A Feature-Independent Approach for Analyzing Calcium Activity

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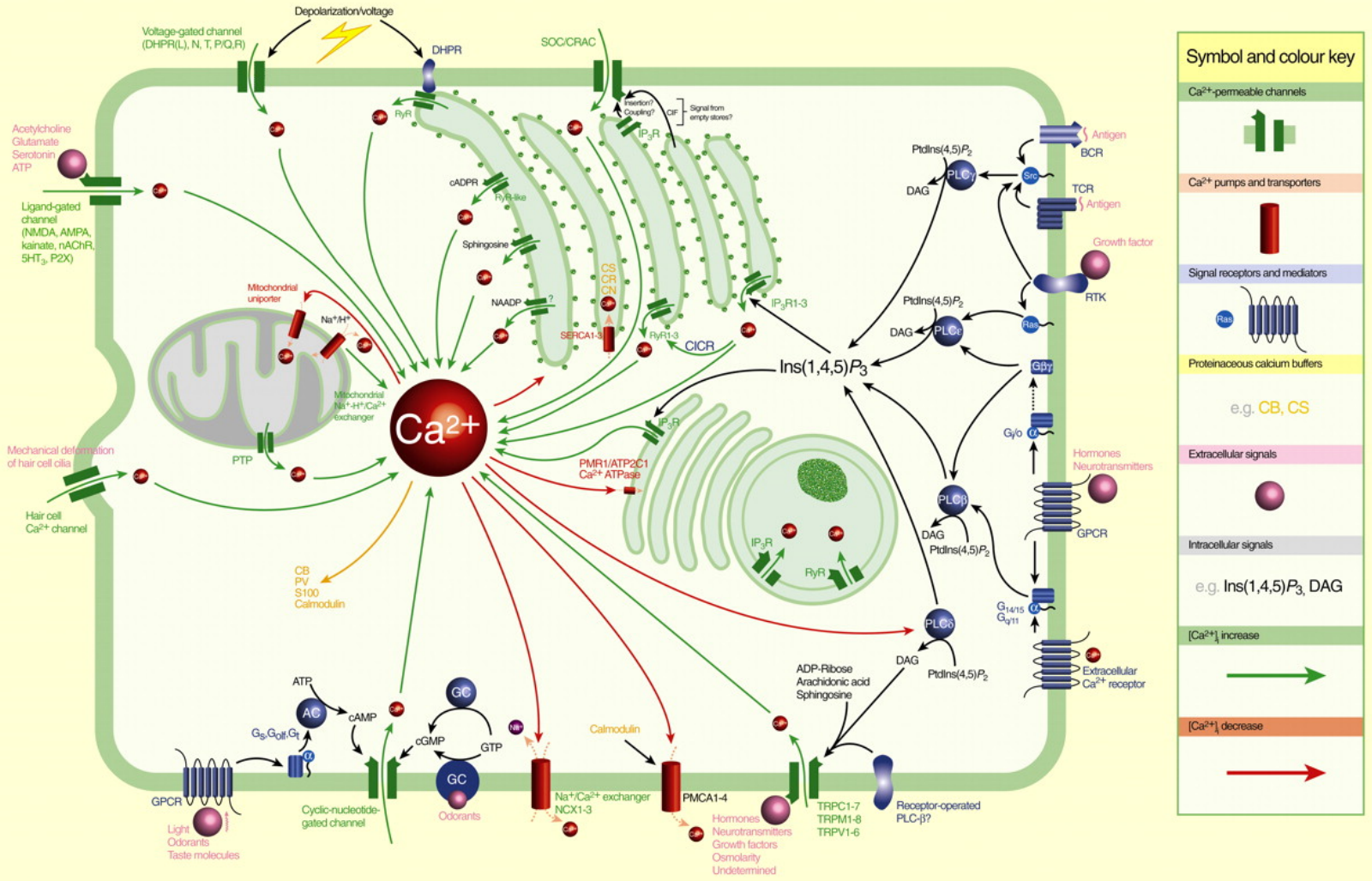
Journal of Cell Science

Intracellular Calcium Signalling

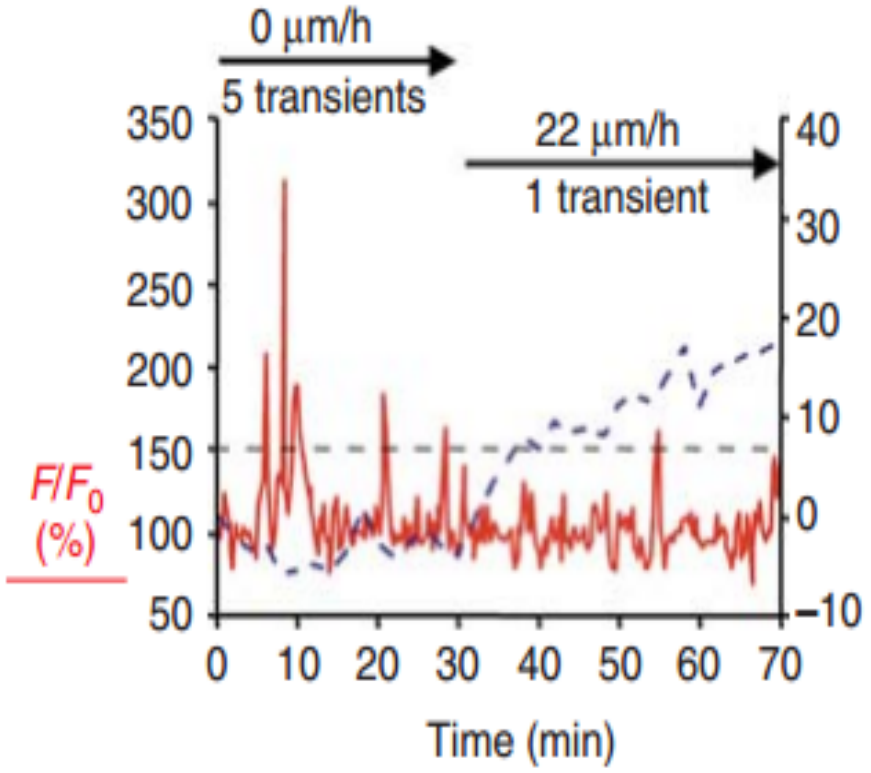
Martha C. Nowycky and Andrew P. Thomas



Types of calcium activity

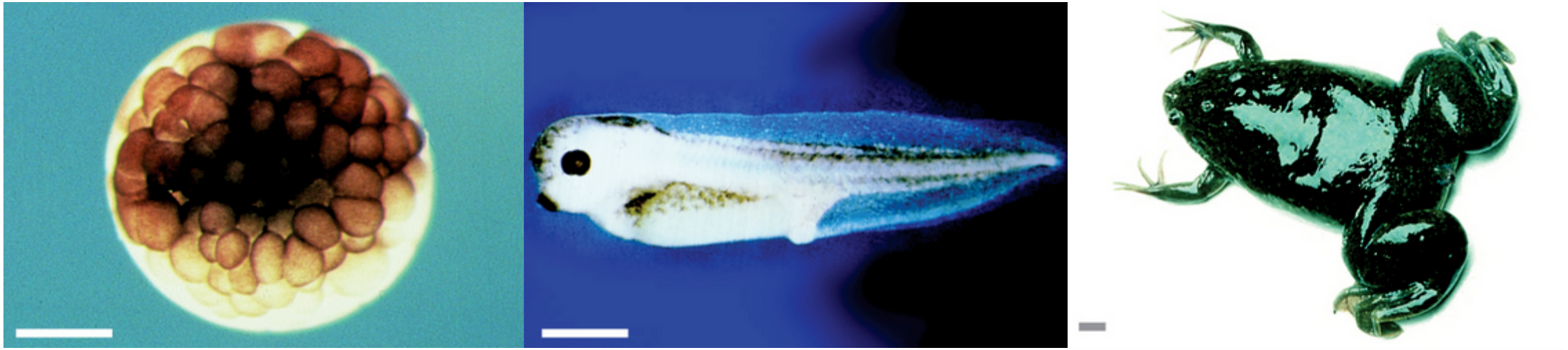
- http://cohenweb.rc.fas.harvard.edu/
- http://safeshare.tv/v/eXu7uXU4Bu8
- http://safeshare.tv/v/BH06WgFua_4

