BF571 Spring 2019

Homework Assignment #1 – Due Monday Feb 11, 2019 by 10am.

Part 1 (2 points)
Choose a type of biological network that interests you.
For this network, provide:

a. A description of the meaning of a node in this network.
b. A description of the meaning of an edge in this network.
c. A reference to a paper that discusses this type of network. Summarize in a few lines whether and why the network representation is useful in this paper.

Part 2 (4 points)
A bacterial cell has the shape of a sphere with radius *R*. This cell produces ATP (using membrane-bound ATP synthetases) at a rate *A* per unit surface. The cellular internal machinery consumes ATP at a rate *B* per unit volume. Assume that *A* and *B*, rather than having fixed values, depend themselves on *R* as follows: $A = A_0/R$; $B = B_0/R$, with A_0 and B_0 constant.

a. Express the ATP production (*p*) and consumption (*c*) rates as a function of *R.*
What is the maximal radius (R_{max}) energetically sustainable by this cell?
b. At what cell radius (R_s) will the cell produce maximal surplus of ATP?
c. If the cell is growing from a radius R_s to a radius R_{max}, what is the total surplus ATP produced throughout its growth process? (hint: this question requires computing an integral)

Part 3 (4 points)
Consider the following coupled logistic equations for two replicators, with concentrations x and y:

$$\frac{dx}{dt} = r_1 x \left(1 - \frac{x+y}{K_1}\right)$$
$$\frac{dy}{dt} = r_2 y \left(1 - \frac{x+y}{K_2}\right)$$

a. List the possible steady states of these equations (assuming K1 > K2), and determine which of these steady states is stable/unstable.
b. Solve the equations numerically, using Matlab, Python or an equivalent programming language (See sample scripts provided with lectures). Try 6 different sets of values of the intrinsic growth parameters (r1, r2), and carrying capacity (K1, K2), and plot the time dependent abundances of the two species under each set of parameters.
c. Find a set of parameters that will lead to coexistence of the two species.
d. Show through examples or reasoning what parameter(s) determine the winner of the competition in case the two species don't coexist.