

Open PhD position 2026/2027



Institute of Experimental Botany
of the Czech Academy of Sciences

RNA–protein condensates and their integrative role in pollen development and stress response

Project Description

Introduction

Gene expression in eukaryotic cells is increasingly understood as a spatially organized process that occurs within dynamic, membrane-free cellular compartments. These RNA–protein condensates, formed through liquid–liquid phase separation, include stress granules, processing bodies (P-bodies), and other specialized ribonucleoprotein (RNP) assemblies. Such condensates provide an additional regulatory layer by coordinating mRNA storage, translation, and decay in a context-dependent manner.

The male gametophyte of flowering plants offers a particularly powerful system to study these processes. Pollen grains accumulate large pools of mRNA during development, which are subsequently mobilized in a highly selective manner during pollen germination and rapid pollen tube growth. These events occur under fluctuating environmental conditions and rely on fast and flexible post-transcriptional regulation. Despite this, the presence, dynamics, and functional relevance of RNA–protein condensates in pollen remain poorly explored.

This knowledge gap is especially relevant under heat stress, a major factor limiting plant fertility. Emerging evidence suggests that dynamic reorganization of RNA–protein condensates is a key cellular strategy to cope with elevated temperatures, yet systematic analyses in plant reproductive cells are lacking.

Aims

The primary aim of this PhD project is to elucidate the **role of RNA–protein condensates** in the **development, germination, and stress adaptation of the male gametophyte**. The project will identify and characterize condensate types present in pollen, analyze their dynamics during developmental transitions, and assess their functional impact on translational regulation and reproductive fitness.

Specific objectives include:

- (i) characterization of the **composition and dynamics of RNA–protein condensates** in pollen grains and pollen tubes,
- (ii) investigation of their **role in mRNA storage and selective translation**,
- (iii) analysis of their reversibility and **reorganization in response to heat stress**, and
- (iv) evaluation of the consequences of **condensate disruption** for pollen viability, pollen tube growth, and fertility.

The project will integrate modern concepts of phase separation into plant reproductive biology and significantly advance our understanding of post-transcriptional regulation in pollen.

Methods and experimental approach

The project will primarily use the model plant *Arabidopsis thaliana*. Transgenic lines expressing fluorescently tagged RNA-binding proteins and mRNA reporters will be employed. Live-cell confocal microscopy will be a central tool to monitor condensate formation, dynamics, and dissolution in real time.

Heat-stress experiments, transcriptomic and translomic analyses, proteomic characterization of condensate components, and functional pollen assays (viability, germination, pollen tube growth) will complement imaging-based approaches. The project will combine descriptive and functional analyses to link cellular organization with physiological outcomes.

Expected background of the student

Applicants should have a basic background in molecular or cell biology, preferably with an interest in gene regulation and plant stress biology. Motivation for experimental research, critical thinking, and willingness to learn advanced imaging and omics techniques are essential. Prior experience with microscopy or RNA biology is advantageous but not required.

Research environment, collaboration, and funding

The project will be conducted at the Institute of Experimental Botany of the Czech Academy of Sciences, within the Laboratory of Pollen Biology, in collaboration with Faculty of Science, Charles University, and international partners.

The PhD student will be co-funded by the supervisor through grant and institutional resources guaranteed by the host institution. Funding availability is secured and will not disadvantage the applicant during the admission process.

Suggested reading

- Alberti S, Gladfelter A, Mittag T (2019) Considerations and Challenges in Studying Liquid-Liquid Phase Separation and Biomolecular Condensates. *Cell* 176: 419-434
- Chaturvedi P, Wiese AJ, Ghatak A, Závěská Drábková L, Weckwerth W, Honys D (2021) Heat stress response mechanisms in pollen development. *New Phytol* 231: 571-585, DOI: 10.1111/nph.17380
- Hafidh S, Honys D (2021) Reproduction Multitasking – the Male Gametophyte. *Annu Rev Plant Biol* 72: 581-614, DOI: 10.1146/annurev-arplant-080620-021907
- Hafidh S, Potesil D, Muller K, Fila J, Michailidis C, Herrmannova A, Fecikova J, Ischebeck T, Valasek LS, Zdrahal Z, Honys D (2018) Dynamics of the Pollen Sequestrome Defined by Subcellular Coupled Omics. *Plant Physiol* 178: 258-282
- Klodová B, Potěšil D, Steinbachová L, Michailidis C, Lindner AC, Hackenberg D, Becker JD, Zdráhal Z, Twell D, Honys D (2023) Regulatory dynamics of gene expression in the developing male gametophyte of *Arabidopsis*. *Plant Reprod* 36: 213-241

Application form: <https://forms.gle/zxDLQjYW149rYd356>

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