Feature-Dependent Calcium Analysis



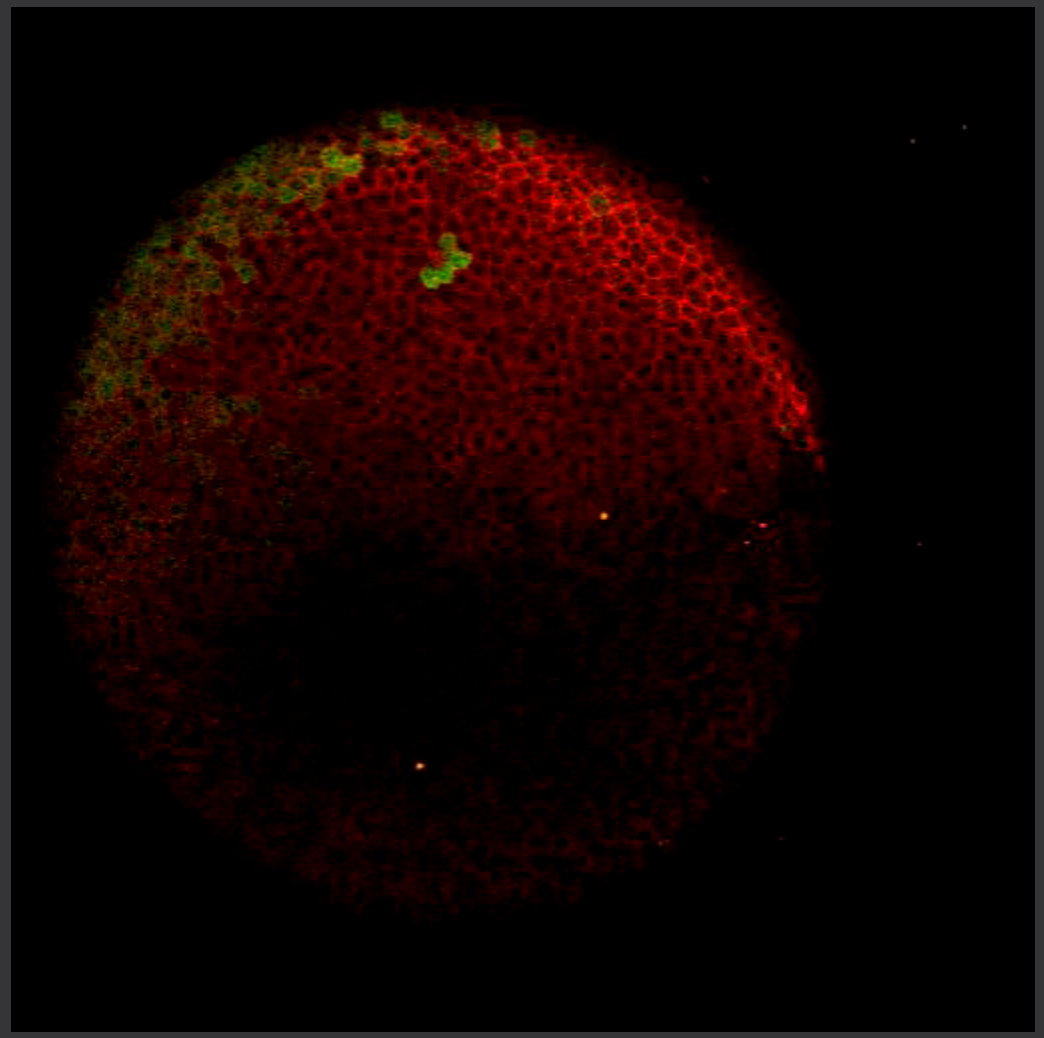
Spitzer et al., 2011

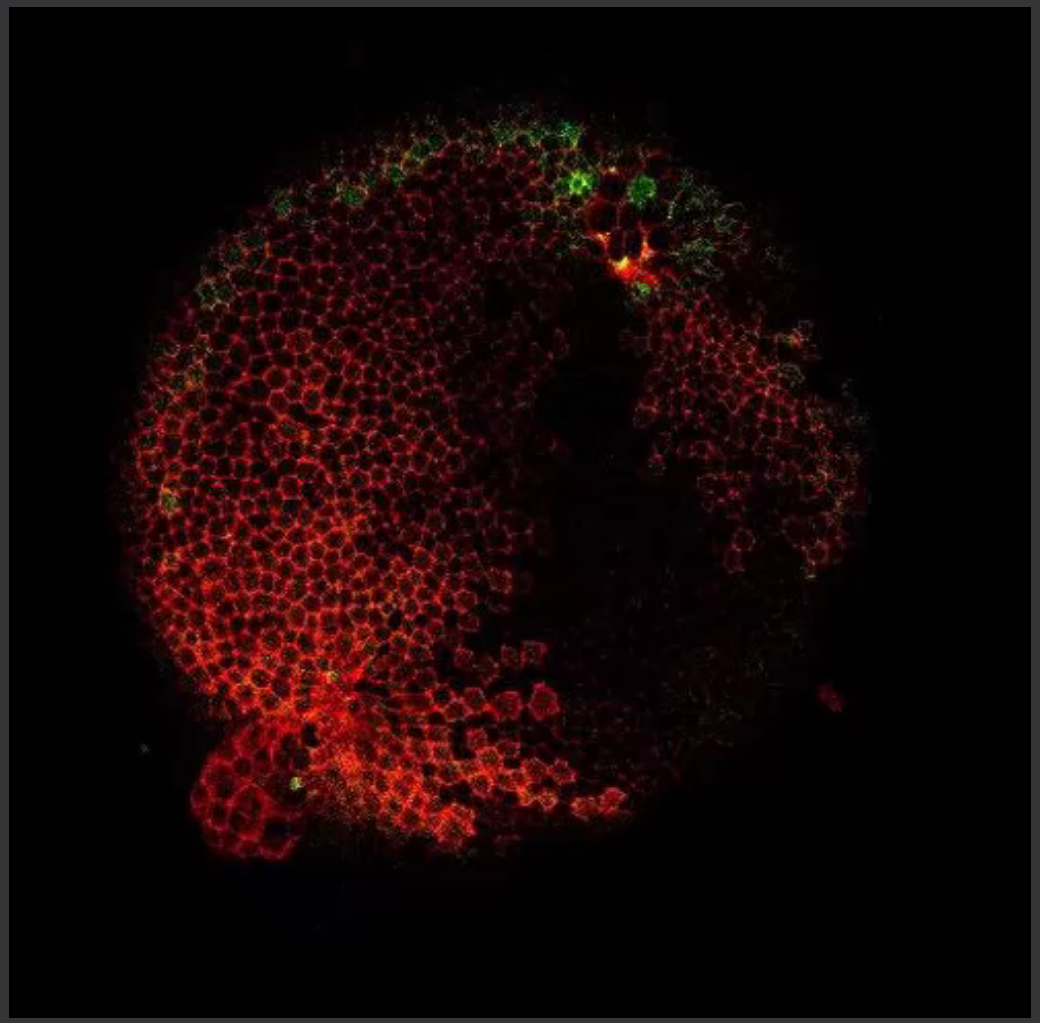
Model



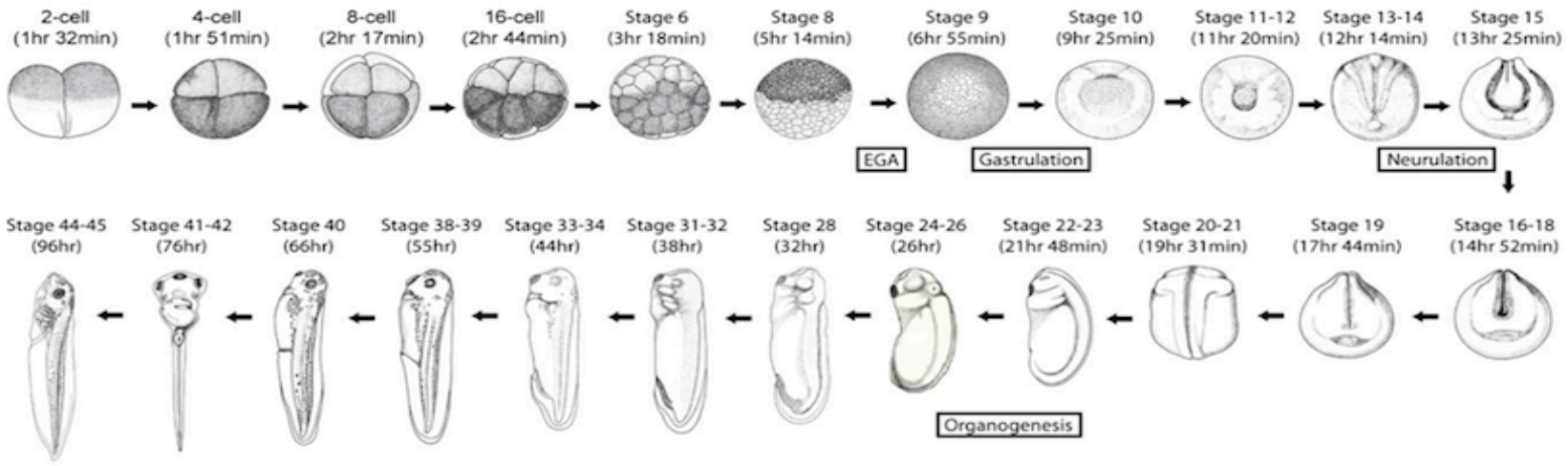
Xenopus laevis

http://www.mun.ca/biology/desmid/brian/BIOL3530/DEVO_03/ch03f03.jpg



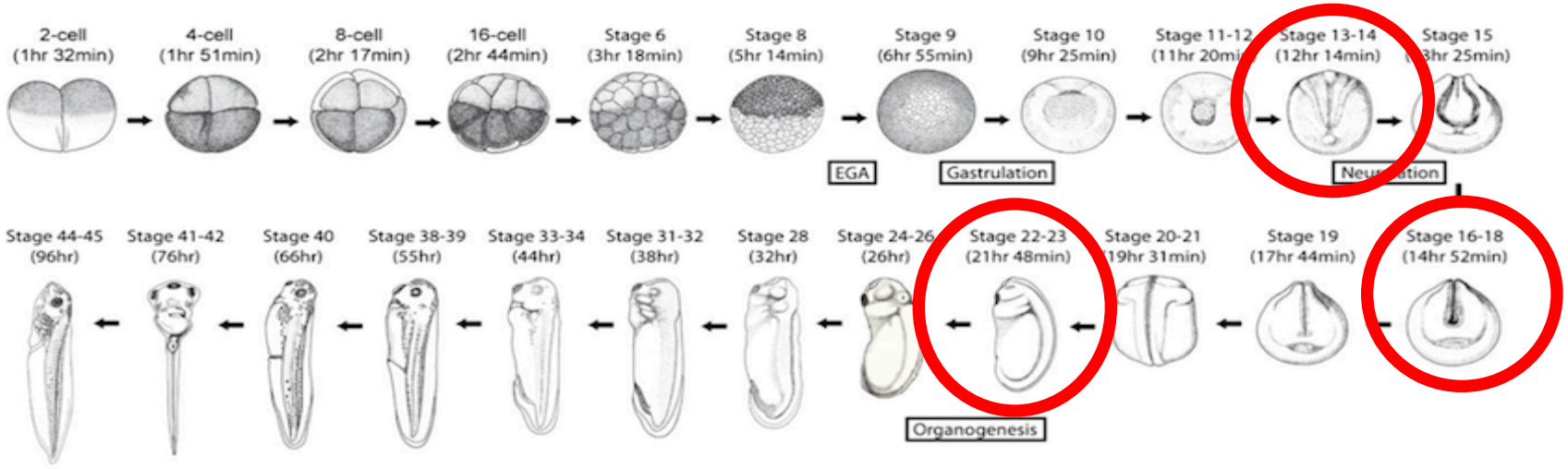


Model



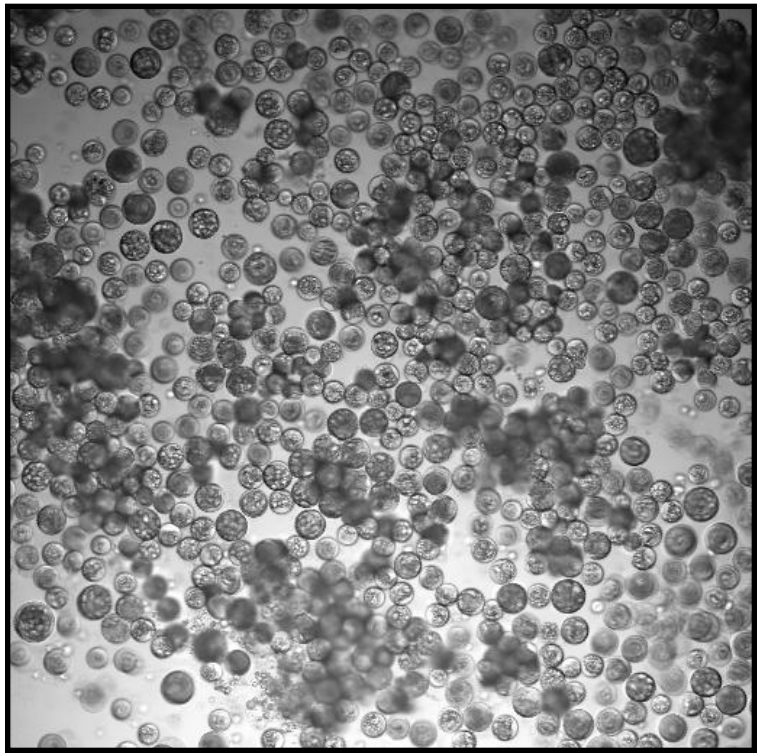
Xenbase.org

Model

