2-protein team would be lost without each other

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Just as a hard-charging person sometimes needs a calming partner to be more effective, so it is with a pair of critical proteins that promote cell division and growth in the rapidly expanding root tip of plants.

One of the pair, a molecule called Scarecrow, physically restrains its highly influential counterpart from going farther than it should and doing more work than is needed.

As a result of this restraint, Scarecrow and its partner, called Short-root, manage to assemble a single ring of waterproofing that enables the plant to perform the critical function of controlling how much water and nutrient it takes in via the root.

"Knowing more about how plants developed this key ability to keep water out and let nutrients in is another step toward engineering plants that may be used to replace fossil fuels," said Duke biologist Philip Benfey. "It's also another step toward a better understanding of how humans work."

This emerging picture of the complex interplay between genes and proteins is the latest finding to come from Benfey's examination of the model mustard plant Arabidopsis thaliana.

"It's a simple model for us to get at some very complex relationships between genes and proteins and cells," said Benfey, the Paul Kramer Professor of Biology and director of Duke's new Center for Systems

Biology in the Institute for Genome Sciences & Policy.

Benfey and Duke postdoctoral fellow Hongchang Cui published the findings in the April 20, 2007, issue of the journal *Science*.

The fast-growing root tip of Arabidopsis is literally a timeline of how generic, undifferentiated cells reach various specialized fates and begin doing specific tasks within the plant. It is also a perfectly symmetrical structure that can be easily sectioned, viewed and photographed.

There are 17 different cell types in the root tip, arising from four basic kinds of undifferentiated stem cells. Their fates are established by signaling proteins, called transcription factors, that turn genes on and off to regulate the supply of particular molecules within the cell and thus determine its fate.

Most signaling proteins, especially in animals, move readily across many layers of cells, becoming more scarce farther from their source because they end up bound to receptors in cells along the way. But Short-root is different; it goes only so far and then stops, Benfey said. Earlier work by Benfey's group had zeroed in on Short-root as a key player in normal development. Short-root was named for the disorder exhibited by plants that lack this key regulatory gene.

In Arabidopsis, Short-root is produced in the center of the root tip and moves outward to adjacent cells. Along the way, it promotes cell division and identity. In the single layer of cells called the endodermis, it also activates a gene to manufacture its partner, Scarecrow, which is also a transcription factor.

Scarecrow's job, in turn, is to control Short-root. It actively binds to and restrains the potent Short-root to the endodermis layer, where the waterproofing layer is established. The endodermis is a ring of cells interspersed with a waterproofing material that is arranged like the mortar between bricks. The cells function much like kidneys, filtering minerals from water and passing them in toward the center of the root tip. A plant with no endodermis would essentially drown, while one with multiple layers might starve.

"In the same way that emails can cause trouble if they are forwarded to the wrong person, cellular messages can disrupt development if they go astray," said Susan Haynes of the National Institute of General Medical Sciences, a part of the National Institutes of Health. "Benfey's studies describe a novel and important mechanism that prevents the Short-root message from being forwarded to the wrong cell layer in the developing root."

The supply of bound Scarecrow/Short-root complexes in a cell of the endodermis forms a feedback loop with the genes to ensure that the plant keeps making enough Scarecrow to bind up all the arriving Short-root.

Benfey and Cui have found this same restraint and feedback mechanism at work in the root tips of rice, and they believe it is the reason that nearly all plants have a single layer of endodermis.

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Source: Duke University

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