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# How lichen's 3D architecture temporally and spatially regulates the passage of water, gases and food

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Lichens have developed unique strategies to control water, oxygen and photosynthate (sugar product) fluxes between the algal photobiont and its fungal host that provide a model for gas-liquid separation and transport. We measured in parallel the kinetics of dehydration (water content), light trapping by charge separation and oxygen evolution (chlorophyll fluorescence emission) from full hydration to the dehydrated state. Kinetics show two distinct temporal stages in lichen dehydration: rapid loss of free, extracellular water, followed by slower loss of intracellular water associated with a discontinuous (rapid) decrease in charge separation. The former shows that water saturation does not prevent lichens from being photosynthetically active and allows gas transport ($CO_2$ and $O_2$) to occur during water logging. The latter observation indicates that dehydration is used to cooperatively turn off photosynthesis. This is hypothesized to trigger transport of algal-derived sugars to the fungal host. Confocal microscopy of lichens shows that the 3D architecture has distinct zones of physical space for gas and water transport between alga and fungus. Algal cells are encased in a hydrophobic shell that limits water accessibility and channels $CO_2$ and $O_2$ gas respectively to the photobiont and fungus (for respiration). Algae are connected to a single hydrophilic fungal filament that delivers water and recovers algal products (sugar & $O_2$), synchronized to the daily solar cycle. This bipolar chemical asymmetry enables such counter transport. Hence, the daily hydration/dehydration cycle serves as a pump.