Cystozygotes of Green Algae and their Germination

During a field trip in 2013 to bogs and wetlands in the Kitzbühel area in Tyrol, it turned out that some samples contained yellowish-orange-red cells in jelly sheaths that I had not seen before (Fig. 1).

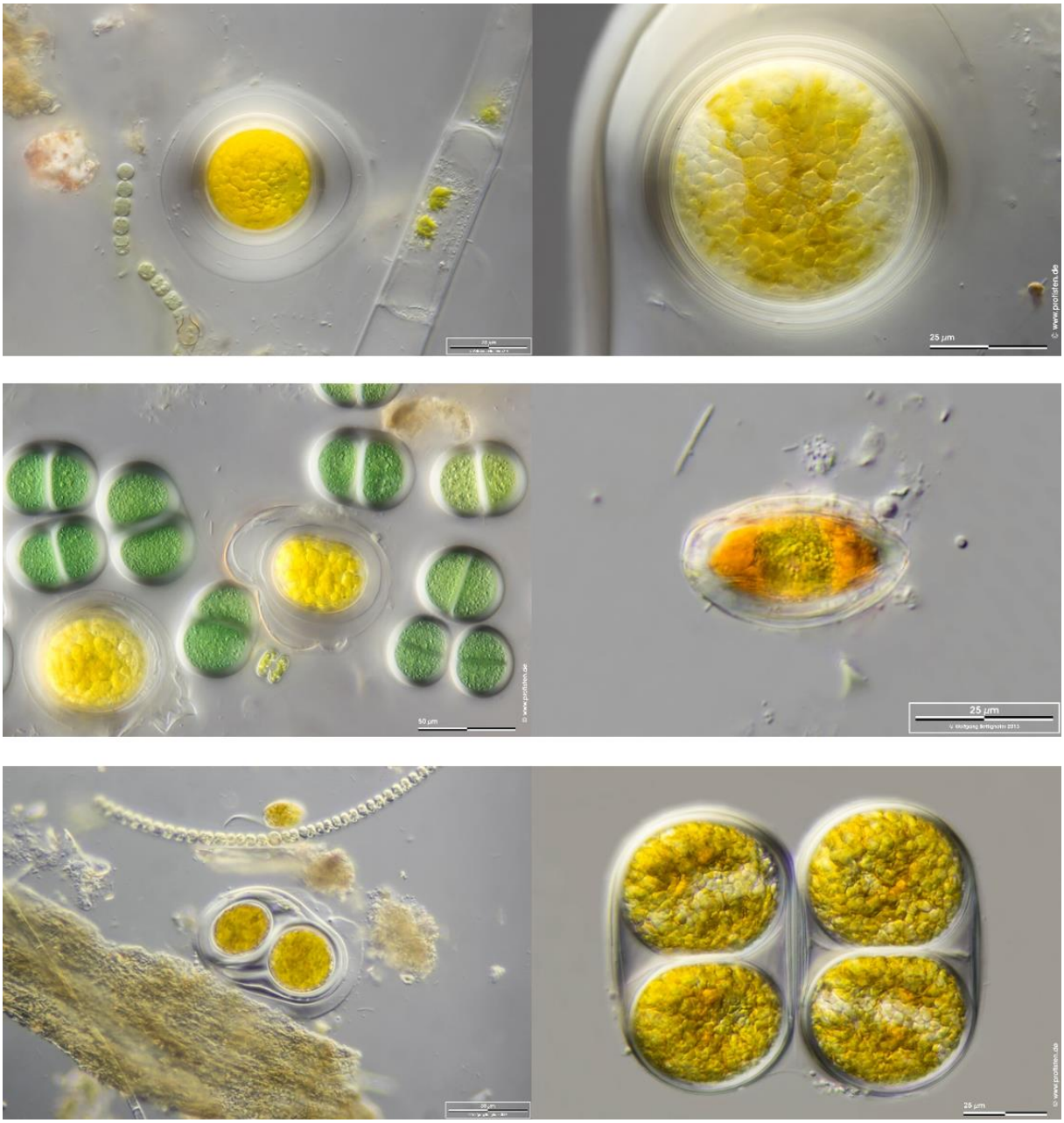

Fig. 1: Cystozygotes of Chlorophytes. In the picture in the middle row on the left you can see two yellow cystozygotes, cyanobacteria of the species *Chroococcus turgidus* and a small desmid.

