【Grant-in-Aid for Transformative Research Areas（A）】

Symplast; intercellular communication mechanism in plants under environmental changes

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Purpose and Background of the Research

●Outline of the Research

Individual plant cells are not completely independent; they are connected to each other by plasmodesmata, which cross the cell walls of adjacent cells and connect their cytoplasm. The cytoplasmic spaces shared by plasmodesmata and phloem throughout the plant are collectively referred to as the symplast. Traditionally, the symplastic pathway was thought to be primarily involved in the translocation of nutrients such as sugars and amino acids. However, recent research has shown that the symplast is a more dynamic platform for signal transduction than previously thought. This transformative research project aims to make significant advances in the understanding of plant growth regulation and environmental adaptation mechanisms under fluctuating environmental conditions by re-evaluating intercellular and intertissue communication from the perspective of the symplast.

●Symplast

In general, each cell is an independent compartment. Hence, multicellular organisms exchange information with surrounding cells through the membrane. In plants, however, individual cells are not completely independent, but are connected by a tunnel structure, “plasmodesmata”, that penetrate the cell wall and communicate between neighboring cells (Fig. 1A). In addition, phloem is a living cell tube system connected via sieve pores of about 1 μm in diameter, which are thought to be formed by the expansion of plasmodesmata (Fig. 1B). The cytoplasmic space shared throughout the body via plasmodesmata and phloem is called the “symplast” and has been considered to be a site of molecular translocation in a wide range of areas of the plant body. However, the mechanisms of formation and functional regulation of plant symplast are still largely unexplored.

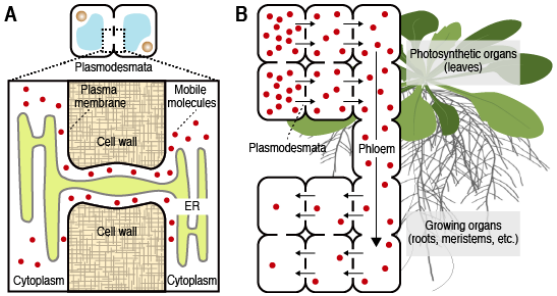

Fig. 1. Symplast connects intercellular and whole plant. (A) Structure of plasmodesmata. (B) Long-distance molecular transport through plasmodesmata and phloem.

●Long-distance signaling

It has been conventionally thought that the symplast pathway is used primarily to translocate nutrients such as sugars and amino acids. One of the major discoveries that changed this concept was the discovery of florigen, FT protein, that is transported from the leaf to the apical meristem via the phloem, in the early 2000s. However, it was still not clear how much plants depended on long-distance signaling through the symplast. Researchers in this project has revealed that the polypeptide CEPD, which is induced in leaves in response to nitrogen deficiency in plants, is transferred to roots via phloem and activates nitrogen uptake.

●Long-distance signaling (cont.)

More recently, Grx peptide, a nitrogen sufficiency signal, was also found (Fig. 2). These findings suggest that the symplast is a more dynamic site of signal transduction than previously thought, and that plant development and environmental responses are regulated by the translocation of various signaling molecules between cells and tissues.

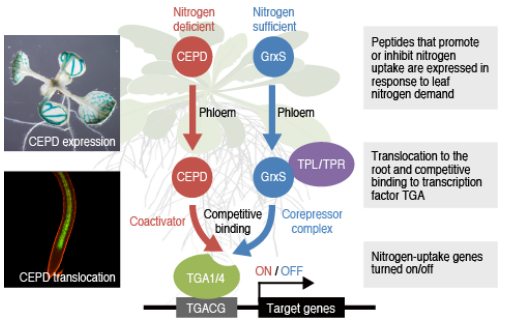

Fig. 2. Nitrogen homeostasis regulated by phloem mobile signals induced in leaves.

Expected Research Achievements

●Principles of symplast formation

The mechanisms of formation of plasmodesmata and regulation of mass transport are not well understood. The project leader discovered that plasmodesmata can be formed newly at the graft interface. Furthermore, grafting was shown to be possible even between distantly related plant species, demonstrating that the principles of symplast formation are conserved across species (Fig. 3). In this area, we will further elucidate the details of the mechanism of plasmodesmata formation by focusing unique phenomena including plasmodesmata formation in the invasion organ of the parasitic plant.

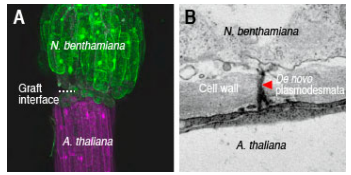

Fig. 3. (A) Interfamily graft. (B) Plasmodesmata at graft boundary.

●Identification of mobile molecules via symplast

The project leader has identified mRNAs that move long distances and will elucidate the individual functions and transport mechanisms of these symplast-mobile mRNAs. In addition, symplast-mobile non-secretory peptides are an understudied class of molecules that have received little attention. In this project, we will expand the repertoire of novel molecules. We will also investigate the transport pathways through which these signaling molecules exert their functions.

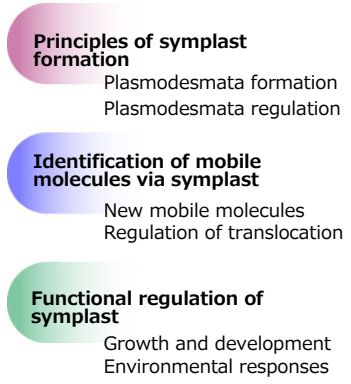

Fig. 4. Three research targets.

●Functional regulation of symplast

It is still unclear how functional regulation of plasmodesmata and symplast-translocating molecules regulate plant development, growth, and environmental responses. In this project, we will elucidate the mechanisms of developmental growth and environmental responses driven by the symplast by focusing on molecular transport through the symplast and its regulation.

As described above, these three research targets (Fig. 4) will enhance our understanding of intercellular mechanisms in plants with a perspective of symplast.

Homepage Address, etc.	https://plant-symplast.jp