk is lacking; definite metabolous activity. One saucer- to ribbon-shaped chromatophore, usually pushed into a unilateral position. Two flagella of unequal length projecting more from one side of the protoplast, close to the wall. Two distinct contractile vacuoles at the base of the flagella. Reproduction: 1. By budding, in which case the pores of mother and daughter organism are turned toward one another; 2. division of the protoplast, escape of the daughter protoplast which then, free-swimming, forms a new lorica; 3. division of the protoplast outside the lorica. Cyst have not been observed.— The inner wall of the lorica shows a cellulose reaction.

Key for the classification of the Kephyriopsis species:

A. Lorica cone-shaped.

I. Lorica narrowing at base.

a) Length and width of lorica equal. ..... Kephyriopsis conica 1.

b) Lorica 3 times longer than wide. ..... Kephyriopsis heverlensis 2.

II. Lorica broadened at base.

a) Lateral wall undulate ..... Kephyriopsis elegans 3.

b) Lateral wall not undulate but reticulate ... Kephyriopsis ornata 4.

B. Lorica cylindrical, short, rounded at both ends .. Kephyriopsis cineta 5.

C. Lorica globose, with one very shallow transversal groove. Kephyriopsis lata 6.

D. Lorica oviform or ellipsoidal.

I. Lorica short oviform, solid, wall reticulate ... Kephyriopsis ovum 7.

II. Lorica elongated, ellipsoidal, fragile, with smooth wall. Kephyriopsis ellipsoidea 8.

Diceras REVERDIN, 1917

Cells in tightly fitting lorica, free-swimming, oviform, ellip- p.208
soidal, or globose; At opposite poles of a lorica are two (one each) more or less long, sturdy, hyaline, plain, tapering spines of either equal or unequal length, either both evenly curved, or one curved, the other straight. There is one species with three spines, but these are not in the same plane of projection but extended in different directions. Apparently, the cells may exist in various stages (at least in the case of Diceras chodatii), namely with or without flagella of which there are one or two, in the latter case with one longer and one shorter flagellum. (It is highly probable that, in "uniflagellate" forms, the very short secondary flagellum has been overlooked.) The little vacuolized protoplast completely fills the lorica without entering the hollow spines against which it is even sharply delimited. One yellowish-green chromatophore, band-shaped, parietal, sometimes in the shape of a calotte. In its vicinity, there are always several distinct granuli, presumably assimilations. Two pulsating vacuoles are located in the anterior portion of the cell, here and there are still other, larger, vacuoles. An eyespot is lacking. Membrane and spines of the lorica of Diceras chodatii consist, according to REVERDIN, of cellulose (similar to Dinobryon); for Diceras ollula, cellulose tests resulted (according to FOTT) in a negative reaction. Cell division within the lorica and subsequent escape of one or of both daughter protoplasts from the old lorica has been observed.

Key for the classification of the Diceras species: p.209

A. Lorica oviform (14 X 6 μ), spines of unequal length (40 and 24 μ). The shorter spine follows the longitudinal direction of the longer cell axis, the longer spine stands in an acute angle to it. In lateral position, the organism appears asymmetric. ..... Diceras chodatii 1.

B. Lorica ellipsoidal (10 X 4 μ), spines of equal length (about 18 μ), leaning evenly against the longitudinal cell axis. The organism appears symmetric in lateral position. ..... Diceras ohridana 2.

C. Lorica reniform (size 7-5 μ) with 2 spines of equal length (about 25 μ) at opposite poles following the direction of the longitudinal axis. Diceras phascolus 3.

D. Lorica globose (6.5-8.5 μ in diameter) with 2-3 spines laterally attached to the lorica and pointing in different directions (25-32 μ long). Diceras ollula 4.

Dinobryon EHRENBERG, 1835 p.211

Ever since LEMMERMANN (1910) we distinguish 3 sections for the genus Dinobryon:

Section 1: Epipyxis (EHRENBERG) LAUTERBORN; Cells always sessile, solitary or in unicellular groups, never united in branching colonies.

Section 2: Dinobryopsis LEMMERMANN; cells solitary, free-swimming. Surface of lorica sometimes distinctly sculptured with thicker costae. Plankton organisms (not to be confused with the liberated individuals of the following section). p.212

Section 3: Eudinobryon LAUTERBORN; cells united in more or less strongly arborescent free-swimming colonies; euplankters. (Colonies may sometimes dissolve into individual cells each with its campanulate lorica.)

Section: Dinobryopsis

Unicellular free-swimming forms. Protoplast known only of one species (Dinobryon acuminatum); the same applies to cyst formation. Knowledge of this group is still insufficient.

Furthermore, REVERDIN (1919) described two "new" species observed in the Lake of Geneva:

1. Dinobryon campanuliforme REVERDIN. — The campanulate lorica of this "species" corresponds exactly to that of Dinobryon sociale var. americanum so that I, personally, believe the species described by REVERDIN to merely represent liberated individuals of Eudinobryon, particularly since the latter also inhabits the Lake of Geneva; I have noted that KRIEGER (1930) shares this opinion.

2. Dinobryon elegans REVERDIN, with its evenly cone-shaped lorica is hardly different from the individual cup of Dinobryon sociale, that is, from its variation stipitatum; KRIEGER (loc.cit.) also shares this opinion.

While, then, in the case of forms with a plain lorica, it is possible to confuse their identity with that of liberated individuals of colonial Dinobryon species (section Eudinobryon), this is quite inconceivable in the case of solitary forms whose lorica is sculptured with helical costae. These spiralling ridges seem to be a specific characteristic of the section Dinobryopsis. Similar loricae have never been observed in the Eudinobryon section. p.213

Taxonomic key for the Dinobryon species:

I. Lorica plain, without helical costae, sometimes slightly undulate.

1. Lorica cylindrical, slightly undulate. Mouth straight, base slightly broadened, short, and quite evenly tapered to a point. Dinobryon acuminatum 1.

2. Lorica cylindrical, mouth slanted, base extended into a long seta. Dinobryon borgeii 2.

3. Lorica broad campanulate, flaring away from the protoplast; mouth straight truncate. ..... Dinobryon urceolatum 3.

II. Lorica sculptured with spiralling costae.

1. Lorica narrow, fusiform; mouth widens like a funnel. Regular, not monosymmetric. ..... Dinobryon spirale 4.

2. Anterior portion of lorica more cylindrical; on account of the usually obliquely mounted conical base, the lorica is monosymmetric.

a) With two spiralling costae crossing one another, mouth straight. Dinobryon marssonii 5.

b) With one spiralling costa, mouth slanted. ... Dinobryon suecicum 6.

Section: Eudinobryon p.216

Free-swimming colonial forms. The colonies consist either of only few (Dinobryon bavaricum), [illegible] or of very numerous cells so that the colonies are thick and bushy (Dinobryon sertularia with var. thyrsoideum, Dinobryon sociale). The colonies of other species are, by contrast, rather loose and spreading because the lateral loricae are strongly asymmetrical and, since the conical base stands at an angle to the rest of the lorica, bent outwards (Dinobryon divergens, Dinobryon cylindricum var. palustre, Dinobryon bavaricum var. vanhöffenii). For some species, dense as well as loosely formed colonies have been reported; this observation has been interpreted as seasonal dimorphism. However, conclusive evidence has yet to be obtained to confirm this point of view. Nearly every body of water hosts its specific, little varying, local type; due to the diversity of the environmental factors, this results in a vast variety of forms. The loricae of a colony are in most cases of equal length, but sometimes their size is diminishing toward the top of the colony (Dinobryon balticum, a marine species), in other colonies it may be increasing (Dinobryon sociale).

Taxonomic key for the Dinobryon species: p.222

(after KRIEGER)

A. Lorica vasiform.

1. Colonies thick and bushy; loricae short and broad, the basal portion (var. protuberans only) with lateral protuberance.
Dinobryon sertularia 1.

2. Colonies loosely assembled; loricae longer. Cysts with hooklike neck.
Dinobryon cylindricum 2.

B. Anterior portion of lorica more or less cylindrical, usually undulated, the rest of the lorica attenuated to form in most cases a very long "stem." Colonies elongated, consisting frequently only of a limited number of cells. ..... Dinobryon bavaricum 3.

C. Lorica conical, forming a pointed bag; often elongated (in var. americanum with indication of a stalk). ..... Dinobryon sociale 4.

D. Anterior portion of lorica cylindrical, followed by angular, usually undulate, connective zone for the often obliquely attached basal cone.

1. Anterior portion of lorica undulate. Connective zone not very distinctly marked. Basal portion in most cases with two lateral projections. Planktonic in dystrophic bodies of water. Dinobryon pediforme 5.

2. Anterior portion of lorica not always undulate (except for var. schauinslandii). Connective zone usually broadened, angular or undulate. Basal portion conical, without lateral projections. Inhabits oligotrophic or eutrophic waters. ..... Dinobryon divergens 6.

E. Lorica funnel-shaped, wall thicker at base, elongated into a fine solid stalk. ..... Dinobryon behningii 7.

Hyalobryon LAUTERBORN, 1896

p. 234

Cells sessile, with extremely delicate, more or less cylindrical or oblong-oviform lorica which is made up, either in its entire length or only at the anterior end, of successive growth rings nesting funnellike one upon the other, more or less bending away from each previous one. Solitary or in colonies, sometimes standing individually closely together in groups, or in pseudocolonies. True colonies are formed by laterally superimposed attachment of the daughter lorica to the outside of a mother lorica. Cells more or less fusiform, and attached to the inner wall or to the bottom of the lorica by a delicate hyaline contractile stalk; anterior end slanted and indented. Two chromatophores, usually rather dissimilar; eyespot in most cases present. With two fine flagella of unequal length. Contractile vacuoles in the anterior or median portion of the cell. Cysts (as far as observed) ellipsoidal, with porus and plug. Nutrition is holophytic and p. 235 heterotrophic (in the latter case, food particles are ingested directly into the strongly amoeboid anterior end of a cell).

Taxonomic key for the Hyalobryon species:

I. Solitary forms, individuals often side by side in groups, never in arborescent colonies.

a) Growth rings numerous, distributed over the entire lorica.

1. Lorica more or less cylindrical, basal portion barely wider.

α) Lorica not stipitate, growth rings spreading only slightly. Hyalobryon lauterbornii 1.

β) Lorica stipitate, growth rings in close succession and spreading widely. ..... Hyalobryon mucicola 2.

2. Lower third of lorica distinctly widened, base pointed.

α) Lorica from the basal widening all the way to the straight mouth cylindrical, not stipitate. Protoplast attached to the bottom of the lorica. Growth rings in close succession, slightly spreading (12-15 in number). ..... Hyalobryon cylindricum 3.

β) Mouth straight, slightly widened; protoplast attached to bottom of angular bending lorica, the latter without stipe. Hyalobryon wigrense 4.

γ) Mouth oblique truncate, not widened; protoplast attached laterally to the inner wall of the lorica which has a short stipe. Hyalobryon voigtii 5.

b) Growth rings limited to apical part of the lorica, limited in number (1-3).

1. Lorica attenuated towards base.

α) Protoplast laterally attached to inner wall. Hyalobryon borgeii 6.

β) Protoplast attached to the bottom of the lorica. Hyalobryon deformans 7.

2. Lorica cylindrical, not attenuated towards base, obtusely rounded. Protoplast attached to the bottom of the lorica. Hyalobryon leickii 8.

II. Colonial, arborescent forms.

a) Anterior portion of lorica with numerous short, little spreading, growth rings; the hyaline anterior end of the protoplast not protruding from the lorica. ..... Hyalobryon ramosum 9.

b) Anterior part of the lorica with 1-2 growth rings. Anterior end of the protoplast protruding markedly from the lorica. True colony formation rare. ..... Hyalobryon leickii 8.

p. 239

Subclass 2: Rhizochrysidinae

These organisms are known only in the rhizopodial form. Intermediate forms in which the flagellated phase is a temporary phase in the life cycle (e.g., Chrysamoeba) have — as far as free-swimming species are concerned — been classified among the corresponding chrysomonads.

