

# Evolution of Sexual Reproduction in Plants (EVOREPRO)

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ERA-CAPS

ERA-NET for Coordinating  
Action in Plant Sciences



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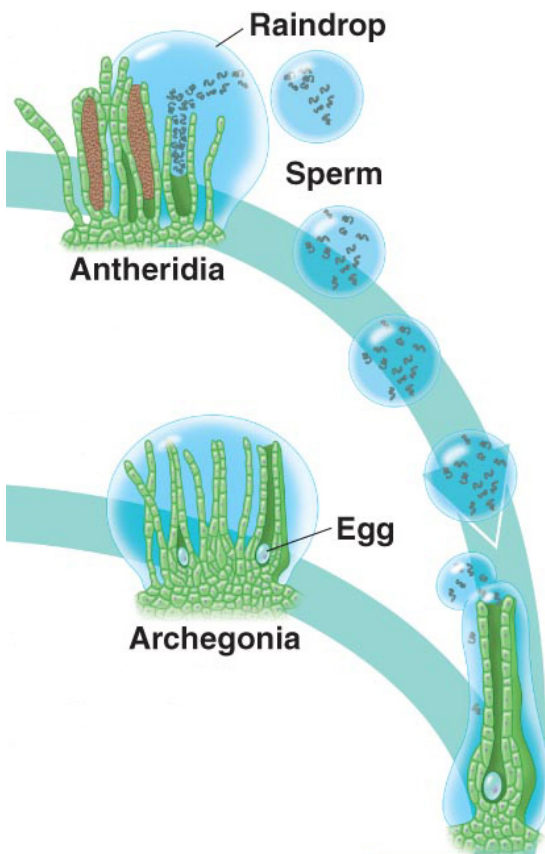