This is what cystozygotes of green algae (chlorophyta) that develop during sexual reproduction can look like. Reserve substances (starch, oil) are accumulated, and carotenoids mask the green of the chlorophyll. These cystozygotes tolerate desiccation and typically require a short or a longer dormancy before they can germinate again. It remained unclear which algal species were behind them, because in those days there was not enough time to collect the zygotes from the various Petri

dishes using a dissecting microscope and to observe their further development (possibly after their required dormancy periods).

In the summer of 2021, again I had an opportunity to get a couple of such cystozygotes in a sample, namely in an old bog sample from Pass Thurn, also near Kitzbühel in Tyrol, which had been in a Petri dish at my kitchen window for almost one and a half years. I was able to isolate cystozygotes of the green alga *Eremosphaera viridis* from this and observe their development to the vegetative state (Fig. 2).

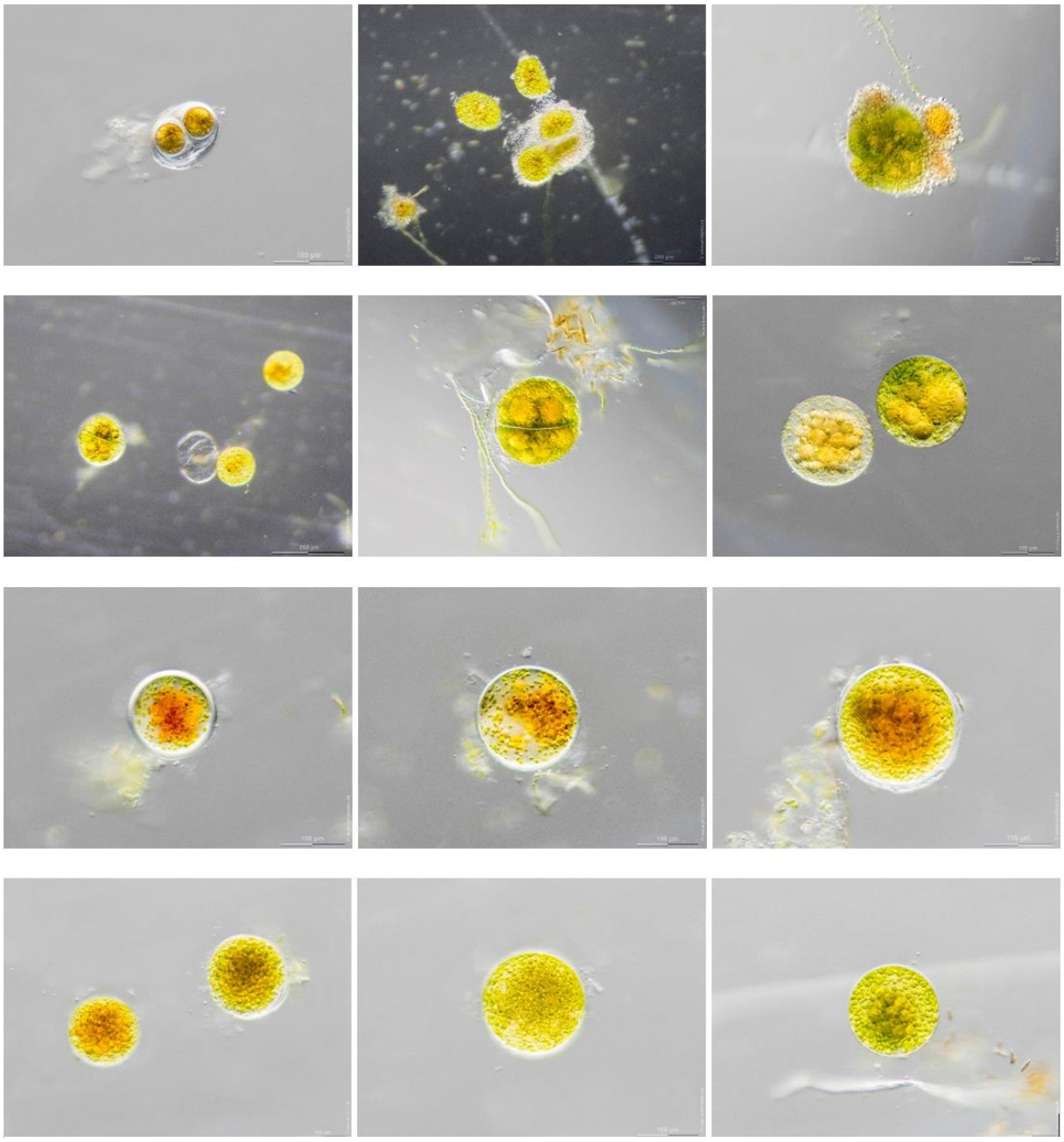

Fig. 2: Images from the developmental series of vegetative cells from the cystozygotes.

