Problem Set 1
January 21, 2015
Due: February 6 (by email)

Problem 1. In class, we discussed the phase portrait of the dynamics of a receptor-ligand interaction that follows the following kinetic model:

$$\frac{du}{dt} = \frac{L_o}{K_d}(1-\eta u)(1-u) - u \tag{1}$$

Suppose the receptor-ligand system under consideration is EGF binding to EGF receptor. Using Matlab,

(a) Generate a phase portrait for $\frac{L_o}{K_d} = 1$ and $\eta = 2$. Indicate all fixed points for the system. Are these point(s) stable or unstable? Why?

(b) Assuming $u(0) = 0.1$, plot $u(t)$ for $L_o = K_d$ and $\eta = 0.1$, 1 and 10.

(c) For the three cases plotted in (b), at what time (min) does the system reach 90% of its steady-state condition?

Problem 2. In class, we developed kinetic models for a *monovalent* receptor-ligand system. In many cases, however, the valency of a receptor (and/or ligand) is greater than 1. For example, PDGF receptor is bivalent. That is, each receptor contains two sites for ligand binding. Antibodies are another type of "receptor". They bind to antigens and are multivalent. One class of antibodies, called IgG antibodies, contain two binding sites for its antigen whereas IgM antibodies contain 10 binding sites for its antigen.

(a) Consider a bivalent receptor that binds to a monovalent ligand. Write the kinetic model (i.e., the elementary reactions, the associated rate laws and the mass balances) for this system. Caution: be wary of the fact that the ligand can bind the receptor in two ways.

(b) Consider another situation where the ligand is a dimer composed of A and B domains. Moreover, the receptor has two binding sites (A' and B'). A' binds the A domain of the ligand, and B' binds the B domain of the ligand. Sketch the different elementary reactions that you can envision for this sytem. You need not write the rate equations or mass balances.