Advanced Principles of Biomolecular Engineering - Spring 2020
CHEME 7770: Problem Set 2

February 18, 2020

1. Simulate σ_{70} induced dual emission green fluorescent protein (deGFP) expressionin an E. coli TX/TL 2.0 cell free reaction run in an Eppendorf tube with constant working volume of V_L= 15μL. A mathematical model (written in Julia) for this cell free system has been developed and posted on GitHub at https://github.com/varnerlab/CHEME-5440-7770-S20.

   a. Starting from a well mixed material balance around species i written with respect to an abstract volume basis $\mathcal{B}$, show the balance equations governing mRNA (m) and protein (p) concentration are given by:

$$\dot{m} = r_X u - \theta_m m + \lambda \tag{1}$$

$$\dot{p} = r_L w - \theta_p p \tag{2}$$

   where $\mathcal{B} = \mathrm{V}_L$

   Solution:

   The specific material balance equations for mRNA $\dot{m}$ transcription and translation to protein $\dot{p}$ is given by:

$$\dot{m} = r_X u - (\mu + \theta_m)m + \lambda$$
$$\dot{p} = r_L w - (\mu + \theta_p)p$$

   where μ is the dilution term which can be computed using:

$$\mu = X^{-1}\dot{X} + V_R^{-1}\dot{V}_R$$

   This equations shows two sources of dilution: dilution due to change in cell mass and dilution due to change in volume of cell culture. In this case, the equations reduce to form (1) and (2) since this is a cell free system without whole cells ($\dot{X} = 0$), having a constant working volume of 15μL ($\dot{V}_R = 0$).