# Exercise sheet 2
# Systems Biology class 2014

April 3, 2014

Return by email to jean.hausser@weizmann.ac.il until April 6th 2014 at the latest with `[SB14] Exercise sheet 2` in the subject of the email.

## 1 Why aren't all genes autoregulated?

In the second lecture, we saw that negative autoregulation has two useful features — speedup of response time, and reduction in noise. Why then don't all transcription factors negatively regulate themselves? Discuss at least two different reasons (150 words maximum).

## 2 Autorepression with Hill input function

A repressor cooperatively represses its own promoter. Its production rate is described by a Hill function with Hill coefficient $n$, halfway induction $K$ and maximal production $\beta$.

$$dX/dt = \beta/(1 + (X/K)^n) - \alpha\, X \tag{1}$$

Using the approximation of strong auto-repression $X/K \gg 1$, determine a formula for the steady state level $X_{\mathrm{st}}$. Use this formula to plot $X_{\mathrm{st}}$ as a function of $\beta/\alpha$ for $n = 1, 2, 3, 4$. For plotting, assume $K = 1$.

$\beta > \alpha$ for most proteins. Which value of $n$ has the most robust steady state with respect to variations in $\beta$?

## 3 Alternating stable and unstable fixed points

Sketch out a phase plane — that is the synthesis and decay rate vs X concentration plane — analysis for a gene regulation system in which the input function $f(X)$ intersects the removal curve five times. Analyze the stability of each of the five fixed points using only graphical considerations.

*optional:* Explain why, for continuous input functions, there must be an unstable fixed point between any two stable ones.