Often environmental factors induce sexual reproduction. If the environmental conditions are suitable for the organisms, they reproduce simply and very effectively asexually (mitotic cell division); depending on the species, 2, 4, 8, 16 ... autospores are formed (power of 2). Autospores are unflagellated spores that have the shape of the mother cells. If the environmental conditions

deteriorate (e.g. imminent dehydration or the onset of winter), the green algae can divide generatively (meiosis) and form robust survival cells (cystozygotes). Many permanent stages have carotenoids in the plasma, i.e. they are colored yellow/orange/red/brown, because the carotenoids protect against UV radiation (this is especially important for the chromosomes).

Figures 3 to 6 show stages in the development of *Eremosphaera viridis* vegetative cells from the cystozygotes.

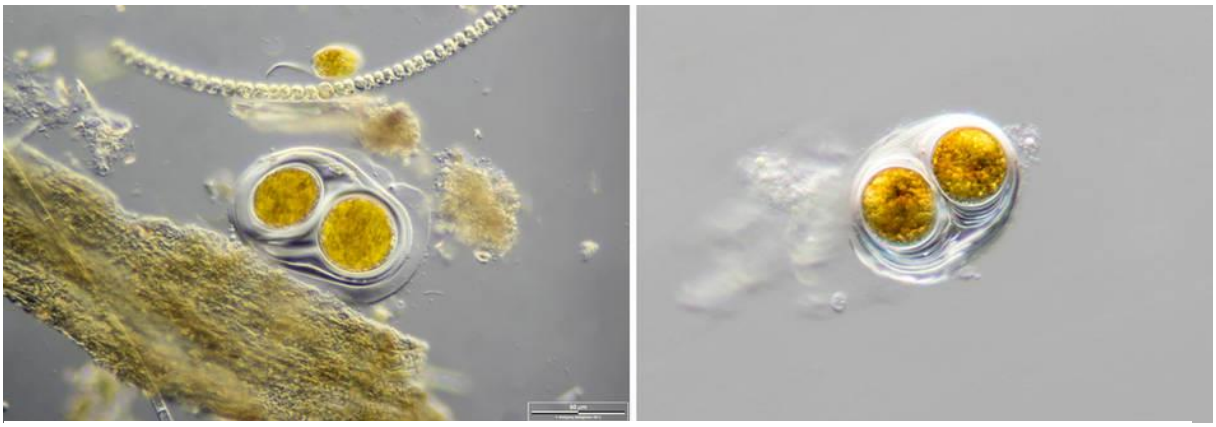

Fig. 3: Cystozygotes of *Eremosphaera viridis*. The image on the left is from the sample of 2013, the one on the right from the observation in 2021 (sample of 2019). Scale bar indicates 50 µm.