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Providence

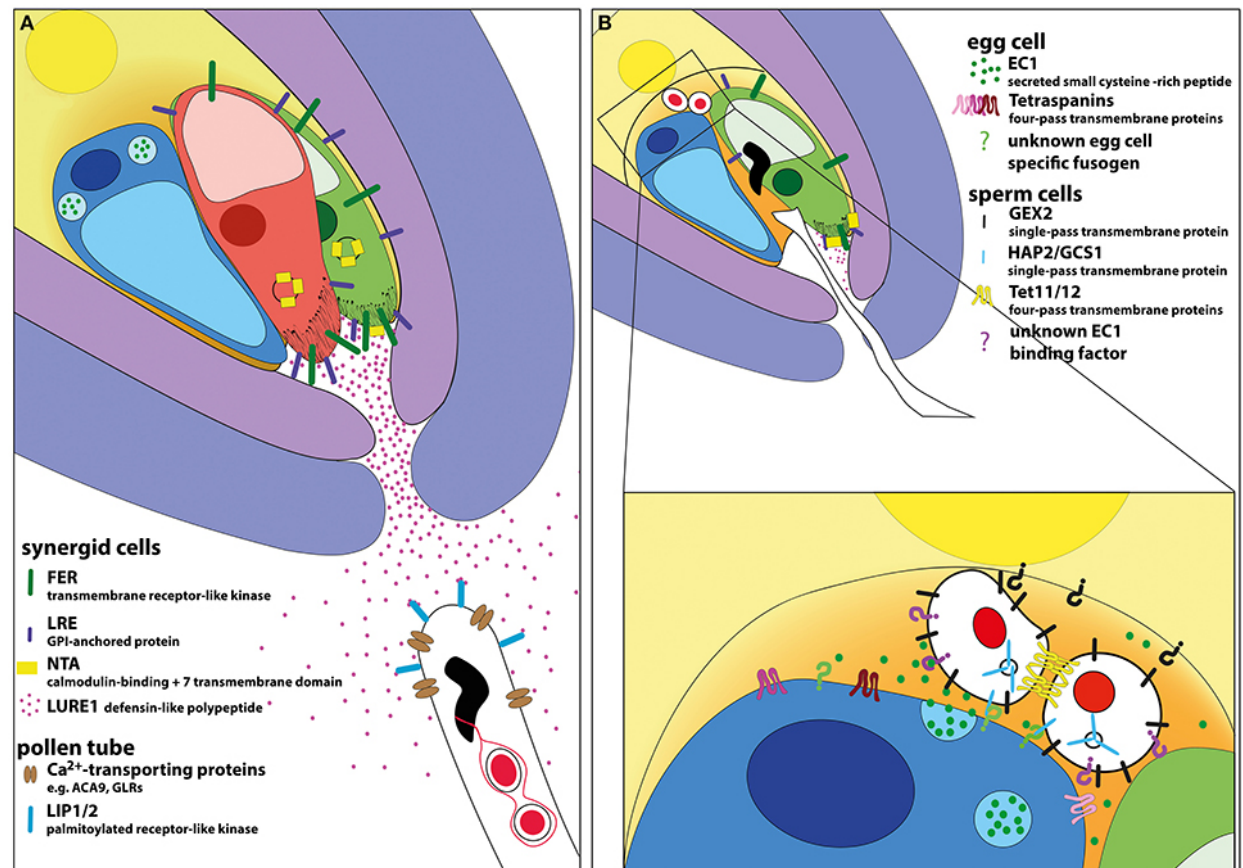


# Evolution of fertilization mechanisms in land plants

## Fertilization in Mosses



## Double Fertilization in Angiosperms



# Objectives & Approach

Identification of novel and missing key components involved in gamete development and fertilization processes:

- germ cell division and specification
- gamete interaction and activation
- prevention of polyspermy
- chromatin re-programming and epigenetic inheritance

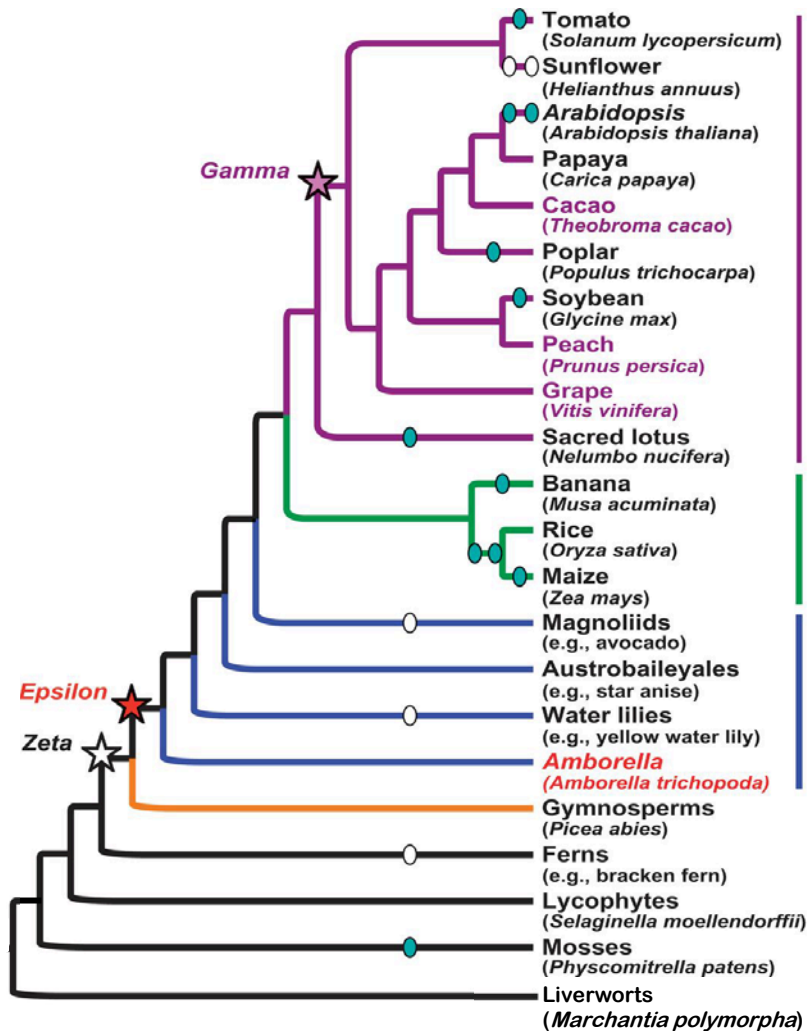


Phylogenetic analyses with co-expression networks based on comprehensive transcriptome data of 7 species to identify key components of evolutionarily conserved and/or angiosperm-specific pathways

