# Division of Biochemistry
## - Molecular Biology -

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### Visitors

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| Dr QU, Li-Jia | College of Life Science, Peking University, China, 2–17 August 2006 |
| Ms LIU, Jingjing | College of Life Science, Peking University, China, 7 August–7 October 2006 |
| Mr LI, Linchuan | College of Life Science, Peking University, China, 7 August–7 October 2006 |
| Dr HWANG, Ildoo | Pohang University of Science and Technology, Korea, 26–27 May 2006 |
| Dr CHO, Hyung-Taeg | Chungnum National University, Korea, 26–27 May 2006 |
| Dr KIM, Gyung-Tae | Dong-A University, Korea, 26–27 May 2006 |

## Scope of Research

This laboratory aims at clarifying the framework of regulatory network between genetic programs and environmental stress responses through the study on structure-function relationships of genetic materials and cellular proteins in higher plants. The current major subjects are the two-component response regulators involved in cytokinin signaling, HD-Zip proteins and phosphatidyl-inositol 4-phosphate 5-kinases required for phospholipid signaling, COP9 signalosome modulating protein degradation, and cyclines and CDKs controlling cell cycle.

## Research Activities (Year 2006)

### Presentations

Signal Transduction Regulating Morphological Differentiation of Plant Cells, Aoyama T, Symposium: A New Line in the Study of Plant Totipotency, 28 January (Nagoya).

Plant Morphogenesis Responding to Environmental Stimuli, Tsuge T, COE Seminar: Chemicalbiology Mini-Symposium, 15–16 March (Kyoto).

COP9 Signalosome: The Key Modulator of Signal Transduction in Plants and Animals, Tsuge T, International Symposium on Biotechnological Approaches for Agriculture and Medicine, 2 November (Busan, Korea).

### Grants

Oka A, Two-component Regulatory System of Phosphorelay Involved in Cytokinin Signaling, Grant-in-Aid for Scientific Research (B), 1 April 2004–31 March 2007.

Aoyama T, Roles of Phospholipid Signaling in Root-hair Formation, Grant-in-Aid for Scientific Research (B), 1 April 2004–31 March 2007.

## A Key Regulator of Ploidy Levels in Endoreduplication of *Arabidopsis thaliana*

Eukaryotic cells generally proliferate through the mitotic cell cycle, which allows cells to maintain their DNA content at the 2C level after each cell division. Here 1C is the DNA content of a haploid genome. However, certain cells undergoing differentiation increase their DNA contents to 4C or higher as a result of endoreduplication. It is thought to be a process in which chromosomal DNA is successively duplicated in the absence of mitosis. Plants exhibit endoreduplication more frequently than animals. Endoreduplication often occurs during the differentiation of cells that are highly specialized in their morphology or metabolism. An *Arabidopsis thaliana* trichome, a large branched cell on the surface of aerial organs (Figure 1), generally has a DNA content of 32C. Maize endosperm cells, which accumulate starch and storage proteins, usually undergo four to five successive endocycles during seed development. Other cells, such as those in leaves and roots, also exhibit high ploidy. *Arabidopsis* cotyledons and leaf pavement cells have ploidy levels from 2C to 32C and from 2C to 16C, respectively. Moreover, the ploidy levels of *Arabidopsis* hypocotyls vary depending on growth conditions, with levels of 2C to 8C under normal light conditions and 2C to 16C in darkness.

Although the involvement of various cell cycle–related proteins in endoreduplication has been shown, it is still unclear which proteins play key regulatory roles in endoreduplication, especially in the process of terminating endocycle succession at the appropriate ploidy levels. To identify key regulators of endoreduplication in plants, we searched for cell cycle–related genes expressed during *Arabidopsis* trichome development, in which endoreduplication occurs instead of the mitotic cell cycle. *CDKA;1* has been revealed to be expressed during trichome development [1]. During the course of identifying cyclins that are involved in endoreduplication, we found that the promoter of a cyclin A gene, *CYCA2;3*, is active not only in proliferating tissues but also in developing trichomes in the termination period of endoreduplication. Null mutations of *CYCA2;3* semidominantly promoted endocycles and increased the ploidy levels achieved in mature organs, but they did not significantly affect the proportion of cells that underwent endoreduplication. Consistent with these characteristics, expression of the CYCA2;3–GFP fusion protein restrained endocycles in a dose-dependent manner. Moreover, a mutation in the destruction box of CYCA2;3 stabilized the fusion protein in the nuclei and enhanced the restraint. These results indicate that CYCA2;3 acts as a key regulator of ploidy levels in *Arabidopsis* endoreduplication, presumably through suppressing endocycle succession [2].

[1] Imajuku Y, Ohashi Y, Aoyama T, Goto K, and Oka A, *Plant Mol. Biol.* **46**, 205-213 (2001).
[2] Imai K, Ohashi Y, Tsuge T, Yoshizumi T, Matsui M, Oka A, and Aoyama T, *Plant Cell*, **18**, 382-396 (2006).

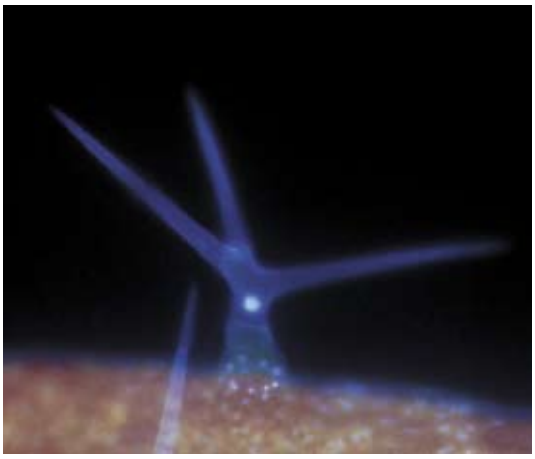

**Figure 1.** Microscopic observation of a trichome protruding from an *Arabidopsis* leaf surface. The pale blue circular body is the 32C nucleus visualized by DAPI staining.

Aoyama T, Information Transfer from Soil Environmental Signal towards Regulation of Root-hair Formation, Grant-in-Aid for Scientific Research on Priority Areas, 1 April 2006–31 March 2008.

Aoyama T, Morphological and Functional Differentiation of Root Hairs for Nutrient Absorption, Exploratory Research Grant from Institute of Sustainability Science, 1 April 2006–31 March 2008.

Tsuge T, Novel Regulation Linking Plant Morphogenesis to Environmental Response, Kyoto University Start-up Fund, 1 January–31 March 2006.

Tsuge T, A Novel Mechanism of COP9 Signalosome Controlling Adaptive Responses, Grant-in-Aid for Scientific Research (C), 1 April 2006–31 March 2008.

Tsuge T, Genetic Networks for Dorsal/Ventral and Width/Length Determination of the Leaf, Heiwa-Nakajima Foundation, 1 April 2006–31 March 2007.

Tsuge T, Stress-Response-Controlling Factor (COP9 Signalosome) Involved in Regulation of both Human Carcinogenesis and Plant Photomorphogenesis, The Naito Foundation, 1 December 2006–30 September 2008.

### Award

Tsuge T, Awarded Guest Professor of Brain Korea 21 Silver-Bio Research Center, Dong-A University, Busan Korea, 1 March 2006–28 February 2007.