One order: Rhizochrysidales.

This group includes those chrysomonads which are known only in the rhizopodial form, without flagella, and which, particularly as far as reproduction is concerned, no longer produce flagellate swarmers but divide again into amoeboid daughter cells. Whether or not one or the other form facultatively still maintains a flagellated phase which, so far, has only escaped attention, or whether the flagellated phase has been completely inhibited in individual species and has, hence, been completely abandoned, is subject to further investigations. In any event, we are dealing here with an artificial, probably not homogeneous group since the forms that it includes relate possibly to entirely different flagellated chrysomonads which, due to the loss of their flagella, no longer show their true relationships. To these have to be added also those forms in which the chromatophores show considerable regression or do even no longer exist so that such achromatic species have assumed an entirely rhizopodial appearance and reveal their relationship to the chrysomonads only by an occasional formation of typical siliceous cysts. p. 241

The order of the Rhizochrysidales can be divided into five families:

A. Cells naked.

Family 1: Rhizochrysidaceae. — Forms without lorica, solitary or in colonies, free-swimming or sessile. Flagellated transitory stages; several planktonic species.

B. Cells with lorica.

Family 2: Chrysothecaceae. — Most forms have a thick-walled brown lorica with one or more (2-5) pores, free-swimming or sessile on a substratum. The protoplast does not completely fill the lumen of the lorica in which it is often freely suspended; with a simple or more complex (dichotomously branched) system of rhizopodia. Found among other algae as a mud-dweller, not observed among plankton. Free-swimming forms: Chrysotheca DOFLEIN (not Chrysotheka SCHERFFEL = Chrysothecopsis CONRAD), Eleutheropyxis SCHERFFEL, Chrysamphitrema SCHERFFEL. Epiphytic forms: Chrysothecopsis CONRAD = Chrysotheca epiphytica SCHERFFEL. p. 242

Family 3: Stylococcaceae. — Forms with delicate hyaline loricae attached to a substratum by a long hairlike stipe. Protoplast with one or more spokelike-radiating rhizopodia. Not planktonic. (Stylococcus CHODAT, Rhizaster PASCHER.)

Family 4: Lagynionaceae. — Forms with a usually delicate, hyaline lorica; without stipe, in most cases directly attached with its broad base to a substratum(never riding on the latter by means of pronglike transversal outgrowths). Protoplast (as far as known) with one very fine rhizopodium projecting through the necklike elevated mouth of the lorica. Not planktonic. (Lagynion PASCHER, Heterolagynion PASCHER, Chrysocrinus PASCHER.)

C. Plasmodial organisms, normally surrounded by a thick envelope.

Family 5: Myxochrysidaceae. — One species: Myxochrysis paradoxa PASCHER. Multicellular plasmodium with numerous contractile vacuoles and chromatophores. The tough envelope has a brown color due to iron infiltration. Nutrition is partly holophytic and partly heterotrophic. The plasmodia are motile by means of broad pseudopodia. Food intake through special

hernialike [tuck-in] pseudopodia. Multiplication is by formation of multicellular bodies, leading to formation of swarmers of the Chromulina-type, or of one- to many-celled amoebae; cyst formation has also been reported. New plasmodia are formed by fusion of individual amoeboid cells. The genus points to a relationship between flagellates and myxomycetes. Not planktonic.

Family: Rhizochrysidaceae

Cells naked, solitary or in colonies, free-floating or sessile (epiphytic). Several species among plankton or neuston.

Key for the determination of the genera:

A. Cells solitary or united in amorphous colonies ("nests"). Not all species of this genus are plankters. ..... Rhizochrysis (below)

B. Cells joined one to another to form linear colonies; planktonic. Chrysidiastrum (p.77)

C. Cells united in reticulate colonies (filar plasmodia); planktonic. Chrysarachnion (p.77)

D. Cells united to more or less doughnut-shaped colonies with a common gelatinous envelope that is infiltrated with numerous granules of a denser gelatinous substance; tychoplanktonic. .... Chrysostephanosphaera (p.78)

Taxonomic key for the Rhizochrysis species: p. 244

A. Pseudopodia in most cases numerous (rarely very few, to 1 pseudopodium only); fine to very delicate, clearly recognizable as prolongation of the cytoplasm, plain, or branched at the distal end, more or less long.

I. Minute forms (3-5 µ without the pseudopodia), planktonic. Rhyzochrysis planctonica 1.

II. Larger forms (up to 7.5 µ), pseudopodia very delicate; observed among neuston in aquariums. ..... Rhizochrisis polymorpha 2.

III. Forms with a diameter of 10-15 µ (without the pseudopodia).

a) Pseudopodia very fine and long, not branched. Rhizochrysis gracillima 4.

b) Most pseudopodia long, branching, with more or less broad base. Rhizochrysis scherffelii 3.

B. Pseudopodia not very numerous (sometimes only 1); short, broadly lobed, plump or pointed.

I. Pseudopodia broadly lobed. ..... Rhizochrysis crassipes 5.

II. Pseudopodia pointed. ..... Rhizochrysis major 6.

C. Not with the typical pseudopodia, but with numerous delicate long "acicula;" cells spherical (35-45 μ). ..... Rhizochrysis limnetica 7.

Chrysidiastrum LAUTERBORN, 1913

p. 246

Cells about spherical, naked, joined to one another by plasma bridges to form free-floating linear colonies of 2 to 24 cells, not surrounded by gelatinous mass. Pseudopodia delicate, acicular, with tubercular thickenings, radially arranged (up to 10 in number). It is suspected that the pseudopodia are not one of the permanent characteristics of this genus. The single chromatophore within a cell is discoid to laminate. Cyst formation has been observed (KISSELEW); they are globose, with a two-layered thick membrane, and enclosed by a considerably larger capsule, allegedly 27 μ in diameter. The only species: Chrysidiastrum catenatum LAUTERBORN.

Chrysarachnion PASCHER, 1916

p. 247

The usually polygonal cells are connected with one another by delicate cytoplasmic processes to form a more or less wide- or close-meshed net thus representing a plasmodial colony of up to 200 cells or more; small reticulate colonies (2 or 4-8 cells) have also been observed which, through division and by retaining their rhizopodial connections, gradually become larger colonies of that nature. Individual cells in side-view lenticular. The rhizopodia develop only in the direction of the largest cross-sectional plane. Since this applies to all cells, they as well as the rhizopodia systems all lie in one and the same plane. However, this is true only under con-

ditions of quiescence, "in agitated waters, everything changes." Most cells have a single platelike, pale yellowish-brown chromatophore. The amoeboid protoplast is highly metabolous. The rhizpodia show considerable cytoplas- p.248
matic activity; they are delicate with occasional nodular thickenings. Nutrition is holophytic as well as holozoic, the latter being preferred. Multiplication is by division of a cell into two (possibly also three) daughter cells — apparently in only one direction ? — Formation of swarmers has not been observed. — One species: Chrysarachnion insidians PASCHER.

Chrysostephanosphaera SCHERFFEL, 1911

Up to 16 cells are arranged in a ring in the equatorial region of the gelatinous colonial envelope; the latter is infiltrated with usually small, glossy excretion-granules. The cells are ellipsoidal-spherical to biconvex, slightly metabolous, with extremely delicate, sometimes forked, rhizopodia all of which project horizontally from the equator of the two biconvex areas for some distance beyond the gelatinous envelope. Each cell with two parietal chromatophores on opposite sides, and two pulsating vacuoles orientated within. Reproduction is by cell division and dissociation of larger colonies. Flagellated stages at present unknown.

Subclass 3: Chrysocapsinae p.249

Immobile stages (without flagella) in gelatinous palmelloid (tetrasporoidal) colonies are predominant; motile monadal stages facultative.

One order: Chrysocapsales.

The Chrysocapsales include those Chrysomonads "which go through the greater part of their life cycle in an immobile palmella condition, thereby forming small brown gelatinous clusters to relatively large, often floa-

ting, gelatinous masses of mucus which are either epiphytic on other aquatic plants (peat mosses, etc.), or floating and – having been torn off the substrate – drifting" (PASCHER). Only very few species are known to lead a planktonic, that is, a secondarily planktonic existence.

The order of the Chrysocapsales consists of 4 families: p. 250

A. Cells in spherical or amorphous colonies, gelatinous strands, etc.; without apical growth. No gelatinous spines, sessile or free-floating. Family: Chrysocapsaceae

With the genera: Chrysocapsa, Gloeochrysis, Chrysospora, Phaeosphaera, Phaeocystis, Chrysosaccus, Tetrasporopsis, Chrysotilos, Chalkopyxis, etc.

B. Cells forming epiphytic circular colonies which are mostly monostromatic (rarely multistromatic) in the central portion, with a single cluster of long apical gelatinous setae; without apical growth. One species is known to be temporarily free-floating. Family: Naegeliellaceae

Only genus: Naegeliella.

C. Cells united in penicillate thalli which are usually profusely branched; with apical growth.

1. Apical growth restricted to a certain group of cells (apical meristem). Family: Celloniellaceae

   One genus: Celloniella.

2. Apical growth restricted to one apical cell. ... Family: Hydruraceae

   With the genera: Hydrurus, Nanurus.

Family: Chrysocapsaceae p. 251

Colonies are small, globose to ellipsoidal or may be filamentous, often branching; cell division is not restricted to a particular "growth zone." Colonies may be sessile, floating or drifting. Reproduction by formation of swarmers in that the more or less spherical to oval cells escape from the gelatinous envelope in a flagellate stage (in some species, they no longer leave the matrix), swarm for a time, then come to rest, secrete a gelatinous envelope, and resume cell division.

We shall, here, deal with the following genera of the family of Chrysocapsaceae: Chrysocapsa, Tetrasporopsis, Chrysotilos, and Chalkopyxis.

I. Cells united in ellipsoidal to globose colonies, most of them free-floating. ..... Chrysocapsa

II. Cells united in more or less extensive anastomosing or compact membranous, slippery colonies. Young colonies are tubular or saccate, attached to substratum from which they may later become detached to be free-floating, or they may be sessile for the greater part of their existence and be detached only occasionally. . Tetrasporopsis (below)

III. Colonies may be flocculent, compact, or reticulate, that is, netlike fragmented; size up to 1 mm, golden-brown to very dark brown, with distinct gelatinous envelopes around individual cells or cell groups. The cells may be naked or surrounded by an iron-incrustated 2-valved shell. The latter usually adhere for some time after bursting to the newly-formed (2 or 4) daughter cells. ..... Chrysotilos

IV. Small (up to 0.5 mm) colonies, initially sessile, later liberated; often aciniform, eventually dissociating into colonial fractions. Cells in groups of 2 or 4 peripherally distributed in the often massive, radially striated gelatinous envelope. Globular 2-valved cysts with tough, iron-incrustated wall; fragments of the latter usually adhere for some time after bursting to the young germlings.
Chalkopyxis (p. 81)

Tetrasporopsis LEMMERMANN

p. 253

Cells globular, oval to nearly spherical, sometimes somewhat angular, embedded in a consistent hyaline gelatinous matrix which matures into a reticularly meshed or compact membrane of an olive-brown color. Young thalli are tubular or saccate, but as they grow older they become membranous due to splitting; they are slippery-slimy. Each cell has one or two chromatophores. Reproduction, as far as known, is by longitudinal division and formation of swarmers (Chromulina-type). ..... Two species have been described:

I. Cells embedded in more or less extensive, reticularly meshed, gelatinous membranes; colonies usually sessile, occasionally free-floating.
Tetrasporopsis reticulata 2.

II. Cells assembled in compact membranous thallus, lodged on a substratum while young, later allegedly free-swimming. Tetrasporopsis fuscescens 1.

