Last lecture today!
Final due today in class or 68-371 (< 3PM)

Developmental Systems Biology

‘Building an organism starting from a single cell’

Introducing: *Drosophila melanogaster* (or the fruitfly)

Great book: ‘The making of the fly’ by Peter Lawrence

recent experimental paper explores relation between bicoid and hunchback quantitatively:

only gene that makes hb more noisy is Staufen
How can you make a steep step in hunchback exactly in the middle of the embryo from a noisy bicoid gradient?

Nobody knows ...
Perhaps not!

Aegerter-Wilmsen et al.
Model for the robust establishment of precise proportions in the early Drosophila embryo
*Journal of Theoretical Biology* 234, 13 (2005)

\[ \frac{\partial \text{[Bcd]}}{\partial t} = D_{\text{Bcd}} \nabla^2 \text{[Bcd]} + k_{\text{Bcd ti}}(0.03 \text{EL} < x < 0.13 \text{EL}) - k_{\text{Bcd br}[\text{Bcd}]} \]

\[ \frac{\partial \text{[Stau]}}{\partial t} = D_{\text{Stau}} \nabla^2 \text{[Stau]} - k_{\text{Stau-hb form}[\text{Stau}][h]b} + k_{\text{Stau-hb distint}[\text{Stau} - h]b} + k_{\text{Stau-br}[\text{Stau}]} + k_{\text{Stau-ant rel}[\text{Stau}][x = 0]} + k_{\text{Stau-post rel}[\text{Stau}][x = \text{EL}]} \]

\[ \frac{\partial \text{[Stau-ant]}{\partial t} = -k_{\text{Stau-ant rel}[\text{Stau}][x = 0]} \]

\[ \frac{\partial \text{[Stau-post]}{\partial t} = -k_{\text{Stau-post rel}[\text{Stau}][x = \text{EL}]} \]

Main model, cont.

\[ \frac{\partial \text{[hb]}{\partial t} = D_{\text{hb}} \nabla^2 \text{[hb]} - k_{\text{Stau-hb form}[\text{Stau}][hb]} + k_{\text{Stau-hb distint}[\text{Stau} - h]b} - k_{\text{hb br}[hb]} + k_{\text{ctl}[\text{Bcd}]} \]

\[ \frac{\partial \text{[Stau - hb]}{\partial t} = D_{\text{Stau-hb}} \nabla^2 \text{[Stau - hb]} + k_{\text{Stau-hb form}[\text{Stau}]h]b} - k_{\text{Stau-hb distint}[\text{Stau} - h]b} \]

\[ \frac{\partial \text{[Hb]}{\partial t} = k_{\text{u}[hb]} \]

Model is robust against two fold change in parameters


I Systems Microbiology (13 Lectures)

‘The cell as a well-stirred biochemical reactor’

L1 Introduction
L2 Chemical kinetics, Equilibrium binding, cooperativity
L3 Lambda phage
L4 Stability analysis
L5-6 Genetic switches
L7-9 E. coli chemotaxis
L10-11 Genetic oscillators
L12-13 Stochastic chemical kinetics

II Systems Cell Biology (10 Lectures)

‘The cell as a compartmentalized system with concentration gradients’

L15 Diffusion, Fick’s equations, boundary and initial conditions
L16-17 Local excitation, global inhibition theory
L18-19 Models for eukaryotic gradient sensing
L20-21 Center finding algorithms
L22-24 Modeling cytoskeleton dynamics

III Systems Developmental Biology (2 Lectures)

‘The cell in a social context communicating with neighboring cells’

L24-25 Drosophila development
Main take home messages from this course:

1. **translate the biology into a quantitative model:**
   
   *given the biology set up the coupled differential equations that capture the essence of the biological phenomena*
   
   (not trivial since often many papers came up with a different model given the same biological phenomenon, which assumptions to make is critical)

2. **analysis of the system of differential equations**
   
   stability analysis (both in space and time)

3. **interpretation of the mathematical analysis, what are the biological conclusions?**
   
   e.g. if the imaginary part of the eigenvalue is non zero, what does this mean for the underlying biology?

4. **develop a taste for the potential of these systems approaches for biological problems that you may encounter in the future**

THE END

HAPPY HOLIDAYS