

Enhancement of photosynthesis (CO₂ uptake) and plant growth through the promotion of stomatal opening

A step forward towards improving crop production and reducing atmospheric CO₂

Nagoya, Japan – By determining the key factor in regulating photosynthesis and plant growth, scientists, Prof. Toshinori Kinoshita, Dr. Yin Wang and co-workers at Nagoya University’s WPI Institute of Transformative Bio-Molecules (WPI-ITbM), have succeeded in developing a method to increase photosynthesis (CO₂ uptake) and plant growth through the promotion of stomatal opening. The study, published in the online Early Edition (EE) the week of December 23, 2013 of Proceedings of the National Academy of Science (PNAS), is expected to contribute to the promotion of plant production and towards the development of a sustainable low-carbon society.

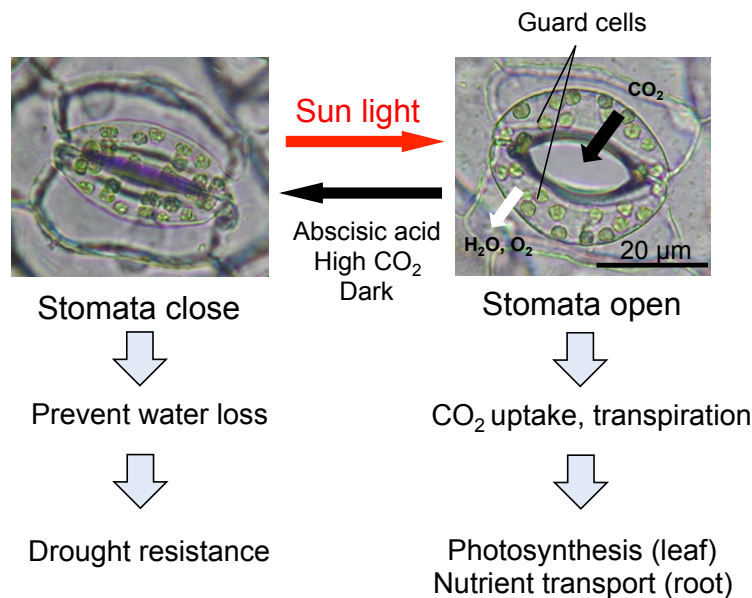


Figure 1. Stomatal movement (an example of Commelina plant)

Light induces stomatal opening. Abscisic acid (a phytohormone synthesis respond to drought stress), high CO₂, dark may induce stomatal closure. Stomata pore is the essential pathway of CO₂ uptake for photosynthesis.

Stomata are small pores located on the surface of leaves that control gas exchange with the external environment, and are the primary inlet for the uptake of CO₂ (Figure 1). “Stomatal resistance, which suppresses gas exchange through the stomata, is considered to be the major limiting factor for CO₂ uptake by plants during photosynthesis,” explains Prof. Kinoshita, “very few reports have existed focusing on the induction of stomatal opening. Therefore, we decided to develop a method to manipulate stomatal opening in view of increasing photosynthesis (CO₂ uptake) and plant production.”

