Dynamic Models in Biology

Lab 10

Jonathan Levine

Fall 2023

**Baseline Run**

Running the simulation for the stochastic transcription model at baseline:

The state vector, in this case the one dimensional [M], fluctuates over time

A blue line graph with numbers

Description automatically generated

In the non-transient dynamics, the distribution of M is centered around ~11.4:

A graph of a number of mrna molecules

Description automatically generated

The deterministic form of this model is:

For this model at steady state:

For the baseline run, this is equal to 10/1=10, which is close to the mean of the histogram of non-transient M values above.

**Varying Reaction Rates**

Varying the production rate kr, we see that the mean number of M increases. This is expected since the fixed point is proportional to kr:

A group of graphs showing different numbers

Description automatically generated with medium confidence

Looking at the summary statistics of these distributions as a function of kr, we see that the mean is linearly proportional to kr (as expected from the fixed point), and COV is inversely proportional to kr on a log-log scale.

A graph of a logistic diagram

Description automatically generated with medium confidence

Looking now at the degradation rate instead, we see the same relationships, but this time for 1/dr, since the fixed point of the corresponding deterministic system was inversely proportional to dr:

A comparison of a graph

Description automatically generated with medium confidence

**Bursting**

A graph with blue lines

Description automatically generatedA blue line graph with numbers

Description automatically generatedIf we change the transcription step to a burst of 5 rather than 1 (right), the time trace is much noisier than baseline (left):  
  
  
  
  
  
  
  
  
  
  
  
  
  
  
  
  
  
This can also be visualized in the histograms (baseline on left, burst=5 on right):

A graph of a number of mrna molecules

Description automatically generatedA graph of a function

Description automatically generated  
  
  
  
  
  
  
  
  
  
  
  
  
  
  
  
In addition to increasing the noise and slightly increasing the mean, we can also see that the histogram has a long tail in high M, as the large bursts allow for large random effects that build.

This is readily apparent in the frequency domain, where the non-transient time traces show an increase in higher frequency noise as the burst factor increases:

A graph of a graph showing a number of different colored lines

Description automatically generated