MB&B 562: Exercise 8

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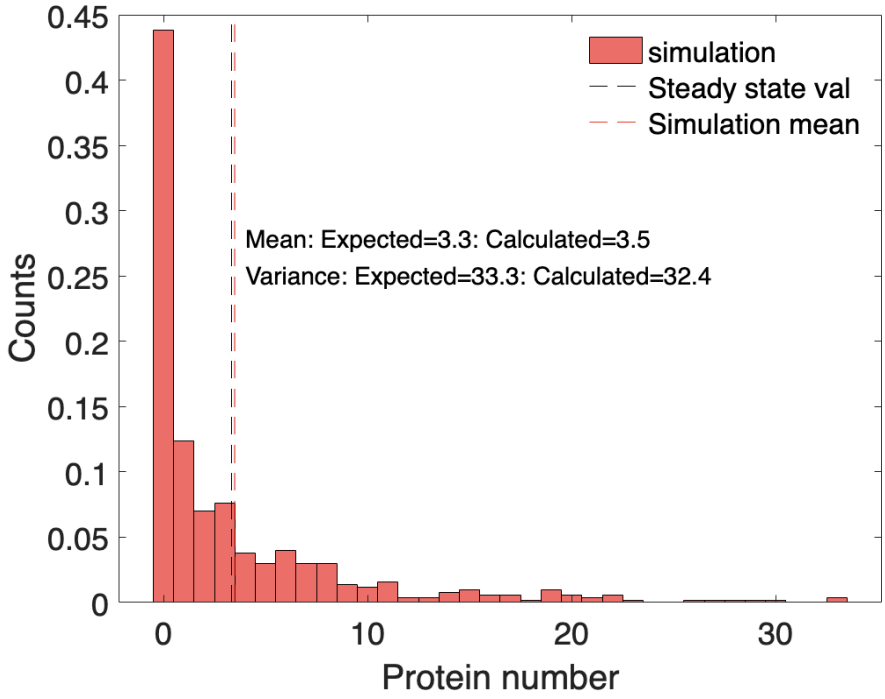
Question 1

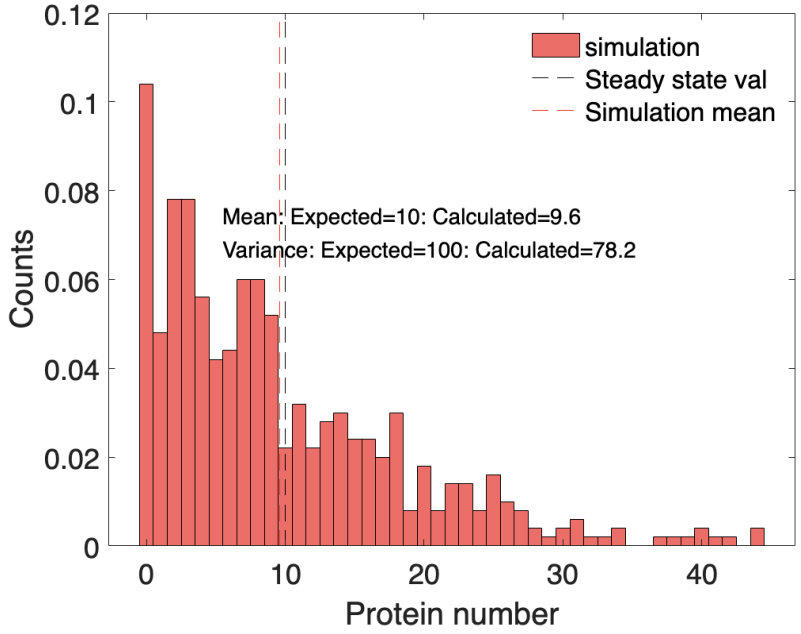
Observed Mean and Std. Deviations of final protein concentrations.