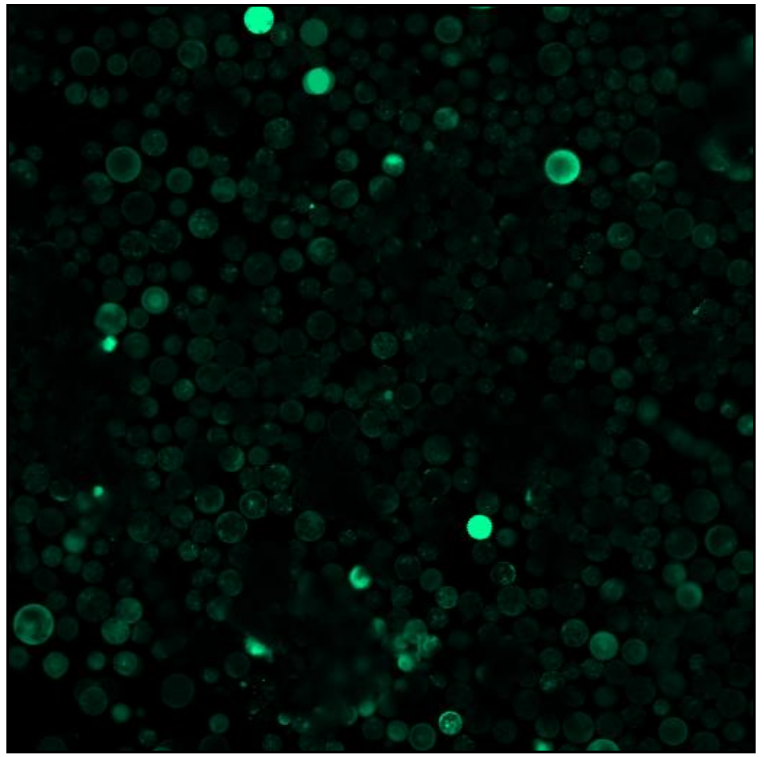


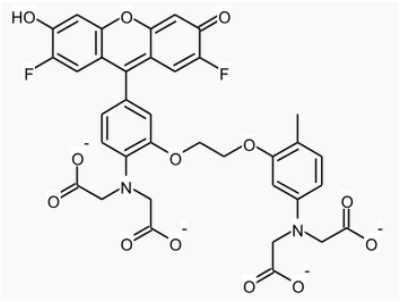
Xenbase.org

Model



Bright Field

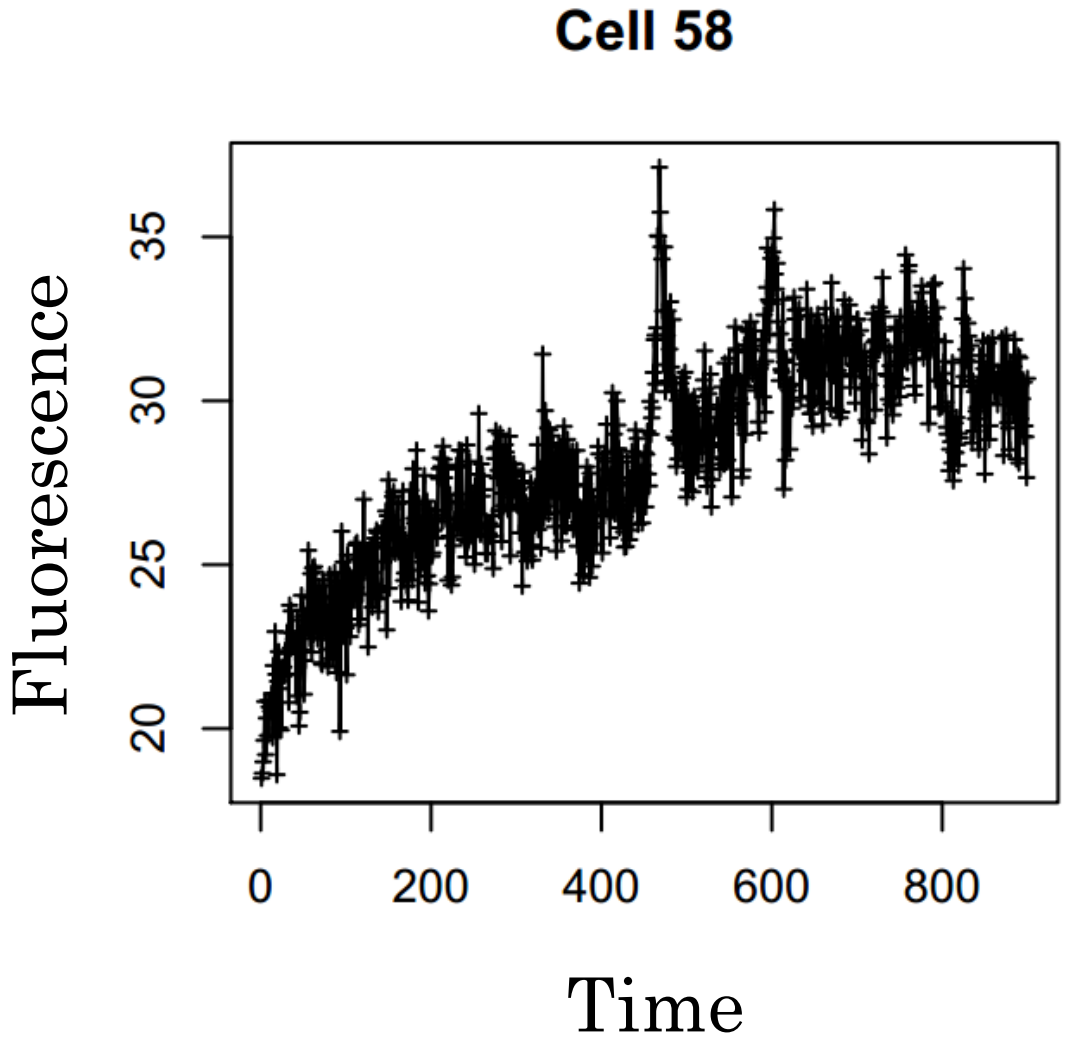




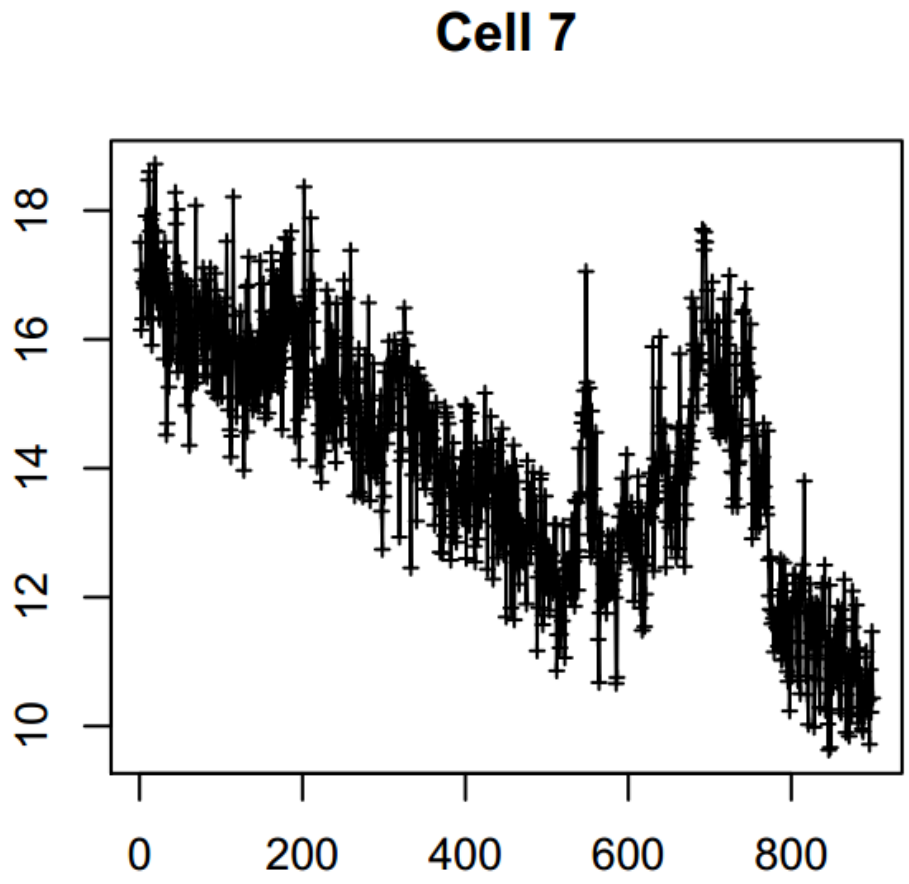
Wikipedia

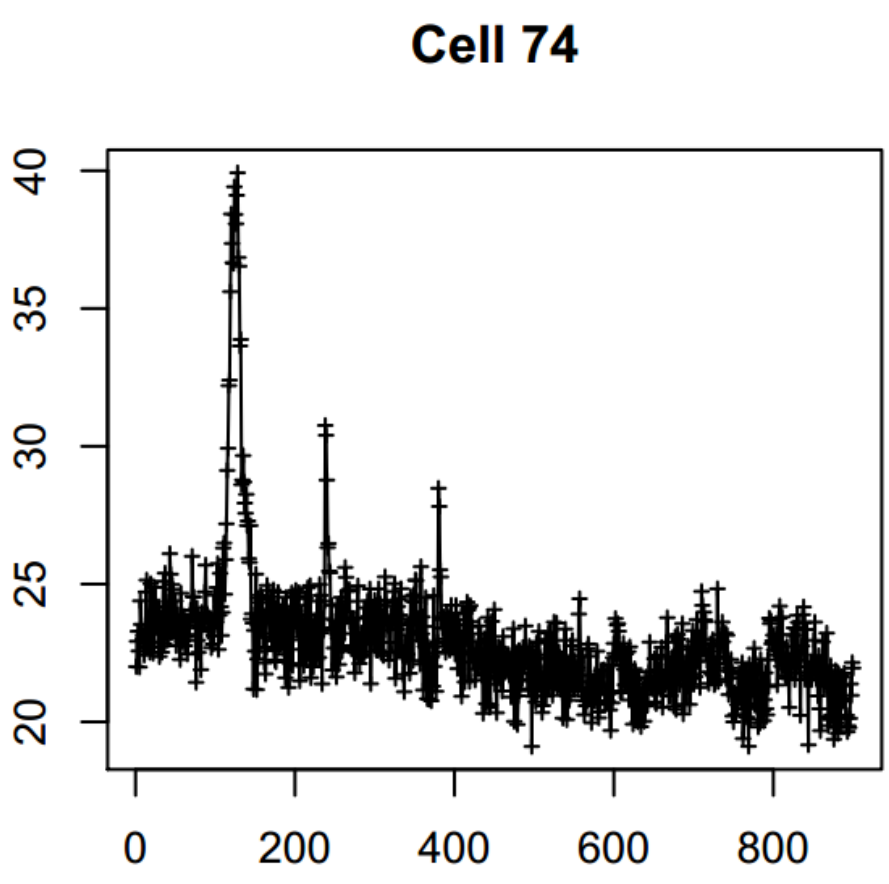
Fluo-4

Microscopy Images from Brittany Lewis Honors Colloqium Talk 20110303

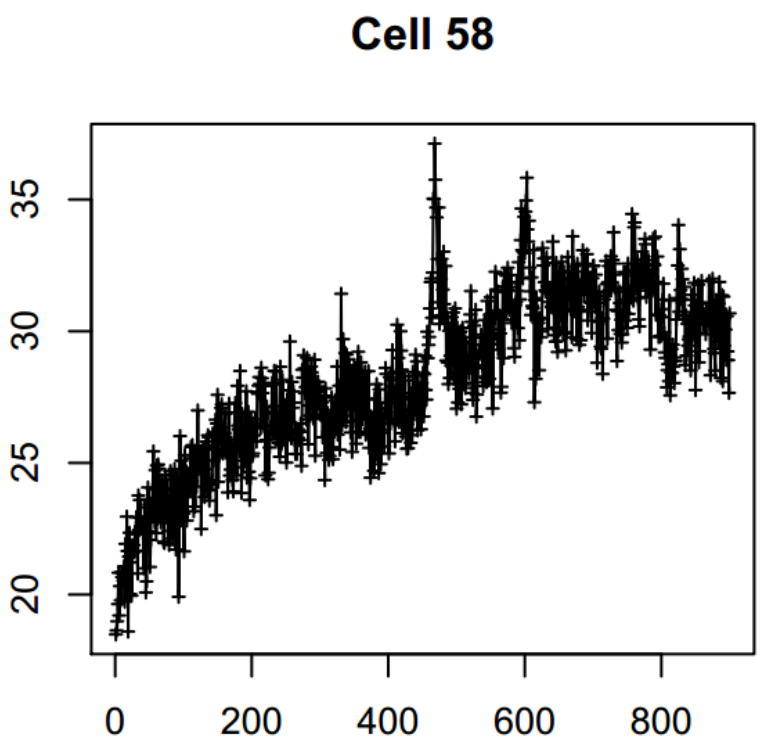

Cell 58
Fluorescence
20
25
30
