THE GENUS DEBARYA.

EDGAR NELSON TRANSEAU
Department of Botany, Ohio State University

The taxonomic history of the *Zygnemales* is characterized by more, or less, futile attempts to use the chromatophores, the various types of conjugation and reproduction, the characters of the spores, or the methods of gamete formation as the basis of classification. The splitters have had their innings and have postulated numerous genera which later on had to be abandoned because of the discovery of new species which were intermediate, or which exhibited two or more conflicting generic characters. The history of the genus *Mougeotia* is a striking example, which as now understood includes *Mesocarpus*, *Craterospermum*, *Plagiospermum*, *Staurospermum* and *Gonatonema*.

The various groupings into families and subfamilies have been equally various and futile, and the best scheme at the present time seems to be to consider the *Zygnemales* as an Order of the *Akontæ* co-ordinate with the *Desmidiales*. The Order Zygnemales consists of a single family: the Zygnemaceæ. This family includes 6 genera: *Debarya*, *Mougeotia*, *Temnogametum*, *Pleurodiscus*, *Zygnema*, and *Spirogyra*. Altogether about 200 valid species have been described. Under this arrangement the natural relationships of the species and genera are more readily visualized, and certainly less obscured than by the use of a larger number of arbitrary subdivisions.

The genus *Debarya* was founded by Wittrock in 1872 to more definitely classify the "Mougeotia glyptosperma" described and figured by De Bary in 1858. There are two outstanding features of this alga: (1) the form of the zygospore is absolutely unique among the known *Zygnemales;* and (2) as the gametes form and contract toward the conjugating tubes pectic compounds and cellulose accumulate within the gametangia replacing them. The chromatophore is quite similar to that of *Mougeotia*. In 1894 Palla described "Mougeotiopsis calospora" as a new genus and species which resembles *Debarya* in the solidification of the gametangia but which differs from *Debarya* in the apparent absence of pyrenoids. In 1898 W. and

G. S. West questioned the validity of this observation and of its use as a generic character, and in 1900 renamed it *Debarya calospora* based on material collected in Yorkshire which had pyrenoids. In 1897 the Wests also transferred to this genus the "Zygogonium læve," described by Kuetzing in 1849, as *Debarya lævis*. In both these species the cell shape is more that of a *Zygnema* than of a *Mougeotia*, and the chromatophores are rather indefinite structures with two, three, or several pyrenoids only remotely resembling *Mougeotia*. In 1903 the Wests added a fourth species, *Debarya desmidioides* with short cells and indefinite rod-shaped chromatophores, each with two distinct pyrenoids.

Debarya americana was described by the writer in 1915. This species has cells and chromatophores intermediate between *Mougeotia* and *Zygnema*. The chromatophores are usually definite and platelike with two pyrenoids but at the time of conjugation often thickened around each pyrenoid and more or less dumbbell-shaped. In the latter condition these chromatophores are quite similar to those of *Zygnema vaucherii* Ag. var. *stagnale* (Hassall) Kirchner.

At the same time *Debarya decussata* was described in which the vegetative cells are indistinguishable from those of *Zygnema*. The reproductive structures, however, both zygospores and aplanospores, are entirely different from those of *Zygnema decussata* which it otherwise closely resembles. In addition to structural differences this alga has the characteristic secretion of pectic material and cellulose occupying the gametangia, or the sporangium, and adhering to the mature spore.

The zygospores and method of conjugation of *Zygnema spirale* described by Fritsch from South Africa are quite similar to those of *Debarya decussata* even to the tendency toward spiral twisting of the conjugated filaments. This form must therefore be transferred to *Debarya* if we accept the accumulation of pectic compounds and cellulose in the gametangia as the most important charactertisic of this genus, and are willing to concede that the chromatophores are of secondary importance. We must not overlook the fact that in the present genus *Mougeotia* there are not less than four forms of chromatophores (1) the single axile plate (most species), (2) the rod-shaped (*M. capucina*), (3) two parallel platelike chromatophores with the nucleus between (frequent in *M. robusta*), and (4) two axile

plates one in either half of the cell with the nucleus between (*M. punctata* mss.).

In 1895 Hallas described a peculiar conjugate under the name *Zygnema reticulata* which produced only aplanospores, whose vegetative cells in part resemble *Zygnema* and in part (according to her figures) *Mougeotia* with several pyrenoids in a chain. The aplanospores resemble those of *Debarya decussata* in having the sporogenous cells solid instead of empty as in *Zygnema*.

