Modeling animal tissues in *VirtualLeaf*: Towards an off-lattice Cellular `Potts' model

Harold Wolff[1,2], Lance Davidson[1] and Roeland Merks[2,3,*]
Presenting author: merks@cwi.nl

1. Department of Bioengineering, University of Pittsburgh, Pittsburgh, PA
2. Centrum Wiskunde & Informatica, Amsterdam, The Netherlands
3. Mathematical Institute, University Leiden, Leiden, The Netherlands

Cell-based modeling is a computational modeling paradigm used for problems of biological development. It predicts collective cell behavior and morphogenesis from the underlying behavior of single cells. A widely used cell-based method is the cellular Potts model that represents cells as patches on a regular lattice and represents intercellular forces using a Hamiltonian description. A Metropolis algorithm mimics displacements of the cell-cell interfaces as a function of the Hamiltonian and a random cell motility term. As a disadvantage of the cellular Potts model, lattice artifacts may appear for some parameter choices. Off-lattice methods of course do not suffice from lattice artifacts, and include vertex-based approaches that describe cells as irregular polygons or as the faces in an irregular tessellation Many vertex-based approaches are limited in how well they represent membrane fluctuations: the cell-cell interfaces are straight by definition and deterministic solutions are used, precluding the modeling of phenomena driven by such fluctuations, e.g., differential-adhesion driven cell sorting. Here we introduce a recent extension of our vertex-based cell-based modeling framework for plant development, *VirtualLeaf*, for modeling cell motility in confluent tissues. *VirtualLeaf* represents membrane fluctuations by randomly moving the vertices at the cell-cell interfaces depending on a Hamiltonian. To represent relative cell movement, we introduce a new topological rearrangement operator, elementary to T1 and T2 transitions, that we named "slide". The new model reproduces typical results of cellular Potts simulations, including differential-adhesion cell sorting, and gives new insight into published simulations of topological ordering in epithelial tissues. Although the new method is currently limited to the simulation of confluent tissues, it provides a first step towards an off-lattice solver of the Cellular Potts model.