

# ***Mycoplasma genitalium*** **Whole Cell Model**

**Jonathan Karr  
Jayodita Sanghvi  
Jared Jacobs  
Derek Macklin  
Markus Covert**

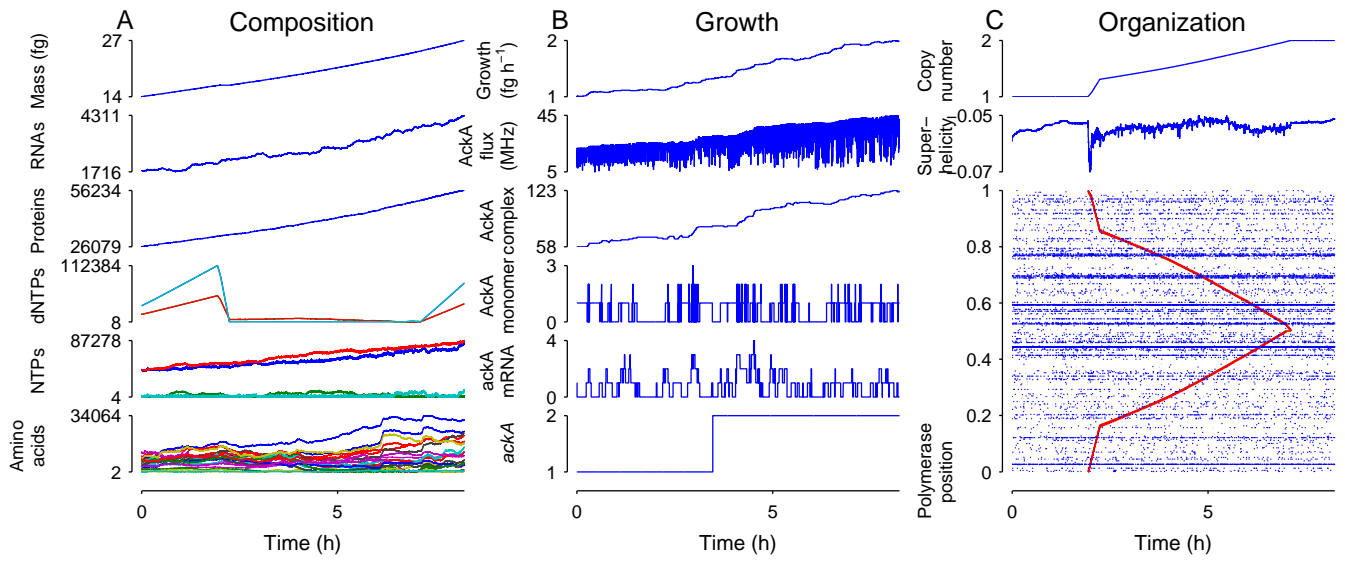
**Stanford University  
[covertlab.stanford.edu](http://covertlab.stanford.edu)**

# M. genitalium Whole Cell Model

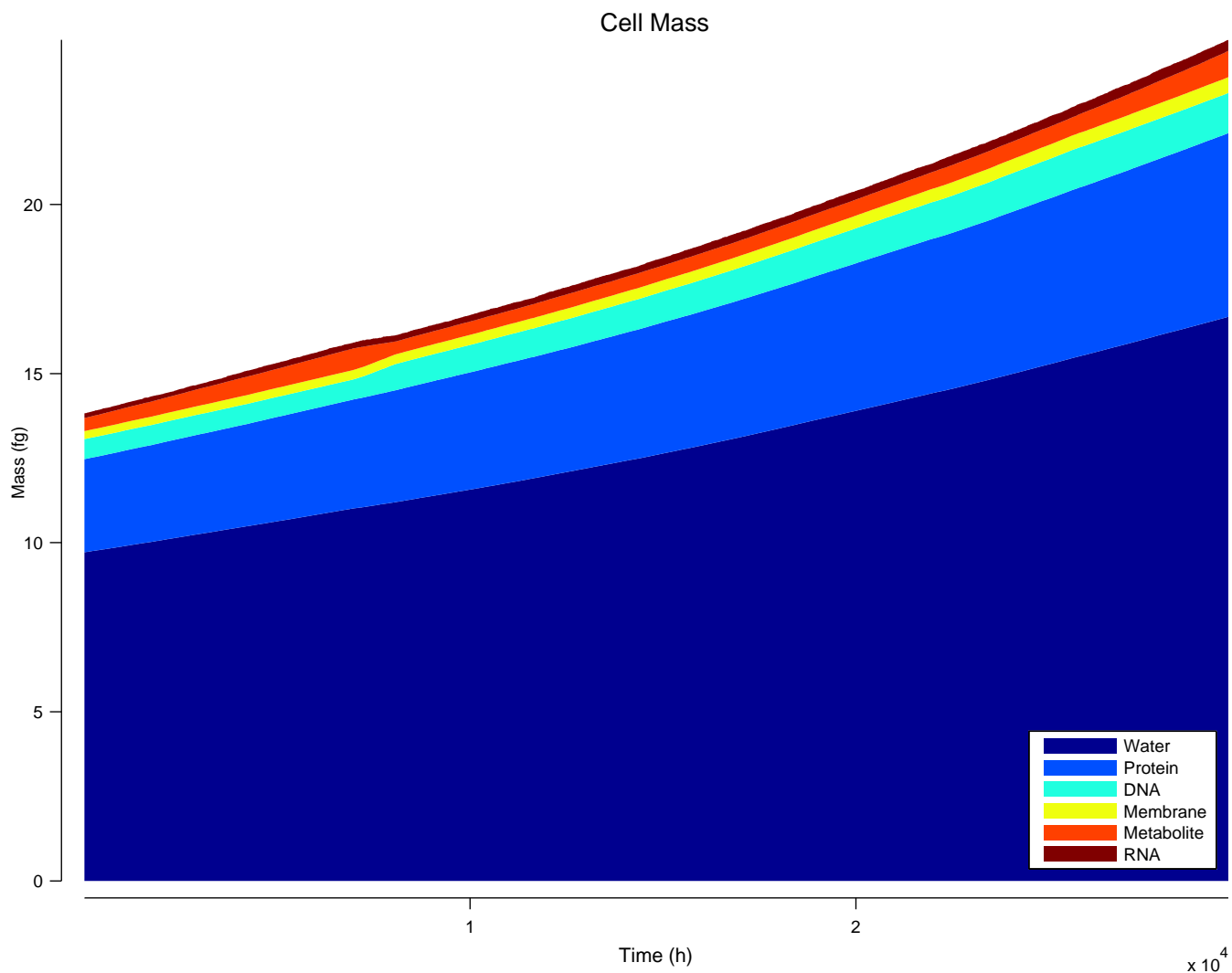
<b>Single Cell Dynamics</b>	<b>1</b>
Growth .....	1
Cellular Composition .....	2
Cellular Composition .....	3
Nucleotides .....	4
Nucleotides .....	5
Translation .....	6
Translation .....	7
Translation .....	8
Stalled Ribosomes .....	9
Stalled Ribosomes .....	10
Chromosome Organization .....	11
Chromosome Organization .....	12
Chromosome Organization .....	13
Chromosome Organization .....	14
Chromosome Organization .....	15
Chromosome Organization .....	16
<b>Population Dynamics</b>	<b>17</b>
Growth .....	17
Growth .....	18
Cellular Composition .....	19
Metabolism .....	20
Energy Production .....	21
Energy Production .....	22
Nucleotide Concentrations.....	23
Amino Acid Counts.....	24
Process ATP Requirements .....	25
Process ATP Allocations .....	26
Process ATP Usages.....	27
Process GTP Requirements.....	28
Process GTP Allocations.....	29
Process GTP Usages .....	30
Replication Initiation .....	31
Replication .....	32
Replication .....	33
Replication .....	34
Transcription .....	35
RNA Maturation.....	36
RNA Maturation.....	37
Translation .....	38
Translation .....	39
Protein Maturation .....	40
Protein Maturation .....	41
Supercoiling.....	42
DNA Repair .....	43

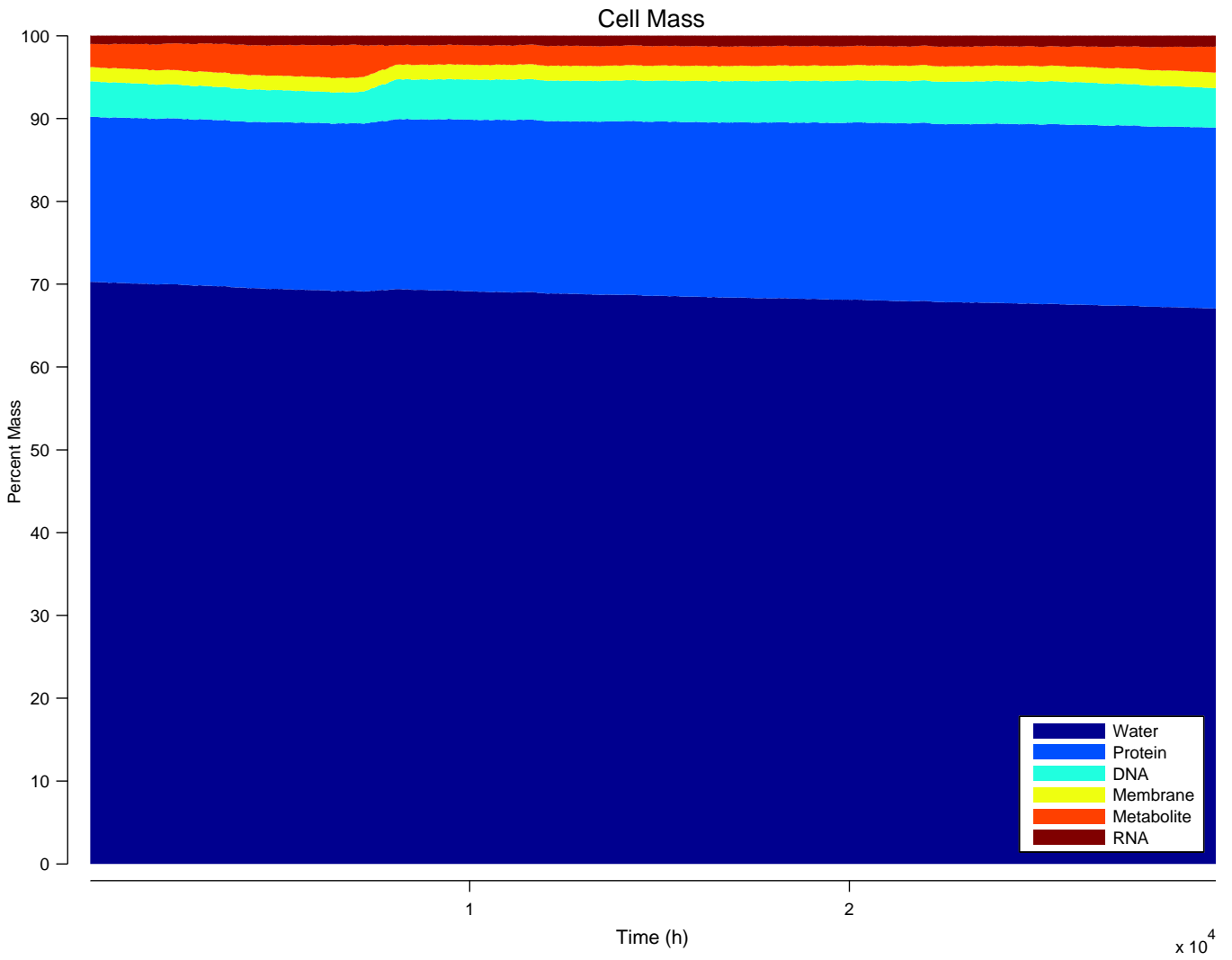
Cell Division .....	44
Cell Division .....	45
Immune Activation.....	46
Unsynchronized Population.....	47
Simulation Runtime .....	48
<b>Population Statistics</b>	<b>49</b>
Biomass Composition.....	49
Biomass Composition.....	50
Metabolite Concentrations .....	51
dNMP Composition .....	52
Nucleotide Composition .....	53
Nucleotide Composition .....	54
Nucleotide Composition .....	55
Amino Acid Composition.....	56
Amino Acid Composition.....	57
Amino Acid Composition.....	58
RNA Composition.....	59
RNA Composition.....	60
Gene Expression .....	61
Gene Expression .....	62
tRNA Expression .....	63
tRNA Expression .....	64
Protein Expression .....	65
Protein Expression .....	66
Macromolecule Expression.....	67
Macromolecular Complexes .....	68
RNA Half Lives.....	69
RNA Half Lives.....	70
Replication .....	71
Secondary Replication Initiation .....	72
RNA Synthesis .....	73
Protein Synthesis.....	74
Cell Cycle Phase Durations .....	75
Cell Cycle Phase Distribution.....	76
Cell Cycle Phase Lengths .....	77
Cumulative Growth Vs. Cell Cycle Phase Durations .....	78
Cumulative Growth Vs. Cell Cycle Phase Times .....	79
Initial Growth Vs. Cell Cycle Phase Durations .....	80
Initial Growth Vs. Cell Cycle Phase Times.....	81
Initial Vs. Cumulative Growth.....	82
Initial Growth Rate Vs. End Time.....	83
Final Growth Rate Vs. End Time .....	84
Cell Mass Distribution.....	85
Blocked Decay Events.....	86
Process ATP Usage .....	87
Process GTP Usage.....	88
Warnings.....	89

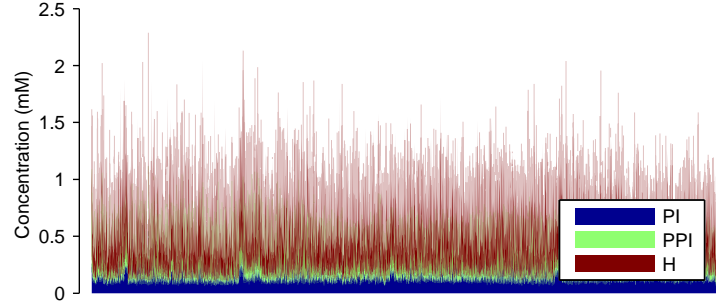
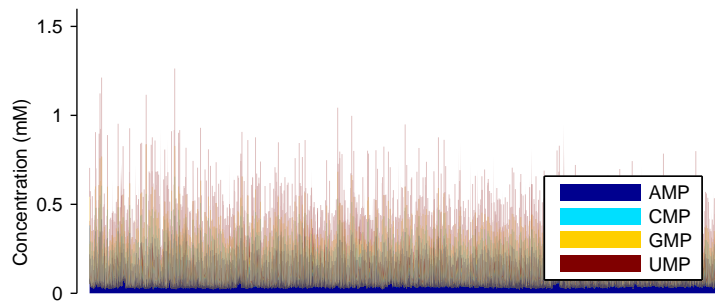
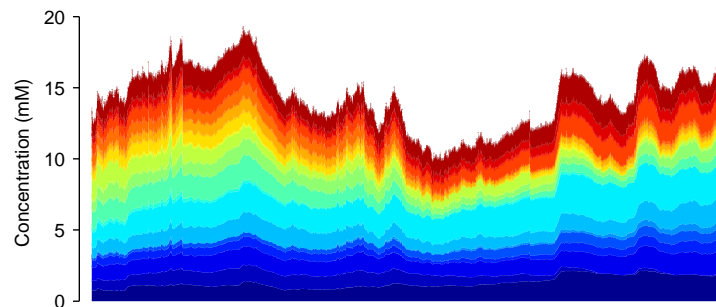
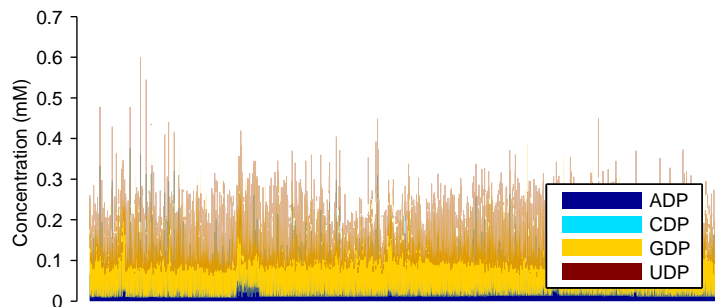
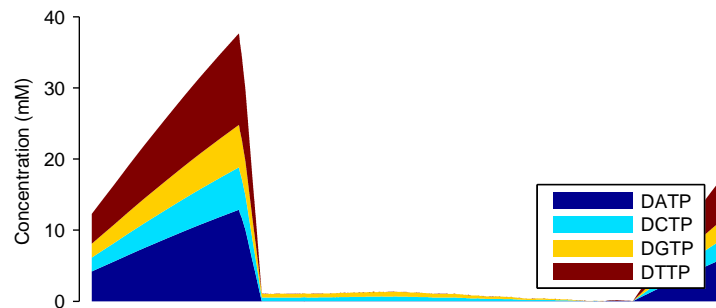
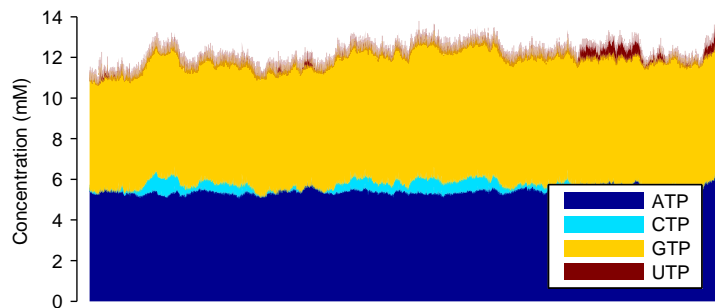
<b>Simulation Structure</b>	<b>90</b>
Metabolic Model.....	90
Shared Gene Products .....	91
Shared Metabolites .....	92
Shared Metabolites .....	93
Shared Metabolites .....	94



Growth





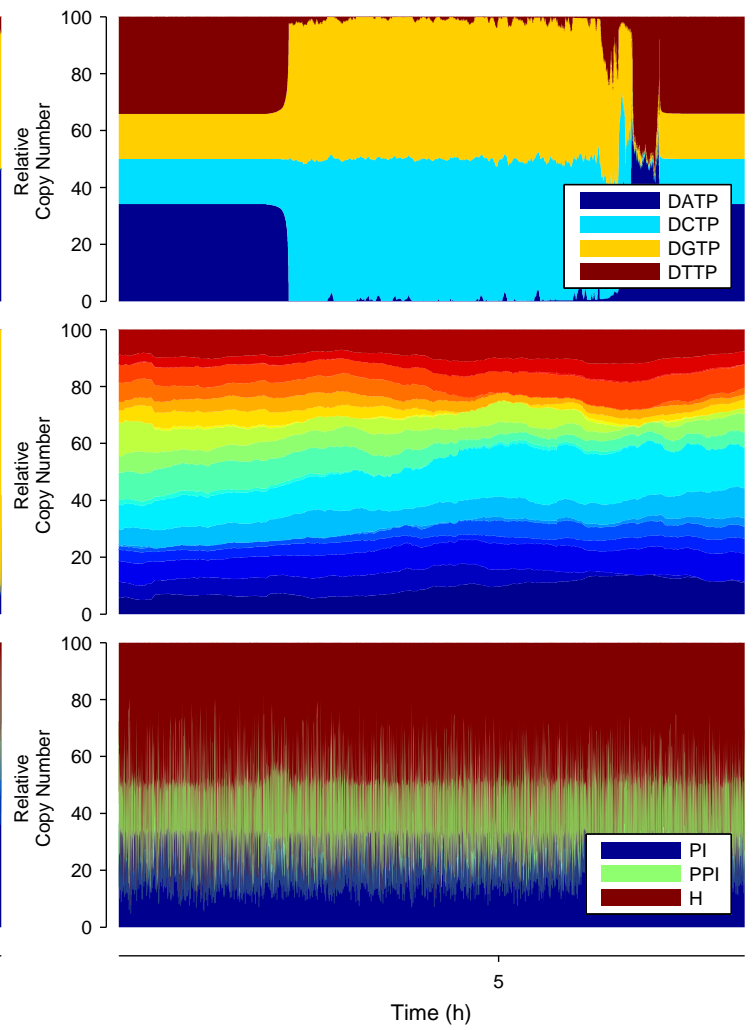
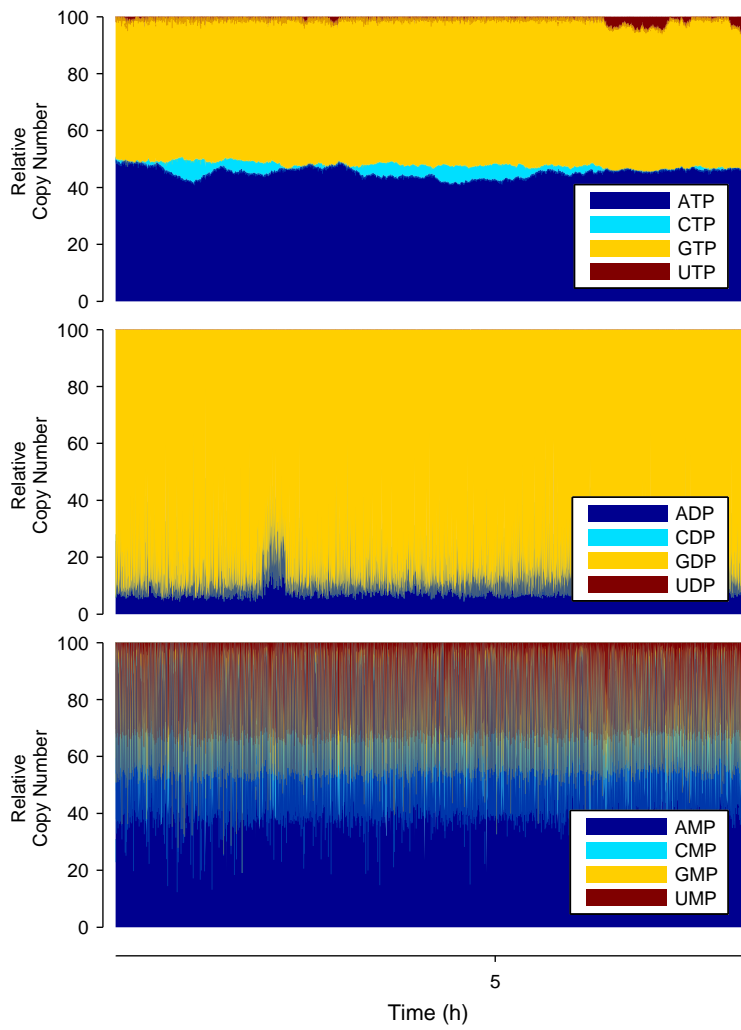


Time (h)

Time (h)

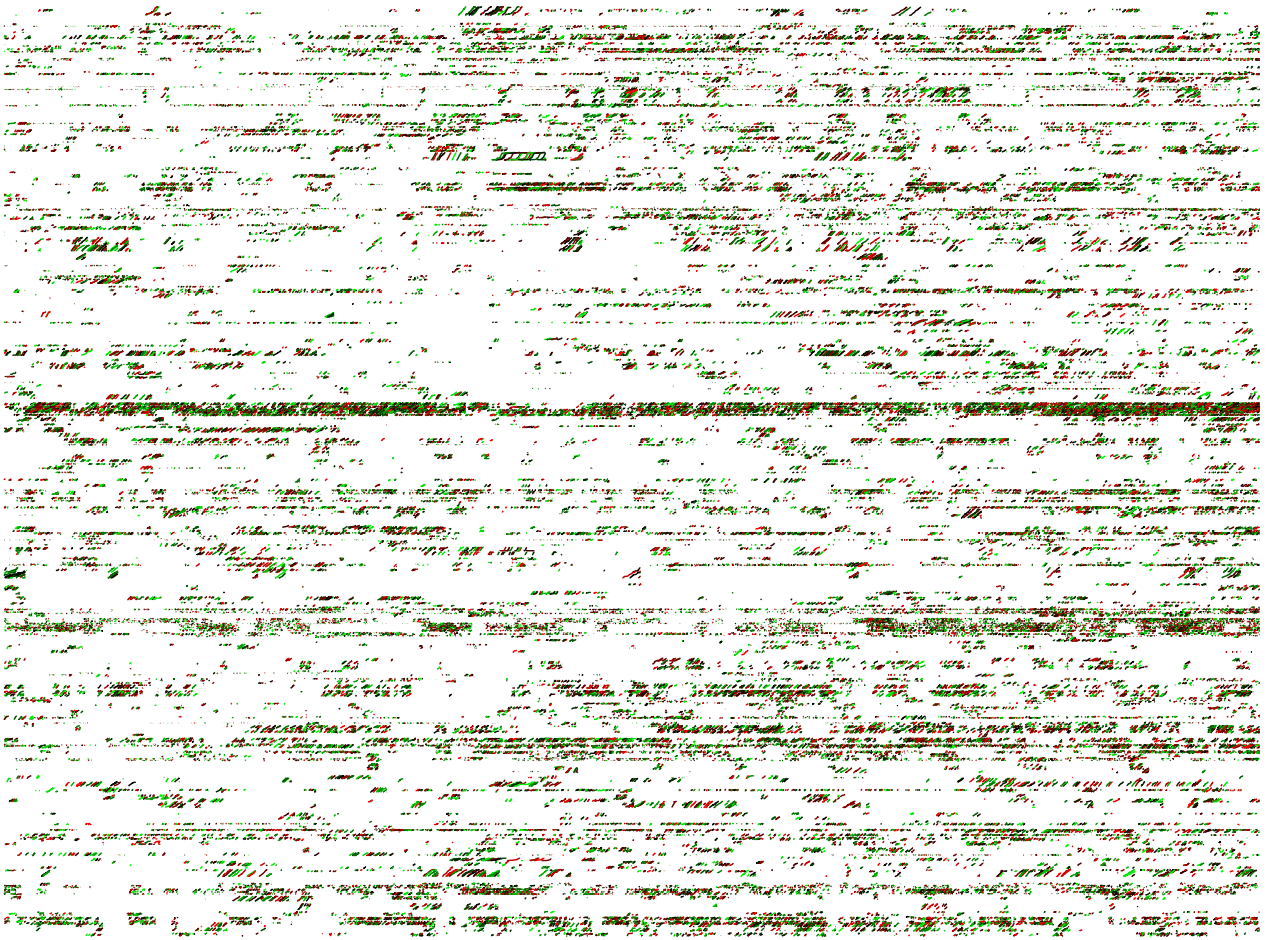
# Nucleotides





# Nucleotides

Ribosome Position

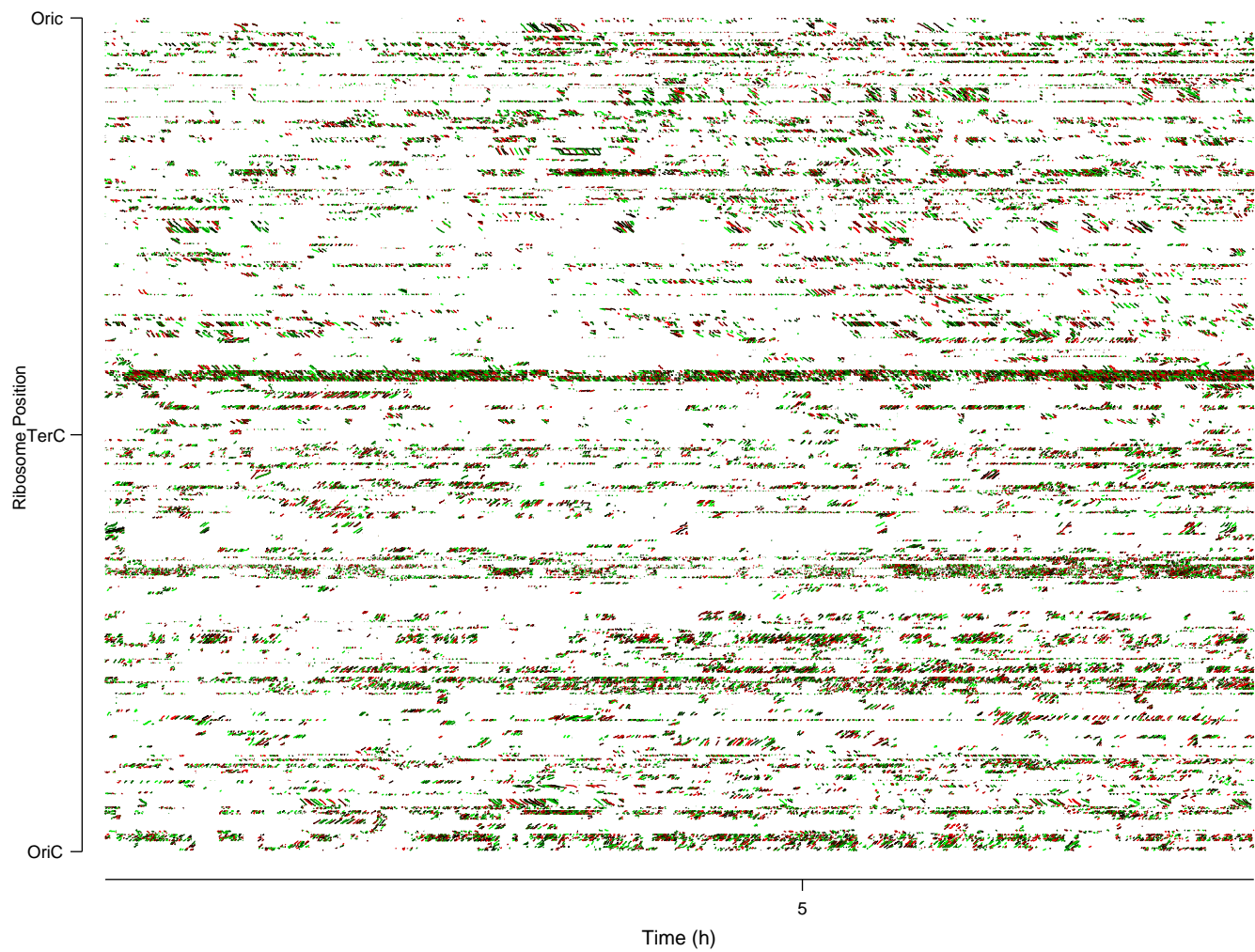


5

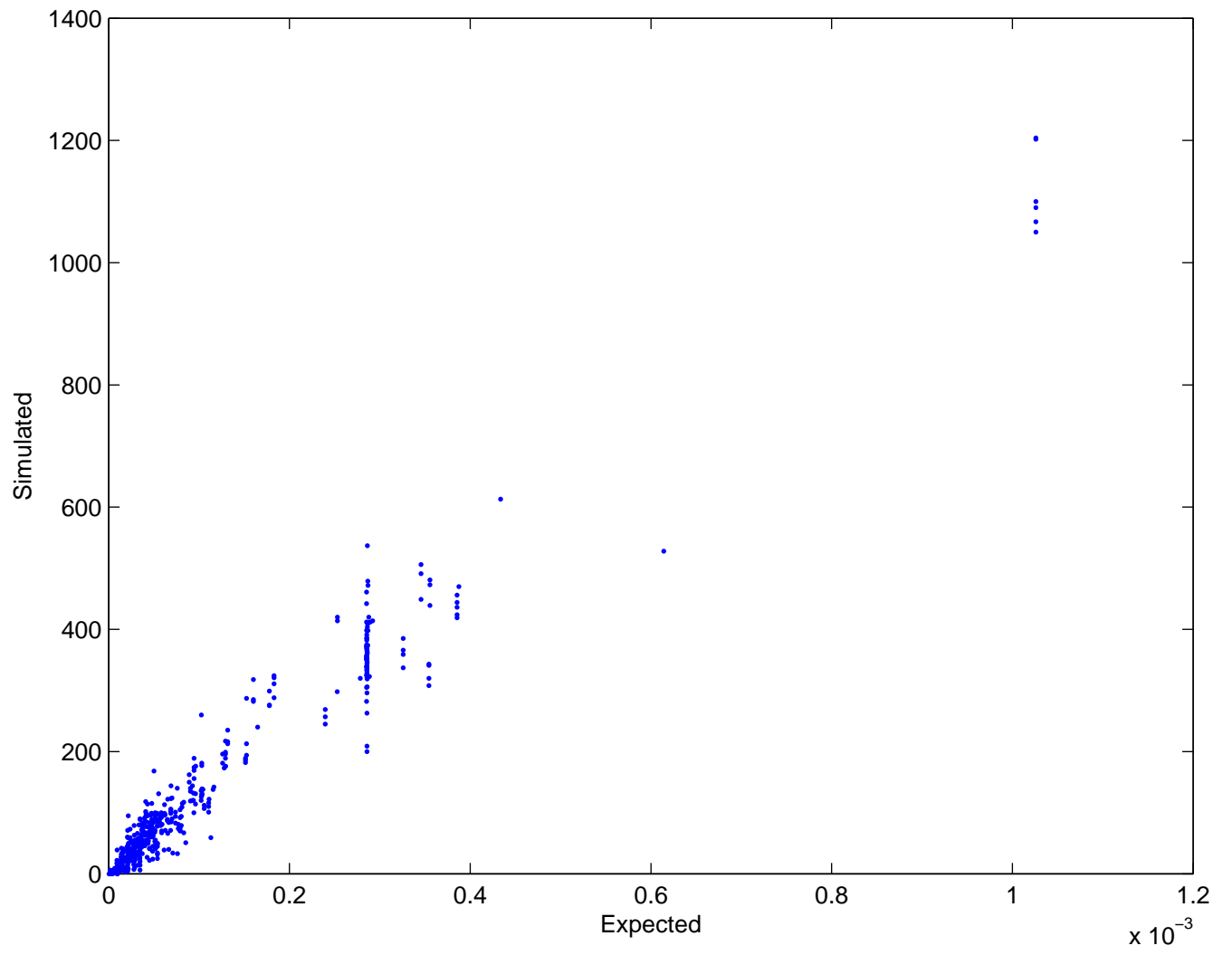
Time (h)

Translation

6

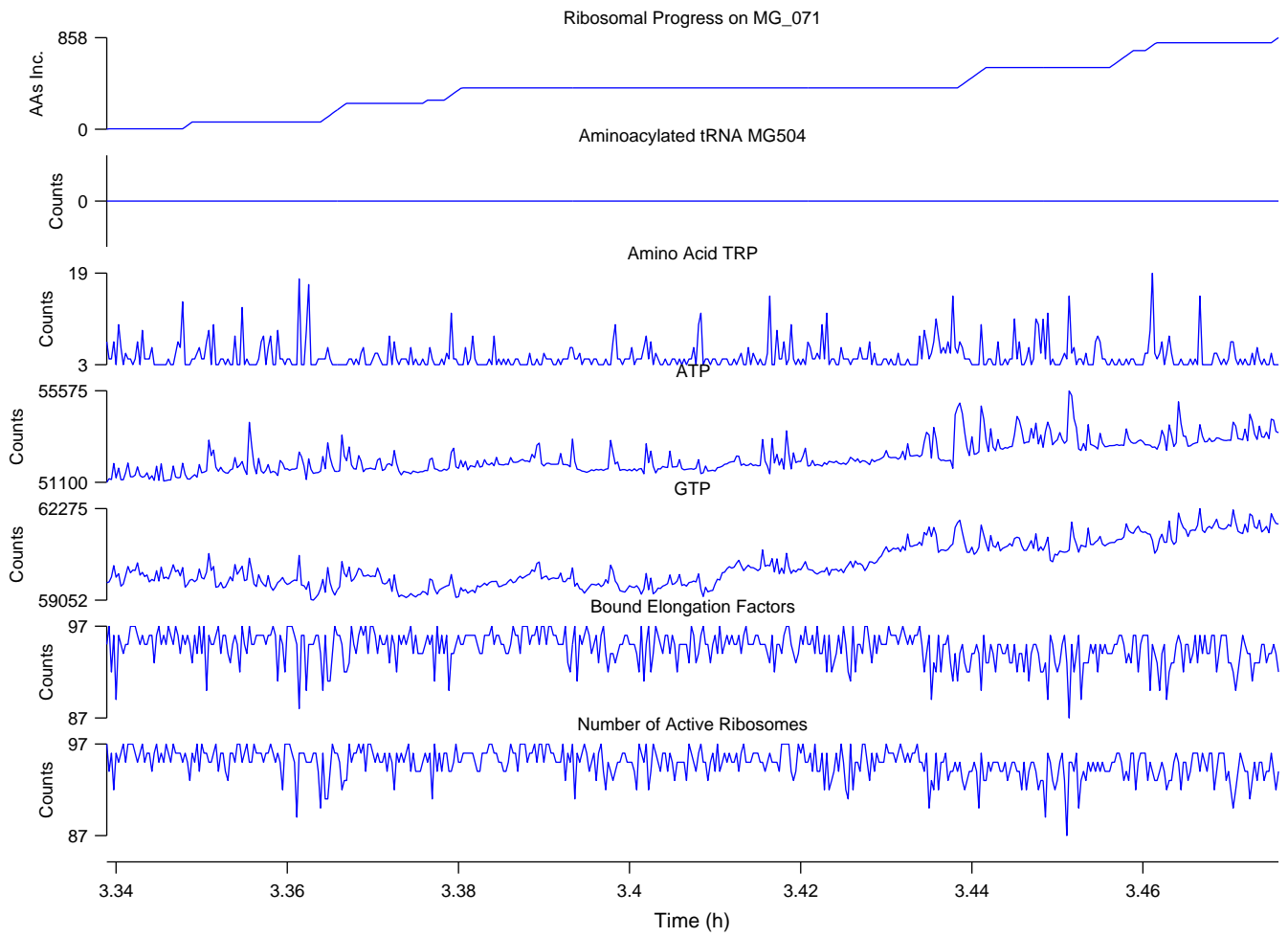


Translation

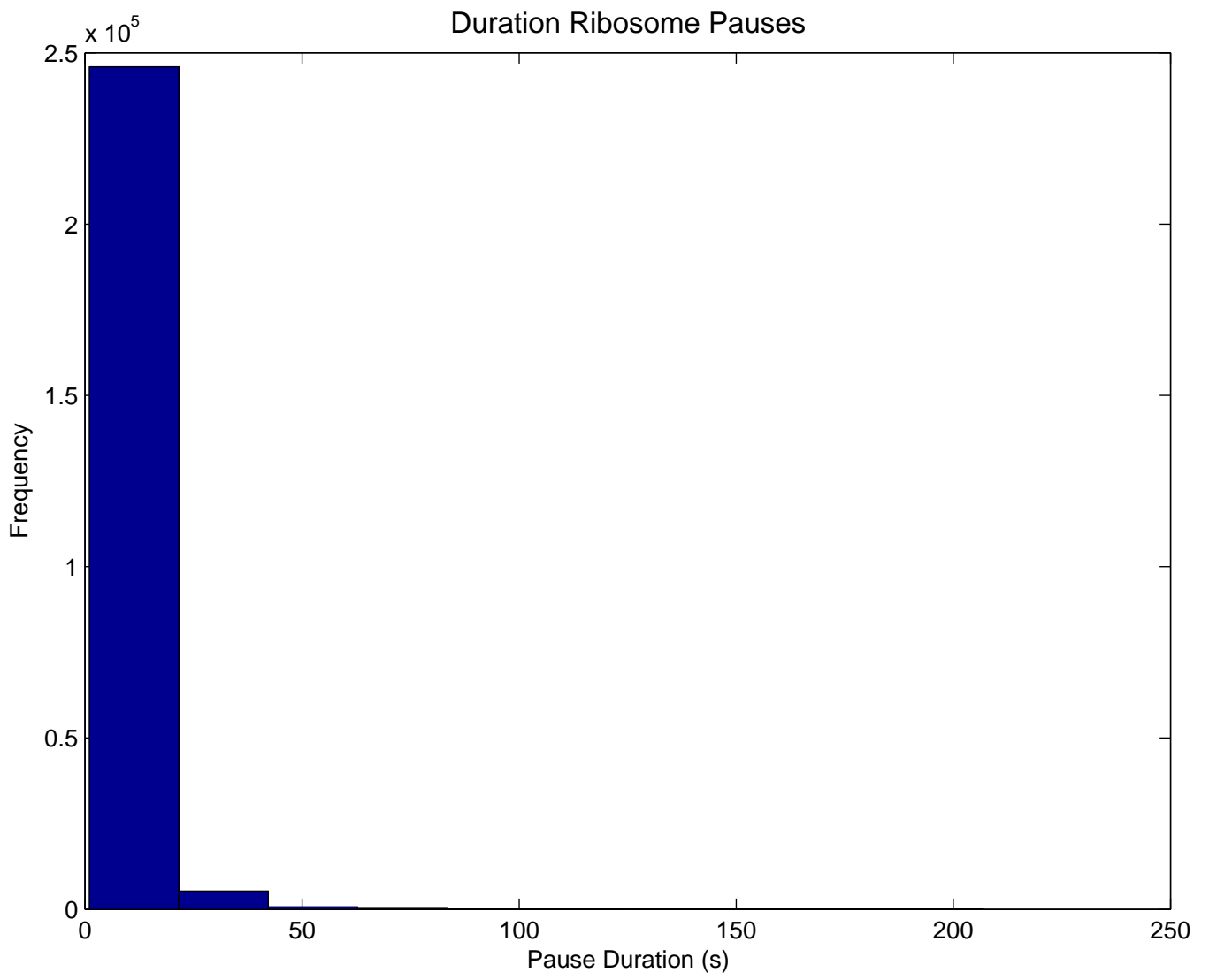


Translation

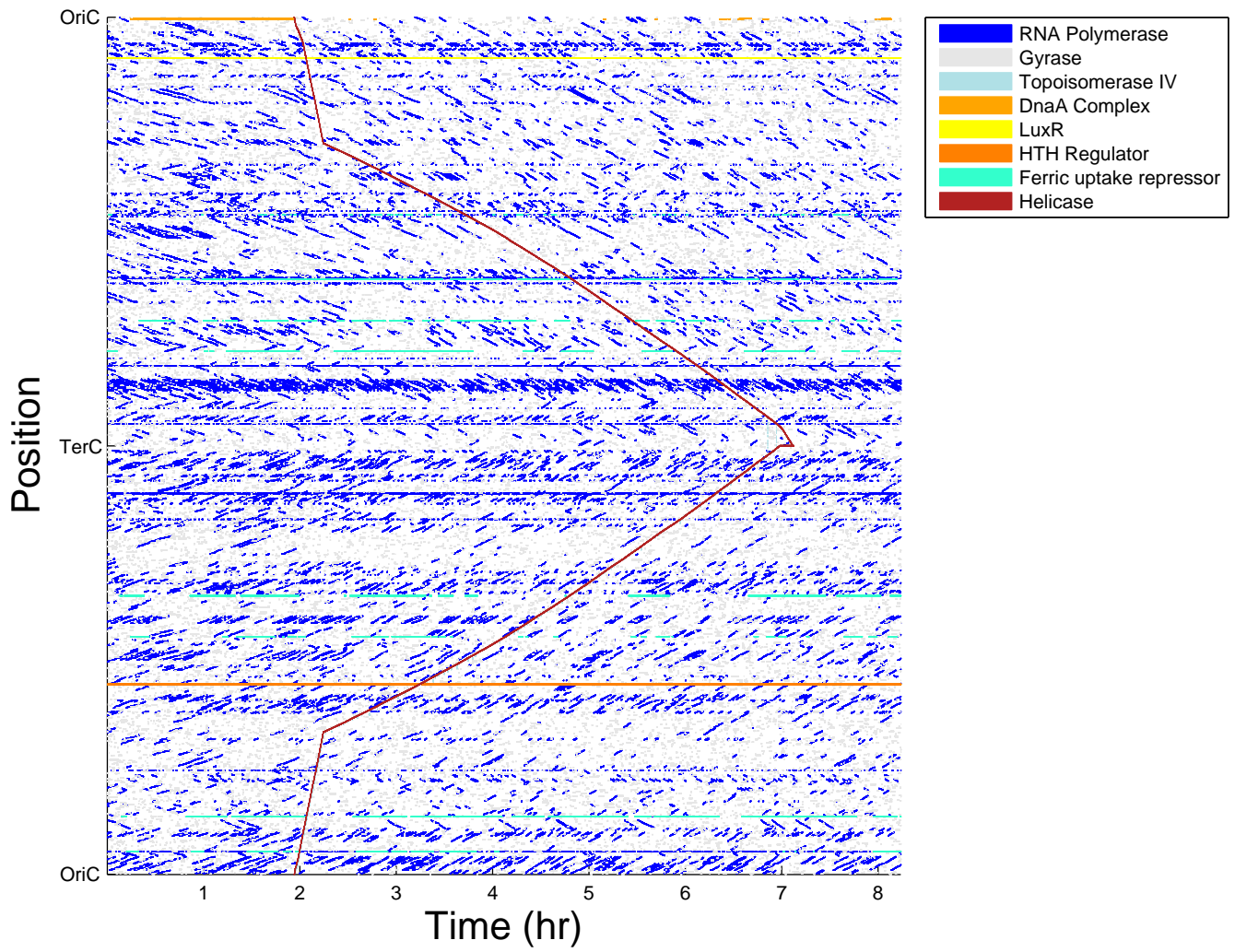
# Longest Ribosome Stall Simulation: 2011:10:19 02:53:45 #1

