

CALIFORNIA INSTITUTE OF TECHNOLOGY  
Bioengineering

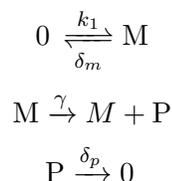
**BE 150**

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Winter 2012

**Problem Set #5**

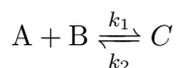
Issued: 8 Feb 2012  
Due: 15 Feb 2012

1. For this problem, we return to our standard model of transcription and translation process.



where  $M$  is the mRNA concentration,  $P$  is the protein concentration.

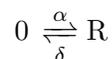
- (a) Simulate the stochastic system above until time  $T = 100$  using the *transcription-translation* model in Symbiology model *hw5.sbproj*. Use the following parameters:  $k_1 = 0.2$ ,  $\delta_m = 0.5\gamma = 5$ ,  $\delta_p = 0.5$  Plot the resulting number of mRNA and protein over time.
  - (b) Now assume that the proteins are degraded much more slowly than mRNA and the rate of protein degradation is 0.05. To maintain similar protein levels, the translation rate is now 0.5. Simulate this system as above. What difference do you see in protein level? Comment on the effect of protein degradation rates on noise.
2. *Volume and noise.* Consider the bi-molecular reaction



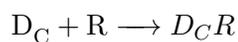
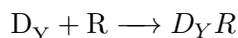
in which  $A$  and  $B$  are in total amounts  $A_T$  and  $B_T$ , respectively. Compare the steady state value of  $C$  obtained from the deterministic model to the mean value of  $C$  obtained from the stochastic model as the volume is changed in the stochastic model. What do you observe? You can perform this investigation through numerical simulation by running the *volume* simulation in the Symbiology script *hw5.sbproj*.

3. *Intrinsic and extrinsic noise* (based on Elowitz, et al. *Stochastic Gene Expression in a Single Cell, Science, 2002.*) Consider a model for stochastic gene expression in a single cell.

Production and degradation of RNA polymerase:



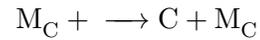
Binding of RNA polymerase to YFP and CFP



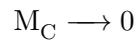
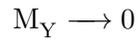
Transcription of YFP and CFP



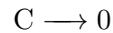
Translation of YFP and CFP



Degradation of YFP and CFP mRNA



Degradation of YFP and CFP protein



- (a) Assume that the RNA polymerase levels are constant, in other words, that  $\alpha = \delta = 0$ . What do you expect to be the dominant form of noise observed (intrinsic or extrinsic)?
- (b) Assume that the RNA polymerase levels are noisy, and as an example take  $\alpha = \delta = 50$ . How does this change affect intrinsic and extrinsic noise?
- (c) Run the simulation *runner.m* for both values of  $\alpha = \delta$  in parts a) and b) and plot. Verify your reasoning from parts a) and b).