Comparative Ultrastructure of Snow- and Ice-Algae from Polar and Alpine Habitats

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During polar and alpine summers, snow and ice fields of these regions are inhabited by cold adapted algae. Mass accumulations can cause phenomena like “red snow” due to their secondary pigmentation. Little is known about the ultrastructure of these organisms which have to thrive in habitat with harsh abiotic conditions. Here, we investigate the principal cytological adaptation strategies of these cold-adapted organisms by means of TEM.

In general, two not closely related orders of green algae (Chlorophyta) are involved in the phenomenon of snow and ice algae – the Chlamydomonadales (mainly in wet snow) and the Zygnematales (mainly on wet glacier ice surfaces).

Despite similar ecological demands due to habitat parameters (extreme temperatures, low nutrients, high irradiation or e.g. limited availability of liquid water), we observe distinct differences in the ultrastructure of these two groups. The principal differences in the cytoarchitecture are also confirmed from places which are remote from each other, namely coastal Antarctica, the European Alps or the island of Spitsbergen (High Arctic) [1,2].

The cyst-stages of the Chlamydomonadales snow algae (*Chlamydomonas nivalis, Chloromonas nivalis*, etc) possess large amounts of cytoplasmic storage compounds, namely lipid bodies and organelles of an unknown nature filled with crystalline particles (Fig. 1) [3]. The cells are encapsulated with thick cell walls (sometimes multilayered).

In contrast, the cells of Zygnematales ice algae (*Mesotaenium berggrenii, Ancylonema nordenskiöldii*, etc) show a pronounced vacuolization despite the probable danger of ice crystal formation [1]. The chloroplast contains always a pyrenoid with starch sheath (Fig. 2). The cell walls as the boundaries to the extreme environment appear comparable thin and less rigid. The cells contain only few crystalline enclosures.

Consequently, no general or common answer to the habitat is realized in the ultrastructure. While the Chlamydomonadales species stay most of the time of their life cycle as metabolic active cysts stages with thick cell walls, the Zygnematales species obviously do not require any kind of morphological protection. Instead, they actively grow and divide on glacier surfaces as long as suitable wet and light conditions remain.

The detailed analysis of the ultrastructure is a valuable basis for the understanding of the physiological processes in these microalgae.

References:

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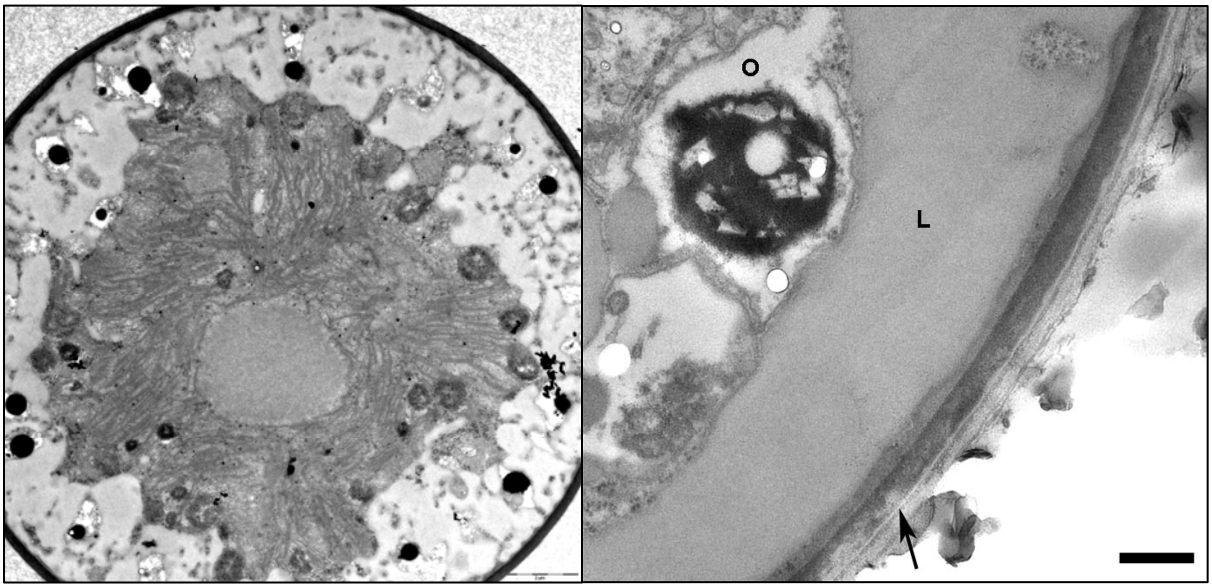

Figure 1. Overview of the ultrastructure of a red cyst of *Chlamydomonas nivalis* (Alps; left) and detail of a orange Chlamydomonadacean cyst from Spitsbergen (right). **L** lipid body, **O** unknown organelle with crystalline content. Scale 0.5 µm. Environment: snow

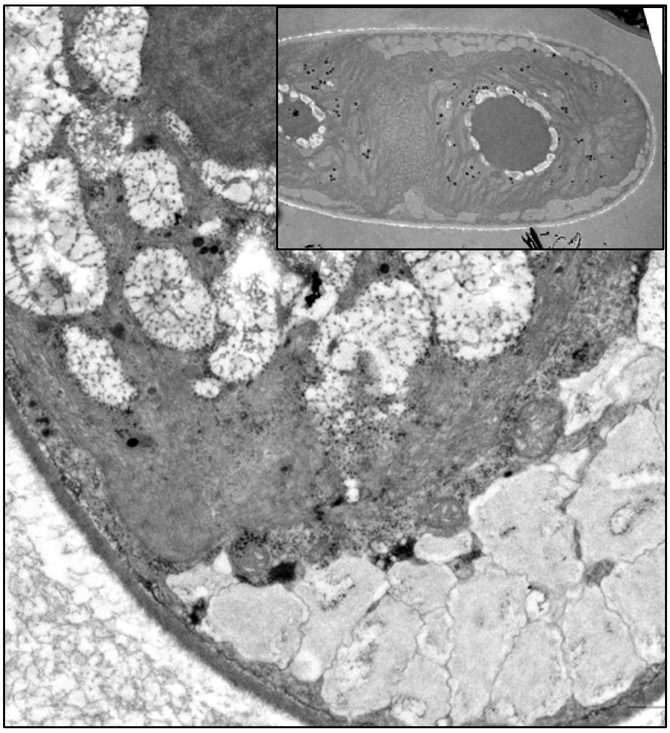

Figure 2. Overview and detail (inset) of the ultrastructure of *Mesotaenium berggrenii* (Zygnematales) from the Alps. Environment: glacier ice

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