35
0
200
400
600
800
Time

Feature Shape

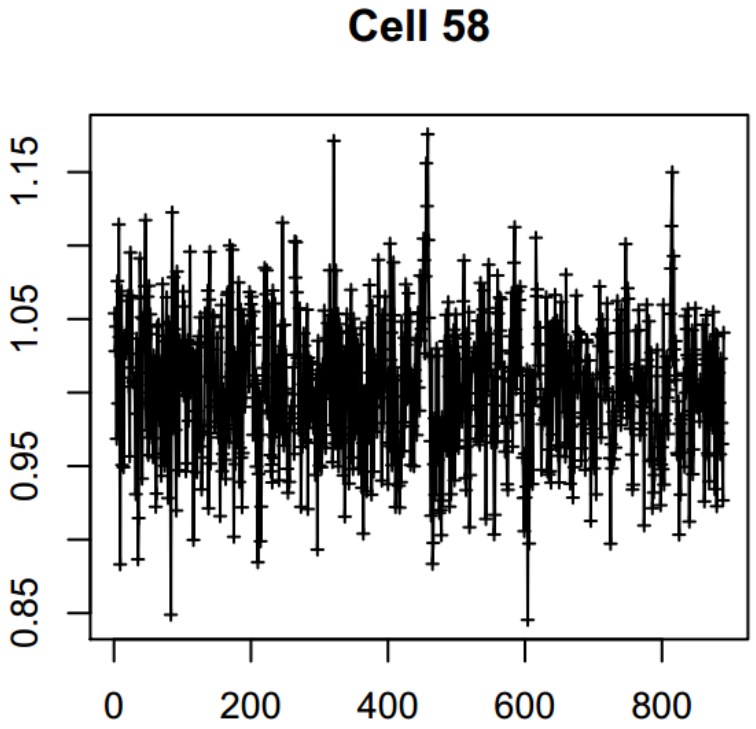




Trend Removal

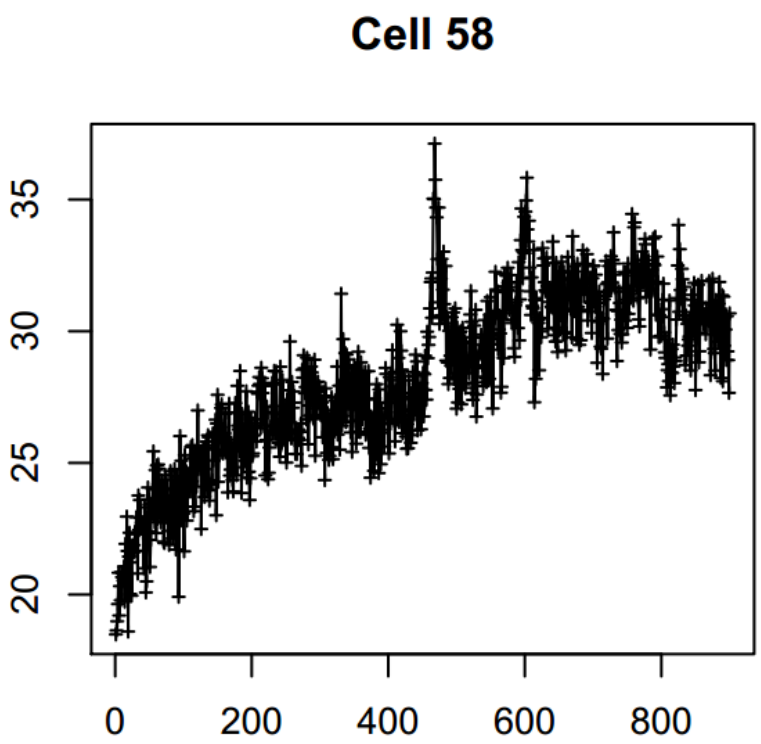


Raw Data



Moving Average

Trend Removal



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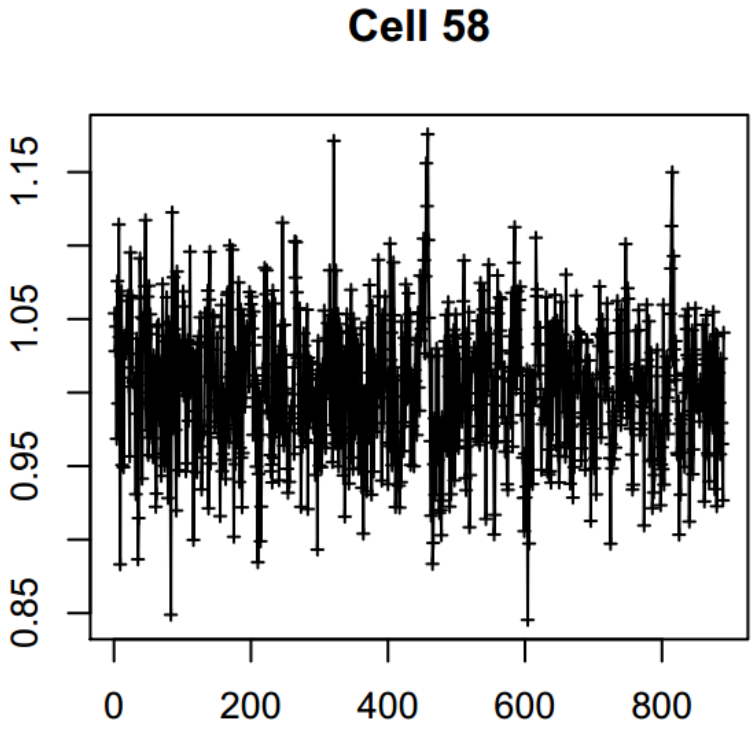
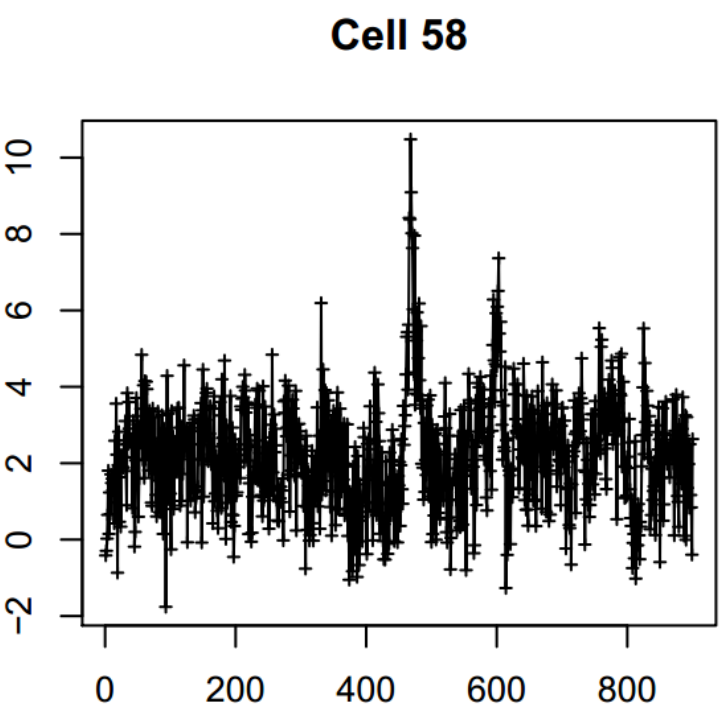
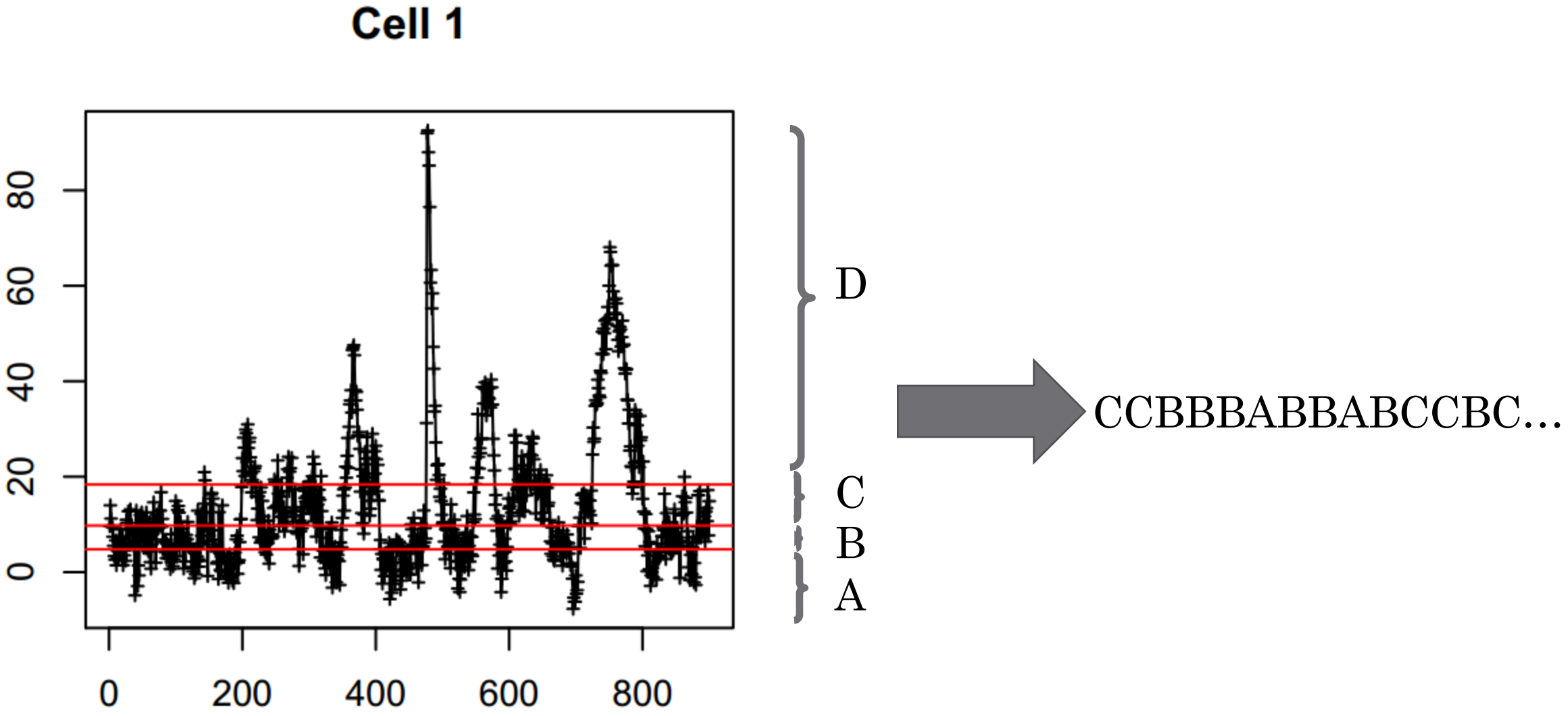


Moving Average



Baseline Correction

