Water found to provide blueprints for root architecture

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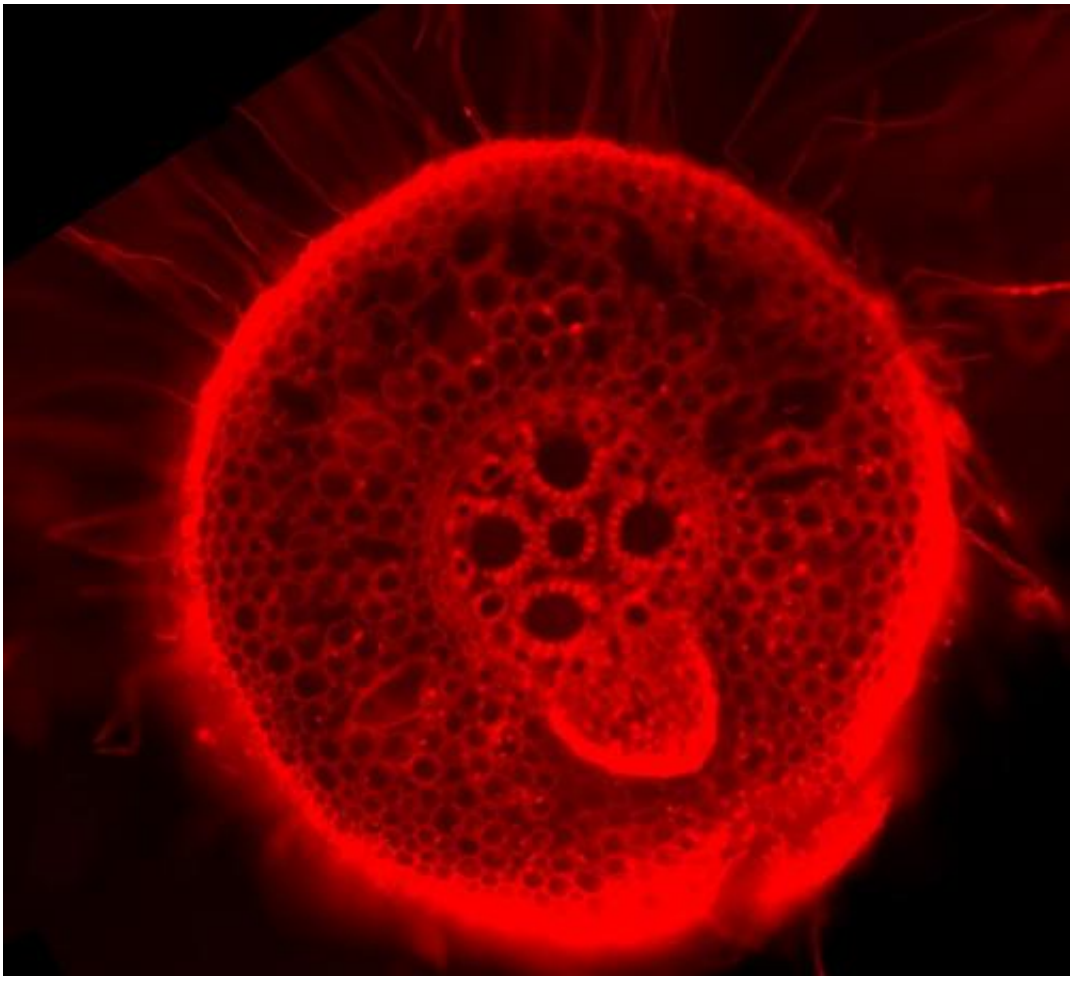

This is a cross section of a maize root showing the development of a root branch towards water. The photo is credited to Neil Edwards II. Credit: Neil Edwards II

Soil is a microscopic maze of nooks and crannies that hosts a wide array

of life. Plants explore this environment by developing a complex branched network of roots that tap into scarce resources such as water and nutrients. How roots sense which regions of soil contain water and what effect this moisture has on the architecture of the root system has been unclear.

New research from a team led by Carnegie's José Dinneny focuses on how physical properties of a root's local environment control root branching and through which developmental pathways these signals act. Their findings, published by *Proceedings of the National Academy of Sciences*, describe a novel process called hydropatterning that allows plants to optimize root branching for water uptake.

Plant roots form a branching network like that above ground, with lateral roots growing out from a main axis. Because water is not uniformly distributed in soil, the structure of the root system networks needs to be regulated in ways that optimizes soil exploration, while limiting growth into water-poor regions.

Dinneny and his team developed methods for growing roots in environments in whiche the distributions of water and air around the root were highly controlled. By analyzing the position where new branches formed, the researchers found that plants tend to place these root branches in close proximity to where water exists, while tiny root hairs appear in areas exposed to air.

Their work revealed that opposite sides of the same single root are optimized to take advantage of air or water resources when the environment is varied. Working with colleagues Malcolm Bennett and Sacha Mooney at the University of Nottingham, micro-scale X-ray tomography was used to build 3-D models of roots growing in soil and revealed that similar processes occur in this more-natural environment.

This is a cross section of a rice root showing the development of a root branch towards water. The photo is credited to Pooja Aggarwal. Credit: Pooja Aggarwal

"We had completely underestimated the spatial acuity of the patterning system in the root. It was fascinating to discover that roots can respond to environmental conditions that vary over distances as small as 100 microns, which is the size of a typical soil particle," said Dinneny.

The team named the new phenomenon hydropatterning and they observed it in several plant species, including the important crop plants maize and rice. The process is controlled by signaling pathways in the plant that are distinct from previously characterized drought responses suggesting that hydropatterning could be important for regulating root branching under non-stressful growth conditions.

"This simple observation opens up a whole new area of investigation for us," Dinneny said. "How plant cells distinguish between wet and dry environments is an important frontier that may lead to a better understanding of how plants efficiently use water."

More information: Plant roots use a patterning mechanism to position lateral root branches toward available water, *PNAS*: www.pnas.org/cgi/doi/10.1073/pnas.1400966111

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