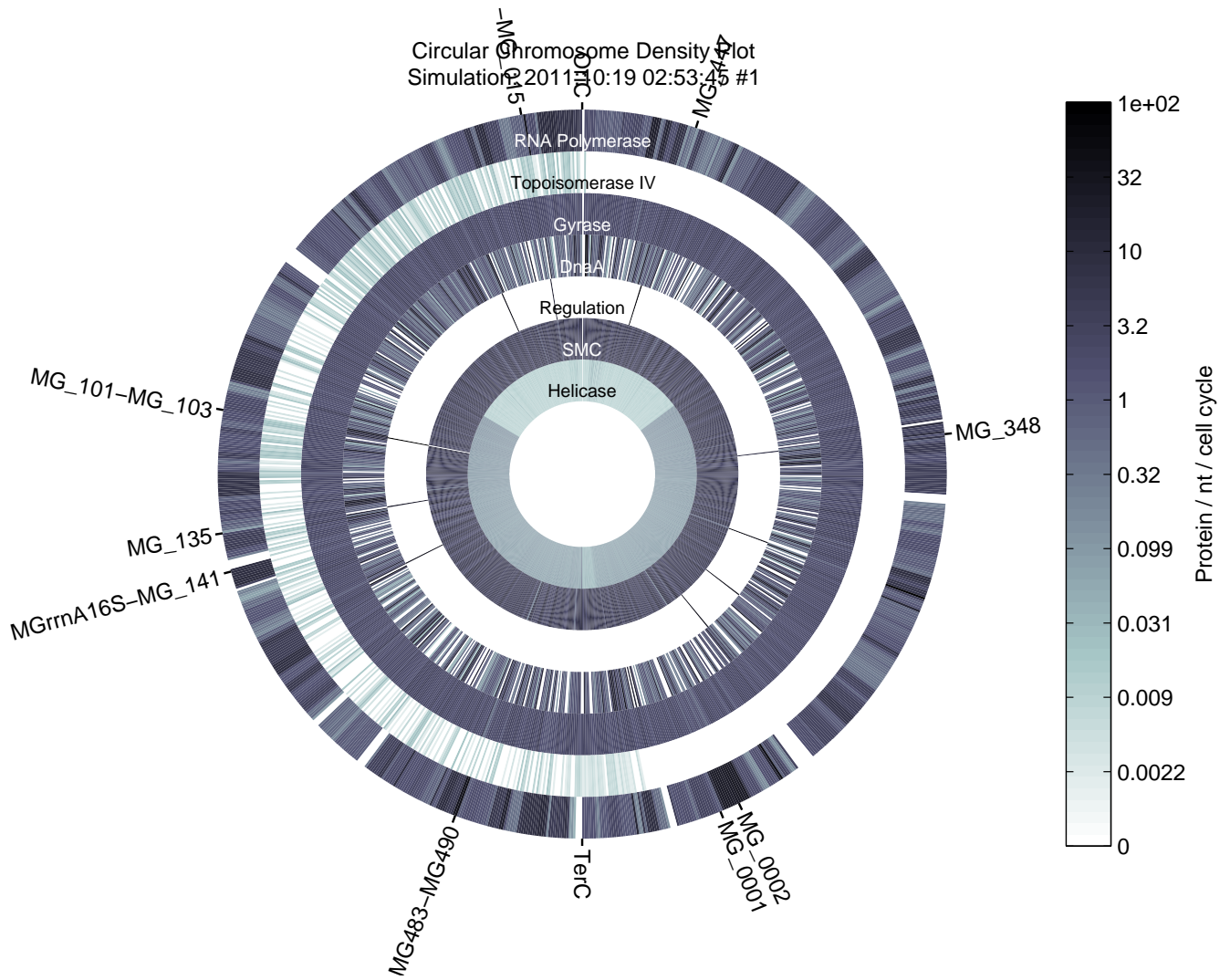


Stalled Ribosomes



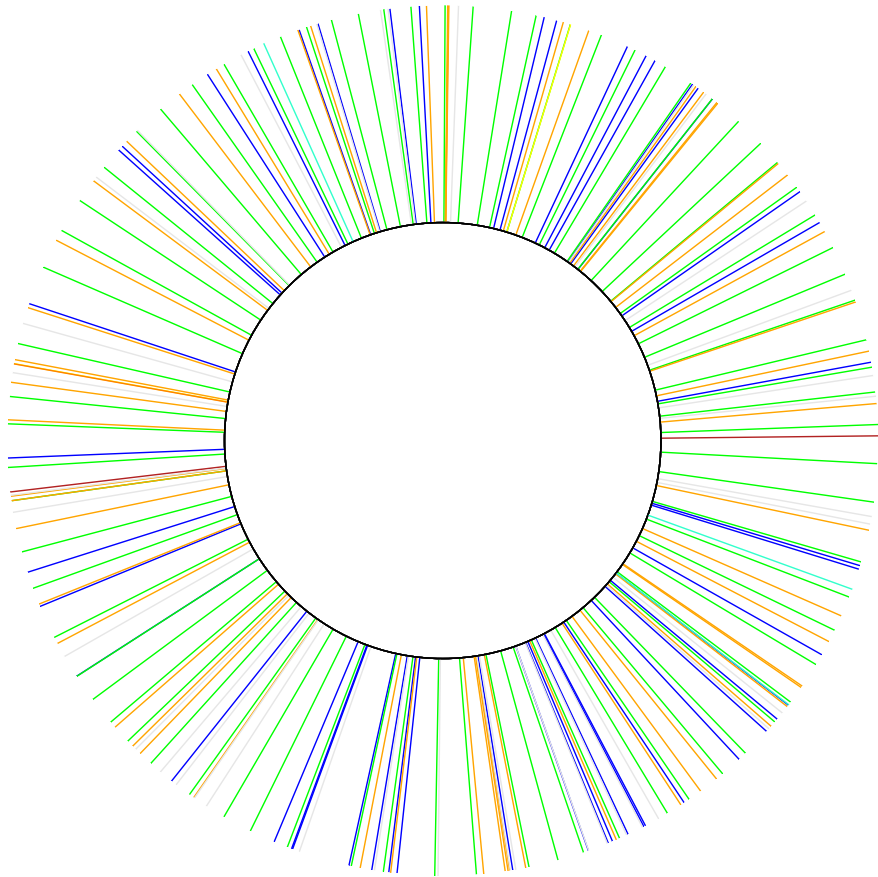
Stalled Ribosomes



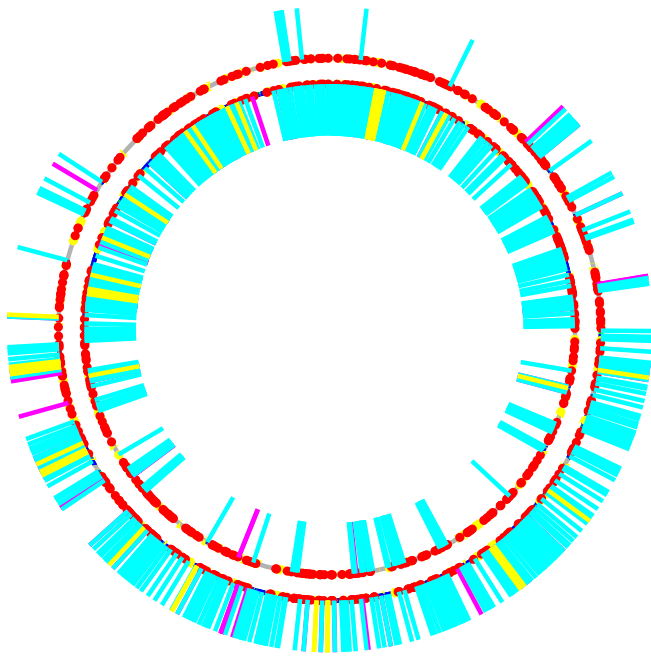


## Chromosome Organization

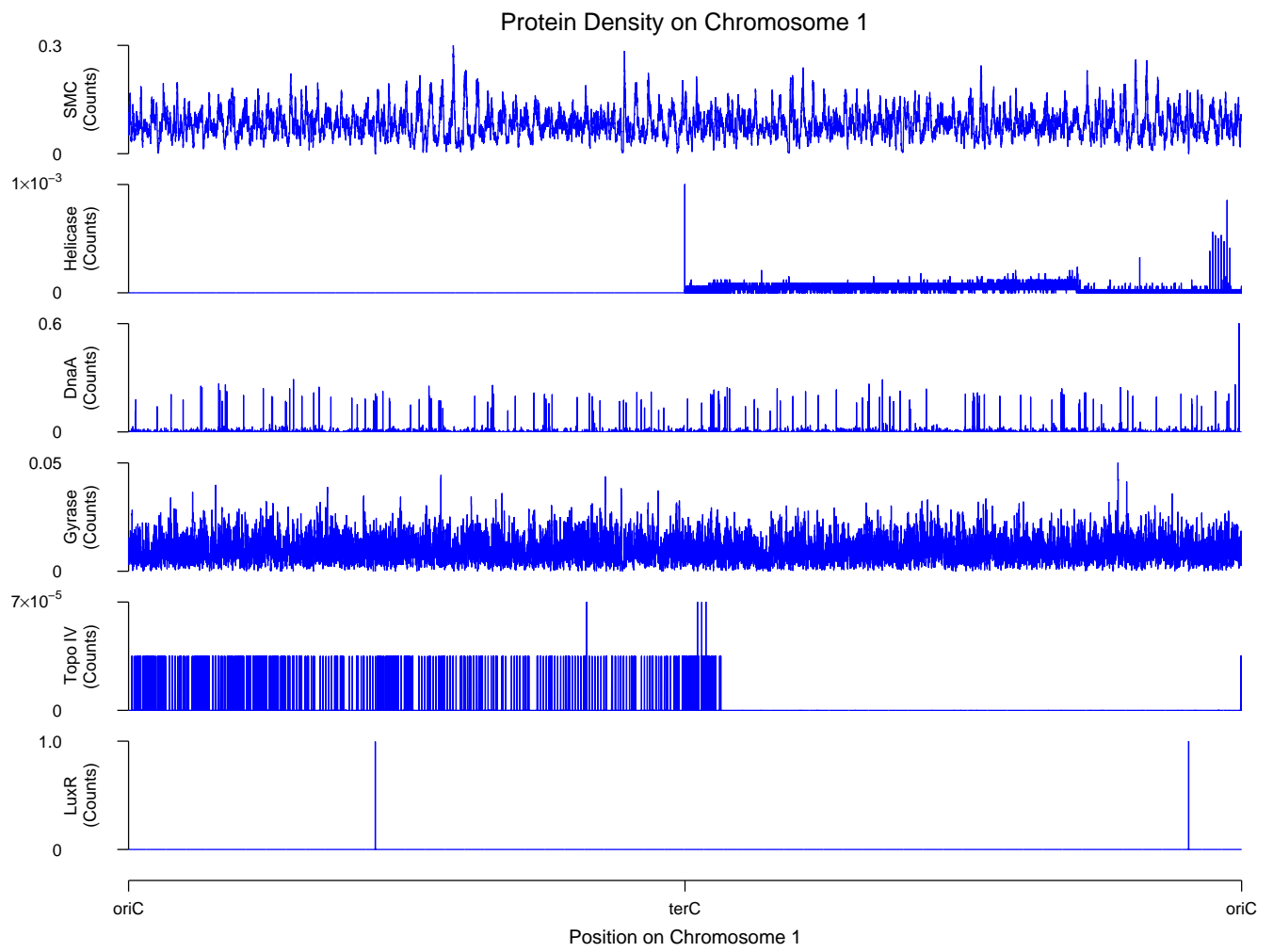


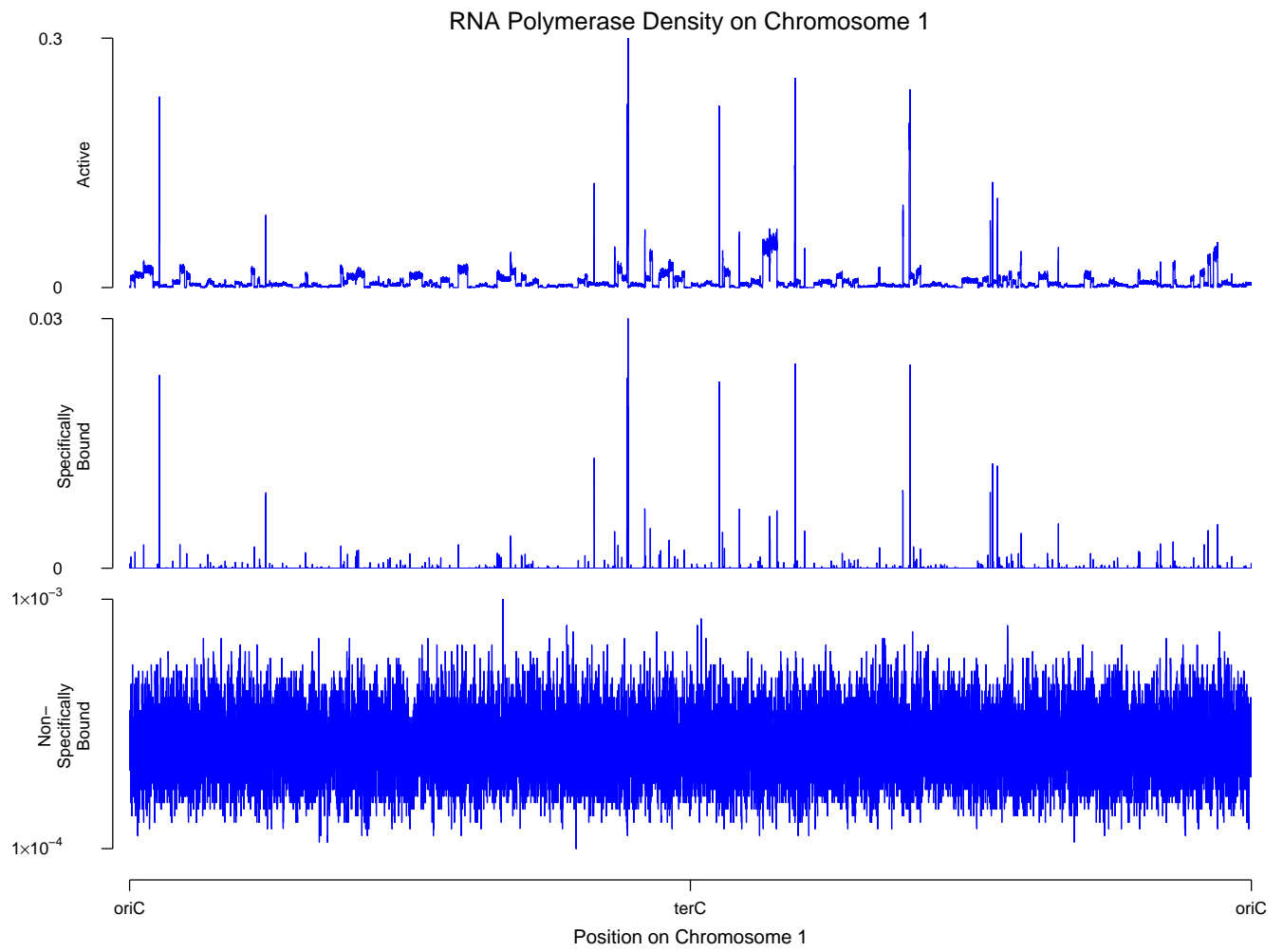


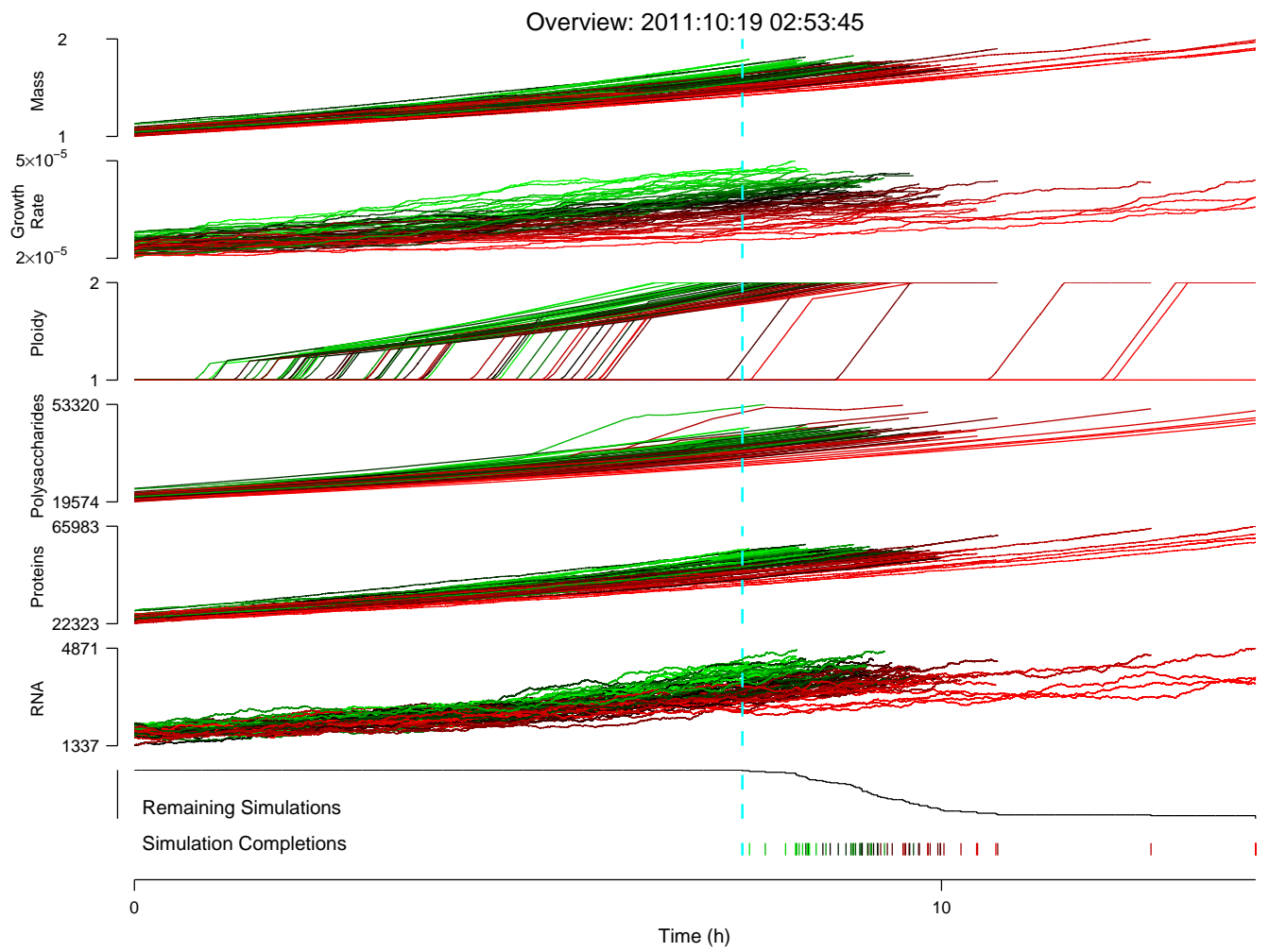
- RNA Polymerase
- SMC
- Helicase
- DnaA
- DnaA Complex
- Gyrase
- Topoisomerase IV
- LuxR
- HTH Regulator
- Ferric uptake repressor

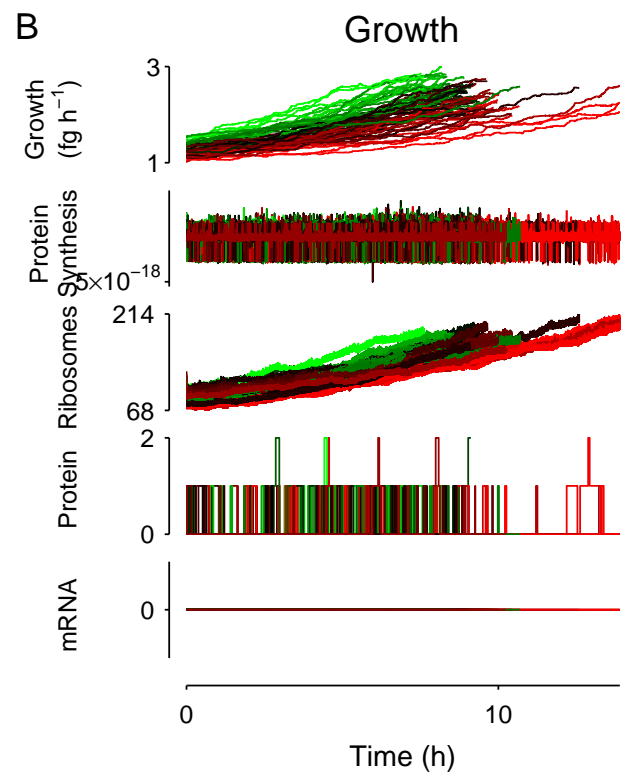
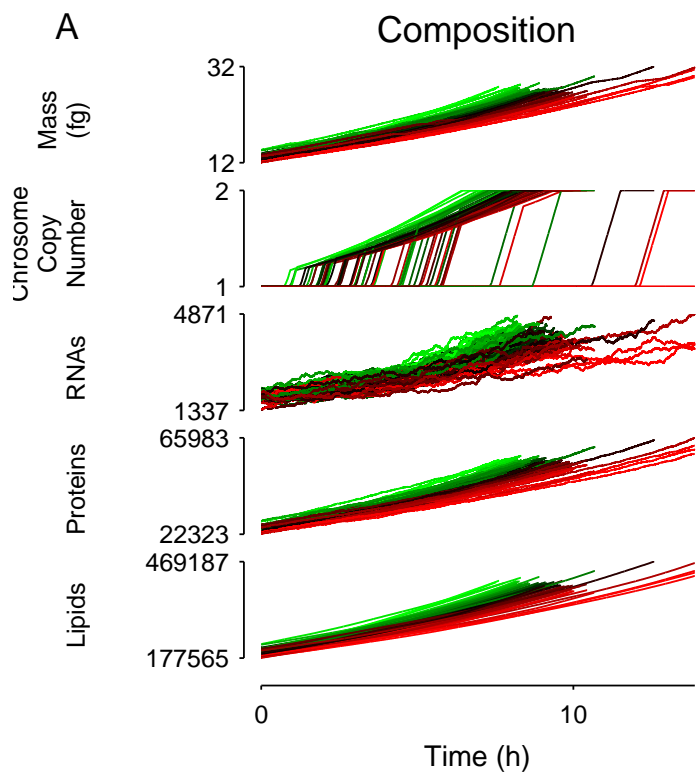


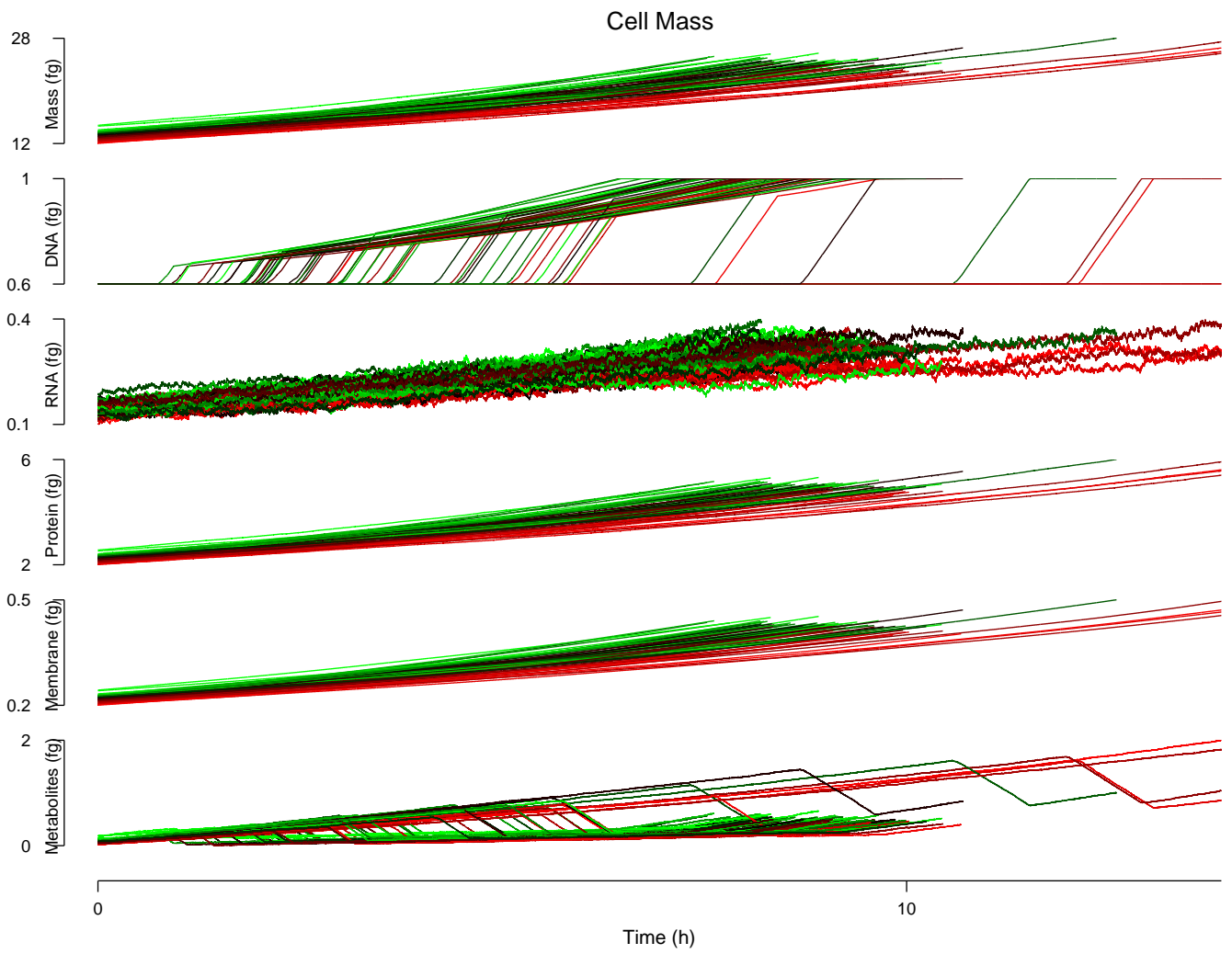
⋯ Chromosome  
 — Polymerized  
 — Gene  
 — TU  
 — Bnd Prot  
 — Damage  
 — Exp RNA  
 — Ex



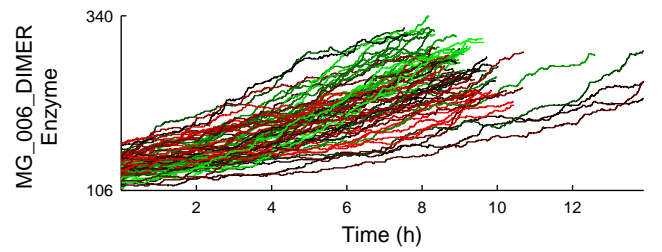
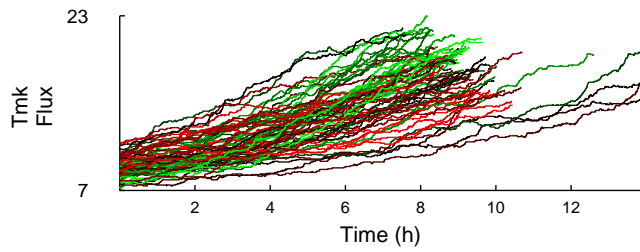
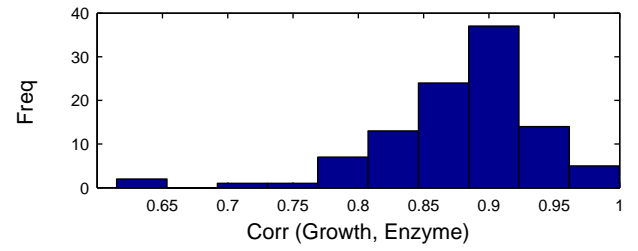
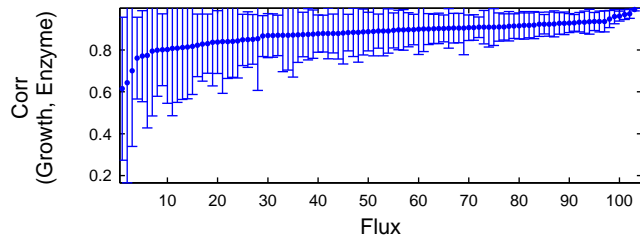
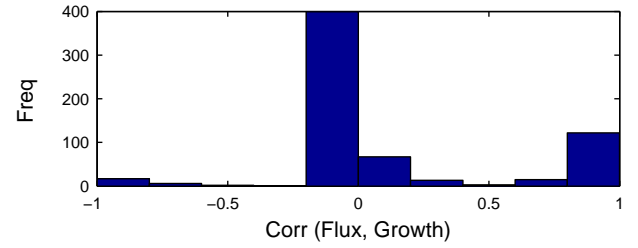
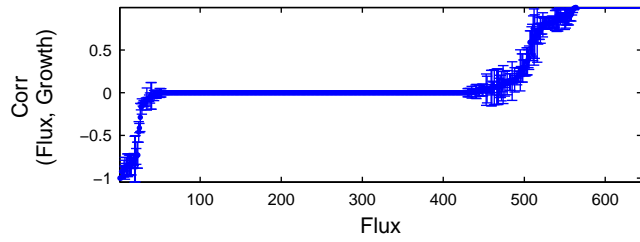
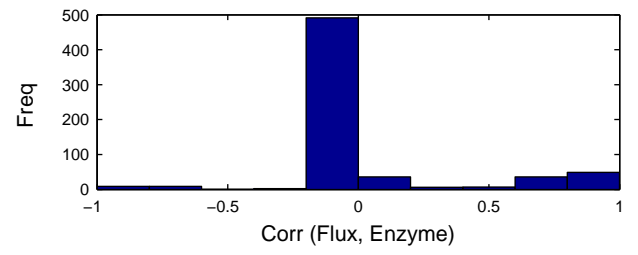
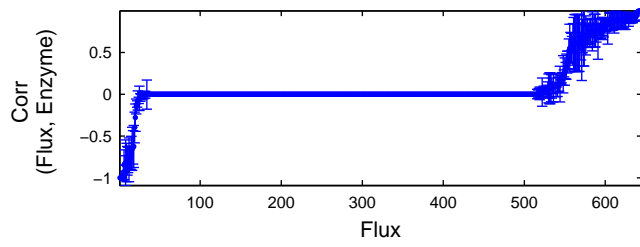