Discretization by Quantiles



Transition Matrix

CCBBBABBABCCBC…

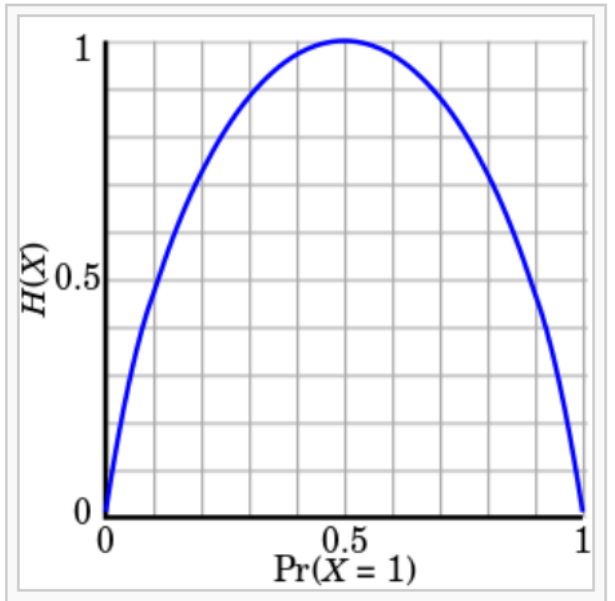
	A	B	C	D
A	.3	.2	.5	0
B	.7	.2	.05	.05
C	.2	.4	.6	.4
D	.05	.25	.4	.3

Information Entropy

	A	B	C	D
A	.3	.2	.5	0
B	.7	.2	.05	.05
C	.2	.4	.6	.4
D	.05	.25	.4	.3

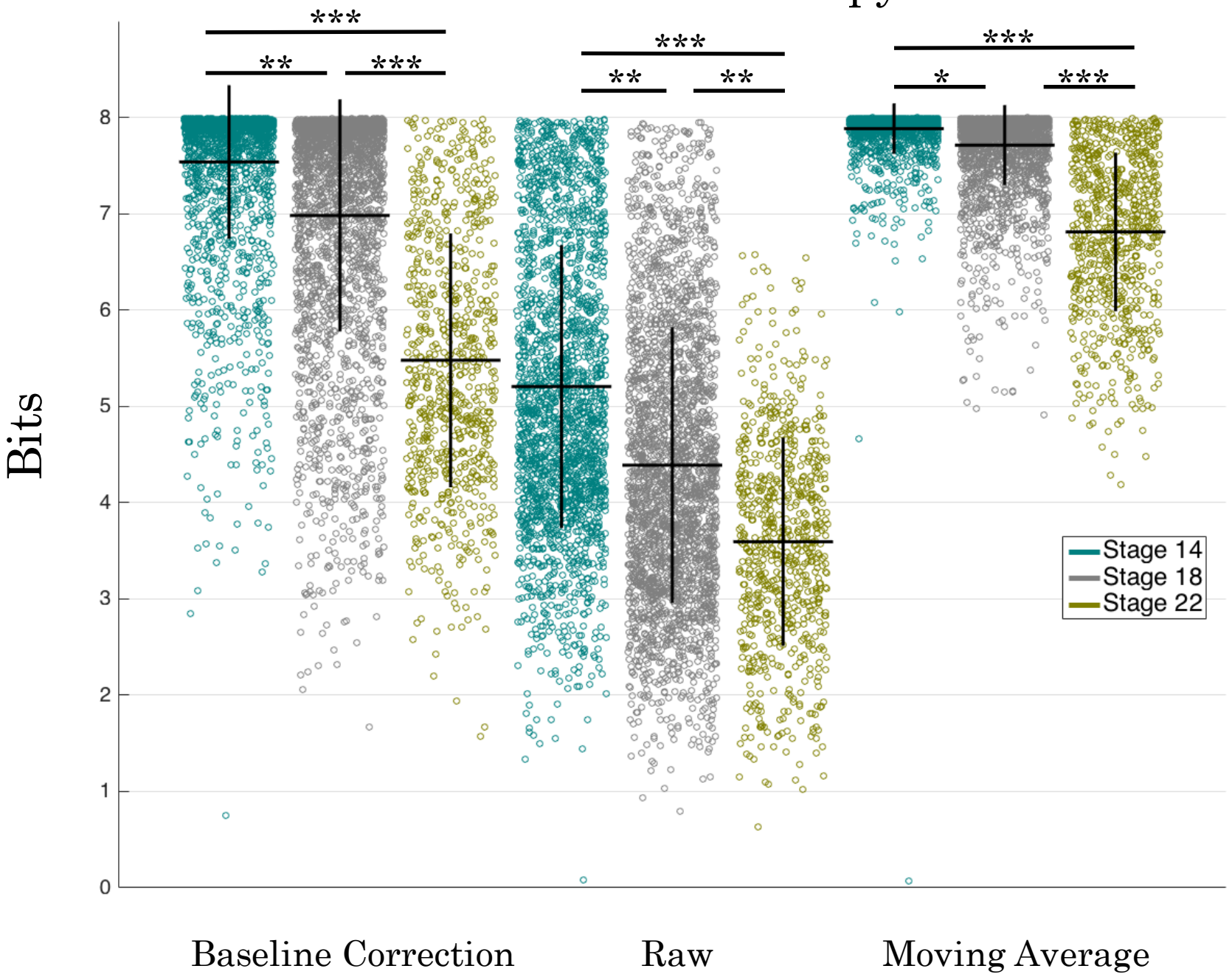
$$H(M) = \sum_{r=1}^{n} H(R) = \sum_{r=1}^{n}\sum_{c=1}^{n} m_{r,c} \log_2 m_{r,c}$$

