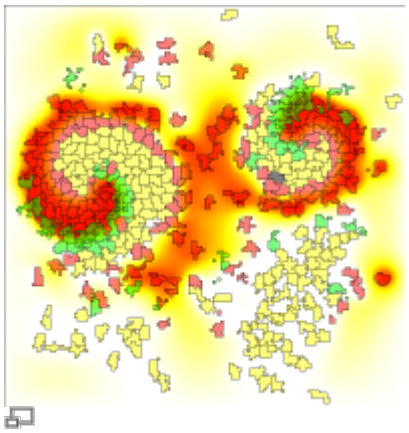
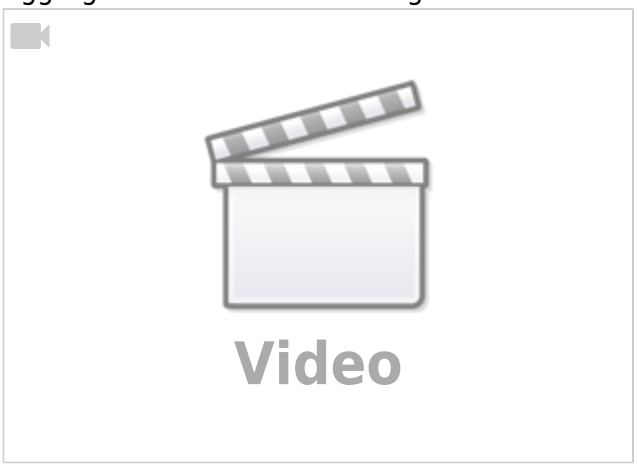
Multiscale models

Dictyostelium



Aggregation of amoebas through chemotaxis towards waves of cAMP.



Introduction

This model show chemotactic aggregation of Dictyostelium. It was constructed by students attending the ECMI modeling week 2012 in Dresden.

Model description

This model shows an interesting coupling between CPM cells and reaction-diffusion PDE. Cell state depends on the perceived concentration of cAMP, and determines whether a cell produces cAMP and whether it performs chemotaxis. The PDE is governed by a Fitzhugh-Nagumo-like model of an excitable medium, which causes traveling waves upon excitation. Chemotaxis through those waves causes cell aggregation.

Background colors indicate the cAMP concentration. Cells are color-coded according to their phase: excitable/resting (yellow), excited/chemotactic (green), refractory/resting (red).

Model

h Dictyostelium.xml |h

```
extern>
http://imc.zih.tu-dresden.de/morpheus/examples/Multiscale/Dictyostelium.xml
```

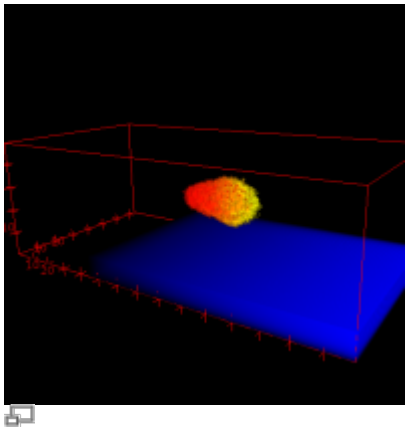
In Morpheus GUI: `Examples → Multiscale → Dictyostelium.xml`

References

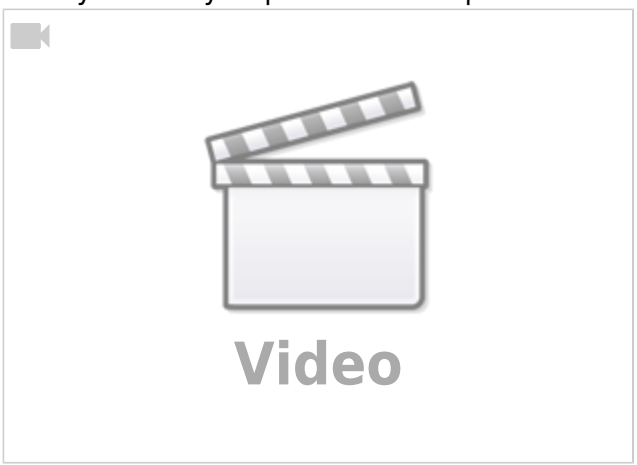
- Rost F, Quintero A, Myllykoski M, Igolkina A, Rohde O'Sullivan Freltoft A, Dixit N, Morphogenesis and Dynamics of Multicellular Systems. *ECMI Newsletter*, 52, 2012.
- Savill N and Hogeweg P. Modelling morphogenesis: from single cells to crawling slugs. *J. Theor. Biol*, 184:229–235, 1997.

MembraneProperties: Cell polarization and chemotaxis

Note: MembraneProperties are not available in public version of Morpheus.



Cell dynamically re-polarizes in response to switching external gradient



Introduction

This model of cell polarity shows the coupling of three model formalisms:

- A cellular Potts model
- A PDE model, solved on the membrane of the cell
- And an external gradient.

The cell membrane polarizes in response to the external gradient. Chemotactic cell motility depends on the polarity of the cell and the external gradient.

Description

This example implements two models of cell polarity: Meinhardt's substrate-depletion model and Edelstein-Keshet's wave-pinning model. The user can switch polarity model by `Disabling`/`Enabling` the relevant `System`.

The model defines a one-dimensional reaction-diffusion system (`MembraneProperty`) representing membrane-bound molecules, and is mapped to a cellular Potts model defining a discrete shaped cell. An external gradient, specified in a PDE, provides a signal for the polarization of the cell. In turn, the polarity of the cell influences its `chemotaxic` behavior.

After a switch in direction of the gradient, the cell re-polarizes in the new direction and starts to move up the gradient, iff the wave pinning model has been selected.

Model

h CellPolarity.xml |h

```
extern>
http://imc.zih.tu-dresden.de/morpheus/examples/Multiscale/CellPolarity.xml
```

Note: This model is not available in Morpheus GUI.