Chalkopyxis PASCHER, 1931

p. 256

"Minute colonies (up to 0.5 mm), initially attached to substrate, later free-floating; often aciniform-lobular, eventually dissociating into colonial fractions. The colonies are yellowish-brown, individual cells in definite peripheral position, usually in groups of two or four. In some colonies there is a distinct differentiation of the gelatinous envelope into a watery center, membranous interstitial layers, and a tough outer gelatinous wall showing radial striation. The protoplasts of individual cells are ellipsoidal to slightly ellipsoidal-compressed, with a large yellowish-brown chromatophore occupying most of the cell leaving the anterior end free for the contractile vacuole. The only species known so far is without an eyespot. To these colonies belong attached or unattached globose or ellipsoidal to reversed oviform cysts with pronounced Fe-incrustation of their tough walls consisting of two halves which may be similar or dissimilar, are often differing in thickness, and enclose the cyst in a shell-like fashion. Inside a cyst, a cell is attached with its anterior end to the bottom of the wall while the chromatophore-bearing end points to the roof of the wall, the latter surrounding the cell with some distance. Such cysts may be formed also within the colony, and they are not always p. 257 formed by only one protoplast but may involve generations of up to sixteen cells." ... The only species known so far:

Chalkopyxis tetrasporoides PASCHER. — With the characteristics described for the genus. Zells measure 9-12 μ. "So far repeatedly observed free, or epiphytic on Utricularia, Rhizoclonium, Microspora and other algae, in the water holes at the Pirtschen Pond near Františkovy Lázně in Bohemia" [Czechoslovakia] (PASCHER).

Chrysotilos PASCHER, 1931

Colonies in the form of "minute golden- to very dark-brown flakes, spanglets, or pellicles which may be either compact or arborescent and reticulate during all phases; the gelatinous matrix is usually very obscurely layered, only the gelatinous envelope immediately around a cell or group of cells is more distinct. The protoplasts of the individual cells may be naked or loosely surrounded by thick-walled iron-incrustated 2-valved shells. The protoplasts are ellipsoidal to almost globose, sometimes closely appressed to one another. The large parietal chromatophore has a definite eyespot and one contractile vacuole. Division is longitudinal and often in rapid succession so that groups of two and four daughter protoplasts occur which then separate gradually. Upon division of cells encapsuled in Fe-incrustated shells, the two valves — which are often very dissimilar — burst apart and remain temporarily in caplike fashion on the newly-formed cell groups until they become gradually completely detached whereupon they remain (irregularly distributed) embedded in the gelatinous envelope. Under unfavorable conditions, the daughter cells may again undergo encystment, or they may be subject to a series of cell divisions. If division takes place in rapid succession, formation of the tough iron-incrustated valves does not take place. The latter may be similar but, more often, they are unequal and sometimes they may exist only in form of minute disks. p. 258

The colonies never reach a notable size (1 mm at the most). Very soon the gelatinous matrix shows holes and crevices and becomes, eventually, a meshy reticulate structure in which individual cells or cell groups are found only in gelatinous pockets, rarely along the connective threads. The tiny gelatinous nests are liberated when the meshwork of threads finally

breaks down completely; since division continues in the liberated colonial fragments, new drifting colonies are formed. Swarmers are pronounced dorsiventral, with one not entirely parietal, more dorsally placed, platelike chromatophore and one distinct eyespot. From the obliquely truncate anterior end projects, out of a slight notch, one flagellum the length of which exceeds that of the cell body; situated at its base is one contractile vacuole. — Smooth-walled siliceous statospores with a large pore and conspicuous plug, and formed endogenously, have also been observed. Occasionally, one or (less frequently) both halves of the wall of the cyst that formerly surrounded the protoplast which now, in turn, formed the statospore, are found attached to the latter." (PASCHER, 1931).

Only one species is known so far:

Chrysotilos ferrea PASCHER. — With the characteristics described for the genus. Cells measure 7-9 µ. "Occurs as a very patchy water bloom on the surface of puddles along Alpine pastures such as the "Pauschenalm" and the "Herrenalm" near Lunz in Lower Austria." (PASCHER)

Family: Naegeliellaceae

With one genus: Naegeliella CORRENS, 1892

Cells united in discoid colonies which may be entirely monostromatic or (less frequently) multistromatic in the central portion, and are always surrounded by gelatinous envelopes. Projecting from the apical ends of the cells is a cluster of very long, often repeatedly branched gelatinous setae. An axial cytoplasmic filament among the ensheathed setae has been observed as a definite feature of two species. Each cell contains one chromatophore and food reserves in the form of oil. Reproduction is by division when in an immobile state, as well as by swarmers. Three species are known so far: Naegeliella flagellifera CORRENS, Naegeliella natans SCHERFFEL, and Naegeliella britannica GODWARD. They are forms that live epiphytic on water plants, only N. natans has occasionally been observed in free-floating colonies.

Subclass 4: Chrysosphaerinae p. 260

Cells immobile, without flagella, with a more or less thick and tough wall, solitary or aggregated in nonfilamentous colonies.

One order: Chrysosphaerales

The immobile thick-walled spherical cells may be solitary and sessile or aggregated in simple colonies that are mainly epiphytic, rarely free-floating. In addition to these normal cell formations there exist motile swarmers, rhizopodial and palmella stages, gloeocysts, and occasionally also spores. Cyst formation has been observed in some species.

Within the class of Chrysophyceae, this order is homologous with the Heterococcales (of the Heterocontae) and the Clorococcales of the Chlorophyceae. As far as presently known, they represent a relatively small group of genera belonging to three families.

Family 1: Chrysosphaeraceae. — With the characteristics just described. The membranous, more or less spherical cells of several genera are without a gelatinous envelope, but the cells of two uncertain genera p. 261 are embedded in a globose gelatinous matrix.

Family 2: Stichoglocaceae. — The short-cylindrical, ellipsoid, oviform or spherical cells are united in small, planktonic, gelatinous colonies in the form of small groups in which the cells are joined end to end by adhesion or by short gelatinous stipes. Swarmers are not reliably known, but cysts have been observed.

Family 3: Chrysostomataceae. — This (doubtful) family includes forms completely similar to the siliceous cysts of many chrysomonads, and which CHODAT did not consider merely as temporary resting stages, but believed to represent the actually vegetative "normal phase" in the life cycle.

Family 1: Chrysosphaeraceae

With the characteristics described.

Reliably known are (according to PASCHER, 1925) the following genera: Chrysosphaera PASCHER, Chrysobotris CONRAD, and Epichrysis PASCHER; uncertain or not completely known are: Sphaerochrysella PASCHER (= Phaeococcus W. & G.S. WEST), Phaeogloea CHODAT, and Selenophaea CHODAT.

Following here is a description of an epiplanktonic Epichrysis species which, although not a plankter itself, deserves our attention because of its interrelations with the plankton:

Epichrysis melosirae K.J.MEYER, 1930

Cells spherical, up to 10 μ in diameter, epiphytic on Melosira baicalensis WISLOUCH. Cellular envelope thin, tightly surrounding its contents. One platelike yellow chromatophore, curved according to the curvature of the surface of the cell. With one contractile vacuole (contracting at intervals of about 10 seconds) and leucosin granules. Reproduction is p. 262
by formation of swarmers ("zoospores" according to MEYER) of which 2-8 are produced by repeated division of the protoplast. The first division is in the direction of the point of attachment. The zoospores escape from the mother cell through a fissure in the cellular wall at the apex whereby the empty cellular envelopes often remain in great numbers attached to the Melosira filaments. The zoospores (swarmers) are naked, oval or somewhat globose, with one flagellum (Chromulina-type) at the anterior end. The flagellum has about 1 1/2 times the length of the cell body. There is one contractile vacuole in the achromatic anterior end. The chromatophore is oval, platelike, and curved (in optical section shaped like a horseshoe). One small eyespot in the anterior cell portion, several leucosin granules in the plasma. The swarmers come after 1-2 hours of swarming again to rest on

a Melosira filament, withdraw their flagella, and secrete a thin cellular envelope. Other forms of multiplication (palmella stages, autospores) have not been observed. Resting stages (statospores, cysts ?) occur sometimes in that the protoplast secretes a new, rather thick, wall inside the maternal cellular envelope so that the latter becomes clearly visible. These resting cells feature 2 chromatophores (which points to the process of cell division), a number of leucosin granules, but no contractile vacuole. A porus has not been found in the wall.

This epiplankter is found in large numbers epiphytic on Melosira baicalensis in Lake Baikal (e.g., during 1926 and 1929) in the vicinity of the Koternikow lighthouse. — The simple life cycle is apparently due to the epiplanktonic mode of life.

In outlining the family of the Chrysosphaeraceae [p. 85], two uncertain, insufficiently known genera have been mentioned. One of these (Sphaerochrysella) is planktonic; unfortunately, it remains as yet unknown whether the other (Phaeogloea) may be considered as a planktonic form or not. Both forms shall here be described briefly*.

Phaeogloea CHODAT, 1922 p. 263

Cells spherical or ellipsoidal, with a distinct and firm membrane. They are peripherally arranged in globose gelatinous colonies in which they are evenly distributed. The trough-shaped chromatophore measures 5-6 μ or slightly more. The cells produce typical Ochromonas swarmers without eyespot. The longer flagellum has about the same length as the cell body. Frequently, the swarmers do not escape completely from the gelatinous colonial envelope so that they come to rest while still imprisoned in it; in this case, they revert again into immobile cells. In addition to the for-

*Translator's note: The description of Sphaerochrysella (p. 262 of German original) is not marked for translation.

mation of swarmers, autospores may also be formed whereby only one spore or two of them may leave the maternal cellular envelope. The empty membrane is easily spotted in the gelatinous matrix. One species: Phaeogloea mucosa CHODAT. —

Family 2: Stichogloeaceae

Cells united in gelatinous colonies; known only as planktonic forms. The colonies are membranoid, of irregular shape or globular. The cells may be embedded in the gelatinous matrix, or project with their peripheral ends beyond the gelatinous envelope; they may loosely adhere to one another or may be joined by short gelatinous processes to form small moniliform groups. Each cell has one or two yellowish-green or brownish chromatophores. Swarmers are, as yet, not reliably known; formation of typical chrysomonadal cysts has been observed. One genus: Stichogloea.

The genus Stichogloea which, for a long time, had been placed among the Heterkontae should, according to recent opinion (PASCHER), be classified among the Chrysosphaerales. Unfortunately, many aspects concerning the morphology and phylogeny of this genus still await clarification. WILLE once had the splendid idea (which he has since abandoned) to create on behalf of this genus the family of Stichogloeaceae. However, the present author would like to revive this collective name.

The author distinguishes the following two Stichogloea species: p. 266

I. Colonies membranoid flat, or irregular extent; cells ellipsoidal to almost cylindrical, in two (?) varieties even spherical, irregularly arranged, often more or less in linear formation, without gelatinous processes at the poles of the cells. The peripheral third of the cell is usually projecting from the gelatinous matrix. .... Stichogloea olivacea 1.

II. Colonies globular, ellipsoidal; cells oval to oviform, in most cases arranged in serial formation, often with distinctly visible, short, gelatinous processes at the poles. Cells completely covered by the gelatinous sheath. ..... Stichogloea doederleinii 2.

Class V: Colorless flagellates incl. the epiplanktonic forms

The reason for placing this group of organisms (which, here, for the first time will be dealt with from a planktonological point of view) immediately after the Chrysomonadae lies mainly in the fact that many of the flagellates are descendants of pigmented chrysomonads. However, those colorless forms whose relationship with pigmented flagellates is still obscure shall also be considered here. On the other hand, colorless Dinoflagellates, Cryptomonadales, Volvocales, Euglenales, etc. shall be dealt with after discussing the aforementioned groups.

Being faced with the vast number of true phytoplankton organisms, that is, the euphytoplankters, one cannot deny the obvious fact that most of them — regardless to which class of algae they may belong — are of a distinct coloration which is caused by the pigments essential to photosynthesis, while only a few species are colorless. This holds true especially for the limnoplankton, but less so for the heleoplankton which is subject to strongly fluctuating ecological conditions.

