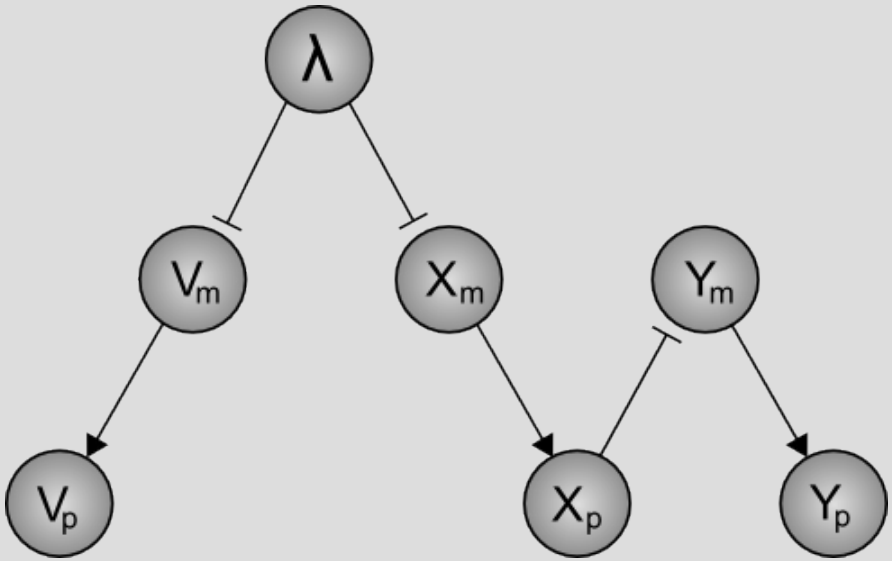
Mathematical Modeling

Want a set of equations to model the chemoattractant switch from recruitment signal to chemical gradient

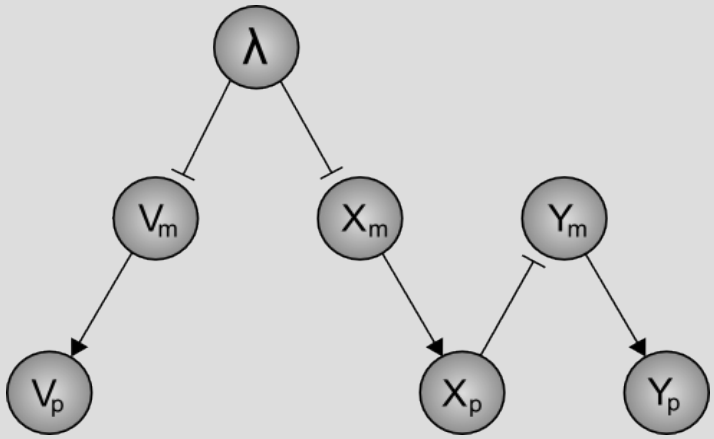
Genetic Regulatory Network (GRN)



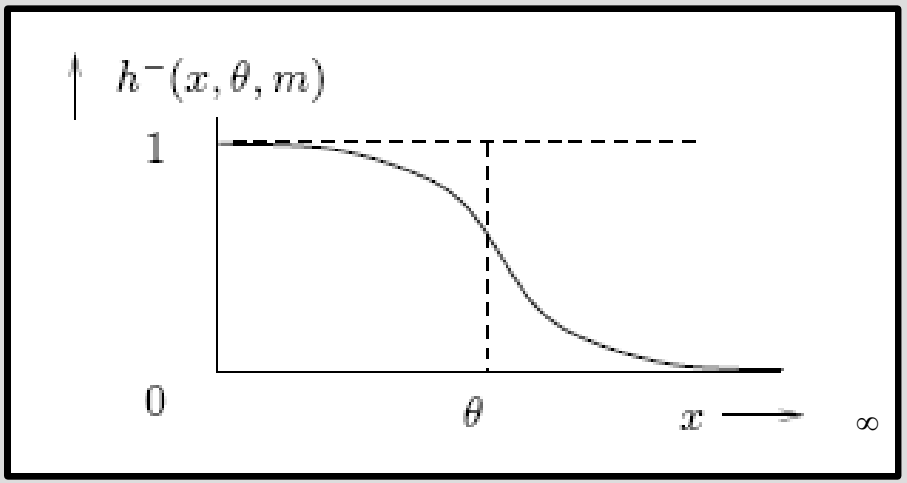
- V (cheW * concentration)
  - recruitment signal
- Y (cheW concentration)
  - chemical gradient
- X (TetR concentration)
  - represses Y
- λ - parameter that changes on contact with particle

Forming Equations

- Change in concentration = synthesis – degradation
- **mRNA concentration**
  - Synthesis rate modeled using *Hill Equation*



Hill Equation



$$h^-(x, \theta, m) = \frac{\theta^m}{x^m + \theta^m}$$

- x = conc. of repressor
- θ = threshold parameter
- m = cooperativity param.

