Studies on Nuclear Division in Desmids.

I. *Hyalotheca dissiliens* (Sm.) Bréb.

BY

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With Plate VIII and four Figures in the Text.

INTRODUCTION.

THE only account which has so far appeared of the division of the nucleus in Desmids is that by Lutman,¹ in which he describes the cell- and nuclear division in *Closterium*.

It was therefore suggested by Professor G. S. West that this subject was a suitable one for investigation, and the present contribution is intended to be the first of a series of papers dealing with the nuclei and nuclear division of Desmids.

The fact that very little is known of the cytology of Desmids is probably largely due to the difficulty of obtaining suitable material to work upon. It is by no means an easy matter to obtain a continual supply of any of the larger Desmids. They usually occur in places which are not easily accessible, and when brought indoors they cannot be kept for any length of time in a healthy condition. The ordinary culture-methods which serve for the common filamentous Algae are a complete failure as far as Desmids are concerned, and the conditions under which they divide or form zygospores seem to be so highly specialized that it has not been possible to determine them up to the present time. So that, while it is possible accidentally to discover Desmids in quantity in a dividing condition, the possibilities of finding them at any particular time or inducing them to divide by artificial means are rather remote.²

Hyalotheca dissiliens is the only Desmid I have been able to obtain, so far, in sufficient quantity to give complete results, and it is for this reason alone that it has been chosen for the initial paper. Unfortunately, the nucleus in *Hyalotheca* is too small to give entirely satisfactory results.

No attempt will be made in this paper to compare the results obtained with those of Lutman or to discuss their bearing with regard to other Conjugatae. I hope to complete shortly the investigation of several of the

¹ B. F. Lutman : Cell and Nuclear Division in *Closterium*. Bot. Gaz., 51, 1911.

² Some of the larger species of *Closterium* are an exception to this statement, as they will grow and multiply rapidly in large tanks in greenhouses, &c., and will also survive culture experiments.

larger Desmids, and all discussion will be deferred until these results can be summarized.

TECHNIQUE.

Material was at first fixed in weak Flemming's mixture diluted to half strength, as Lutman found this the most satisfactory fixing reagent for *Closterium*. It did not give entirely satisfactory results in the case of *Hyalotheca*. There was not much shrinkage of cell contents, but staining results were not good after using this reagent, possibly owing to the thick gelatinous sheath which is present in *Hyalotheca*. Stronger fixing reagents were tried, and of these Bouin's picroformol solution was found to give the best results. This solution therefore has been tried for all the later work. Heidenhain's iron-alum-haematoxylin was used for staining. In order to prevent shrinkage it was found necessary to exercise special care in transferring the stained material from xylol to Canada balsam. The material was transferred from xylol to a solution of Canada balsam diluted with xylol to about one-fifth of its original strength. This was then allowed to evaporate slowly until it reached its original strength.

Collections of *Hyalotheca* were made during the winter and spring and dividing filaments occurred in every collection. The greatest number of dividing filaments was present in material fixed towards midnight, but plenty of dividing filaments were to be found in material fixed as early as 4 p.m.

RESTING CELL AND NUCLEUS.

In the resting state the cell contains two chromatophores with the nucleus lying between them (Pl. VIII, Fig. 2). Seen from the end each chromatophore is star-shaped, the centre of the star being formed by a large pyrenoid from which the plates of the chromatophore appear to radiate (Fig. 1). The starch-sheath of the pyrenoid is very large, and is made up of separate plates. The number of pyrenoids is not constant. Filaments in which every chromatophore contained two pyrenoids were of frequent occurrence, and filaments with chromatophores containing three and four pyrenoids were sometimes found. Their arrangement in a transverse row in the cell suggests that they are formed by longitudinal division of the existing pyrenoid, but no division of pyrenoid was ever observed except the transverse division of the pyrenoid during division of the cell; so that it is impossible to state whether these extra pyrenoids arise by division of existing pyrenoids or *de novo*.