Recently Fritsch has figured and discussed a quite similar form from South Africa which reproduces by akinetes. Its vegetative cells in some cases resemble those of *Zygnema*, sometimes have four stellate chromatophores, and sometimes 2 or 4 greatly elongated chromatophores. Through the kindness of Miss E. Stephens of Capetown I have examined some of this material, and also a later collection of this same alga from another locality in which aplanospores were present. Some of the akinetes and aplanospores are shown in Figures 38 to 44. For the reasons stated above I believe this form is best classified as a *Debarya*.

Finally we must not overlook *Debarya africana* G. S. West in which the secretion from the gametes occurs only during the initial stages of conjugation. This is the only species in which it does not continue until the fusion of the gametes.

Clearly all the species here grouped under *Debarya* have (1) the common habit of secreting pectic material and cellulose during the formation and migration of the gametes, and (2) the whole of the contents of the conjugating cells enters into the formation of the zygospore. The first of these characteristics distinguishes this genus from both *Mougeotia* and *Zygnema*. The second separates it clearly from *Mougeotia*.

In several species of *Mougeotia*, for example *M. uberosperma*, *M. capucina*, and *M. tropica*, there are solid processes extending into the sporogenous cells from the zygospores, or the aplanospores. These are not formed, as in *Debarya* during the development and migration of the gametes, but immediately after the union of the gametes. Consequently these species differ from those here placed in *Debarya* in that the secretion of solid material follows conjugation and a part of the contents of the conjugating cells remains in the otherwise empty gametangia.

In view of all these facts the genus *Debarya* may be defined as follows:

DEBARYA Wittrock 1872.

Wittrock, V. B. 1872. Om Gotlands och Oelands Sotvattensalger Bih. Kgl. Swensk. Vet-Akad. Handl. Vol. 1, No. 1; Transeau, E. N. 1915. Notes on the Zygnemales. Ohio Jour. Sci., Vol. 16, p. 20.

Vegetative cells cylindrical or slightly constricted at the ends, varying from 1 to 16 diameters in length. The chromatophores vary from an axile plate with 2 or several pyrenoids, to an axile two lobed body with 2 pyrenoids, and finally to two radiate or elongate bodies each with one or several pyrenoids. Reproduction by zygospores *formed of the complete contents* of the gametangia and occupying the conjugating tube. The zygospores are not *separated from the gametangia by cross walls*. In the process of conjugation, as the gametes form and pass into the conjugating tube, a secretion of pectic material and cellulose occurs which either greatly thickens the gametangium walls or fills the gametangia. In Debarya more than in any of the genera of the *Zygnemaceæ* the spores vary in form and disposition of their cell walls. Aplanospores having walls similar to those of the zygospores occupy only a part of the sporogenous cell, the remainder being filled with pectic material and cellulose. Parthenospores and akinetes occur not infrequently in several of the species.

KEY TO THE SPECIES OF DEBARYA.

1. Forming aplanospores.....11
1. Forming zygospores.....2
2. Veg. cells usually with more than 2 pyrenoids in an axile chrom.....3
2. Veg. cells with *only 2* pyrenoids in an axile chromatophore..... 7
2. Veg. cells with 2 or more *radiate chromatophores*.....9
3. Diam. vegetative cells more than 18 microns.....4
3. Diam. vegetative cells less than 18 microns.....6
4. Spore wall smooth, spores extending beyond the tube.....5
4. Spore wall scrobiculate, spores contained in the tube.....3-D. lævis
5. Zygospores 50–56μ in diameter.....1-D. africana
5. Zygospores 30–40μ in diamtere.....2-D. immersa
6. Spores quadrangular, smooth.....4-D. hardyi
6. Spores discoid with 3 prominent encircling ridges.....5-D. glyptosperma
6. Spores globose, or subglobose, pitted.....6-D. calospora
7. Spores compressed ovoid, scrobiculate.....7-D. americana
7. Spores quadrangular ovoid smooth.....8
8. Diam. veg. cells 7.7–8.6μ.....8-D. desmidioides
8. Diam. veg. cells 10–12μ.....9-D. cruciata
9. Veg. cells with 2 radiate chromatophores.....10
9. Veg. cells with 2–7 radiate chromatophores.....10-D. reticulata
10. Spores 30–36μ x 48–54μ.....11-D. spiralis
10. Spores 24–30μ x 30–48μ.....12-D. decussata
11. Diam. veg. cells 18–30μ, spores symmetrically ovoid.....10-D. reticulata
11. Diam. veg. cells 16–20μ, spores unilaterally ovoid.....12-D. decussata
11. Diam. veg. cells 36–42μ, spores symmetrically ovoid.....13-D. pectinata