Trial 1



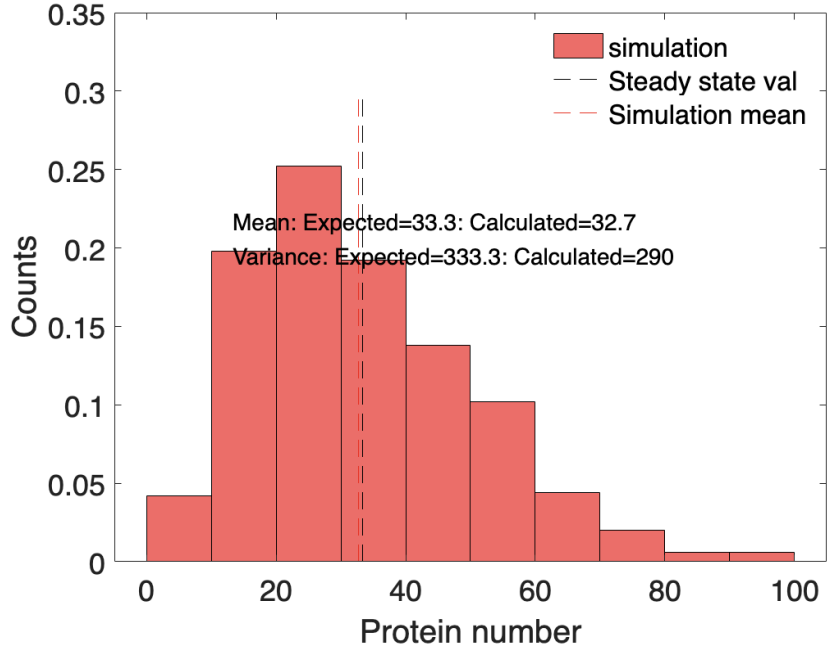
Mean: 3.5
SD: 5.692

Trial 2



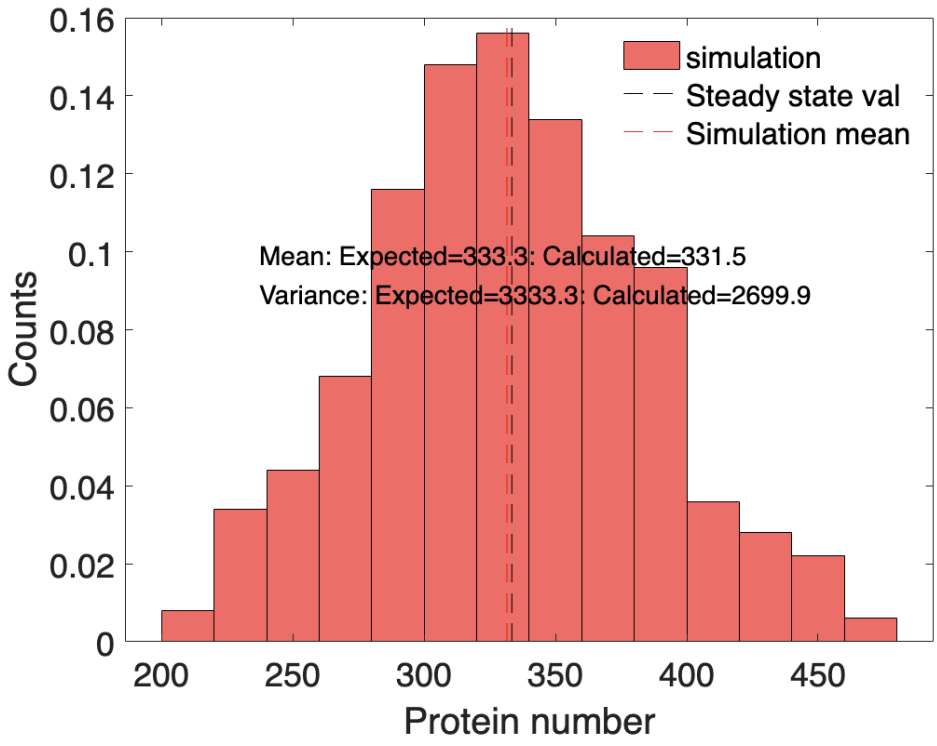
Mean: 9.6
SD: 8.843

Trial 3



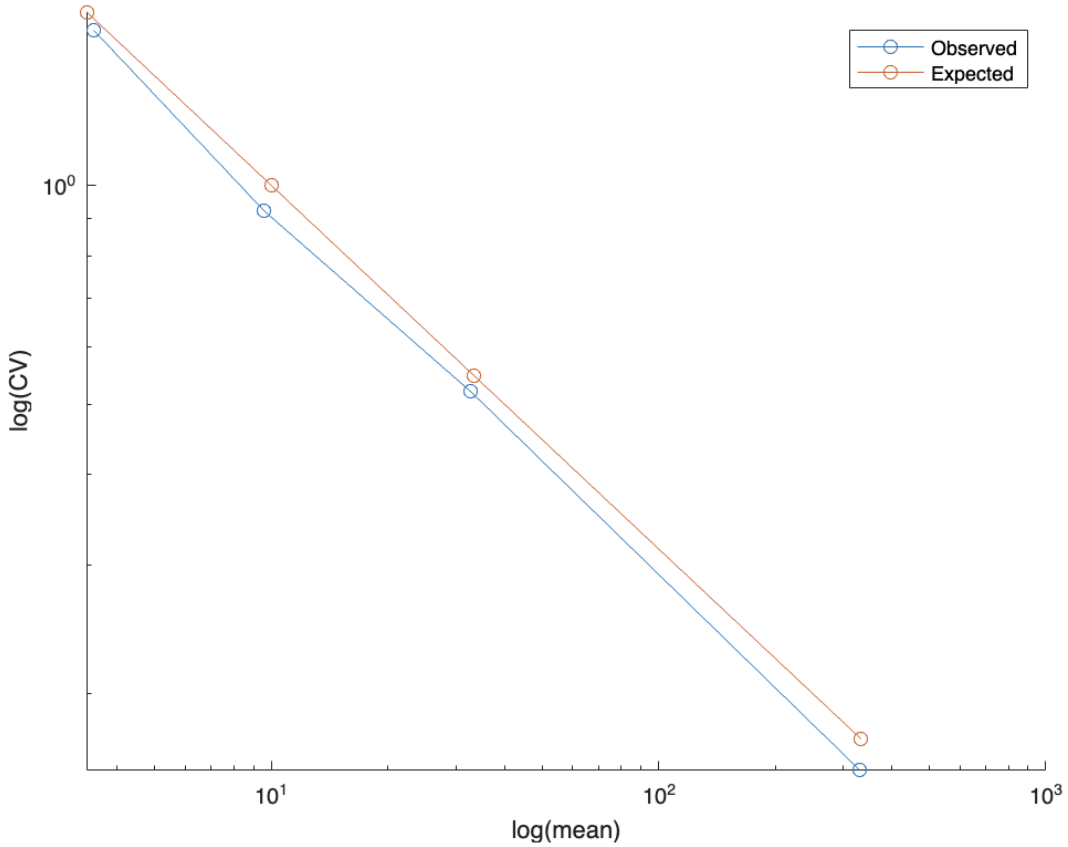
Mean: 32.7
SD: 17.029

Trial 4



Mean: 331.5
SD: 51.961

Plot of CV against Mean on a log-log plot.



There is an (almost) linear relationship with a negative slope between the log of coefficient of variation and the log of mean of the protein concentrations; this is perfectly linear when plotted for the expected values. This means that the coefficient of variation, i.e., noise decreases exponentially as the mean increases.

This kind of noise that fades away as the number of particles (protein concentration, in this case) increases is termed shot noise, and can hence be modeled by a Poisson process. Statistically, the fluctuations are more prevalent, i.e. SNR is very low or CV is very high, and as the number of measurements increases, the fluctuations become negligible.

