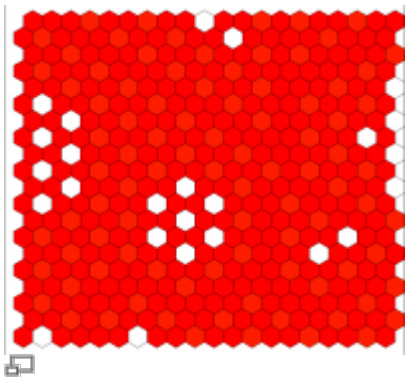
Ordinary differential equation models

Coupled ODE lattice: Lateral signaling



Patterning as a result of lateral inhibition and lateral stabilization.

Introduction

This example model cell fate decisions during early patterning of the pancreas (de Back et al., 2012). The simple gene regulatory network of each cell is coupled to adjacent cells by lateral (juxtacrine) signaling.

Model description

The model defines a lattice of cells with a simplified hexagonal epithelial packing. This is specified in `Space` using a `hexagonal` lattice structure of size $(x,y,z)=(20,20,0)$ with periodic boundary conditions. The lattice is filled by seeding it with a `Population` of 400 cells.

Each cell has two basic `Properties` X and Y representing the expression levels of Ngn3 and Ptf1a that are coupled in a `System` of `DiffEqns`.

The `NeighborsReporter` plugin is used to couple the cells to their directly adjacent neighbors. This plugin checks the values of X in neighboring cells and outputs its mean value in `Property` Xn.

This model uses a number of `Analysis` plugins:

- `Gnuplotter` visualizes the values of Y with a `ColorMap` that maps values to colors. It outputs to screen (interactive mode) or to PNG (local mode).
- `Logger` records the values of X and Y expression to file and, at the end of simulation, shows a time plot.

- The first `HistogramLogger` records and plots the distribution of X and Y expression cells over time.
- The second `HistogramLogger` records and, after simulation, plots the distribution of τ, the time to cell fate decision (see reference).

Model

h LateralSignaling.xml |h

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

In Morpheus-GUI:
`Examples → ODE → LateralSignaling.xml`.

Things to try

- Change the lattice structure from hexagonal to square. See `Space/Lattice`.
- Change the strength of lateral stabilization b and observe the pattern. See `CellTypes/CellType/System`.
- Change the noise amplitude and observe time to cell fate decision (τ).

Reference

W de Back, J X Zhou, L Brusch, On the Role of Lateral Stabilization during Early Patterning in the Pancreas, *Journal of the Royal Society Interface*, 10:79, 2013.