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Molecular and mechanical interactions in early mammalian embryo

Mammalian embryogenesis is a dynamic process involving gene expression and mechanical forces between proliferating cells. Despite a wealth of research and identification of the key genes contributing to the development of the early embryo, the precise nature of these interactions is still elusive. We have developed a computational modeling framework by which we can analyze the process of embryo development and differentiation to specific tissues during its first 4.5 days [1]. We combine mechanical and biochemical interactions between the cells to investigate how different mechanism contribute to the specification of the trophectoderm, primitive endoderm and alignment of the embryo axes. In the case of the trophectoderm formation we compare robustness of two models by which the characteristic pattern of Cdx2 and Oct4 transcription factors forms: gene expression is influenced by position of the cell or both expression and position are regulated by the pattern of symmetric/asymmetric divisions depending on the Cdx2 levels. During endoderm formation we examine influence of differential adhesion, geometrical constraints and stochastic active movement of cells on efficiency of endoderm layer specification. We demonstrate how purely mechanical factors can be responsible for alignment of the animal-vegetal and embryonic-abembryonic axes of the embryo. This work by combination of the cell-based spatial mechanical simulations with a genetic network approach hints that these two domains may be inseparably linked and that taking their interactions into account can be necessary for explaining mammalian embryogenesis.

References

[1] P. Krupinski, V. Chickarmane and C. Peterson, *Simulating the mammalian blastocyst - molecular and mechanical interactions pattern the embryo* to appear in PloS Comp. Biology