Scientists transfer genes from poppy to a different species to prevent self-pollination

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Silique from selfed transgenic Arabidopsis thaliana SI line (top) is small and has no seed set, while silique from selfed non-transformed Arabidopsis thaliana (bottom) is large and sets normal level of seed. Credit: Noni Franklin-Tong

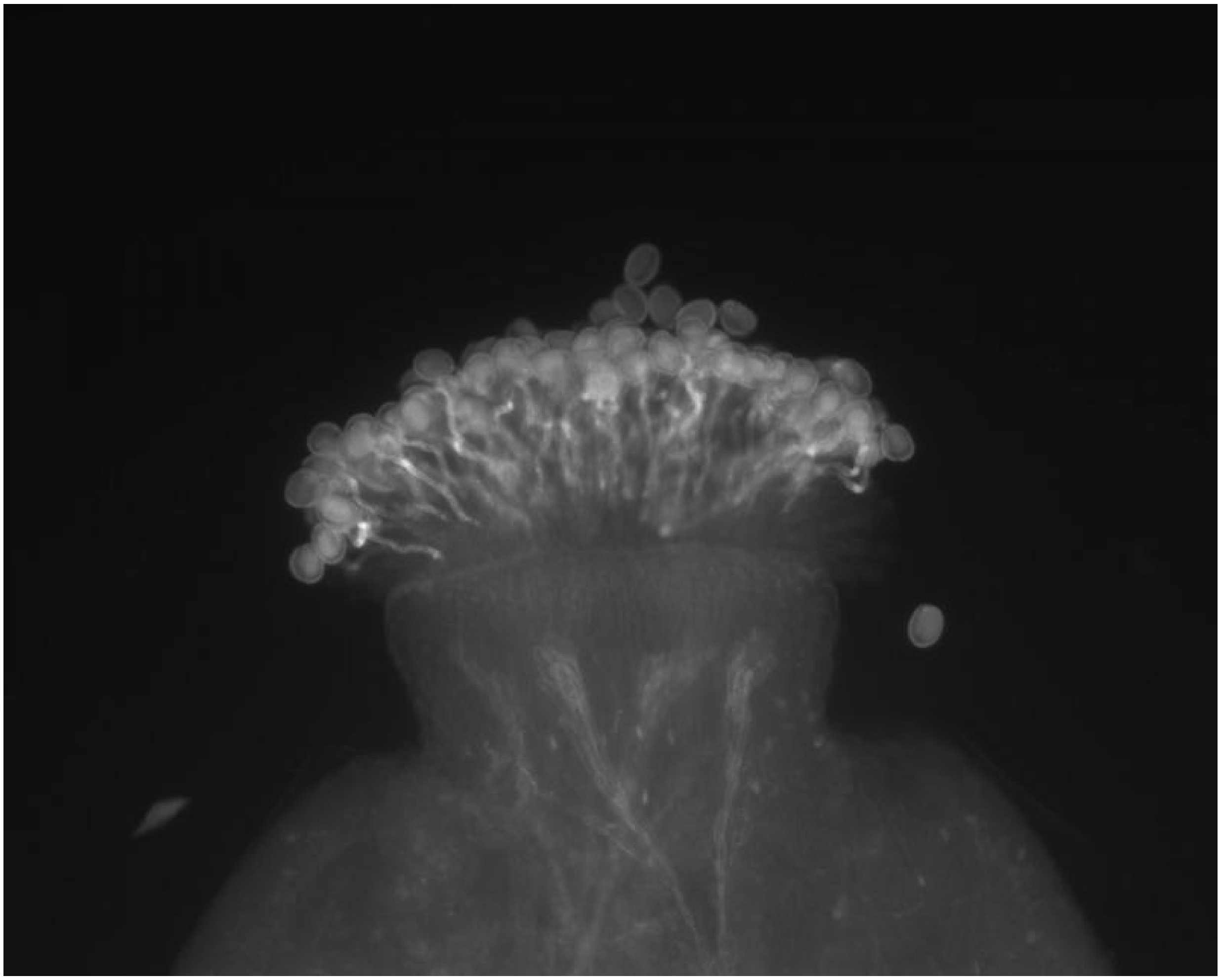
University of Birmingham (UK) scientists have created a plant that rejects its own pollen or pollen of close relatives, according to research published in the journal *Science* today (5 November 2015).

