Laboratory of Biological Diversity

MANO Group

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Plant cells can induce, degenerate and differentiate their organelles to adapt to environmental changes. This flexibility of plant organelles is the basis of the strategy for environmental adaptation in plants.

The aims of our research group are to clarify the molecular mechanisms underlying the induction, differentiation, and interaction of organelles, and to understand the integrated functions of individual plants through organelle dynamics.

I. Molecular mechanisms of peroxisome dynamics and functions in plant cells

Peroxisomes are single-membrane bounded organelles, which are ubiquitously present in eukaryotic cells, and they are involved in various biological processes such as lipid metabolism and photorespiration. To understand peroxisome dynamics and functions, we have been analyzing a number of Arabidopsis mutants having aberrant peroxisome morphology (*apem* mutants) and peroxisome unusual poisoning (*peup* mutants). Based on analyses using these mutants a part of the mechanism of division, protein transport, and degradation of peroxisomes were revealed. In addition, we revealed that the physical interaction between peroxisomes and chloroplasts is dependent on photosynthesis (Figure 1).

Recently, we found that peroxisome functions are required for the reproductive process. Therefore, peroxisomes in gametes and gametophytes were visualized, and their dynamics are currently under investigation.

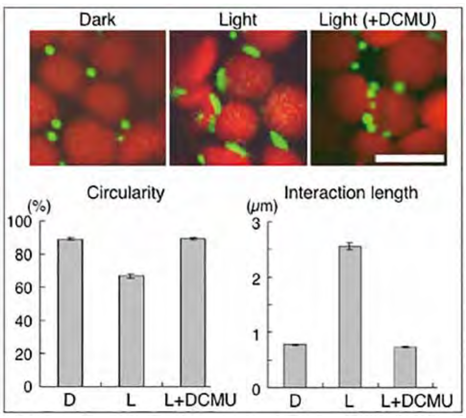

Figure 1. Photosynthesis-dependent chloroplast-peroxisome interaction. Chloroplasts and peroxisomes are visualized with autofluorescence (red) and GFP (green). Morphology of peroxisomes and interaction length between chloroplasts and peroxisomes are different in dark and light conditions. Even in light conditions, the photosynthesis inhibitor, DCMU, causes the dark-dependent phenotype. Bar: 10 μm.

II. Accumulation mechanism of seed storage oils and proteins

Plant seeds accumulate huge amounts of storage reserves such as oils, carbohydrates and proteins. Humans use these storage reserves as foods and industrial materials. Storage reserves are different among different plant seeds. Wheat, maize and rice seeds mainly accumulate starch, whereas rapeseed, pumpkin and sesame contain large amounts of oils. Soybean contains proteins as a major reserve. We are analyzing the mechanisms controlling oil and protein contents in seeds, and trying to apply our knowledge and techniques for increasing beneficial storage reserves.

III. Construction of The Plant Organelles Database 3 (PODB3)

PODB3 was built to promote a comprehensive understanding of organelle dynamics. PODB3 consists of six individual units: the electron micrograph database, the perceptive organelles database, the organelles movie database, the organellome database, the functional analysis database, and external links. Through these databases, users can obtain information on plant organelle responses to environmental stimuli of various tissues of several plant species, at different developmental stages. We expect that PODB3 will enhance the understanding of plant organelles among researchers.

Publication List:

〔Original papers〕

- Motomura, K., Le, Q.T.N., Hamada, T., Kutsuna, N., Mano, S., Nishimura, M., and Watanabe, Y. (2015). Diffuse DCP2 accumulates in DCP1 foci under heat stress in *Arabidopsis thaliana*. Plant Cell Physiol. *56*, 107-115.
- Oikawa, K., Matsunaga, S., Mano, S., Kondo, M., Yamada, K., Hayashi, M., Kagawa, T., Kadota, A., Sakamoto, W., Higashi, S., Watanabe, M., Mitsui, T., Shigemasa, A., Iino, T., Hosokawa, Y., and Nishimura, M. (2015). Physical interaction between peroxisomes and chloroplasts elucidated by *in situ* laser analysis. Nature Plants *1*, 15035.

〔Original papers (E-publication ahead of print)〕

- Kanai, M., Mano, S., Kondo, M., Hayashi, M., and Nishimura, M. Extension of oil biosynthesis during the mid-phase of seed development enhances oil content in Arabidopsis seeds. Plant Biotechnol. J. 2015 Oct 26.
- Kimori, Y., Hikino, K., Nishimura, M., and Mano, S. Quantifying morphological features of actin cytoskeletal filaments in plant cells based on mathematical morphology. J. Theor. Biol. 2015 Nov 10.
- Ueda, H., Yokota, E., Kuwata, K., Kutsuna, N., Mano, S., Shimada, T., Tamura, K., Stefano, G., Fukao, Y., Brandizzi, F., Shimmen, T., Nishimura, M., and Hara-Nishimura, I. Phosphorylation of the C-terminus of RHD3 has a critical role in homotypic ER membrane fusion in Arabidopsis. Plant Physiol. 2015 Dec 18.

〔Review article〕

- Goto-Yamada, S., Mano, S., Yamada, K., Oikawa, K., Hosokawa, Y., Hara-Nishimura, I., and Nishimura, M. (2015). Dynamics of the light-dependent transition of plant peroxisomes. Plant Cell Physiol. *56*, 1252-1263.