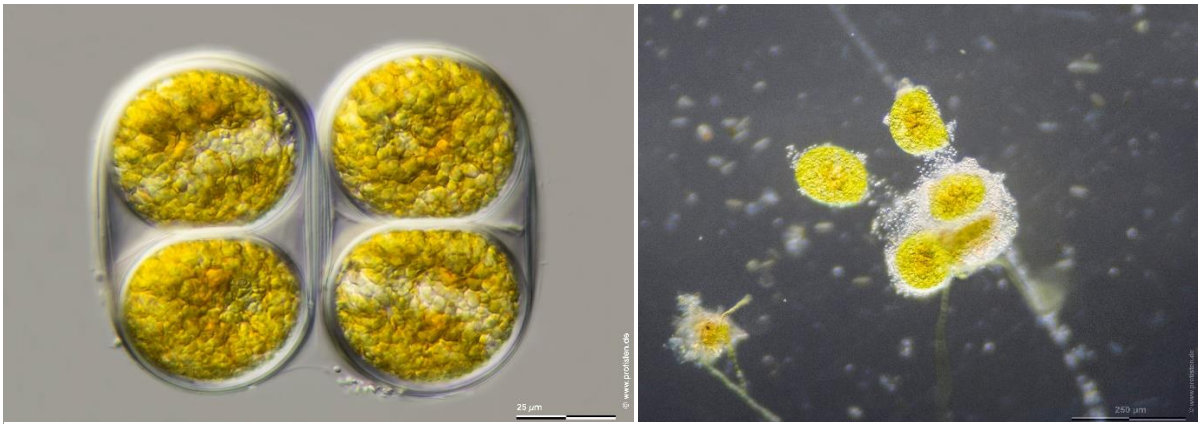

Fig. 4: In the first step, the cystozygote cells divide (asexual, mitotic) in their protective gelatinous shell (left image, from 2013). In the further division steps, the original gelatinous protective layer is dissolved (right image, from 2021). Scale bars indicate 25 µm (left) and 250 µm (right).

Fig. 5: Cell in asexual division. The reserve substances (oil) and the protective carotenoids from the cystozygote phase are still clearly visible. In the overview picture on the right a cell in asexual division (left); in the middle of the picture is an empty cell envelope of a mother cell, which remains after asexual division. In the right part the two autospores after leaving mother's cell wall. Scale bars indicate 100 µm (left) and 250 µm (right).

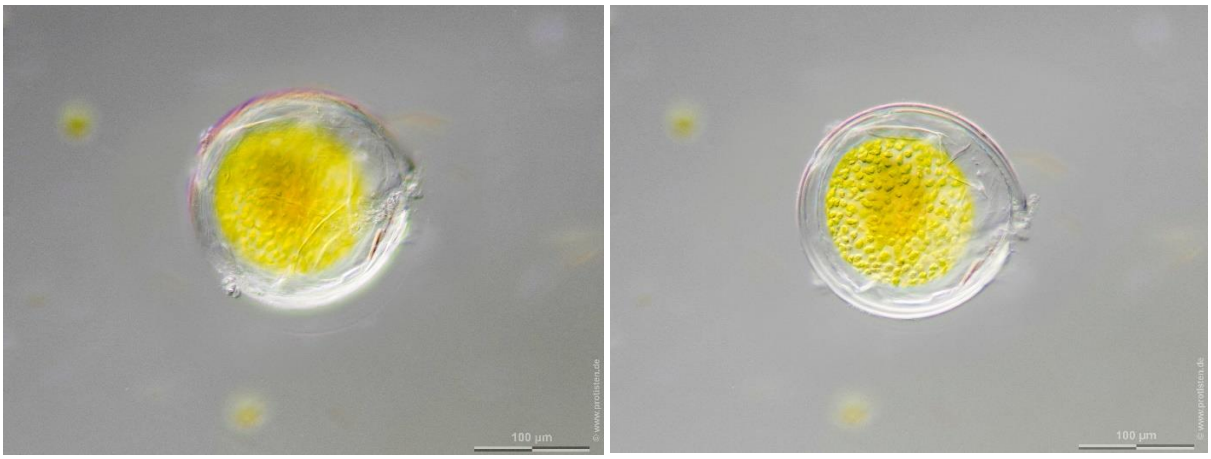

Fig. 6: After asexual division, in which the cell envelope of the mother cell usually bursts and releases the division products called autospores. In this case one of the autospores remained in the old envelope. Remnants of the carotenoids can still be seen in the core area in the middle of the cell. Scale bars indicate 100 µm.

Fully developed cells of *Eremosphaera viridis* in vegetative state

Figures 7 and 8 show details of cells in vegetative state.

