Module 1: Delta-Notch (ODE systems, ODEs on a grid)

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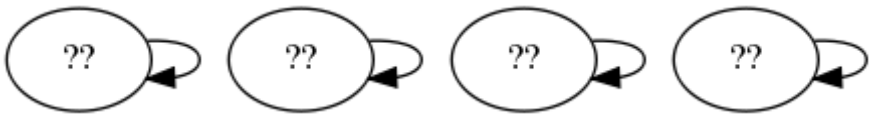
Aim

- learn about ODE models (dynamics in morpheus, steady states analytically)
- develop first models

Description

- get to know what students know about ODEs and adjust the module to the pre-knowledge
- give them very simple sketches of biomolecular models, which they should translate into ODEs, e.g.



- could be translated to the following ODEs:

$$\begin{align} \dot A &= k1 \\ \dot A &= k2 A \\ \dot A &= - k3 A \\ \dot A &= k4 - k3 A \end{align}$$

- discuss those ODEs by
  - steady state analysis
  - simulate in morpheus
- then discuss the delta-notch sketch with two species
  - start with the Collier model
  - let them simplify the Collier model sketch (remove the delta or notch species)
  - let them develop an ODE for this system (they should be able to do so from the above examples)
  - they could come up with something like:

$$\begin{align} \dot X_1 &= c \frac{\theta^n}{\theta^n + X_2^n} - k X_1 \\ \dot X_2 &= c \frac{\theta^n}{\theta^n + X_1^n} - k X_2 \end{align}$$

- this system is bistable for certain parameter ranges, if the students are advanced they might find this out themselves
- bistable e.g. for $\theta=0.5$, $n=4$, $c=k=1$
- if they have this system running in morpheus go spatial and let them simulate the system on a square and hexagonal grid
- then you could also move to shaped cpm cells or even moving cells

- students won't do so much on their own in this session, it is a lot teaching on ODEs (don't be theoretical here, not enough time!) and introducing morpheus

Paper:

- Collier, J. R., McInerney, D., Schnell, S., Maini, P. K., Gavaghan, D. J., Houston, P., & Stern, C. D. (2000). A cell cycle model for somitogenesis: mathematical formulation and numerical simulation. J. Theor. Biol., 207(3), 305-316.

Morpheus models

h ExponentialGrowth.xml |h

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