$$H(X) = \sum_{i} p_i \log_2 p_i$$



Wikipedia

Information Entropy



* $|d| \geq 0.20$

** $|d| \geq 0.50$

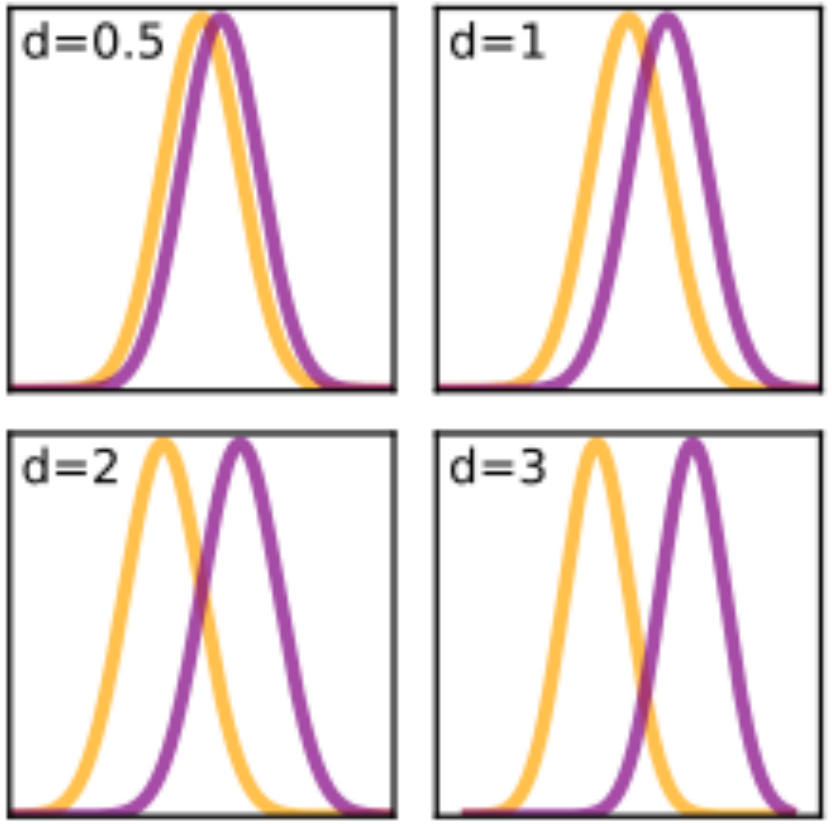
*** $|d| \geq 0.80$

Doing statistics with large (>> 100) N

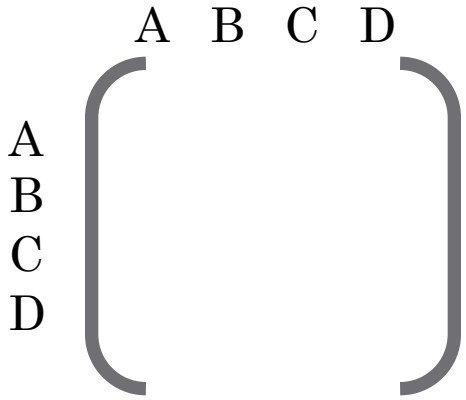
- Cohen's D

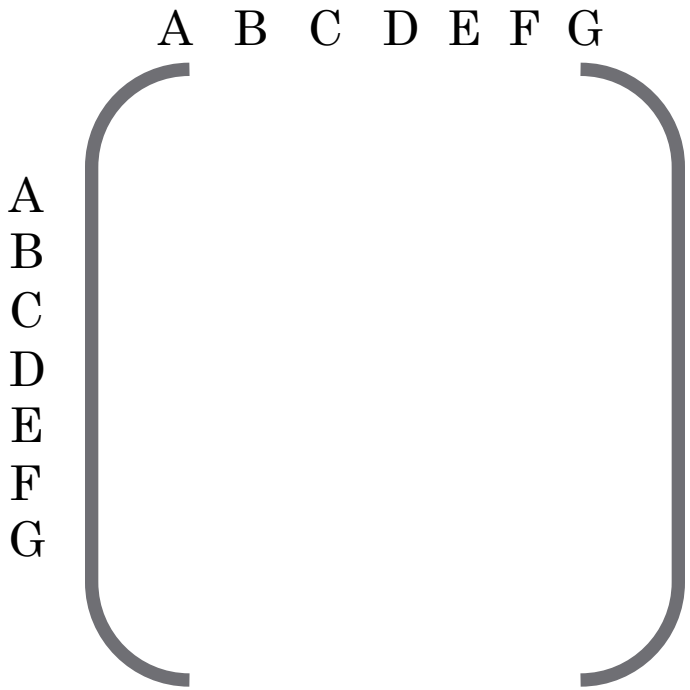
$$d = \frac{\bar{x}_1 - \bar{x}_2}{s}.$$

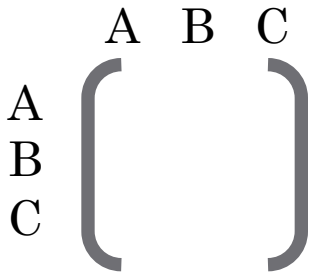
$$s = \sqrt{\frac{(n_1 - 1)s_1^2 + (n_2 - 1)s_2^2}{n_1 + n_2 - 2}}$$



Assumptions: Resolution

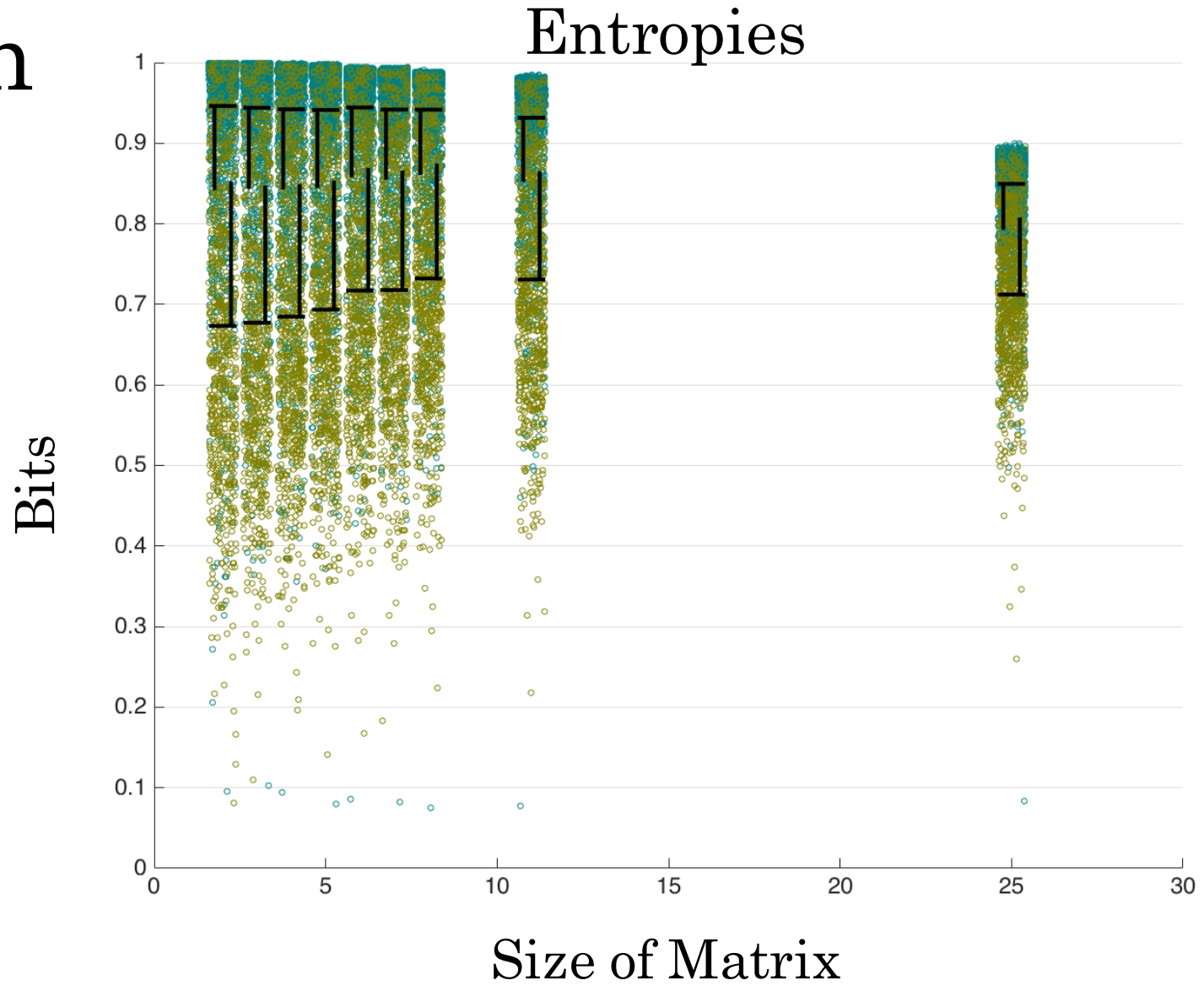




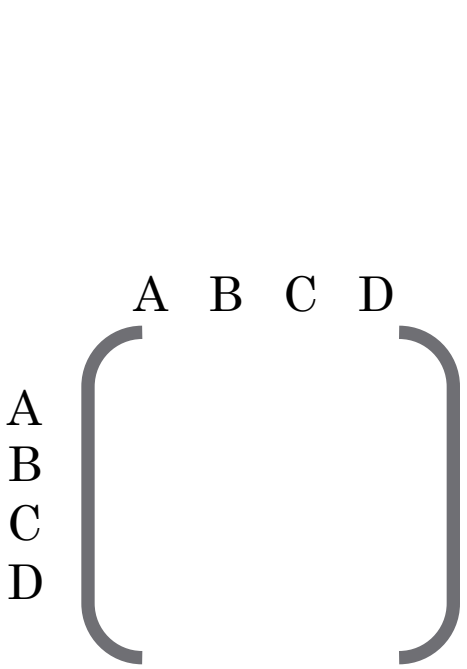


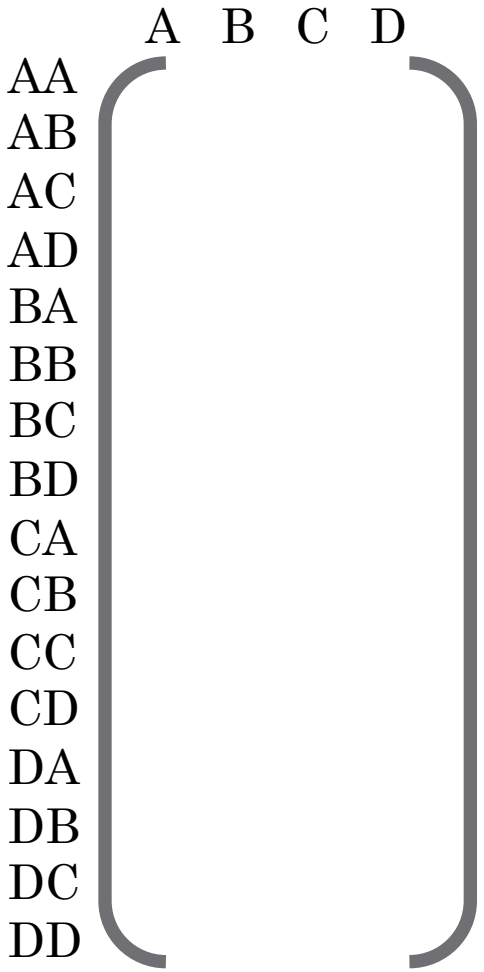
Resolution

Matrix Size	|d|
1	0
2	2.1339
3	2.1772
4	2.1476
5	2.1287
6	2.1115
7	2.1060
8	2.0853
11	2.0777
25	1.9948