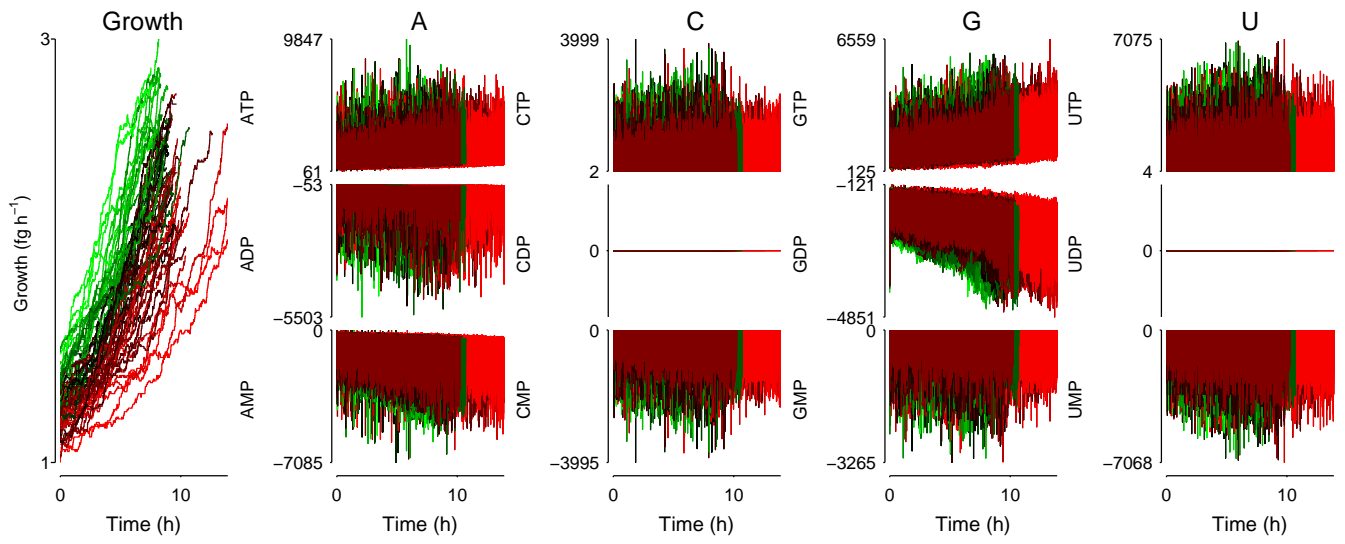




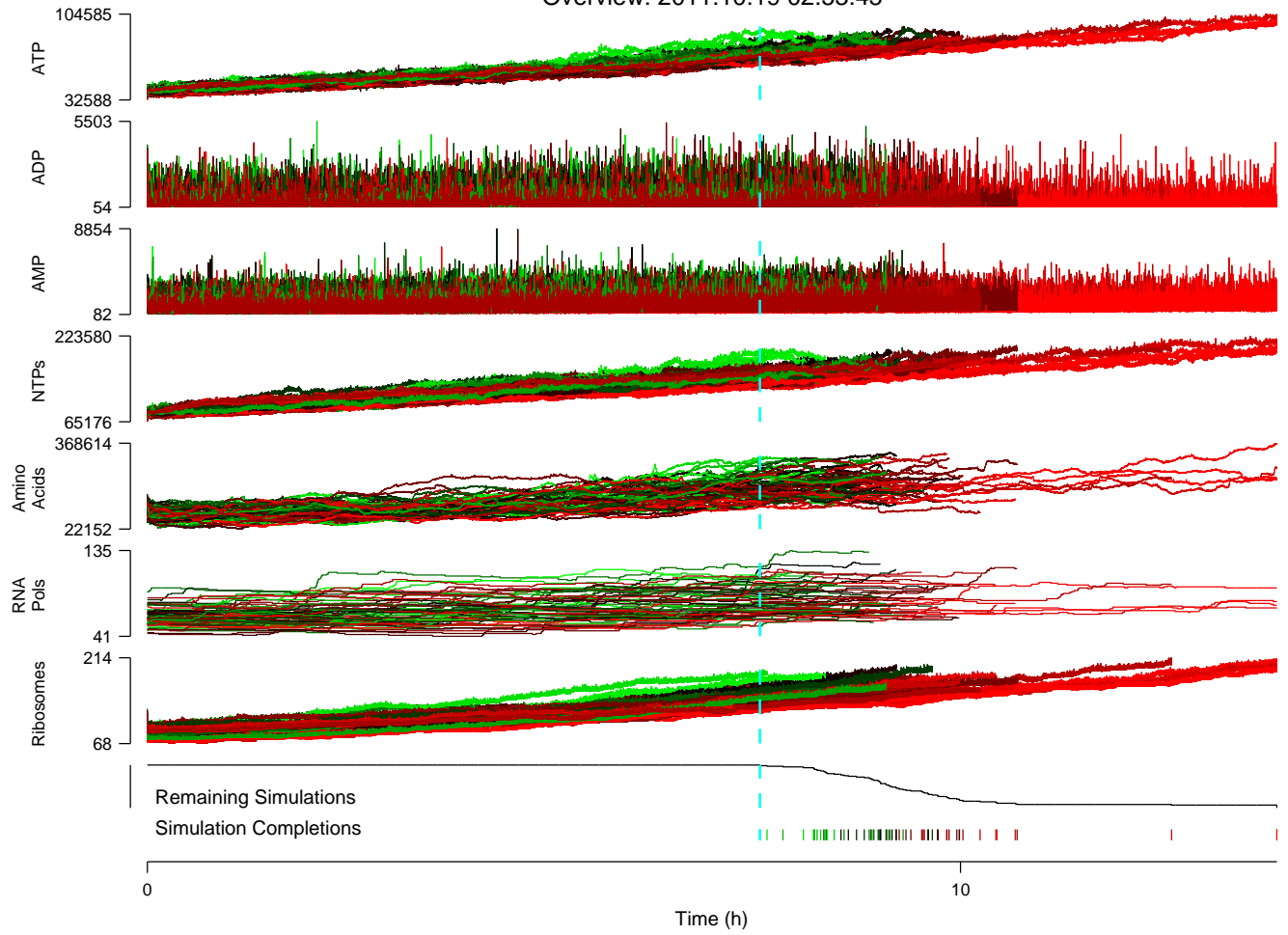
# Cellular Composition



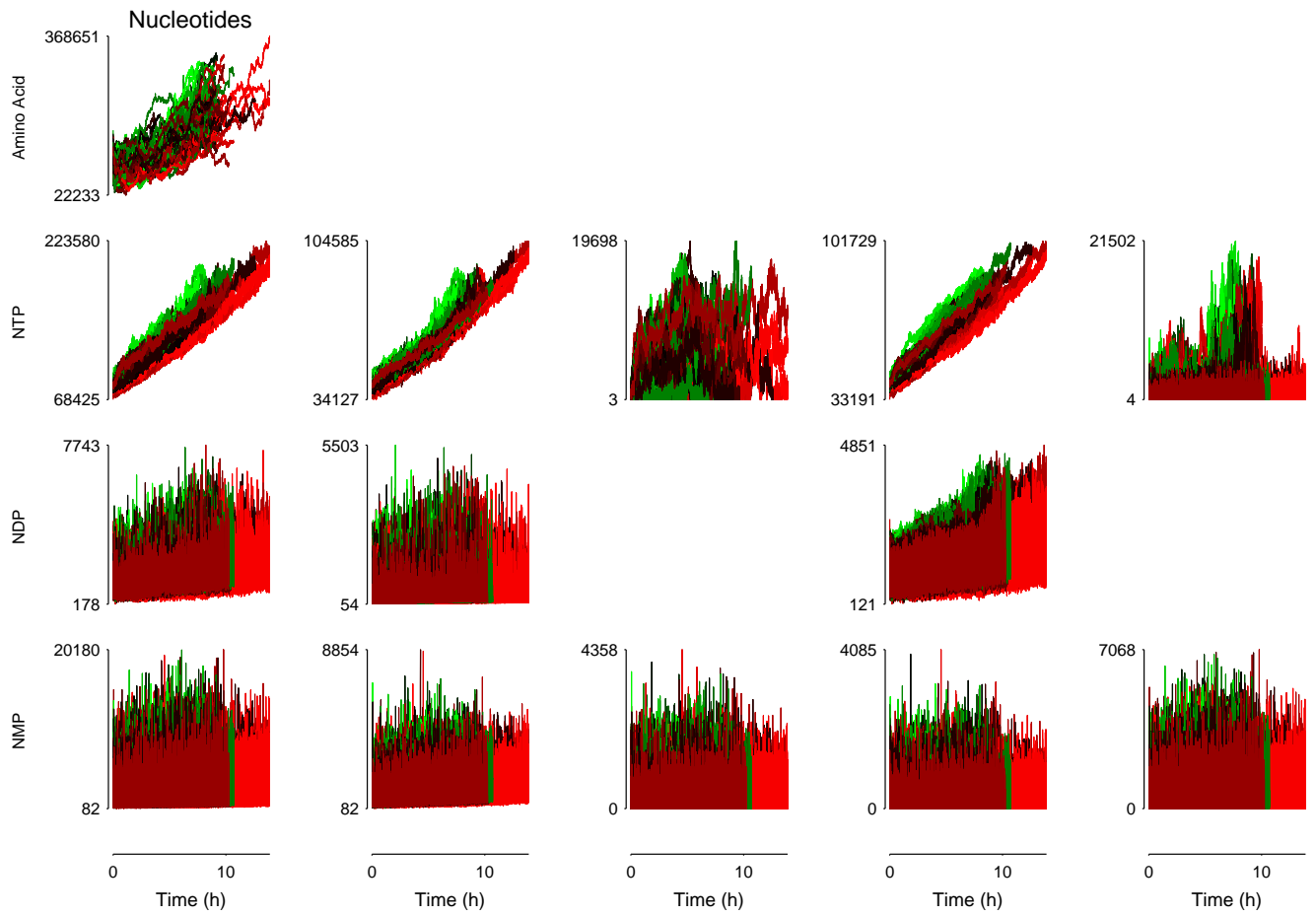




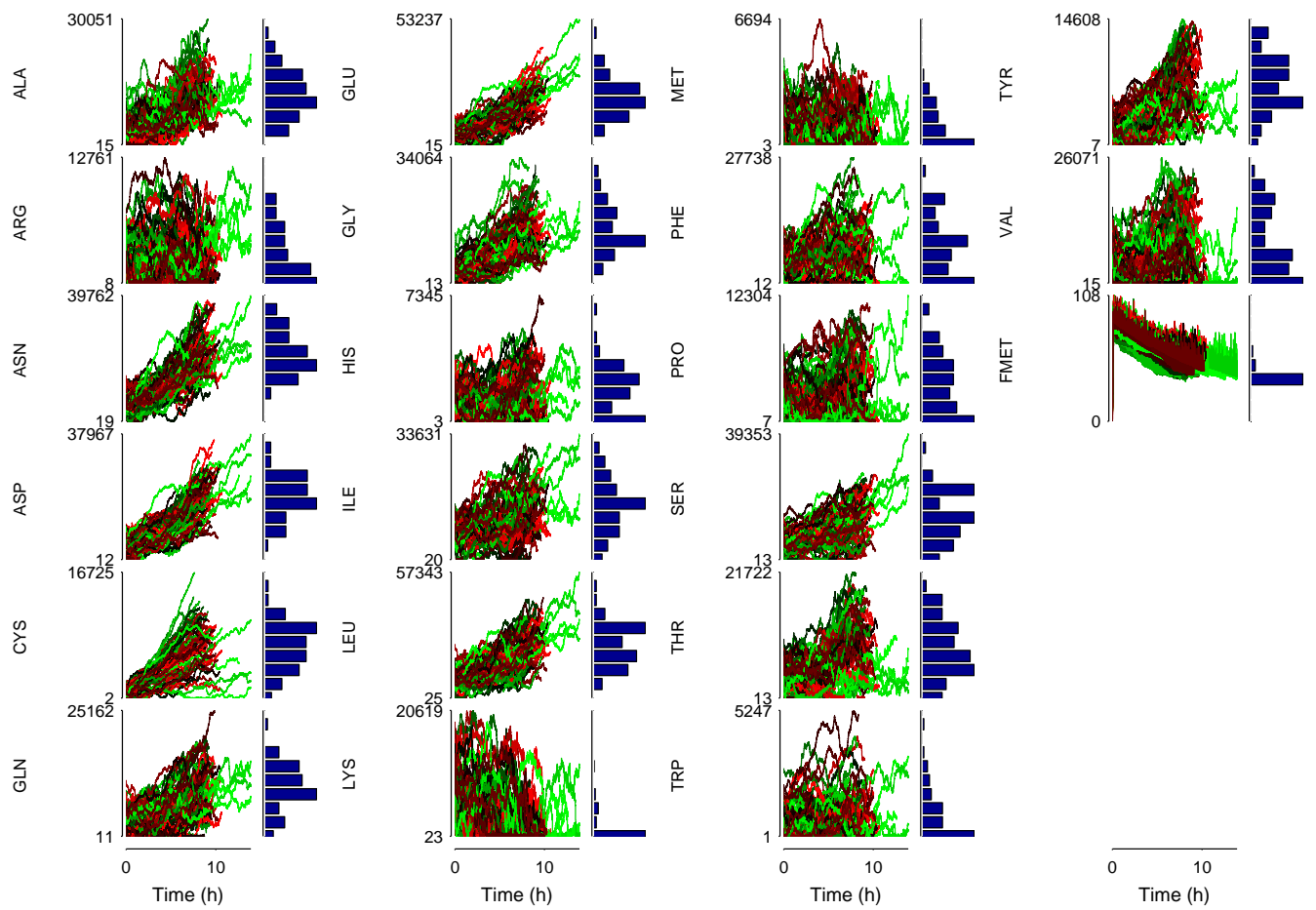
Overview: 2011:10:19 02:53:45



Energy Production

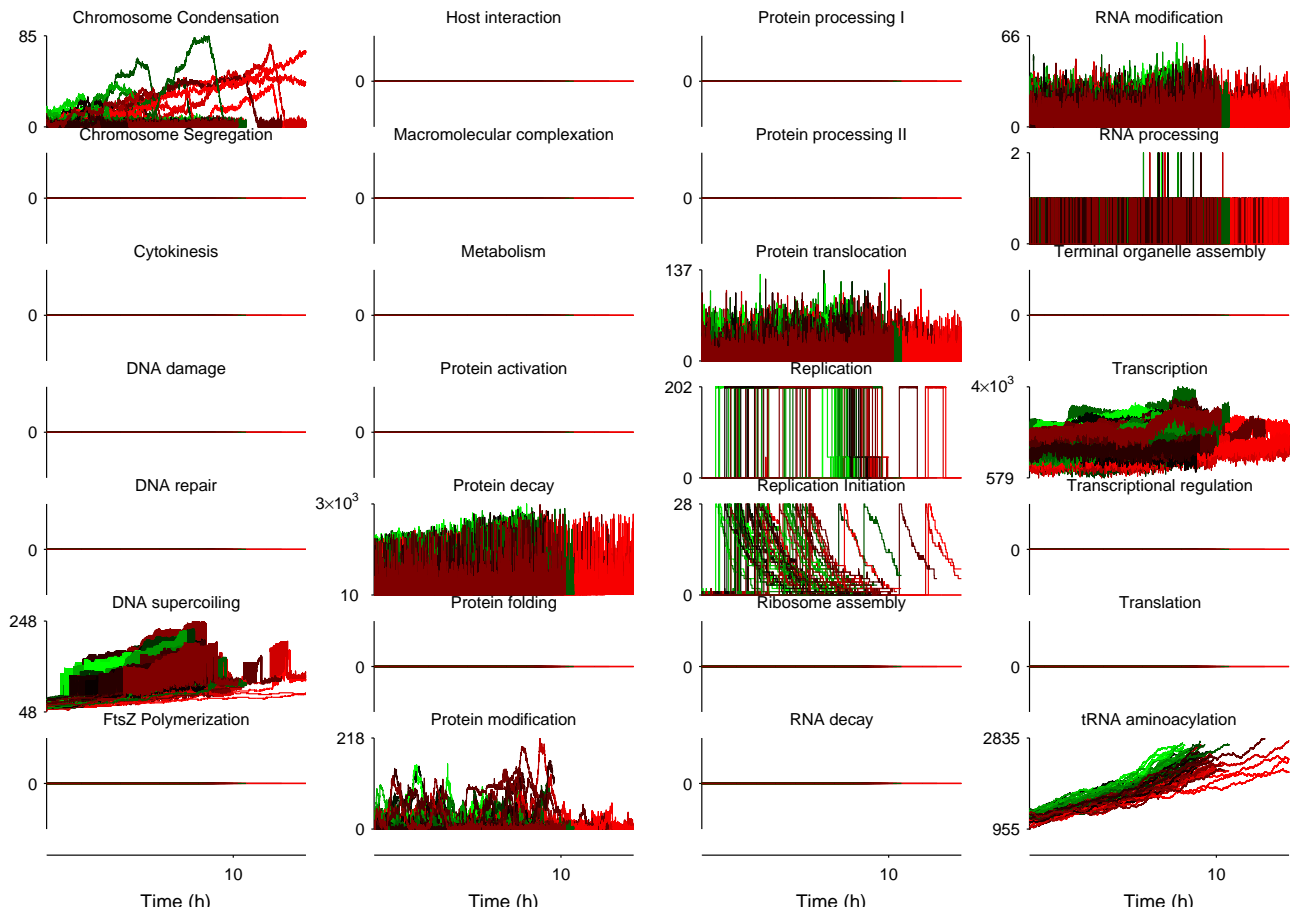


## Nucleotide Concentrations



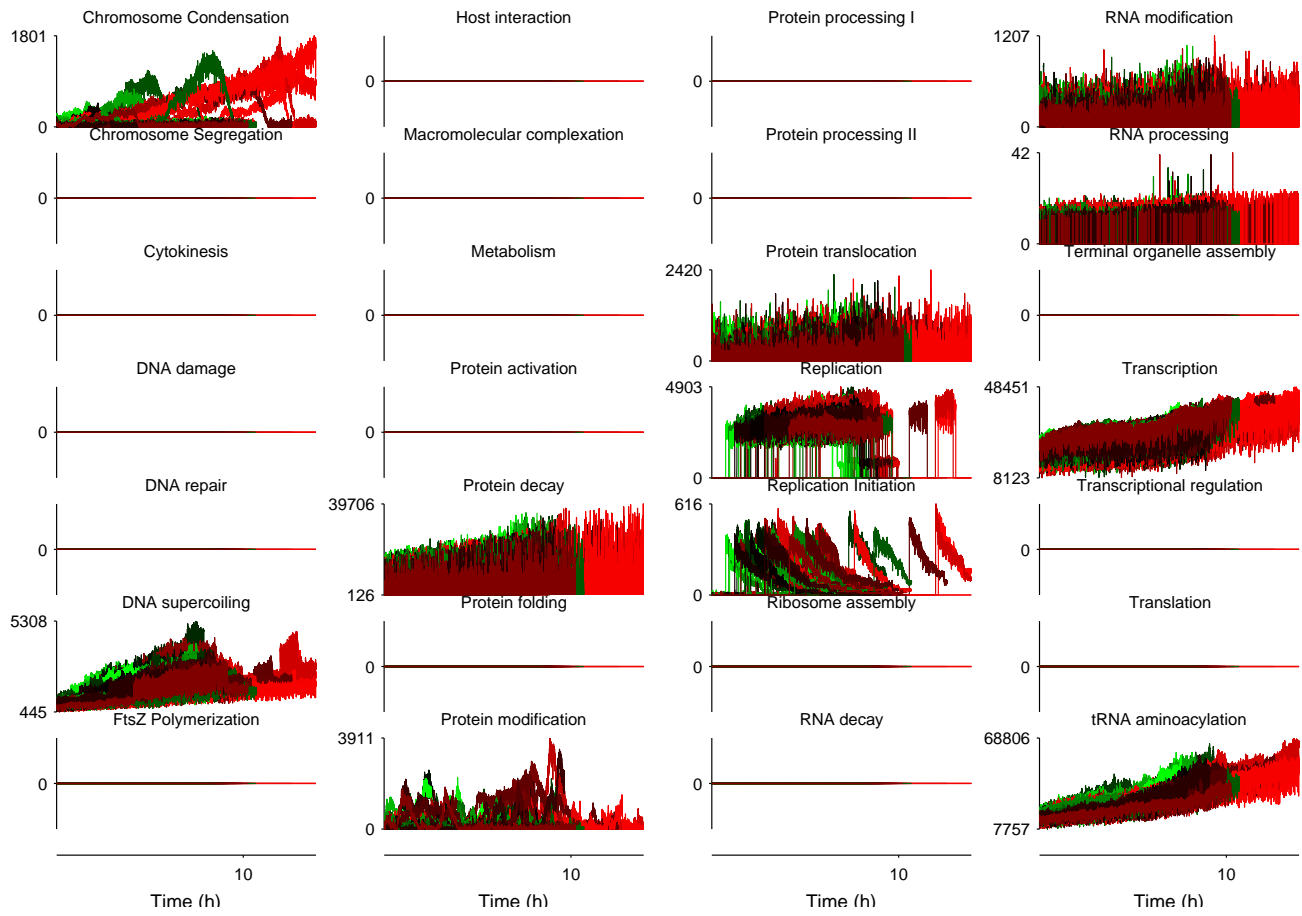
# Amino Acid Counts

# Requirements [ATP] Simulation Set: 2011:10:19 02:53:45



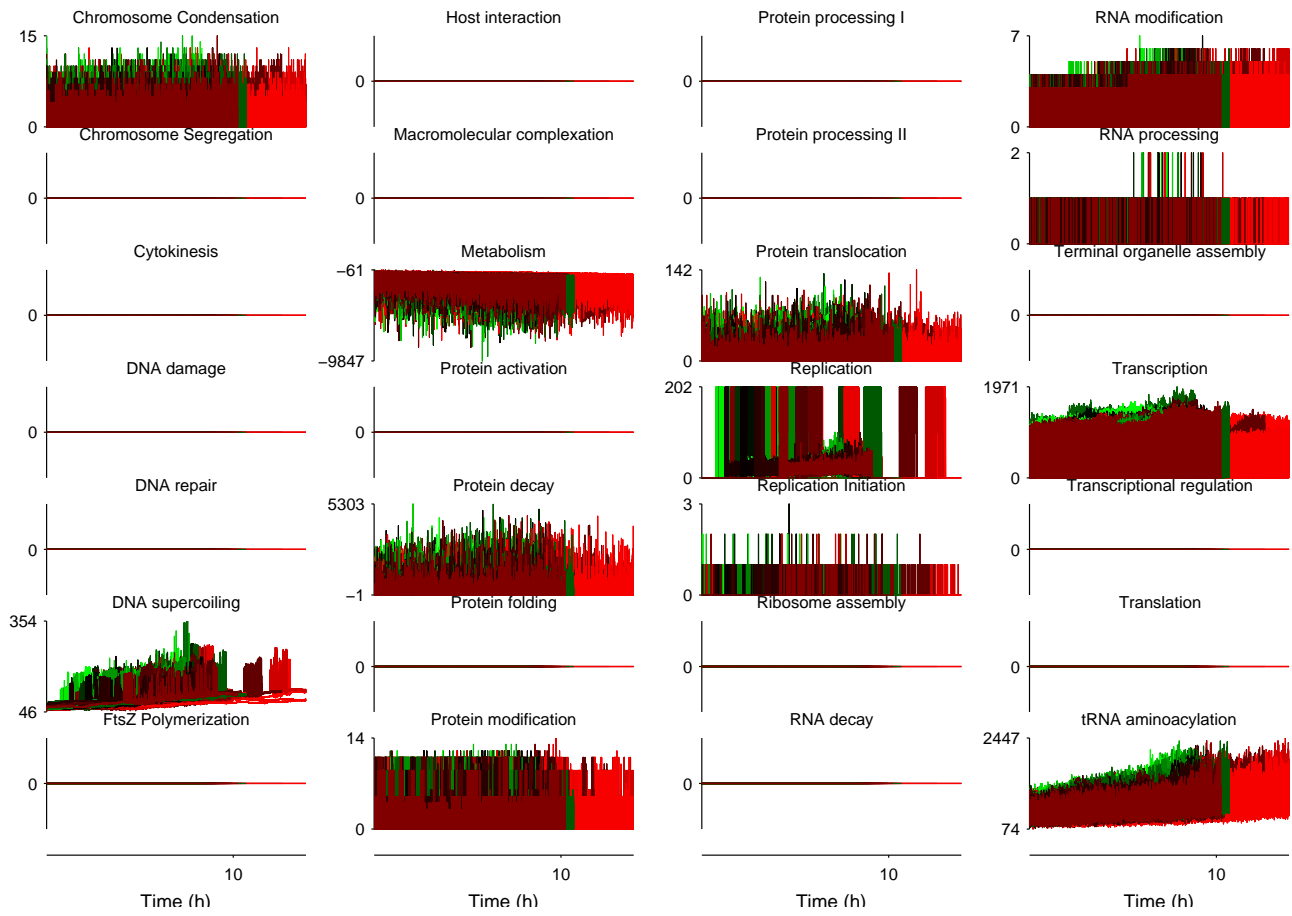
# Allocations [ATP]

Simulation Set: 2011:10:19 02:53:45

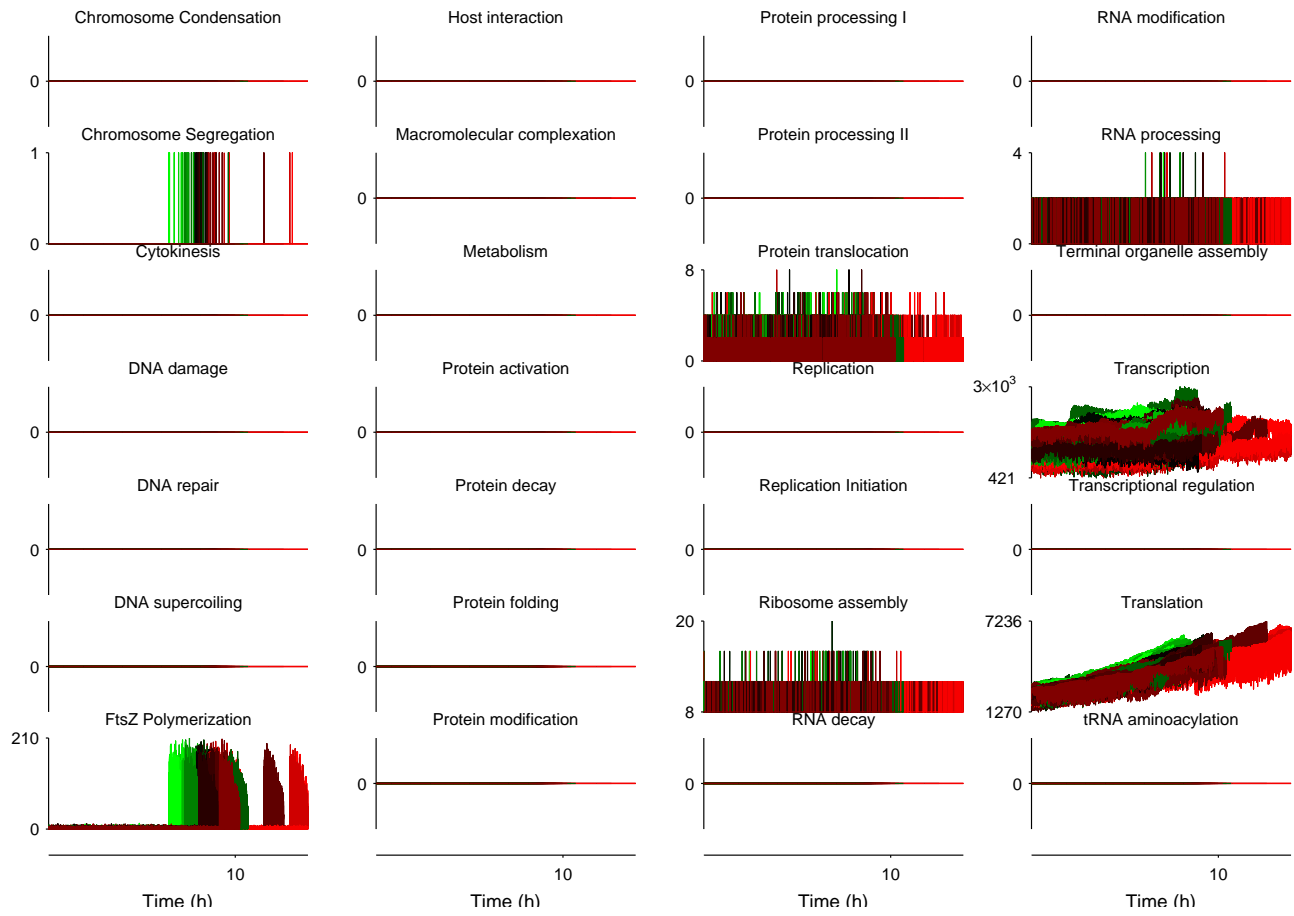


# Usages [ATP]

## Simulation Set: 2011:10:19 02:53:45



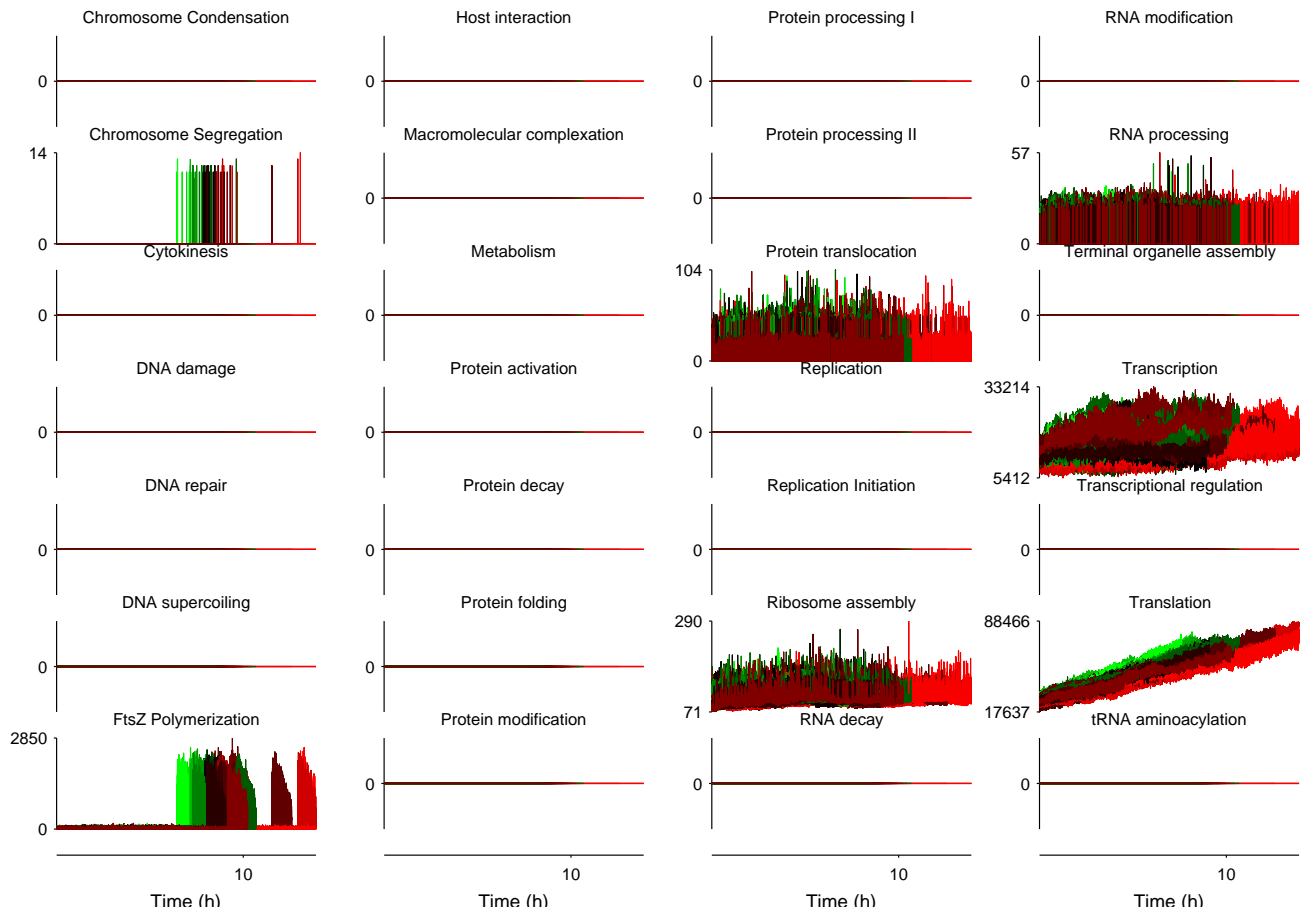
# Requirements [GTP] Simulation Set: 2011:10:19 02:53:45





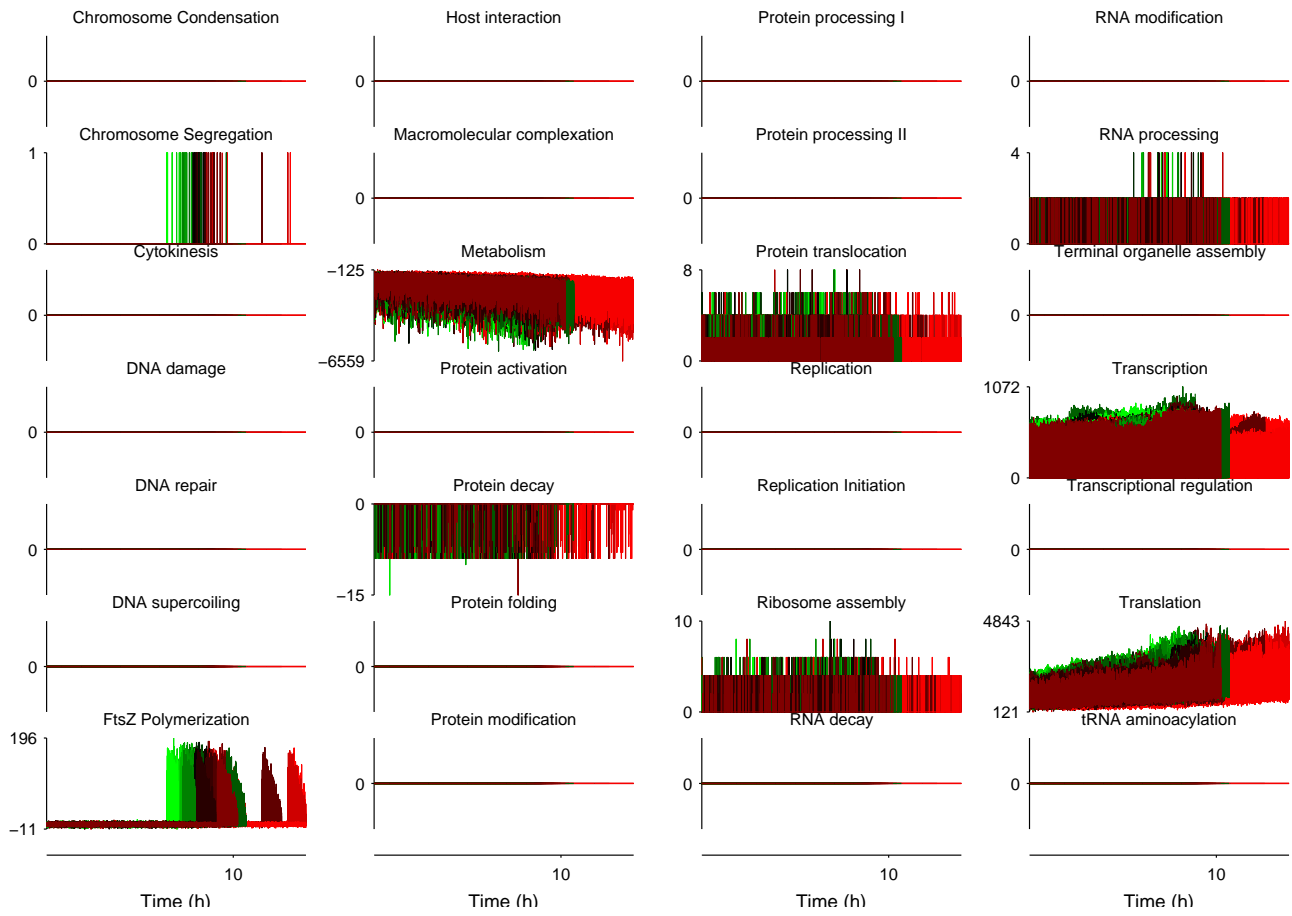
# Allocations [GTP]

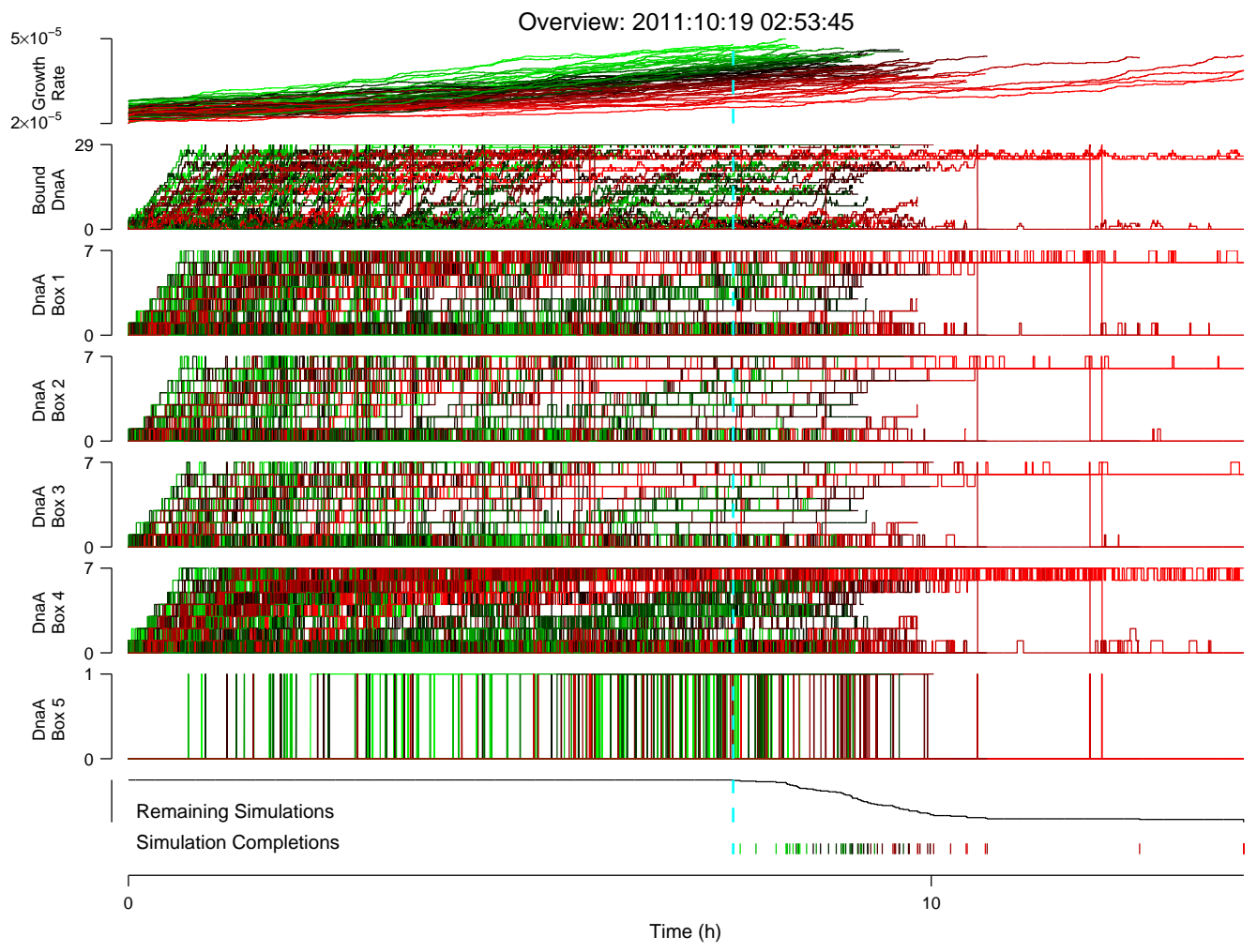
## Simulation Set: 2011:10:19 02:53:45



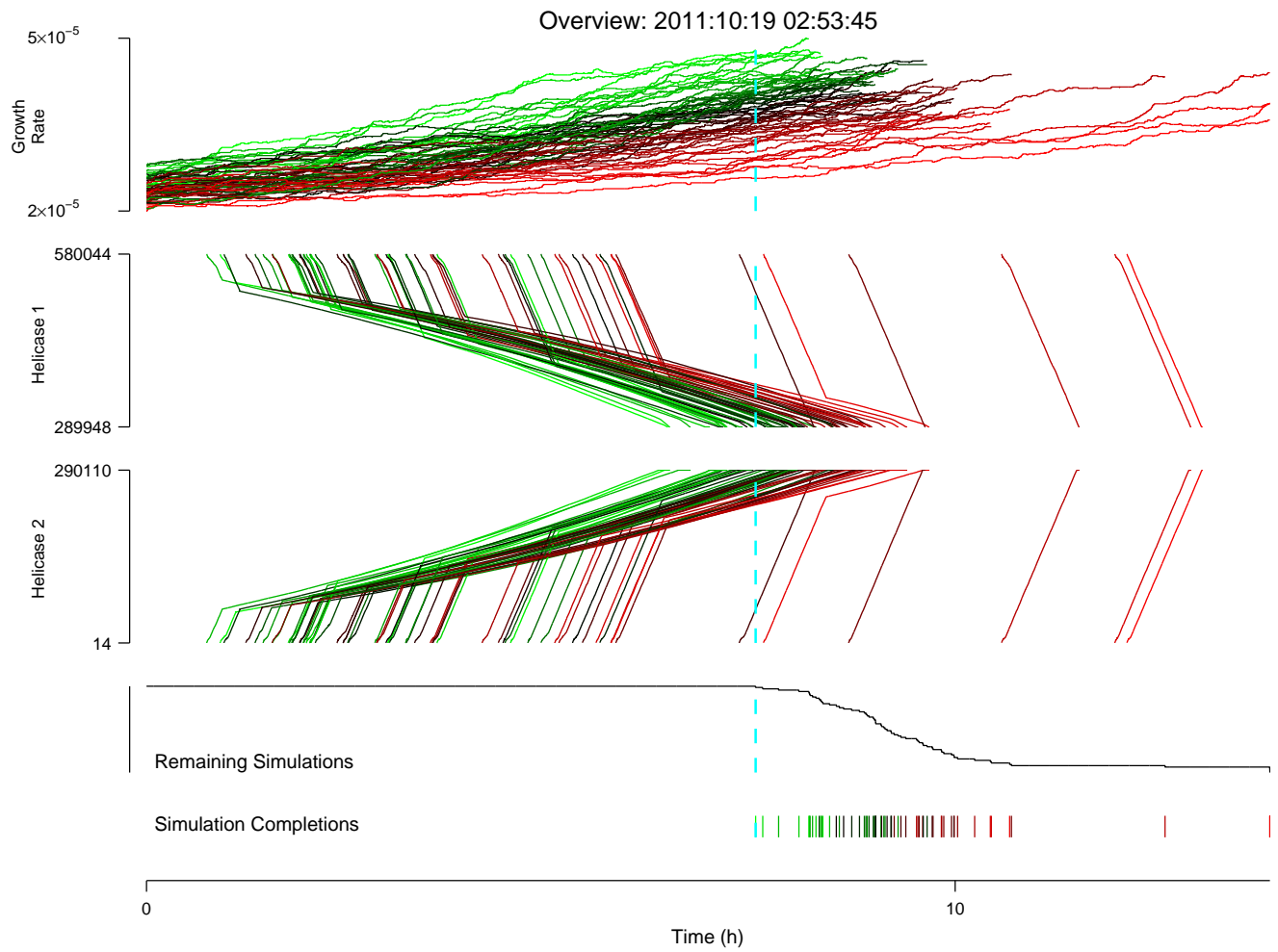
# Usages [GTP]

