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The role of promiscuous molecular recognition in the evolution of self-incompatibility in plants

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Bisexual flowering plants are at high risk of self-fertilization, which would produce less fit offspring (known as 'inbreeding depression'). Hence, more than 100 flowering plant families have developed various mechanisms to avoid self-fertilization, generally called 'self-incompatibility'(SI). Under these mechanisms, the species is subdivided into multiple 'types' or 'classes', such that a pollen grain cannot fertilize a maternal plant of its own type. The type is encoded by a single highly polymorphic locus that encodes for both male and female type-specifying proteins. Self-incompatibility relies on specific molecular recognition between these highly diverse proteins, such that the combination of genes an individual possesses determines its mating partners. Although a few dozen mating specificities are known from population surveys, previous models struggled to pinpoint the evolutionary trajectories by which new specificities evolved. In this talk, I will discuss a novel theoretical framework we recently proposed to study the evolution of the collaborative non-self-recognition self-incompatibility, found in the Solanaceae and Rosacea plant families. This framework uniquely incorporates the molecular recognition between male and female-determinant proteins into the evolutionary model. Our modeling framework crucially relies on interaction promiscuity and facilitates many-to-many interactions between the female and male-determinant proteins, in agreement with empirical evidence. Using this framework, we found that most members of the population spontaneously self-organize into 'compatibility classes', such that members of each class are incompatible with each other but compatible with all members of all other classes, in agreement with empirical findings. The model exhibits a dynamic balance between class birth and death and shows a stable equilibrium in their number. These behaviors prevail under a broad range of parameters. Lastly, I will discuss the selection pressures driving the evolution of the self-incompatibility genes and how they reconcile the possibly conflicting requirements to simultaneously attract some partners but repel others. Our work highlights the importance of molecular recognition promiscuity to the evolution of multi-component biological systems. Promiscuity was found in additional systems suggesting that our framework could be more broadly applicable.

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