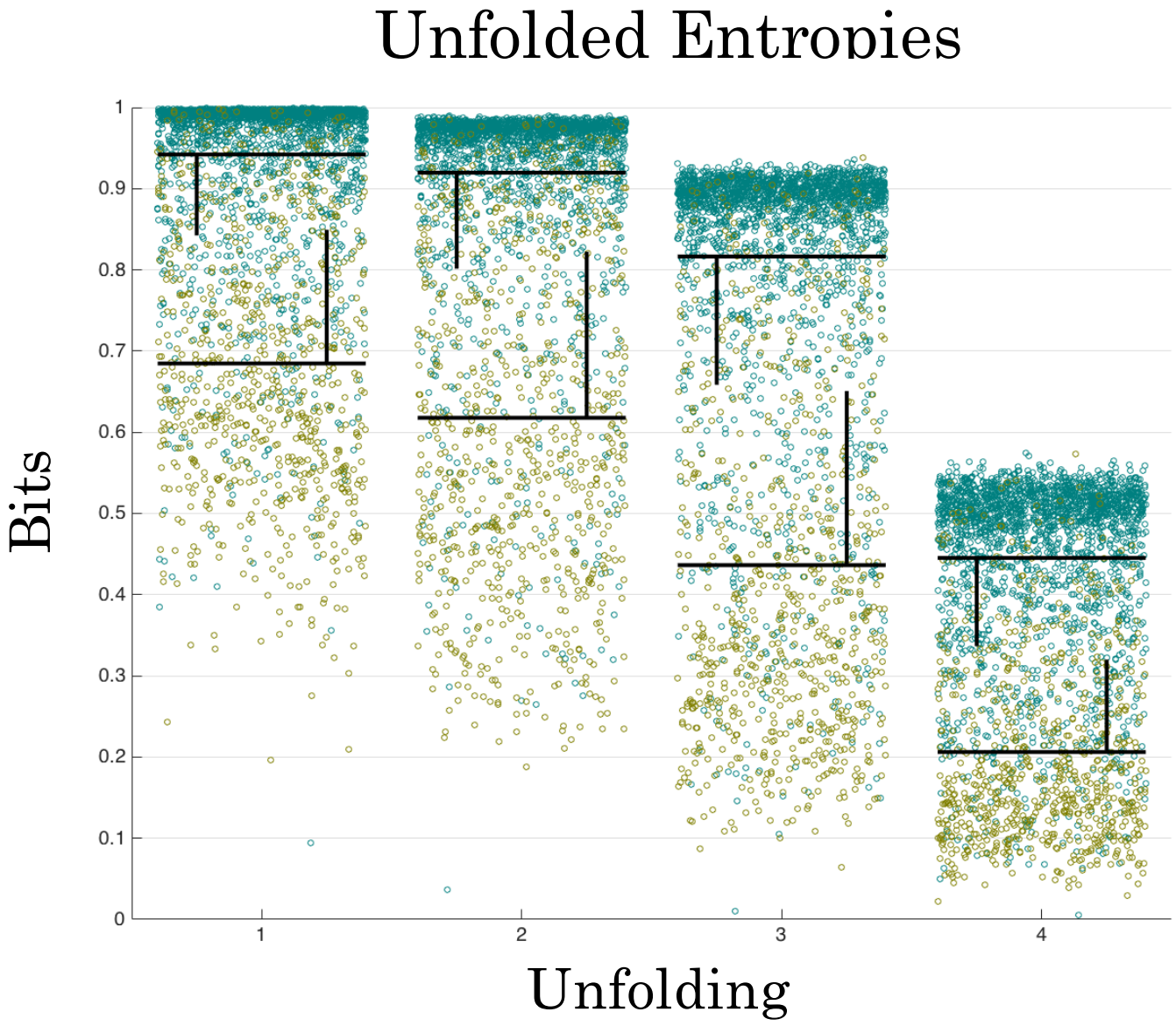
Assumptions: Unfolding



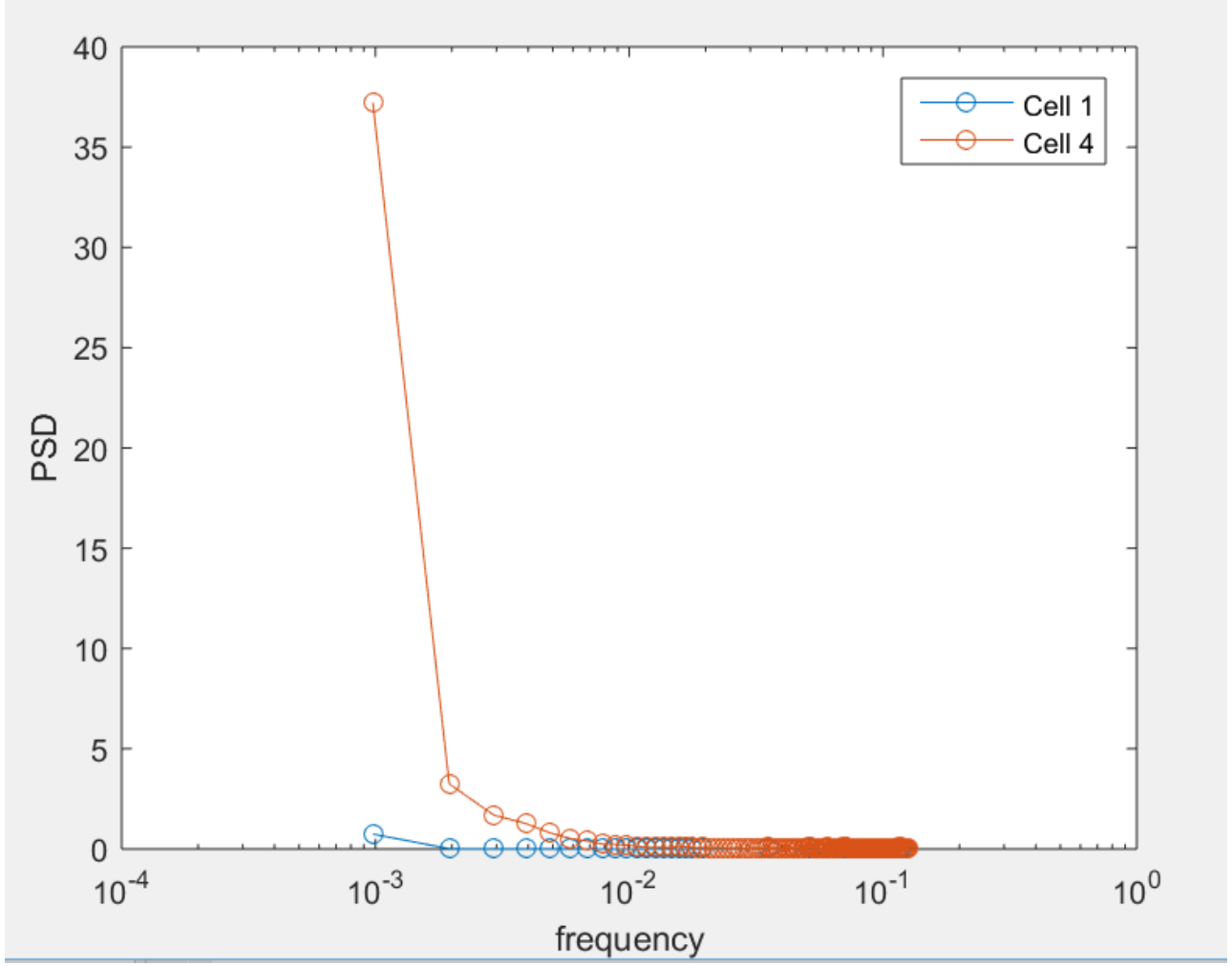


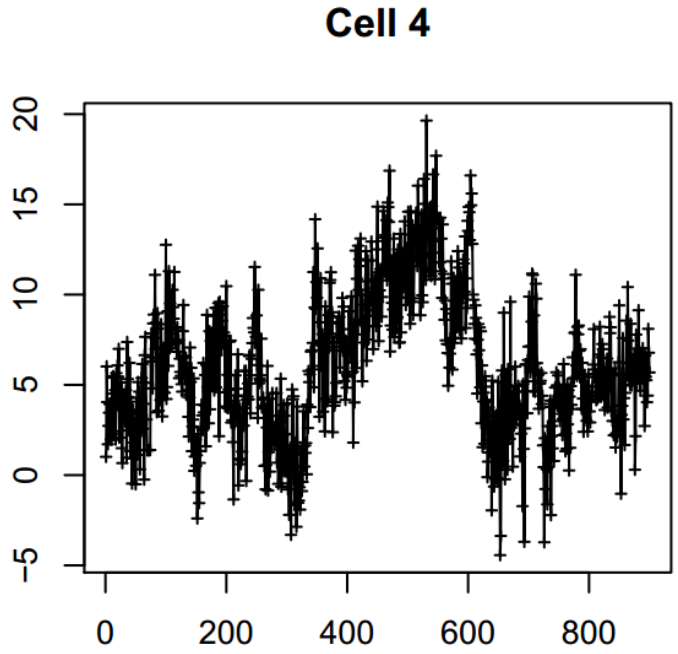
Unfolding

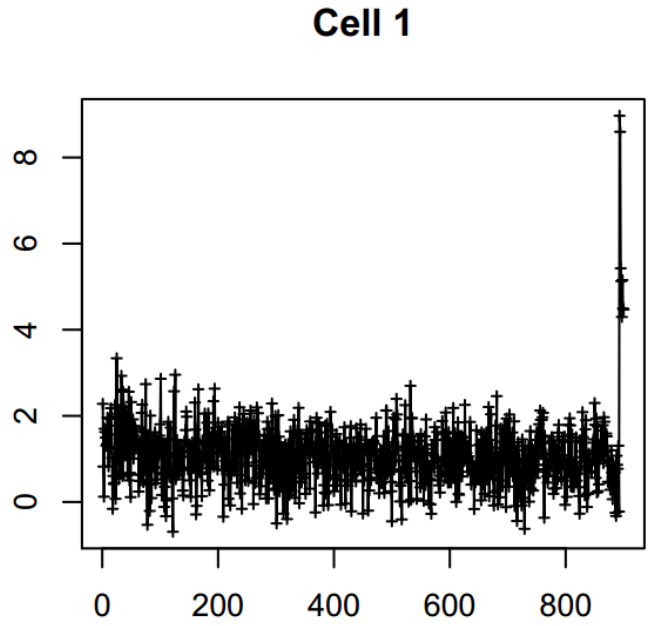
Unfolding	|d|
1	2.1476
2	2.0751
3	2.1812
4	2.1732

