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学 位 論 文 の 要 約

博士の専攻分野の名称　博士（生命科学）　　氏　名　　Maeng Changhyun

学 位 論 文 題 名

Study on the Extreme Environmental Stress Tolerance of *Physcomitrium patens* and Its Adaptability to Space Environments
(ヒメツリガネゴケの極限環境ストレス耐性とその宇宙環境への適応性に関する研究)

This dissertation examines the extreme environmental stress tolerance of *Physcomitrium patens* and its potential adaptability to space environments. As rapid environmental changes challenge plant survival, understanding the resilience mechanisms of organisms like *P. patens*, a model bryophyte with a unique evolutionary history, is vital. Additionally, the exploration of its adaptability to extraterrestrial conditions provides insights for sustaining biological systems in space.

The study explores how *P. patens* tissues—protonema, brood cells, and sporophytes—respond to extreme conditions, including UV radiation, freezing, high temperatures, and vacuum environments. Sporophytes demonstrated superior resilience, retaining germination rates under extreme UV-C radiation, prolonged freezing at -80° C, and exposure to 55° C heat, outperforming protonema and brood cells. Remarkably, sporophytes maintained over 95% germination after exposure to vacuum and vacuum UV conditions. A space exposure experiment on the International Space Station confirmed sporophytes' high viability, with over 80% germination after nine months. UV radiation emerged as the primary stressor, but sporophytes were predicted to survive over 15 years in space.

The dissertation further investigates the role of abscisic acid (ABA) in enhancing photoprotection against intense light. ABA treatment strongly induced non-photochemical quenching (NPQ) by regulating proteins such as LHCSR and PsbS and activating the xanthophyll cycle. This mechanism likely played a key role in plants' adaptation to terrestrial environments and offers strategies for mitigating light stress in space. Additionally, the protective role of the sporangium in thermotolerance was analyzed. The sporangium shields spores from heat and synthesizes protective compounds like flavonoids and melanin, essential for mitigating oxidative stress and maintaining viability.

This research highlights the extraordinary resilience of *P. patens* sporophytes, offering applications in both Earth and space. On Earth, it provides insights for improving crop resilience to climate change. In space, *P. patens* could be integral to bioregenerative life support systems, supporting oxygen production, carbon dioxide sequestration, and extraterrestrial ecosystem development. By uncovering stress tolerance mechanisms in *P. patens*, this dissertation addresses critical challenges in environmental and space biology, paving the way for innovative solutions.