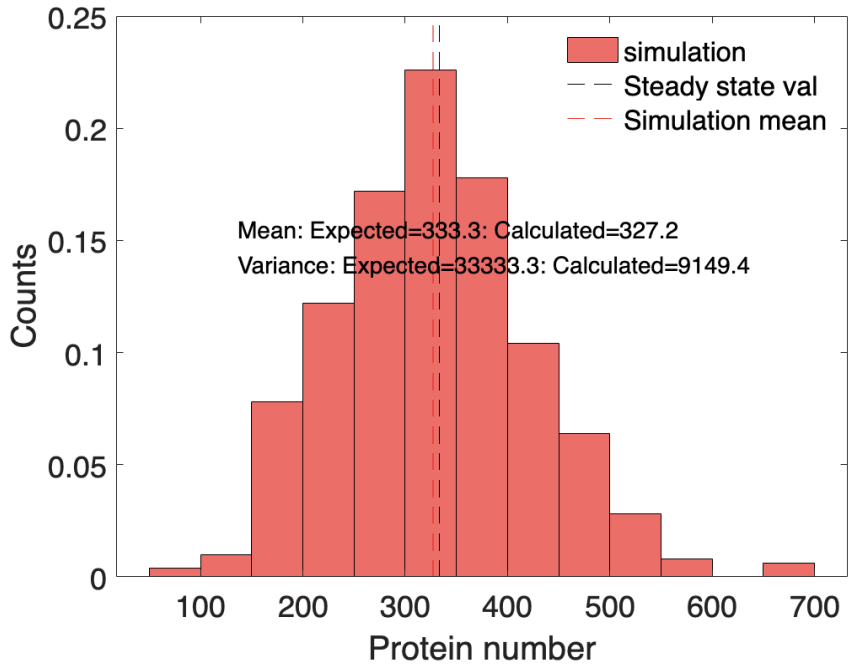
Expected values of CV based on model parameters.
[these values were also used to plot the Mean vs. CV log-log plot above]

Trial 1: 1.7321
Trial 2: 1.0
Trial 3: 0.54772
Trial 4: 0.17321

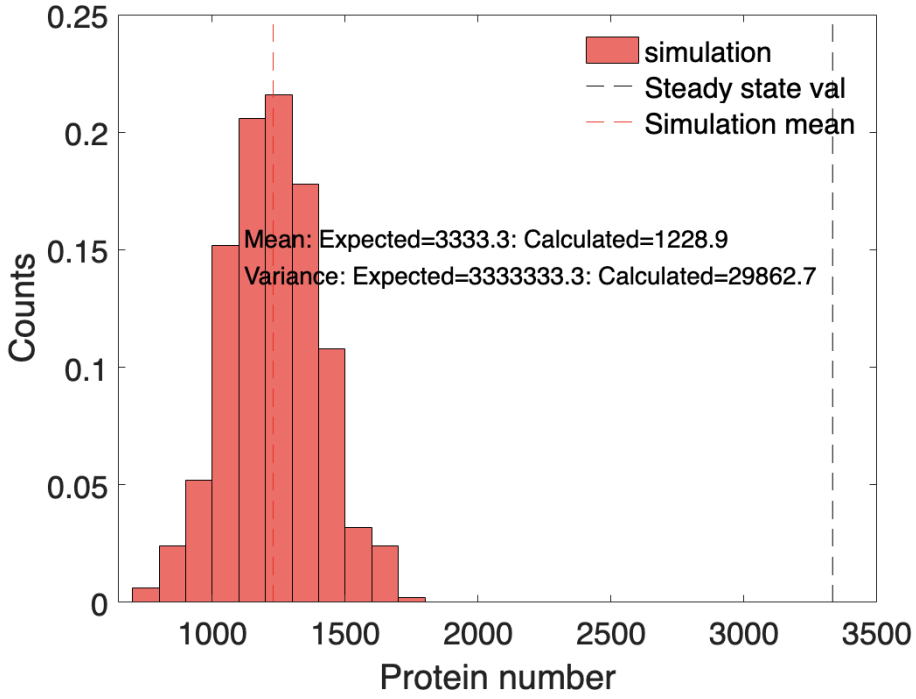
Question 2

Mean and variance from the new parameter settings.