Functional analyses of candidate genes in *Physcomitrella*, *Marchantia*, *Arabidopsis*, maize and tomato.



# WP1: Sample collection and transcriptome analysis



→ Tomato\*

→ Arabidopsis\*

→ Rice

→ Maize\*

→ Amborella

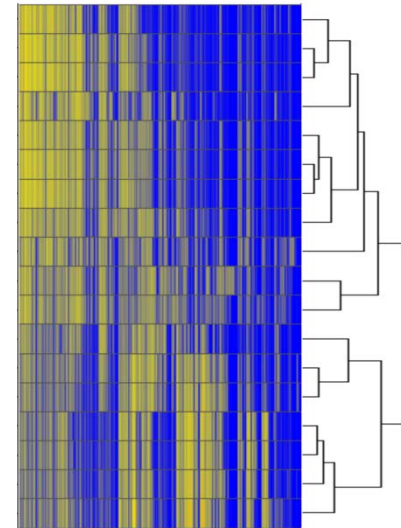
→ Physcomitrella\*

→ Marchantia\*

## Transcriptome analyses

Male gametes

Female gametes



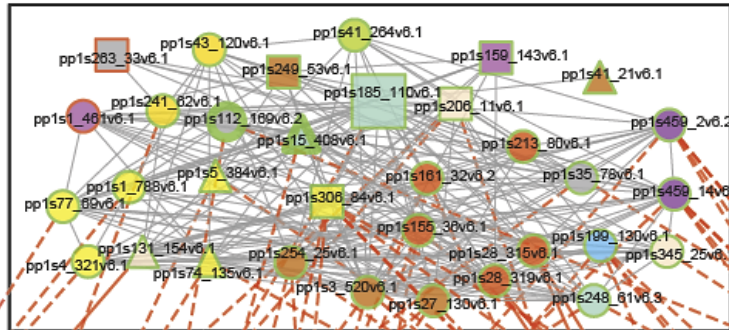
Additional  
diverse tissues

Hony and Twell (2004) Genome Biology  
Pina et al. (2005) Plant Physiology  
Borges et al. (2008) Plant Physiology  
Leydon et al. (2013) PLoS Genetics