The nucleus is spherical in shape; though in stained preparations it often appears to be somewhat flattened by pressure from the pyrenoids. The nucleolus is comparatively large and stains deeply with chromatin stains. The reticulum is inconspicuous, stains faintly, and appears to have few, if any, chromatin granules.

DIVISION OF NUCLEUS AND CELL.

The first sign of division in the nucleus is the appearance of granules on the nuclear network, which consequently shows up more clearly on staining (Fig. 3). At the same time the nucleolus stains less deeply and finally disintegrates. The small size of the nucleus makes it exceedingly difficult to follow exactly what happens in the succeeding stages. The granules appear to increase in size and decrease in number, so that probably the chromosomes are being formed on the spireme. The gradual disappearance and disintegration of the nucleolus makes it improbable that the chromosomes come bodily out of the nucleolus.

The next stage that could be definitely seen was the collection of the chromosomes on the equatorial plate (Pl. VII, Fig. 6). The chromosomes are short broad rods, almost granules, and about twelve in number. A definite spindle could not be seen, but fibres could clearly be seen attached to the chromosomes and pulling the daughter chromosomes to the opposite poles of the nucleus (Figs. 7 and 8).

In the reconstruction of the daughter nuclei the chromosomes lose their identity, granules appear in the nucleus, and these gradually fuse to form the large nucleolus (Figs. 9-12).

The daughter nuclei begin to separate immediately they are formed, and to move in opposite directions towards the surface of the cell, where they take up a position opposite the pyrenoid.

Formation of the new cell-wall was not observed in detail. It is always completed before the division of the chromatophore begins, so that for a time the cell has only one chromatophore.

As the chromatophore divides the nucleus slips in between the two halves until it finally reaches the pyrenoid and, during the division of the pyrenoid by constriction, remains firmly pressed up against it. The division of the chromatophore and pyrenoid is probably largely influenced by the presence of the nucleus. No trace of division appeared in the chromatophore until the nucleus had moved round to the surface of the cell and taken up its position opposite the pyrenoid. Constriction does not take place equally all round the chromatophore, division always being further advanced in the part in which the nucleus lies (see Text-figs. 1-4, p. 382).

The division of the pyrenoid and chromatophore has already been figured and described by Schmitz,¹ but the close connexion between the division and the presence of the nucleus was not noted.

The starch-sheath of the pyrenoid seems to be fairly intact at the completion of the division of the nucleus, though signs of disintegration have already appeared. It is not until the beginning of division in the chromatophore that it decreases rapidly in size, and at the end of this process no trace of the starch-sheath is visible.

¹ Schmitz, F. : Die Chromatophoren der Algen. *Verhandl. d. naturf. Ver. Bonn*, Bd. x1, 1880

The fact that the starch-sheath does not noticeably diminish in size during division of the nucleus, but only during division of the chromatophore, suggests that the presence of a large quantity of starch in the cell is not in itself sufficient to induce division. The presence of two or more

Illustrating successive stages in the division of the chromatophore and pyrenoid.

pyrenoids in the cell is probably due to the fact that, although the conditions necessary for active starch-formation are present, the extra conditions necessary to induce nuclear division are absent, and additional pyrenoids are therefore formed to carry off the surplus starch.

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DESCRIPTION OF PLATE VIII.

Illustrating Miss Acton's paper on *Nuclear Division in Desmids*.

- Fig. 1. End view of cell, showing chromatophore and pyrenoid. $\times 1,450$.
 Fig. 2. Resting cell and nucleus. $\times 1,450$.
 Figs. 3-5. Gradual disappearance of nucleolus and probable formation of spireme. $\times 1,450$.
 Fig. 6. Appearance of chromosomes. $\times 2,000$.
 Fig. 7. Metaphase. $\times 2,000$.
 Fig. 8. Anaphase. $\times 2,000$.
 Figs. 9 and 10. Telophase. $\times 1,450$.
 Fig. 11. Daughter nuclei beginning to migrate to the surface. $\times 1,450$.
 Fig. 12. Nucleolus re-formed in the daughter nuclei. $\times 1,450$.

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Huth, London.

ACTON - HYALOTHECA DISSILIENS.