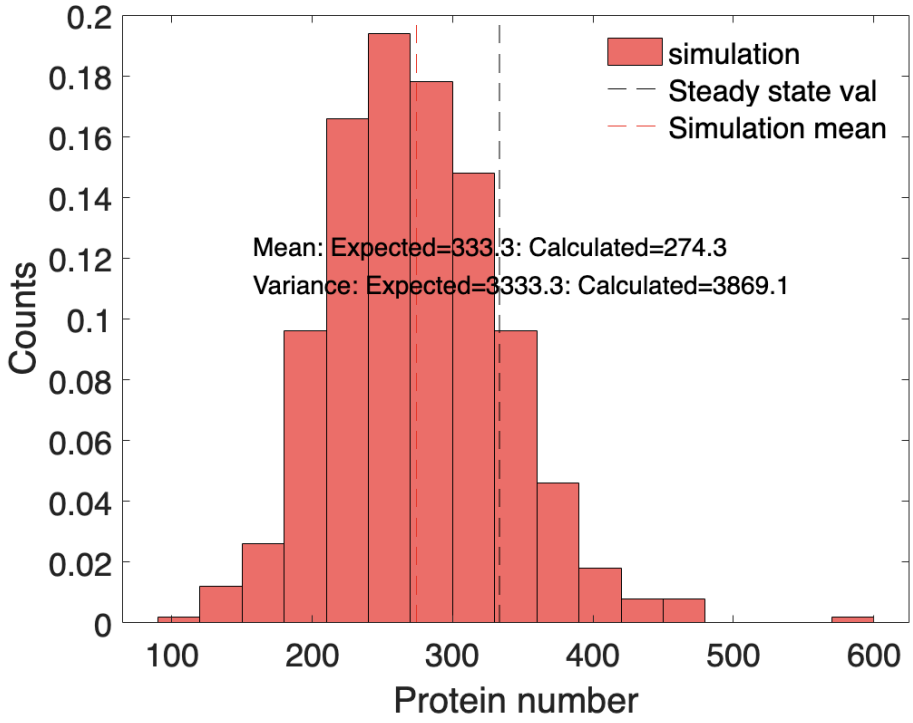
Case A1: Decrease alpha 10-fold.



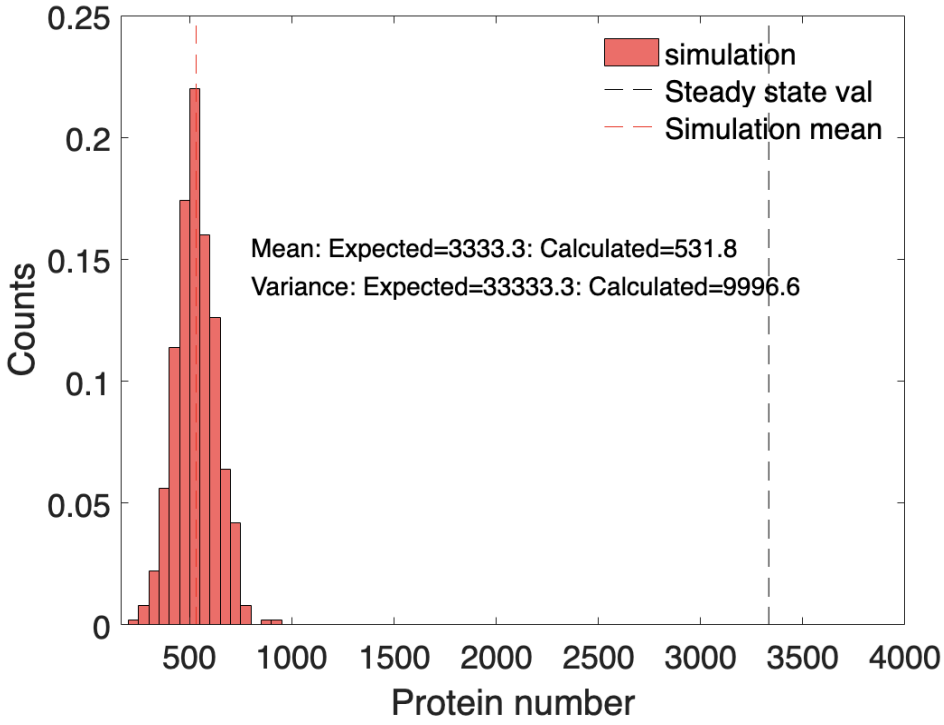
Case A2: Decrease alpha 100-fold.