1. *D. africana* G. S. West. 1907. Jour. Linn. Soc. Bot Vol. 38, p. 104; pl. 5, fig. 3. Vegetative cells 23–26μ x 90–200μ chromatophores with 5–8 pyrenoids; zygospores globose-ovoid, 50–56μ in diameter,

filling the conjugating tube and extending nearly to the opposite thickened walls of the gametangia; spore wall smooth. Fig. 1. Nyassa, Africa.

This is the only species of the genus in which the gametangia do not become filled with pectic material and cellulose, as the gametes move into the tube during conjugation. There is a thickening of the walls, however, except at the center of each transverse wall.

2. *D. lævis* (Kuetz.) W. & G. S. West. 1897. Jour. Roy. Micros. Soc. p. 476; Mougeotia lævis Archer, Jour. Micros. Soc. 8: 65. 1869; Zygogonium læve Kuetzing, Spec. Alg. p. 447, 1849; G. M. Smith, Wis. Acad. Sci. Art. & Lett. 18 : 561, 1916; G. S. West, British Freshwater Algæ, p. 128, Fig. 46, C-E, 1904.

Vegetative cells 20–26μ x 20–100μ, chromatophores with 2–4 pyrenoids; fertile cells elongated; zygospores filling the conjugating tube ellipsoid to ovoid 20–36μ x 42–50μ, median spore wall scrobiculate. Fig. 18. Europe; Wisconsin.

3. *D. immersa* W. West. 1902. Jour. Bot. 40 : 144; 41 : 58. Vegetative cells 20–24μ x 20–75μ, zygospores ovoid to subglobose, 30–40μ x 30–48μ, filling the tube and extending into the gametangia, median wall smooth. Not figured. India.

4. *D. calospora* (Palla) W. & G. S. West. 1898. Annals of Bot. 12 : 49; Jour. Bot. 38 : 289; Mougeotiopsis calospora Palla, Berichte Deutsch. Bot. Gesellsch. 12 : p. 228, 1894; G. S. West, British Freshwater Algæ, p. 128, Fig. 46, B, 1904. Vegetative cells 11–18μ x 11–72μ, chromatophores with several pyrenoids more or less distinct; zygospores ovoid to globose, 18–26μ in diameter; median wall pitted, brown. Fig. 3. Europe.

5. *D. americana* Transeau. 1915. Ohio Jour. Sci. 16 : 18. Vegetative cells 9–12μ x 27–120μ, chromatophore an axile plate with two pyrenoids; fertile cells 10–14μ x 75–180μ; zygospores ovoid to quadrate ovoid 20–40μ x 30–40μ; parthenospores 15–20μ x 20–30μ, unilaterally ellipsoid with retuse ends, median spore wall minutely and irregularly verrucose, yellow-brown. Figs. 6, 7, 16 and 17. Ontario, Michigan.

6. *D. decussata* Transeau. 1915. Ohio Jour. Sci. 16 : 19. Vegetative cells 16–20μ x 24–50μ chromatophores as in *Zygnema* with two pyrenoids; zygospores ovoid to quadrate-ovoid, and irregular, 24–30μ x 30–48μ, angles rounded, retuse, or produced; aplanospores unilaterally ovoid, the plane of the convex side changes in successive cells, 17–25μ x 20–40μ parthenospores 15–20μ x 20–30μ, median wall in all the spores scobiculate; akinetes with smooth heavy walls, 18–20μ x 20–36μ. Fig. 28–33. Illinois, Michigan, Pennsylvania, Iowa, Ontario. In some collections only aplanospores occur, in others only zygospores. A majority of the collections contain both.

7. *D. hardyi* G. S. West. 1909. Jour. Linn. Soc. Bot. 39 : 51, Pl. 2; Algæ, Camb. Bot. Handbooks Vol. 1, p. 341, Fig. 213. 1916. Vegetative cells 6.4—7.5μ x 57–120μ, chromatophore an axile plate with 2–4 pyrenoids; zygospores quadrangular with straight or concave sides, angles retuse, 22.5–27μ. Figs. 2, 11, and 12. Spores possibly not mature. Australia.

