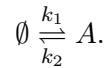


**Additional exercises, Reaction dynamics**

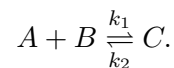
**Exercise 1:** Define the ordinary differential equations describing the time evolution of all molecules in the following reactions:

**A. Production/degradation**



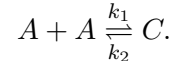
(Assume a mass action formalism).

**B. Dimers**



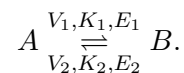
(Assume a mass action formalism).

**C. Homodimers**



(Assume a mass action formalism).

**D. Enzymatic transformation**



(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.**

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