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学 位 論 文 内 容 の 要 旨

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)

Rapid environmental changes driven by climate change and human activity pose significant challenges to plant survival and ecosystem stability. Understanding how plants adapt to extreme environments is critical for addressing these challenges and for exploring potential solutions to sustain life in harsh conditions, both on Earth and in space. In this context, *Physcomitrium patens* (*P. patens*), an early terrestrial plant with remarkable stress tolerance, provides a valuable model for studying resilience mechanisms and their applications.

This dissertation investigates the extraordinary resilience of *P. patens* to extreme environmental stresses, including UV radiation, extreme temperatures, vacuum, and the combined stressors of the space environment. Sporophytes, in particular, exhibited exceptional stress resistance, maintaining high germination rates even after prolonged exposure to the external environment of the International Space Station (ISS). These findings highlight the potential of *P. patens* as a biological resource for space applications, such as bioregenerative life-support systems and extraterrestrial ecosystem establishment.

The study also explores the role of abscisic acid (ABA) signaling pathways in mediating light stress adaptation. ABA signaling was found to regulate non-photochemical quenching (NPQ) by modulating key proteins such as LHCSR and PsbS, as well as xanthophyll pigments. This mechanism not only sheds light on the evolutionary adaptations of early land plants to intense light conditions but also provides a foundation for enhancing plant resilience in extraterrestrial environments with intense radiation.

In addition, the structural and biochemical adaptations of the sporangium, which contribute to thermotolerance, were analyzed. The sporangium’s protective functions against high-temperature stress underscore its critical role in ensuring sporophyte survival under extreme conditions, further emphasizing its potential for space exploration.

By addressing these topics, this dissertation emphasizes the relevance of *P. patens* as a model organism for both basic research and applied space biology. The exceptional resilience of *P. patens* positions it as a promising candidate for sustainable life-support systems in space, including oxygen production, carbon dioxide absorption, and the creation of extraterrestrial ecosystems. These findings not only enhance our understanding of plant survival mechanisms but also pave the way for innovative solutions to support human life in space.