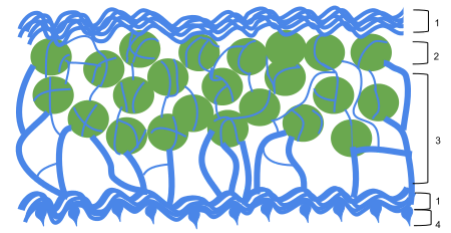


Symbiosis in lichens

Symbiosis in lichens is the mutually beneficial symbiotic relationship of green algae and/or blue-green algae (cyanobacteria) living among filaments of a fungus, forming lichen.^{[1][2][3]}

Living as a symbiont in a lichen appears to be a successful way for a fungus to derive essential nutrients, as about 20% of all fungal species have adopted this mode of life.^[4] The autotrophic symbionts occurring in lichens are a wide variety of simple, photosynthetic organisms commonly and traditionally known as “algae”. These symbionts include both prokaryotic and eukaryotic organisms.^{[5][4][3][2]}



Schematic cross section of lichen, a symbiosis between green algae and a fungus. 1. Thick layers of hyphae, called the cortex 2. Green algae 3. Loosely packed hyphae 4. Anchoring hyphae called rhizines.

Overview of lichens

"Lichens are fungi that have discovered agriculture" — Trevor Goward^[1]

A lichen is a combination of fungus and/or algae and/or cyanobacteria that has a very different form (morphology), physiology, and biochemistry than any of the constituent species growing separately. The algae or cyanobacteria benefit their fungal partner by producing organic carbon compounds through photosynthesis. In return, the fungal partner benefits the algae or cyanobacteria by protecting them from the environment by its filaments, which also gather moisture and nutrients from the environment, and (usually) provide an anchor to it.^{[5][4][3][2]}

The majority of the lichens contain eukaryotic autotrophs belonging to the Chlorophyta (green algae) or to the Xanthophyta (yellow-green algae). About 90% of all known lichens have a green alga as a symbiont. Among these, Trebouxia is the most common genus, occurring in about 20% of all lichens.^[6] The second most commonly represented green alga genus is Trentepohlia. Overall, about 100 species are known to occur as autotrophs in lichens. All the algae and cyanobacteria are believed to be able to survive separately, as well as within the lichen; that is, at present no algae or cyanobacteria are known which can only survive naturally as part of a lichen.^[7] Common algal partners are Trebouxia, Pseudotrebouxia, or Myrmecia.^[5]

The prokaryotes belong to the Cyanobacteria, which are often called by their old name “*bluegreen algae*”. Cyanobacteria occur as symbionts only in about 8% of known lichens. The most commonly occurring genera of symbiotic cyanobacteria are Nostoc^[7] and Scytonema.^[4]

Nomenclature

Both the lichen and the fungus partner bear the same scientific name, and the lichens are being integrated into the classification schemes for fungi. Depending on context, the taxonomic name can be meant to refer to the entire lichen, or just the fungus that is part of the lichen.