

New insight on the reproductive evolution of land plants

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Arabidopsis thaliana. Credit: Wikipedia.

Around 470 million years ago, plants began to conquer the terrestrial surfaces. The first examples had a small axis terminated by a structure

capable of forming spores, almost like current mosses. The appearance of plant organs mediated the explosive radiation of land plants, which shaped the surface of our planet and allowed the establishment of terrestrial animal life.

However, evolving a diversity of organs, such as roots, leaves, or immobile gametes, requires coordinated genetic changes: the rise of new genes, the repurpose of genetic material, and the development of new regulatory programs. In a study published in *Nature Plants*, a consortium between Europe—including the team led by GREEN-IT member and then IGC, now ITQB NOVA PI at the Plant Reproduction and Evolution Laboratory Jörg Becker—the United States and Singapore introduced an atlas that compiles gene expression data from ten different species of land plants. This is the largest such collection to date. Focusing on the detailed analysis of the collected data, the team looked to identify novel and missing components involved in the formation of sex organs and cells. "Comparing data from such different species allowed us to distinguish genes that are important for the reproduction of all land plants from those that only matter for flowering plants," explains Jörg.

The comparative analysis of the atlases revealed that a large portion of the gene expression remained unchanged throughout evolution, when looking at equivalent organs from different species. The data also showed that the establishment of organs relies heavily on the repurpose of existing genetic material. "We saw that many groups of genes appeared long before the corresponding organ, and this tells us that they emerged through the repurpose of genetic material that already existed," explains the researcher.

The team also looked for patterns in the development of female and male gametes. "We were interested in comparing the first land plants, which have swimming sperm and need water for their reproduction, with plants with non-swimming sperm, which is inside the pollen grain and

does not depend on water for its mobility," says Jörg. The team found that in contrast with female gametes, male gametes presented a high number and conservation of genes, indicating that male reproduction appears to be more specialized than female. Among them, proteins that regulate gene expression—transcription factors—and proteins responsible for transferring phosphate to other proteins—kinases—which are potentially important for the making and function of pollen.

This work also allowed the establishment of the EVOREPRO database, a user-friendly online tool that allows the browsing and comparative analysis of the genomic and transcriptomic data derived from samples across thirteen members of the plant kingdom. This database may be a valuable resource for further studies and validation of key genes involved in organogenesis and land [plants](#) reproduction.

Plants are our greatest source of food and materials and the comprehension of their function is essential to be able to counteract the current issues that plague this resource, and find long term sustainable solutions. "Knowing the genes important for the development and function of a specific organ gives us an indication of which [genes](#) to manipulate to elevate its function. We are looking for those that make sperm and egg development more heat resistant, for example, and for ways to overcome the fertilization barriers between different plant species to obtain superior quality hybrids," concludes Jörg.

More information: Irene Julca et al, Comparative transcriptomic analysis reveals conserved programmes underpinning organogenesis and reproduction in land plants, *Nature Plants* (2021). [DOI: 10.1038/s41477-021-00958-2](https://doi.org/10.1038/s41477-021-00958-2)

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