Plant biology meets up with computational wizardry

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These plants in Andy Pereira's laboratory at the Virginia Bioinformatics Institute at Virginia Tech show the effects of drought, one of the circumstances that will stress plants as a result of climate change. Credit: Andy Pereira's laboratory

Over time, plants have evolved to adapt to a constantly changing, often hostile, environment. Unfortunately, they are facing a new and difficult challenge ahead.

Ever since the Industrial Revolution, their environment has become more unpredictable and more extreme, at the same time as the world's population is growing. Food will soon need to be grown where it was not

grown before, and existing agricultural lands will need to be cultivated with crops that have superior stress adaptation abilities.

"A crucial first step along the path to increasing world food security is a fundamental understanding of how plants respond to extreme changes in their environment. Much data, and some databases, have already been accumulated, documenting plants' responses to their environments, but those resources remain scattered. There is a gap between biologists, whose expertise lies in the study of organisms' behavior, and computer scientists, with the necessary domain knowledge to unify existing data, and make them accessible for study and further development," said Ruth Grene, professor of plant pathology, physiology, and weed science.

Biologists have long sought "to understand the early responses of higher plants to abiotic stresses such as drought, flooding, heat, cold, ozone, and salt. The key to understanding the responses is signal transduction pathways," said Lenny Heath, a professor of computer science at Virginia Tech.

Signal transduction pathways are collections of interacting cellular components that activate the response of the cell to an external or developmental signal such as a flood.

Heath and his colleagues, Grene, and Andy Pereira of the Virginia Bioinformatics Institute at Virginia Tech, have just received a four-year grant from the National Science Foundation to provide the computational support for the biologists' questions. The grant is valued at $ 1,057,336.

"Climate change events are expected to exacerbate the severity and duration of current adverse environmental conditions. Elucidation of the genetic response networks regulating plant dynamic responses to changing environments is daily becoming more of a reality.

Bioinformatics approaches are increasingly available to address these questions," said Pereira, the principal investigator on this project.

Currently, the full details of even one stress-signaling pathway remain unclear. "And, although cross-signaling is clearly an important part of adaptive responses, it is unclear to what extent recognition and response pathways for the various abiotic stresses overlap in any one case," Pereira added.

"Our work should empower plant biologists to curate and archive signaling pathways for abiotic stress responses in the Beacon database," Heath explained. Beacon refers to a new systems biology tool that allows the plant biologist to construct and edit signaling pathways. With this information, a curator can integrate current and future data over multiple scales of a cell's organization and across species.

"This project builds upon the community-based, Beacon system to provide computational support for biologists' questions about signaling pathways, thereby empowering those plant biologists to curate and archive signaling pathways for abiotic stress responses in the Beacon database," Heath said. A workshop will be held in fall, 2012, when international experts on particular stresses, and particular plant signaling pathways, will come to Virginia Tech to be trained on the Beacon system.

Their work should allow the computational and statistical means to assess if the activity of one molecule causes a response in a second molecule. Innovative components of the Beacon system allow the possibility of simulating particular environmental conditions in order to identify potential new connections in these networks.

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