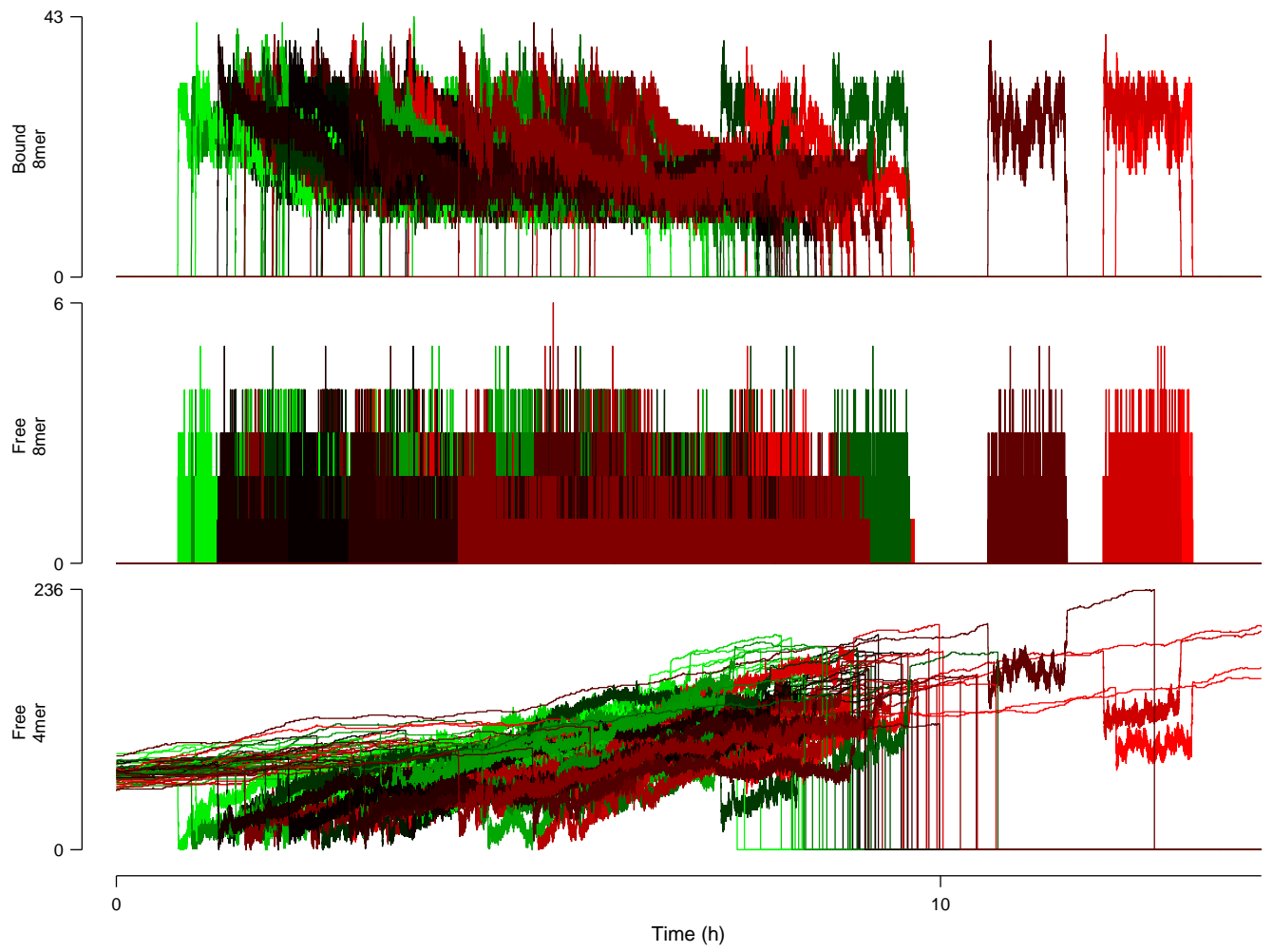
## Simulation Set: 2011:10:19 02:53:45





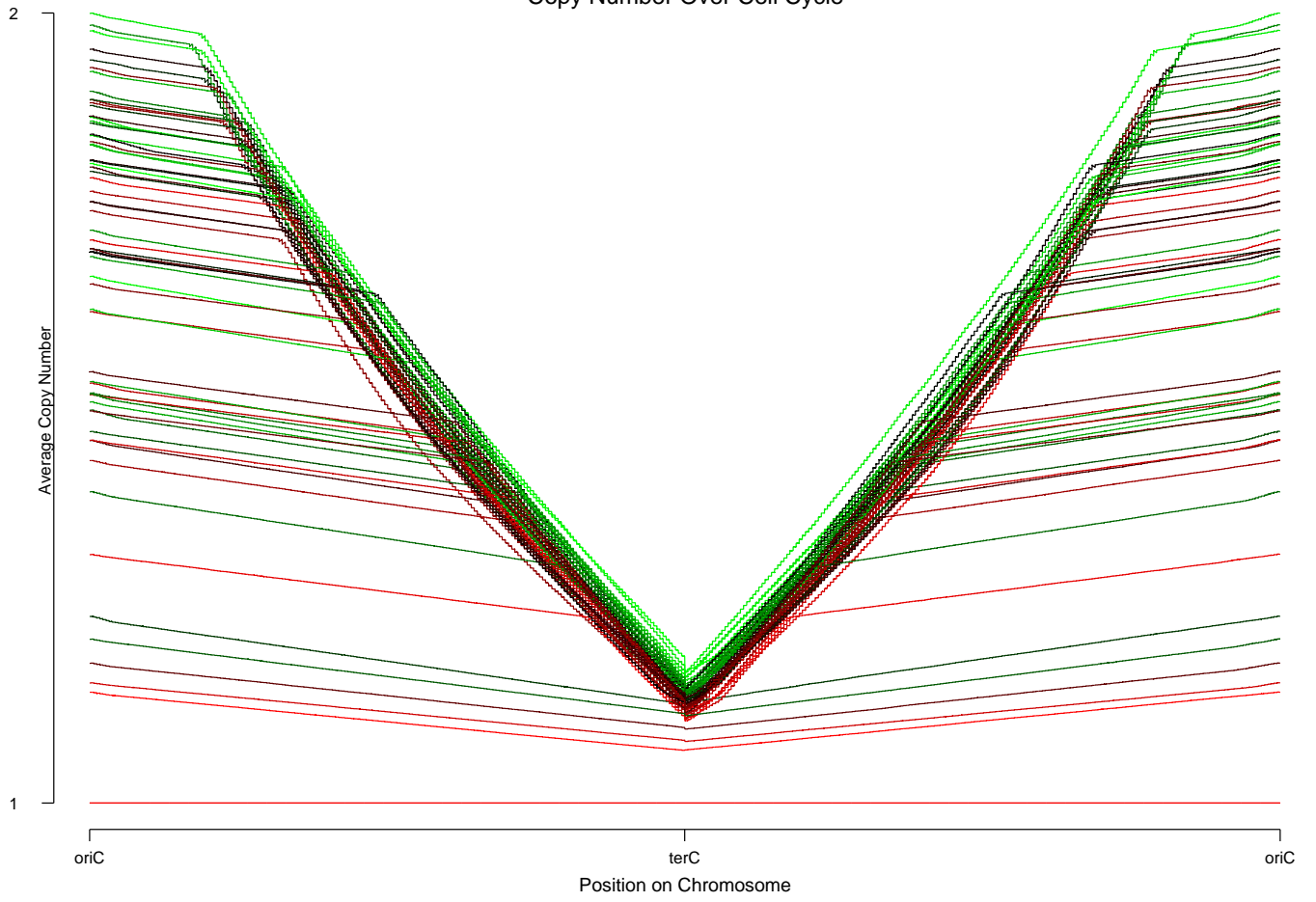
# Replication Initiation



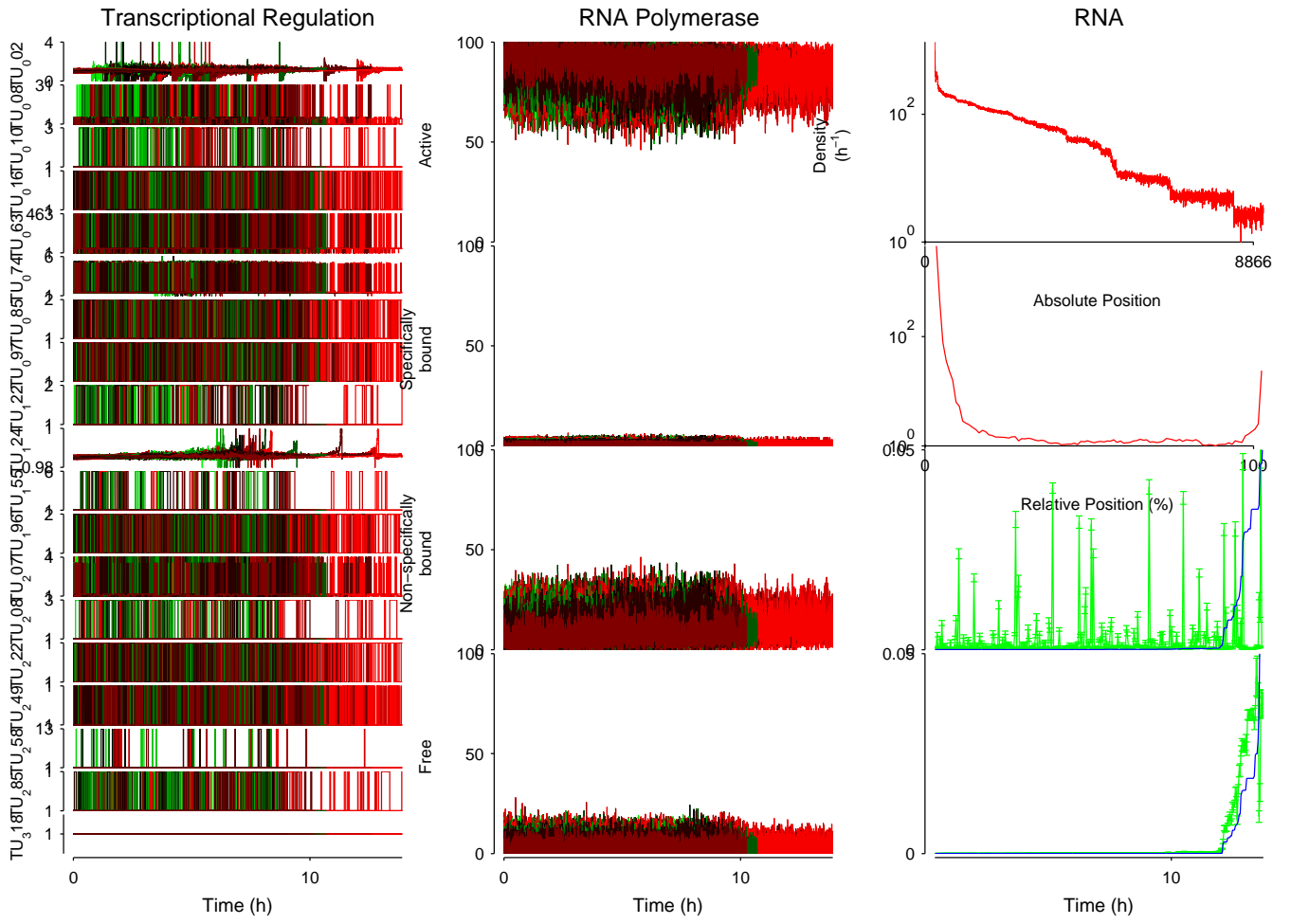


Replication

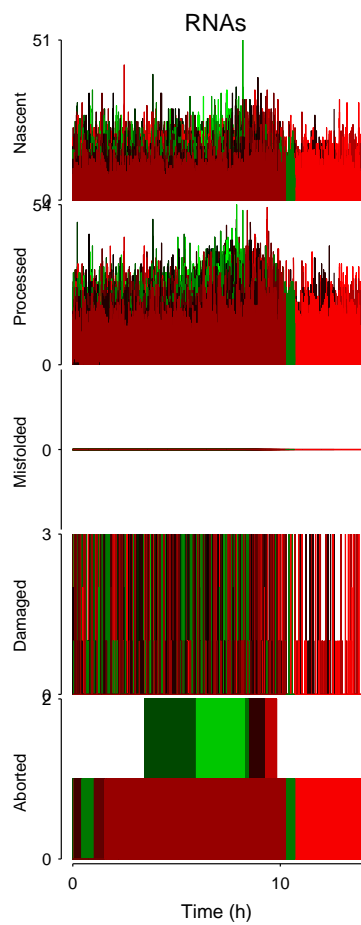
Copy Number Over Cell Cycle



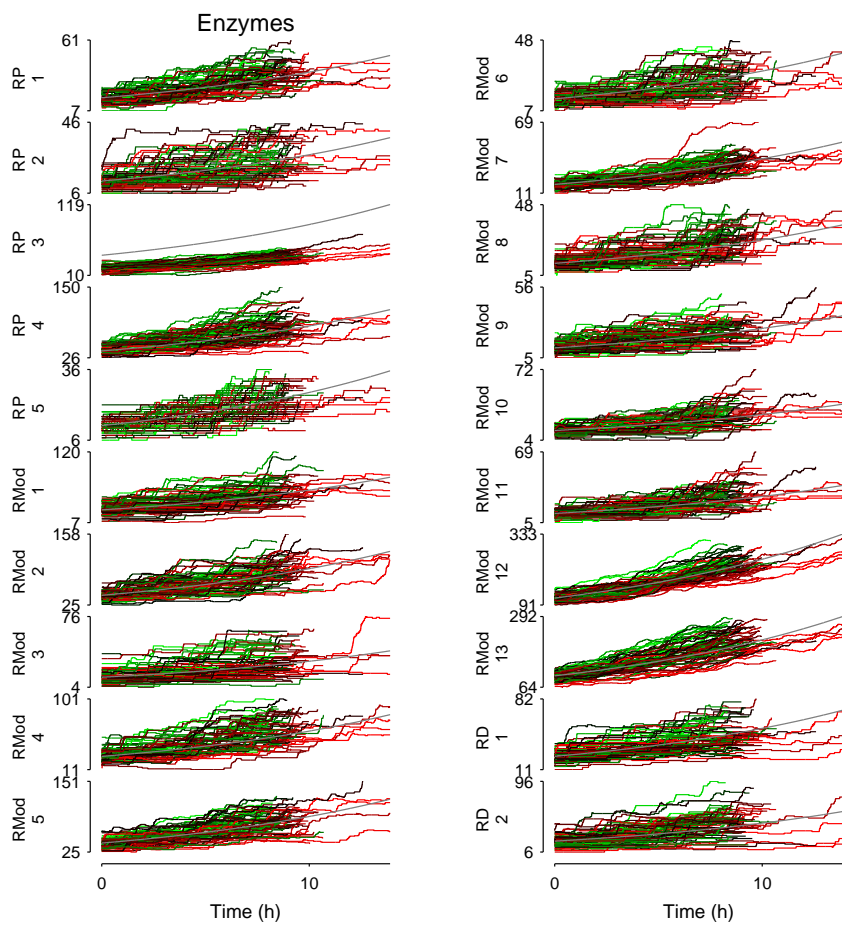
Replication



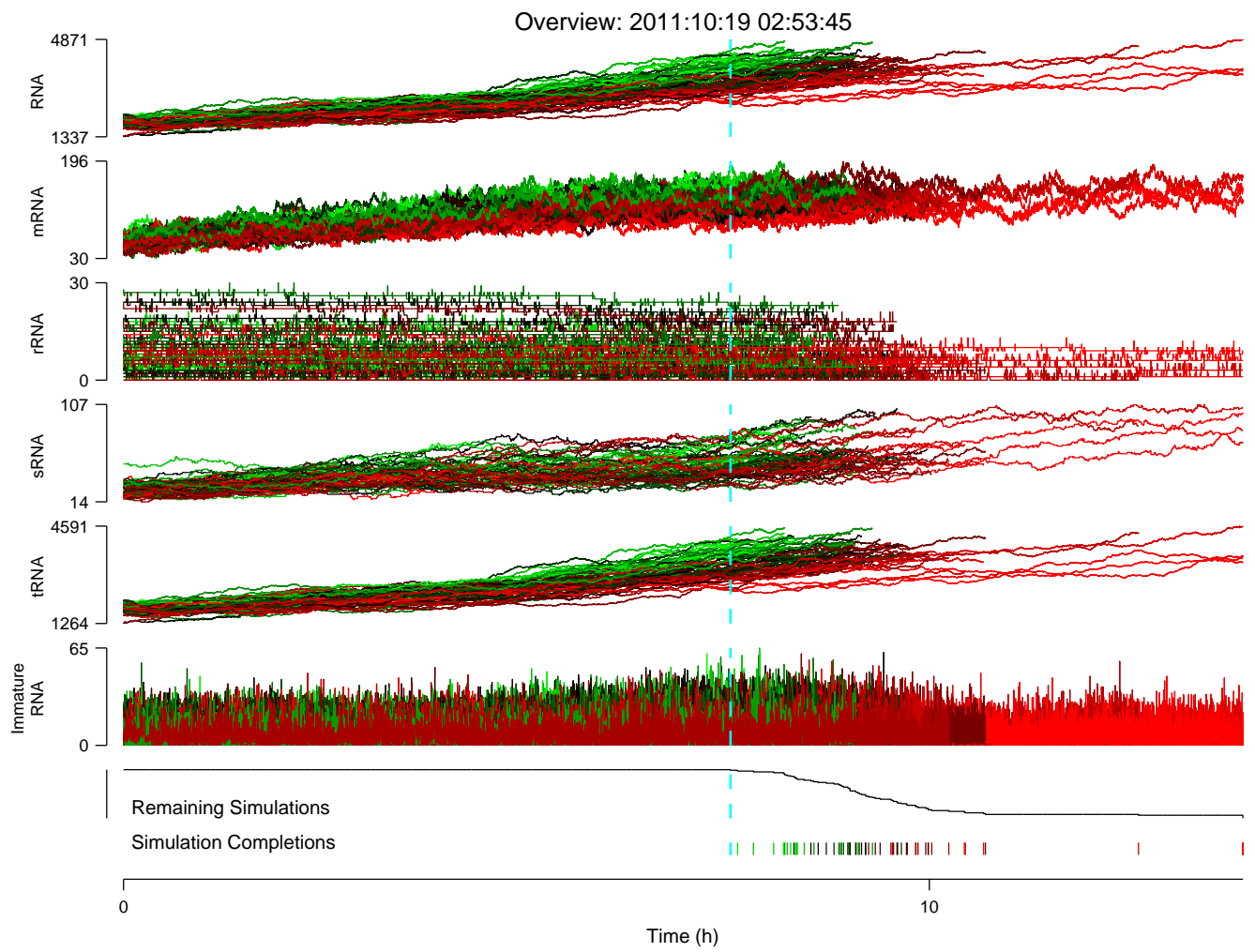
A



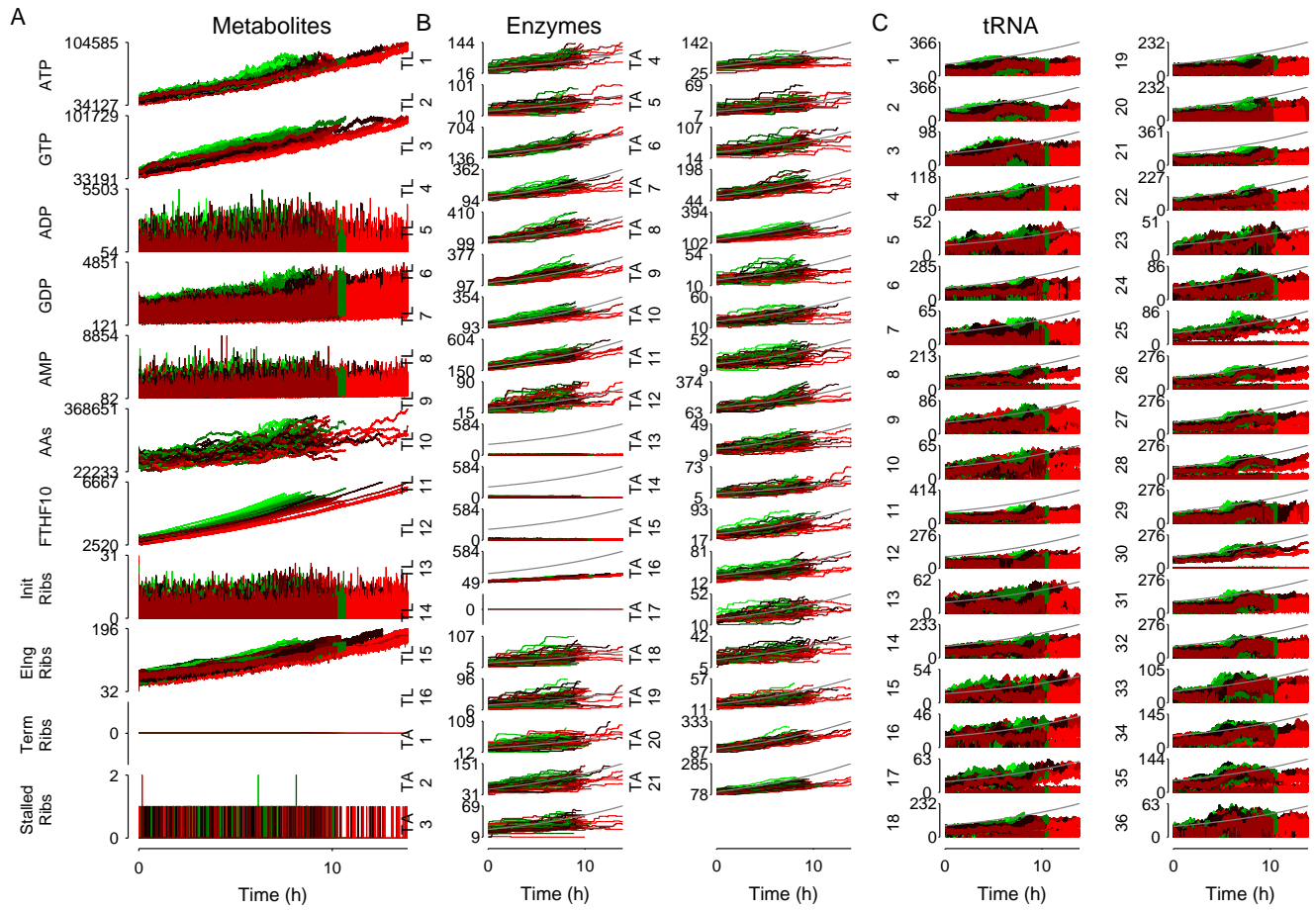
B

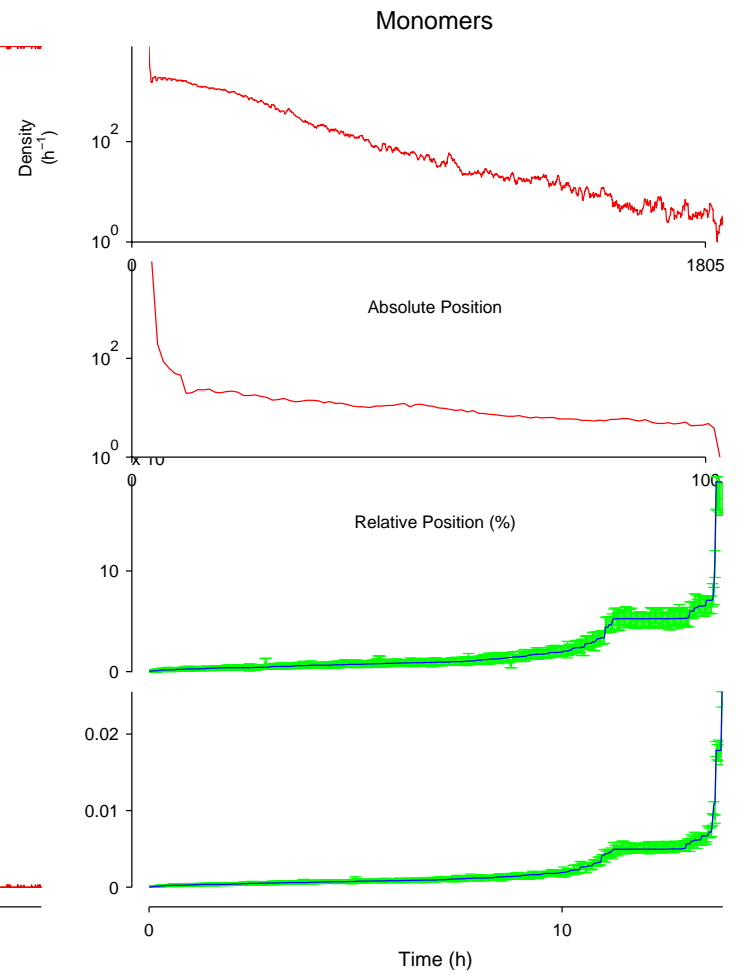
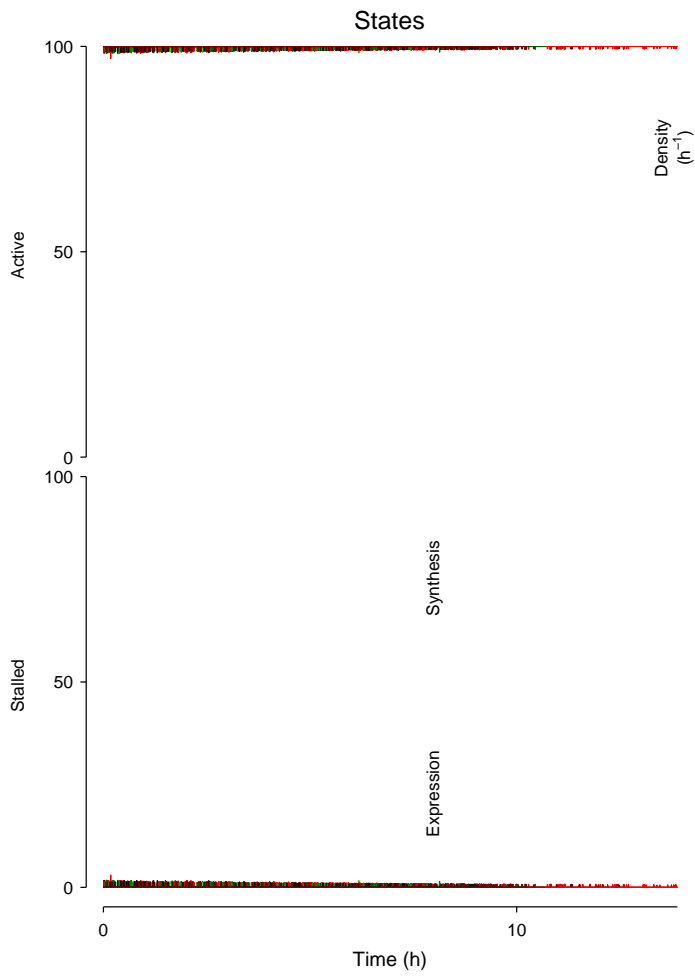




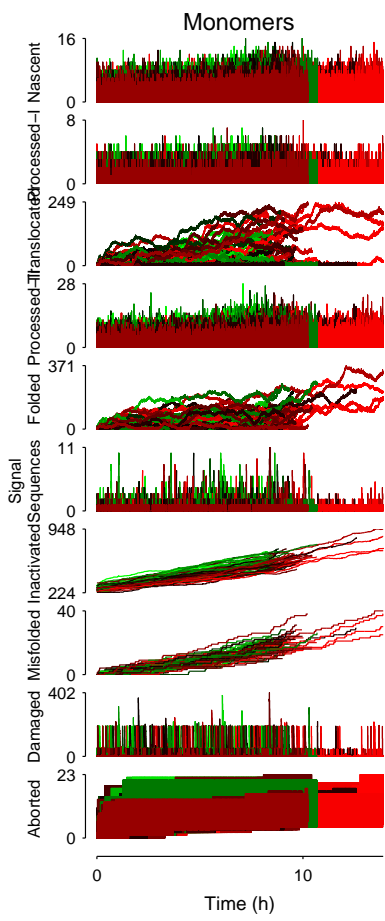


# RNA Maturation

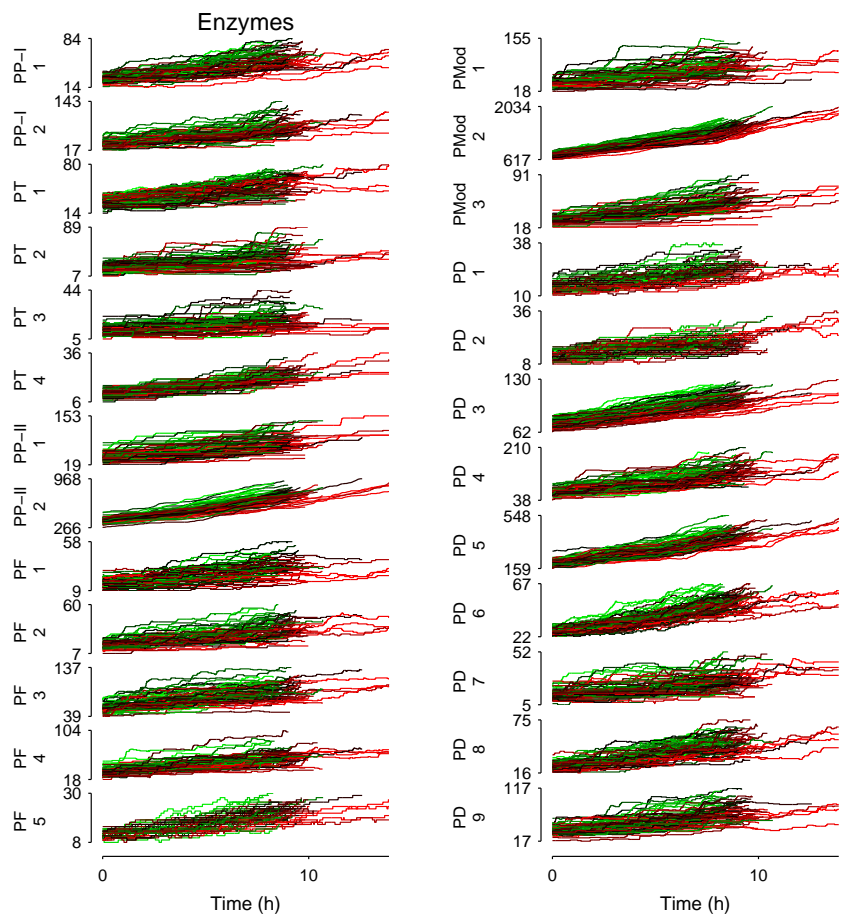


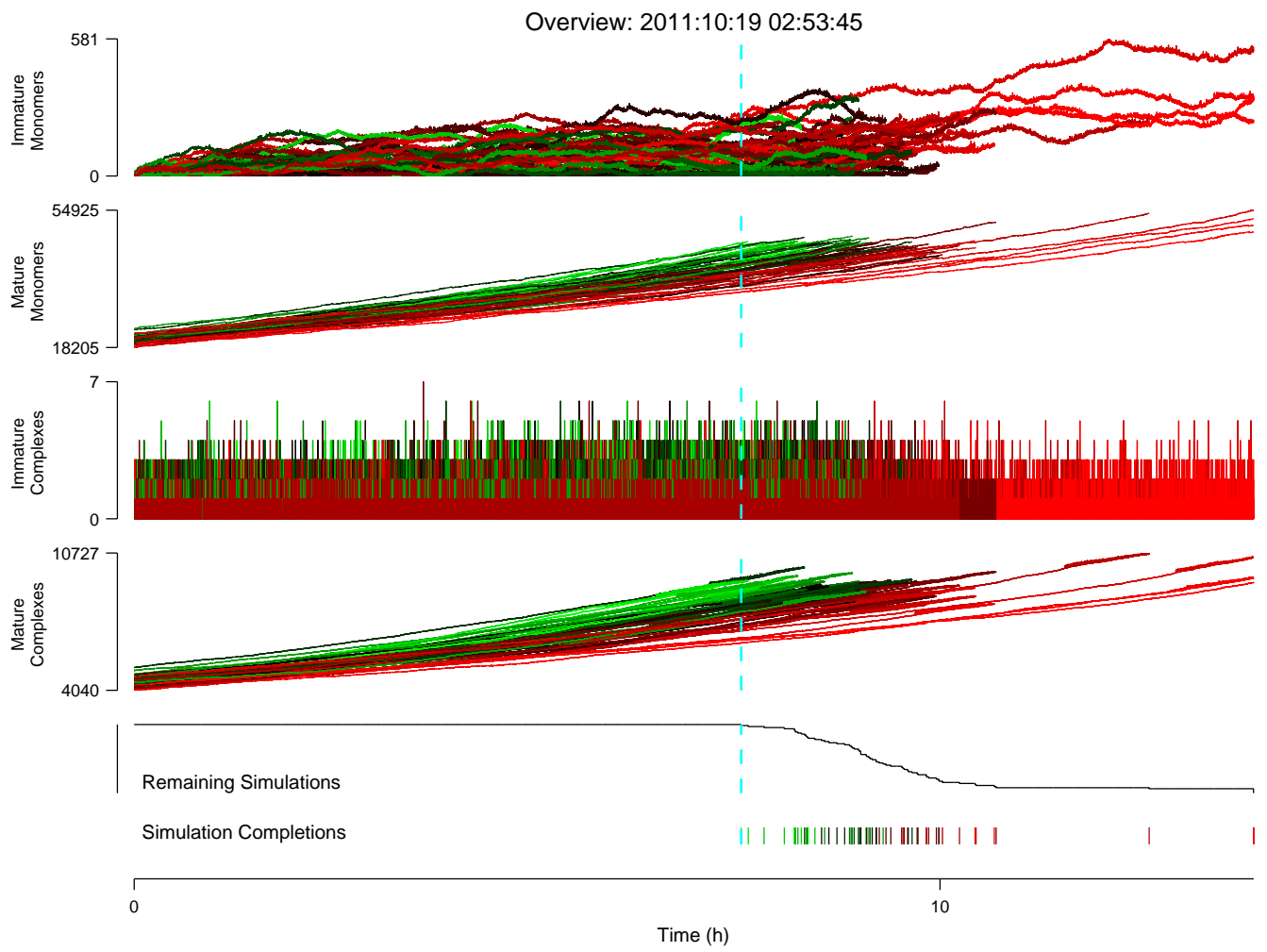


A



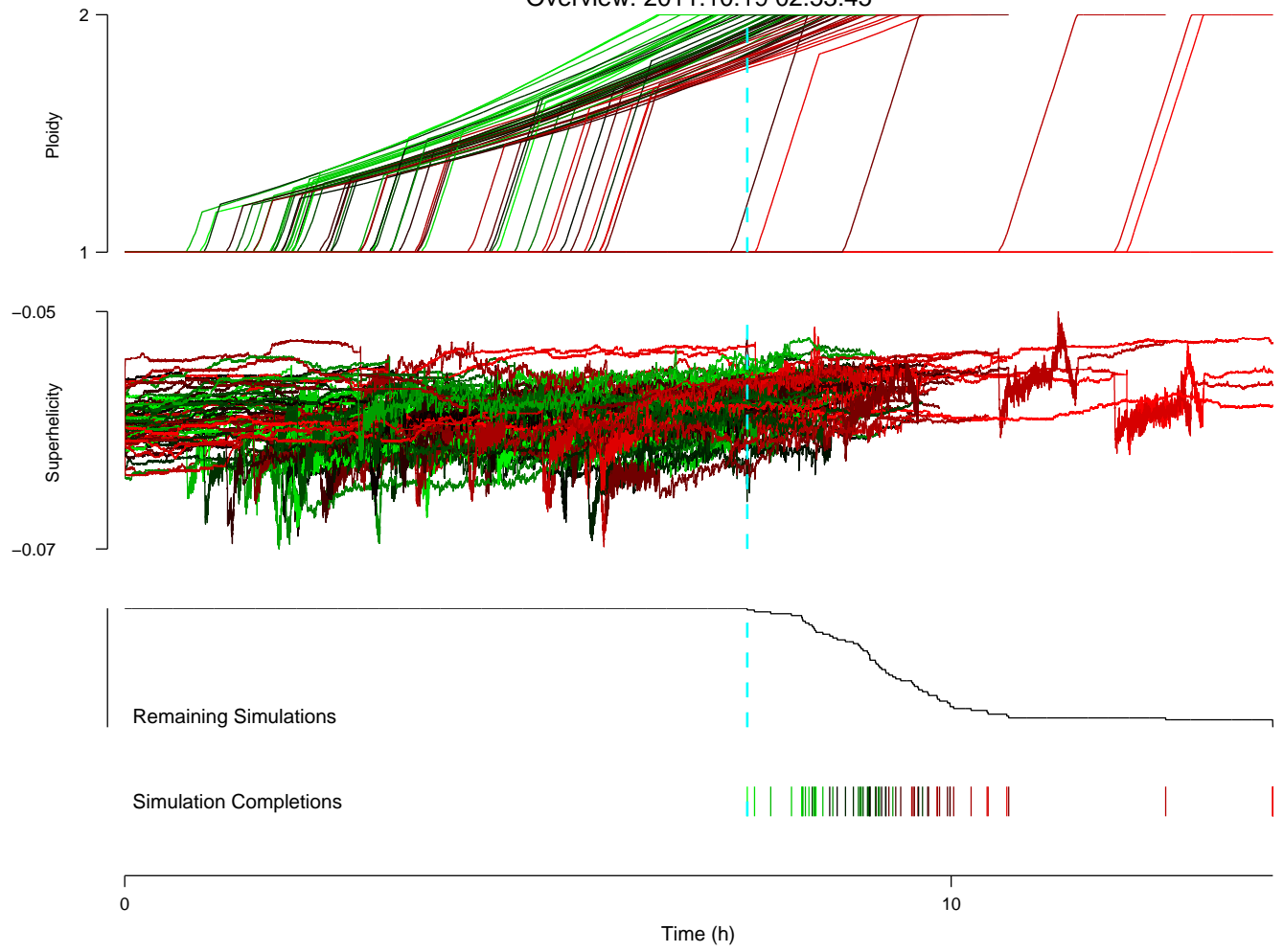
B



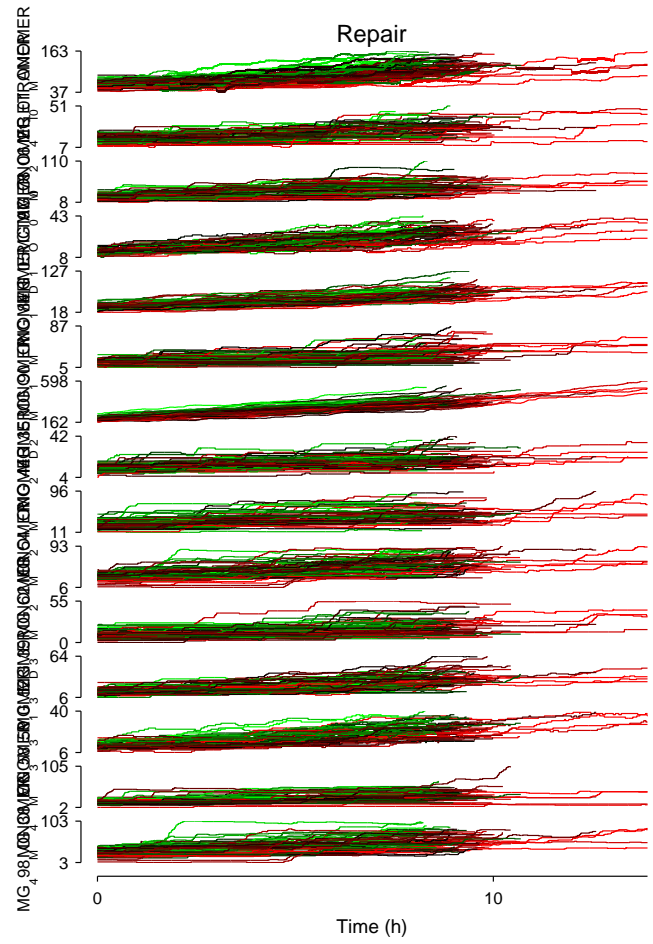
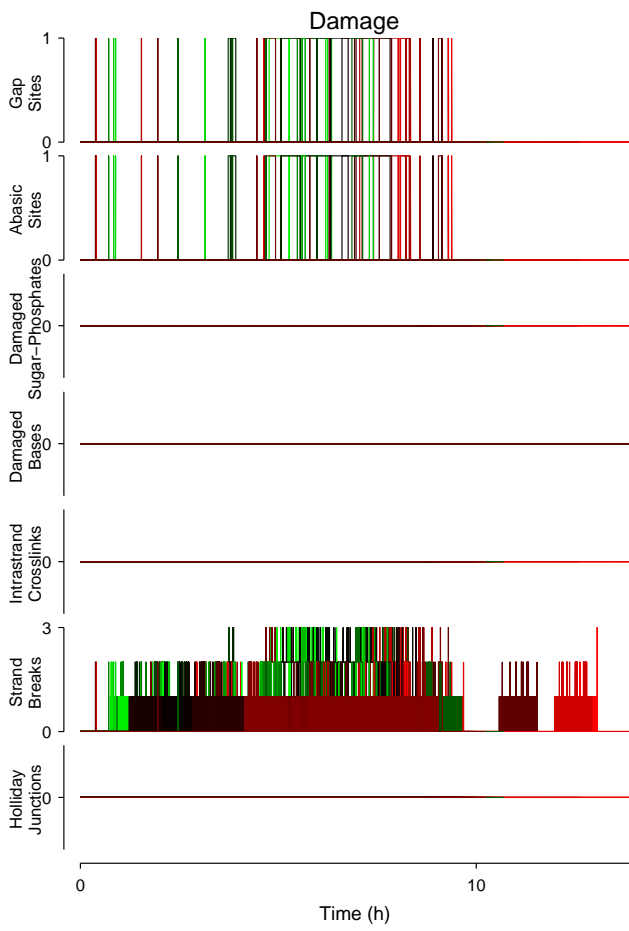


# Protein Maturation

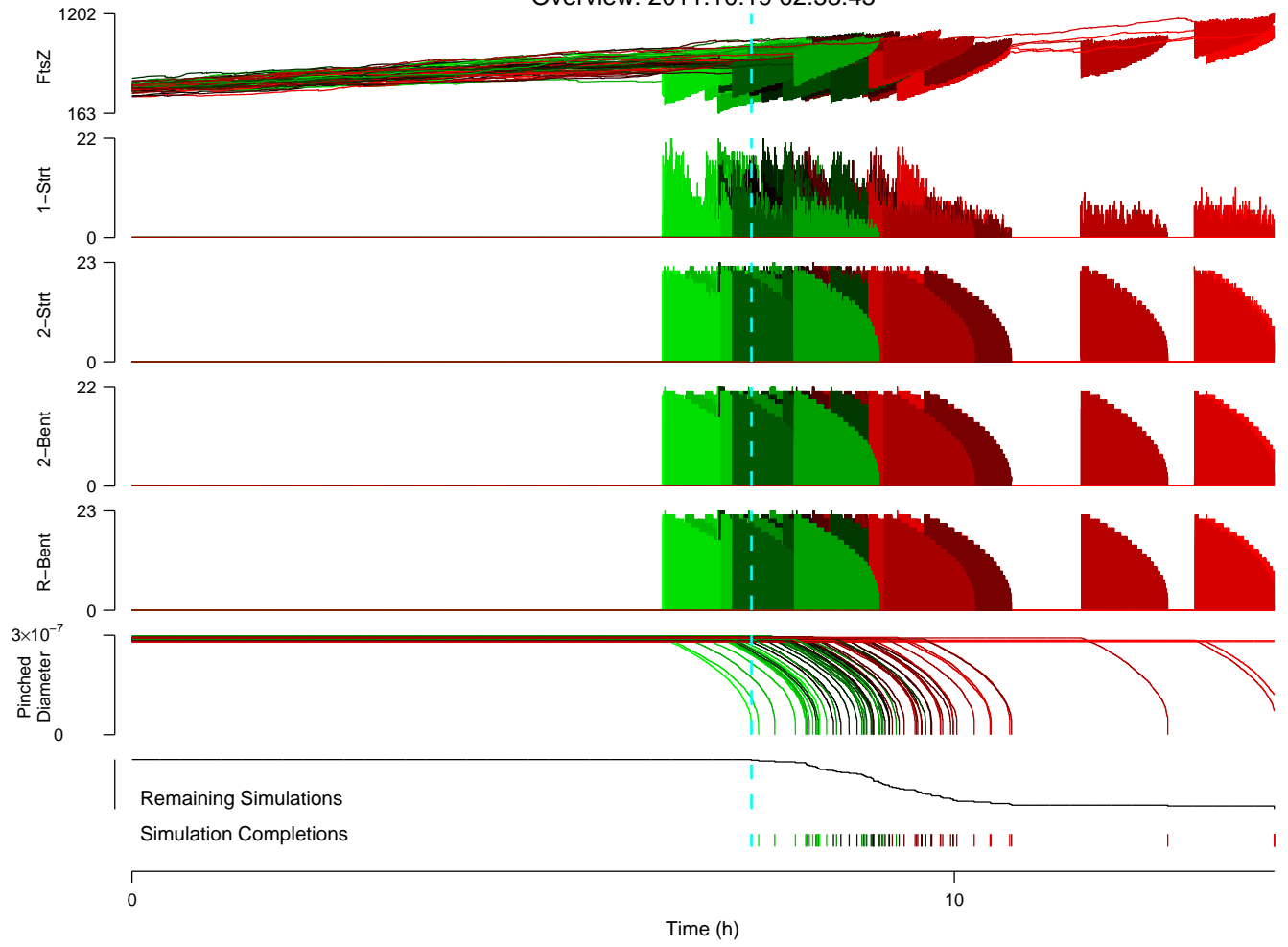
Overview: 2011:10:19 02:53:45



# Supercoiling

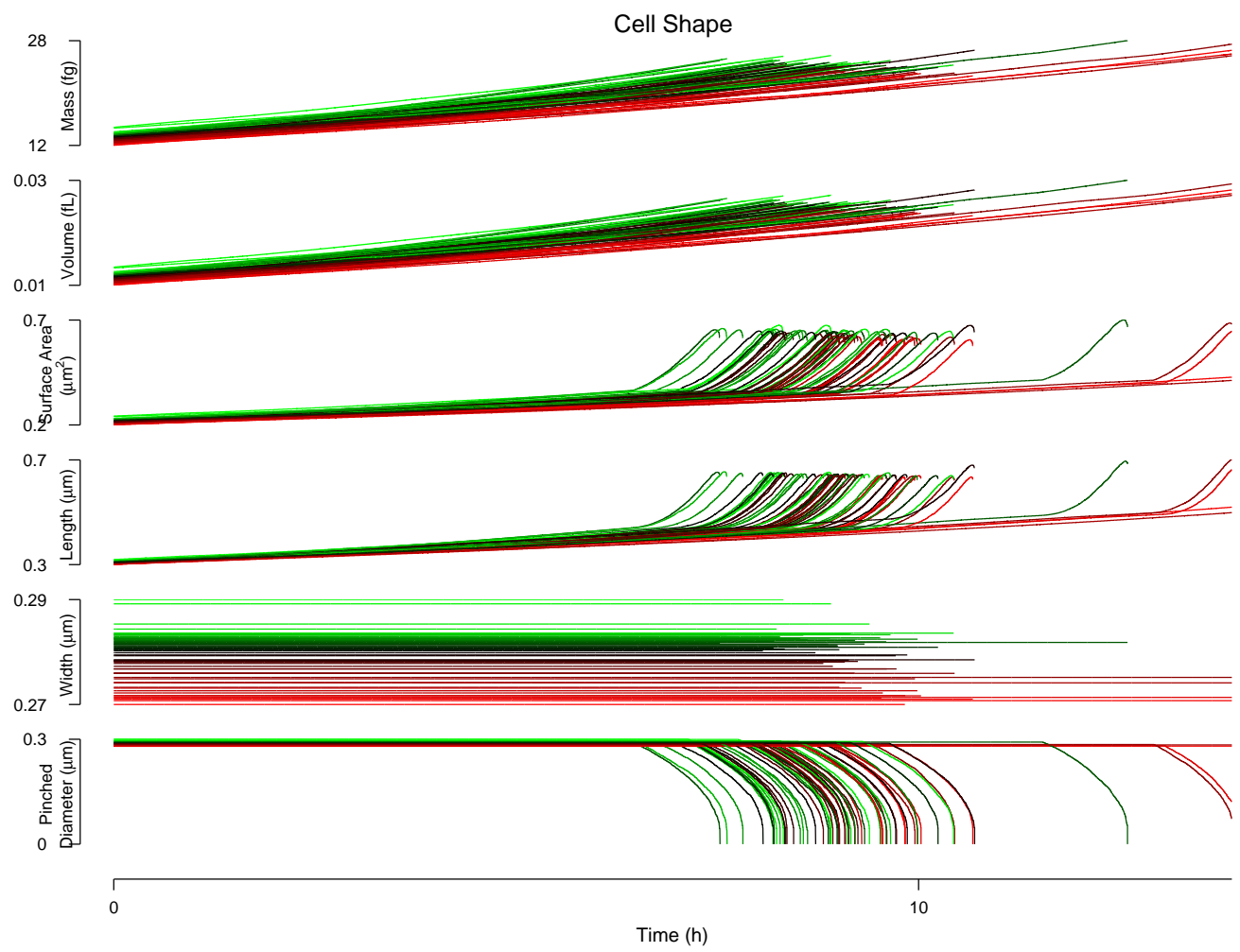


Overview: 2011:10:19 02:53:45

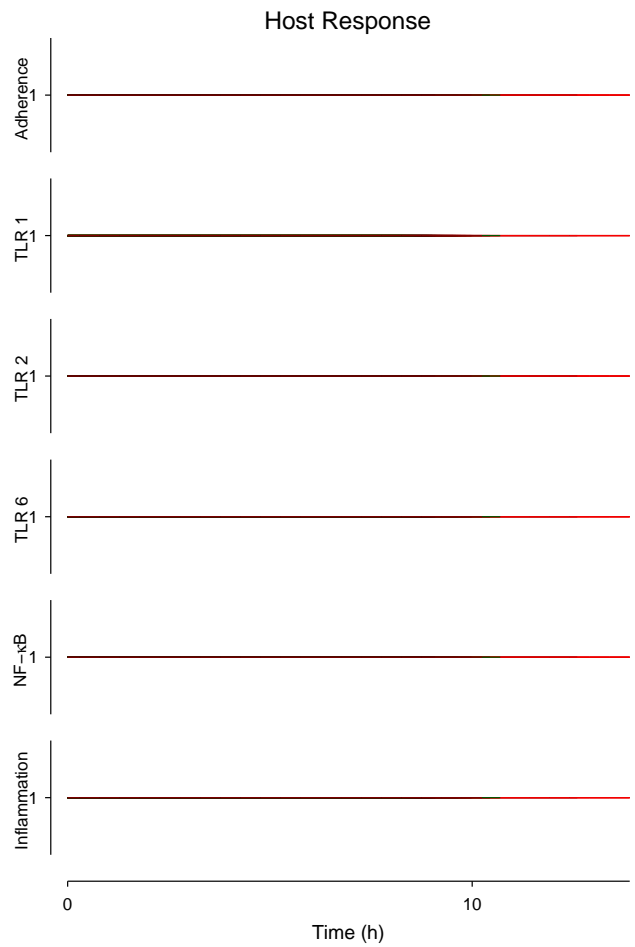
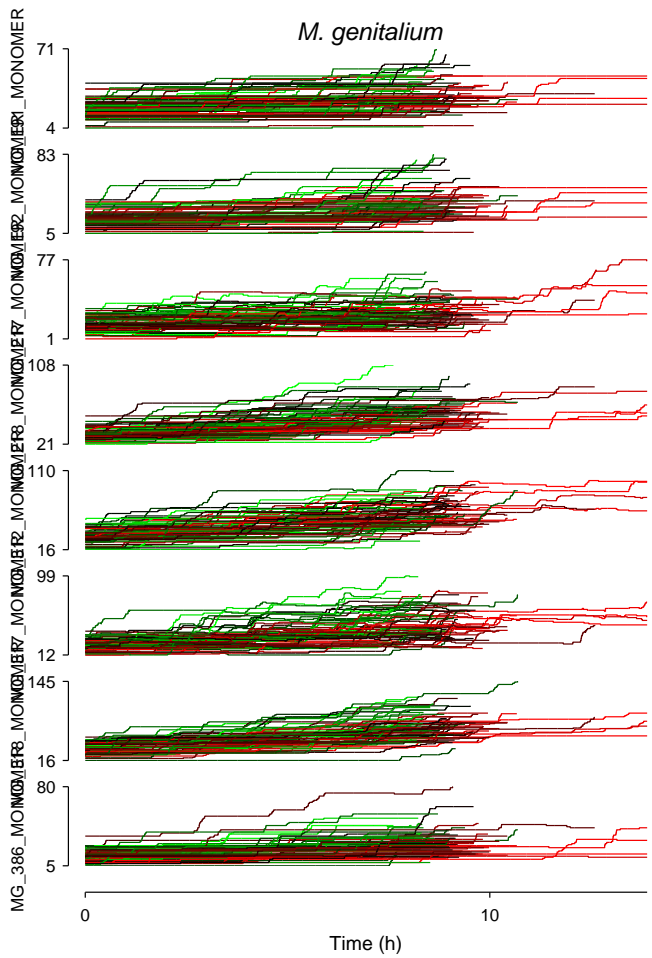