# WP2: Co-function co-expression network analysis

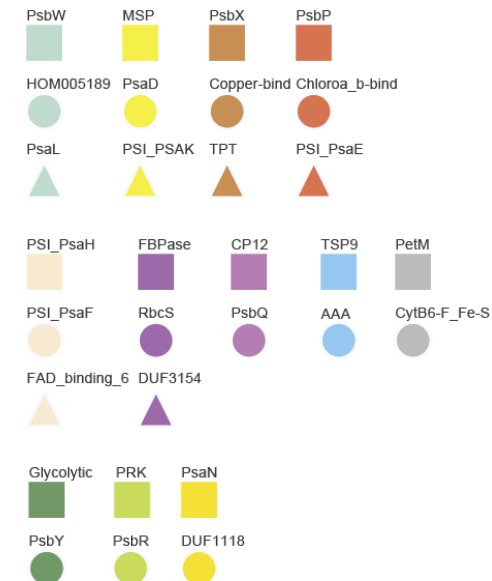


Physcomitrella module 1



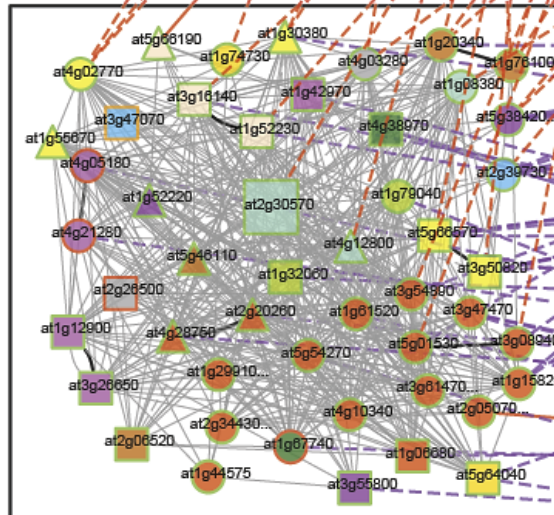
Edge color: event happened in common ancestor of

Green plants Land plants Vascular plants Flowering plants  
Monocots/dicots Rosids, brassicales, malvids/ BEP OS, Oryza/ AT, Arabidopsis/ PP

