Dynamic Organization of Two Dimensional Tissues

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During the development of an organism from the fertilized egg, tissues grow by cell proliferation. Spatial patterns of gene expression are to control the formation of morphologies. An important model system for the study of developing epithelia is the wing development of the fruit fly Drosophila. The wing imaginal disk grows from about 50 to 50000 cells and undergoes several morphological changes. The dynamic organization of cell packings in a developing epithelium can be described theoretically by a vertex model. In this model, the network of adhesive junctions is a force balanced stable configuration of a potential function. Tissue morphologies can be generated by introducing repeated cell division. Cell division leads to local rearrangements and topological changes of the network which implies changes of neighborship relations of cells. We show that the vertex model can quantitatively account for observed tissue morphology and mechanics. Within this framework, one can address additional systems of proteins which control the biophysical cellular properties and thus guide the remodeling of the tissue. An important example are the planar polarity proteins (PCP) which control polar anisotropies in the tissue and play an important role during pupal development. We relate our results to experiments in the wing disk of the fruit fly.