BRITISH DESMIDS: A SUPPLEMENT TO BRITISH FRESH-WATER ALGAE

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INTRODUCTION.

The Desmids, to which this volume is devoted, constitute the first family of the Zygophyceæ,* or, according to some, form a distinct section of the Conjugatæ, closely allied to the Zygnemaceæ.

The configuration of the cells is multiform, from the single cylindrical and spindle-shaped, to those with most complicate but symmetrical, lobate, or dentate outlines, whilst each species retains always its characteristic form. In most cases each cell is divided into two equal and symmetrical halves by a cross constriction, which is either a shallow groove or a deep and narrow incision, so deep as to convey to some observers the impression that each cell consisted of a pair of closely united bodies of equal dimensions. These cells live separate from each other, and are free, or else are united end to end in a filament, whilst each cell retains its own individuality. They are surrounded by a cellulose membrane, which, in some cases, must contain considerable inorganic matter, since, when calcined carefully, the remains still retain their original form. As Ralfs † long ago intimated, "all the Desmidieæ are gelatinous. In some, the mucus is condensed into a distinct and well-defined hyaline sheath or covering, as in *Desmidium cylindricum* and *Staurastrum tumidum*; in others it is more attenuated, and the fact that it forms a covering is discerned only by its preventing the contact of the coloured cells. In general, its quantity is merely sufficient to hold the fronds together in a kind of filmy

* See Cooke, "Fresh Water Algæ," p. 74.
† Ralfs, "British Desmidieæ," p. 15.

cloud, which is dispersed by the slightest touch. When they are left exposed by the evaporation of the water, this mucus becomes denser, and is apparently secreted in larger quantities to protect them from the effects of drought. I have observed more especially that *Tetmemorus granulatus* and *Penium Brebissonii*, under such circumstances, form a distinct mucous stratum." With the exception of *Sphærozosma* the side walls only of the cells united in rows, or chains, are surrounded by mucus, so long as they remain connected, but, when they become free, the flat ends also secrete mucus.

A delicate primordial membrane, intimately joined to the cellulose membrane, surrounds the cell-contents. It appears in most cases to be simply a homogeneous transparent cuticle, rich in nitrogen, and generally bears a plasma stratum of a fine granular appearance, which is deposited on its inner wall. In this plasma stratum earlier observers noticed a visible movement, through the locomotion of the granules, sometimes called rotation or circulation. De Bary, whom we have followed rather closely in this "Introduction," has applied himself to the investigation of these movements, which, he says, are found to a most astonishing extent, particularly in *Closterium lunula* and *Tetmemorus granulatus*, when the cells are in very brisk vegetation and division. He says,* "The small granules of the stratum are impelled very quickly in numerous small streamlets to and fro. These glide in constant change, sometimes from the middle of the cell to the end, at other times in the reverse direction, irregularly gliding by one another, and by those granules which are at rest. At one margin of the semi-cell we find a stream going to the cell end, at the other one going from the end to the middle, so that it appears at first sight to be a rotation analogous to that of *Chara* cells, but we see by constant observation that the movement is always transposed in different directions. Where the plasma is collected in great plenty, we perceive most clearly that the currents exist throughout the whole mass, not alone either in the primordial membrane, or the stratum bounding the watery cell-contents." . . . . "We see that the observed streams are caused by one constant movement of the whole granular plasma-mass, which alternately accumulates at different

* De Bary, "Conjugateen."

points, and again retreats. Whether, therefore, the change in the direction of the streams is, in fact, as irregular as it appears at first sight to be, or whether, on the contrary, one does not follow the other in regular progress around the whole circumference of the cell, has hitherto not been decided, on account of the opacity of the chlorophyll contents." The existence of internal cilia, as maintained by Osborne, is denied, and the appearances accounted for as optical illusions.

All the Desmids are tinted green by chlorophyll, and the colouring matter is confined to bodies of regular form, such special form and structure being very often characteristic of separate genera or species. In some species the endochrome is accumulated in parietal bands, and in *Spirotænia* and *Genicularia* the elongated ribbons are arranged spirally as in *Spirogyra*. Mr. Archer was the first to point out that in *Xanthidium* the endochrome forms in each segment four parietal quarters rather than bands, these interrupted or separated by as many narrow, nearly straight vacancies running down the centre of each front, and each lateral aspect of the segment. In *Mesotænium* the simple laminated endochrome either runs directly through the longitudinal axis of the cell, or sometimes slightly concentrically, as a sharply-defined chlorophyll plate. In most species of *Staurastrum* the endochrome is arranged in plates radiating from a common centre, so that in an end view it presents a more or less perfectly stellate appearance.