While, for the majority of pigmented organisms, nutrition is purely autotrophic, that is, holophytic, as is characteristic for plants, the colorless forms practice heterotrophic nutrition, a way designated as animalistic or holozoic if ready-made food is ingested in the form of minute plants (bacteria, minute algae) and animals, or as saprophytic if the organisms absorb the products of organic decay in a water-soluble form. Finally, there are species which derive nourishment from both autotrophic, heterotrophic or saprophytic mechanisms, that is, for these, nutrition is mixotrophic.

Numerous, highly specialized, species inhabiting sewers or the intestines and/or blood of animals also belong to the group of colorless flagellates. They are dealt with in the field of parasitology and are, of course, of no interest in planktonology.

The large group of colorless flagellates features a vast variety of forms, characterized especially by the structure of the protoplast, the number of flagella, the absence or presence of a lorica, possible formation of colonies, etc.

Systematics: In No. 1 of the Journal "Süsswasserflora"[=freshwater flora], LEMMERMANN (1911) distinguishes among the colorless flagellates (as far as they are not obviously related to the pigmented groups such as the Chrysomonadales, Cryptomonadales, Dinoflagellates, Volvocales or Euglenales and must, hence, be logically grouped with them) the following 3 orders: p. 279

I. Pantostomatinae (below)
II. Protomastiginae (p. 90)
III. Distomatinae (p. 102)

Order 1: Pantostomatinae

Cells naked, in most cases free-swimming, less frequently attached by a slender stalk. One or more (sometimes numerous) flagella which may, occasionally, originate directly at the nucleus. Pteridomonas (thought to be a colorless chrysomonad) features, in addition, a ring of delicate pseudopodia. A blepharoplast may be present or lacking. There are numerous contractile vacuoles, while chromatophores and eyespot are lacking. Asexual reproduction is by division, sexual reproduction by copulation of micro- and macrogametes. Resting spores are known to occur. Nutrition is heterotrophic and saprophytic. There is no cytostome; food is taken up mostly by pseudopodia anywhere at the surface of the cell body.

Family 1: Holomastigaceae. — The polyaxial cells are naked, slightly amoeboid, with numerous flagella evenly distributed over the entire surface. Nutrition is holozoic, food intake through short pseudopodia. With the genus Multicilia CIENKOWSKY. No planktonic forms. p. 28

Family 2: Rhizomastigaceae. — The uniaxial cells are naked, free-swimming, or sometimes amoeboid and sessile; with 1-3, rarely 4, swimming flagella. Asexual reproduction is by division, sexual production by copulation of gametes. Nutrition is holozoic (pseudopodia) or saprophytic. With a large number of genera: Pteridomonas (one species has been identified as a chrysomonad; perhaps all species are chrysomonads), Actinomonas (which is also a chrysomonad), Mastigamoeba, Mastigella, Cercomastix, Cercobodo, Bodopsis, Dimorpha, Acinetactis. — No planktonic forms.

Order 2: Protomastiginae

Cells with delicate periplast, frequently amoeboid, free-swimming or sessile, solitary or in colonies, sometimes with a lorica or surrounded by a gelatinous envelope. Anterior end occasionally with membranous siphon-like process or peristom (Bicoecaceae), or with one or two collar(s). There may be 1-6 flagella, with or without a blepharoplast at their base, often connected with the nucleus or the nuclear karyosome by a fine fibril (rhizoplast), or they may be in contact with a special granule, the kinetonucleus (in which case the principal or metabolic nucleus is designated as "trophonucleus" in contrast to the "kinetonucleus" which is concerned with motor activities). In addition, an undulating membrane may also serve as a motor organ in some species. There may be one or more contractile vacuole(s), but they may also be lacking. Asexual reproduction is by division, sexual reproduction by copulation of gametes. Nutrition may be holozoic or sapro-

phytic, rarely parasitic. Ingestion of food usually at the anterior end through a differentiated portion (cytostome) of the periplast.

Outline of the families belonging to the Protomastiginae: p. 281

(Cross-references are provided only for those families that will be discussed in detail later because they include — as far as is presently known — planktonic and epiplanktonic forms.)

A. With one flagellum.

I. Without cytopharynx or peristome (siphonlike process at the anterior end of a cell).

a) Kinetonucleus and undulating membrane lacking. Free-swimming or sessile, with or without a lorica, mostly solitary forms, rarely in colonies. ..... Oicomonadaceae
In highly polluted, but also in relatively clean waters: Oicomonas, Thylacomonas, Codonoeca, Platytheca, Ancyromonas; a few genera live in the intestines of animals (Rhizomastix, Embadomonas).

b) Kinetonucleus and undulating membrane usually present. Free-swimming, solitary. Found mostly in the blood, less frequently in the intestines of animals. ..... Trypanosomaceae

II. Cytopharynx is lacking, but peristome present. Cells with lorica, solitary or in colonies, sessile, in part epiplanktonic forms.
Bicoecaceae (p.92)

III. With cytopharynx, but without peristome.

a) Cells solitary or in colonies, with or without lorica. Cytopharynx never enclosed in a gelatinous sheath. Free-swimming or sessile.
Craspedomonadaceae (p.94)

b) Protoplast incl. cytopharynx surrounded by thick granular gelatinous envelope. Sessile; in digitate or discoid colonies.
Phalansteriaceae

With one genus: Phalansterium.

B. With two flagella.

I. With undulating membrane; cells solitary, free-swimming. Found mostly in the blood, less frequently in the intestines of animals.
Cryptobiaceae

Genus: Cryptobia (Trypanoplasma).

II. Undulating membrane lacking.

a) Flagella of unequal length.

1. Two swimming flagella (1 primary, 1 secondary).

α) Protoplast with undifferentiated delicate periplast, sometimes with a lorica, sessile or free-swimming, solitary or in colonies. ..... Monadaceae (p.100)

β) Protoplast with differentiated periplast (horn-bearing scales). Cells sessile, stipitate, occasionally free. p.282
Physomonadaceae (p.101).

2. With one swimming and one trailing flagellum, but the former may also be replaced by a mobile cytoplasmic process (Rhynchomonas), and, less frequently, there may be two swimming flagella (Dinomonas). Cells naked, free-swimming or temporarily sessile. Found usually in polluted waters; one species (Provazekella) lives in the intestines of animals. ..... Bodonaceae
Genera: Dinomonas, Bodo, Colponema, Pleuromonas, Rhynchomonas.

b) Flagella of equal length, cells naked, free-swimming or sessile; with lorica (Diplomita), surrounded by globose, granular gelatinous envelope (Spongomonas), or attached to the end of gelatinous tubes (Rhipidodendron, Cladomonas). ..... Amphimonadaceae (p.99)

C. With three flagella.

I. With one swimming and two trailing flagella. Cells with delicate periplast, free-swimming, sometimes attached by its trailing flagella. Apparently mostly dwelling in polluted waters (Dallingeria, Macromastix). ..... Trimastigaceae

II. With 3 swimming flagella (1 primary, 2 secondary flagella). Duplication of secondary flagellum is quite common among Monas-species (but the secondary flagellum may also be completely lacking). Monas spec.

D. With 4-6 flagella.

Cells solitary, free-swimming or attached with their flagella to the with delicate periplast. The majority of forms live in intestines, or are ectoparasites, found also in polluted waters.
Tetramitaceae
Genera: Costia, Monocercomonas, Tetramitus, Trichomastix, Trichomonas, Chilomastix, Hexamastix, etc.

Family: Bicoecaceae

Cells solitary or united in colonies, sessile, with delicate periplast and lorica. Anterior end with membranous probiscidiform process (peristome). One flagellum with a blepharoplast at its base connected to an extranuclear centriole by a rhizoplast. One contractile vacuole. The cytostome may be on the peristome, or between the latter and the flagellar base. Nu-

trition is saprophytic or holozoic. Reproduction by longitudinal division (transverse cell division questionable). Resting spores ?

Outline of the genera:

I. Peristome labiate, membranous, narrow.

a) Protoplast attached inside the lorica by a contractile stalk. Bicoeca (below)

b) Protoplast without contractile stalk. ..... Histiona (p.94)

II. Peristome thick, proboscidiform..... Poteriodendron (p.94) p.283

Ecological behavior: Several species are epiplanktonic; only one species (Bicoeca socialis LAUTERBORN) has been reported to occur as euplanktonic organism. Polluted waters are apparently totally avoided.

Bicoeca (J.CLARK) STEIN

(Syn. Bicosoeca J.CLARK)

Cells solitary or in colonies, changing in shape. Protoplast fastened to the bottom of the lorica by a contractile filament (trailing flagellum) originating from the blepharoplast. Peristome labiate, narrow. Nucleus encircled by 2 doughnut-shaped bodies in life-buoy fashion (parabasal body). Cell motion caused by contraction of the filament (as diagnosed by LEMMERMANN).

Taxonomic key for the Bicoeca species:

I. With individual lorica.

a) Anterior end of cell with a black dot. ..... Bicoeca oculata 1.

b) Cells without black dot.

1. Sessile forms.

α) Lorica oviform, anterior end attenuated or vasiform. Bicoeca lacustris 2.

β) Lorica oval..... Bicoeca ovata 3.

γ) Lorica cone-shaped ..... Bicoeca conica 4.

2. Free-swimming forms; lorica conical or campanulate, composed of rings. ..... Bicoeca planctonica 5.

II. Lorica same as that of Dinobryon, stacked with each base in the previous lorica. ..... Bicoeca dinobryoidea 6.

III. Loricae united to form free-swimming colonies. .... Bicoeca socialis 7.

Histiona M.VOIGT, 1901 p.285

Cells within a lorica, without contractile filament at its base. Peristome labiate, connected with the anterior end of the cell by a sail-like membrane [frenum]. Motility due to cell contractions. The only species: Histiona zachariasii VOIGT (syn. Zachariasia velifera VOIGT). — Lorica conical, without stipe, 13 μ long. Protoplast oval, 13 μ long. Flagellum twice as long as cell body. Posterior end with contractile vacuole.

Observed in ponds, epiphytic on Closterium ehrenbergii MEN. Epiplanktonic existence not observed.

Poteriodendron STEIN, 1878

Cells in stipitate loricae united in arborescent colonies, metabolous, with a contractile filament at the posterior end. Peristome thick, proboscidiform with a flagellum at its base. Nutrition is holozoic. Motility due to contraction of the filament. The only species: Poteriodendron petiolatum STEIN.

Family: Craspedomonadaceae p.286

Cells with or without a lorica, with delicate periplast, sometimes enclosed in a gelatinous envelope, solitary or in colonies, free-swimming or sessile. Anterior end with 1-2 funnelshaped delicate collars; one flagellum with blepharoplast which is connected by a rhizoplast to the karyosome. 1-2 contractile vacuoles. Nutrition is holozoic or saprophytic. Reproduction by cell division, less frequently by budding. Resting spores known of only few species (of the genera Codonosiga and Salpingoeca).

Outline of the genera of the Craspedomonadaceae: p. 287

(Only genera with cross-references are discussed later.)

A. Cells with one collar (cytoplasmic collar).

I. Without lorica.

a) Cells not embedded in gelatinous matrix.

1. Cells solitary, without stipe, or only with a short one. Monosiga (below)

2. Cells with a long stipe, sessile.

α) Stipe plain ..... Codonosiga (p.96)

β) Stipe branching ..... Codonocladium (p.96)

3. Cells united in free-swimming colonies.

α) Colonies stellate ..... Astrosiga (p.96)

β) Colonies in the form of branched or unbranched filaments. Desmarella (p.96)

b) Cells with gelatinous sheath, colony-forming.

