Vorlesung "Modellierung von Zellprozessen"
Aufgabenblatt 4: Modellreduktion und Modellauswahl

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1. **A complete cell model?** Does it make sense to think about complete cell models? (a) Speculate about possible definitions. (b) Estimate roughly the number of variables and parameters in models of living cells. Consider the following types of model: (i) Kinetic model of metabolism without spatial structure. (ii) Compartment model including organelles. (iii) Particle-based model describing single molecules and their complexes in different conformation states. (iv) Model with atomic resolution.

2. **Quasi-steady state** Consider a metabolic pathway $A \to B \to C \to$ with irreversible mass-action kinetics. The concentrations of B and C are described by the differential equation system

$$\begin{aligned} \mathrm{d}b/\mathrm{d}t &= k_1\, a - k_2\, b \\ \mathrm{d}c/\mathrm{d}t &= k_2\, b - k_3\, c. \end{aligned} \tag{1}$$

   Assume that the second reaction is much faster than the other reactions, $k_2 \gg k_1, k_3$. Use the quasi-steady state approximation to replace the first differential equation by an algebraic equation.

3. **Quasi-equilibrium** Assume above pathway, but with a reversible second reaction. The concentrations follow the differential equation system

$$\begin{aligned} \mathrm{d}b/\mathrm{d}t &= k_1\, a - k_{+2}\, b + k_{-2}\, c \\ \mathrm{d}c/\mathrm{d}t &= k_{+2}\, b - k_{-2}\, c - k_3\, c. \end{aligned} \tag{2}$$

   The conversion between B and C is much faster than the other reactions, $k_{\pm 2} \gg k_1, k_3$; use the quasi-equilibrium approximation to express b by an algebraic equation.

4. **All models are wrong.** Discuss the quotation by George Box "Essentially, all models are wrong, but some are useful". What do you think of it? Does it contain helpful advice for modeling?

5. **Model selection.** Consider a given experimental time series and two alternative models A and B that are supposed to explain it. Model A contains more free parameters than B and it also fits the data better. Discuss reasons for choosing model A or model B. What would you do exactly to choose between them, and how could you verify if your choice was correct?