

# Enigmatic lichens: a symbiosis based on desiccation tolerance

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**Abstract**

Lichens are an intricate symbiosis between a fungus (the "mycobiont") and green microalgae and/or cyanobacteria (the "photobiont"), also hosting a plethora of other microorganisms in their microbiota. When the free-living future symbionts leave their habitats in soil, bark or rock, to live together above-ground, they are exposed to severe desiccation and irradiation, accompanied by increased formation of reactive oxygen species (ROS). Lichenization comprises five main stages, the "pre-contact stage", the "contact stage", "envelopment" of algal cells by the fungus, their "incorporation" into a pre-thallus and "differentiation" into a thallus. Due to their desiccation tolerance, lichen thalli can survive in the dry state for long periods, and in the *Cladonia vulcani* thallus, antioxidant and photoprotective mechanisms are apparently more effective by orders of magnitude than those of its isolated partners, supporting survival in the desiccated state. Here, we co-cultured the primary symbionts of *Cladonia grayi* and assessed when the various stages of lichenization were reached using light and scanning electron microscopy. Then, we measured metabolite groups released into the extracellular space, using metabolite profiling (GC-MS), and hormones (LC-MS), providing insights into the availability of compounds potentially involved in the molecular cross-talk required for building a highly desiccation tolerant thallus.