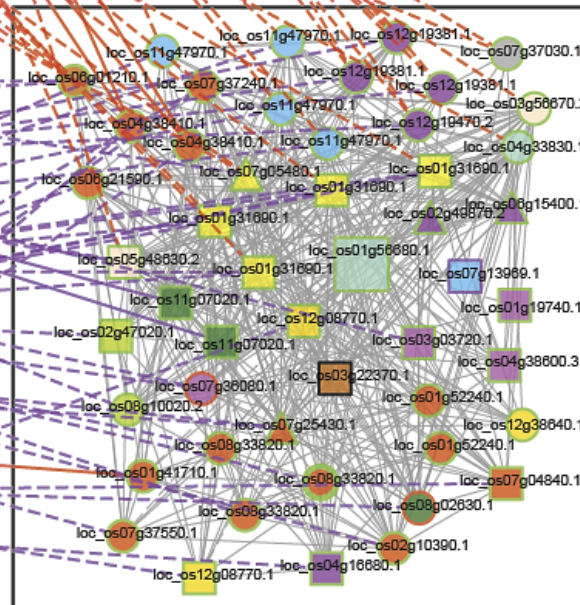


Edge style: event type

— Duplication  
- - - Speciation



Arabidopsis module 2

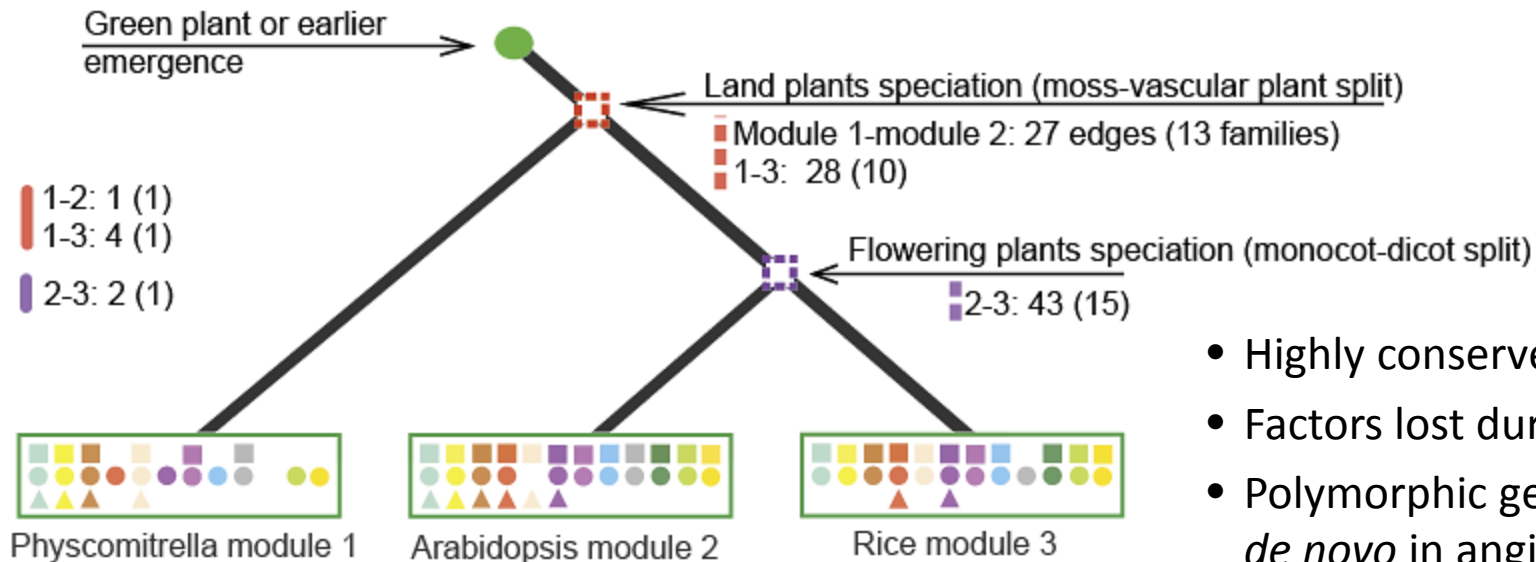


Rice module 3

# WP2: Co-function co-expression network analysis



Phylogenetic interference of pathways – similarities, differences and emergence times



- Highly conserved factors
- Factors lost during evolution
- Polymorphic genes, evolved *de novo* in angiosperm lineage

Edge style: event type

- Duplication
- - - Speciation

Edge color: event happened in common ancestor of

- Green plants
- Land plants
- Vascular plants
- Flowering plants
- Monocots/dicots
- Rosids, brassicales, malvids/ BEP
- OS, Oryza/ AT, Arabidopsis/ PP



