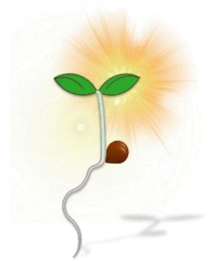
Funded PhD project in Integrated Structural & Cell Biology in Grenoble, France (2025-2028)

Title of the PhD project:

Condensates and Chromatin: How Phase Separation Shapes Plant Temperature Responses



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Keywords: Heat stress response, Liquid-liquid phase separation, thermomorphogenesis

Project summary: Plants, as sessile organisms, must adapt their growth and reproduction to their surroundings. Rising global temperatures due to climate change is one of the most significant challenges facing wild and domestic plant species. Heat stress significantly impacts plant physiology, often reducing crop yields, and has a significant impact in geographic distribution. Plants have evolved heat sensing and response mechanisms, called heat shock response (HSR), that alter development in order to optimize their survival. Central to this response in the model plant *Arabidopsis thaliana*, is Heat Shock Factor A1a (HSFA1a), a constitutively expressed transcription factor (TF) and master regulator of HSR. However, the molecular mechanisms underpinning the activity of HSFA1a, including its oligomerization, DNA-binding and nuclear condensate formation, remain poorly understood.

Under nonstress conditions, HSFA1a is cytosolic and a portion of the protein is bound to heat shock proteins 70 and 90 (HSPs) that act as chaperones, keeping HSFA1a as an inactive monomer. Upon heat stress, HSPs dissociate from HSFA1a and HSFA1a translocates to the nucleus, trimerizes, binds to heat shock elements (HSE) and activates target genes. Recent studies show that HSFA1a is able to displace nucleosomes and act as a pioneer transcription factor, accessing some closed regions of chromatin to trigger efficient HSR. In addition, emerging evidence suggests that trimeric HSFA1a in the nucleus undergoes liquid-liquid phase separation (LLPS). LLPS may enable the formation of HSFA1a-DNA condensates that regulate stress-responsive gene expression. This project investigates how temperature influences HSFA1a's structure, oligomerization, and LLPS, both with and without DNA. It aims to uncover the molecular basis of HSFA1a's nucleosomal DNA binding and the physiological role of LLPS in heat stress response, providing key insights into plant thermoregulation.

Student role: The PhD candidate will investigate HSFA1a's role in plant temperature responses, focusing on its oligomerization, LLPS behavior, and effects on DNA binding and nucleosome displacement. Research will involve recombinant protein expression, biochemical and structural analysis (including SAXS and FRAP), and plant transformation. The candidate will design experiments, analyze data, collaborate with experts, and present findings, gaining broad expertise in molecular biology, biophysics, and plant genetics to advance understanding of plant thermoregulation.

Skills/Qualifications: The ideal candidate holds a Master's degree in molecular biology, biochemistry, structural biology, biophysics, or plant sciences, with experience in molecular techniques, recombinant protein expression, and biochemical/biophysical characterization (preferably SAXS). Fluorescence microscopy skills and familiarity with *Arabidopsis thaliana* transformation are advantageous. Strong analytical, communication, and problemsolving abilities are essential, along with the capacity to work independently and in multidisciplinary teams. The candidate should be motivated to explore plant stress responses and willing to train in advanced techniques while managing multiple research tasks efficiently.

Relevant publications of the team: (5 max.)

Jung J-H*, Barbosa AD*, Hutin S*, *et al.* Nature, 2020.
Hutin S*, *et al*. Proceedings of the National Academy of Sciences, 2023.
Silva CS *#, Nayak A*, Lai X*, *et al.* Proceedings of the National Academy of Sciences, 2020.
Peng M, *et al.* Chen, M. (eds) Thermomorphogenesis. Methods in Molecular Biology, 2024.
Hutin S*, *et al.* 2024 in: Chen, M. (eds) Thermomorphogenesis. Methods in Molecular Biology, 2024.