1. Cells without stipe, irregularly distributed within the gelatinous envelope. ..... Protospongia (p.97)

2. Cells with stipe, in radial formation ..... Sphaeroeca (p.97)

II. Cells with lorica.

a) Cells sessile ..... Salpingoeca (p.97)

b) Cells free-swimming ..... Lagenoeca (p.98)

B. Cells with two cytoplasmic collars.

I. Without lorica.

a) Cells directly attached, or with a short stipe ... Diplosiga (p.99)

b) Cells with a long stipe ..... Codonosigopsis

II. With lorica, which may be very delicate ..... Diplosigopsis

Monosiga S.KENT, 1880

Cells with a delicate periplast, without lorica, directly attached or with a very short stipe, sometimes with short pseudopodia. Reproduction is by cell division.

I. Cells spherical or oviform ..... Monosiga ovata 1. p. 288

II. Cells fusiform ..... Monosiga fusiformis 2.

III. Cells club-shaped or almost cylindrical..... Monosiga angustata 3.

Codonosiga (J.CLARK) STEIN

(Codosiga J.CLARK, 1866)

Morphologically similar to Monosiga from which it differs only by its long, branched or unbranched stipe with which the cells are attached to the substratum. Reproduction is, in addition to cell division, also by budding. Resting spores have been observed.

I. Stipe unbranched ..... Codonosiga botrytis 1.
II. Stipe branched ..... Codonosiga furcata 2.

Codonocladium STEIN, 1878

p.289

Cells sessile on long stipe. Colonies umbellate or corymbiferous, otherwise similar to Monosiga.

I. Colonies umbellate ..... Codonocladium umbellatum 1.
II. Colonies corymbose ..... Codonocladium corymbosum 2.

Astrosiga KENT, 1880

Cells with a delicate periplast, without lorica, nterior end with a long terminal flagellum, the base of which is surrounded by a well-developed, single, hyaline collar. The cells are united in stellate colonies p.290 in that their attenuated posterior ends, or the long stalks to which one or more of them are attached, meet centrally. Reproduction is by cell division. Resting spores unknown.

I. Cells without stalk, radially arranged with their posterior ends, which are tapered to a point, put together.
Astrosiga disjuncta 1.
II. Cells with long stalk ..... Astrosiga radiata 2.

Desmarella KENT, 1880

Cells with a delicate periplast and single cytoplasmic collar, without lorica, laterally united to form uniseriate, branched or unbranched, filamentous (desmos = chain) colonies. Reproduction is by division of in-

dividual cells and of the colonies.

I. Colonies in the form of unbranched filaments.
   a) Cells 6 μ long, oval ..... Desmarella moniliformis 1.
   b) Cells 9.5-11 μ long, oviform; collar 4-5 μ high (slightly lower than that of the previous species. Desmarella brachycalyx 2.

II. Colonies irregularly branched ..... Desmarella irregularis 3.

Protospongia KENT, 1880 p. 291

Cells with delicate periplast, without lorica; several cells are grouped together within a common gelatinous envelope. The flagellum has more than twice the length of the cell body; with a simple cytoplasmic collar. Reproduction is by division. The only freshwater species: Protospongia haeckelii KENT.

Sphaeroeca LAUTERBORN, 1894 p. 292

Cells with a delicate periplast, without lorica, posterior end with a stalk; united in great numbers (several hundred to many thousands) in a common gelatinous envelope in which they are radially arranged to form, in most cases, spherical colonies. With a simple cytoplasmic collar surrounding the base of the long flagellum. Reproduction is by division.

I. Stalk twice as long as cell body; colonies consist of several hundred individuals. ..... Sphaeroeca volvox 1.

II. Stalk shorter than cell body; colonies consist of several thousands of individuals. ..... Sphaeroeca pedicellata 2.

Salpingoeca J.CLARK, 1867

Cells with a delicate periplast, enclosed by a lorica with which it is attached either directly or by a stipe to the substratum. The simple cytoplasmic collar projects through the opening of the lorica; only rarely is it confined to inside the lorica. There is one contractile vacuole.

Reproduction is, in most cases, by longitudinal division, rarely by budding. Resting spores inside the lorica, globose or oval, with a thin membrane or naked (according to LEMMERMANN). ...

... The genus includes close to 30 species of which we shall mention only the eight* that were observed to lead an epiplanktonic existence and may be identified on the basis of the following

key:

A. Lorica directly attached to substratum, with rounded or pointed base which is rarely prolonged into a short hollow stipe.

I. Lorica with a gelatinous sheath, sitting on its broad base. Salpingoeca marssonii 1.

II. Lorica without gelatinous sheath. p. 293

a) Lorica spherical, hyaline ..... Salpingoeca pyxidium 2.

b) Lorica reversed oviform, with a short necklike process. Salpingoeca amphora 3.

c) Lorica oviform ..... Salpingoeca minuta 4.

d) Lorica shaped like a Florence flask, hyaline. Salpingoeca amphoridium 5.

e) Lorica short, vasi- or fusiform, its base extended into a hollow stalk, truncate ..... Salpingoeca frequentissima 6.

B. Lorica short (at the most 20 μ long), vasiform, with a more or less long filamentous stalk.

I. Open end of lorica narrower than its median portion. Salpingoeca convallaria 7.

II. Open end of lorica as broad as its median portion or slightly broader.

a) Protoplast filling the lorica completely .... Salpingoeca elegans 8.

b) Protoplast not completely filling the lorica. Salpingoeca ringens 9.

Lagenoeca KENT, 1880 p. 295

Cells free-swimming, with delicate periplast, enclosed by a lorica without stipe. One swimming flagellum, one contractile vacuole. Reproduction is by longitudinal division while at rest, and inside the lorica.

*) Translator's note: Nine (not eight) species are listed.

Taxonomic key for the Lagenoeca species:

A. Lorica urn-shaped, posterior end with spines ... Lagenoeca cuspidata 1.
B. Lorica globose, smooth ..... Lagenoeca globulosa 2.
C. Lorica oval, smooth ..... Lagenoeca ovata 3.
D. Lorica reversed oviform, smooth ..... Lagenoeca obovata 4.

Diplosiga FRENZEL, 1891 p. 296

Cells sessile, with delicate periplast, without lorica. Two cytoplasmic collars, one flagellum, one contractile vacuole. Reproduction by cell division.

I. Cells directly attached to substratum. Diplosiga socialis 1.
II. Cells stipitate ..... Diplosiga franceii 2.

Family: Amphimonadaceae p. 297

Cells free-swimming or sessile, naked, surrounded by a gelatinous envelope or living in gelatinous tubes, less frequently attached within a lorica. Two flagella of euqal length projecting forward from two blepharoplasts (diplosome) which are connected with the nuclear karyosome by a rhizoplast. The latter may sometimes be completely (Spongomonas, Rhipidodendron) or partially dissolved. There are 1 or two contractile vacuoles. Reproduction is by cell division. Nutrition is saprophytic, or holozoic with the assistence of food vacuoles (according to LEMMERMANN).

Amphimonas DUJARDIN, 1841

Cells naked, free-swimming, or sessile on slender stipe.
Amphimonas cyclopum (KENT) BLOCHMANN (syn. Deltomonas cyclopum KENT). — Cells reversed oviform or clubshaped, about 8 μ long. Attached with its markedly attenuated posterior end. Flagella of the same length as the cell body. There is one contractile vacuole situated just before the median part of the cell. — Observed in standing waters, epiphytic on water plants, crustaceans (Cyclops); epiplanktonic form.

Family: Monadaceae

As has been emphasized repeatedly throughout the present work (cf. especially p.277*), the family of Monadaceae should be eliminated because the origin of all of its members can be traced back to the chrysomonads (Ochromonadales). Since the material to be dealt with in this monograph has been so grouped that the pigmented flagellates are discussed first, followed by the colorless genera among the flagellates, the "family" of Monadaceae may just as well be discussed here still within the group of colorless flagellates which we know anyway to be extremely inhomogeneous — more or less as a matter of tradition, so to speak. It is also not without interest to obtain an overview of the colorless genera grouped, here, together as a family of Monadaceae. p.298

Outline of the genera belonging to the Monadaceae:

A. Cells solitary (in rare cases temporarily united in colonies).

I. Without lorica.

a) Periplast smooth, undifferentiated; cells mostly solitary.

1. Both flagella capable of motion ..... Monas

2. Primary flagellum rigid ..... Sterromonas

b) Periplast differentiated, clothed with siliceous platelets bearing siliceous horns ..... Physomonas
characterized as a separate family (Physomonadaceae), see p.101.

II. With stipitate lorica, sessile; protoplast fastened to the bottom of the lorica by a delicate filament. ..... Stokesiella

B. Cells united in colonies, sessile.

I. Without lorica.

a) Cells individually fastened to the ends of arborescently branching stalks ..... Dendromonas (p.101)

b) Cells fastened in groups to the ends of arborescently branching stalks.

1. Stalks colorless, rigid ..... Cephalothamnion (p.101)

2. Stalks yellow or brown, flexible ..... Anthophysa

II. With lorica; colonies of Dinobryon-type structure ..... Stylobryon

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*) Translator's note: Page 277 of the German original not submitted for translation.

Dendromonas STEIN, 1978

Cells with a delicate periplast, sitting individually on the ends of colorless branching stalks, thus united to richly ramified colonies. Cell with one primary and one secondary flagellum, one contractile vacuole. Reproduction is by longitudinal division, whereby each daughter cell secretes a new gelatinous stalk so that the colonies assume a peculiar dichotomous structure. p. 299

I. Colonies corymbose, stalks rigid ..... Dendromonas virgaria 1.
II. Colonies arborescent ..... Dendromonas laxa 2.

Dendromonas has been recognized as a colorless chrysomonad and represents the parallel form to the chromatophore-bearing Chrysodendron (PASCHER, 1927).

Cephalothamnion STEIN, 1878

Cells with a delicate periplast, sitting in groups on the ends of colorless branching stalks. Cells have two flagella of unequal length, one contractile vacuole. Reproduction is by cell division; new colonies are formed by escaping cells. Nutrition is holozoic. p. 300

Family: Physomonadaceae

Cells without chromatophores, with differentiated periplast.

The only representant of this family is the genus Physomonas of which special mention had been made already in discussing the Ochromonadales (p. 52).

Physomonas KENT, 1880/81

Cells free-swimming or sessile. In the latter case with a filametous, flexible, hyaline or brownish stalk (1-3 times the length of the cell body) on which the usually close to pyriform cell is sitting with its

attenuated posterior end. In their motile state, the cells tend to change their shape more readily and may then be spherical, ellipsoidal or oblong with a rounded posterior end. Spherical cells measure about 13.5 μ. The periplast is covered with minute (about 2 μ) discoid siliceous platelets each of which bears, centrally, a fine siliceous seta. These setae are standing at right angle to the surface all around the cell. The rounded anterior end features two flagella of unequal length: Primary flagellum about twice as long as the cell body, secondary flagellum only half that long. Nucleus in the anterior portion of the cell. The so-called "oral ligament" [frenum ?] (a minute curved plate of obscure function) is in contact with the nucleus. Two contractile, alternatingly pulsating, vacuoles each of which seems to be produced by the coalescence of individual smaller vacuoles. ...

Order 3: Distomatinae p. 301

Cells solitary, free-swimming, colorless, always slightly compressed, of bilateral symmetry, with delicate periplast, mostly ovi- or fusiform. Blepharoplasts usually present; one or more contractile vacuoles, occasionally lacking (Octomitus). Most forms are binucleate, some have 2 axial rods (Hexamitus, Octamitus). Chromatophores and eyespot are lacking. Food reserves in the form of fatty oil, less frequently in the form of granules consisting of a substance allied to glycogen. Food intake by way of 2 special cytostomes, the mode of nutrition is holozoic or saprophytic, sometimes parasitic. Multiplication is by cell division. Resting spores have been observed (Urophagus, Ortomitus).

"The cell apears as if it consists of a pair of laterally coalesced protoplasts" (LEMMERMANN, 1914); hence, in a sense, diploidal individuals.