8. *D. cruciata* Price. 1911. New Phytologist 10 : 87; 11 : 60. Vegetative cells 10–12μ x 30–60μ, chromatophore with 2 pyrenoids; conjugation between cells usually after dissociation of the filaments; zygospores quadrangular with concave or rarely straight sides, angles produced or slightly concave, 20–24μ x 28–32μ, median wall smooth. Fig. 13, 14 and 15. Spores possibly not mature. England.

9. *D. desmidioides* W. & G. S. West. 1903. Jour. Bot. 41 : 7, Pl. 446; G. S. West, Algæ Camb. Bot. Handbooks Vol. 1, p. 341, Fg. 213. 1916. Vegetative cells 7.7–8.6μ x 19–56μ constricted at the ends, chromatophore an axile plate with 2 pyrenoids; conjugation between free cells after dissociation of the filaments; zygospores 20–24μ x 22–30μ, median wall smooth. Figs. 8, 9, and 10. Spores possibly not mature. England.

10. *D. glyptosperma* (De Bary) Wittrock. 1872. K. Svenska Vet. Akad-Handl. 1 : 35; Conjug. p. 78, T 8. Fig. 20–25; Mougeotia glyptosperma De Bary, A., Conjugatæ p. 78, 1858; G. S. West, British Freshwater Algæ, p. 128, Fig. 46, A. 1904.

Vegetative cells 9–16μ x 50–200μ, chromatophore an axile plate with several pyrenoids; zygospores lenticular to compressed ovoid, with median wall marked by three parallel ridges and polar projections, connected by radial lines; shorter axis 30–48μ, longer 42–72μ. Fig. 4. Europe; N. Zealand, New Hampshire, Massachusetts, Minnesota, Florida, Michigan.

Var. formosa Transeau. 1915. Ohio Jour. Sci. 16 : 18. Vegetative cells 7.5–9μ in diameter; zygospores 24–30μ x 30–42μ, median wall steel blue; otherwise like the type. California.

11. *D. reticulata* (Hallas) Transeau. 1915. Ohio Jour. Sci. 16 : 20; Zygnema reticulata Hallas. E., 20 : 1–16. 1895.

Vegetative cells 18–30μ x 35–100μ, with 2–7 chromatophores resembling those of *Zygnema*; zygospores unknown; sporogenous cells up to 240μ in length, inflated toward the middle, aplanospores subglobose to ellipsoid up to 35μ in diameter, median wall yellow, scrobiculate, and irregularly reticulate. Spores give rise to 1, 2, or 3 filaments on germination. Fig. 19–27. Europe.

12. *D. spiralis* (Fritsch) Comb. nov. Zygnema spiralis Fritsch, F. E., Annals South Africa Museum 9 : 564. 1918.

Vegetative cells 18–25μ x 40–130μ with two stellate chromatophores; zygospores quadrately ovoid formed in the greatly enlarged conjugating tube but extending into the gametangia, 48–54μ x 30–36μ. Mature spores lacking so that the character of the median wall is unknown. Figs. 34–37. South Africa.

13. *D. pectinata* (Fritsch) Comb. nov. Zygnema pectinatum, Fritsch, F. E., Roy. Soc. S. Africa 9 : 55. 1921.

Vegetative cells 36–42μ x 83–200μ with two stellate, or greatly elongated stellate chromatophores each with one pyrenoid, or more rarely 2 or 3 pyrenoids; zygospores unknown; akinetes swollen toward the middle to 80μ, with walls 6–8μ thick, sometimes obliquely ventricose alternating in successive cells; aplanospores 70–94μ x 100–128μ ellipsoid, or with polar thickenings, outer wall 4–8μ thick smooth, median wall irregularly tuberculate. Figs. 38–44. Kentani District, South Africa.

EXPLANATION OF FIGURES.

PLATE I.

Fig. 1. *Debarya africana*, showing slight thickening of walls and pits in the centers of the cross walls. After G. S. West.

Figs. 2, 11, 12. *Debarya hardyi*, showing early stage of conjugation and immature zygospores. After G. S. West.

Fig. 3. *Debarya calospora*, vegetative cells and mature spores. After G. S. West.

Fig. 5. *Debarya glyptosperma*, mature spores. Drawn from material collected near Boston, Mass.

Figs. 6, 7, 16, 17. *Debarya americana*, mature spores and vegetative cell, from material collected by A. B. Klugh, Kingston, Ontario.

Figs. 8, 9, 10. *Debarya desmidiodes*, vegetative filament and spores. After G. S. West.

