Modeling the emergence of polarity patterns in meristemic auxin transport

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Arabidopsis thaliana is one of the most common plants in Europe and Asia. Although it is a weed, it is the model organism for plant genomics. Indeed it has a small genome ($\simeq$ 157 Mbps) that was completely sequenced in 2000 [1] and much functional information is now known and available in curated databases [2].

Our main interest is the floral morphogenesis and floral organ specification, e.g., petals and carpels [3,4]. At the heart of these developmental processes is auxin, a diffusing hormone whose non-homogeneous concentration profile in plants tissues represents a first marker (morphogen) for organ primordia and as a consequence for cell differentiation [3,5,6]. The importance of such a study lies in the understanding of the mechanisms of morphogenesis, a fundamental phenomenon characterizing many living organisms in the earlystages.

As illustrated in [7,8,4], many approaches can be followed to study this kind of phenomenon, according to the biological level of interest, e.g., genetic regulation or macroscopic pattern formation. In our case, we want to re- produce the concentration profiles of auxin through a generalized reaction- diffusion model [9] in a cell-based model. In our model, auxin is produced, diffuses and is degraded. As demonstrated in [10,11,12], this is not enough to ensure cellular differentiation : therefore we introduce active transport processes across cellular membranes, modeling both the intra-cellular space and the apoplast, i.e., the space between two nearest neighbor cells. On the cellular membrane we include the two auxin transporters, known as PIN1 and AUX1 [11], allowing in particular a cellular polarization of the PIN1 transporters [13]. The challenge is to understand how observed polarity can emerge in this system and how it drives morphogenesis. We have implemented these models in one and two dimensions and adjusted the parameters to reproduce the observed concentration profiles [14]. Focusing in particular on cell polarization, we have observed that two different peculiar regions arise as a function of diffusion - unpolarized one in the high diffusion regime and a polarized one otherwise - in both of the models.

Further directions will concern the study of phyllotaxis, i.e., the high regular patterns identified in the disposition of organs in plants [15,16] through a straightforward extension of the model.

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