Meso- to polysaprobic organisms, some of them inhabiting polluted waters, others the intestines of various animals, often in large numbers. Hexamitus and Urophagus are leading among the forms typical of putrefying liquids, and are very important destroyers of bacteria. Gyromonas and Spironema avoid polluted waters. Planktonic organisms are not known for this order, consisting of one family.

Family: Distomataceae

With the characteristics of the order.

Outline of the genera:

A. With a maximum of 8 flagella.

I. Four flagella ..... Gyromonas SELIGO

II. Six flagella ..... Trigonomonas KLEBS

III. Eight flagella.

a) Usually 3 flagella at each corner of the anterior end, 2 flagella at the posterior end; not differentiated into flagella of locomotion and cytostomal cilia.

1. Food intake not by way of a posterior rostelliform cytostome.

α) Posterior end with 2 lateral peristomes .. Hexamitus DUJARDIN

β) Peristomes and rostelliform cytostome ("beak") lacking; food intake not limited to the posterior end (inhabitants of intestines). ..... Octomitus PROWAZ p. 302

2. Food intake by way of a posterior rostelliform cytostome ("beak"). Urophagus KLEBS

b) Each of both lateral margins with 4 flagella in approximately central position, differentiated into flagella of locomotion and cytostomal cilia. ..... Tropomonas DUJARDIN

B. Numerous cilialike flagella in two longitudinal rows at the anterior end. Spironema KLEBS.

Class VI: Heterokontae
(Xanthophyceae) p. 304

These microorganisms include motile, flagellate, or immobile, frequently solitary, often multicellular, sometimes sessile, forms. The chromatophores are usually discoid, small, as a rule characteristicall yellowish-green,

but occasionally also of a true chrorophyll-green color; in addition to xanthophyll, they often contain a great deal of carotene and react, therefore, upon admixture of hydrochloric acid with a change in color to blue. Pyrenoids are, as a rule, lacking and have been observed in a few forms only. Food reserves are accumulated in the form of oily substances as well as leucosin and volutin. There is never a formation of starch. Vegetative cells as well as cysts often have a wall consisting of two parts of equal or, frequently, unequal size; most of these walls contain only traces of cellulose, but great amounts of peptic compounds, frequently also some silica. Furthermore, the wall shows a more or less typical bivalved structure (overlapping halves fitted one inside the other, or H-shaped segments). In other genera, the wall may often be homogeneous, or consist occasionally of two parts of almost equal, or of unequal size. Motile stages with a long primary flagellum and a short secondary flagellum; both flagella are usually in approximately apical position and projecting at a slight angle; in rare instances, only 1 flagellum (reduction of the secondary flagellum). Reproduction is by formation of zoospores, autospores, cell division, dissociation of filaments. Resting stages have been reported in the form of palmella stages and various forms of statospores (akinetes).

Sexual reproduction (fusion of gametes) appears to have been observed in very few instances (for Tribonema by SCHERFFEL, for Botrydium by ROSENBERG); however, observation of these activities are incomplete. In any event, cytological investigations of sexual reproduction have not been reported. p. 305

.... The Heterokontae consist of the following 6 orders:

I. Vegetative life in motile condition. p.306

a) Flagellate level of organization ..... Heterochloridales (below)

b) Rhizopodial organization ..... Rhizochloridales (without planktonic forms).

II. Vegetative life in immobile condition:

a) Gelatinous colonies or cell aggregations by means of gelatinous junctures; occasionally slight transition to flagellate organization. ..... Heterocapsales (p. 106)

b) Cellular forms with a firm, often slightly mucous wall.

1. Uninucleate (except for Ophiocytium)

α) Solitary, sessile or free, may also form various types of colonies, but never in filaments ..... Heterococcales (p. 108)

β) Formation of filaments ..... Heterotrichales (p. 117)

2. Multinucleate, siphonaceous "unicellular" algae (without planktonic forms). ..... Heterosiphonales

Comparison with other divisions of algae (e.g., the Chrysomonadae, Dinoflagellates, Chlorophyceae) demonstrates a number of interesting parallelisms in the external appearance and shape of the cells, as may be illustrated with the following comparison of Heterokontae with Chlorophyceae: Heterochloridales—Volvocales, Heterocapsales—Tetrasporales, Heterococcales—Protococcales, Heterotrichales—Ulotrichales, Heterosiphonales—Siphonales. The convergence in form and shape is sometimes extremely striking.

Order: Heterochloridales p.307

Flagellate forms of the Heterokontae. Cells (as far as known) solitary, naked or with a very little differentiated periplast; often metabolous, frequently rigid, with two disk-shaped or oblong platelike chromatophores, and two flagella of unequal length projecting from the anterior end of the cell body (Nephrochloris GEITLER is an exception in that it has only one flagellum). Contractile vacuoles are present. Some forms show a

dorsiventral structure. — Reproduction is by longitudinal division of motile cells or gelatinous palmella stages. Cyst formation by secretion of a wall with two overlapping halves, impregnated with silica. Nutrition is holophytic with a marked tendency toward an amoeboid mode of life and, hence, holozoic nutrition. Some forms may, upon loss of their flagella, become completely amoeboid.

Phacomonas LOHMANN, 1903

Protoplast lenticular; broad side nearly circular, narrow side elliptic. Each broad side houses a large, yellow, bowl-shaped chromatophore. Anterior end with two, somewhat stout, flagella of unequal length sitting relatively far apart on knobby protuberances. Primary flagellum twice as long as the cell body, secondary flagellum of the same length as the cell. Frequently, a strongly refractive and sharply delimited granule can be seen in basal position; in addition also oil droplets. Pulsating vacuoles are lacking in marine forms, but may be present, in duplicate and in anterior position, in freshwater forms. The phases of cell division, palmella stages, and cysts have not been subject to observation.

PASCHER (1925) holds that the position of this flagellate with the Heterokontae is doubtful.

Order: Heterocapsales p. 309

"Embraces those Heterokontae that spend their vegetative life imprisoned and immobile in a gelatinous matrix throughout which the cells are irregularly distributed, either individually or in groups, so that the colonies assume palmella or Gloeocystis character. The motile flagellated stage is formed only for reproductive purposes, in most cases simply by

direct metamorphosis of immobile into flagellated cells which then escape from the gelatinous colony as swarmers. Multiplication takes place mainly within the gelatinous matrix so that, under certain conditions, rather large colonies may be formed." (PASCHER)

Family: Heterocapsaceae

The gelatinous colonies of free-floating freshwater forms are globose or amorphous. The cells are either irregularly distributed through the gelatinous matrix or, depending upon previous cell division, in groups of two or four; they may also be radially arranged and closer to the periphery of the gelatinous matrix which surrounds each cell completely.

The only genus to be taken into consideration here is Gloeochloris PASCHER, since Leuvenia GARDNER, which has previously been classified among this family, might better be placed with the Heterococcales.

Gloeochloris consists of two species: p.310

A. Cells ellipsoidal, swarmers with 1 long flagellum.
Gloeochloris planctonica 1.

B. Cells more spherical; swarmers with 2 flagella (1 primary, 1 secondary).
Gloeochloris minor 2.

Appendix to the Heterocapsales (doubtful genus)

Dictyosphaeriopsis SCHMIDLE, 1903

Small, slightly lobed, gelatinous colonies, free-swimming or temporarily attached. Cells in peripheral and radial formation, their shape may be ellipsoidal to oviform; protoplast with two parietal chromatophores p.311 and central nucleus; pyrenoids and starch have not been observed. The gelatinous matrix appears without structure, only upon staining becomes a special gelatinous sheath visible around each cell. Multiplication by division into two daughter cells. Swarmers unknown. One species: D. palatina SCHMIDLE.

Order: Heterococcales

Solitary or united in colonies (but never in the form of permanent filaments), free or sessile. The mostly uninuclear cells (some forms become multinuclear with advancing age) feature a firm wall; one or more chromatophores. — Reproduction is by characteristic zoospores or by internal division into 2-4 or more autospores. In some genera there is (as far as is known) only autospore-, in others only zoospore-formation; in still others, both forms of reproduction have been observed. Similar to the Protococcales (among the Chlorophyceae), of which the Heterococcales are a homologous order, autospore formation appears as a result of inhibited zoospore formation. The liberation of swarmers as well as of autospores is made possible by a sliding apart of the two halves of the wall surrounding the vegetative cell (as far as the latter exist). Formation of bivalved cysts has been observed in several species.

Very few of the Heterococcales are euplanktonic organisms. p.312

PASCHER (No.2 of "SÜsswasserflora" [freshwater flora] 1925) divides the Heterococcales into the following five families:

Family 1: Halosphaeraceae. — Cells free; with zoospores and autospores, or only with the latter; uni- or multinucleate. To this family belong the two marine genera Halosphaera and Meringosphaera, as well as the freshwater forms that are of interist here, namely Botrydiopsis and (according to the report by SMITH) also Leuvenia.

Family 2: Chlorobotrydaceae. — Cells free, solitary, in groups of two, or united in irregular colonies; uninucleate. Reproduction exclusively by means of autospores. To this family belong the following planktonic genera: Chlorobotrys, Pseudotetraëdron, and Centritractus; among these, Pseudotetraëdron seems to be the only euplankter.

Family 3: Chlorotheciaceae. — Cells sessile, mostly uninucleate, with advanced age multinucleate. No planktonic forms.

Family 4: Sciadiaceae. — Cells free or sessile, solitary or in colonies, cylindrical or toroidal; mature cells always multinucleate. Of the only genus (Ophiocytium), certain forms occur tychoplanktonic in large numbers.

Family 5: Botryococcaceae. — Cells united in homogeneous or composite gelatinous colonies; in the latter case, the colonial components are frequently connected, one to another, by gelatinous strands. Zoospores confirmed. Genera: Botryococcus, Stichogloea, and Askenasyella.

Synopsis of the Heterococcales (after PASCHER): p.313

Fam. Pleurochloridaceae: Solitary, free-living Heterococcales without noteworthy longitudinal growth.

Pleurochlorideae: Cells spherical, without noteworthy gain in size. Genera: Pleurochloridella, Pleurochloris, Chloridella, Sklerochlamys, Diachros.

Botrydiopsideae: Cells spherical to oblong. Very pronounced gain in size (one form is occasionally sessile). Genera: Botrydiopsis (p.111), Excentrochloris, Perone.

Monodeae: Cells ellipsoidal to oblong, ovi- or fusiform, with two distinct poles, without noteworthy gain in size. Genera: Ellipsoidion, Monallanthus, Nephrodiella, Monodus, Chlorocloster, Pleurogaster, Rhomboidella, Prismatella.

Trachycystideae: Cell wall evenly sculptures, cells spherical to oblong, without setae. Genera: Arachnochloris, Trachycystis, Endochloridion, Akanthochloris, Trachychloron, Aulakochloris, Chlorallanthus.

Asterogloeeae: Same as before, but in gelatinous colonies. Genus: Asterogloea.

Chlorocoryneae: Same as oblong Trachycystideae, but sessile and with a unilateral membranous plug. Genus: Chlorokoryne.

Meringosphaereae: Spherical, with floatation-serving setae, wall probably sculptured and consisting of two halves. Genera: Meringosphaera, Radiosphaera, Skiadosphaera (marine plankton).

Polyedrielleae: Cells in principle spherical, but may also be hemispherical to cup-shaped. Cell wall with nondensified bumps and (always ?) sculptured. Genera: Vischeria, Polyedriella, Chlorogibba. p.314

Tetraëdrielleae: Cells tetrahedral, or in the form of a truncate prismatic cylinder. Cell wall sculptured. Genera: Tetraëdriella, Tetrakenton, Tetragoniella, Schilleriella (?).

Goniochlorideae: Cells pillowlike compressed, evenly triangular or quadrangular in top view; cell wall is sculptured. Genus: Goniochloris.

Fam. Gloeobotrydaceae: Few to many cells in regular or irregular formation embedded within a homogeneous or stratified gelatinous matrix. Genera: Gloeobotrys, Chlorobotrys (p. 112).

