Quantitative Physiology I / Molecular and Cellular Systems; BMEN E4001x
HW3: Modeling and membrane transport
Due Oct. 29, 2025, 11:00PM

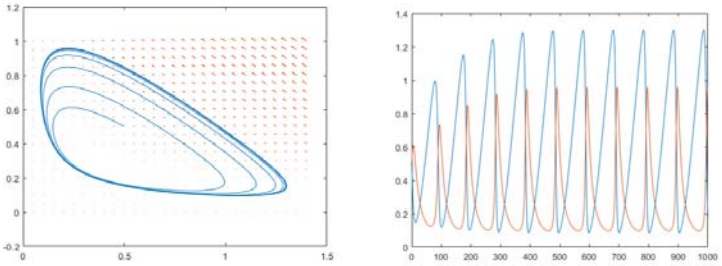
1) Oscillations (20 points)

1.1) Using MATLAB, simulate the Sel'kov glycolysis system presented in K&S section 1.3. Specifically, generate the two figures below describing concentrations as a function of time. The quiver plots (arrows) are not needed. Use the following parameters: (10 pts.)

γ (gamma) =2 α (alpha) = 1.0 ν (nu) = 0.0285 η(eta) = 0.1

Simulate over a period of $\tau = 0 \ldots 1000$; $\sigma_1(t=0) = 0.5$; $\sigma_2(t=0) = 0.5$

Include your code along with the graphs.



1.2) Now, simulate with $\nu = 0.035$, representing a higher rate of ATP introduction into the system. Include graphs of σ_1 vs. σ_2 and σ_1,σ_2 vs. time for this new value of ν. (7 pts)

1.3) Interpret qualitatively why the behavior at $\nu = 0.035$ is different than that at 0.0285. (3 pts)

The text describes a Hopf bifurcation, which is of mathematical importance, but we are looking for a descriptive explanation based on the chemical reaction. While not required as an answer for this question, plotting u1 and u2 as a function of τ may help in understanding what is going on.

For your reflection (not graded):

- In part 1.2, increasing ν models increasing the rate at which ATP is added to the system. Can you identify a change in a different parameter that will restore the oscillatory nature of the original ($\nu = 0.0285$) system?

2) Membrane transport (10 points)

For your 3 favorite membrane pumps, active carriers, exchangers, or cotransporters, describe:

- The target molecules(s) that is (are) being transported,
- The physiological role of the target molecule(s), and
- The driving force for this transport (such as ATP or concentration gradient of a molecule)

No more than 4 sentences for each protein. For example (but don't count this as one of your three):

The Na/glucose cotransporter proteins promote uptake of glucose into cells, using a gradient of Na^+ ions to drive this process. ATP is not needed for this transport.