A Diffuse Interface Framework for Modeling the Evolution of Multi-cell Aggregates as a Soft Packing Problem

S. Rudraraju[1] ,J. Jiang[2] , D. Auddya[1] ,T. Topal[2] ,L. V. Diaz[3] , K. Garikipati[2]

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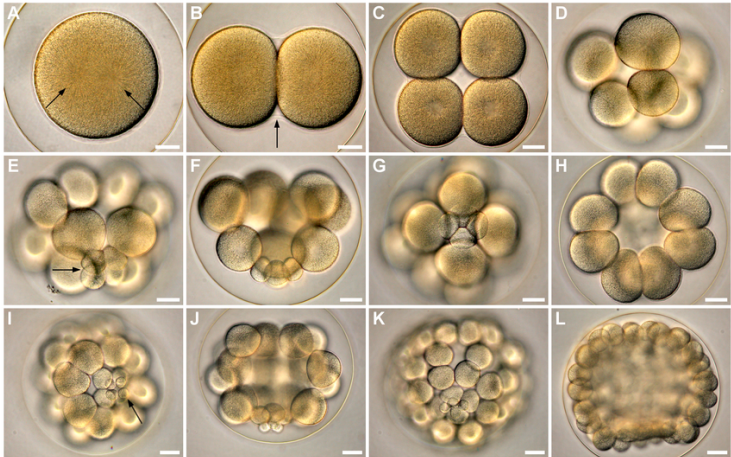
[3] Oakland University, Michigan

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Soft packing problem: Overview

- Motivation
    - Embroyogenesis
    - Tumor growth
- Previous models
    - Vertex based, cell based, cellular automata.
- Phase field formulation of soft packing
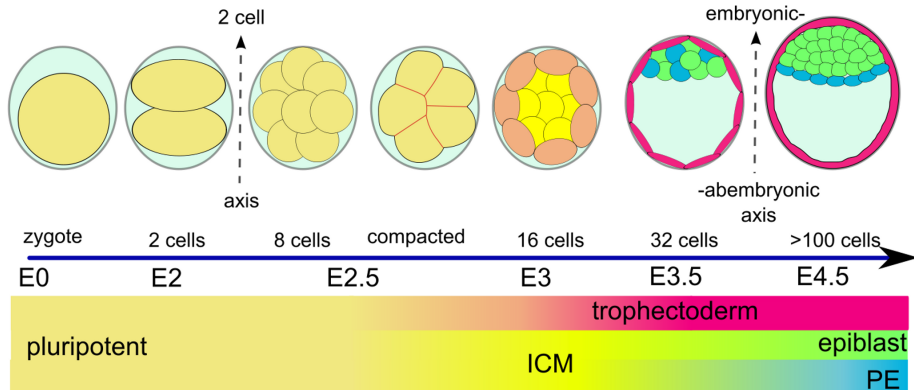- Mechanics of soft packing
- Material models
- Summary

Motivation: Embroyogenesis

Early cleavages of C. subdepressus under light microscopy [Reference: B. C. Vellutini and A. E. Migotto, PLOS One, 2010]
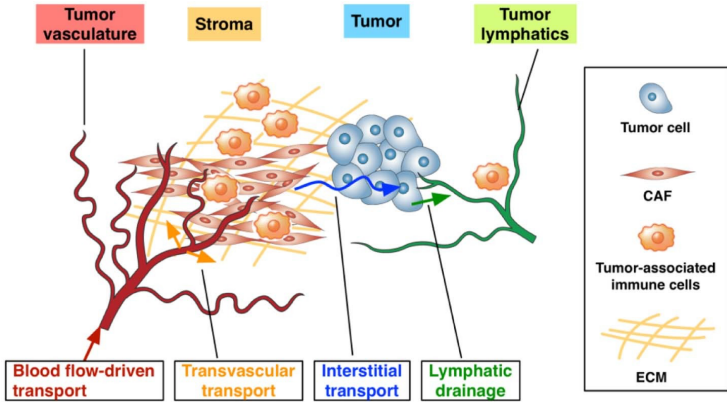
Embroyogenesis in C. subdepressus

