Wave of gene expression gives root tips wild ride

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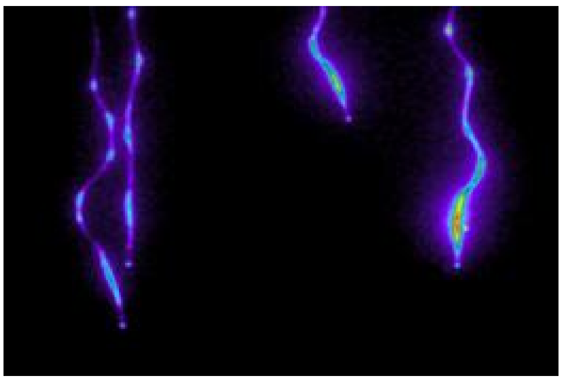

The cells of growing root tips glow as gene expression peaks, leaving behind a series of spots where branching lateral roots will later emerge. Phil Benfy lab, Institute for Genome Sciences & Policy

Duke researchers have found a surprising parallel between the development of an animal's spinal column and a plant's root system. Both appear to be controlled by a "molecular clock" that governs a regular spatial pattern of development.

"It appears there are similar underlying processes in both plants and animals, suggesting that the number of ways the problem can be solved is limited," said Philip Benfey, director of the Center for Systems Biology at the Duke Institute of Genome Sciences & Policy. "This must be a very efficient solution."

The clock is driven by a wave of gene expression that travels up from the tip of the roots and reaches its peak every six hours, Benfey's team reports in the September 10th issue of *Science*. The wave is made up of thousands of genes, including two separate groups that trade off their activity; when one group is high, the other is low and vice versa.

In vertebrates, the early formation of transient structures called somites that are the precursors of vertebrae is similarly periodic, depending on a rhythmic wave of gene expression that moves though the developing tissue. When the wave of gene expression encounters a set of responsive cells, those cells are specified to become the next somite. This mechanism ensures each vertebrate species ends up with the correct size and number of vertebrae.

In the case of plant roots, these peaks of gene expression mark the spots where root branches can later form. It doesn't mean those sites will necessarily sprout new root branches, but it does mean they are "competent" to do so. "This wave is the first step in a multistep process," Benfey said. "It gets the spacing right."

The researchers were able to uncover this pattern by measuring gene expression separately in the upper and lower portions of 20 individual roots of Arabidopsis thaliana, each at different points along the cycle. They then used a sophisticated algorithm to piece together a complete time series of one cycle or oscillation.

The timing of the gene expression wave is largely independent of the rate at which a root is growing. As a result, roots that grow more slowly will have the potential to pack in more branches over a short length. Those growing quickly, as they presumably would when the living is easy and there is little need to "branch out," would end up with more widely spaced branch roots.

"Producing pre-determined sites in a periodic fashion seems to be an efficient solution to coordinate growth with the exploration of soil for resources," said Miguel Moreno-Risueno, a post-doctoral researcher in Benfey's lab who led the study.

The team still needs to work out exactly what is happening at the cellular level. For instance, they say that the gene expression wave moves from one cell to the next, but that isn't completely clear.

Collaborators on the study include Jaimie Van Norman and Jingyuan Zhang, of Duke; Antonio Moreno of Instituto de Acustica in Spain; and Sebastian Ahnert of the University of Cambridge. The work was supported in part by grants from DARPA and the National Institutes of Health.

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