Biologists discover 'control center' for sperm production

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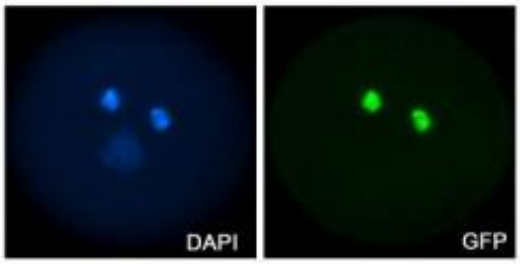


Pictured is a fluorescence image of an *Arabidopsis* pollen grain showing sperm cell-specific expression of a GFP-tagged marker of the IMPa-8 promoter along with a corresponding DAPI-stained image of the same pollen grain. The DAPI image shows the two densely-stained sperm cell nuclei and the diffusely-stained vegetative cell nuclei. In the GFP image, fluorescence is confined to the sperm cell nuclei, illustrating sperm cell-specific expression. The authors show that sperm cell specification of several genes, including IMPa-8, is regulated by the germline-specific transcription factor DUO POLLEN 1 (DUO1). Thus DUO1 has a major role in shaping the germline transcriptome and functions to commit progenitor germ cells to sperm cell differentiation. Credit: Image generated by Hoda Khatab (University of Leicester)

Biologists at the University of Leicester have published results of a new study into the intricacies of sex in flowering plants.

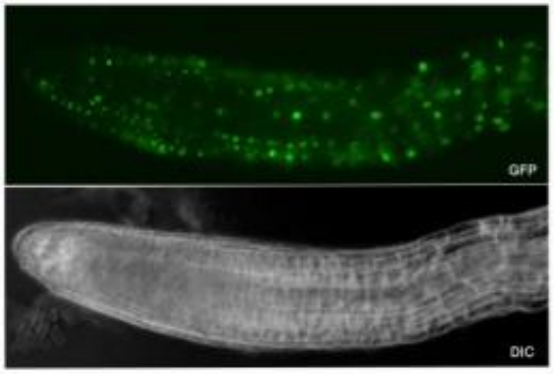
They have found that a gene in plants, called DUO1, acts as a master switch to ensure twin fertile sperm cells are made in each pollen grain.

The research identifies for the first time that DUO1 switches on a battery of genes that together govern sperm cell production and their ability to produce seeds..

The findings have implications for plant fertility, seed production – and could be used to help produce improved crops to help meet food shortages. This work also formed part of one of the author's PhD thesis (Dr Michael Borg, University of Leicester).

The new study is reported in the journal *The Plant Cell* and was funded by the Biotechnology and Biological Sciences Research Council (BBSRC).

Professor David Twell and colleagues in the Department of Biology at the University of Leicester previously reported the discovery of a master regulator protein called DUO1 that has a critical role in allowing precursor reproductive cells to divide once to form twin sperm cells. The discovery of a battery of genes governed by DUO1 has shed light on the mechanisms by which plants control sperm cell formation and fertility.



Pictured is an image of an *Arabidopsis* root showing expression of GFP-tagged DUO POLLEN 1 (DUO1) transcription factor along with a DIC image of the same root showing the different cell files. DUO1 is normally restricted to sperm cells because its expression has been shown to be germline-specific. It is

normally technically challenging to study genes active within plant sperm cells because plant sperm are tiny and encased within tough pollen grains. Using these genetically modified plants, the researchers were able to survey the target genes switched on by DUO1. Credit: Image generated by Lynette Brownfield (University of Leicester)

Professor Twell said: "Unlike animals, flowering plants require not one, but two sperm cells for successful reproduction. These two sperm cells are housed within pollen grains, which act as a vehicle to deliver the sperm cells to the female sex cells within a flower.

"One sperm cell will join with the egg cell to produce the future plant or embryo, whilst the other will join with a second cell deep within the flower (the central cell) to produce a nutrient-rich tissue called the endosperm. Together these two structures make up the seeds and grains that form the staple food of humans and livestock across the globe.

"A mystery in this 'double fertilisation' event was how each pollen grain could produce the pair of sperm cells needed to make seeds. We now report that the regulatory gene DUO1 switches on a battery of genes that together govern sperm cell production and their ability to fuse with the egg and central cells. So in effect DUO1 acts as a master switch to ensure twin fertile sperm cells are made. "

Their new study expands on their previous work on pollen development and has identified a battery of new genes that collectively ensure male fertility in flowering plants.

The study of genes active within plant sperm is technically challenging because their sperm cells are not only tiny, but they are encased within tough pollen grains and as such are difficult to isolate. "We overcame

this problem by genetically forcing plants to make DUO1 in plant roots, a place it is not normally found because DUO1 is normally restricted to sperm cells. By studying these genetically modified plants, we were able to survey the target genes switched on by DUO1."

The researchers also report on the mechanism by which DUO1 switches on its target genes. Being a regulatory protein, DUO1 was shown to bind to short DNA sequences near the genes that it targets, which in turn allows DUO1 to control a wide variety of processes needed for sperm cell production.

"This work provides insight into the genetic mechanisms by which fertile gamete production is achieved in flowering plants. Such knowledge will also be helpful in devising strategies for the targeted manipulation of sperm cells, enabling plant breeders to control crossing behaviour in crop plants." This work also provides new molecular tools for the manipulation of plant fertility and hybrid seed production as well the means to control gene flow in transgenic crops where the male contribution may need to be eliminated.

Professor Twell added that the study is timely given the challenges of breeding improved crops to meet the demands of food shortage and food price inflation the world is currently facing.

Provided by University of Leicester