A crystal-clear view of the arms race between a rice blast effector and an immune receptor

Abstract:
Arms race co-evolution drives rapid adaptive changes in pathogens and in the immune systems of their hosts. Pathogens deliver an array of molecules, called effectors, that manipulate cellular processes and enable colonization. In turn, intracellular NLR immune receptors detect pathogen effectors and initiate an immune response that halts colonization. This immune response imposes a strong evolutionary constraint on pathogens and, as a consequence, pathogen effectors evolve to escape immune recognition and are highly variable. To keep up with rapidly evolving pathogens, plants have evolved complex immune networks, with NLR receptors forming one of the most diverse protein families. NLRs often occur as allelic series with differential pathogen specificities, the determinants of which are just starting to be elucidated.
The rice NLR Pik recognizes AVR-Pik effectors from the blast fungus Magnaporthe oryzae, triggering immune responses that limit rice blast infection. Different rice blast strains harbour variants of AVR-Pik effectors that escape immune recognition. On the other hand, Pik NLR receptors occur as an allelic series with differential recognition specificity for these variants. Juan Carlos' group combined X-ray crystallography and biophysical analysis to dissect the mechanistic basis of the arms race co-evolution between the rice NLR Pik and the rice blast effector AVR-Pik. They uncovered how allelic variation in a heavy metal associated (HMA) domain integrated in the receptor Pik-1 confers differential binding to AVR-Pik variants, underpinning narrow or broad-spectrum resistance. Furthermore, they described how different NLR receptor alleles converge toward the same molecular mechanism for extending pathogen recognition.
They applied this knowledge to develop a structure-guided engineering approach to expand the response profile of a Pik allele with narrow-spectrum recognition. This provides a proof-of-concept that plant NLR receptors can be engineered to develop bespoke resistance against some of the most destructive plant diseases in modern agriculture.