

# Extremotolerance and Resistance of Lichens: Comparative Studies on Five Species Used in Astrobiological Research I. Morphological and Anatomical Characteristics

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**Abstract** Lichens are symbioses of two organisms, a fungal mycobiont and a photoautotrophic photobiont. In nature, many lichens tolerate extreme environmental conditions and thus became valuable models in astrobiological research to fathom biological resistance towards non-terrestrial conditions; including space exposure, hypervelocity impact simulations as well as space and Martian parameter simulations. All studies demonstrated the high resistance towards non-terrestrial abiotic factors of selected extremotolerant lichens. Besides other adaptations, this study focuses on the morphological and anatomical traits by comparing five lichen species—*Circinaria gyrosa*, *Rhizocarpon geographicum*, *Xanthoria elegans*, *Buellia frigida*, *Pleopsidium chlorophanum*—used in present-day astrobiological research. Detailed investigation of thallus organization by microscopy methods allows to study the effect of morphology on lichen resistance and forms a basis for interpreting data of recent and future experiments. All investigated lichens reveal a common heteromerous thallus structure but diverging sets of morphological-anatomical traits, as intra-/extra-thalline mucilage matrices, cortices, algal arrangements, and hyphal strands. In *B. frigida*, *R. geographicum*, and *X. elegans* the combination of pigmented cortex, algal arrangement, and mucilage seems to enhance resistance, while subcortex and algal clustering seem to be crucial in *C. gyrosa*, as well as pigmented cortices and basal thallus protrusions in *P. chlorophanum*. Thus, generalizations

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