Fig. 7: The image shows the parietal chloroplasts, each with a central pyrenoid (arrow). Chloroplasts of *Eremosphaera viridis* can also bear two pyrenoids. The bright rings that surround them are the sectional images of their starch sheaths. In green algae (Chlorophyta and Streptophyta), the pyrenoids are distinctive production sites for the reserve substance starch. Scale bar indicates 25 µm.

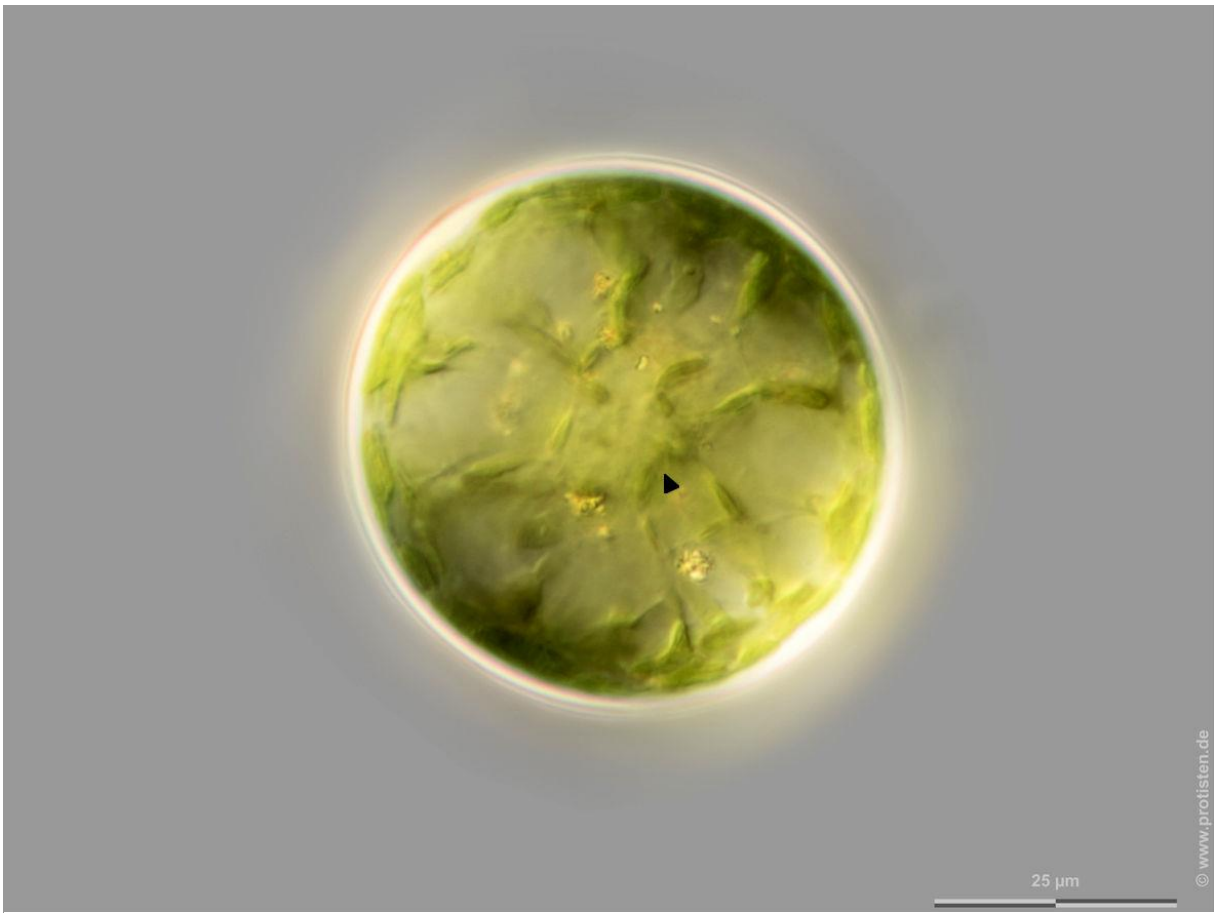

Fig. 8: The spherical cell body is largely filled with a sap vacuole. The chloroplasts are mainly on the surface of the sphere, covered by a thin layer of cell plasma, the cell nucleus (the arrowhead shows the location) is in the center. Scale bar indicates 25 µm.