New details revealed on how plants maintain optimal sperm-egg ratio

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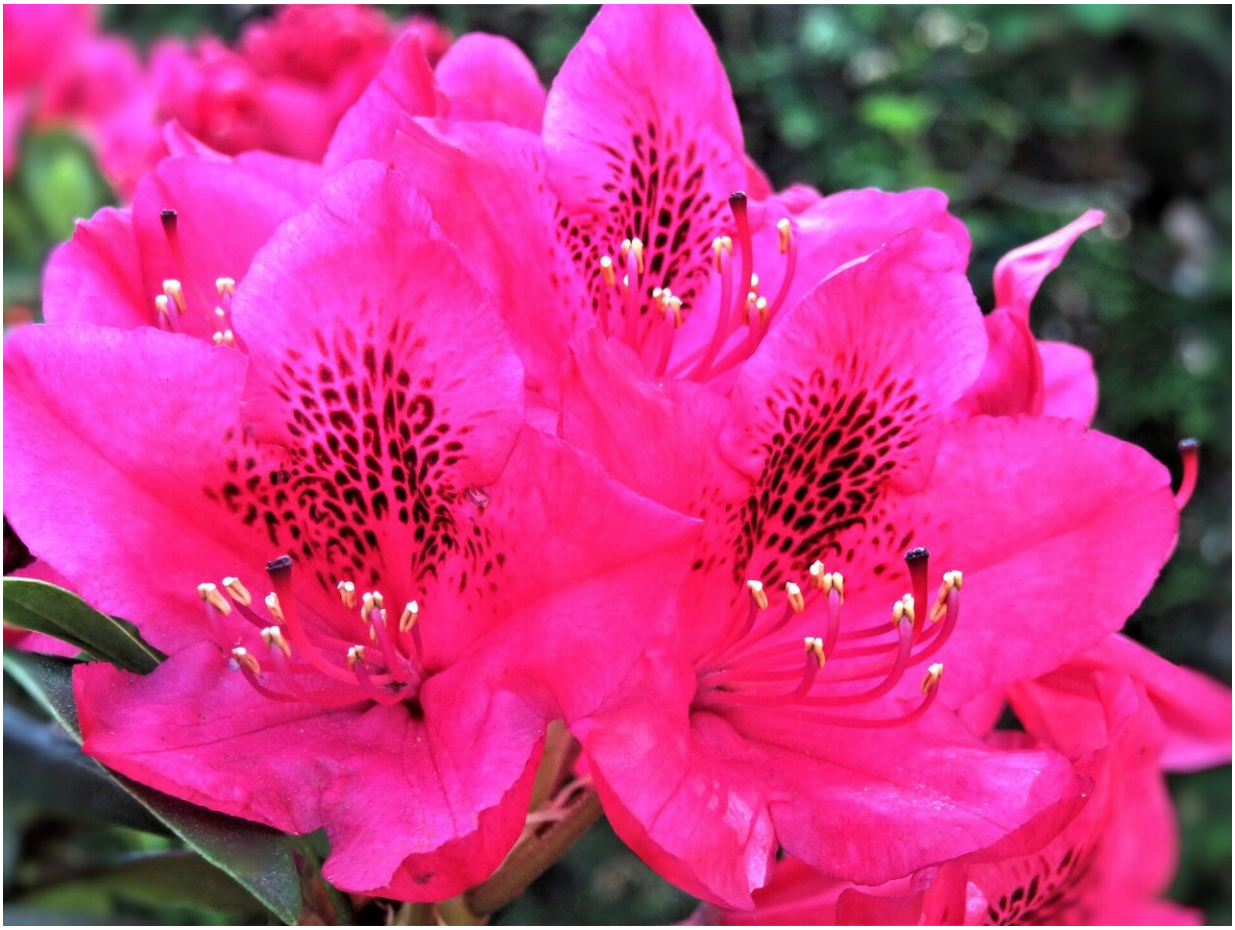

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Current molecular biochemistry, microscopy and genetic techniques

have become so powerful that scientists can now make mechanistic discoveries—supported by multiple lines of evidence—about intimate processes in plant reproduction that once were very difficult to examine, says molecular biologist Alice Cheung at the University of Massachusetts Amherst.

She is the senior author of a new paper in *Nature* describing how she and her team used such tools to solve, in unprecedented detail, the mystery of how flowering plants avoid polyspermy. As the name suggests, polyspermy results from multiple sperm entering and fertilizing an egg, a condition harmful to the zygote. In plants, preventing polyspermy also means higher chances for more females to be fertilized and ensures better seed yields, both of which are agriculturally important, Cheung points out.

For years, she and her long-time collaborator Hen-Ming Wu have led a team that includes a former postdoctoral associate, Qiaohong Duan, a current postdoc Ming-Che (James) Liu, and several graduate students in investigating FERONIA's dual roles in reproduction. For the current paper Duan and Liu are co-first authors.

Cheung says, "It is very exciting to be able to explain how in multiple steps a plant creates an environment in its ovule, where the egg cell is located, that is first receptive to an incoming pollen tube to deliver sperm, but once fertilization is ensured it will instantly switch to block more pollen tubes from approaching to guard against polyspermy." These two acts are controlled by a gene called FERONIA, she adds, which encodes the FERONIA receptor kinase that senses signals on the cell surface and instructs the cell to respond appropriately.

Cheung says one of the key discoveries in their latest work is FERONIA's role in the cell wall and, in particular, its ability to interact with pectin, a sugar polymer in the wall. As conditions vary, one form of

this polymer, called de-esterified pectin, can maintain a malleable wall, for example, so the first pollen tube arriving at the egg chamber inside the ovule can penetrate. But this pectin can also abruptly harden after the first pollen tube has penetrated, blocking more from entering.

This special pectin also triggers other activity, they discovered. Cheung and colleagues say they observed for the first time that de-esterified pectin serves as a signal to trigger an environment enriched in nitric oxide (NO) at the entrance to the egg chamber. In a series of bioassays, molecular interaction and biochemical analyses, they show that this gaseous signaling molecule modifies and de-activates a chemoattractant produced by the female to guide pollen tubes to their targt. This quick change insures that late-arriving pollen tubes cannot approach an already fertilized ovule.

Cheung explains, "As a gas, NO can diffuse very quickly, maybe even instantly as it is produced. The title of our paper, 'FERONIA controls pectin- and nitric oxide-mediated male-female interaction' captures how our latest work connects these two FERONIA- controlled conditions. What led us to our findings is that without FERONIA, the cell wall is deficient in de-esterified pectin, but with FERONIA present, the wall works both as a source of signal molecules to trigger NO and also a physical barrier."

The molecular biologist says that because of its almost global importance to plant survival that her group and others have demonstrated, there are now likely dozens of labs around the world—from plant stress physiologists to molecular structural biologists—pursuing different aspects of FERONIA and its related proteins. Cheung says some of these proteins function together in very intriguing ways, so "there is immense potential for advances in plant biology and fundamental signal transduction mechanisms from this very active field."

More information: FERONIA controls pectin- and nitric oxidemediated male–female interaction, *Nature*, DOI: 10.1038/s41586-020-2106-2 , nature.com/articles/s41586-020-2106-2

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