Figs. 13, 14, 15. *Debarya cruciata*, conjugating cells and immature zygospores. After Price.

Fig. 18. *Debarya lævis*, vegetative cell and mature zygospores. After G. S. West.

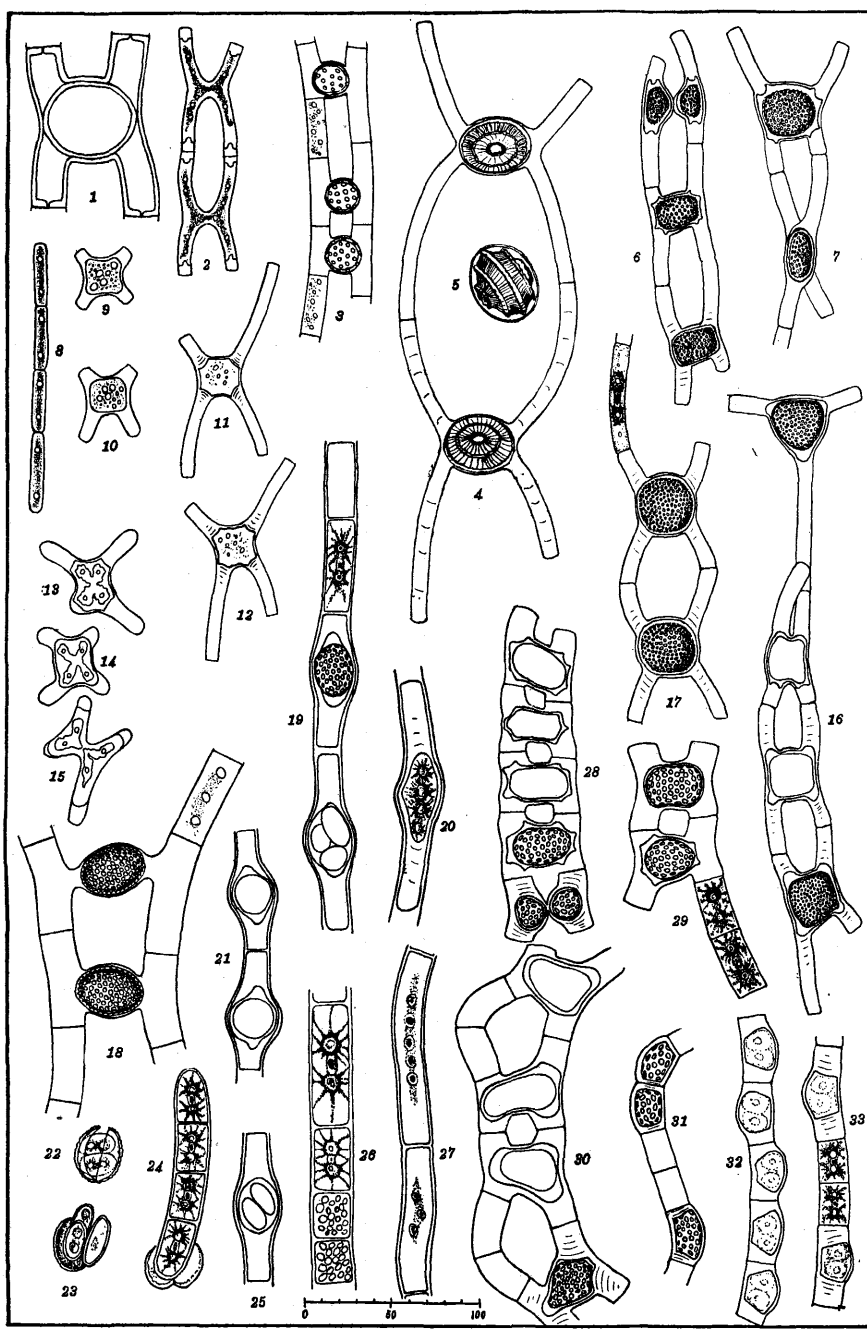
Figs. 19–27. *Debarya reticulata*, vegetative cells, aplanospores, akinete, (Fig. 20), and germinating aplanospores. After Hallas.

Figs. 28–33. *Debarya decussata*, vegetative cells, zygospores, parthenospores aplanospores (Fig. 31), and akinetes (Figs. 32–33). Drawn from material collected at Charleston, Illinois.

PLATE II.

