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Plant by Numbers

'Colouring' plant innards gives U of G biologist inside look at rarely seen metabolic processes

BY ANDREW VOWLES

He learned biology by painting and sketching plants in his native India. Now Prof. Jaideep Mathur, Molecular and Cellular Biology (MCB), uses imaging and computer technology to "colour in" plant cells here at Guelph. By using art to help reveal their inner workings, Mathur hopes to deepen our understanding of plants and their uses in everything from mitigating pollution to feeding the masses with genetically modified crops.

Prof. Jaideep Mathur, Molecular and Cellular Biology, draws scientific inspiration from art. Photo by Martin Schwalbe

Using fluorescent tags and other molecular biology tricks and a painterly eye sharpened since those boyhood hours spent with a pencil or paintbrush in hand, he has developed a system for colour-coding the varied organelles inside plant cells. Recalling the first inklings of this work in Germany about a decade ago, he says: "I started looking for ways to essentially colour the inside of the plant cell."

More than just a kind of paint-by-numbers for cell biologists, Mathur's system allows him to watch what few biologists have seen: how plants respond to environmental stresses in real time. Being able to see interactions between individual parts inside a plant cell will allow us to learn more about the effects of, say, environmental pollutants that may harm not just green things but all living things on the planet.

The longtime plant scientist uses lines of fluorescent proteins developed in his lab and elsewhere like packages of marker pens to selectively colour different cellular components and compartments, from cell walls and chloroplasts to vacuoles and microtubules. Although other researchers use similar systems, he says his is the most extensive collection of fluorescent proteins for studying plant parts.

On the computer monitor in his Axelrod Building office, for instance, that fiery orange-red body is the plant cell's nucleus. The mitochondria, or the cell's energy factories, show up as luminous green branching structures. And those otherworldly forms dotted in yellow and orange, he explains, are the cell's Golgi bodies and peroxisomes.

Mathur may distinguish those multi-coloured structures in still pictures taken under the microscope. More important, he's able to use these marker lines to watch what happens as cell parts respond to stimuli in real time. He's even used live cell visualization to observe changes in the plant's cytoskeleton as the cell grows.

Through his project, called Early Intracellular Response Profiling for Plants (IERPP), he hopes to accord plants more respect. Far from a seemingly insentient organism whose rooted lifestyle makes it unable to escape threats, "this is a creature that has developed ways to take things the environment throws at it and still survive," he says.

"What does the plant feel immediately?" So far, says Mathur, we've been unable to observe that instantaneous reaction. Now he's used a confocal laser scanning microscope to watch how internal membranes

in the plant cell change shape only milliseconds after being exposed to reactive oxygen. He hopes to attract other scientists to work with his lab on observing responses to other stressors.

Mathur says we'll need to better understand plants for use as life-support systems for future space missions intended to help humans colonize other worlds. In the meantime, he foresees uses for IERPP technology in following processes inside genetically modified (GM) plants.

He hopes to help improve acceptance of GM plants grown as crops. Showing precisely what happens inside a modified plant cell and comparing it with unmodified parent cells may help allay public fears about the technology, he says.

Mathur is also interested in learning more about proteins involved in plant cell division and growth. Those proteins include actin, the same protein that enables movement in animal muscles. In fact, he's investigating a recent line of research that suggests proteins allowing animal cells to move are the same ones that permit plant cells to grow.

Besides those luminescent shots taken through the microscope, Mathur has used his artistic background to illustrate coloured schematic cutaways of plant cells and their organelles. His work can be viewed on his website at www.uoguelph.ca/~jmathur. The site also includes links to his numerous research papers, including a journal article he co-authored last year with MCB colleague Prof. Rob Mullen on the use of fluorescent proteins for illuminating plant parts. Several journals have used Mathur's images as cover illustrations, including *Trends in Plant Science, Plant Physiology* and *The Plant Cell*.

He's been drawing and painting plants for as long as he can remember, including using coloured chalks to draw on the floor in his childhood home in Lucknow in northern India. He began exhibiting his paintings while studying botany. Art and science intertwined as Mathur paid repeated visits to the university botanical garden to paint the plants he was learning about.

"I love to paint and I love to use colours. I learned my biology through drawing and painting. When I learned the processes of plants, I went into the garden and did about 1,000 paintings."

Intrigued by shape development in plants, he went to the Biological Research Centre in Szeged, Hungary, to work on plant cell differentiation. Then he pursued a series of post-docs, including stints at Germany's Max Planck Institute and in plant labs at Tubingen University and the University of Cologne.

In the mid-1990s at the Max Planck Institute in Cologne, Mathur worked with the first groups to demonstrate the use of green fluorescent protein from jellyfish in plant research. Later at the University of Cologne, he cloned and characterized several new genes from plants.

He came to Canada in 2003, beginning at the University of Toronto, then arriving at U of G in 2004. He started in the Department of Plant Agriculture and transferred to MCB last spring. This summer, he'll move to new quarters in the final phase of Guelph's science complex, along with other plant biologists in his department.

Mathur still paints in his leisure time, mostly impressionistic nature scenes in oil, watercolour and acrylic. Besides using his works in his research talks, he uses painting as a way to prime the creative pump for writing journal articles. "Normally I paint, then sit down to write."