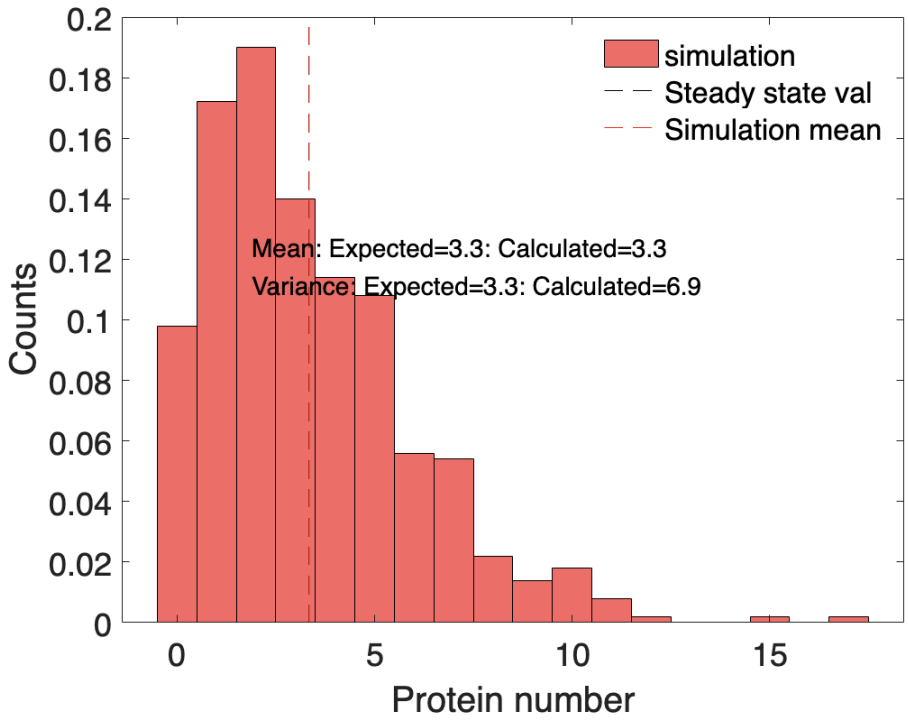
Case A3: Decrease beta 10-fold.



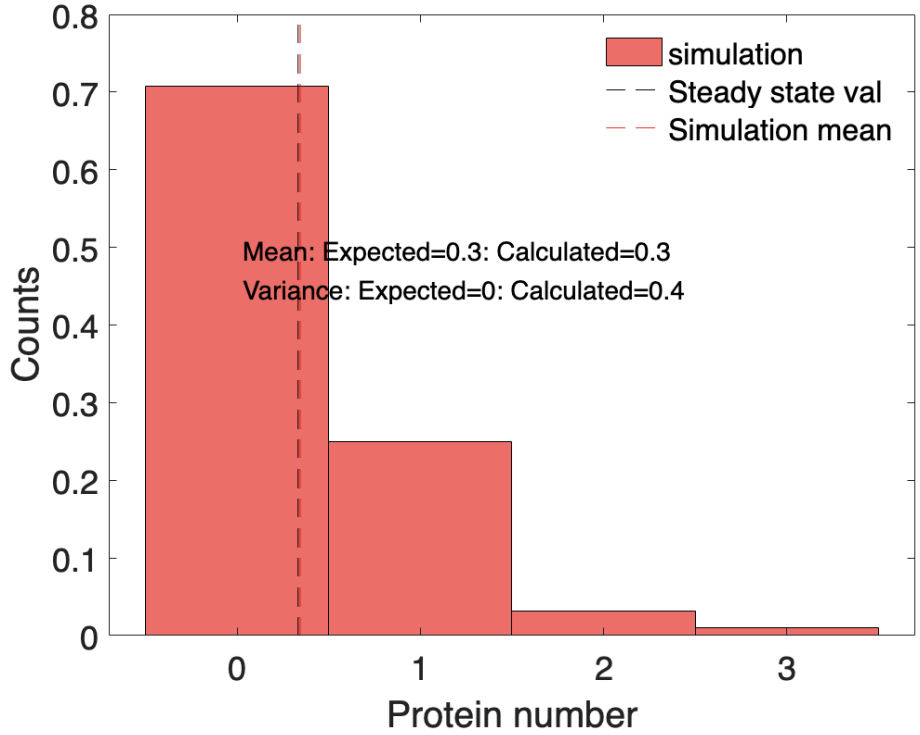
Case A4: Decrease beta 100-fold.