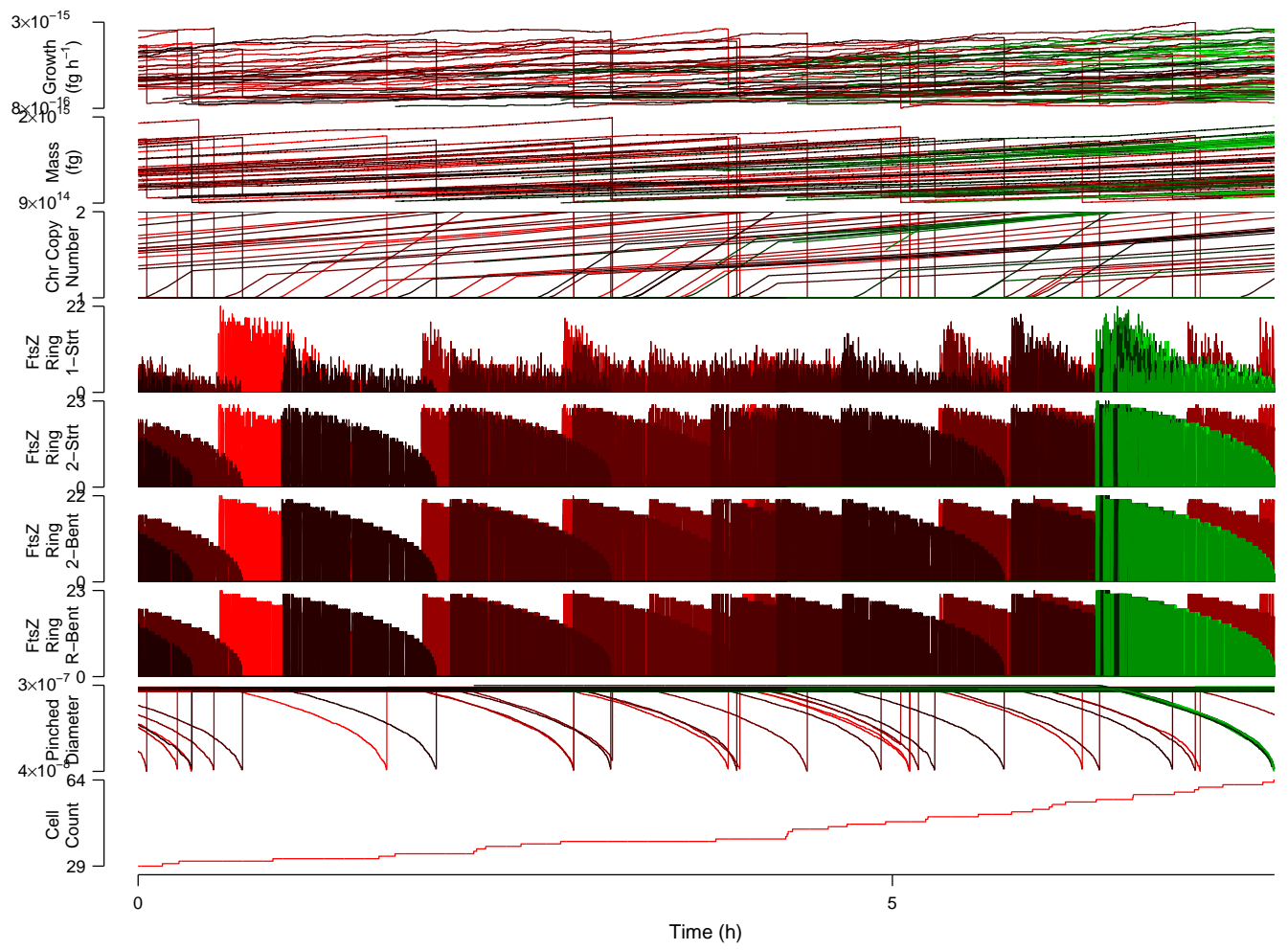
Cell Division





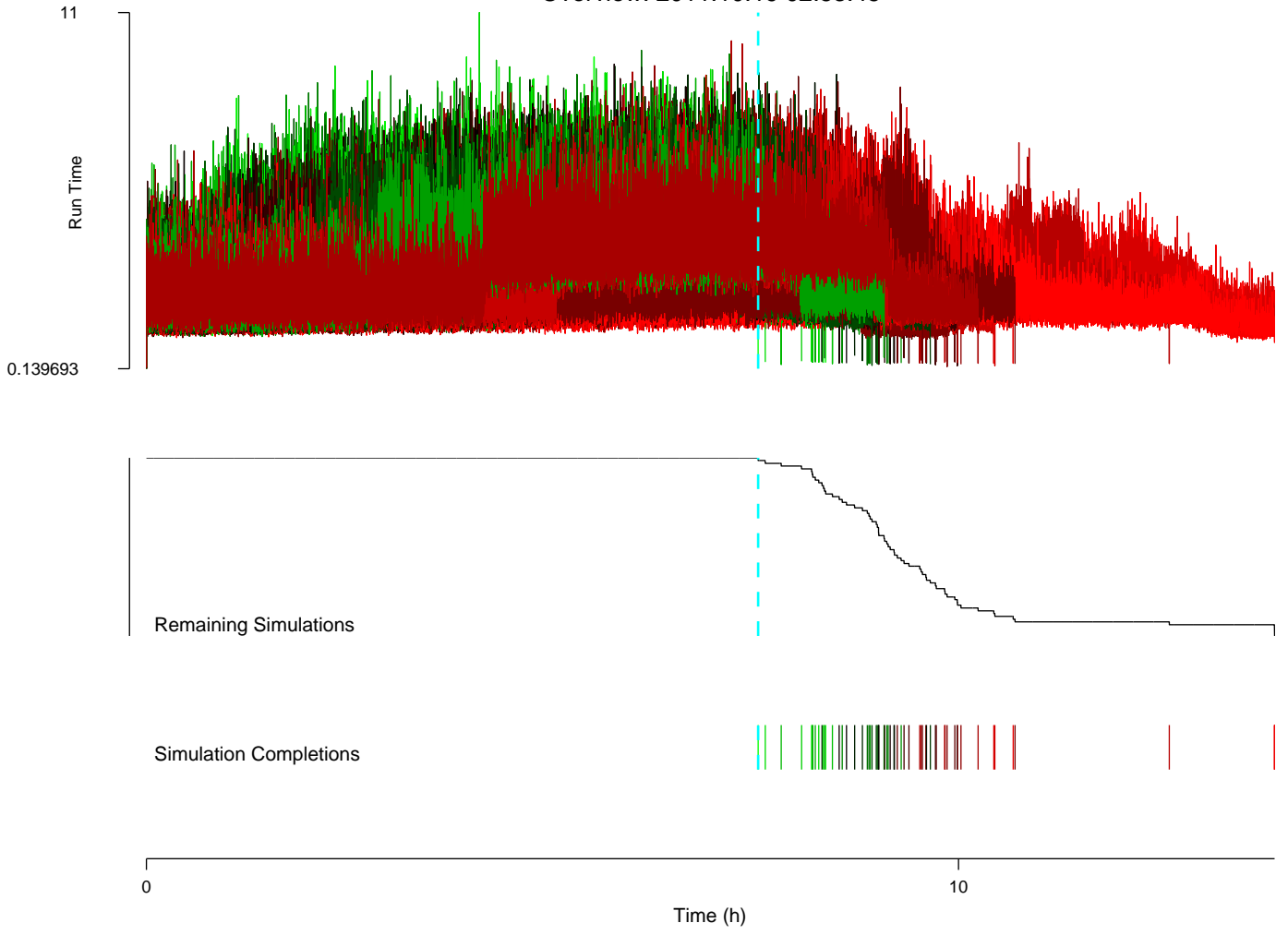
Cell Division



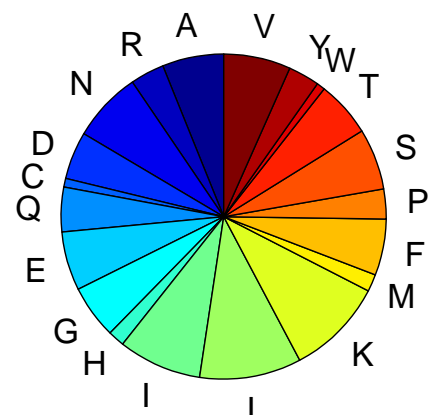
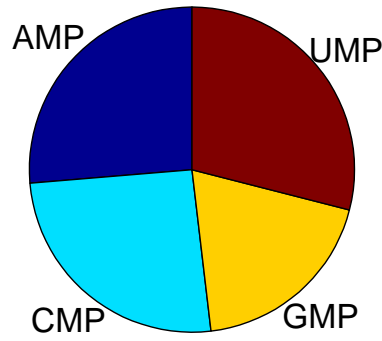
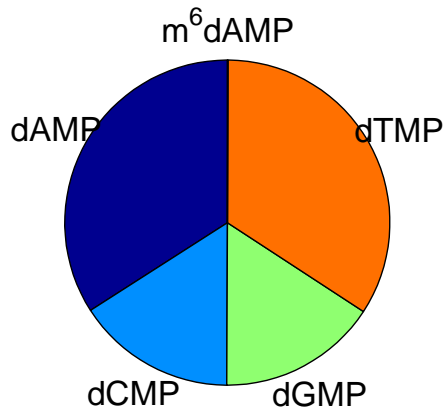
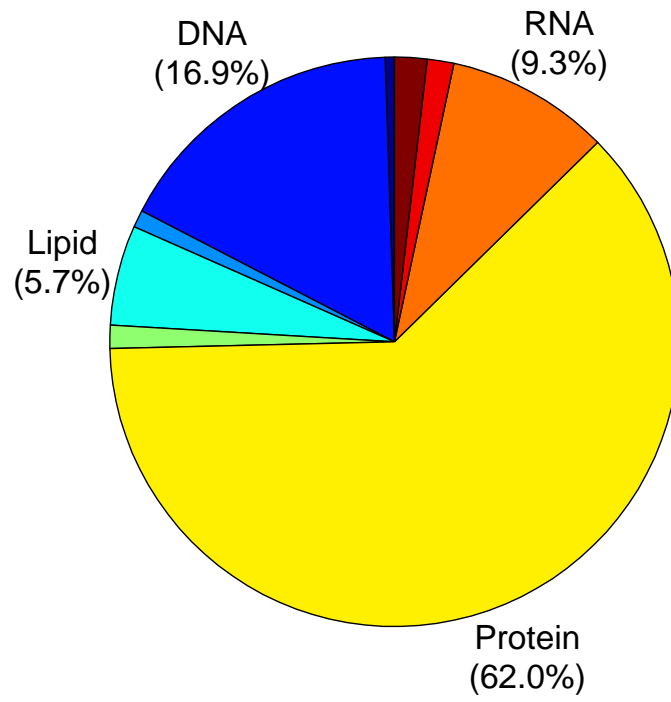


