

# Division of Biochemistry

## – Molecular Biology –

<https://www.scl.kyoto-u.ac.jp/~molbio/index.html>



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### Scope of Research

This laboratory aims at clarifying molecular bases of regulatory mechanisms for plant development, especially plant morphogenesis, with techniques of forward and reverse genetics, molecular biology, and biochemistry. Current major subjects are: 1) phospholipid signaling in cell morphogenesis, 2) the transcriptional network for cytokinin responses, 3) COP9 signalosome modulating signal transduction in the nuclei, and 4) the endoreduplication cell cycle in cell differentiation.

#### KEYWORDS

Morphogenesis

Phospholipid Signaling

RNA

Signal Transduction

COP9 Signalosome



### Selected Publications

Kato, M.; Tsuge, T.; Maeshima, M.; Aoyama, T., *Arabidopsis* PCaP2 Modulates the Phosphatidylinositol 4,5-bisphosphate Signal on the Plasma Membrane and Attenuates Root Hair Elongation, *Plant J.*, **99**, 610-625 (2019).

Lin, Q.; Ohashi, Y.; Kato, M.; Tsuge, T.; Gu, H.; Qu, L.-J.; Aoyama, T., GLABRA2 Directly Suppresses Basic Helix-loop-helix Transcription Factor Genes with Diverse Functions in Root Hair Development, *Plant Cell*, **27**, 2894-2906 (2015).

Wada, Y.; Kusano, H.; Tsuge, T.; Aoyama, T., Phosphatidylinositol Phosphate 5-kinase Genes Respond to Phosphate Deficiency for Root Hair Elongation in *Arabidopsis thaliana*, *Plant J.*, **81**, 426-437 (2015).

Hayashi, K.; Nakamura, S.; Fukunaga, S.; Nishimura, T.; Jenness, M. K.; Murphy, A. S.; Motose, H.; Nozaki, H.; Furutani, M.; Aoyama, T., Auxin Transport Sites are Visualized in Planta Using Fluorescent Auxin Analogs, *Proc. Natl. Acad. Sci. USA*, **111**, 11557-11562 (2014).

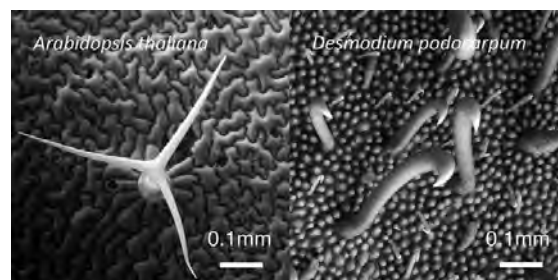
Kato, M.; Aoyama, T.; Maeshima, M., The Ca<sup>2+</sup>-binding Protein PCaP2 Located on the Plasma Membrane is Involved in Root Hair Development as a Possible Signal Transducer, *Plant J.*, **74**, 690-700 (2013).

## Functions of Phosphatidylinositol 4-Phosphate 5-Kinases and Its Product Phosphatidylinositol 4,5-bisphosphate in Plant Cell Morphogenesis

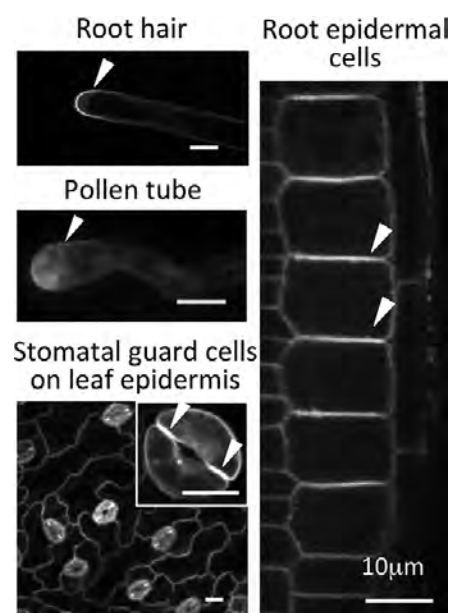
Plants show us a lot of interesting shapes, which are determined by not only the architecture of cell propagation but also the morphology of each cell. In addition, each single cell often exhibits an elaborate shape serving its physiological role (Figure 1). Since plant cell morphogenesis, a process always accompanied with cell wall expansion, is irreversible, it should be progressed in a strictly regulated manner. How can plants regulate cell morphogenesis appropriately? To elucidate molecular mechanisms regulating plant cell morphogenesis, we are studying on phosphoinositide signaling, mainly that of Phosphatidylinositol 4,5-bisphosphate [PIP(4,5)P<sub>2</sub>].

