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Robustness Conditions for the Establishment of Stationary Patterns of Drosophila Segmentation Gene Expression

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Abstract : First manifestation of a segmentation pattern in the early Drosophila development is the formation of expression domains (along with the main embryo axis) of genes belonging to the trunk gene class. Highly variable expression of genes from gap family in early Drosophila embryo is strongly reduced by the start of gastrulation due to the gene cross-regulation. The dynamics of gene expression is described by a gene circuit model for a system of four gap genes. It is shown that for the formation of a steep and stationary border by the model it is necessary that there existed a nucleus (modeling point) in which the gene expression level is constant in time and hence is described by a stationary equation. All the rest genes expressed in this nucleus are in a dynamic equilibrium. The mechanism of border formation associated with the existence of a stationary nucleus is also confirmed by the experiment. An important advantage of this approach is that properties of the system in a stationary nucleus are described by algebraic equations and can be easily handled analytically. Thus we explicitly characterize the cross-regulation properties necessary for the robustness and formulate the conditions providing this effect through the properties of the initial input data. It is shown that our formally derived conditions are satisfied for the previously published model solutions.

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