Unsynchronized Population

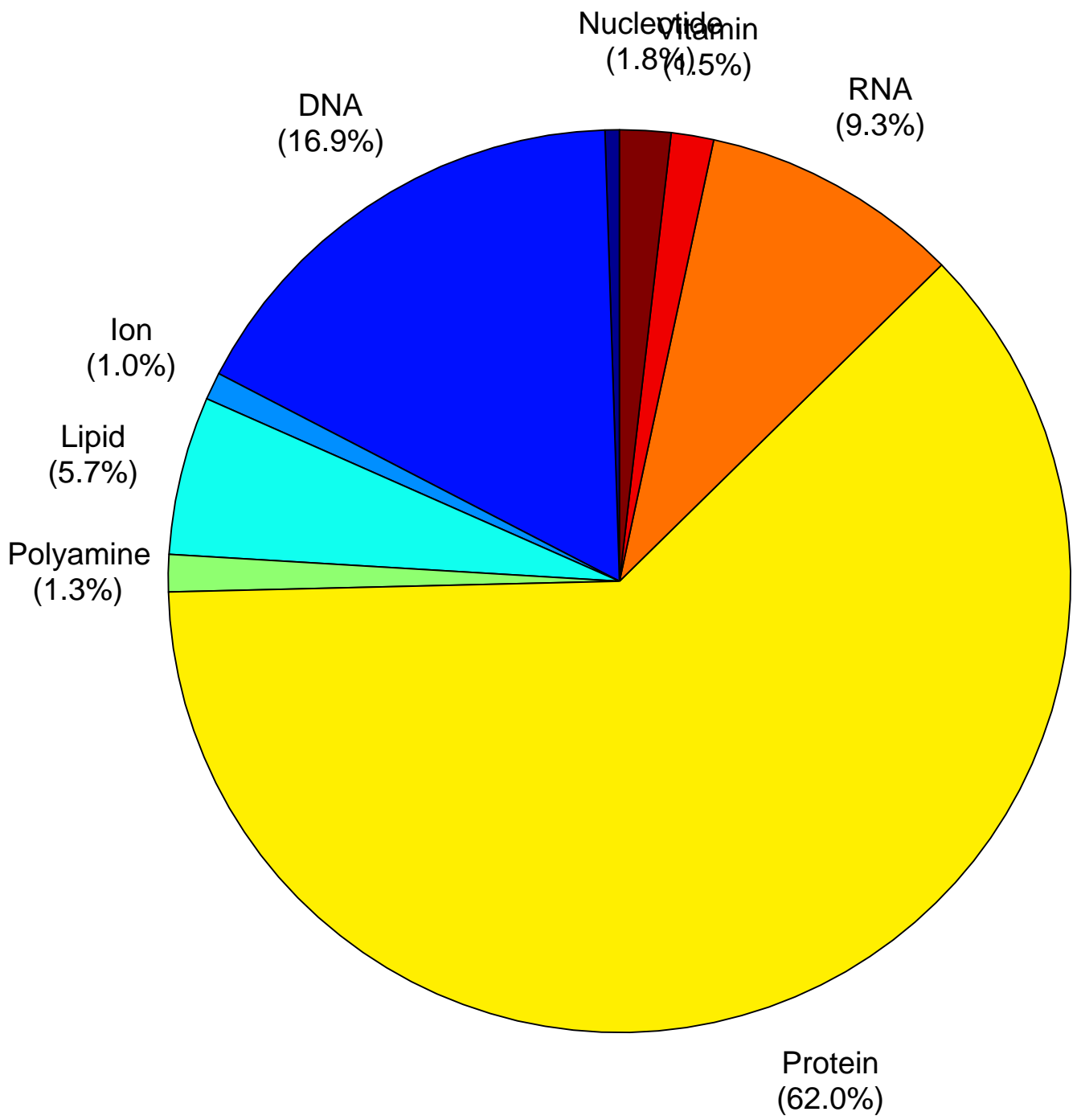
Overview: 2011:10:19 02:53:45



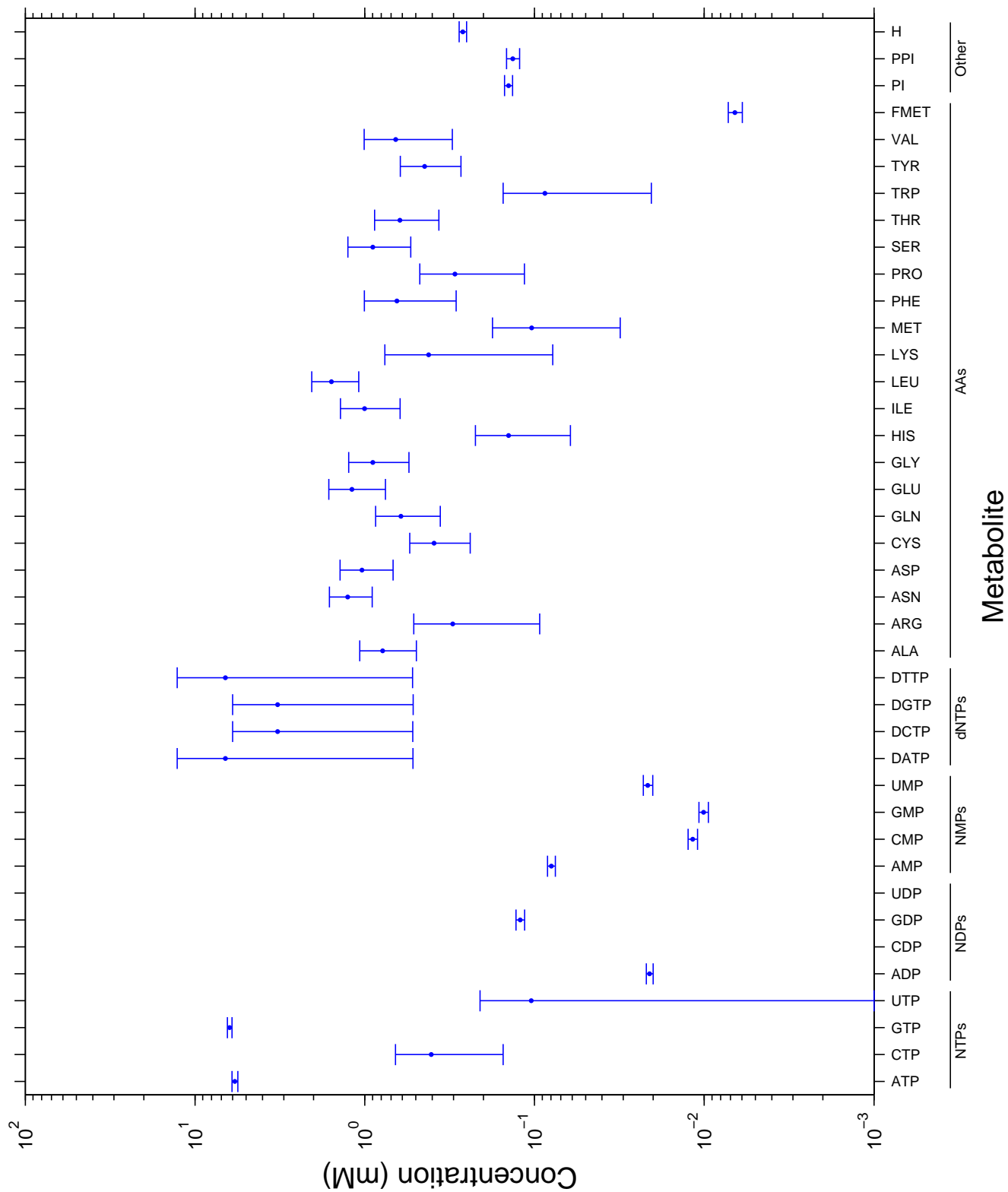
# Simulation Runtime



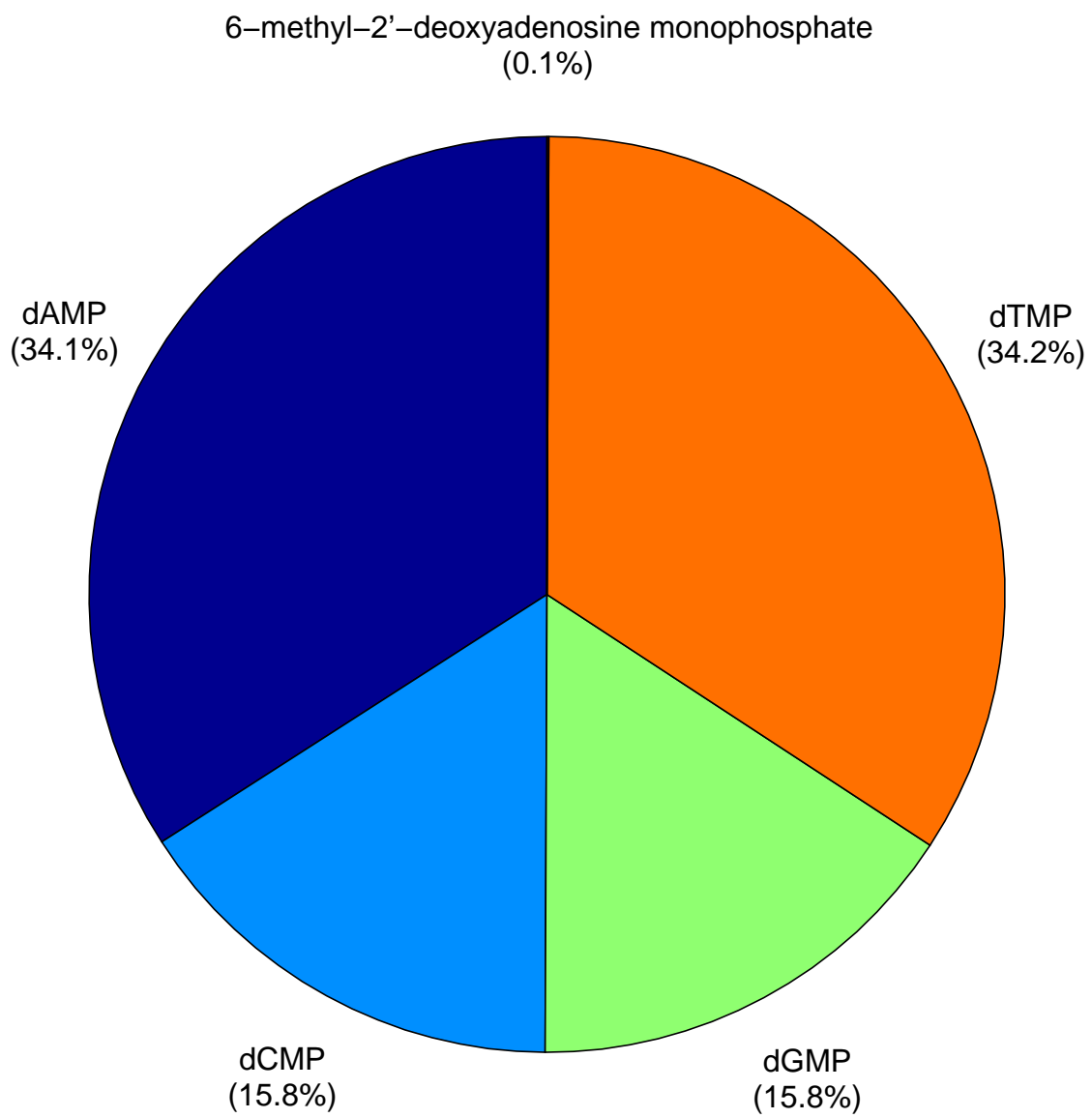
# Biomass Composition



Biomass Composition

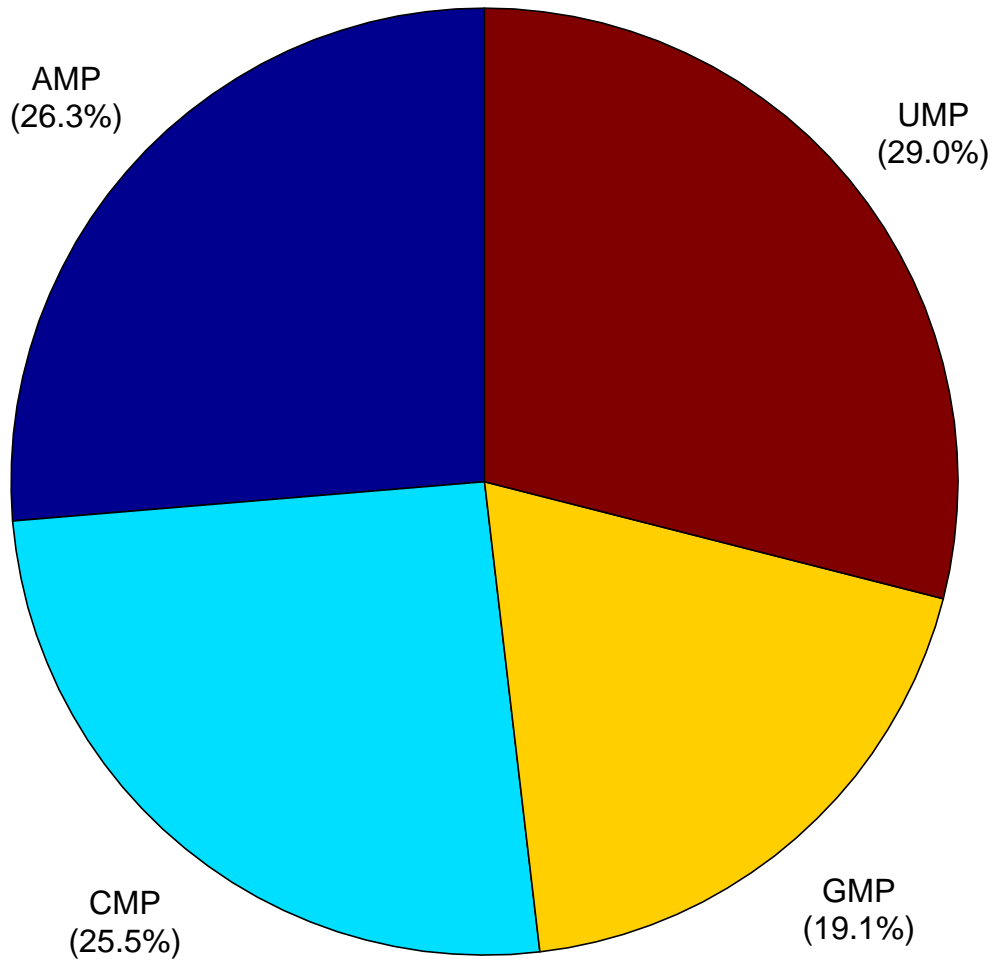


Metabolite Concentrations



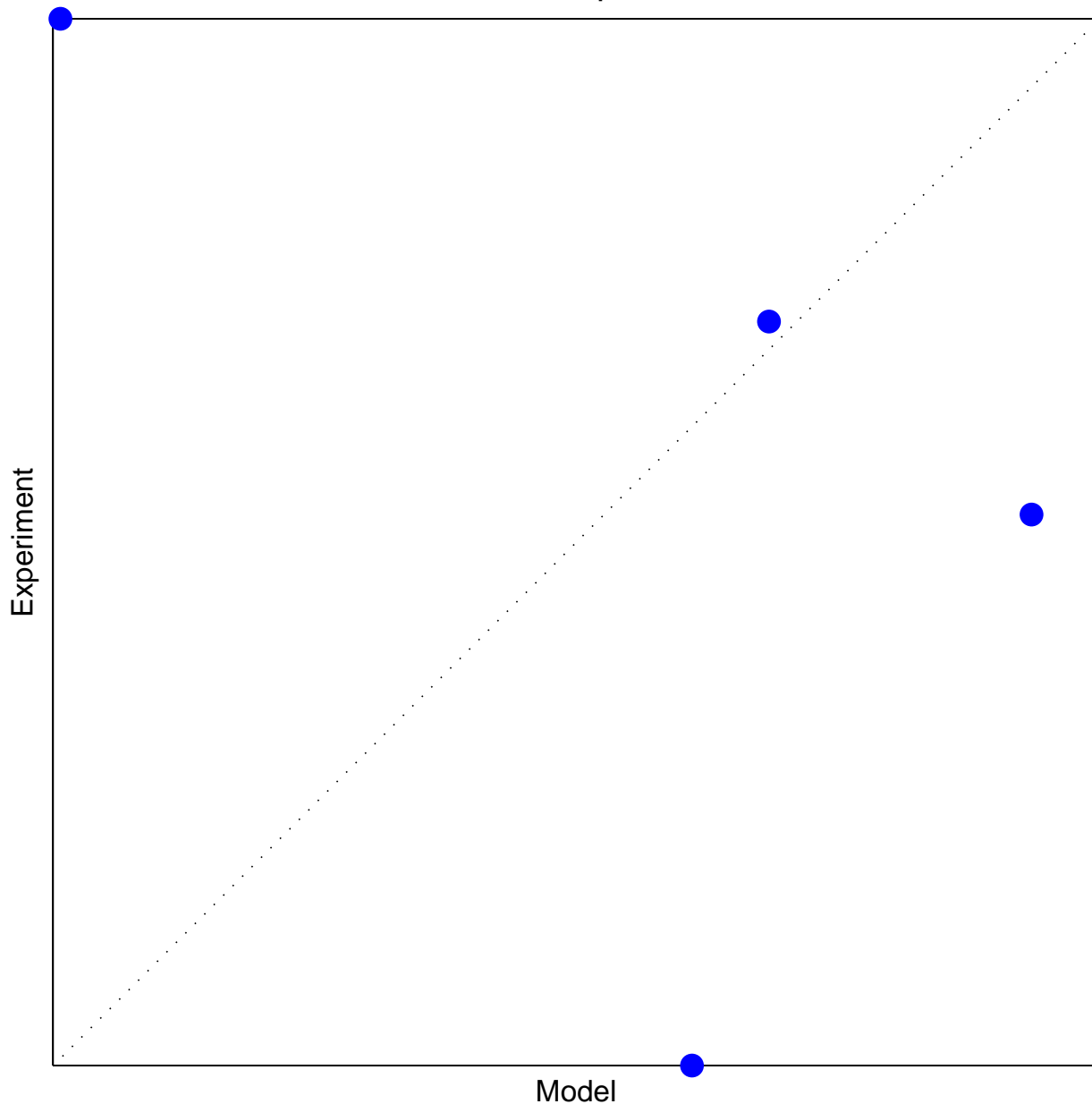
dNMP Composition



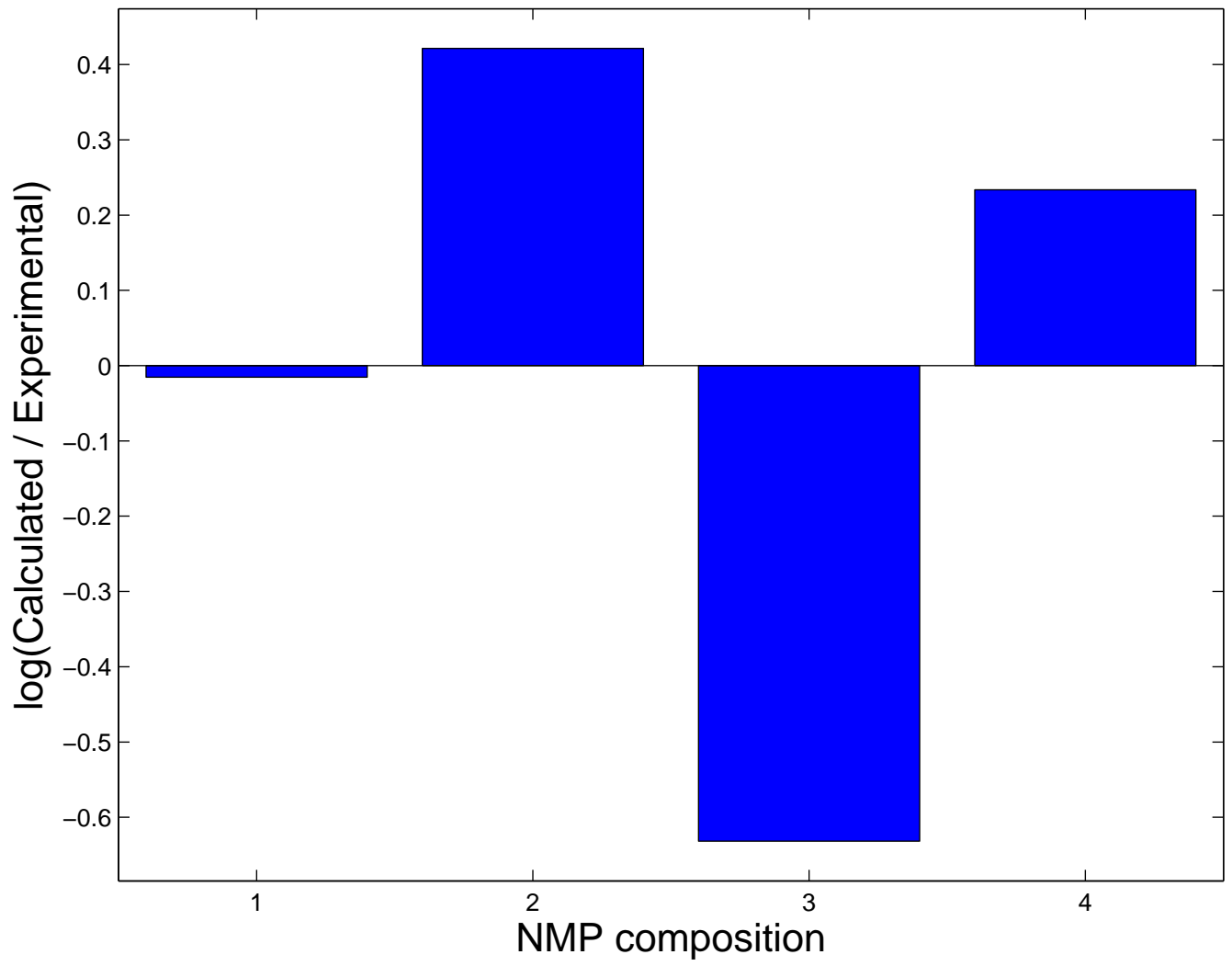


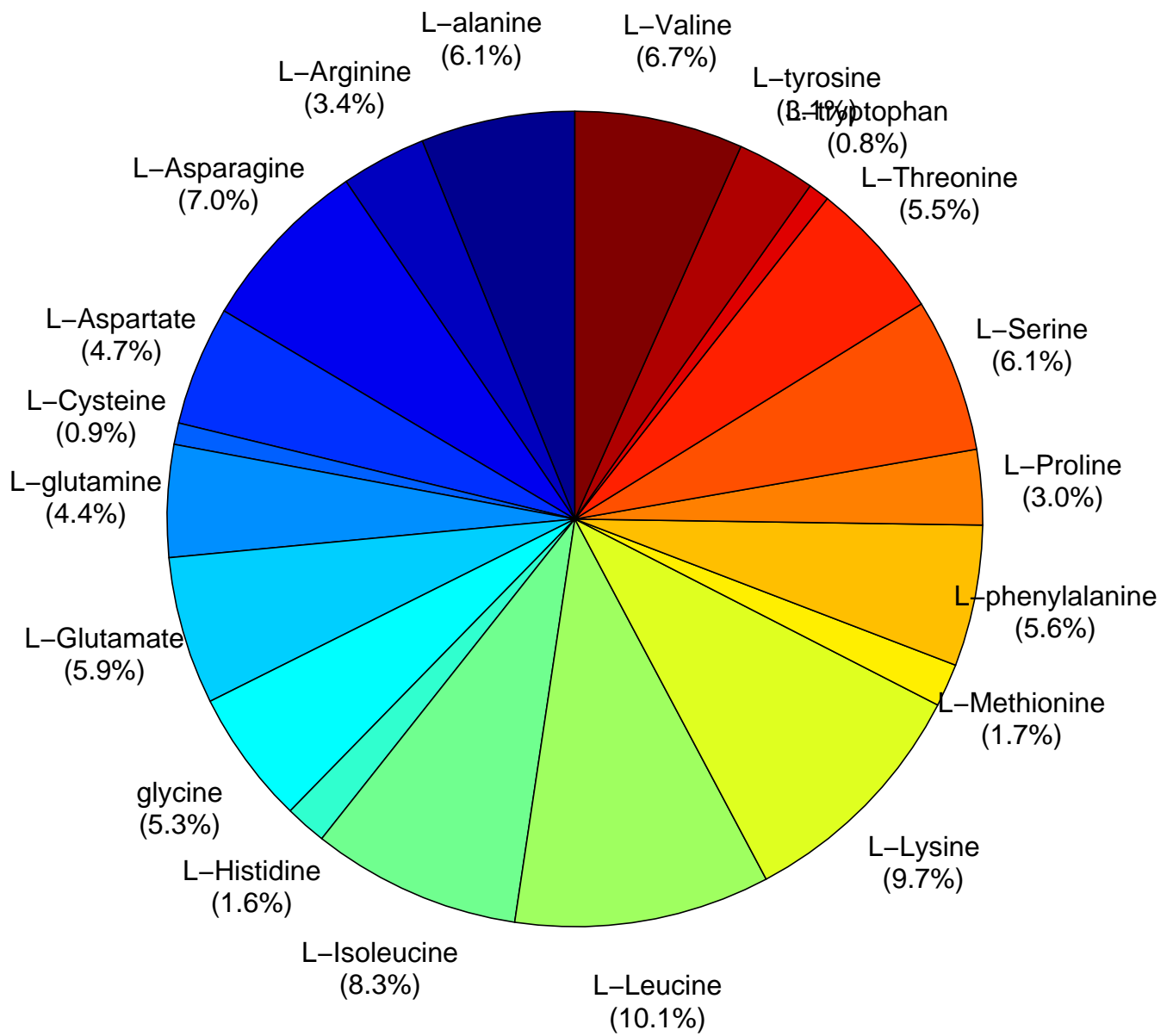
## Nucleotide Composition

# NMP Composition



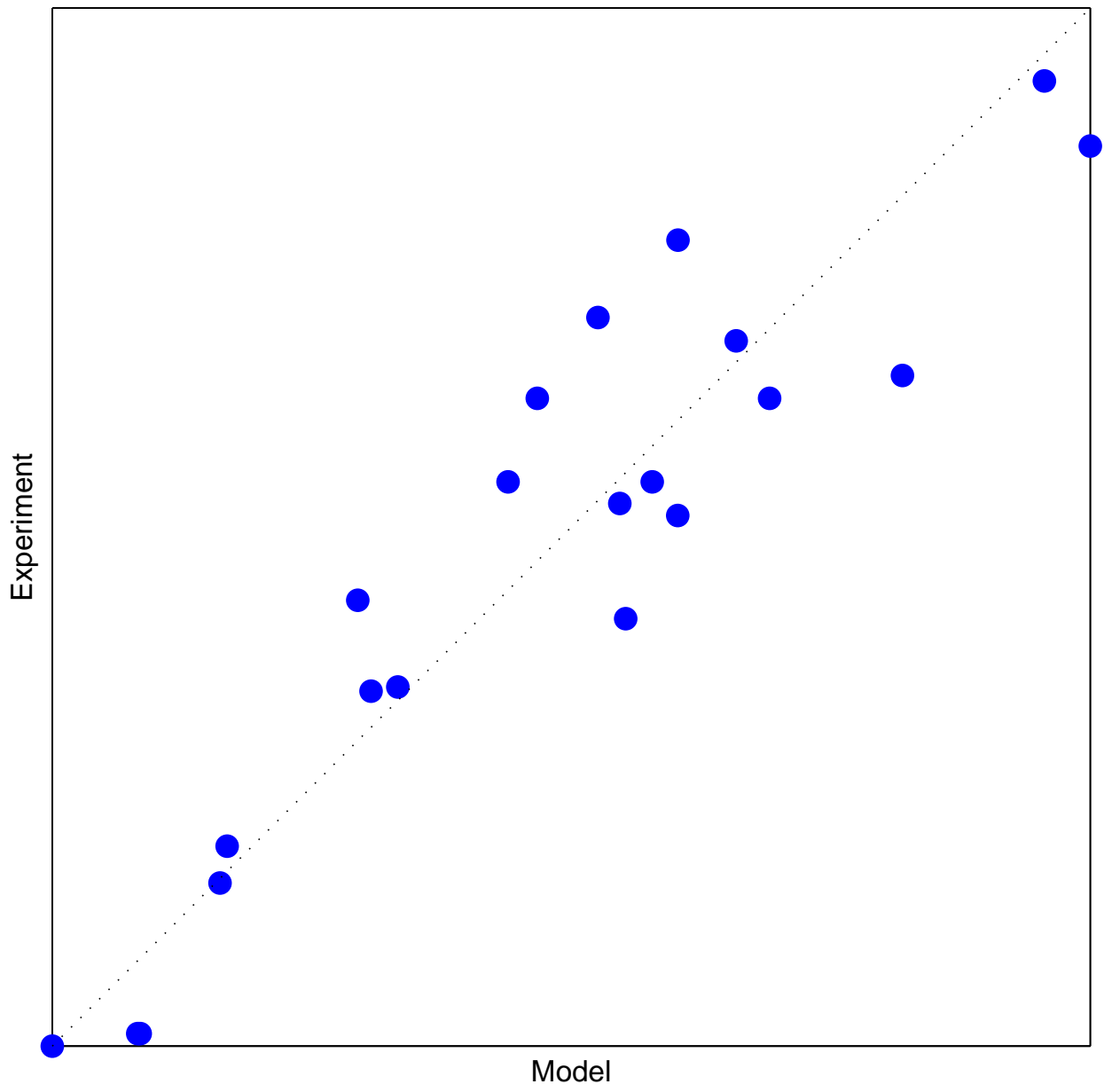
# Nucleotide Composition



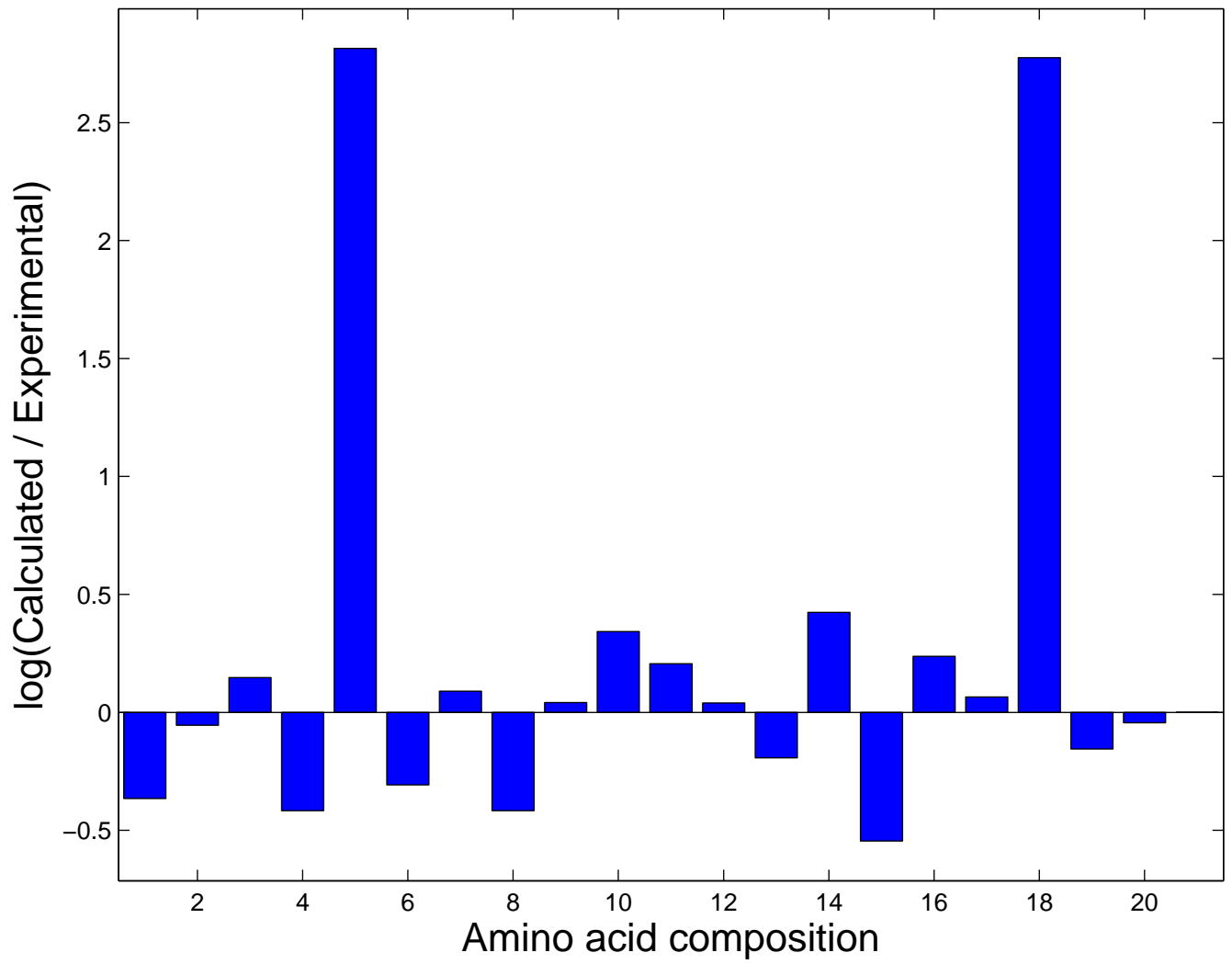


## Amino Acid Composition

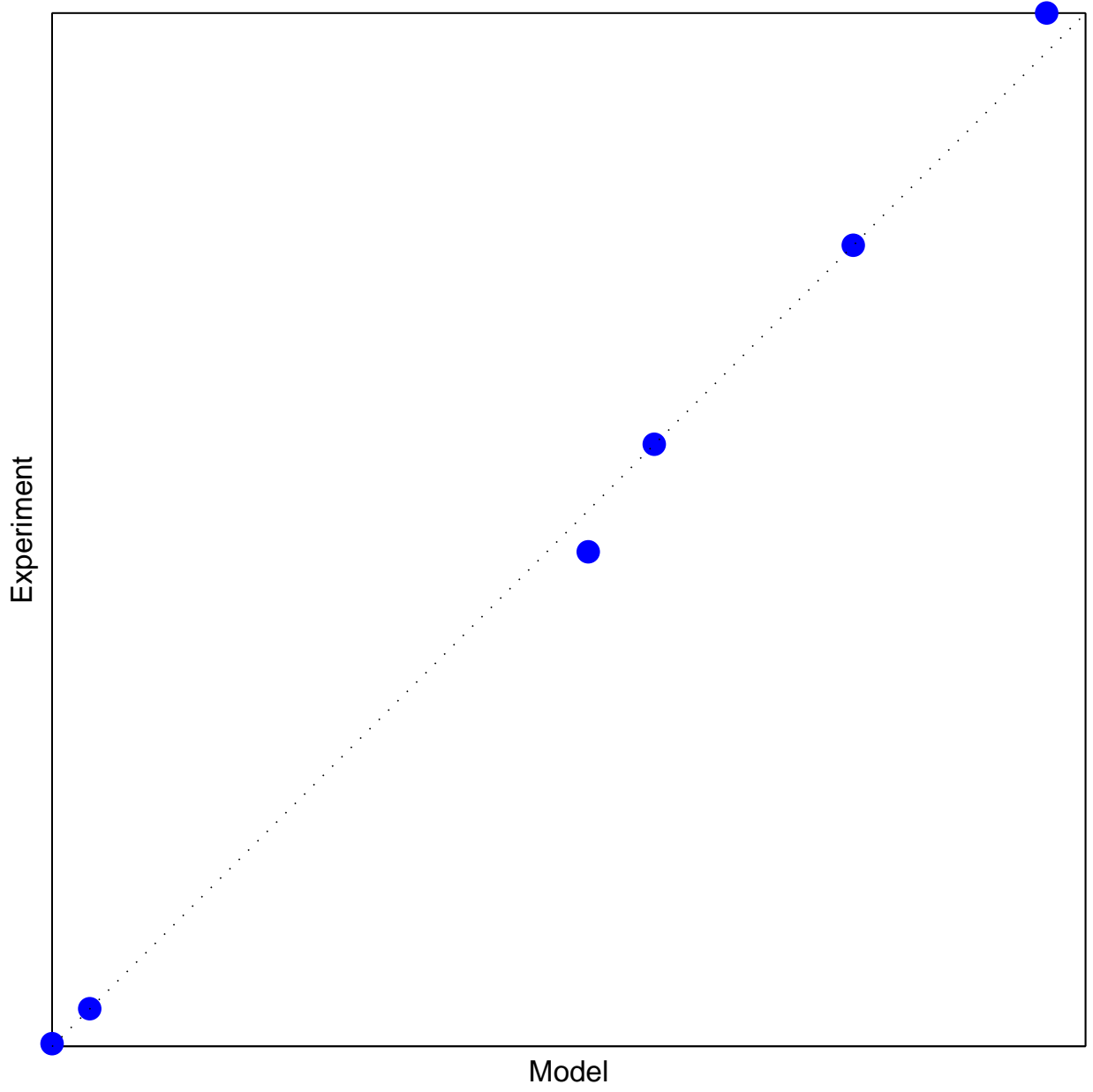
# AA Composition

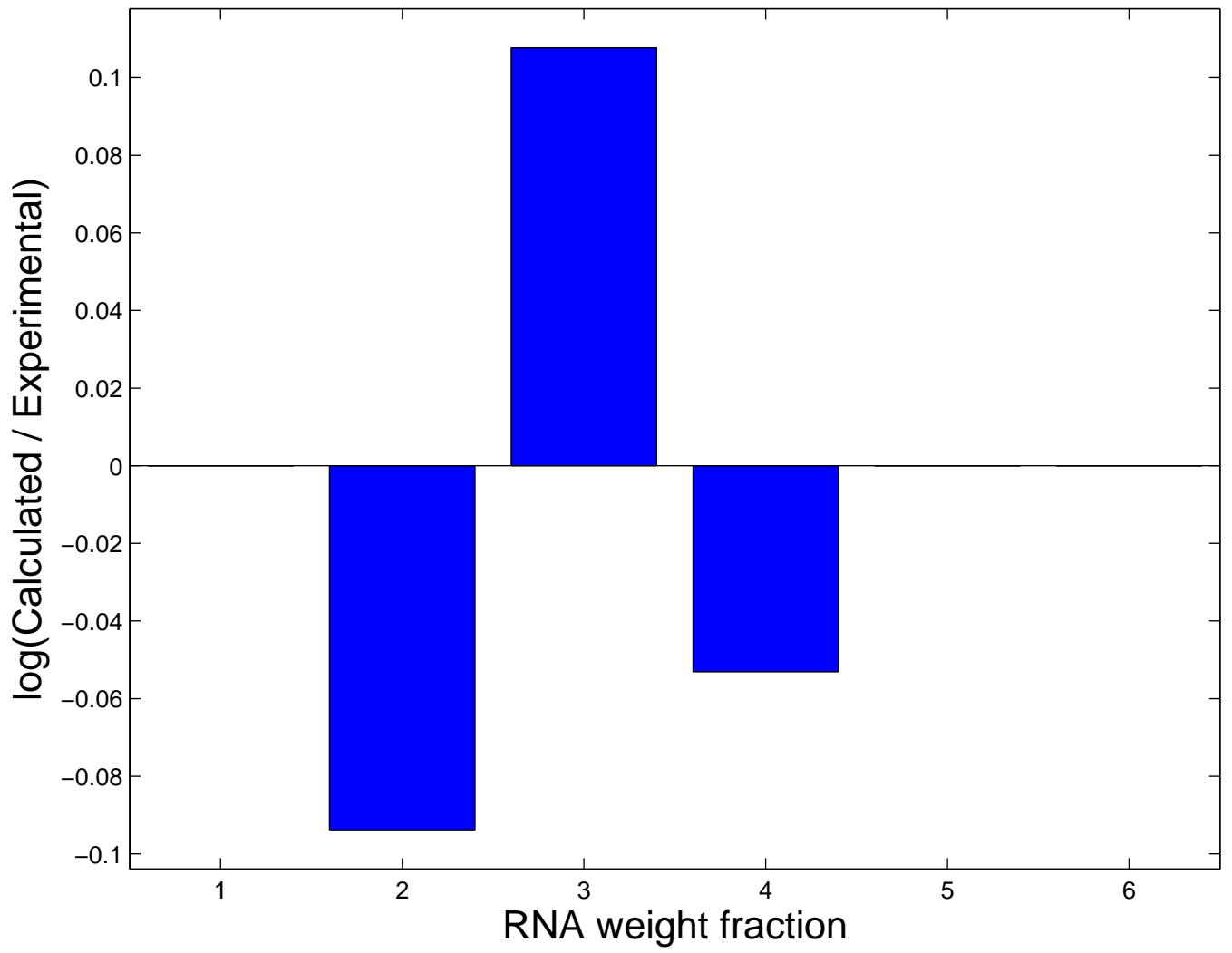


Amino Acid Composition



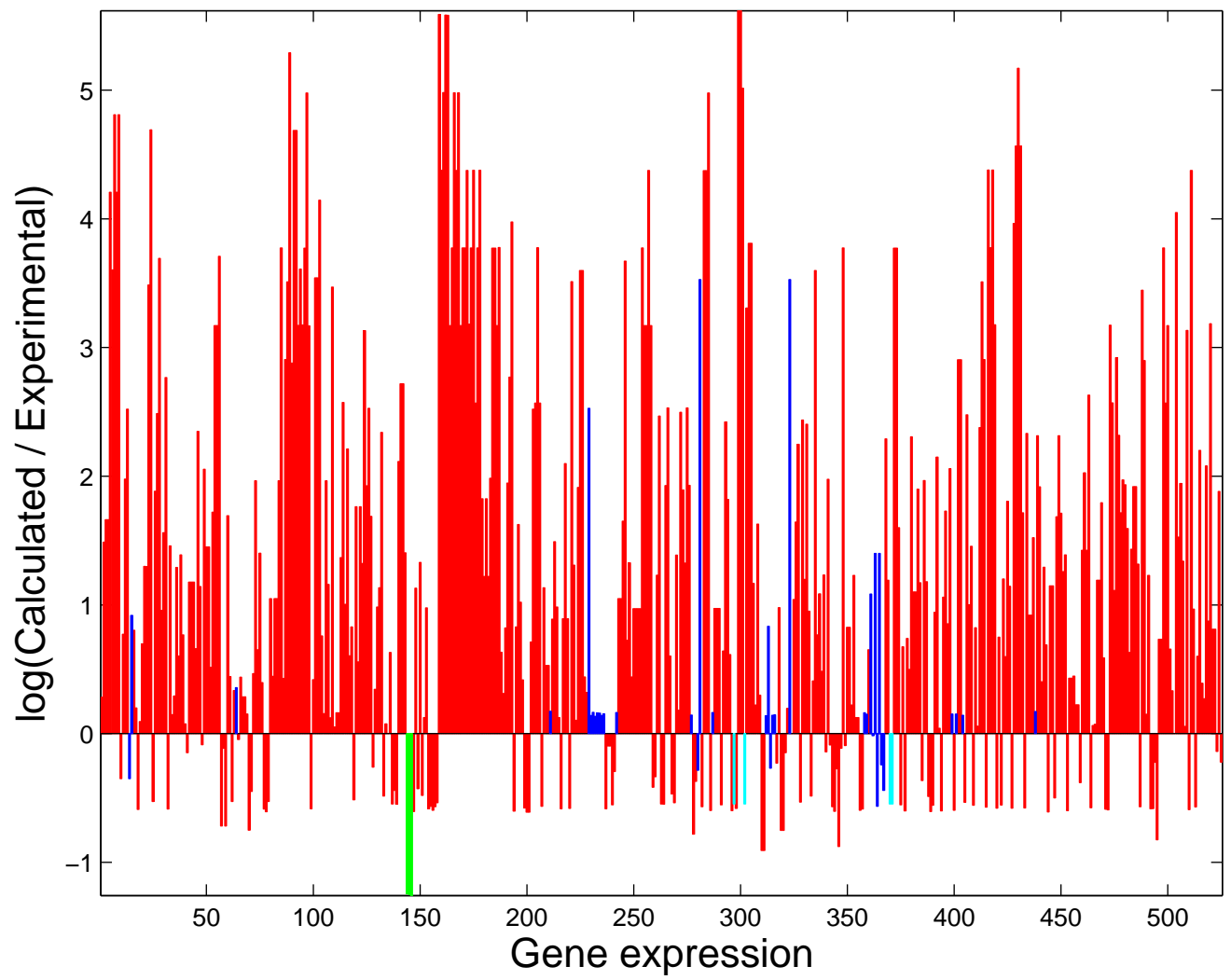
# RNA Composition



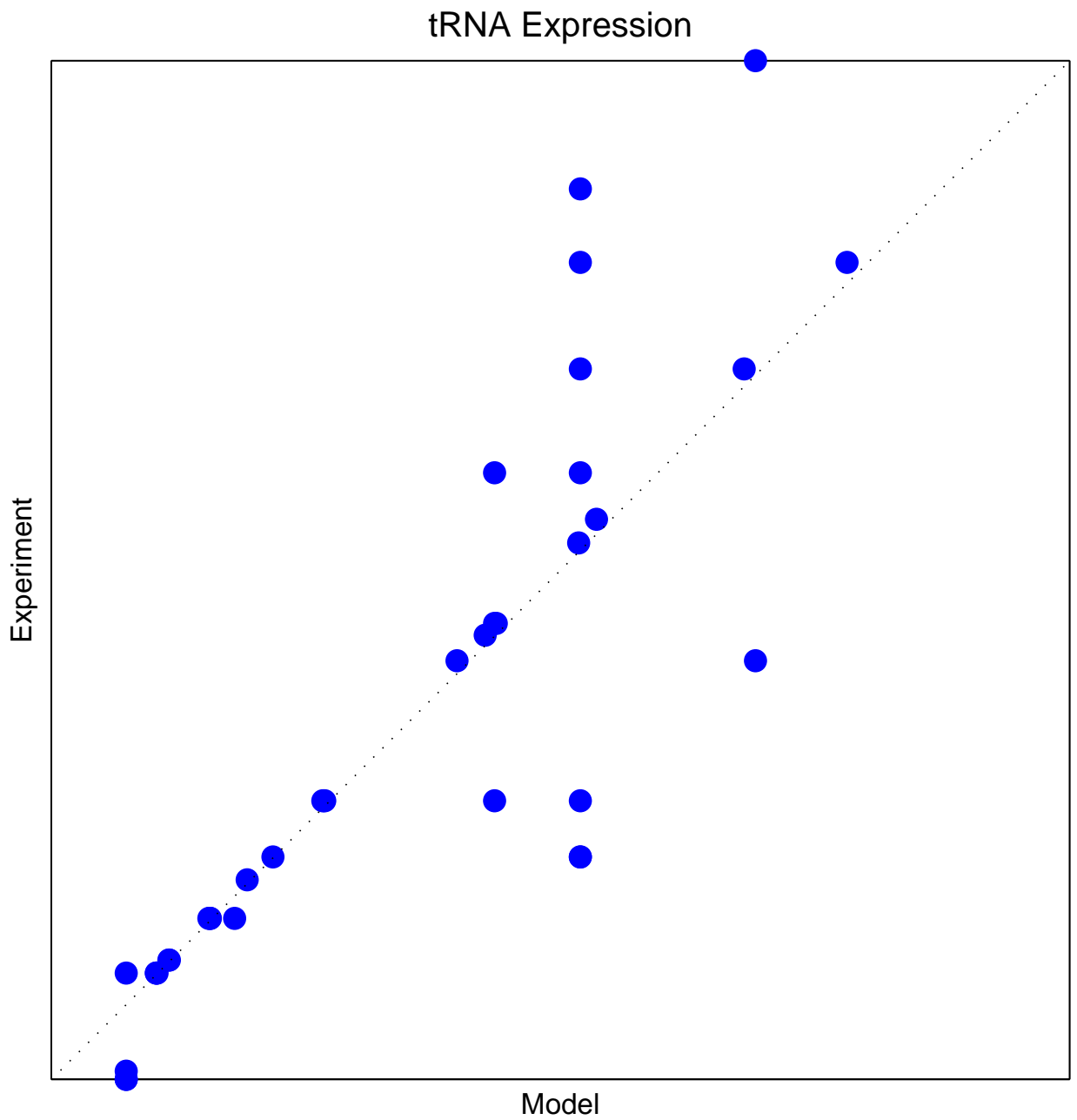




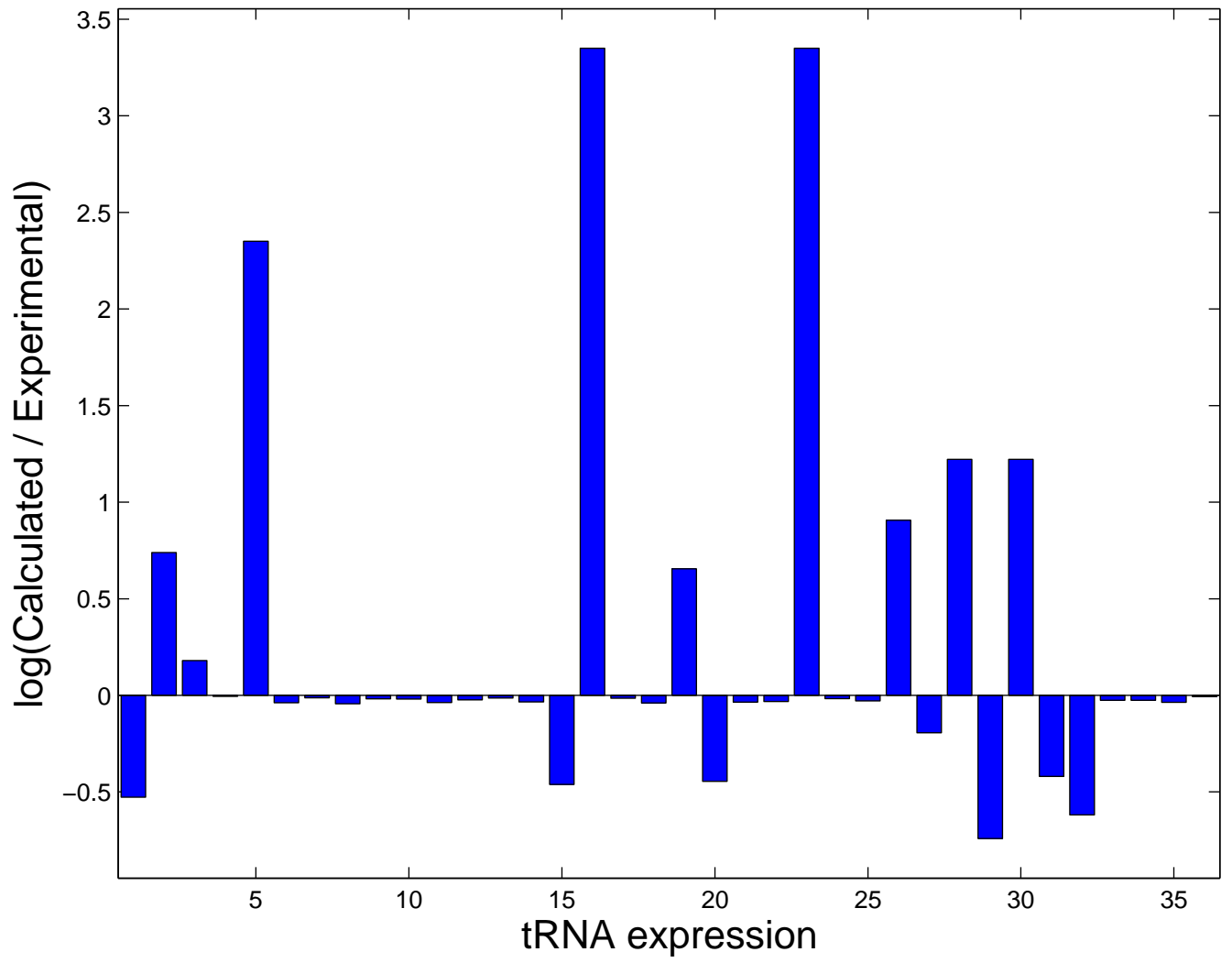




Gene Expression

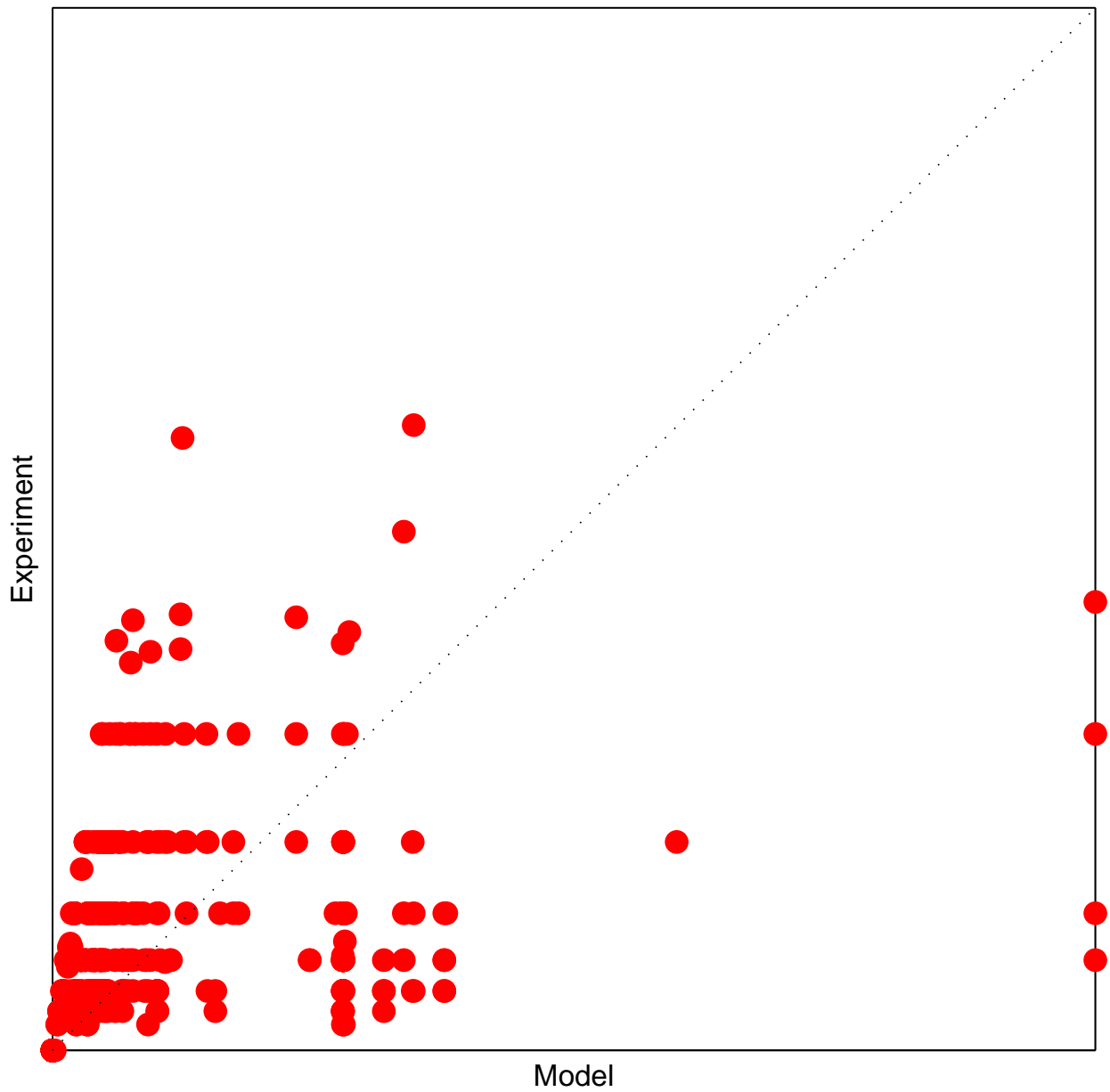


tRNA Expression

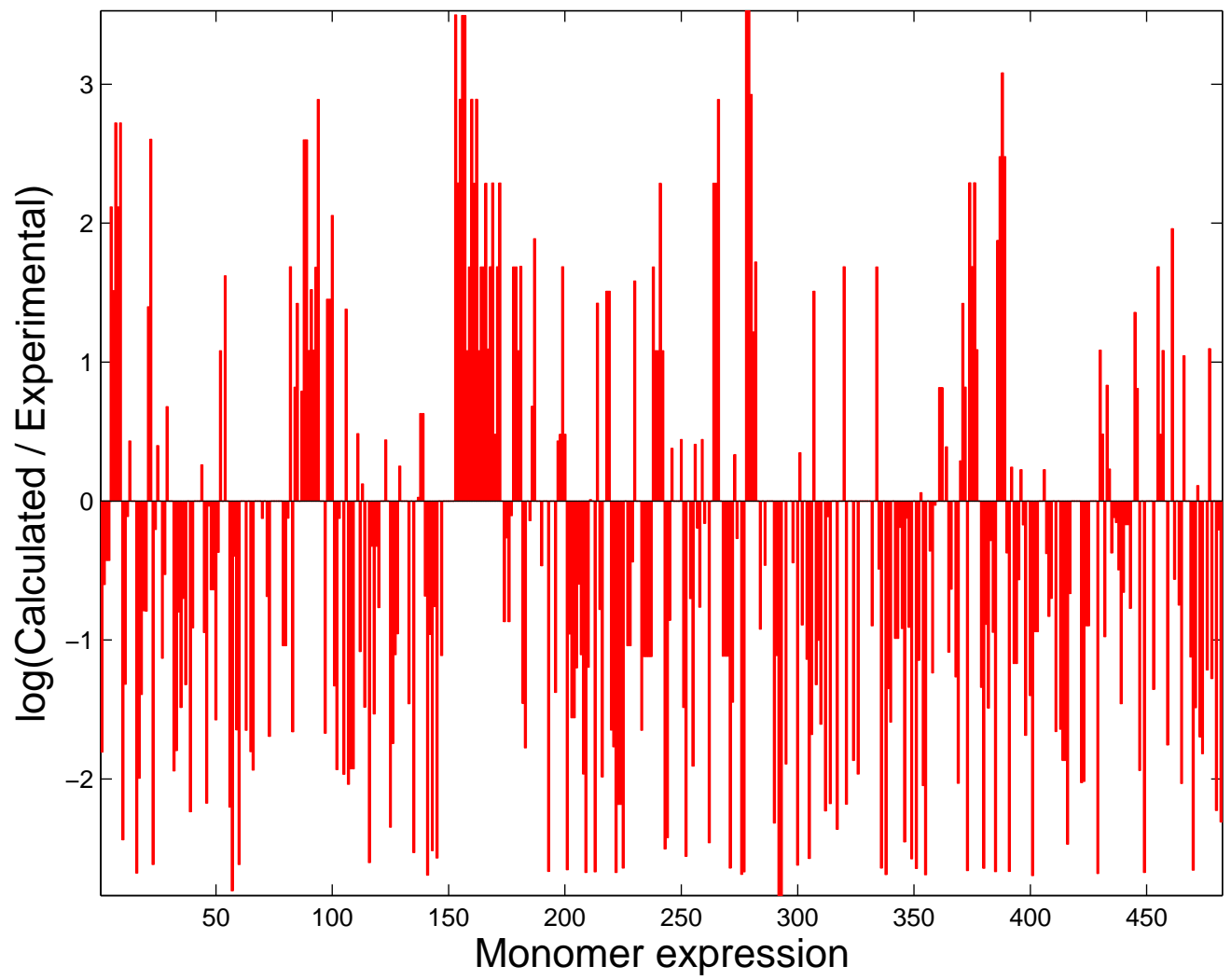


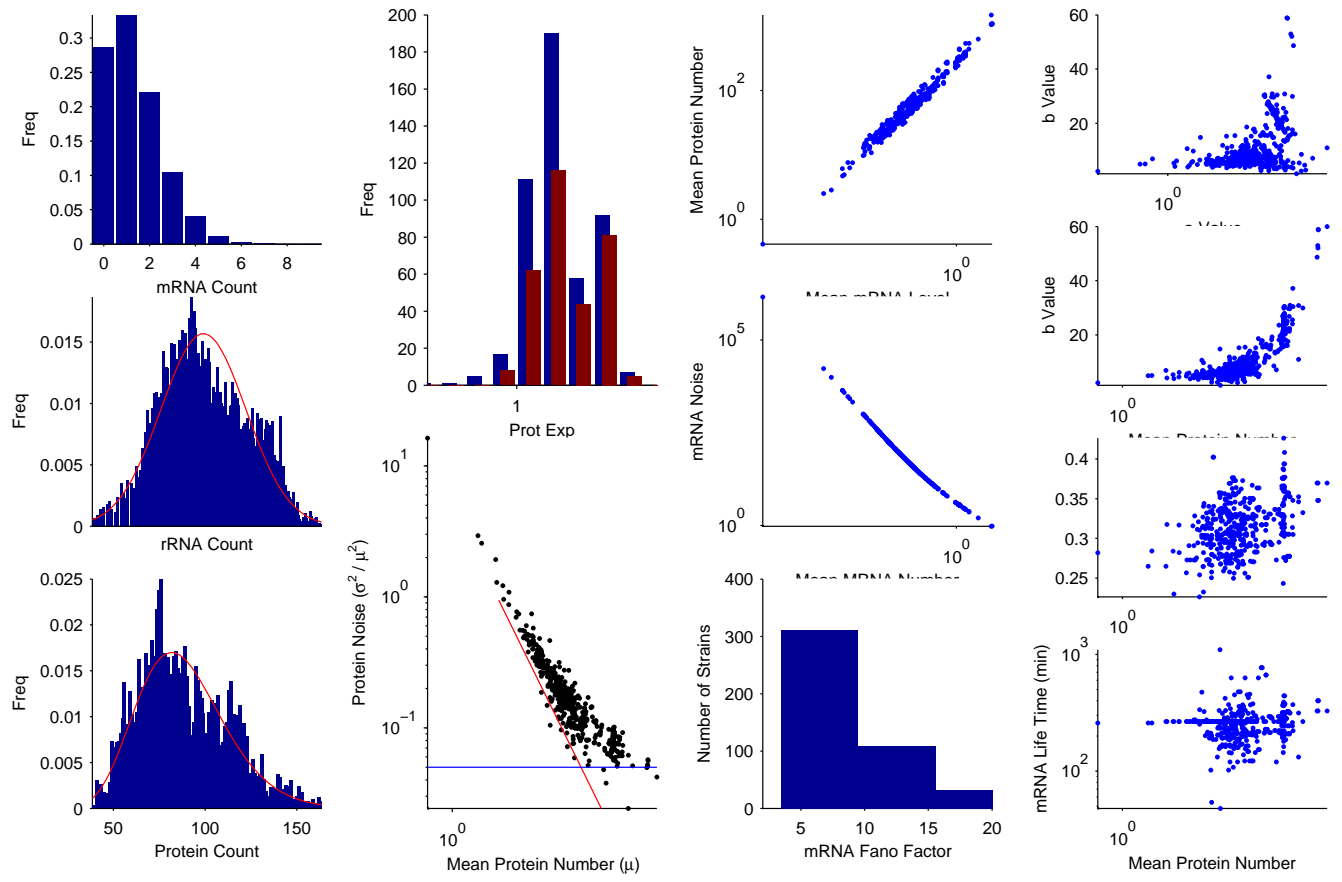
tRNA Expression

# Protein Expression

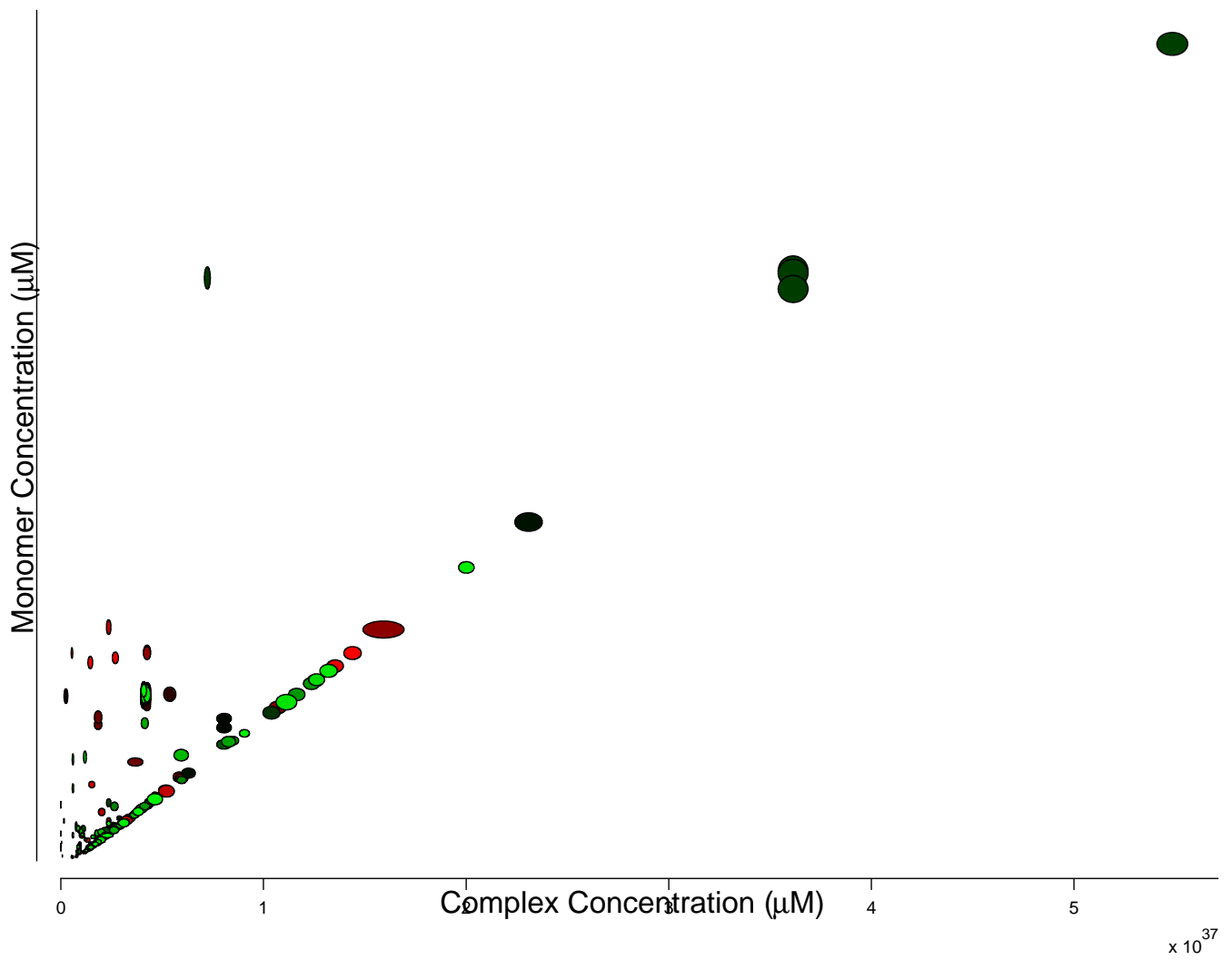


Protein Expression



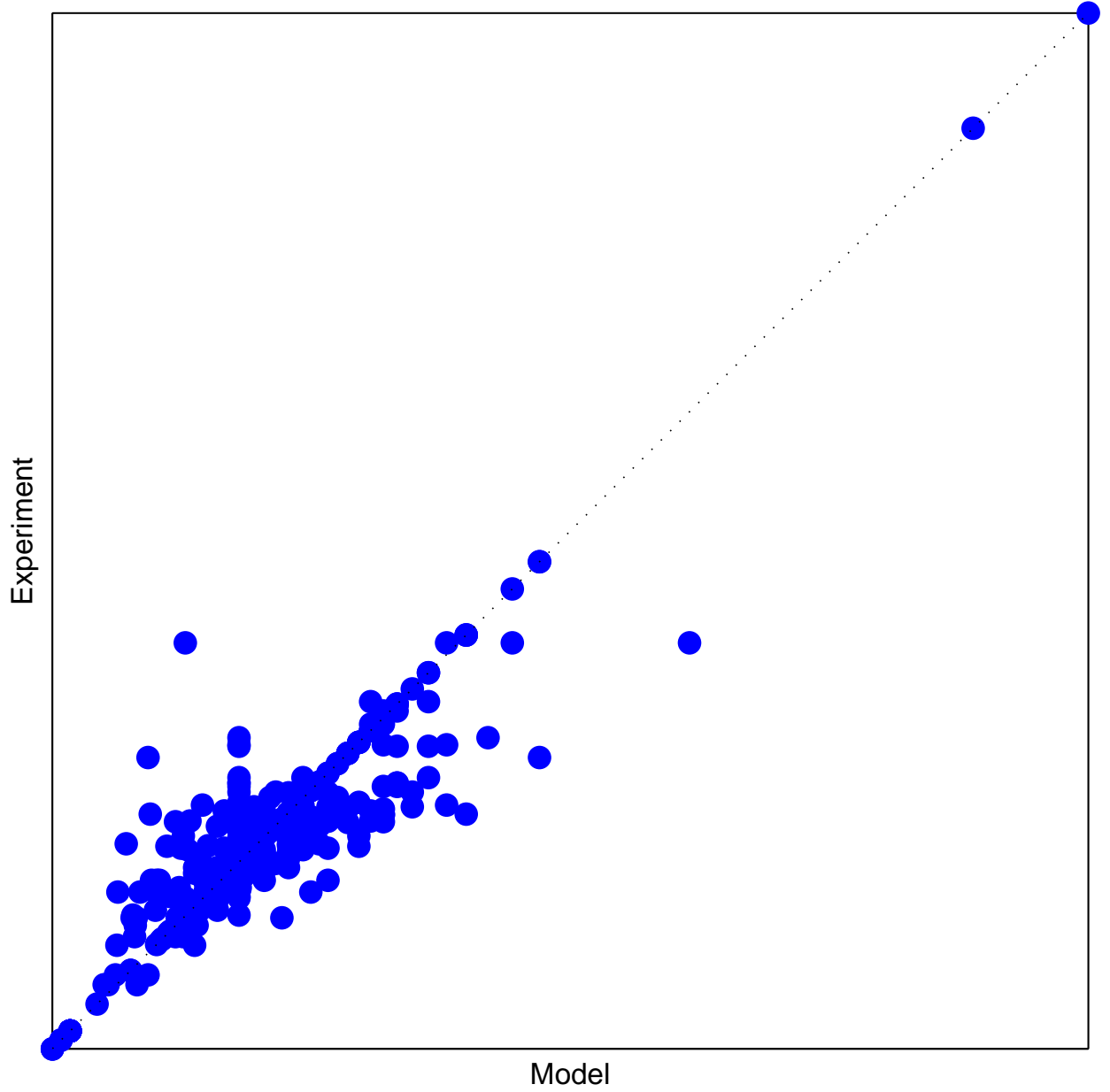


# Macromolecule Expression

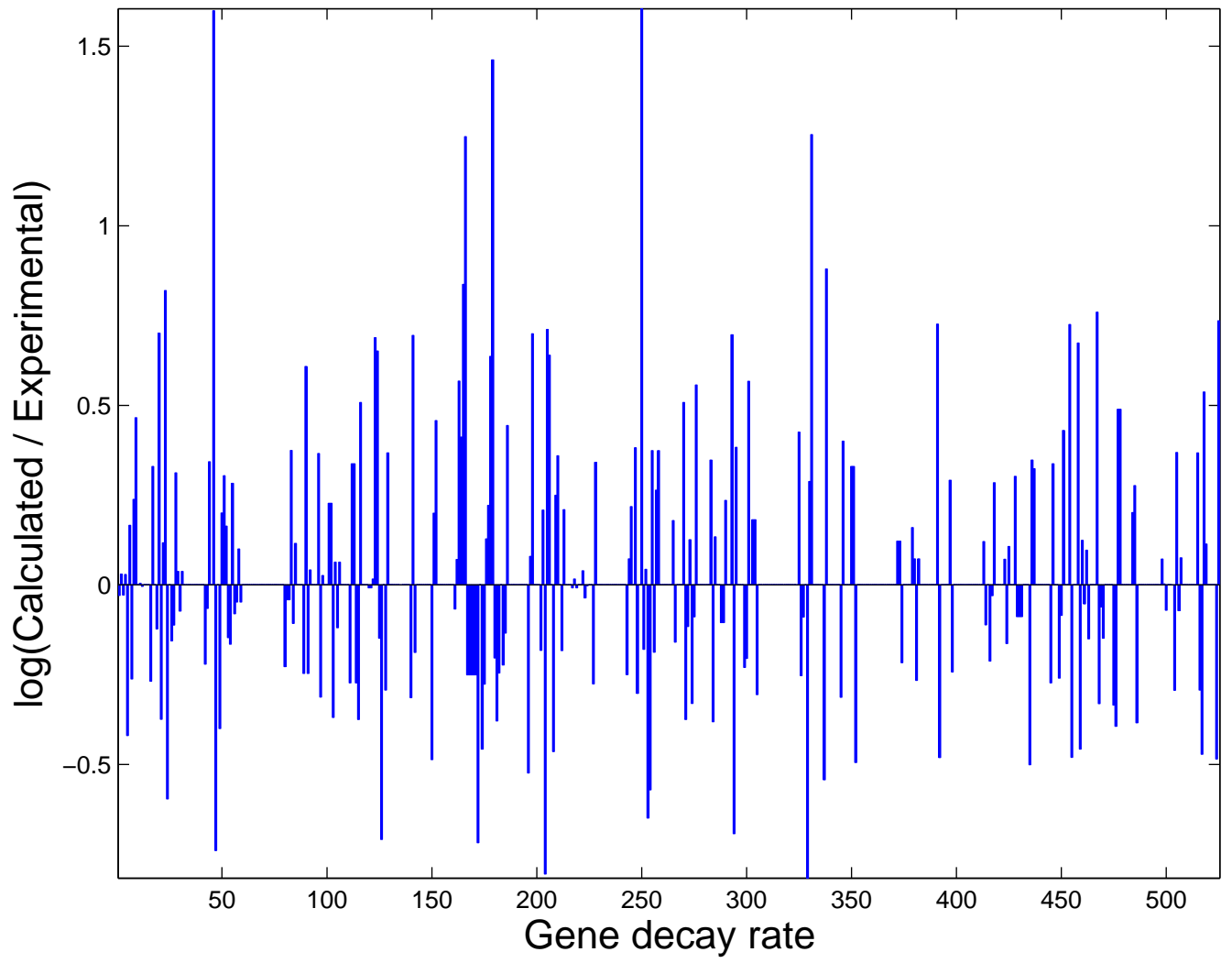


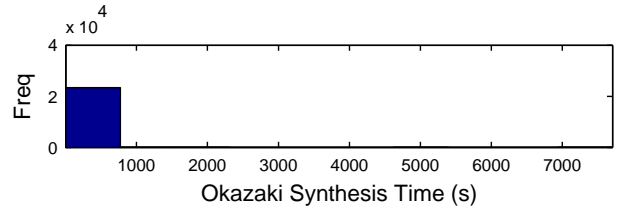
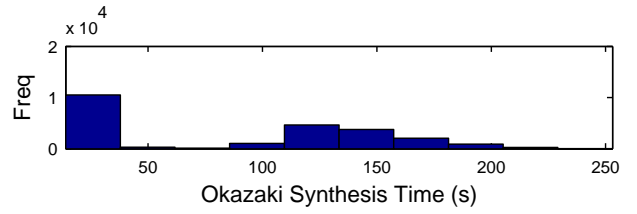
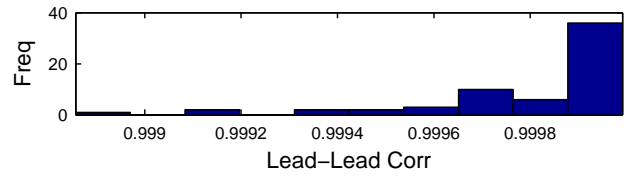
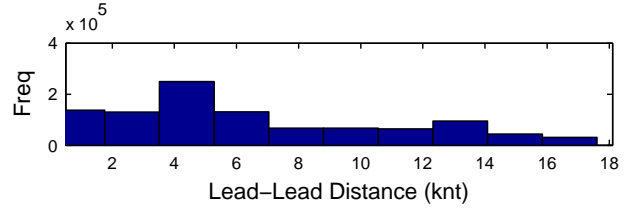
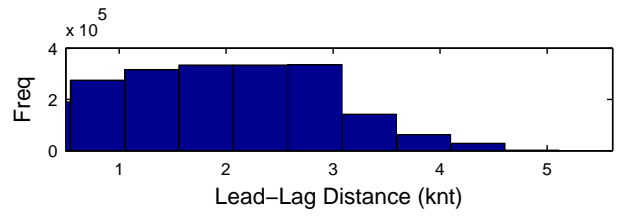
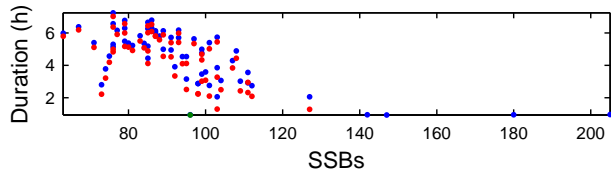
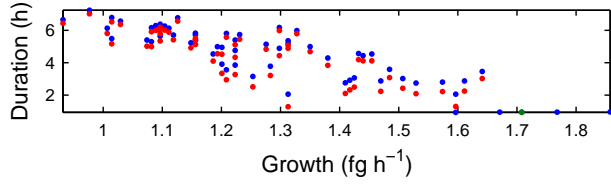
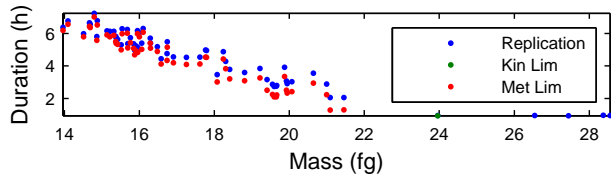