PIP(4,5)P<sub>2</sub>, a minor phospholipid component of eukaryotic membranes, is involved in the regulation of various intracellular events. PIP(4,5)P<sub>2</sub> physically interacts with regulatory proteins for actin cytoskeletal organization and membrane trafficking on the plasma membrane. In addition, its signaling pathways are frequently connected to those of small GTPases belonging to the Rho and Arf families in their upstream and downstream cascades. PI(4,5)P<sub>2</sub> is expected to play a regulatory role in the polarized expansion of plant cells. Indeed, PI(4,5)P<sub>2</sub> exhibits polar localization patterns in various types of cells, including root hairs, pollen tubes, stomatal guard cells and root epidermal cells (Figure 2). We are focusing on functions of PI(4,5)P<sub>2</sub> and its producing enzymes, Phosphatidylinositol 4-phosphate 5-kinases (PIP5Ks), in cell morphogenesis.

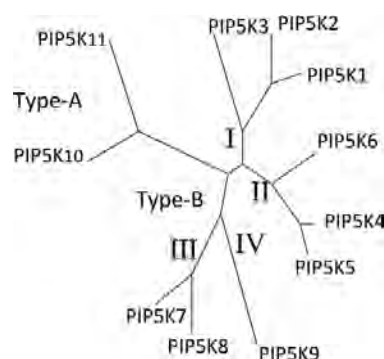
The model plant *Arabidopsis thaliana* encodes two type-A and nine type-B PIP5Ks (Figure 3). Of these, four clades of type-B PIP5Ks, I, II, III and IV, containing *Arabidopsis* PIP5K1-3, PIP5K4-6, PIP5K7-8, and PIP5K9, respectively, are conserved in angiosperms. Type-B PIP5Ks are thought to redundantly play pivotal roles in various processes of plant cells while type-A PIP5Ks are thought to function only in pollens. To elucidate functions of type-B PIP5Ks in cell morphogenesis, we performed genetic analysis using multiple mutants of their genes. As the result, we identified triple mutants with phenotypes that have not seen in single or double mutants of type-B PIP5K genes so far, including those of no root hairs, no pollen tubes, and hypersensitivity to high osmolality. Interestingly, the mutant genes in each triple mutant are not always limited to genes in a single clade, suggesting that type-B PIP5K genes have been evolutionally differentiated in a complicated manner.



**Figure 1.** The leaf surface of *Arabidopsis thaliana* (thale cress) (left) and the seed pod surface of *Desmodium podocarpum* (Japanese bush clover) (right) were observed by scanning electron microscopy. (left) The leaf epidermis of *Arabidopsis thaliana* is covered with a branched spine-like structure called as trichome. Cells making a jigsaw puzzle-like pattern are leaf epidermal cells. (right) The seedpod epidermis of *Desmodium podocarpum* is covered with cells of a bead-like shape and a hook-like shape. The hook-like cells are also trichomes.



**Figure 2.** Subcellular localization patterns of the PI(4,5)P<sub>2</sub> marker, UBQ10 promoter-driven fluorescence protein fusion of 2xPH<sup>PLCδ</sup>, were observed in a root hair, a pollen tube, leaf epidermal cells, and root epidermal cells by confocal laser-scanning microscopy. Arrowheads indicate loci where the PI(4,5)P<sub>2</sub> marker are preferentially localized.



**Figure 3.** Phylogenetic tree of *Arabidopsis thaliana* type-A and type-B PIP5Ks are shown. Clades conserved in angiosperms are labeled as I, II, III, and IV.