# WP3: Gamete interactions and activation



## Evolution of the 4 key stages

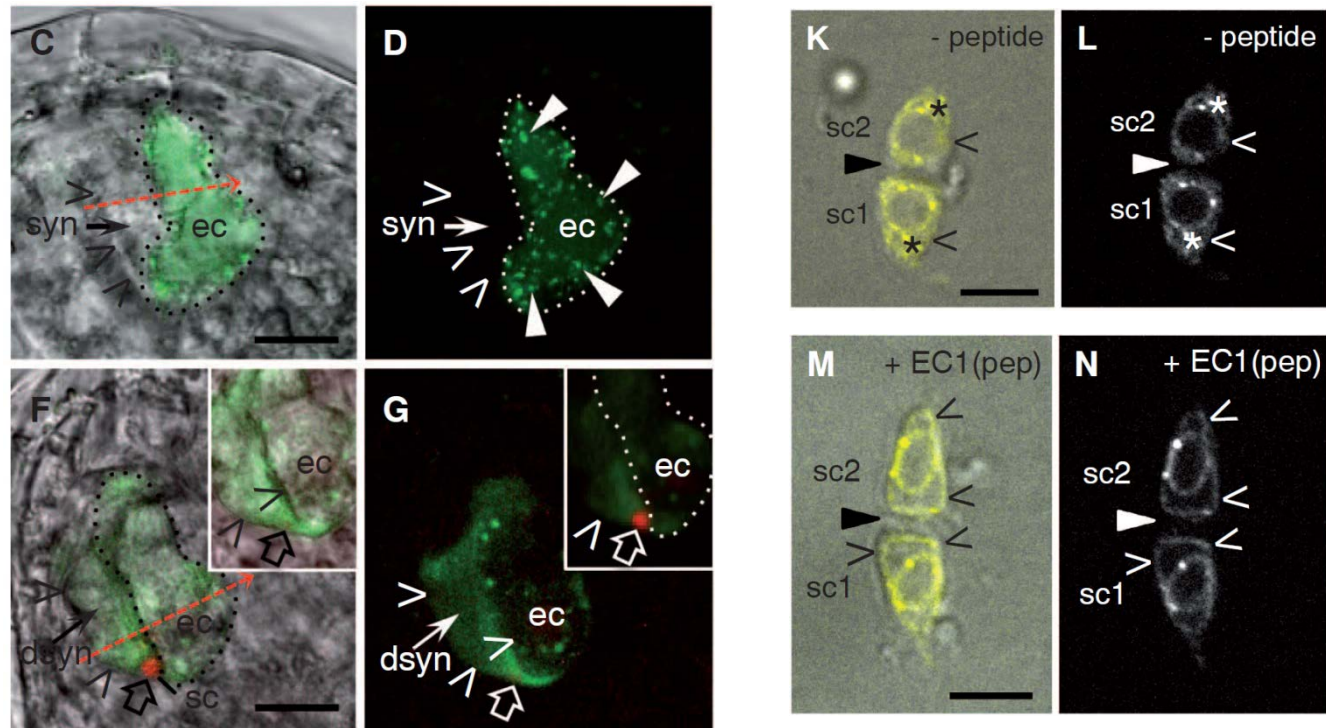
Gametic attraction

Gametic activation

Gamete interaction

Zygote development

- Secreted signalling molecules
- Transmembrane proteins
- Downstream signalling components

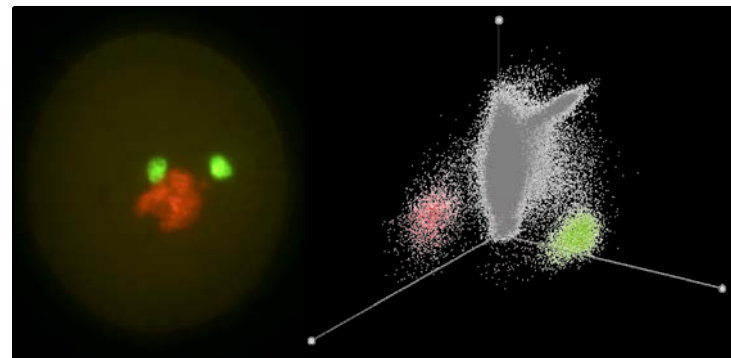
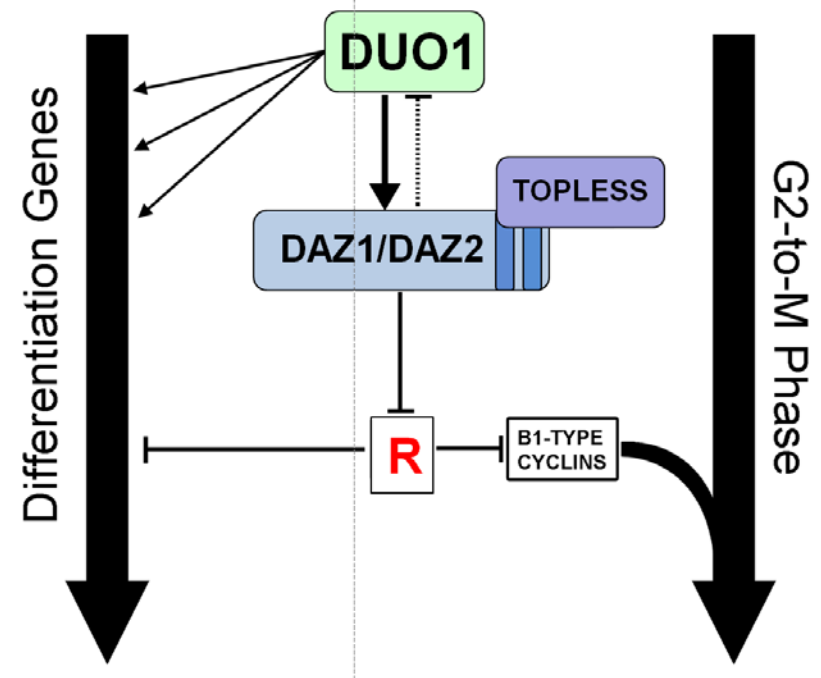
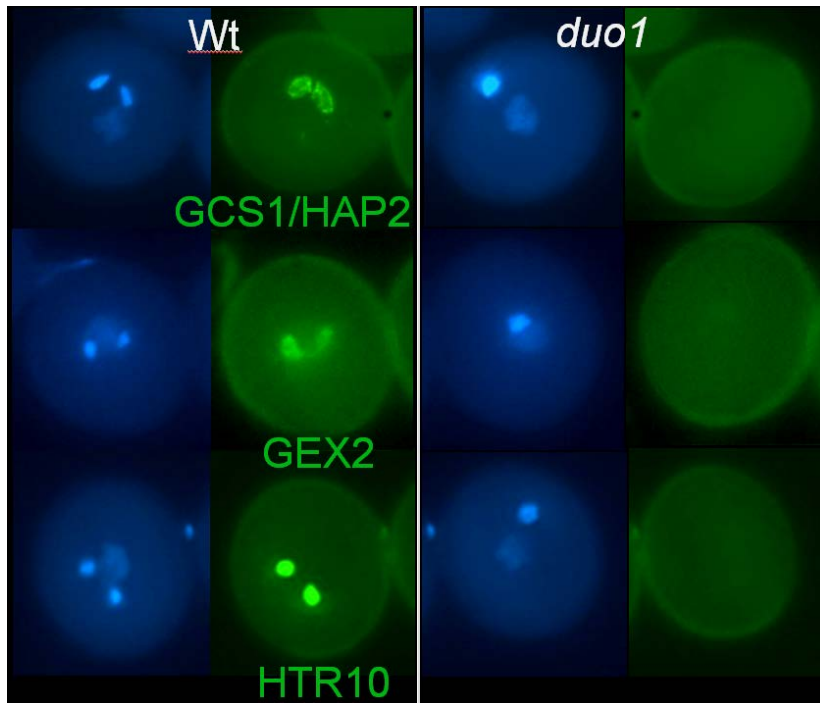