- K = max. transcription rate
- Synthesis rate = K * h
- x → 0, synthesis rate → K
- x → inf, synthesis rate → 0

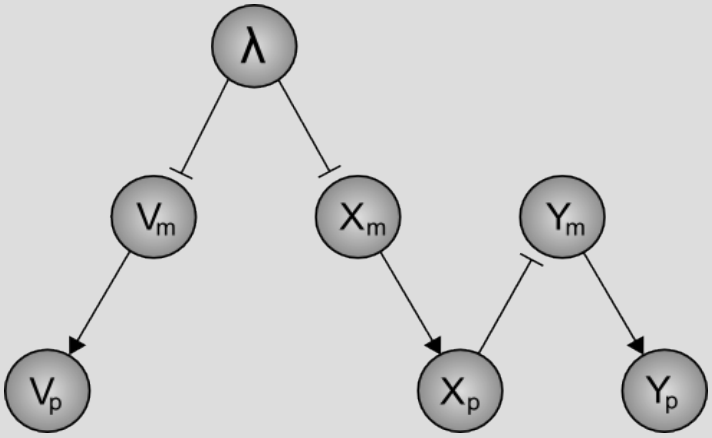
Forming Equations

- Change in concentration = synthesis – degradation
- **mRNA concentration**
  - Synthesis rate modeled using *Hill Equation*
  - Degradation rate proportional to current concentration

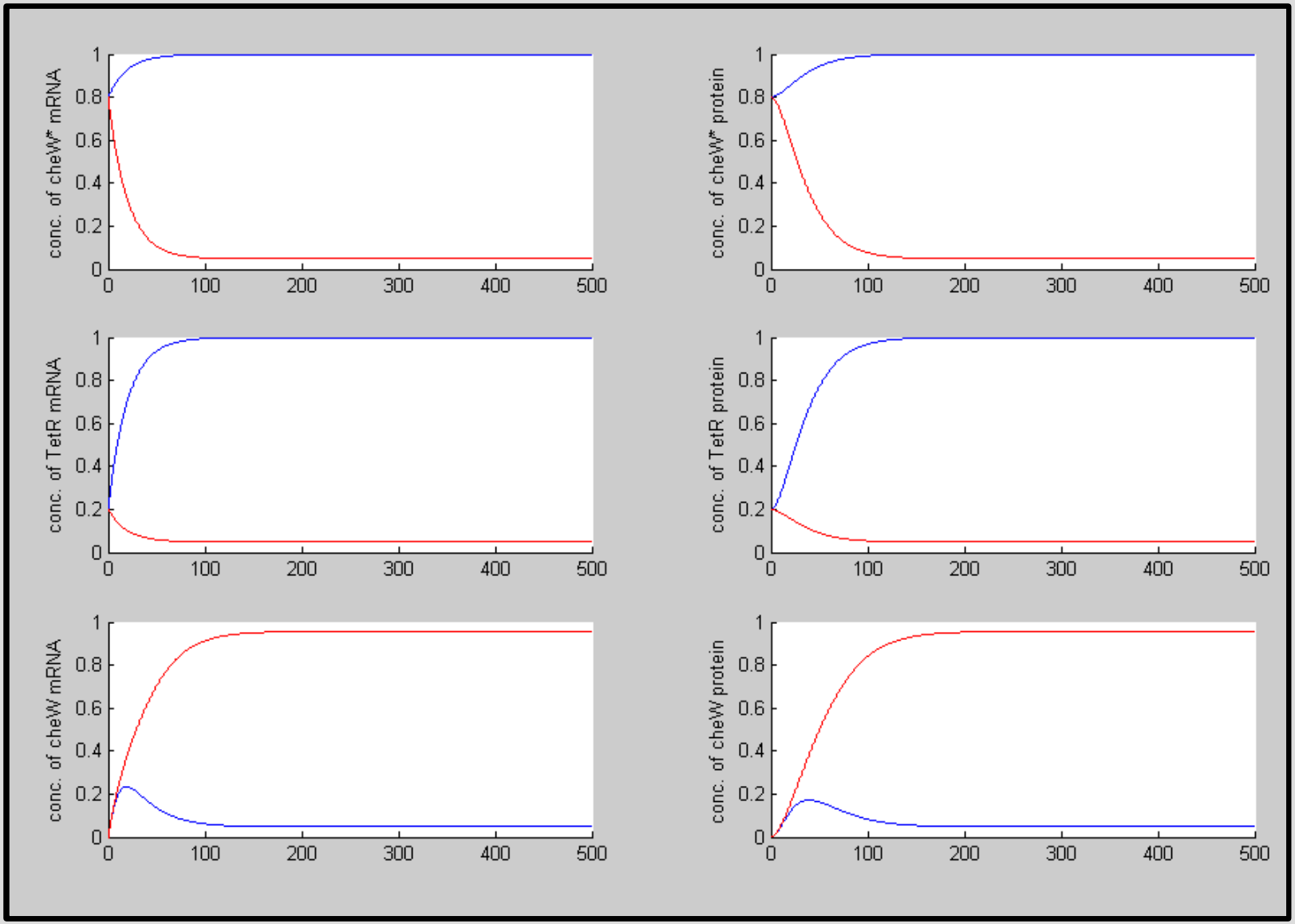
$$\frac{dx_m}{dt} = K_{x_m} . h^{-}(x_r, \theta_r, m_r) \quad - \quad d_{x_m} x_m$$

- **protein concentration**
  - Synthesis rate proportional to mRNA concentration
  - Degradation rate proportional to current concentration

$$\frac{dx_p}{dt} = K_{x_p} x_m \quad - \quad d_{x_p} x_p$$



Simulation


conc. of cheW* mRNA
conc. of cheW* protein
conc. of TetR mRNA
conc. of TetR protein
conc. of cheW mRNA
conc. of cheW protein
0
0.2
0.4
0.6
0.8
1
0
100
200
300
400
500

Parameters

- Max. transcription rates
- Degradation rates
  - cheW*, cheW, tetR (proteins & mRNA)
- Hill function parameters
  - λ, tetR
- Don't know any of these! Any ideas.....?

Next Steps…

- Want to produce GRNs for other aspects of project (check behaviour)
- Also need to consider physical interactions
  - Mechanics-based model
    - Simple – model bacteria as a single point
    - Advanced – model bacteria as a rod
  - Literature research required before deciding