The elongated middle band in the cells of *Closterium* and *Penium* generally exhibit several starch granules arranged in one long row, very exceptionally only one. In other genera the starch granules are fewer, and more irregularly disposed. In rare cases starch granules of determined shape and structure are not to be seen, but the application of iodine will usually detect the amorphous starch which permeates the chlorophyll.

The spaces which remain free between the chlorophyll and the wall plasma are filled with a watery fluid. Within this fluid are suspended in plenty a great number of incommensurably small dancing granules in lively molecular motion. Under this head come the vesicular spaces so often mentioned, as found in the ends of *Closterium*. These terminal vacuoles are often sphærical, or half oval in shape, containing either a few or a great number of dancing granules. If we isolate the separate granules while we crush a cell, they clearly show that they have the form of a very small rhomboidal tablet, with sharp corners and angles. They remain unchanged by burning, or by treatment with concentrated acids and cold alkali. At all events, they answer to inorganic bodies, and are probably small crystals of gypsum, but, on account of their excessive minuteness, the accuracy of this suggestion cannot be tested by closer analysis. Other small granules in the cell fluids of *Cosmarium botrytis* (and perhaps of other species) have a different composition, for they will dissolve readily in reagents, and are destroyed by burning, but are insoluble in alcohol.

The increase of cells in the Desmids by ordinary cell division is by no means uncommon, and may be seen illustrated on several of the plates (Pl. XXXV., f. 5, *c d*; Pl. XLVI., f. 2, *b*; Pl. XLVII., f. 4, *e*; Pl. L., f. 9, *e*). The process has been so often observed and described that it need not be repeated here. It does not differ in its chief characteristics from the similar process in other Algæ. The isthmus, or connecting tube, between the two semi-cells elongates, a hyaline lobe is formed at each retreating base, connate at the convex extremity. These lobes continue to grow in size, becoming coloured, and by degrees attain the form and dimensions of the original semi-cells; meanwhile the old segments are pushed farther and farther apart, until at length separation takes place between the two new semi-cells, and two individuals are free, each with one old semi-cell and one new semi-cell, or daughter cell, combined to form a complete individual.

As to the movements of Desmids very little can be added to what has been stated by Ralfs,* for De Bary confesses that he has nothing of importance to contribute, but that all conclusions as to their animal or vegetable nature must be considered in abeyance. Meanwhile, no one doubts of their truly vegetable nature. Braun† only confirmed Ralfs. Alluding to *Penium curtum* he says, "The plant here named is remarkable for exhibiting the peculiar movement of the Desmidiaceæ more regularly, and more actively, than the other members of the

* Ralfs, "Desmidieæ," p. 20.
† Braun, "Rejuvenescence," p. 208, *note*.

family, a motion very different from that of the Diatomaceæ. It is a remarkable sight to behold all the individuals in a dish of water in a short time turn their long axes to the light, and thus arrange themselves in beautiful streaks in the gelatinous mass. Observation with the microscope shows that it is the younger half of the cell which here turns towards the light."

With this exception hardly any attention has been paid to the influence of light on the movements of Desmids. Stahl recently made some experiments in this direction,* chiefly with *Closterium moniliferum*, which he enclosed in glass tubes, changing the direction of the light by means of mirrors. It soon became evident that the direction of the light exercised a material influence on the position of the longer axis of the cell, this axis having a tendency to place itself in the direction of the rays of light, and that there is also a polarity between the two halves of the cell, in consequence of which one is attracted towards, and the other driven away from the source of light. The direction is subject to alternations, in consequence of which the cell is continually shifting its position through an angle of 180°, presenting each end alternately to the light. In one experiment, at a temperature of 33° C., the time occupied by this reversal of position was from six to eight minutes; in another, where the temperature was 17° C., from fifteen to thirty-five minutes. In addition to this reversal there was also a slow movement of the individual along the bottom in the direction of the source of light. When the light is very intense the conditions are reversed, and the cell places itself with its longer axis at right angles to the direction of the light. Dr. Göbel has made similar experiments on *Micrasterias rotata*, which was found to place itself with the plane of its disk at right angles to the direction of the rays of light. The direction of the chlorophyll band varies with that of the incident light.†