Motivation: Embroyogenesis

Schematic view of morphological and lineage specification steps during the early mouse embryonic development [Reference: Krupinski P, Chickarmane V, Peterson C (2011), PLoS Comput Biol 7(5): e1001128]
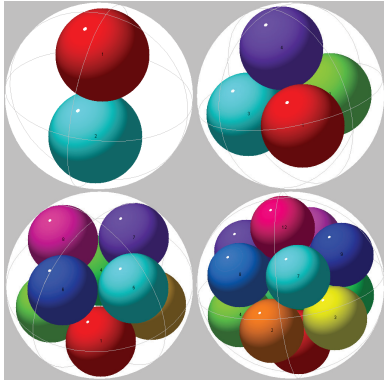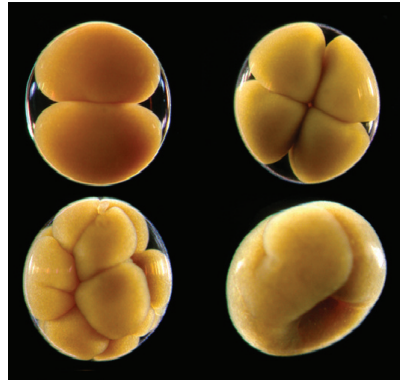
Motivation: Tumor growth

Complexity of the tumor microenvironment [Reference: Bumsoo Han et al., Cancer Letters, Vol. 380: 1, 2016]

Cell packing in growing tumors [Reference: Mills Lab, RPI]

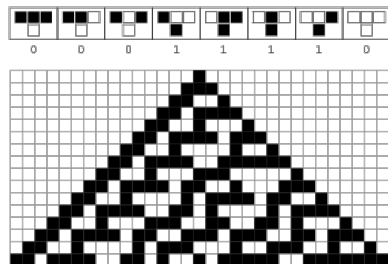# Soft packing of cells in cellular aggregates

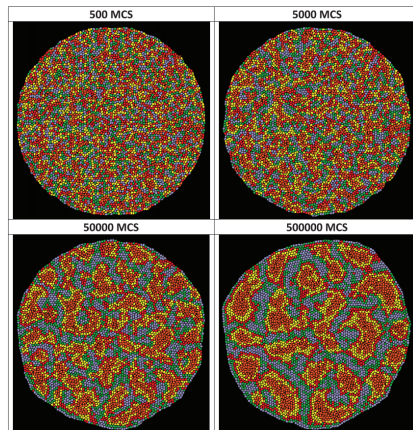Hard Packing of Spheres [1]

Soft Packing of Cells [2]

[1] https://commons.wikimedia.org/w/index.php?curid=29251495
[2] Embryo of Echinaster brasiliensis (A. E Migotto, Universidade de Sao Paulo)
https://www.cell.com/pictureshow/embryogenesis

Relevant numerical models: Cellular automata / High-Q Potts models

Cellular automata rules[1]

Clustering dynamics using CA models[2]

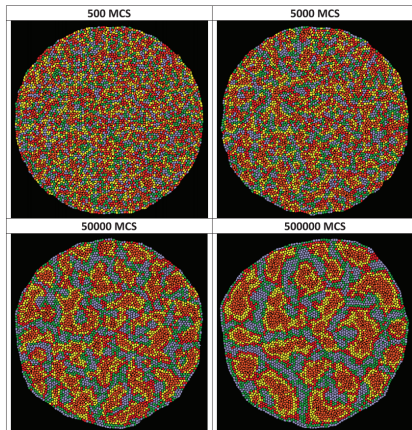[1] http://mathworld.wolfram.com/CellularAutomaton.html
[2] Y. Zhang et al., PLoS ONE 6(10): e24999. doi:10.1371/journal.pone.0024999, 2011

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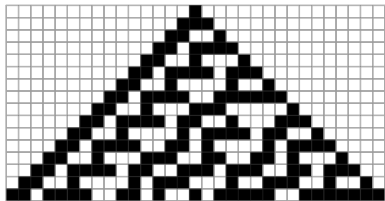
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[2] Y. Zhang et al., PLoS ONE 6(10): e24999. doi:10.1371/journal.pone.0024999, 2011

Soft packing: A phase field approach

Soft packing: A phase field approach

Soft packing: Results

Soft packing: Results

Soft packing: Role of mechanics

Soft packing: Shape model

Shape model: Results

Shape model: Results

Shape model: Extension to material models

Soft packing: Connection to embroyogenesis

Soft packing: Connection to tumor growth

Summary and ongoing work

Thanks!!!