*Egg cell-secreted EC1 triggers sperm cell activation*

Márton et al. (2005) Science  
 Wong et al. (2010) PLoS Genetics  
 Sprunck et al. (2012) Science  
 Costa et al. (2014) Science

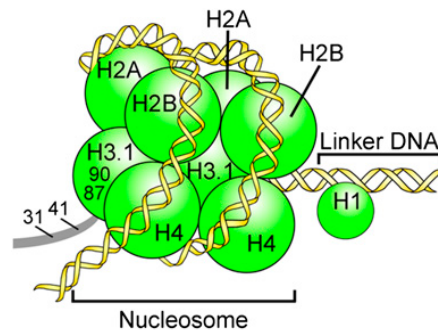
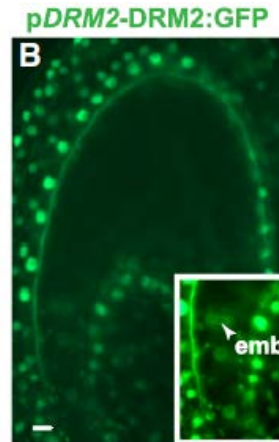
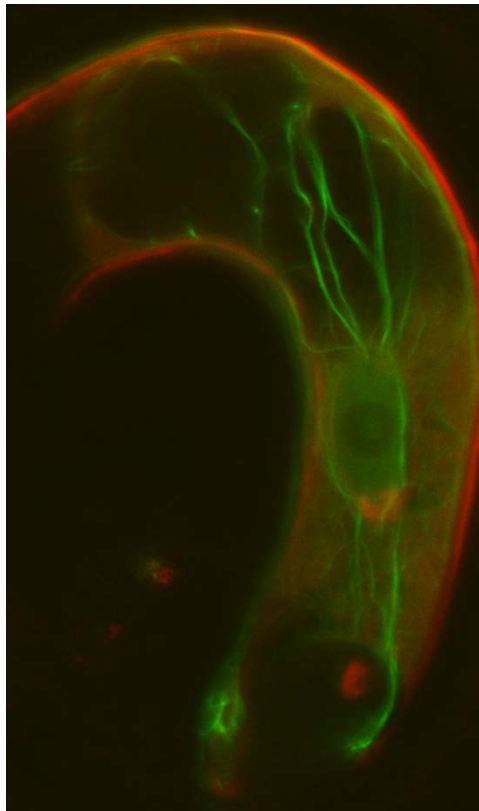


