【Grant-in-Aid for Specially Promoted Research】

Dual function of strigolactones as plant hormones to control growth and as signaling molecules to induce symbiosis: its origin and evolution

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Purpose and Background of the Research

●Outline of the Research

Strigolactones (SLs) are a group of rhizosphere signaling molecules secreted by plant roots that promote symbiosis with arbuscular mycorrhizal (AM) fungi. It began over 500 million years ago in the common ancestor of land plants, has helped propagation of plants on land, and has supported their subsequent prosperity. SLs also act as plant hormones that regulate various aspects of growth and development in flowering plants. Acquisition of the dual function of SLs enabled plants to optimize their proliferation by controlling the balance between nutrient absorption and growth. The receptor of SLs as plant hormones derives from gene duplication of *KAI2*, the receptor of an un-identified ligand tentatively called KL. KAI2 originated from the horizontal transfer of the *RsbQ* gene from bacteria. This research project will tackle how SLs acquired their dual function at the molecular level by using multiple technologies and expertise, including molecular genetics, bioorganic chemistry, developmental biology, and genomics. This research will provide a better understanding of the origin and evolution of the mechanisms that allow plants to optimize their growth to adapt to their environment, which was created by plants and micro-organisms over the past 500 million years. This research will reveal some of the reasons why Earth has been able to be a green planet.

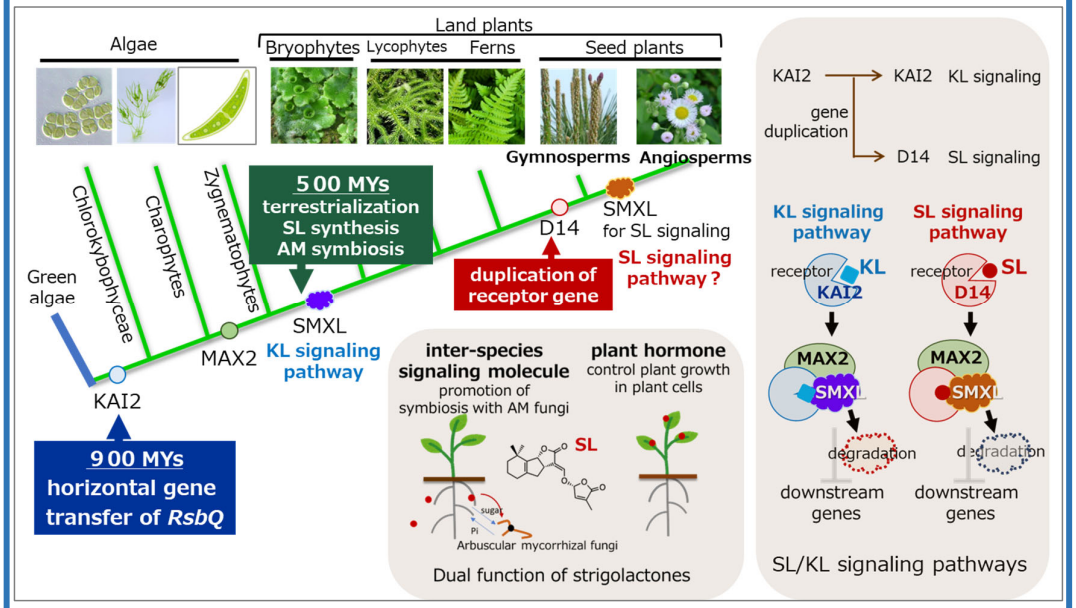

Figure 1. Step-by-step establishment of SL dual function

● Step-by-step establishment of the dual function of SLs over 500 million years

Phylogenetic analyses allowed to map the evolutionary path of the dual function of SL (Fig. 1). The emergence of a KAI2 homolog in the common ancestor of streptophytes is the most ancient event. Recent genome analyses revealed that KAI2 originated from a horizontal transfer of the *RsbQ* gene from bacteria. The major gene set of the KL signaling pathway appeared in the common ancestor of land plants. D14, the SL receptor appeared in the common ancestor of seed plants, and SMXLs which work in the SL signaling pathway appeared in angiosperms. This emphasizes how the dual function of SLs have been established step-by-step over 500 million years.

There are many questions to fully understand the evolution of the dual function of SLs. Firstly, KL is still unknown. The function of the KAI2 homolog in algae and the initiation of KL perception are crucial to understanding the origin of the KL signaling pathway. The evolution of SMXL genes that enabled D14 to act as a SL receptor need to be further understood. The molecular mechanisms of how KL and SL signaling pathways control diverse downstream genes also remain to be elucidated.

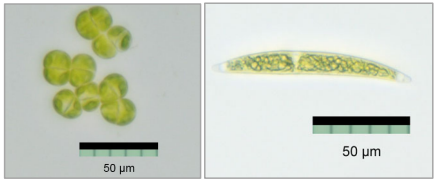

Figure 2. Algae used in this project.
Chlorokybus (left), and *Closterium* (right).

Expected Research Achievements

●Research plan

1. Origin of the ligands
   - Identification of the ligand of RsbQ and KL
   - Identification of KL
2. origin of receptors
   - Function of KAI2 and MAX2 in algae
   - Identification of SL receptors in soil microorganisms including arbuscular mycorrhizal (AM) fungi
3. Establishment of the signal transduction pathways
   - Function of MAX2 in *Closterium* (Zygnematophyceae)
   - Establishment of the KL signaling pathway and subsequent diversification of its function
4. Formation of signaling network with other hormones
   - Cross talk between the KL signaling and cytokinin in *M. polymorpha*

●Importance and necessity of this research

This project aims to reveal the origin and evolution of the unique property of the dual function of SLs using a combination of developmental biology, genetics, genomics and natural product chemistry. This project is a pioneering and highly creative study of the evolution of plant hormone signaling mechanisms and can be expanded to many unknown signaling molecules in plants that play novel and intricate functions.

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