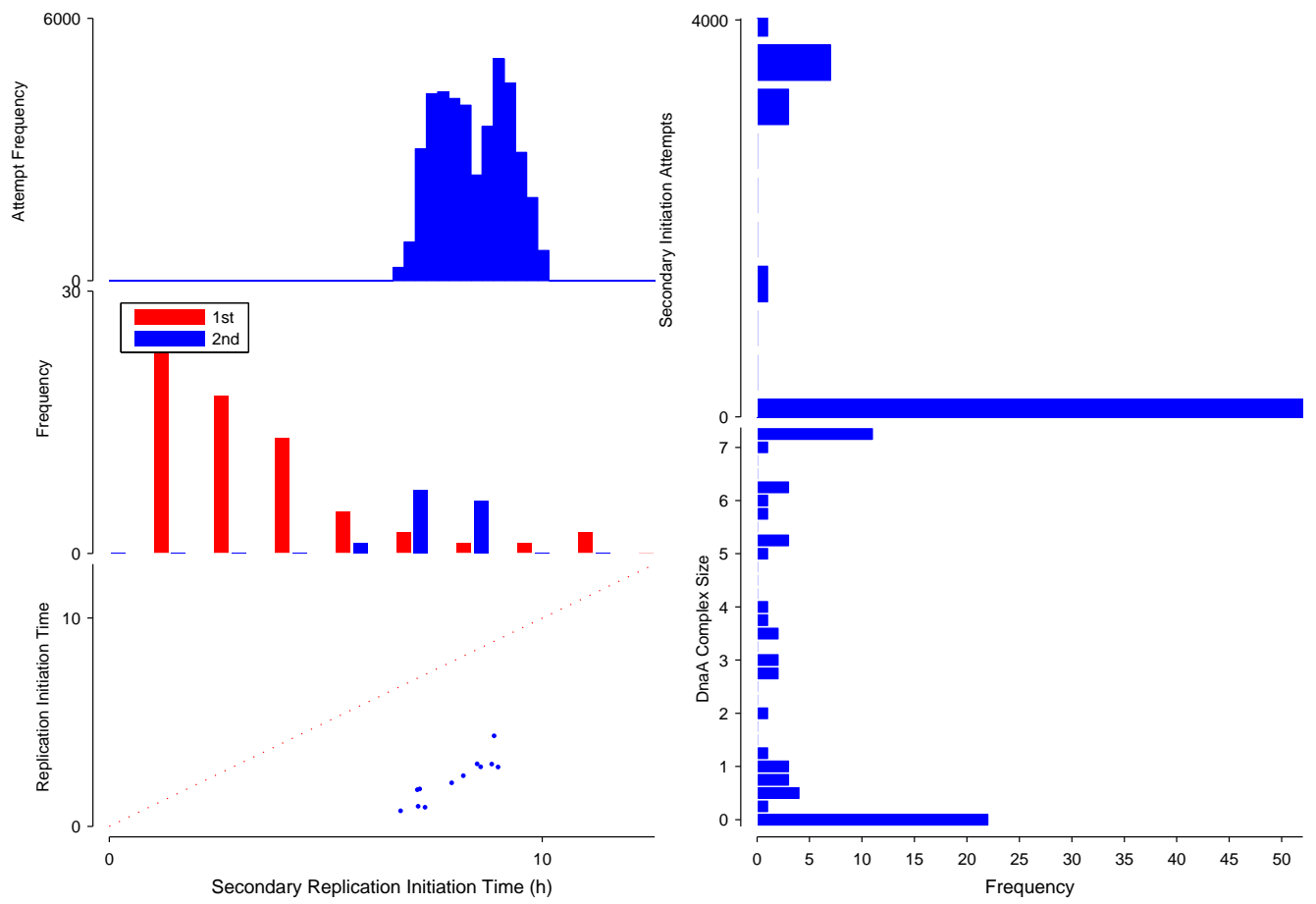
# RNA Decay Rates



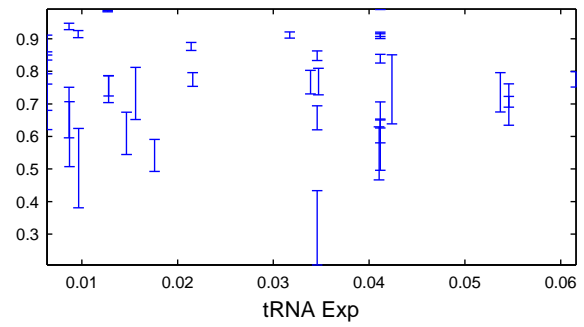
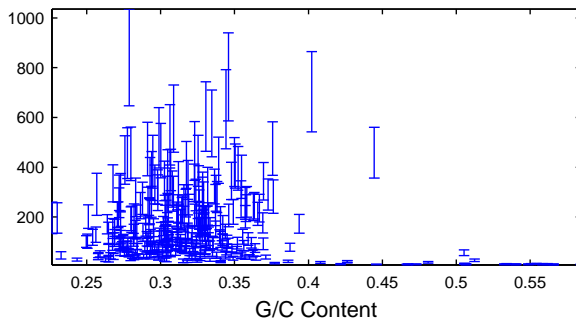
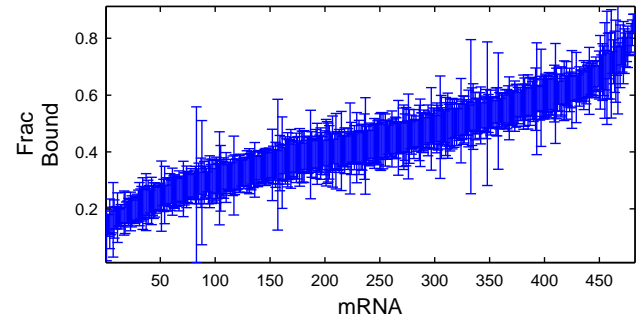
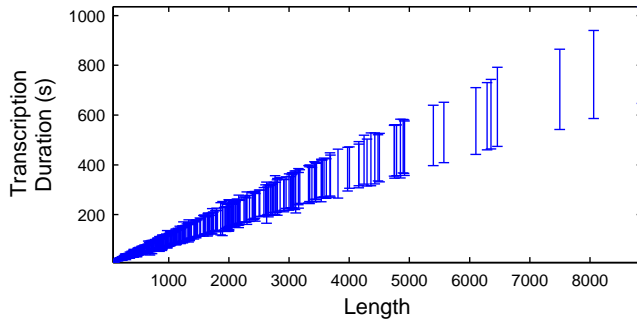
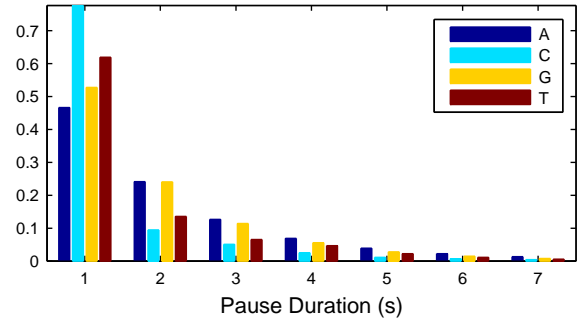
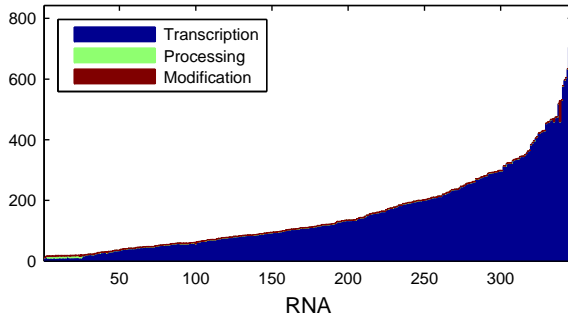
# RNA Half Lives

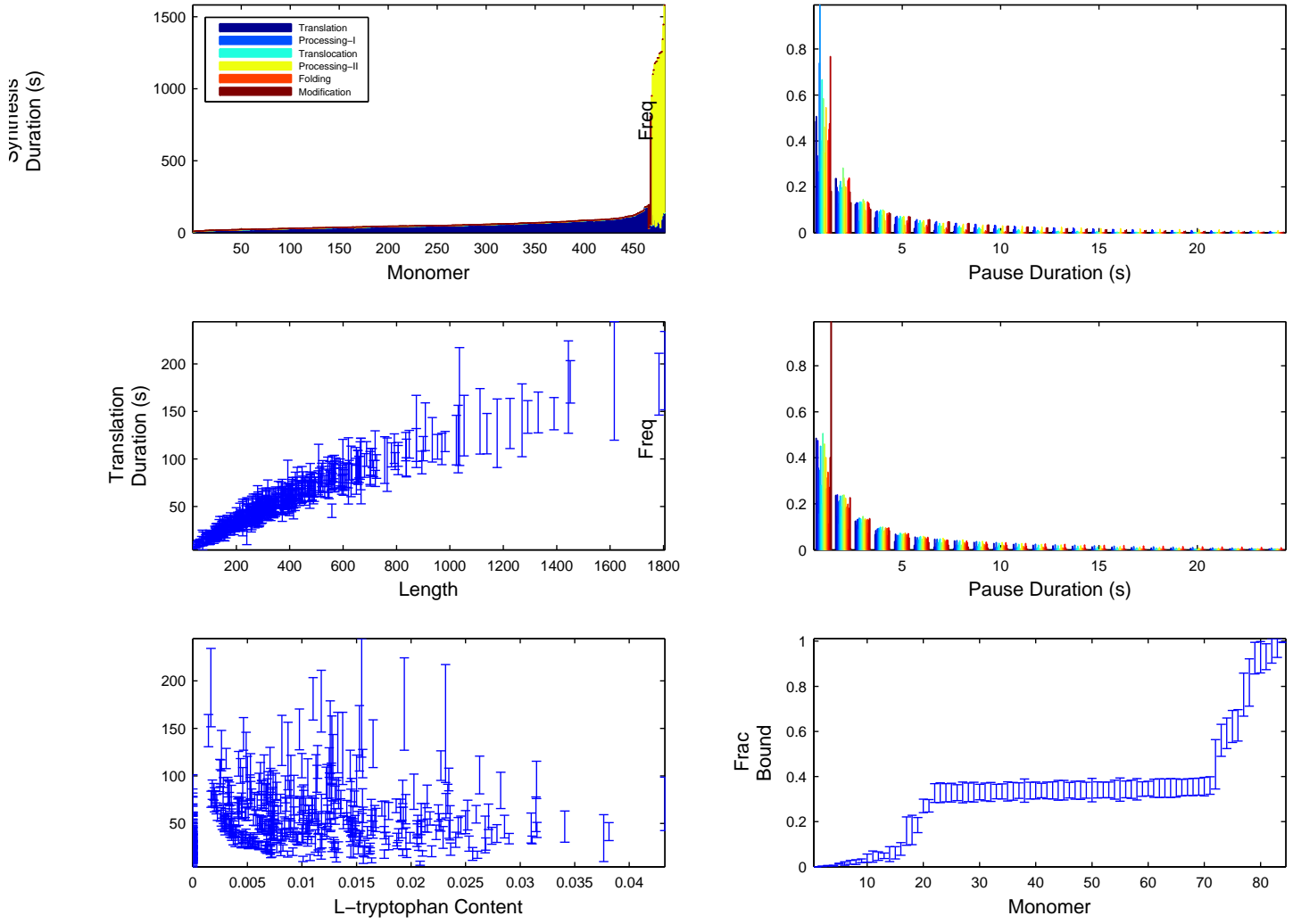




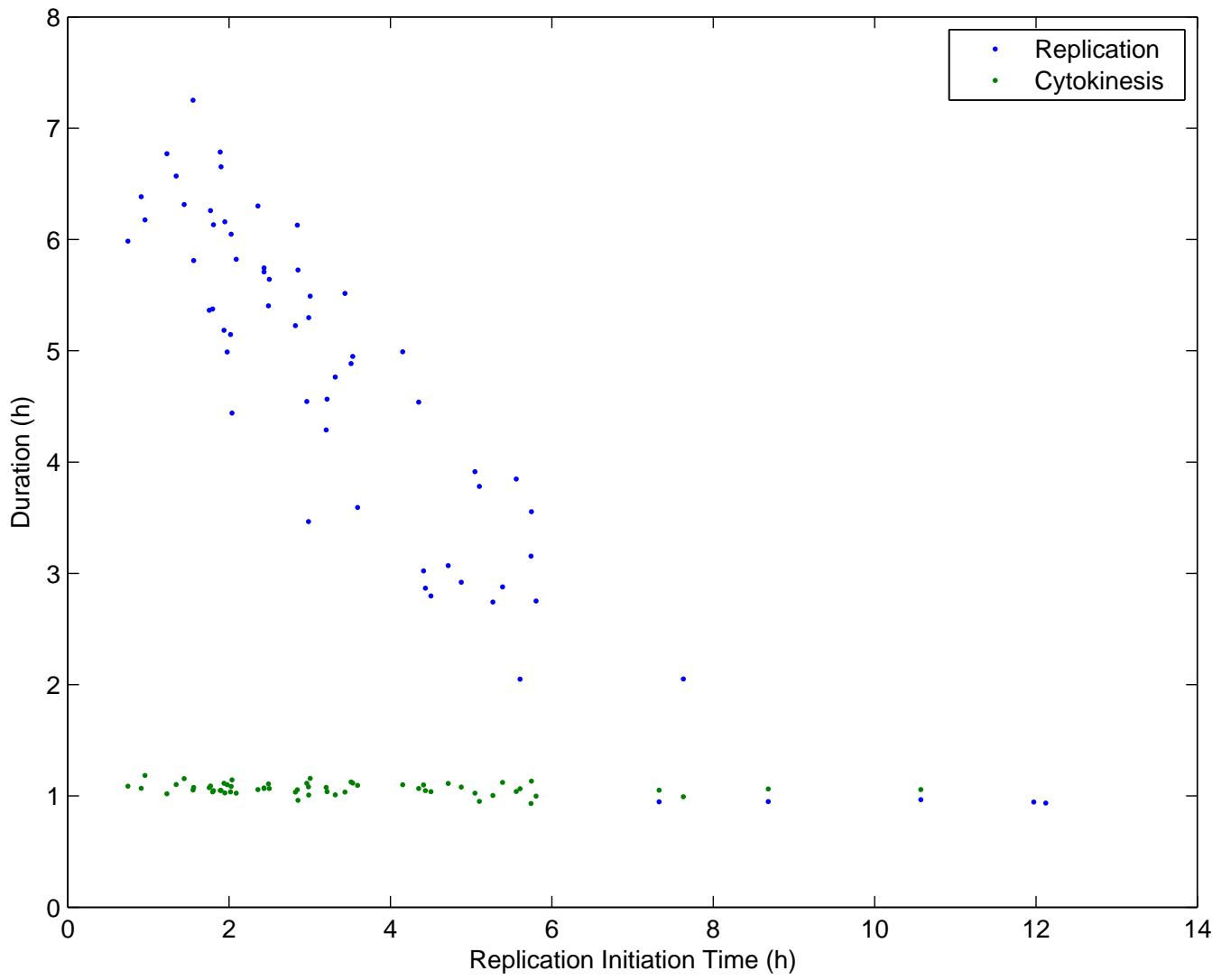


## Secondary Replication Initiation

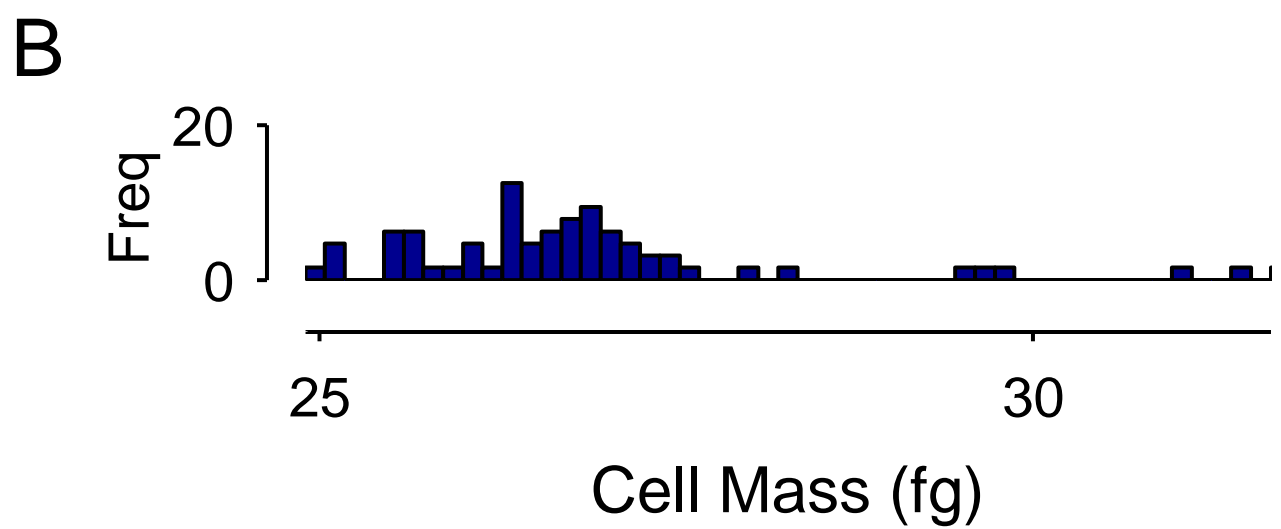
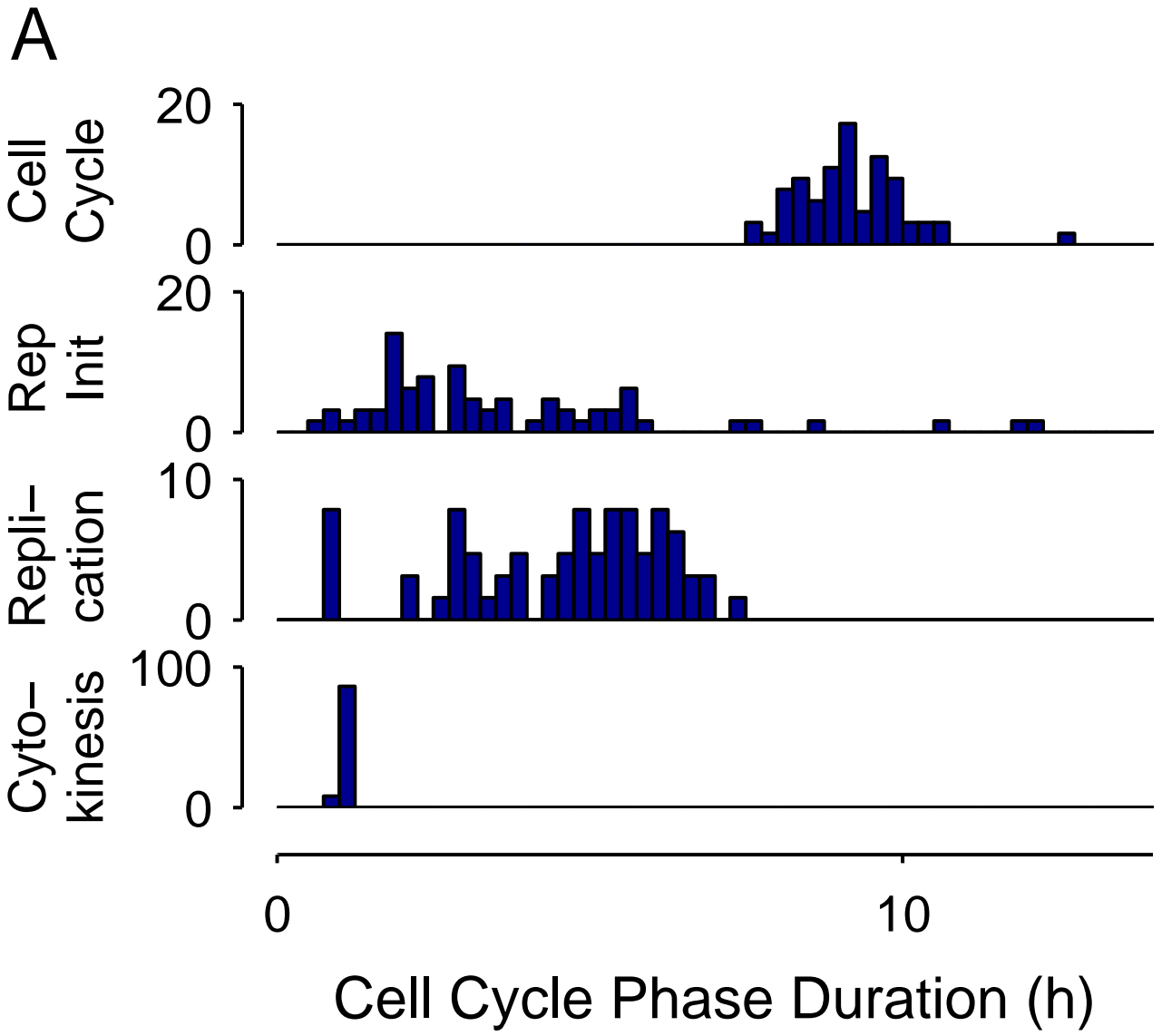




# Protein Synthesis

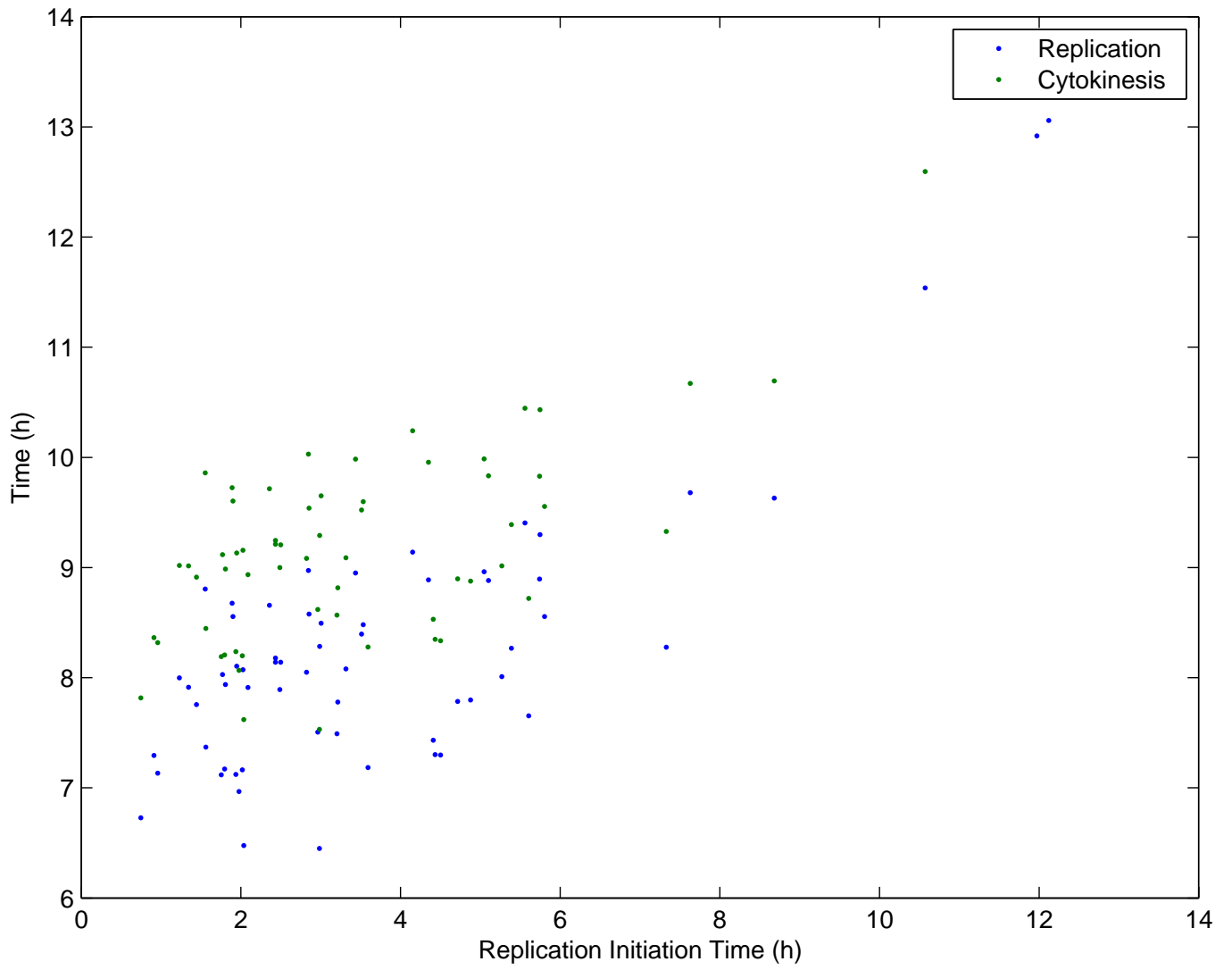


Cell Cycle Phase Durations

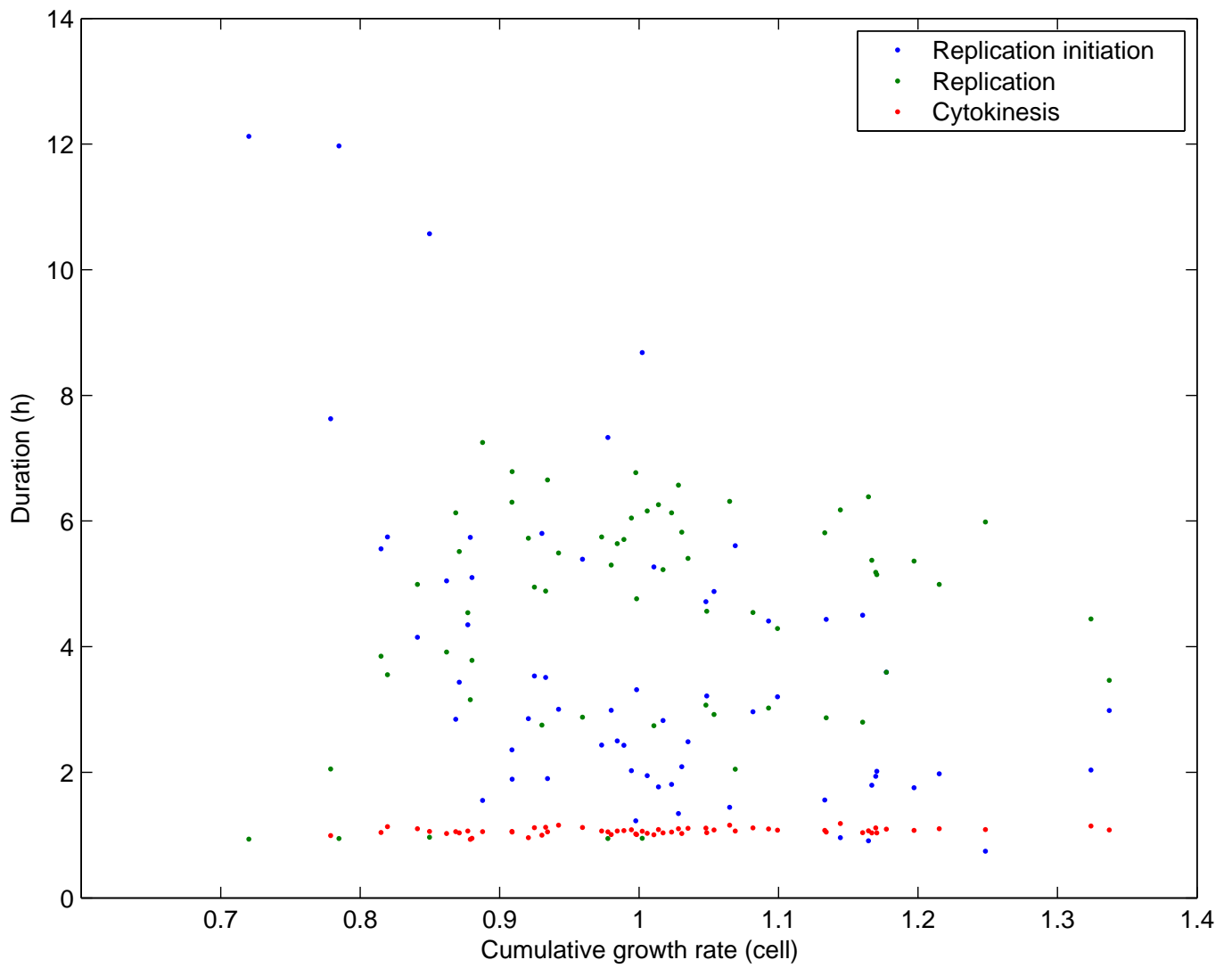


Cell Cycle Phase Distribution

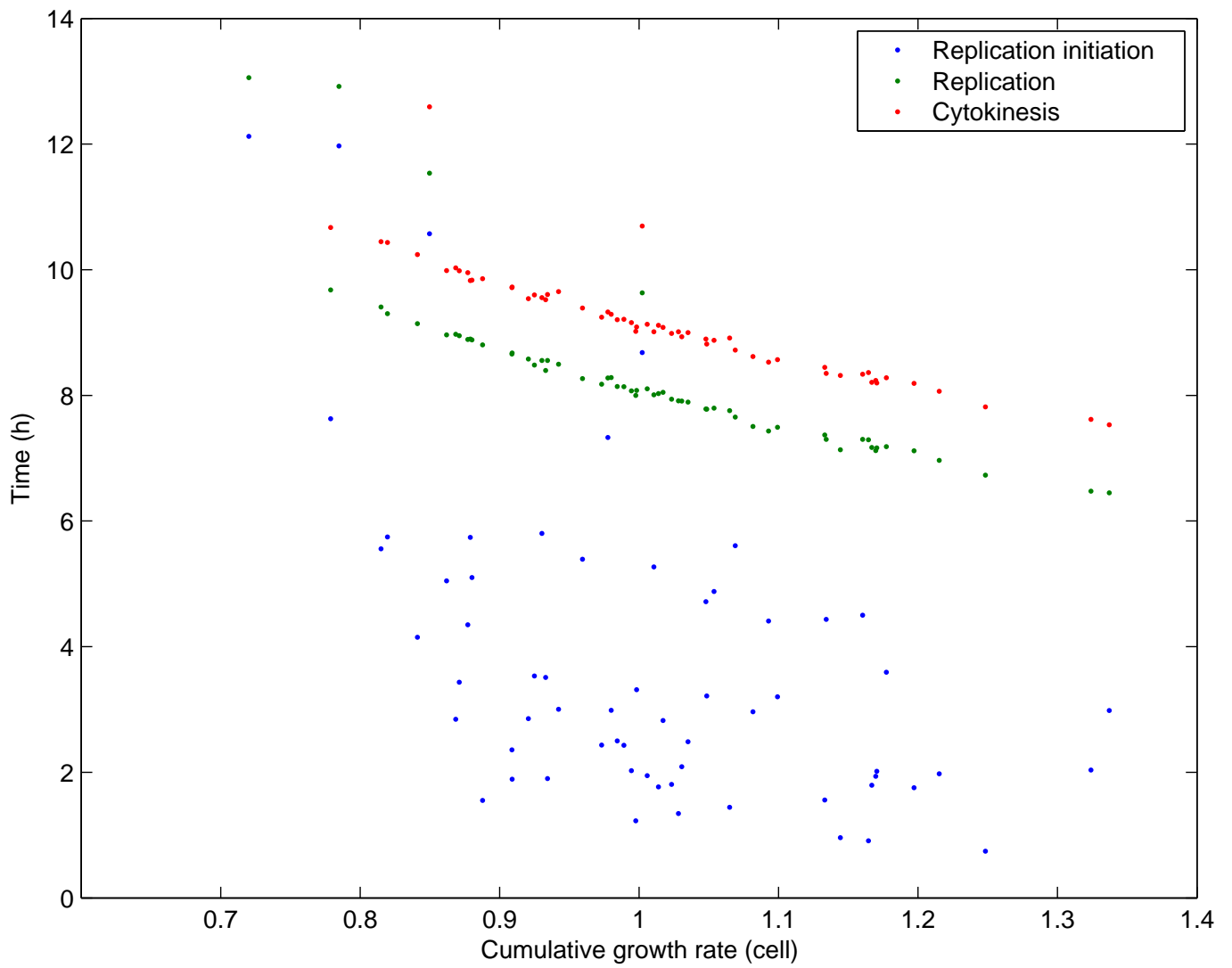




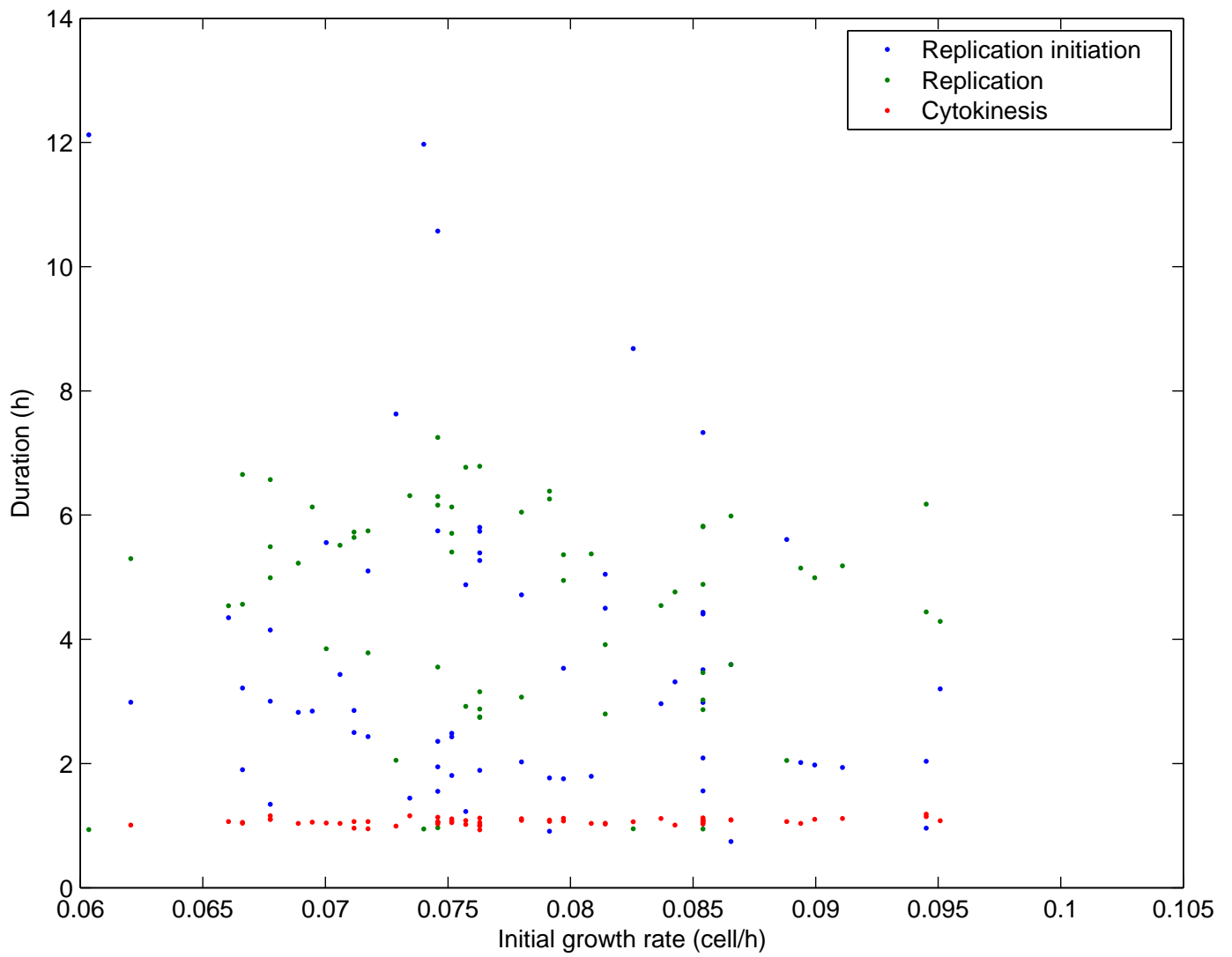
## Cell Cycle Phase Lengths



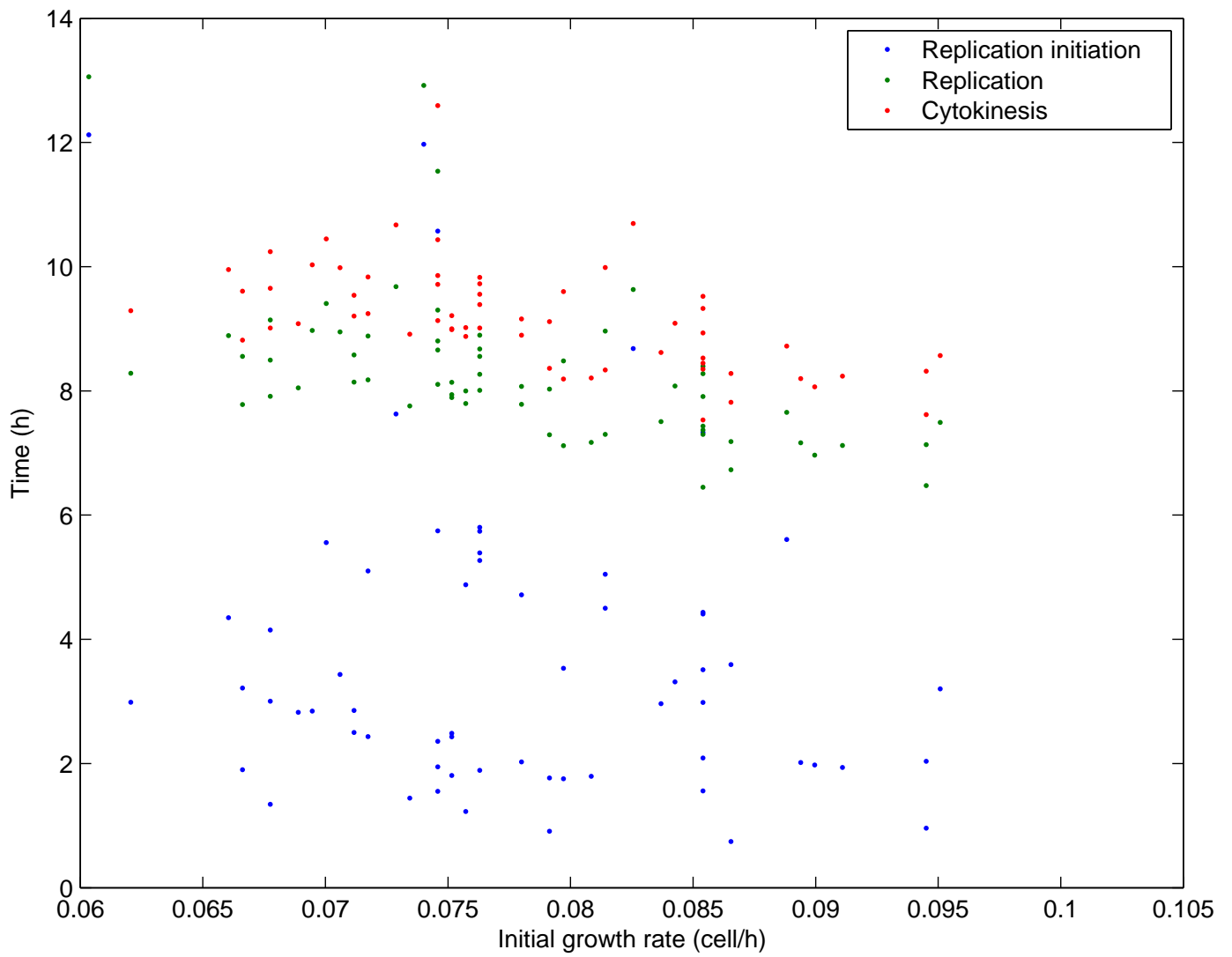
Cumulative Growth Vs. Cell Cycle Phase Durations



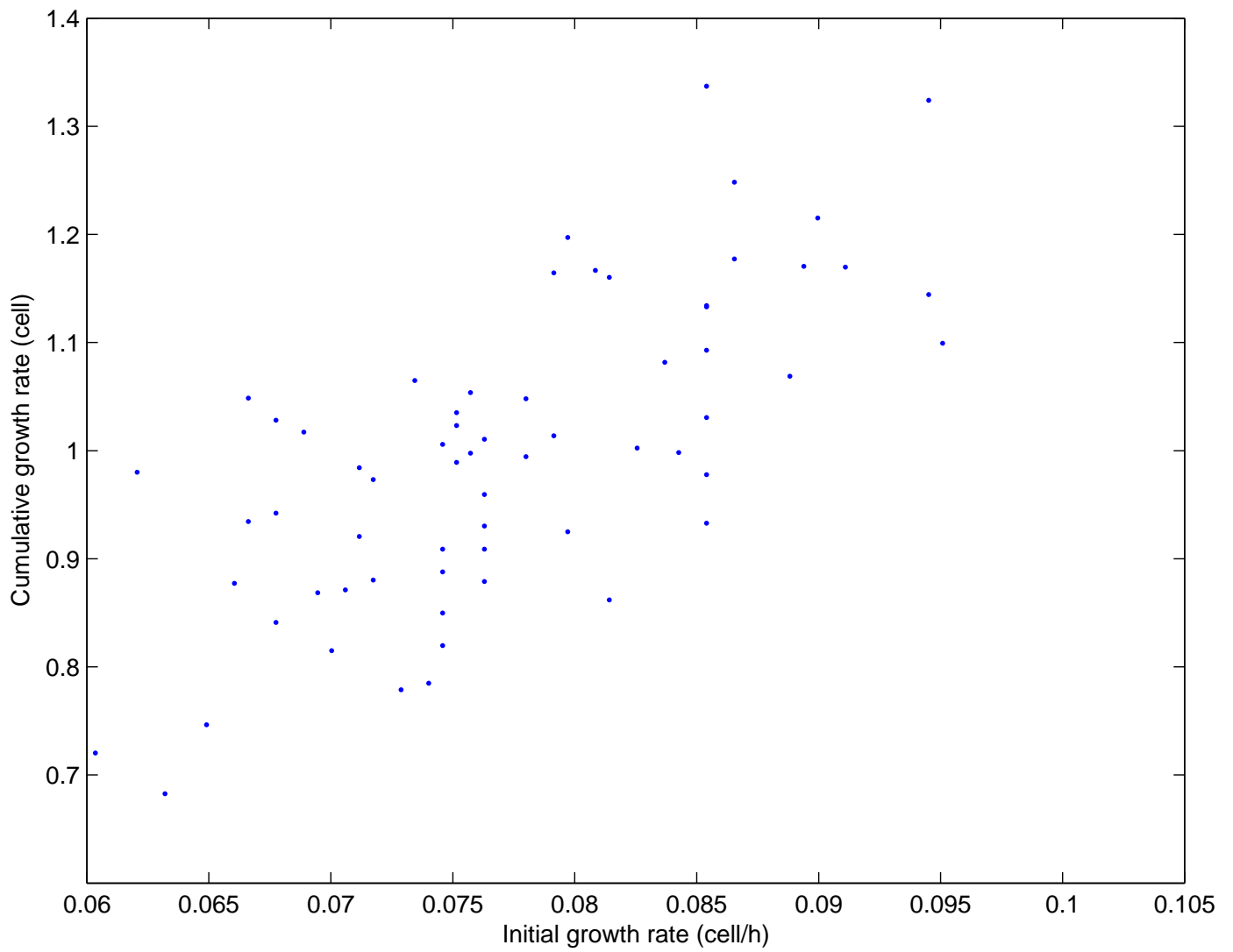
Cumulative Growth Vs. Cell Cycle Phase Times



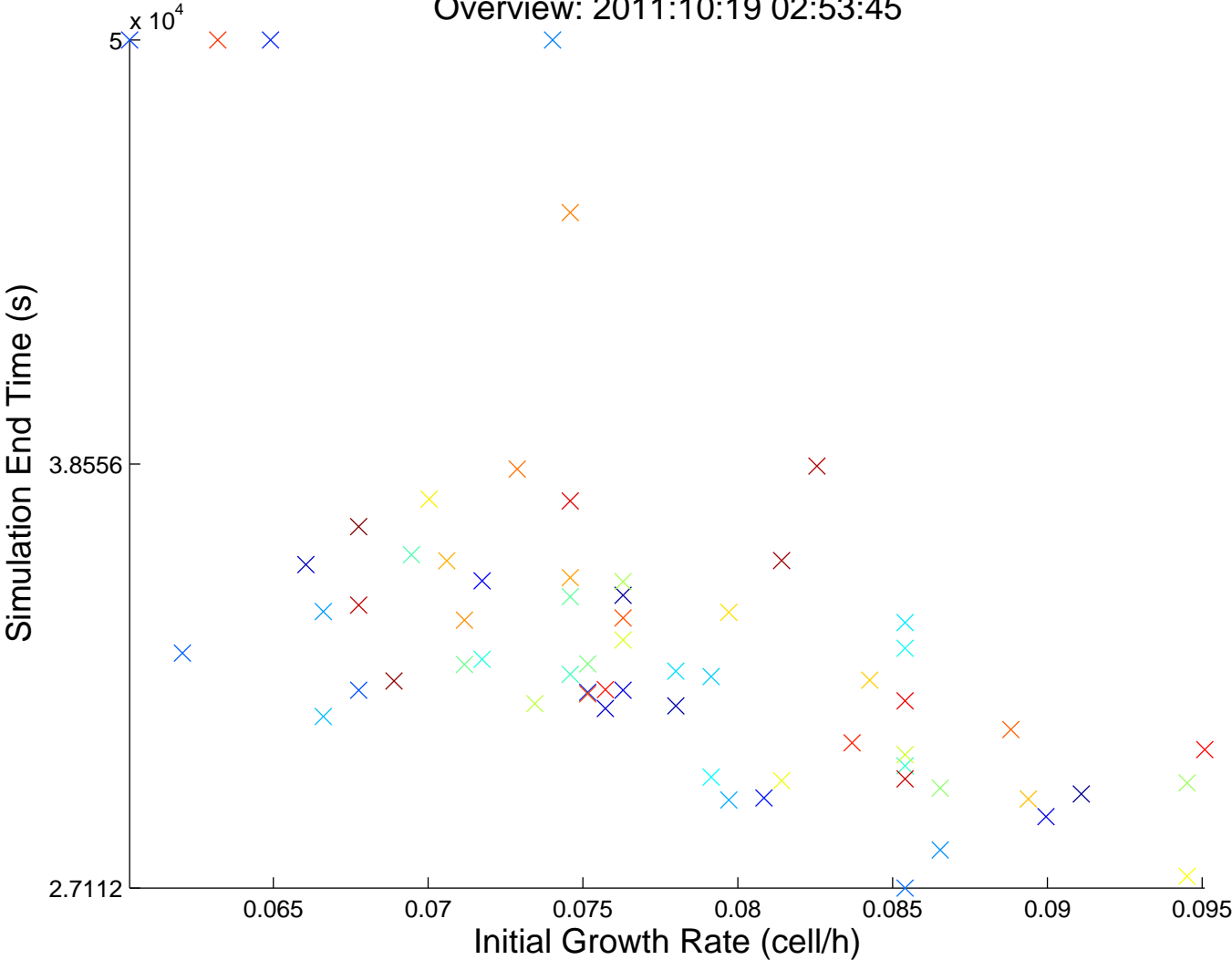
Initial Growth Vs. Cell Cycle Phase Durations