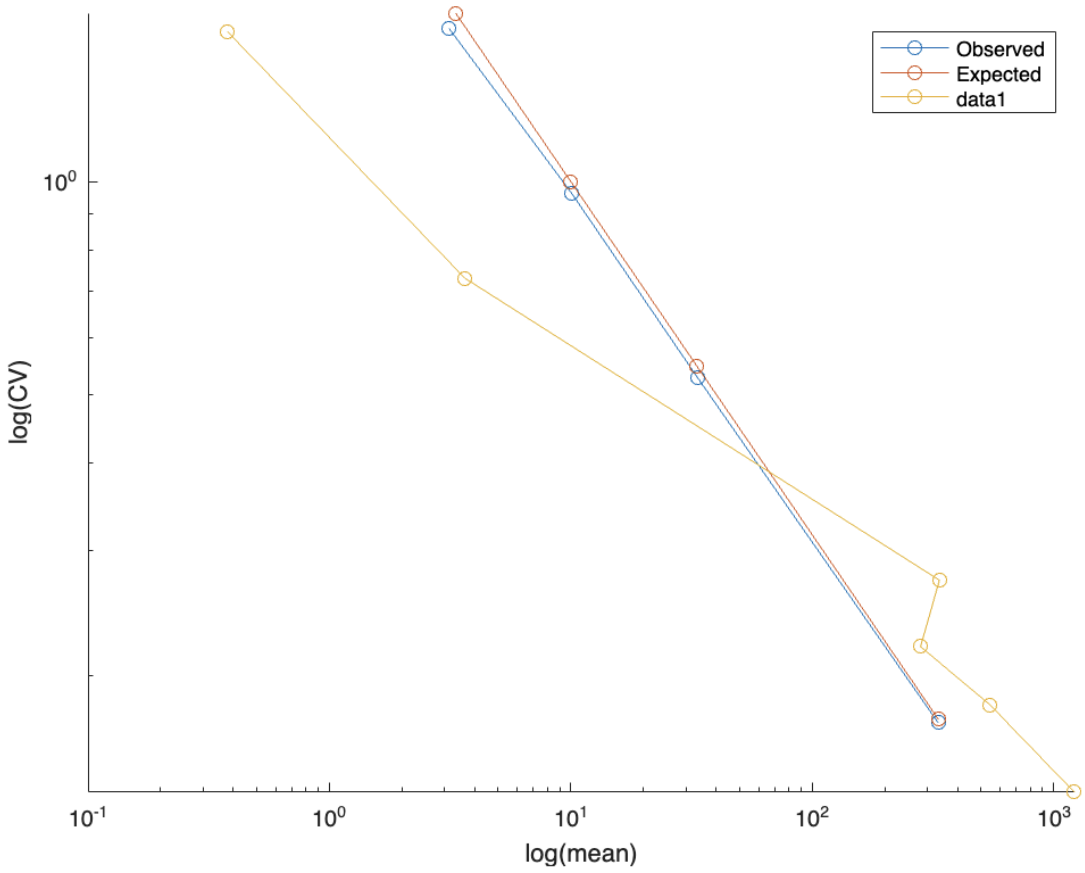
Case A5: Decrease k 10-fold.



