Building a physical cell simulation and comparing with confocal microscopy

Chris Rycroft[1], Daniela Ushizima[2] Robert Saye[1], Cyrus Ghajar[3], Mina Bissel[3], James Sethian[1,2],

[1]Mathematics Department, University of California, Berkeley, CA;
[2]Computational Research Division, Lawrence Berkeley National Lab, Berkeley, CA.
[3]Life Sciences Division, Lawrence Berkeley National Lab, Berkeley, CA;

DISCLAIMER

Chris Rycroft[1], Daniela Ushizima[2] Robert Saye[1], Cyrus Ghajar[3], Mina Bissel[3], James Sethian[1,2],

[1]Mathematics Department, University of California, Berkeley, CA;
[2]Computational Research Division, Lawrence Berkeley National Lab, Berkeley, CA.
[3]Life Sciences Division, Lawrence Berkeley National Lab, Berkeley, CA;

In this project, we aim to make use of the techniques of applied mathematics and physics to create a simulation model for a group of cells that is based upon mechanical principles. With this model, we aim to answer questions about cell morphology, mechanics, and local interactions that would be difficult to address otherwise.

Mechanical and physical effects can have a strong influence on the growth of cells and their behavior, and it is increasingly understood that a cell's microenvironment can play an important role in the development of cancer. Both normal and malignant cells are known to exhibit plasticity, changing their structure and function in response to a variety of external signals. In some cases, malignant cells can undergo reversion, taking on a more normal phenotype when transplanted into healthy milieu.

Computational models provide a powerful tool to understand physical and biological mechanisms. However, many of the widely used methods, such as Agent Based Modeling, employ rules that are based upon qualitative behavior. While these approaches are useful for addressing many biological questions, they are not easily adapted to model mechanics, such as how much pressure one cell exerts on its neighbor.

Developing a model to address these questions requires detailed feedback from experimental data. The images below show three different clusters of mammary epithelial cells grown in vitro. We employ image analysis to quantitatively compare to our simulation data.

This work was partially supported by the Office of Energy Research, U.S. Department of Energy, under Contract Number DE-AC02-05CH11231.