# Linking Genome to Physiome

## Multistationarity: Lab 1

The purpose of this exercise is to explore the dynamics of a very simple but common motif found in genetic and signaling pathways.

---

Consider the following simple system:

$$X_o \xrightarrow{v_1} S_1 \xrightarrow{v_2}$$

where the rate for the first step $v_1 = X_0 + 10 \times {S_1}^n/(15 + {S_1}^n)$

and the rate for the second step, $v_2 = k_1 \times S_1$.

Set $n = 4$ and $k_1$ to a value of 2.0. $X_o$ is assumed to be a boundary species with a value of $X_o = 0.5$. Since the second step is irreversible $X_1$ has been omitted from the pathway diagram (It has no influence). $v_1$ might represent the gene expression rate for a protein $S_1$ and $v_2$ the protein degradation rate.

**Question 1.** Using Excel, create three columns, the first column should contain values from zero to fifteen in steps of 0.1. This column will equal the concentration of $S_1$. Let the second column equal the reaction rate, $v_1$ and the third column $v_2$. Add the rate law for $v_1$ to the second column and the rate law for $v_2$ to the third column, compute the rates using the $S_1$ values in the first column. When entering the third column, it will be convenient to reference the value of the rate constant, $k_1$, from another cell. This will allow you to easily change $k_1$ later on and observe its effect.

Plot $v_1$ and $v_2$ versus $S_1$. Sketch the plot here, make sure you label the $x$ and $y$ axis so that you know what the axes represent.

**Question 2.** How many times do the lines intersect?

**Question 3.** What do the intersection points represent?

**Question 4.** Change the value of $k_1$ to 4.0. How many times do the curves intersect now?

**Stop here for a Software Demo of Jarnac**

**Question 5.** Enter the simple model into Jarnac with all values initialized as described at the beginning of the assignment. You will use Jarnac to compute the time evolution of the system.

Start $S_1$ at a value of 1.0. Run a time simulation for 4 time units or until steady state is reached. Record the final value of $S_1$.

$S_1$:

**Question 6.** Reset $S_1$ to a value of 1.5 and repeat the simulation, record the final value of $S_1$.

$S_1$:

**Question 7.** If there is a difference in the final values in question 5) and 6), what is the explanation? Note that the 'genotype' (parameter values), is identical in each case.