TEK292
Fall 2013

Exercises, Reaction dynamics

Exercise 1: Define the ordinary differential equations describing the time evolution of all molecules in the following reactions:

A. Production/degradation

$$\emptyset \underset{k_2}{\overset{k_1}{\rightleftharpoons}} A.$$

(Assume a mass action formalism).

B. Dimers

$$A + B \underset{k_2}{\overset{k_1}{\rightleftharpoons}} C.$$

(Assume a mass action formalism).

C. Homodimers

$$A + A \underset{k_2}{\overset{k_1}{\rightleftharpoons}} C.$$

(Assume a mass action formalism).

D. Enzymatic transformation

$$A \underset{V_2,K_2,E_2}{\overset{V_1,K_1,E_1}{\rightleftharpoons}} B.$$

(Assume a Michaelis-Menten formalism with the enzymes E_1, E_2).

E. Auto-activation Set up a model for a protein that activates its own transcription, and include a protein degradation term. (Assume a Michaelis-Menten formalism).

F. Auto-repression Set up a model for a protein that represses its own transcription, and include a protein degradation term. (Assume a Hill formalism).

G. AND gate Set up a model for a protein X that is activated if and only if both transcription factors Y and Z are present. (Assume a Michaelis-Menten formalism).

Exercise 2: Analyse the dynamics for two of the examples given in exercise 1.

Exercise 3: Describe in words or with reaction arrows plausible mechanisms leading to the following equations:

A.

$$\begin{aligned}\frac{d[X]}{dt} &= k_1 - k_2[X] + k_3[Y] - V_1\frac{[X][E_1]}{K_1+[X]}\\ \frac{d[Y]}{dt} &= -k_3[Y] + V_1\frac{[X][E_1]}{K_1+[X]}\end{aligned}$$

B.

$$\begin{aligned}\frac{d[X]}{dt} &= k_1 + \frac{k_2[Y]^2}{k_3+[Y]^2} - k_4[X] - V_1\frac{[X][E_1]}{K_1+[X]}\\ \frac{d[Y]}{dt} &= -[Y] + V_1\frac{[X][E_1]}{K_1+[X]}\end{aligned}$$

C.

$$\begin{aligned}\frac{d[X]}{dt} &= k_1 + \frac{k_2[Y]^2}{k_3+[Y]^2} - k_4[X] - V_1\frac{[X][E_1]}{K_1+[X]}\\ \frac{d[Y]}{dt} &= k_5 - [Y] - \frac{k_2[Y]^2}{k_3+[Y]^2}\end{aligned}$$

D.

$$\begin{aligned}\frac{d[A]}{dt} &= a - (b+\beta)[A] + c[A]^2[B]\\ \frac{d[B]}{dt} &= b[A] - c[A]^2[B]\end{aligned}$$