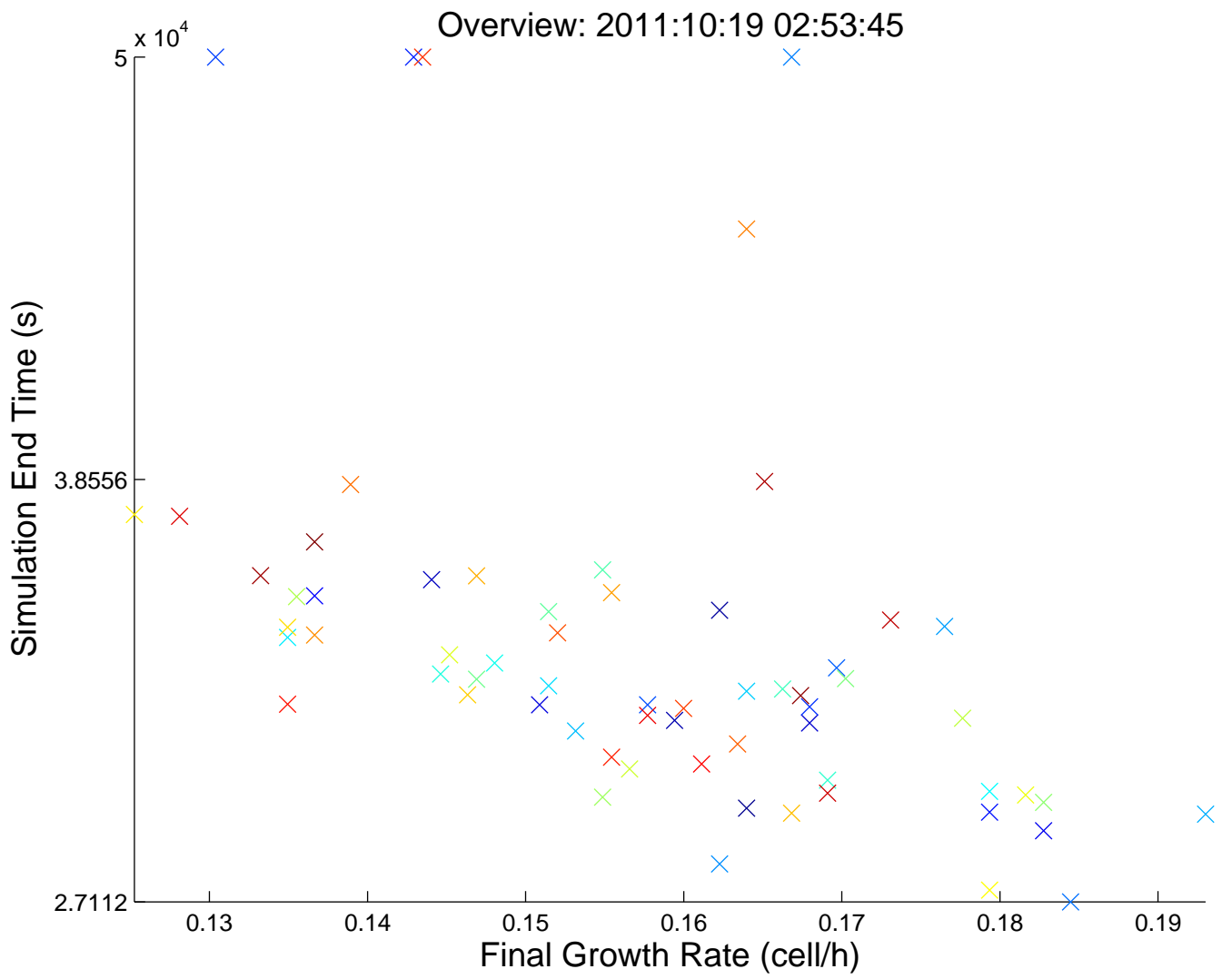
Initial Growth Vs. Cell Cycle Phase Times



Initial Vs. Cumulative Growth

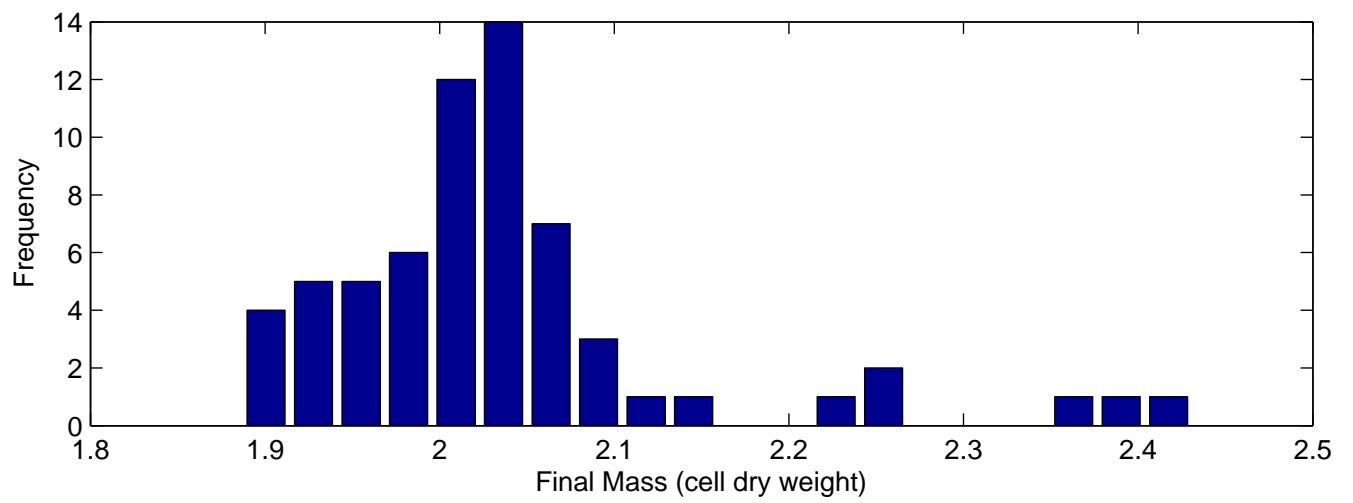
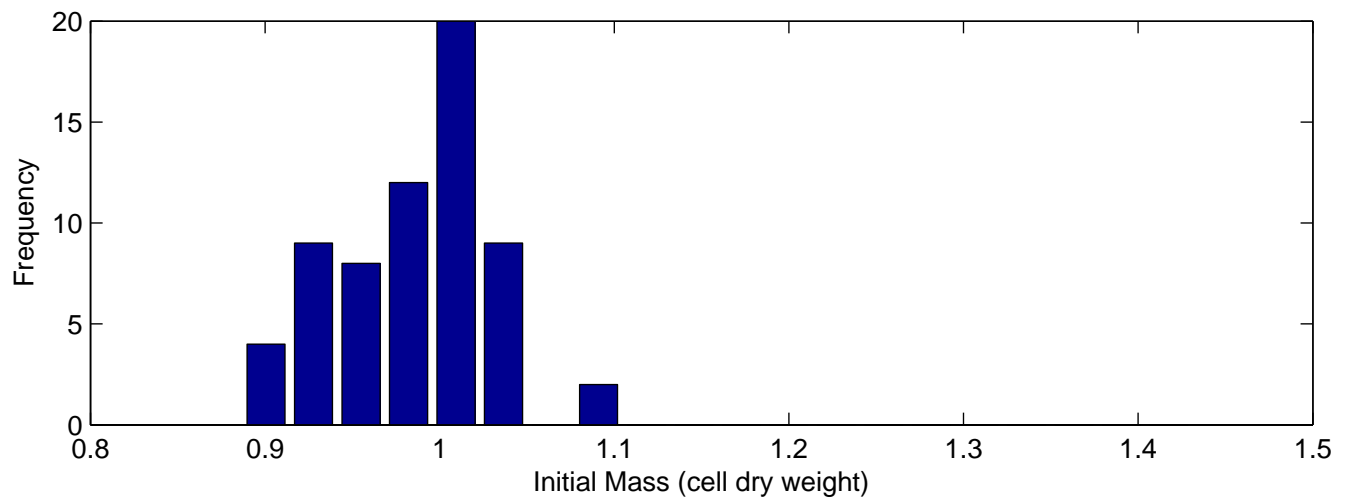


Initial Growth Rate Vs. End Time

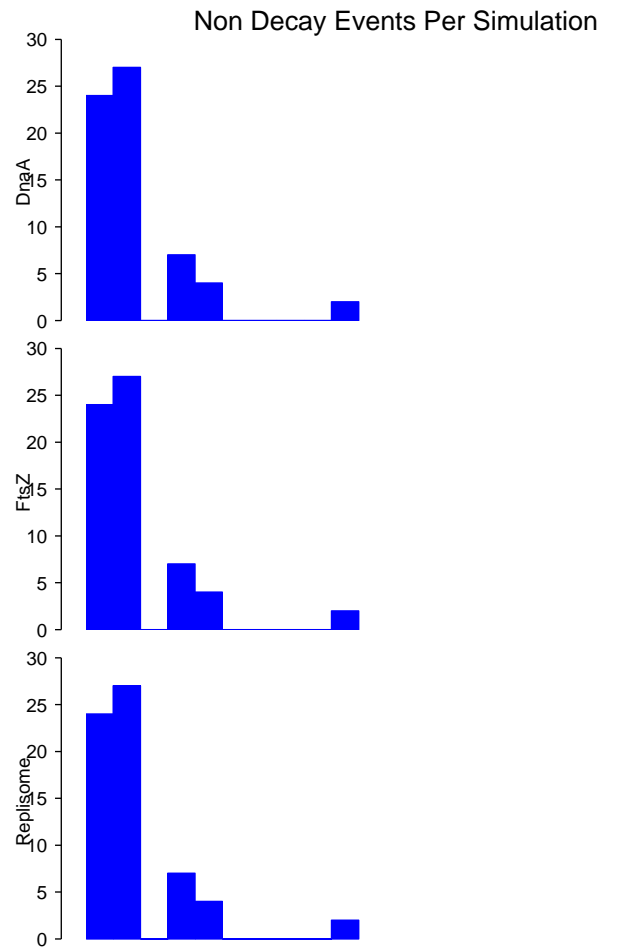
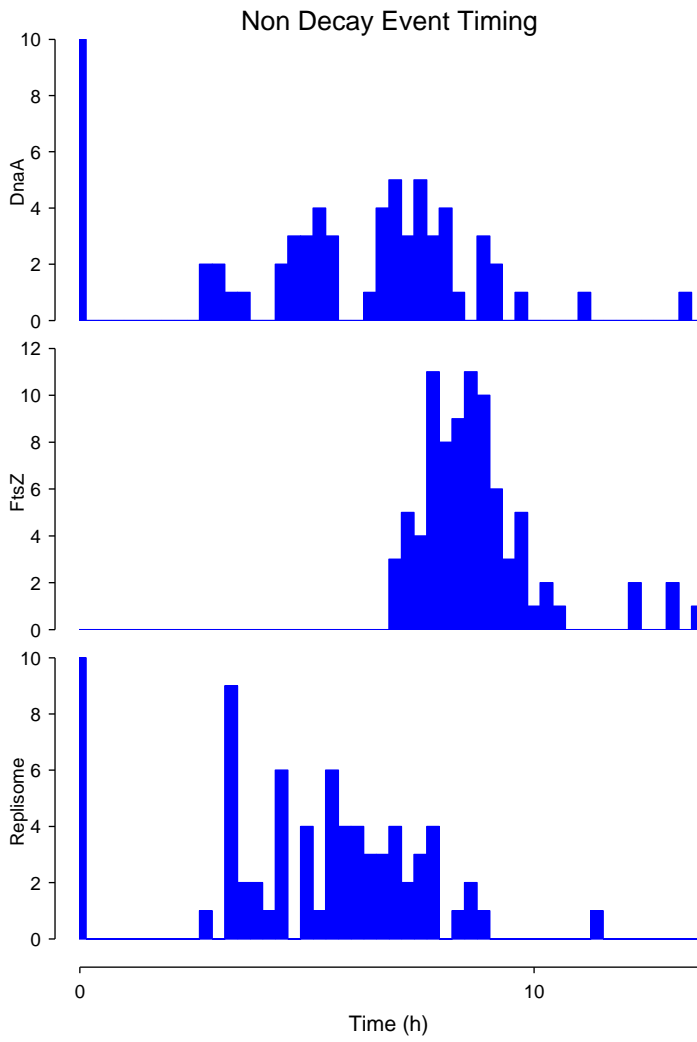


Final Growth Rate Vs. End Time

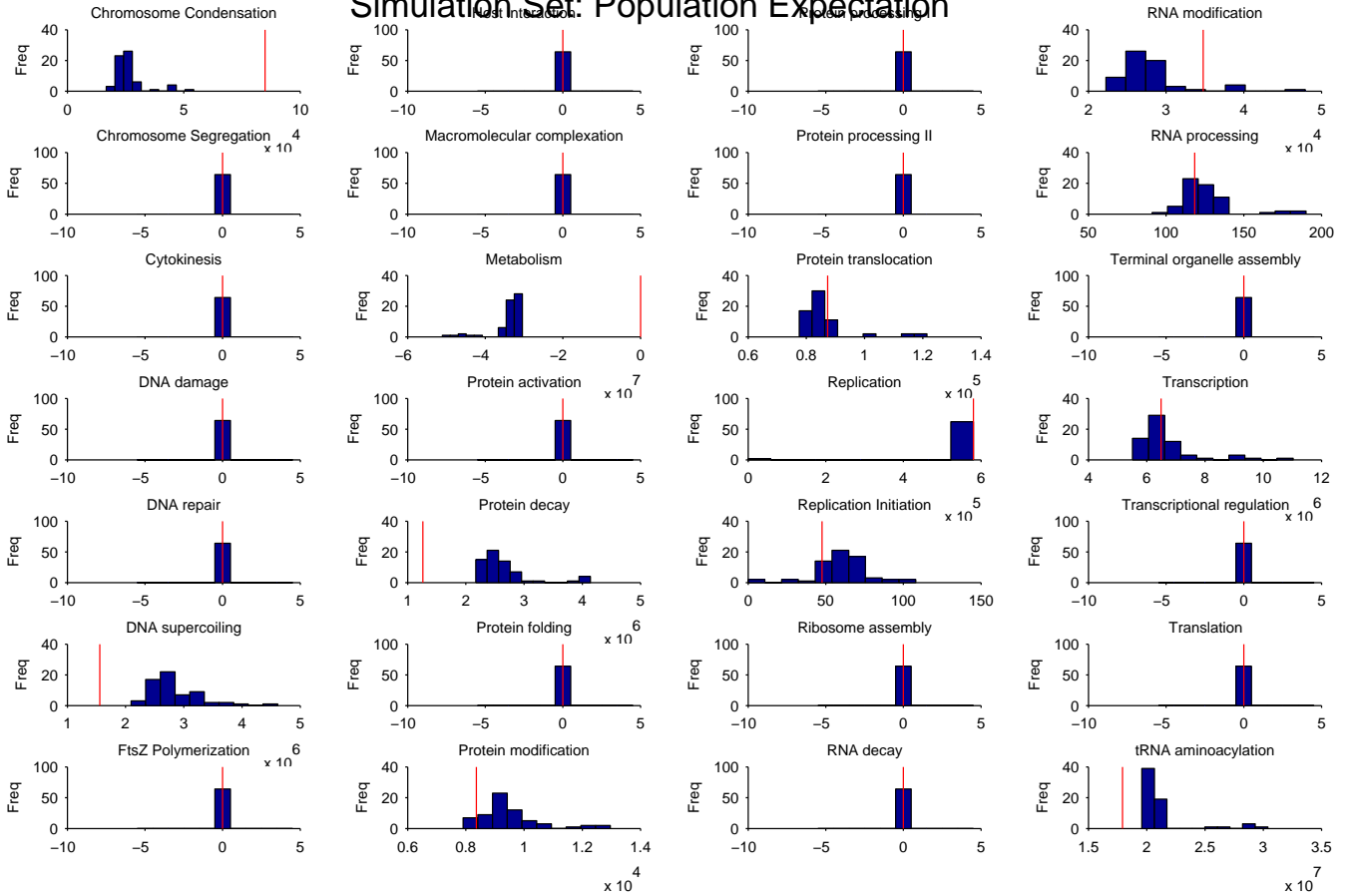




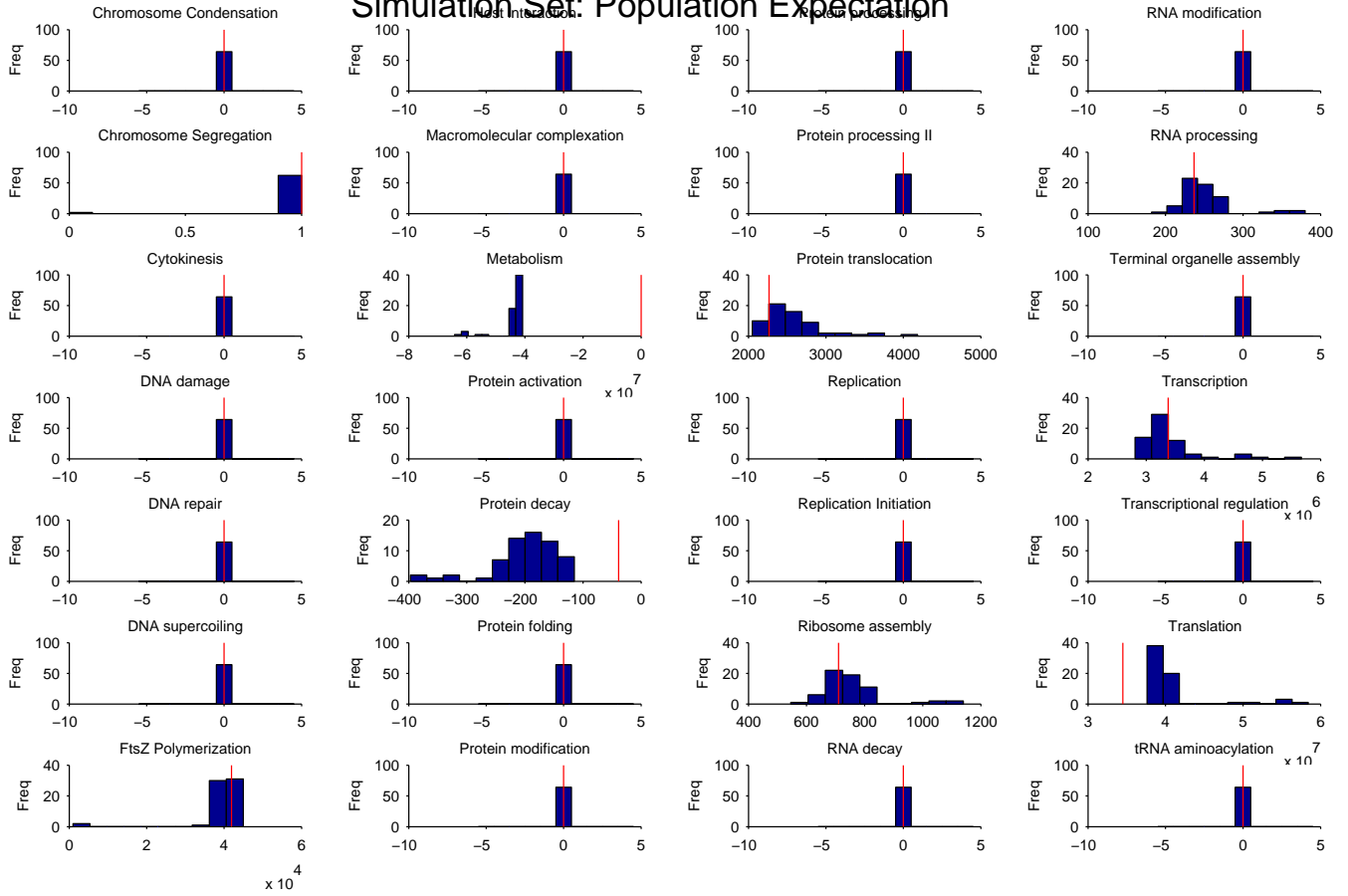
# Cell Mass Distribution

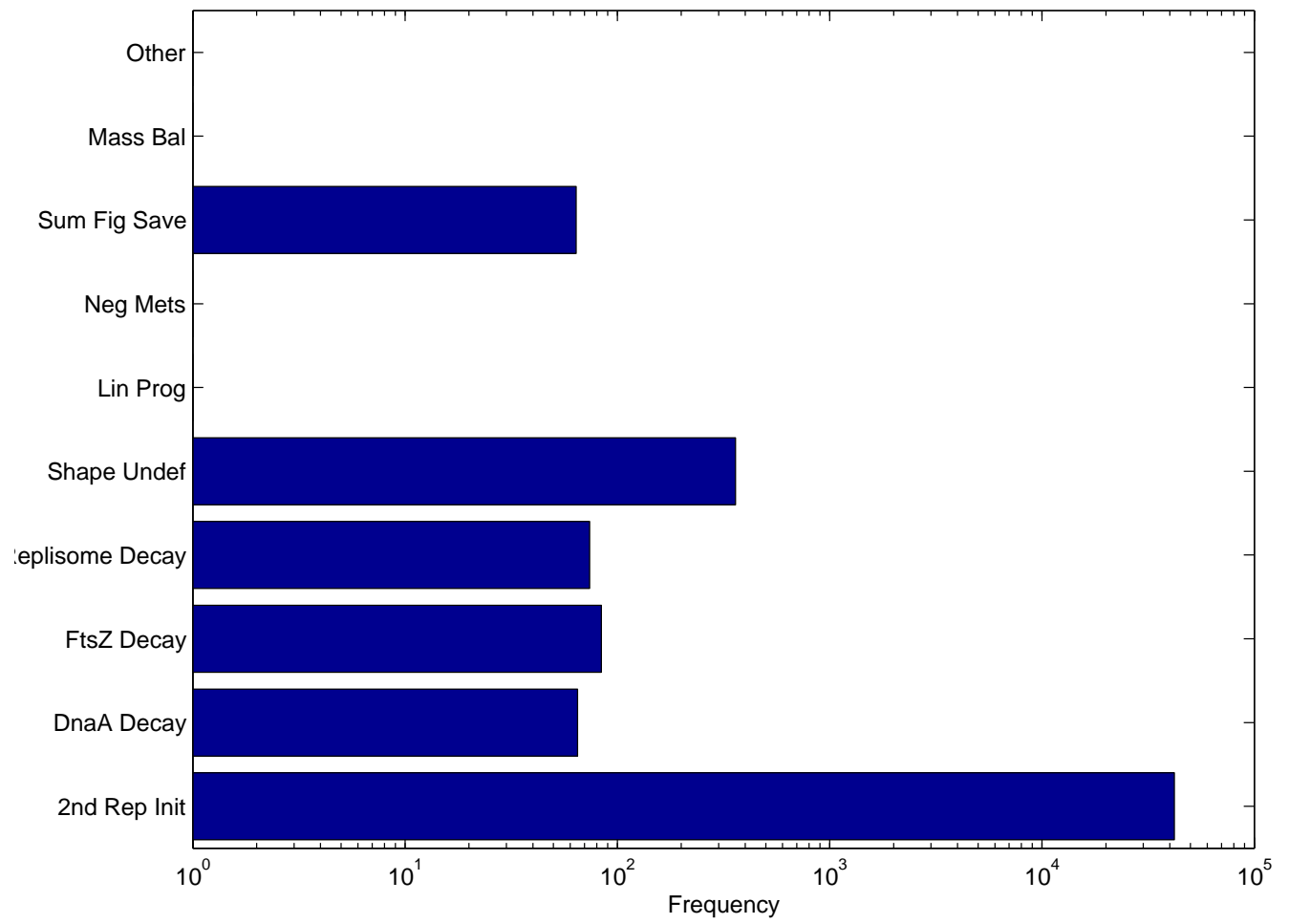


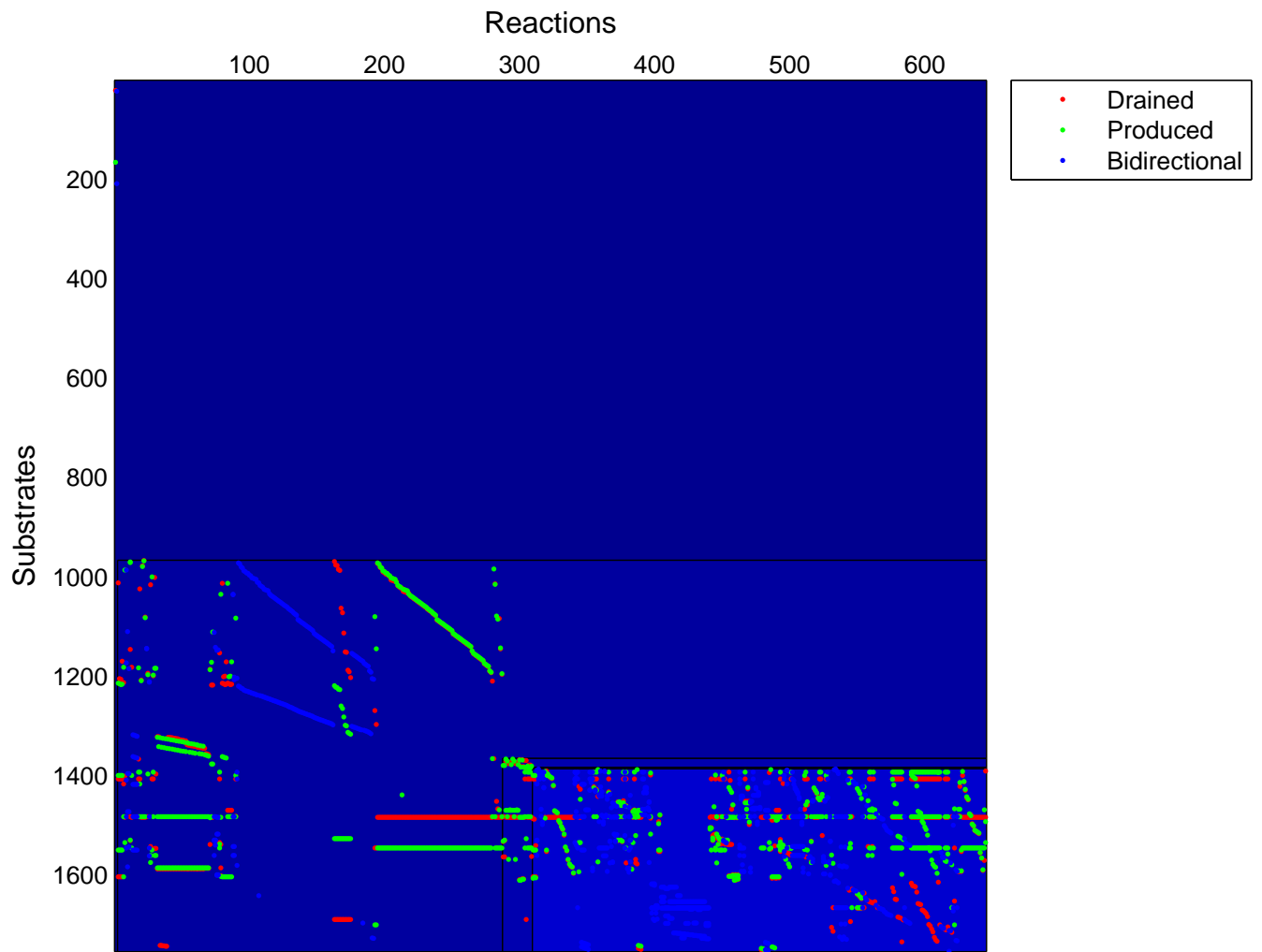
# Usages [ATP] Simulation Set: Population Expectation

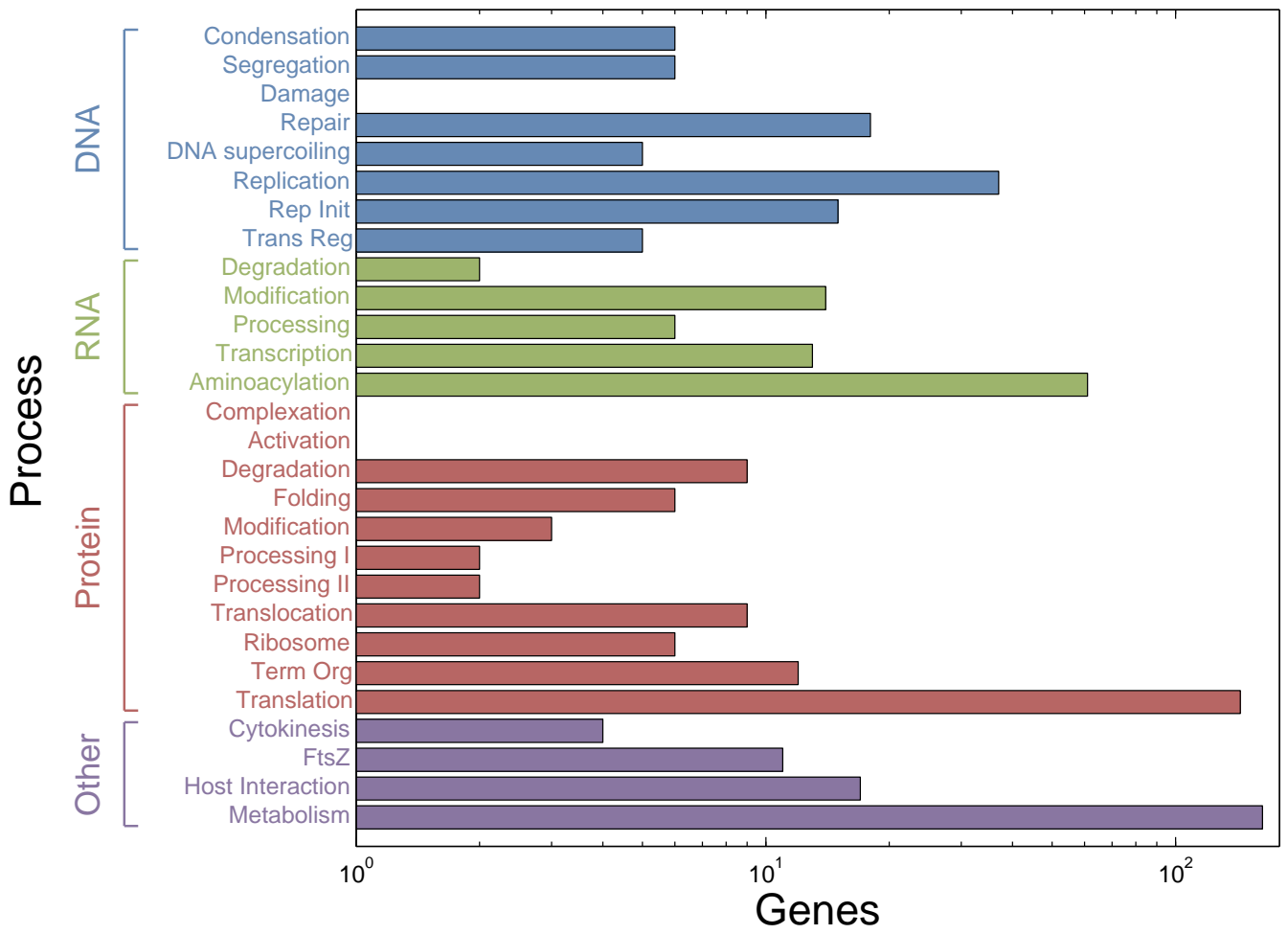


# Usages [GTP] Simulation Set: Population Expectation

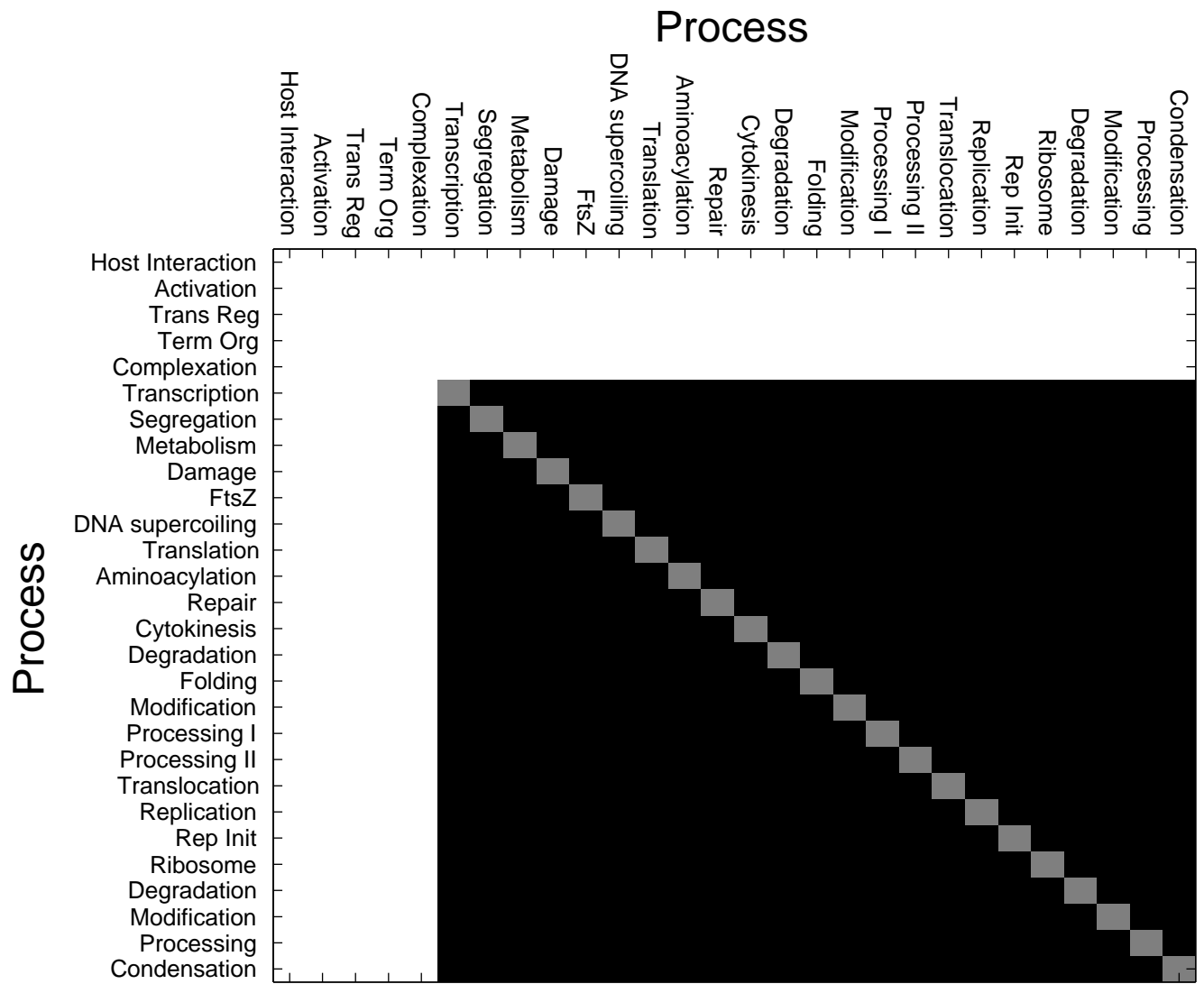






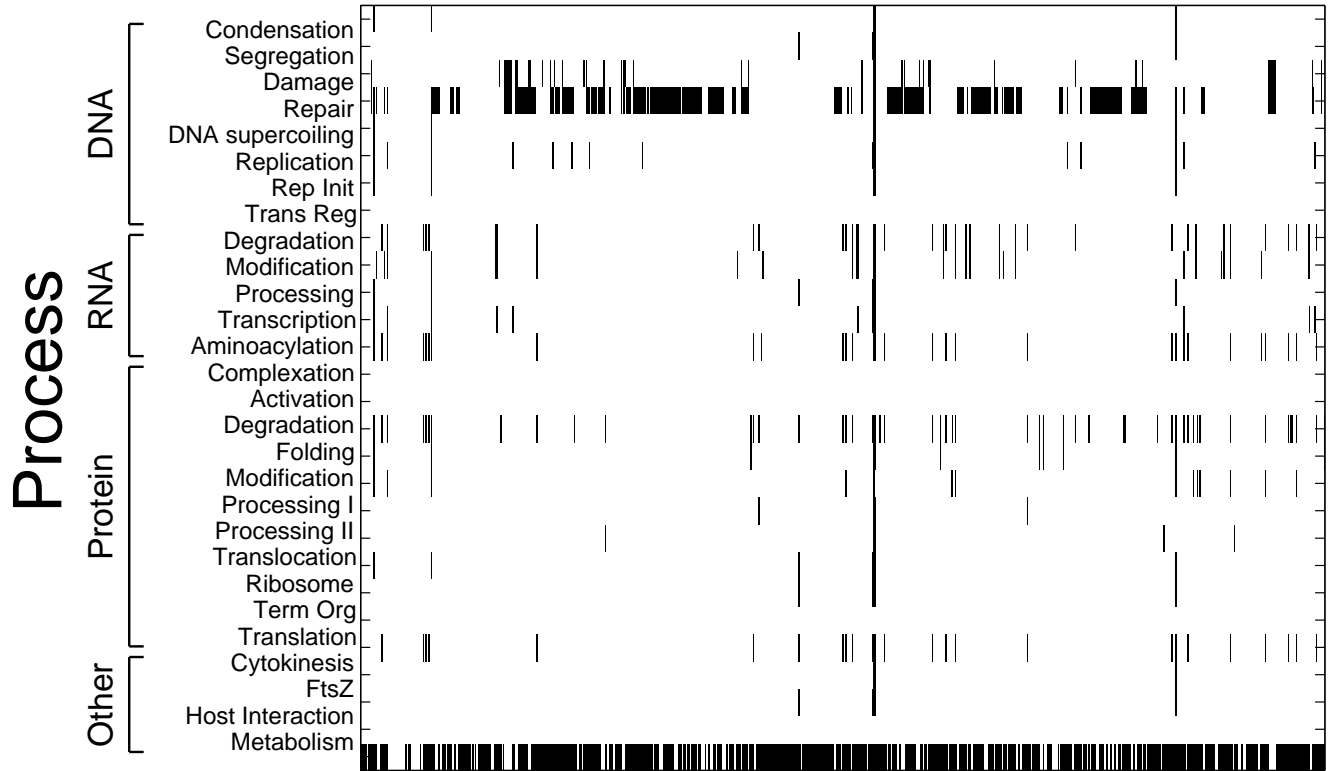


Shared Gene Products

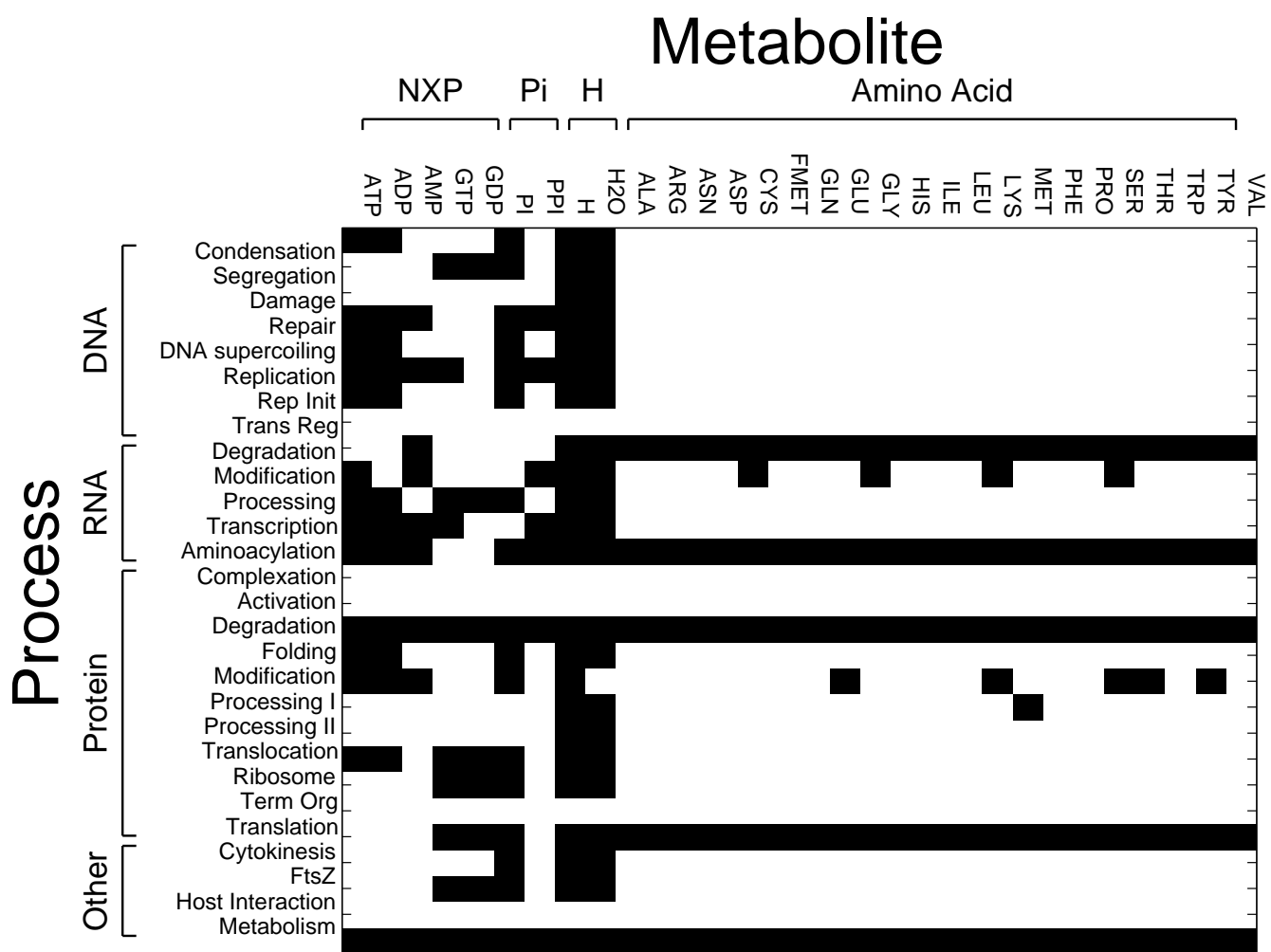




# Metabolite



Shared Metabolites



Shared Metabolites