MASTER THESIS OFFER OF CEPLAS

(FOR COMPUTATIONAL MASTER STUDENTS FROM TECHNICAL UNIVERSITY OF MADRID, UPM)

Title of Master Thesis

Quantitative analysis and modelling of the Arabidopsis shoot apical meristem during the floral transition.

Description of student´s tasks

The student will have the opportunity to apply quantitative image analysis and mathematical modelling to understand the floral transition in the Arabidopsis shoot apical meristem (SAM), the stem cell niche responsible for formation of all the above ground plant organs.

During the floral transition, the identity of the SAM switches from a vegetative meristem, which forms leaf primordia, to an inflorescence meristem, which forms floral primordia. During this transition, the SAM undergoes a visible morphological change from a flat to a domed structure. This project aims to quantify this morphological change and to understand how it is related to the underlying stem cell regulatory network. It will involve computational analysis of a time series of confocal images, and mathematical modeling of the gene expression network that maintains the population of stem cells.

This work will be performed under the supervision of Prof Dr George Coupland and Dr Pau Formosa-Jordan at the Department of Plant Development at the Max Planck Institute for Plant Breeding Research in Cologne.

References

Gruel, J., Landrein, B., Tarr, P., Schuster, C., Refahi, Y., Sampathkumar, A., Hamant, O., Meyerowitz, E. M. and Jönsson, H. (2016). An epidermis-driven mechanism positions and scales stem cell niches in plants. *Science Advances*, *2*(1), e1500989–e1500989. https://doi.org/10.1126/sciadv.1500989

Kinoshita, A., Vayssières, A., Richter, R., Sang, Q., Roggen, A., van Driel, A. D., Smith, R. S. and Coupland, G. (2020). Regulation of shoot meristem shape by photoperiodic signaling and phytohormones during floral induction of Arabidopsis. *In revision*.

Landrein, B., Formosa-Jordan, P., Malivert, A., Schuster, C., Melnyk, C. W., Yang, W. B., Turnbull, C., Meyerowitz, E. M., Locke, J. C. W. and Jonsson, H. (2018). Nitrate modulates stem cell dynamics in Arabidopsis shoot meristems through cytokinins. *P Natl Acad Sci USA* **115**, 1382-1387.

Prerequisites *(languages, informatics skills, bioinformatic skills, other knowledge, etc)*

Experience in coding and scripting is required (most importantly Python and Matlab; C++ or C would be desirable). Some knowledge on modelling gene regulatory networks through ordinary differential equations would be helpful. It is expected that the student is fluent in English.

Training Project

EXTERNAL PRACTICES/MASTER THESIS. The fundamental goal of the external practices is to guide the student in applying his previously acquired knowledge to real tasks in a group work environment the realistically represents the work conditions the students will encounter in their future roles. In this way, the student will be able to get familiar with a working environment (work schedule, responsability, attitude, organization, etc.), and with the adequate working methodology in professional reality, contrasting and applying the acquired academic knowledge.

Activities that will be performed in the academic internship/Master Thesis:

1) Characterization of SAM curvature and gene expression domains during the floral transition. This characterization will be performed using existing confocal images of the shoot meristem with the Regions Analysis Matlab custom made software (https://gitlab.com/slcu/teamHJ/pau/RegionsAnalysis).

The goal of this activity will be to better define the different stages of the floral transition and to understand possible correlations between gene expression domains and meristem morphology. Matlab classification learner algorithms will be used to determine which are the features that best define the different stages of the floral transition.

2) To develop and implement a multicellular computational model of a simplified gene regulatory network of the stem cells in the shoot apical meristem during the floral transition. Simulations will be performed with python scripts and possibly with Tissue/Organism C++ packages (see https://gitlab.com/slcu/teamHJ/tissue and https://gitlab.com/slcu/teamHJ/Organism) . Such simulations will be realized on idealized meristem templates and also on templates extracted from experimental data, starting in 2D (emulating longitudinal meristem sections) and with the possibility to extend it in 3D.

This activity will enable testing how well the current understanding of the stem cell gene regulatory network can recapitulate the observed experimental features quantified in the first part of the project. When recapitulation of the experimental data does not occur, alternative modelling hypotheses about the regulatory network will be generated.

Nº of positions offered:	**1**
Has the student dealings with underage persons?	**NO**
Starting date:	20/09/2021 (Flexible)
End date:	Flexible
Weekly hours *(only for internship in CEPLAS lab):*	Flexible
Working hours *(only for internship in CEPLAS lab):*	Flexible
Fellowhips *(if any, NOT REQUIRED):* **Remuneration (€/month):**	If the student performs the internship in Cologne at the Max Planck Institute some remuneration will be provided.
Academic tutor (UPM/CBGP): *(you need a Tutor from UPM Master, not involved in the research activity)* **Email**:	Krzysztof Wabnik k.wabnik@upm.es
Department/Research Group of UPM/CBGP Academic tutor:	Computational Systems Biology and Genomics, CBGP
CEPLAS Internship/Master Thesis Tutor/Director:	Prof. Dr. George Coupland
Email CEPLAS tutor:	coupland@mpipz.mpg.de
Department CEPLAS tutor:	Prof. Dr. George Coupland

Location of the internship (telecommuting?):	Telecommuting possible, but visiting Cologne and working with experimental colleagues at the Mac Planck Institute for at least some of the internship would be preferred.
CEPLAS Institution:	Max Planck Institute for Plant Breeding Research
To be completed by Internship Office ETSIAAB-UPM: **Number of ECTS (Nº ECTS)**: 15 ECTS	

Send by email to: international.cbgp@upm.es (Pablo Gómez)