Figs. 34–36. *Debarya spiralis*, vegetative cells, conjugating cells, immature zygospores (Fig. 37), zygospore side view (Fig. 35). After F. E. Fritsch.

Figs. 38–44. *Debarya pectinata*, vegetative cells showing variety of chromatophores, akinete (Fig. 40), and aplanospores probably not completely matured. Drawn from material collected by H. A. Pocock, Oct. 23, 1923, Cedar Mountains, Clan William, in shallow stream. For other figures see paper by F. E. Fritsch.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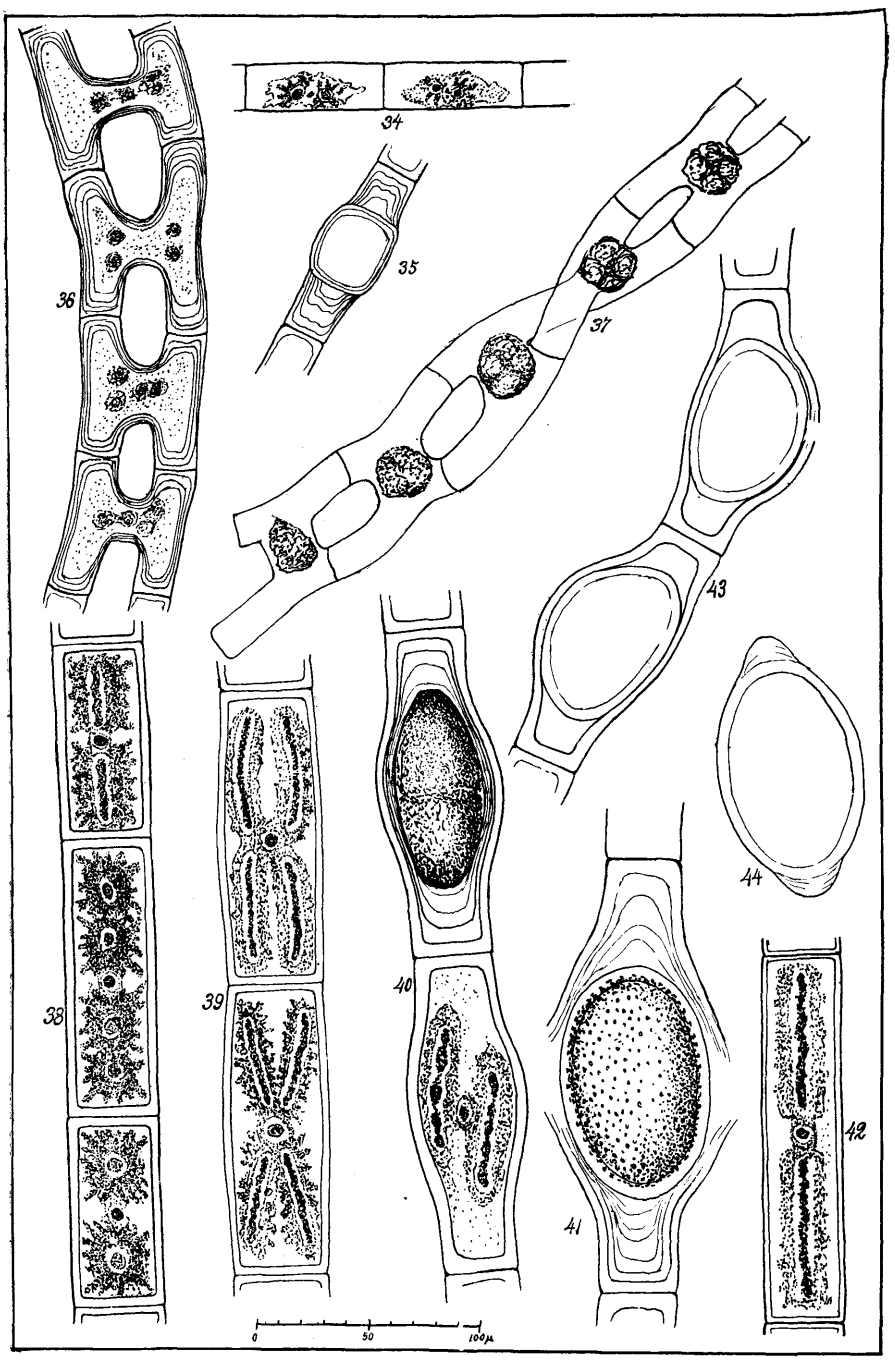
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