Self-pollination or 'selfing' can be bad for a plant resulting in inbreeding and less healthy offspring. This breakthrough could be used to breed stronger more resilient crops faster and at lower cost; a new approach in the quest for a secure and plentiful food supply.

The team took the self-fertile plant thale cress - *Arabidopsis thaliana* - a relative of cabbages, cauliflowers and oilseed rape, and made it self-incompatible by the transfer of just two genes from poppies that enable the recipient plant to recognize and reject its own pollen whilst permitting cross-pollination. Such conversion of a selfing plant to a self-incompatible one has been a long term goal of self-incompatibility research.

The basic anatomy of most flowers means the male pollen is produced next to the female reproductive organs running the real risk of self-pollination, rather than receiving pollen from a different flower transported by the wind or on an insect. When pollen lands on the stigma of a flowering plant the pollen germinates and develops a pollen tube which grows through the stigma and other female tissues and then enters the plant's ovary to affect fertilization. If this involves self-pollen, it results in inbreeding, which can result in a shrinking gene pool and unhealthy offspring. The Birmingham team have made major progress over the last few years in understanding the mechanisms by which the field poppy, *Papaver rhoeas*, avoids this.

A central role is played by two self-incompatibility (SI) proteins: a "receptor", PrpS, made by the pollen and a signal protein called PrsS that is produced by the stigma. Plants have their identities specified by the exact version of PrpS and PrsS they produce. In this way, flowers can recognize that they are interacting with "self" through the PrpS/PrsS interaction, which triggers several chemical signals that cause inhibition of pollen involving a mechanism called "programmed cell death", resulting in incompatible pollen being told to commit suicide before they germinate and begin extending their pollen tube. Conversely, if the pollen and stigma are expressing non-matching SI genes, "self" recognition does not occur and pollination is successful.



Aniline blue staining shows At-PrpS1 pollen is strongly inhibited when pollinated onto cognate At-PrsS1 pistils. Credit: Noni Franklin-Tong

The research team had previously transferred the pollen PrpS gene from the Field Poppy into Arabidopsis thaliana, which is self-fertile. When pollen grains expressing PrpS were exposed to matching female recombinant PrsS proteins, SI-specific recognition occurred, leading to a self-incompatibility reaction with the hallmark features of those observed in poppies.

This latest finding, published in the journal, *Science*, went one step further by putting the female PrsS gene from the poppy into *Arabidopsis thaliana* plants and showing that this gene is expressed in *A. thaliana* pistils and functions to reject matching "self" pollen. Then they demonstrated that *Arabidopsis thaliana* plants co-expressing both the pollen and stigma SI genes exhibit complete rejection of self-pollen. This demonstrates for the first time that just these two poppy SI genes are sufficient to establish a robust self-incompatibility in a highly divergent self-compatible species which is over 100 million years away in evolutionary distance.

Professor Noni Franklin-Tong from the University of Birmingham's School of Biosciences, and lead author of the study said: 'This is a major achievement, as this has been an elusive, important goal of plant scientists for decades. I've often been asked why we were working on poppy, which is not related to any crop plant, because it was assumed that one would have to use closely related genes from relatives of crop plants to achieve this. Now we can say that our persistence has paid off. Our findings open up questions about how plant signalling networks have evolved, as it suggests that by putting in these two genes that act as a lock and key, we can get another signalling pathway and physiological outcome to be specified .'

This study represents a major advance in the quest to utilize self-incompatibility systems as a potential alternative means to breed hybrid plants - plants whose 'hybrid vigour' gives them better yields and strength than their parents. Professor Chris Franklin, co-author on the study, from the University of Birmingham's School of Biosciences, said: 'This represents the culmination of decades of research on Self-Incompatibility S-determinants in the hope that eventually they may be transferred to crops to allow breeding F1 hybrids easier. This research may provide a natural mechanism for producing hybrid plants. Being able to switch a plant's self pollination control on or off could be a major boost for plant breeders and make it much easier and cheaper to produce superior hybrid plants and seeds more easily.'

More information: "The Papaver rhoeas S determinants confer self-incompatibility to Arabidopsis thaliana in planta," www.sciencemag.org/lookup/doi/ … 1126/science.aad2983

Provided by University of Birmingham

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