Extended Cell Model to Simulate Cell Sorting

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Genesis and regeneration of form are fundamental processes in multi-cellular organisms. Cell sorting after differentiation is one such process where cells of different tissues organize themselves in separate patches. Hydra viridissima is an extreme case since it is capable of regenerating its entire body after having its cells randomly mixed. Physical mechanisms underlying segregation have long being disputed in the literature, in fact for nearly 60 years. Differential adhesion (DAH) (1962) among cells of different tissues has been the initial idea, and, despite being challenged by the Differential Surface Contraction Hypothesis (SCH) (1976) just fourteen years after, the first one still dominates biology text books today. DAH explains segregation in analogy with liquid drops of different surface tensions, while SCH attributes the phenomenon to the differences in the rigidity of the cell cortex.

At this point simulations come at hand, simple active matter models with point like particles interacting with harmonic forces show that cell segregation, as proposed by DAH, is indeed reached when adequate differences in forces are used. The difficulty with these point particle models to simulate SCH is the absence of cell structure, that is, they do not correctly emulate the cytoskeleton, a necessary step to approach SCH. Here we propose a model where cells are composed by active particles tightened to a nucleus and to their neighbors by elastic/plastic forces. It can also interact with neighboring cells through elastic short range forces. This results in a cell that may change its form, depending on the interaction with its neighborhood. After adjusting the set of model parameters, we are able to run simulations to test both hypothesis. Initial results show that segregation is reached if we use the same inner structure for all cells and different forces of attraction among different cells. This confirms DAH results of previous simulations with single cells. Now, we explore the cases where cells have different inner structure.