# WP4: Conserved male germline differentiation factors

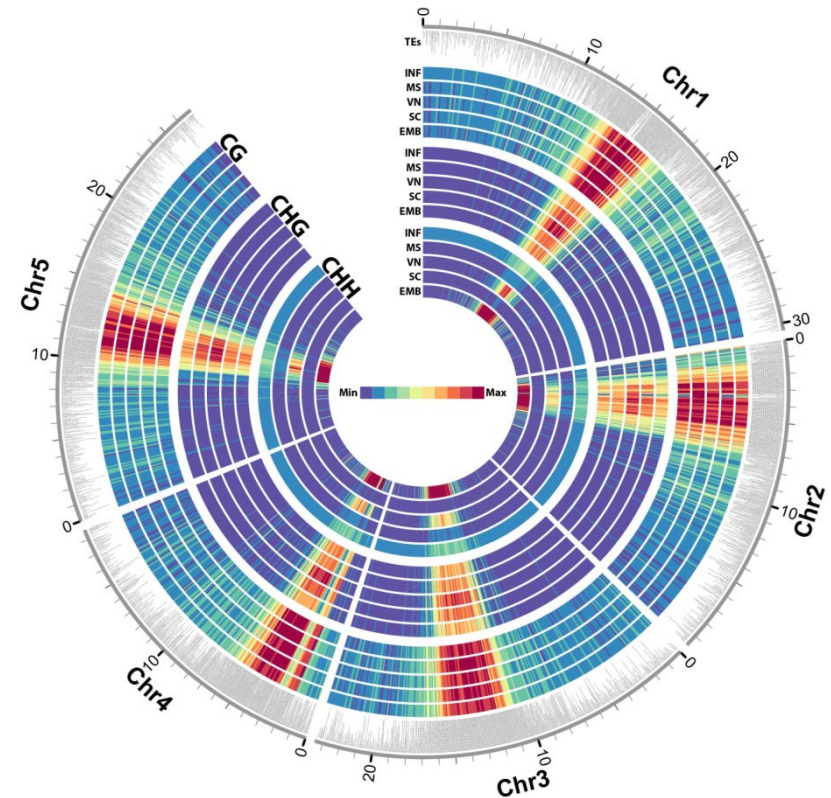


Brownfield et al. (2009) PLoS Genetics  
 Borges et al. (2012) Plant Methods  
 Leydon et al. (2013) Current Biology  
 Borg et al. (2014) Plant Cell

# WP5: Chromatin-reprogramming and epigenetic inheritance



*Karyogamy in Arabidopsis: Histone variants H3.10 in red mark sperm chromatin that fuses with green marked chromatin (H3.3 variant) from the female gamete chromatin. Actin cables in the central cell in green. Picture by T. Kawashima, F. Berger's lab*



Gutierrez-Marcos et al. (2006) *Nature Genetics*  
 Ingouff et al. (2010) *Current Biology*  
 Calarco, Borges et al. (2012) *Cell*  
 Jullien et al. (2012) *Current Biology*  
 Yelangadula et al. (2014) *Cell*

# Expected outcomes

Curated searchable co-expression database to identify conserved gamete-specific co-function networks.



Characterization of novel and conserved key players in sexual reproduction and epigenetic inheritance

Identification of reproductive genes associated with evolutionary transitions from bryophytes to basal angiosperms and to crops.

Novel marker lines to analyse sexual reproduction in *Physcomitrella*, *Marchantia*, maize and *Arabidopsis*.



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