Fam. Botryochloridaceae: Cells of various shapes agglutenated to form regular or irregular colonies.

Botryochlorideae: Few or many cells united in regular or irregular clusters, usually no tetrad cells. Genera: Botryochloris, Sphaerosorus.

Tetraktineae: Cells spherical to linear; colonies consist, at the most, of four cells. Genera: Ilsteria, Tetraktis, Raphidiella.

Chlorellidieae: Multicellular colonies composed of clusters consisting usually of cell tetrads. Genera: Chlorellidiopsis, Chlorellidium.

Fam. Gloeopodiaceae: Groups of cells live in the pockets of gelatinous rods which are either attached to a substratum or connected with one another to free-floating colonies (their classification among the Heterokontae is doubtful).

Gloeopodieae: Mostly unicellular, sessile forms. Genus Gloeopodium.

Botryococcaae: Cells united in floating colonies. Genus: Botryococcus ("Affiliation with the Heterokontae unlikely; most probably a member of the Chlorophyceae").

Fam. Mischococcaceae: Sessile, in di- or tetrachotomously branched colonies. Cells borne on stalks which are formed mainly by polar growth of internally invested membranous layers. Genus: Mischococcus.

Fam. Characiopsidaea: Cells solitary, sessile on stipes formed of membranous substance (sometimes without stipe directly attached). Cell wall homogeneous. Genera: Characidiopsis, Characiopsis, Dioxys, Peroniella, Harpochytrium.

Fam. Chloropediaeceae: Four or many cells laterally adjoined in a monostromatic layer; mostly sessile. Cell wall homogeneous.

Lutherelleae: Cells in groups of four, due to autospore formation. Genus: Lutherella.

Chloropedieae: Cells laterally adjoined to form monostromatic platelets. Genus: Chloropedia.

Fam. Trypanochloridaceae: Cells lobed in stellate fashion; occupying the shells of snails. Genus: Trypanochloris.

Fam. Centritractaceae: Long cylindrical cells, solitary, rarely in colonies; cell wall is composed of two halves. Genera: Bummeleriopsis, Pseudotetraedron, Centritractus.

Fam. Chlorotheciaceae: Sessile or free, solitary or multistoried colonies; cells cylindrical, cell wall composed of two halves; there is either pronounced longitudinal growth or none at all.

Chlorothecieae: No formation of colonies, usually without noteworthy longitudinal growth, sessile. Genera: Hemisphaerella, Chlorothecium.

Sciadieae: Pronounced longitudinal growth, mature cells multinucleate. Solitary or in radial or storied colonies; in the latter case epiphytic [upon empty cell walls of previous cell generations]. Genus: Ophiocytium. p.315

"Finally, it must not be overlooked that even certain filamentous forms of the Heterokontae may become unicellular by dissociation of their filaments (e.g., Heterococcus, Heteropedia, partly also Heterothrix), indeed, even Tribonema and also Bumilleria." (PASCHER)

Family: Pleurochloridaceae

Solitary, nonsessile Heterococcales without remarkable longitudinal growth. Cell wall smooth or sculptured, homogeneous or composed of two halves. Artificial family.

Botrydiopsideae

Cells spherical to short ellipsoidal, or of irregular shape. Gain in size very pronounded; with a smooth, delicate to firm cell wall. Free-living, occasionally attached to substratum.

Botrydiopsis BORZI, 1889

Cells spherical, free-floating with a centrally or slightly excentrically situated nucleus, and many, relatively large, discoid chromatophores in parietal position; without pyrenoid or starch. Food reserves accumulate in the form of oil droplets. The cell wall is composed of two very unequal halves ("like a casserole with a cover"); it often has a reddish color and is slightly impregnated with silica. — Reproduction is by means of zoospores and autospores. The zoospores (swarmers) are produced in great numbers in each mother cell from which they escape in a common gelatinous vesicle.

The zoospores are oval, with two chromatophores usually in lateral position, and two flagella of unequal length (the longer flagellum pointing straight forward, the shorter one sideways; an eyspot may be present or lacking. The zoospores grow directly into new, spherical, vegetative cells. — The autospores are also produced in large numbers (up to 300 and more) in the parent cell, from which they are liberated by mucilaginous disorganization of the parent cell wall. They are spherical and contain several chromatophores; they may either grow directly into vegetative, zoospore-forming cells, or may develop a very thick, smooth wall and accumulate red oil as reserve foods, that is, enter into a rest period [hypnospores]. Sexual reproduction unknown.

Family: Gloeobotrydaceae p.317

Unicellular forms, solitary, or in groups of 2, 4, 8 or more in amorphous (roundish) colonies which may be attached or free-floating. Reproduction by means of swarmers or autospores which are produced in groups of 2, 4, 8, ore more.

Taxonomic key for the genera (after PASCHER):

I. Gelatinous matrix homogeneous, or only slightly stratified whereby stratification is limited to the first stages of division and later disappears. Cells more or less irregularly distributed, sometimes in groups within the colony. Artificial, provisional genus. ..... Gloeobotrys

II. Gelatinous matrix always distinctly stratified, embracing 2, 4, or 8 cells depending upon the sequence of division. The cells are probably lying more in the same plane (Gloeothece-type)..... Chlorobotrys

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Among Chlorobotrys, typical aquatic algae are known (in more or p.319 less acid waters, but also terrestrial algae. Certain forms have been observed, furthermore, on moist mountain sites. The ecologogical range of this genus is, therefore, quite considerable. The following three species are found as tychoplanktonic forms mainly in swampy ponds:

A. Cells with 1 chromatophore; size about 7 μ. ... Chlorobotrys simplex 1.

B. Cells with 2-5 chromatophores; cells 15-20 μ. Chlorobotrys regularis 2.

C. Cells with up to 30, usually small, discoid chromatophores; cells 15-20 μ. Chlorobotrys polychloris 3.

Appendix to the Gloeobotrydaceae: p. 320

A genus with gelatinous colonies of a different structure is

Merismogloea PASCHER, 1938.

Individual cells of this still little known genus are ellipsoidal or spherical, and have usually 2 chromatophores. Each cell is surrounded by a broad gelatinous sheath. Upon division, each daughter cell secretes a new gelatinous envelope while, at the same time, the gelatinous sheath of the parent cell becomes increasingly obscure. By agglutination of the gelatinous envelopes of the individual cells, botryoidal (resembling frog-egg clusters) colonies are formed, which easily disintegrate if pressure is applied. Cell division is somewhat oblique; often, two divisions follow in rapid succession so that groups of 2 and 4 cells are formed.

Family: Mischococcaceae p. 321

(Syn. Heterodendrineae FRITSCH)

"Upon maturity, the cells of this alga are united in arborescent, di- or tetrachotomously or irregularly branched, storied colonies. The colonial structure consists of gelatinous stalks whose ultimate branches terminate in 2 or 4 cells. Reproduction takes place by means of swarmers or autospores. Upon formation of the autospores, the parent wall splits and the two or four autospores are pushed out of the mother cell by the development of a cylinder of material from the inner wall of the parent cell (stalks are, therefore, produced in an entirely different manner than those of the Gloeopodiaceae or the Characiopsidaceae)." (PASCHER) — One genus only: Mischococcus NAEGELI, 1849.

Family: Centritractaceae

p.322

The elongated cylindrical cells are found solitary, rarely united in colonies; the cell wall is composed of two halves.

Of the three genera placed here by PASCHER (1937), namely Bumilleriopsis PRINTZ, Pseudotetraëdon PASCHER, and Centritractus LEMMERMANN, only the two last-mentioned have been observed among plankton.

The genera are distinguishable as follows:

I. Cells ellipsoidal to cylindrical, often somewhat irregularly shaped, straight or slightly curved, with round or slightly elongated ends, without polar spines, not planktonic. ..... Bumilleriopsis p.323

II. Cells more or less oblong cylindrical, each pole with a spine or seta. Centritractus (below)

III. Cells cylindrical, compressed; viewed laterally, cells appear elliptic, viewed from the top, they are tetragonal, with a diagonally projecting spine at each of the four corners. .. Pseudotetraëdron (p.115)

Centritractus LEMMERMANN, 1900

Solitary cells ellipsoidal or cylindrical, poles rounded or cone-like attenuated; with a more or less long, acuminate, straight or slightly curved spine at each pole. The thick cell wall is composed of two halves which overlap each other at the equator of the cell. With two or more parietal chromatophores which may sometimes show a reticulate structure; there are no pyrenoids. Oil droplets are here and there visible in the protoplast. — Reproduction is by transversal division. Somewhat doubtful genus; resembles certain species of Ophiocytium. Three species.

Pond dwellers, in mud, and also tychoplanktonic.

1. Length of the cell body (without the spines) 8-15 µ.
   a) Spines long and strong ..... Centritractus belonophorus 1.
   b) Spines short and delicate ..... Centritractus dubius 2.
2. Length of the cell body (without the spines) 24-37 µ. Centritractus africanus 3.

Pseudotetraëdron PASCHER, 1912

p.324

Solitary cells almost square if viewed from the top, often with slightly convex sides. Projecting from each corner in diagonal direction is a long, straight, delicate spine, the tips of which are tapered to a point. In side-view, the cells appear oblong elliptic. The two halves of the cell wall overlap each other slightly so that a clearly visible line transverses the median of the cell on its square side. The two halves of the cell wall are probably slightly impregnated with silica. Several (up to 10) roundish, discoid chromatophores are quite evenly distributed in parietal position, accompanied by oil droplets which occasionally show a reddish color; there are no pyrenoids. Cell division has not been observed but cyst formation has been reported. The cysts are spherical with a siliceous wall whose hemispherical valves overlap each other at the margins. Subsequent activity unknown. — The only species is:

Pseudotetraëdon neglectum PASCHER. — With the characteristics of the genus. Lateral length of the cell is 8 µ, length of the spines 12-14 µ.

Family: Chlorotheciaceae

p.325

Sessile or free, solitary or forming multistoried colonies. Cells are club-shaped or cylindrical, with a wall composed of two halves. There may be no longitudinal growth at all, or it may be very pronounced.

PASCHER (1937) distinguishes two groups in this family:

Chlorothecleae, which do not form colonies, are sessile und usually without remarkable longitudinal growths; with the genera Chlorothecium and Hemisphaerella.

Sciadieae, whose cells feature pronounced longitudinal growths, live solitary or form radial or storied colonies (in the latter case sessile).

The genus Ophiocytium consists of quite a variety of species (according p.326
to PRINTZ, 1927; "21 Arten in allen Weltteilen" [= "21 species in all parts of the world"]) which may be divided into two sections:

Sect. 1: Euophiocytium WILLE, or Brochidium PERTY. — Cells mostly free and solitary, only rarely united in colonies.

Sect. 2: Sciadium A. BRAUN. — Cells in most cases united in colonies, always sessile.

Taxonomic key for the Ophiocytium species:

I. Cells with a seta or spine on one pole only.

a) Polar process ending in a tiny disk (which may sometimes have been broken off) ..... Ophiocytium majus 1.

b) Process in the form of a spine not terminating in a disk.

1. Spine short ..... Ophiocytium cochleare 2.
(Here, colony formation may sometimes occur in that daughter cells stay [epiphytic] attached to the [empty] parent cell wall, e.g., O. umbellifera RABENHORST.)

2. Spine relatively very long ..... Ophiocytium lagerheimii 3.
(Here, colony formation is quite frequent in that the basal spines are attached to one another. Solitary cells may also be attached by their spine to a substratum.)

II. Cells with a spine on either pole. p.327

a) Cells 2.7-10 μ thick ..... Ophiocytum capitatum 4.
(Colonies may here be formed by attachment of the daughter cells to the end of the parent cell wall, e.g., O. umbellifera LEMMERMANN)

b) Cells more than 10 μ in thickness ..... Ophiocytum bicuspidatum 5.

