Multi-Cell Modeling of Biological Development using the GGH Model and CompuCell3D

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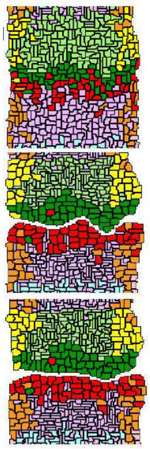

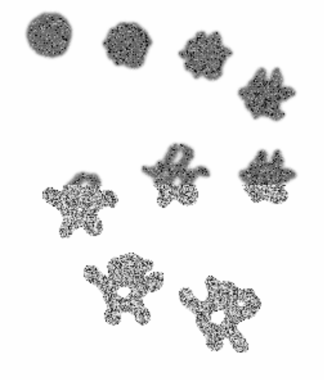

While bioinformatics tools for the analysis of DNA sequences, reaction kinetics models of biomolecular networks and molecular dynamics simulations of biomolecules, are all widely used, multi-cell modeling of developmental processes at the tissue scale is still relatively undeveloped. One of the key reasons for this neglect has been the lack of widely-accepted modeling approaches and the computational difficulty of building such models. Now, a growing community of modelers has settled on the GGH Model, a modeling approach that derives from the familiar Potts model of statistical mechanics, as a convenient methodology to create sophisticated multi-cell simulations of tissue development, creating a *de facto* common modeling approach. The GGH's use of an Effective Energy and constraints to describe cell behaviors simplifies integration of multiple biological mechanisms, while the availability of open-source tools like CompuCell3D for building GGH models makes developing, validating and sharing such simulations much easier for non-specialists. I will introduce the GGH and the modeling environment CompuCell3D (http://www.compucell3d.org/), then apply the GGH to modeling somitogenesis *in vivo*, and to angiogenesis and vasculogenesis *in vitro* (see pictures), illustrating some of the questions this type of modeling can address (*e.g.* error correction mechanisms in development) and discussing its application to other developmental-biology problems including tumor growth, gastrulation, and biofilms. I will also discuss some of the key mathematical and computational issues which GGH models and modeling environments still need to address.

Dr. Glazier received his B.A. in Physics and Mathematics from Harvard University and his M.S. and Ph.D. in Physics from the University of Chicago. His research focuses on experimental and computational approaches to pattern formation in embryology. He has held an NSF/JSPS postdoctoral fellowship in biophysics at the Research Institute of Electrical Communication, Tohoku University, Sendai, Japan, and faculty appointments at the University of Notre Dame and Indiana University, Bloomington, where he is director of the Biocomplexity Institute, Professor of Physics and Adjunct Professor of Informatics and Biology. He is Chair Elect of the Division of Biological Physics of the American Physical Society, an Editor of *Nonlinearity*, *Journal of Computational and Nonlinear Dynamics*, and *Mathematical Biosciences and Engineering*, a Fellow of the American Physical Society and the Institute of Physics (London) and co-founder of SpheroSense Technologies, Inc..