Researchers investigate how plants adapt to climate

November 24 2008, By Kayvon Shargi

(PhysOrg.com) -- How many mouths does a plant need in order to survive? The answer changes depending on climate, and some of the decisions are made long before a new leaf sprouts.

Stanford researchers have found that the formation of microscopic pores called stomata (derived from the Greek word stoma, meaning mouth) is controlled by a specific signaling pathway that blocks activity of a single protein required for stomata development. The findings are described in a paper published Nov. 14 in *Science*.

Stomata are found on almost every terrestrial plant on Earth. Their multiple roles include releasing moisture and oxygen into the environment, providing internal air conditioning for the plant and allowing carbon dioxide to enter the leaf, where it is converted to sugar during photosynthesis. Stomata are essential for the survival of plants and, by absorbing carbon from the atmosphere, play a significant role in maintaining the health of the planet.

Using Arabidopsis thaliana, a fast-growing, flowering plant used for genetic and developmental studies, Dominique Bergmann, an assistant professor of biology, and paper co-authors Gregory Lampard, a postdoctoral fellow, and Cora MacAlister, a PhD student, found a unique structural region on a protein with 10 sites that can be modified by a well-known, environmentally-controlled signaling pathway to dictate the number of stomata a plant makes.

"Scientists have said that the environment affects plant development, but no one could point to a protein that was responsible for that response," Bergmann said. "Now we know a major target inside the cell and how it is regulated."

Knowing how this process works could be used to modify crops in order to maximize their productivity under changing climate conditions. Plants might initially benefit as a result of the increased carbon supply in the atmosphere due to global warming, Bergmann said, but would also respond to those conditions by making fewer stomata. The result? Loss of cooling through stomata could lead to widespread crop failures due to the rise in temperatures associated with global warming.

"There are circumstances where you might want to disconnect the signals plants receive from the environment so they can survive," Bergmann said.

The protein, which the researchers dubbed SPEECHLESS, initiates the first of a three-step cell division process that leads to the formation of stomata in plants. Though structurally similar to SPEECHLESS, two other proteins involved in subsequent steps do not contain the same control region that is regulated by the signaling pathway. This provides a unique mechanism for the signaling pathway to control SPEECHLESS activity in a set of stem-cell-like cells and hence the ultimate development of stomata.

"If I were designing the leaf, that would be the part I would put under really tight control," Bergmann said. "It seems as if that's what plants have done."

Certain trade-offs exist for plants having too many or too few stomata. To help determine the number of stomata a newly sprouting leaf should form, the plant takes key factors about its surrounding climate—carbon

dioxide levels, temperature and humidity—into account.

To perceive these factors, the plant uses the same signaling pathway used to control SPEECHLESS activity. The study identifies a critical junction that connects how a plant can sense environmental conditions with how this information is relayed to stomatal-development pathways. Thus, development of stomata can be altered "on the fly" to better enable the plant to cope with environmental conditions.

For example, a leaf contains fewer pores when carbon dioxide in the atmosphere is in abundance and more when it is limited. If conditions change, this multi-faceted signaling system can enable fine-tuning of stomatal development.

Science paper: www.sciencemag.org/cgi/content/full/322/5904/1113

Provided by Stanford University