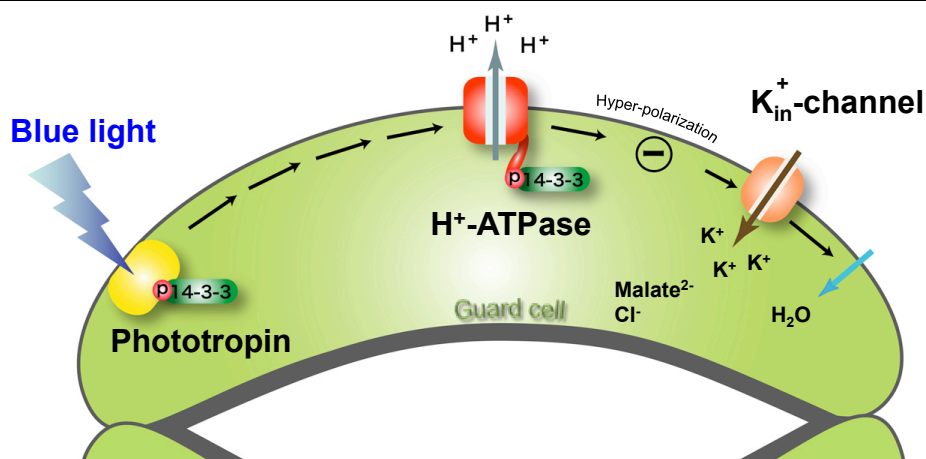


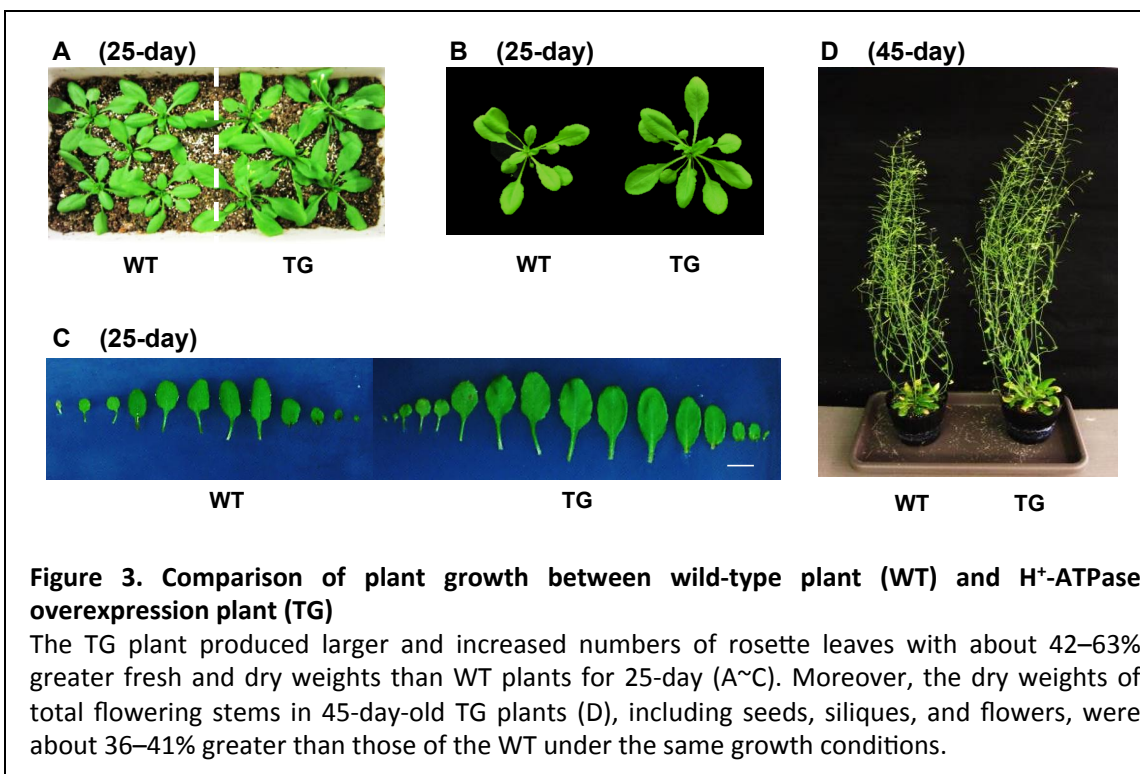
Figure 2. The mechanism of light-induced stomatal opening

When the guard cells are illuminated with sun light, phototropins respond to the blue light and transduce the light signal into the downstream, and then lead to the activation of the plasma membrane H⁺-ATPase through the phosphorylation. The activated H⁺-ATPase induces hyperpolarization of plasma membrane and provides driving force for K⁺ uptake through the K⁺ channel in the plasma membrane. Accumulation of K⁺ in guard cells induces the swelling of guard cells and stomatal opening.

Kinoshita's group has already revealed some of the key factors that mediate stomatal opening (Figure 2). The plasma membrane H⁺-ATPase, an enzyme creating the membrane electrochemical gradients, has been identified as one of the key components. "An increase in photosynthesis (CO₂ uptake) by approximately 15% and a 1.4~1.6 times increase in plant growth of *Arabidopsis* plants was observed by enhanced stomatal opening achieved by overexpressing the plasma membrane H⁺-ATPase in guard cells surrounding the stomata," elaborates Prof. Kinoshita (Figure 3).

Prof. Kinoshita and his co-workers envisage that application of this method will contribute to the increase in the production of crops and fuel plants as well as towards the reduction of CO₂ in the atmosphere. "Identifying that the manipulation of stomatal opening is the key limiting factor in photosynthesis and plant growth enables us to consider strategies to solve current issues in food production and carbon emissions."

This article "Overexpression of plasma membrane H⁺-ATPase in guard cells promotes light-induced stomatal opening and enhances plant growth" by Yin Wang, Ko Noguchi, Natsuko Ono, Shin-ichiro Inoue, Ichiro Terashima, and Toshinori Kinoshita, is to be published on the online Early Edition (EE) in the week of December 23, 2013 in Proceedings of the National Academy of Science (PNAS).



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The JST ALCA program contributes to the reduction of greenhouse gas emissions in the mid and long term and to the realization of a wealthy, low carbon society, aiming to make conceptual breakthroughs and creating “Game-Changing Technology”. ALCA promotes R&D of new basic high-potential scientific knowledge and discovery in order to realize the continual and steady reduction of greenhouse gas emissions.

About WPI-ITbM

The World Premier International Research Center Initiative (WPI) for the Institute of Transformative Bio-Molecules (ITbM) at Nagoya University in Japan is committed to advance the integration of synthetic chemistry, plant / animal biology and theoretical science, all of which are traditionally strong fields in the university. As part of the Japanese science ministry’s MEXT program, ITbM aims to develop transformative bio-molecules, innovative functional molecules capable of bringing about fundamental change to biological science and technology in a Mix-Lab system, where international young researchers from multidisciplinary fields work together. Through these endeavors, ITbM will create “transformative bio-molecules” that will dramatically change the way of research in chemistry, biology and other related fields to solve urgent problems, such as environmental issues, food production and medical technology that have a significant impact on society.

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