III. Cells without spines at either pole ..... Ophiocytum parvalum 6.

Appendix to the Heterococcales: p.329

Leuvenia GARDNER, 1910

(Syn. Osterhautia GARDNER)

This alga changes its appearance with advancing age. The solitary, free-floating cells are spherical when young, with a firm wall and without a gelatinous sheath; they have one or two parietal discoid chromatophores and are uninucleate. As a cell becomes older, its shape becomes

ovi- or pyriform, and there is a considerable increase in the number of chromatophores which are connected to one another by delicate strands of cytoplasm; cells are multinucleate. By direct metamorphosis, young cells are capable of changing into one zoospore with two flagella of unequal length, and with two or more chromatophores; adult cells produce a number of such zoospores. At the beginning of the swarming period (which starts shortly after daybreak), the zoospores are pyriform; toward the end of the period, their shape is amoeboid. Having come to rest, they retract their flagella, lose their contractile vacuoles, assume a spherical shape, and secrete a wall. Palmella stages, though rare, do occur. Cyst formation has also been observed. The cysts are usually spherical, bivalved, and with a thick wall. — One species: Leuvenia natans GARDNER.

Order: Heterotrichales

Filamentous Heterokontae, as a rule unbranched, rarely branched; young stages may be sessile, or the filaments may be free throughout life. Most forms have a characteristic wall, composed of two halves. Differenti- p.330
ation of the filaments into base and apex does not exist (in some forms, at the most slightly indicated). Now and then, the filaments disintegrate into isolated cells; in the case of Bumilleria also with longitudinal cell division. — Asexual reproduction by means of characteristic swarmers; aplanospores and akinetes known. Sexual reproduction has been observed for Tribonema: Union of $\overset{\text{one}}{\wedge}$ gamete that has come to rest by withdrawing its flagella $\overset{\text{with}}{\wedge}$ another that has retained its motility.

Family: Tribonemataceae

Unbranched filaments (abnormal branching may occasionally be observed; simple or repeated forking); otherwise with the characteristics of the order.

The four genera known are distinguished as follows:

A. Filaments composed of cells without a thick gelatinous envelope.

I. Wall of a filament is composed of a linear file of H-pieces.

a) H-pieces clearly evident even in vegetative condition. Tribonema (below)

b) H-pieces not clearly evident in vegetative condition.. Heterothrix

II. After a succession of 4-8 cells in which the structure of H-pieces is not discernible, thicker H-pieces are inserted. ..... Bumilleria p.331

B. The linear arranged cells are embedded in an apparently amorphous, thick, gelatinous matrix. .....Neonema

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Tribonema DERBES & SOLIER, 1856 p.332

Syn. Conferva (auctor. vet. pro parte); Conferva (sensu) LAGERHEIM

Cells united to form uniseriate unbranched filaments without gelatinous sheath. The individual cells are cylindrical or barrel-shaped, face of poles straight. The cell wall is frequently of considerable thickness and distinctly layered. The protoplast contains one or several discoid chromatophores in parietal position and with a yellowish-green pigmentation. Reserves from photosynthesis are stored as oils; volutin has also been reported. A pyrenoid has been observed in only one species; it is lacking in the other. Each cell with 1 nucleus, rarely with 2 or more. However, the number of nuclei is not a diagnostic characteristic for these species. The small granules observed by DERBES & SOLIER consist, according to CHADEFAUD (1936), of a glucide (and not, as thought by HAWLITSCHKA, of calcium sulfate).

Taxonomic key for Tribonema (after PASCHER): p.335

I. Each cell normally with only one chromatophore.

a) Without pyrenoid.

1. Filaments very thin (1.5-2 μ) ..... Tribonema angustissimum

2. Filaments thicker (up to 3 μ) ..... Tribonema monochloron

b) With pyrenoid; filaments about 8 μ in thickness. Tribonema pyrenigerum

II. More than one chromatophore.

a) Frequently with two, rarely with 3 or 4, or with 1 chromatophore(s).

1. Chramotophores conspicuously small; filaments 3-4 μ in thickness. Tribonema elegans

2. Chromatophores of normal to very large size.

α) Chromatophores quite uniformly shaped, in most cases of fairly equal size. Cells at the most 1 1/2 times longer than broad.

- Filaments rigid, maximal 5 μ thick; cells short. Tribonema minus

- Filaments thicker

— up to 7 μ ..... Tribonema acquale

— up to 10 μ ..... Tribonema ulothrichoides

β) Chromatophores rather large and irregularly shaped, or ribbon-like; cells usually very long ..... Tribonema affine

b) Usually several to many discoid chromatophores.

1. Filaments about 3 μ in thickness, mostly with many chromatophores ..... Tribonema subtilissimum

2. Filaments thicker to very thick

α) Filaments about 7 μ in thickness; usually many chromatophores, cells elongated ..... Tribonema vulgare

β) Filaments thicker

- Filaments about 10-13 μ in thickness

— Many chromatophores, cells elongated. . Tribonema viride*

— Few and usually larger chromatophores; cells only twice as long as thick ..... Tribonema intermixtum

- Filaments up to 13-25 μ and more in thickness

— about 13-18 μ; in most cases thick-walled.

— Cells usually short, up to 2, at the most 3 times longer than thick, most of them with only 4-6 chromatophores. ..... Tribonema gayanum

— Cells often longer and of irregular shape, bulging, most of them with large chromatophores. Tribonema utriculosum** p.336

— About 25-30 μ thick; cells usually as long as they are thick ..... Tribonema crassum

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*) Thicker forms (up to 18 μ) occur but are, as yet, little known (PASCHER).

**) Has also been observed with many small, or with very few (1-3), rather large chromatophores (possibly separate species ?).

Epiplanktonic Heterokontae

p. 342

I. Heterochloridales

The following epiplanktonic form is known as a member of the order of Heterochloridales:

Nephrochloris incerta GEITLER & GIMESI, 1925

Cells are very much subject to changes in their shape, in most cases they are broad ellipsoidal, slightly truncate, that is, of a dorsiventral structure, with a very shallow longitudinal furrow, and hence, in cross section reniform. The anterior end is distinctly truncate, naked, and metabolous. Slightly below the anterior pole, a single rather thick flagellum, about twice as long as the cell body, is inserted, and one con- p. 343
tractile vacuole is situated at its base. With one (sometimes 2 ?) parietal chromatophore in the form of a broadly curved plate lining the entire cell, of a bright yellow-green color. In the posterior cell portion, one or two highly glossy, oily droplets. Reproduction is by longitudinal division. Cysts unknown.

II. Rhizochloridales

Stipitococcus W.&.G.S.WEST, 1898

has been reported as an epiphytic organism of the order Rhizochloridales, then with 2 species. Syn.(?): Stylococcus SCHMIDLE.

Cells ellipsoidal or oviform, more or less irregular, attached by a more or less long, fine stipe. The protoplast is surrounded by a campanulate lorica, open at the distal end. With one or two parietal, curved chromatophores in the form of irregular plates, without pyrenoid. One nucleus in central position or closer to the anterior end . Food reserves accumulate in the form of oil. The anterior end features a system

of pseudopodia which differs, however, in the various species. Reproduction is by means of swarmers. The genus is, in part, doubtful. So far, three species have been reported:

A. Lorica ellipsoidal, protoplast with a delicate, long, apical rhizopodium. Stipe relatively long. ..... Stipitococcus lauterbornei 1.

B. Lorica oviform, protoplast with a pseudopodial lobe (?), marginate or also pointed. Stipe shorter. Anterior end sometimes with a tuft of delicate rhizopodia. ..... Stipitococcus urceolatus 2.

C. Lorica campanulate, stipe long. ..... Stipitococcus vas 3.

III. Heterococcales p.344

The order of Heterococcales (Families: Mischococcaceae, Characiopsidaceae, and Chlorotheciaceae) reportedly includes also several epiplanktonic forms.

Family: Characiopsidaceae

"Cells solitary, with homogeneous cell wall, green, or also colorless; their shape varies markedly from genus to genus; all have the common characteric of being sessile, attached either by a cytoplasmic stipe which may sometimes be quite long, or affixed to the substratum by a prolongation of the cell wall.

The following key may, at least, augment overall orientation as regards the presently known five genera (after PASCHER, 1938): p.345

A. Cells with eyespot and contractile vacuoles, most cells with a definite stalk ..... Characidiopsis

B. Cells without eyespot or contractile vacuoles, with or without stalk.

I. Cells usually evidently longer than the stalk, or without the latter.

a) Cell development mostly in longitudinal direction of the stalk.

1. Cells in most cases developed perpendicular to the substratum. Characiopsis

2. Cells green or colorless, in the latter case also developed perpendicular to the substratum, otherwise parallel to it, arched or resting on it. ..... Harpochytrium

b) Cell development mostly transverse to the direction of the stalk, often broader than high, in optical section almost triangular; cell wall with two verrucae or thorns ..... Dioxys

II. Cells as long as stalk, or shorter ..... Peroniella

Taxonomic key for some of the Characiopsis species: p.347

A. Epiphytic on algae.

I. Cells without a true stalk, but attached by the attenuated prolongation of the cell base which is often markedly thickened at the point of attachment.

a) Cells pointed at their free ends, with a conspicuous yellowish or brownish calotte ..... Characiopsis crassiapex 1.

b) Cells without such apical calotte..... Characiopsis subulata 2.

II. Cells abruptly ending in a short stalk.

a) Few or up to 8 chromatophores. Cells pointed, often with a minute acicula; [illegible] up to 15 µ in length. ..... Characiopsis minuta 3.

b) Many chromatophores. Cells broad tubular, often almost angular, attenuated towards the top, without an acicula; 30-50 µ in length. ..... Characiopsis turgida 4.

c) Cells spherical to transverse ellipsoidal, mostly with 2 chromatophores; stalk short, thick, excentric. ..... Characiopsis gibba 5.

d) Cells fusiform, one flank more or less convex; one chromatophore, stalk short, not sharply delimited ..... Characiopsis anabaenae 6.

III. Cells gradually extended into a frequently long stalk.

a) Cells pointed.

1. Stalk half as long as the cell, the latter evenly tapered toward either end, usually not bent to one side.

α) Stalk abruptly widening into the discoid pedicle with which the cell is attached. Cells 20-25 µ long. Characiopsis acuta 7.

β) Broadening of stalk, to meet discoid pedicle, starts at about half its length. Cells 10-15 µ long ... Characiopsis minor 8.

2. Stalk often of considerable length, and thin; it is longer than the usually slender cell which is tapered to a point at both ends, and often stands at an oblique angle.
Characiopsis longipes 9.

b) Cells not pointed, reversed ovi- to pyriform. Stalk at least half as long as the cell body. ..... Characiopsis pyriformis 10.

B. Epiphytic on animal organisms.

p. 348

I. On the shells of rhizopods (Difflugia); cells navicular. Characiopsis difflugicola 11.

II. On crustaceans; cells cylindrical, resembling a sausage. Characiopsis cylindrica 12.

Peroniella GOBI, 1887

p. 352

Solitary cells spherical, ellipsoidal or pyriform, with a delicate wall, affixed to a substratum by a longer or shorter, more or less slender, often filamentous stalk, which is very delicate, straight or curved, and does not always terminate in a basal disk. Each cell contains one or more parietal discoid chromatophores, without pyrenoids. Nucleus in central position. Due to accumulated oil, the cell contents assume occasionally a golden-yellow color. Up to 8 zoospores of uniform size are formed simultaneously within a cell; they are pyriform and escape from the parent cell through a lateral crack in the wall; allegedly with one flagellum which, supposedly, changes into a stalk (?) once the swarmers have come to rest for germination. In addition, statospores are reportedly also formed in that the contents of a vegetative cell become dark green due to condensation, and the cell wall grows thick. Sexual reproduction unknown.

A. Mature cells with several or many discoid chromatophores. Cells spherical; size: 20 µ. ..... Peroniella hyalothecae 1.

B. Cells with 1-3 chromatophores; 6-10 µ long (without the stalk), the latter straight. Cells ovi- or pyriform. .... Peroniella planctonica 2.
