Quiz Preparation
BIOE5060: Biomolecular Dynamics and Control
Spring 2015
Instructor: A. Asthagiri

Posted March 2, 2015 in preparation for Quiz 1.
Text in black color font will be covered in the upcoming quiz. Text in red font will be covered in a future quiz.

I. Engineering principles and analysis

Developing model schematic for systems of biomolecular reactions

- Elementary reactions
- Coarse-grain kinetic models where every elementary step is not represented

Converting schematics into a mathematical model

- Mass-action kinetics
- Rate laws from elementary reactions
- Mass balances

Analyzing mathematical models

- Non-dimensionalizing and dimensionless parameters
- Phase portraits for analyzing systems with single time-dependent variable
  - fixed points
  - stable and unstable steady-states
- computational ODE solvers (Matlab coding *not* on the Quiz)

Positive feedback

- bistability
- hysteresis
- irreversible switches

II. Application to biomolecular systems

Receptor-ligand (R-L) dynamics

- Biology of receptor-ligand binding and trafficking
  - non-covalent molecular interactions
  - modes of receptor-ligand communication
  - types of receptors and ligands
  - pathways of trafficking: internalization (endocytosis), recycling, degradation, synthesis
- Modeling and analysis of R/L binding and trafficking
  - governing equations
  - transient and steady-state responses
  - significance of key non-dimensional parameters: $\frac{K_d}{L_o}$ and η
- Strategies to measure parameters of R/L dynamics

Enzyme kinetics

- Covalent modifications
- Role of enzymes in kinetics and thermodynamics of a reaction
- Modeling and analysis of enzyme systems
  - single substrate/enzyme model
    - quasi-steady state (QSS) assumption
    - conditions under which QSS is valid
    - Michaelis-Menten kinetics and constant
- Case studies of enzymatic systems
  - dimeric enzyme and apparent cooperativity (T/R)
  - apparent vs true cooperativity (hemoglobin)
    - quantifying cooperativity: Hill equation and coefficient
  - substrate cycle mediated by two enzymes: Goldbeter-Koshland (GK) switch
    - conditions required for GK switch

Feedback in signaling pathways

- MAP kinase cascade and positive feedback in frog oocyte maturation