The conjugation of Desmids and formation of the zygospore is very similar in all species. The cells lie surrounded by loose and indistinctly circumscribed mucus in pairs together, always crossed in *Staurastrum*, and parallel in *Closterium*. In *Closterium lunula* the concave sides are turned towards each other; in

* "Verh., Physikal Med. Gesell. Wurzburg," xiv. (1880), p. 24.
† "Journal of Royal Micros. Society," iii. (1880), pp. 318.

other species parallel or crossing each other in different ways. Out of the contiguous sides each cell projects a short cylindrical "copulation process," rounded at the ends. Each advances towards the other until they meet and coalesce. In some species the process emerges in the first instance from a gaping fissure in the original cell wall; in others there is no cracking of the cell or cross fissure of the membrane. The "copulation processes" are in all cases surrounded by a tender membrane; at the free end the membrane is thicker. The contents of the "process" consist of a colourless plasma of watery fluidity, in which separate granules are suspended.

Both "copulation processes" swell, apparently at the same time, into wide bladders, of which one quickly attains a semicircular form, touching the other inwardly with a flat surface. The parting wall which separates them is immediately dissipated. The primordial membranes are melted into one, and a continually swelling middle space is formed, uniting the two cells. At this time the primordial membrane has been loosened from the cell membrane of the four half-cells, and gradually retreats towards the middle. At the first, only protoplasm and colourless fluid pass over from the old cells into the middle space, then follow the cell-kernels from both sides; and, lastly, the chlorophyll, with the last ends of the primordial utricle. In the cases observed by De Bary there elapsed 15, 20 to 40 minutes from the first swelling of the processes until the complete absorption of the primordial membrane from the four half-cells.

From this point forward there are slight variations, in different species, in the development of the zygospore from the swollen central space lying between the old semi-cells. In *Cosmarium botrytis* the middle space is, during its swelling, surrounded by a tolerably thick, but uncommonly tender, membrane, having the appearance of a homogeneous gelatinous wall. Inside the mucous bladder, which is continually becoming paler, the primordial membrane contracts itself to a regular globular form. Already, after 10-15 minutes, it possesses a visibly tender, almost completely smooth, cellulose skin. After about two hours the first intimations of the later spikes of the zygospore are visible as small projections of the cell wall. The successive formation of the three skins which clothe the ripe zygospore then follow.

The difference between the forms of copulation consists in this, that the middle space in *Closterium parvulum* is surrounded by a permanent cellulose skin; in the others by a mucous membrane, which often becomes invisible. Most of the conditions described by Ralfs range themselves between these two forms, or are transitions towards them.

The structure of the mature zygospore corresponds in the Desmidieæ with that of *Zygnema*, &c. There exist three cuticles in succession from the outside to the inside; the outer cuticle of cellulose; the middle cuticle, generally, though not always, tinged, and often very dark-brown; and a colourless inner cuticle exhibiting the reaction of cellular tissue.

The ripe zygospores of *Cosmarium*, *Euastrum*, and allied species are known to have on their outer surface prickles and projections of various shapes. In extreme youth the surface is smooth. Soon we see numerous projections thrown up, until the prominences assume the characteristic form and size of the mature prickles of the species. Their membrane thickens itself, while it deposits new cellulose sheaths from the outward end towards the inside. The spines, therefore, soon become solid bodies. In the contents of the ripe zygospore has been found chlorophyll and starch, the latter partly replaced by fat.

Observation of the process of germination, or the development of new individuals from the zygospore, seems to be rare. Wolle summarizes the result of De Bary's observations thus—"The envelope of the matrix or zygospore is primarily thin and smooth, but by degrees it acquires increased thickness, and in the Cosmariums usually a granular, tuberculated, or, more frequently, a spinous surface, the spines being sometimes simple, but commonly forked at the extremities. The next step, so difficult to be traced, is the opening of the wall of the zygospore, setting free small spheres of sarcode. As they issue they enlarge, and acquire a gelatinous or thin membranous wall. The wall thickens, and the sphere enlarges, the contents constrict first in one direction, and then transversely to the plane of the first incision. These parts