Case A6: Decrease k 100-fold.



Plot of CV against Mean on a log-log plot, including additional cases.



The plot of CV against mean for the new trials is again linear with a negative slope. The points that deviate slightly from the line could perhaps be explained by the fact that at very low protein synthesis rates, even though the noise reduces, the reaction probability is too low for the protein numbers to increase enough to manifest in a higher corresponding mean.

Question 3

Observed Mean and Std. Deviations of final protein concentrations.

Trial 1

Mean: 0.104
Variance: 0.10139

Trial 2

Mean: 0.312
Variance: 0.34735

Trial 3

Mean: 0.956
Variance: 0.93193

Trial 4

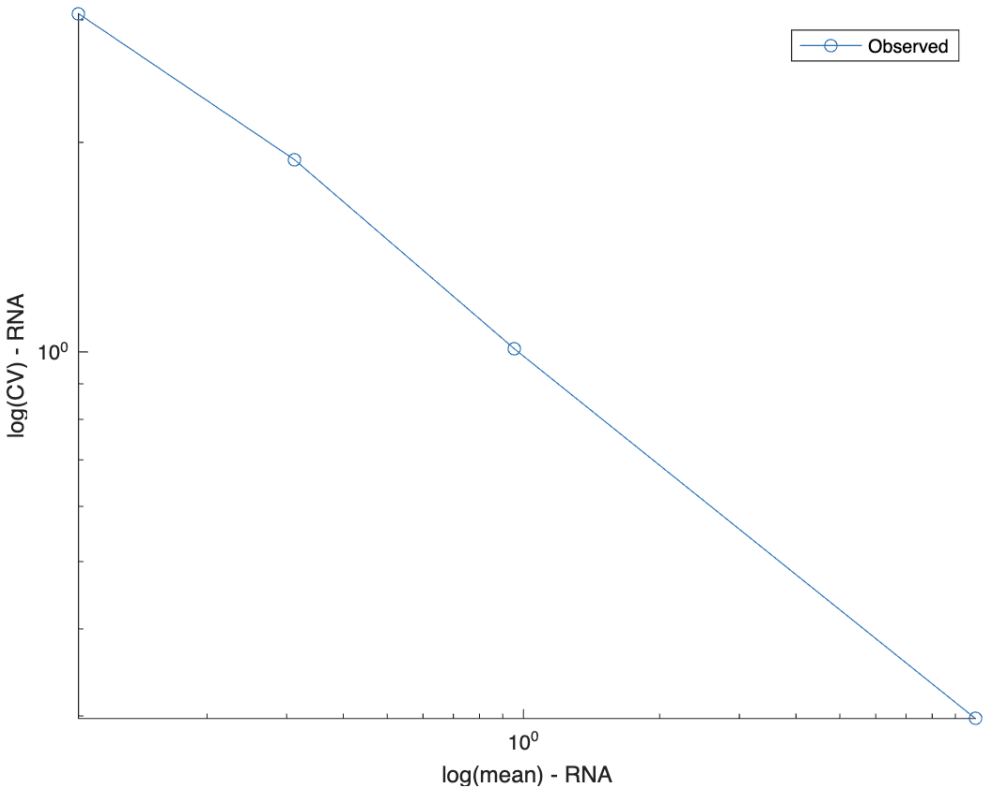
Mean: 9.966
Variance: 8.7864

Plot of CV against Mean on a log-log plot (RNA concentration)

Once again, there is a linear relationship with a negative slope between the log of coefficient of variation and the log of mean of the RNA concentrations. This means that the coefficient of variation, i.e., noise decreases exponentially as the mean increases.

This is once again a form of shot noise; the slope is negative, and the fluctuations/noise inherent in the process fades away as the RNA concentration increases.

[Plot follows].


Observed
log(CV) - RNA
10^0
10^0
log(mean) - RNA