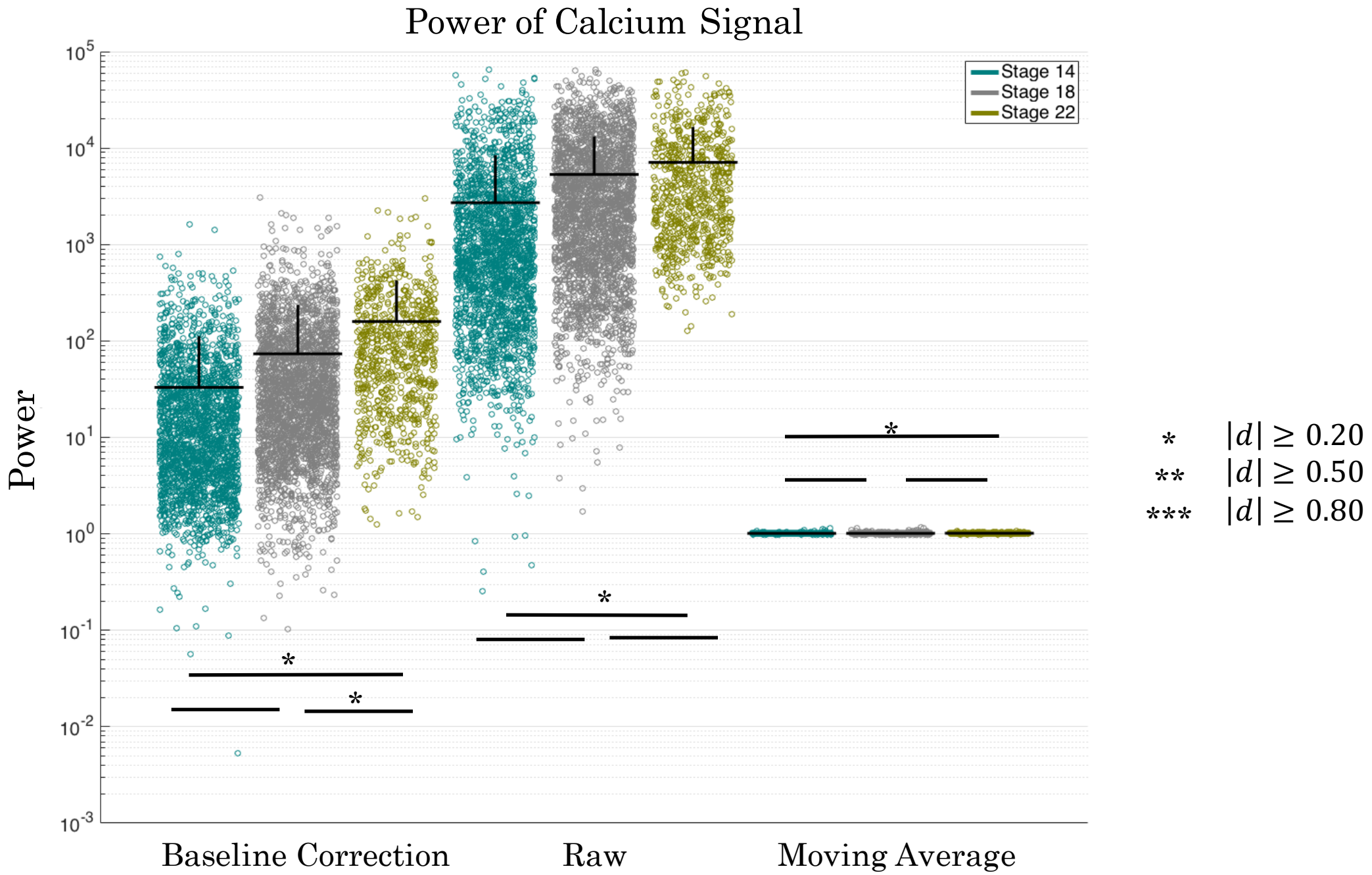


Power Spectral Density

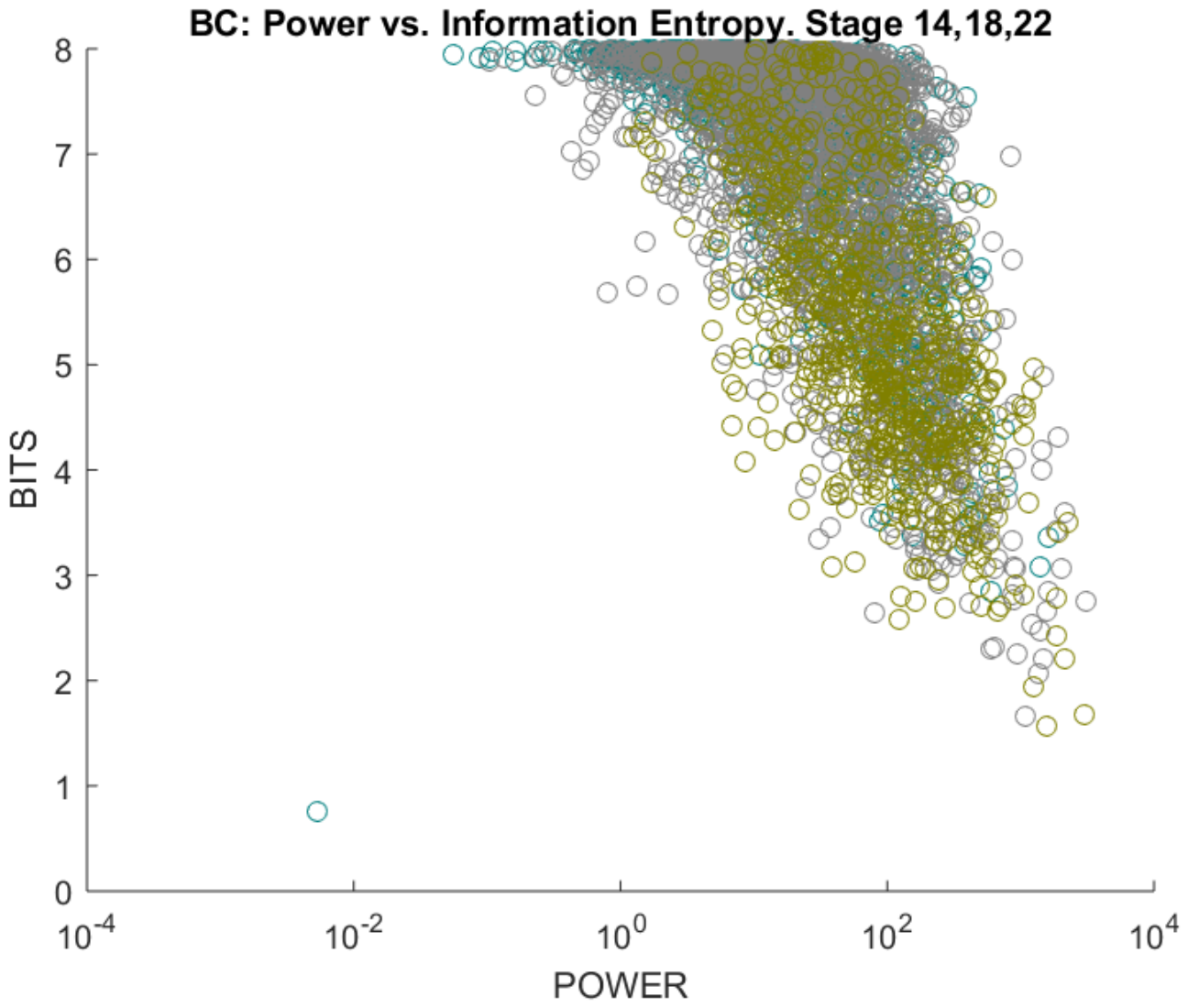




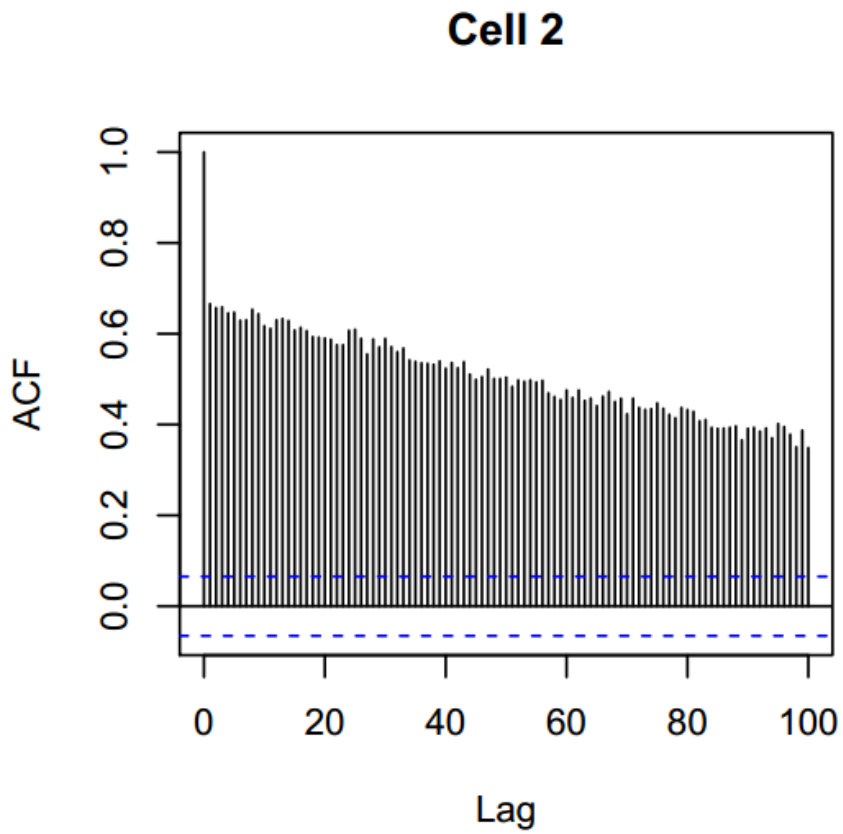



Power of Calcium Signal
Power
Stage 14
Stage 18
Stage 22
Baseline Correction
Raw
Moving Average
*
*
*
*
*
* |d| ≥ 0.20
** |d| ≥ 0.50
*** |d| ≥ 0.80

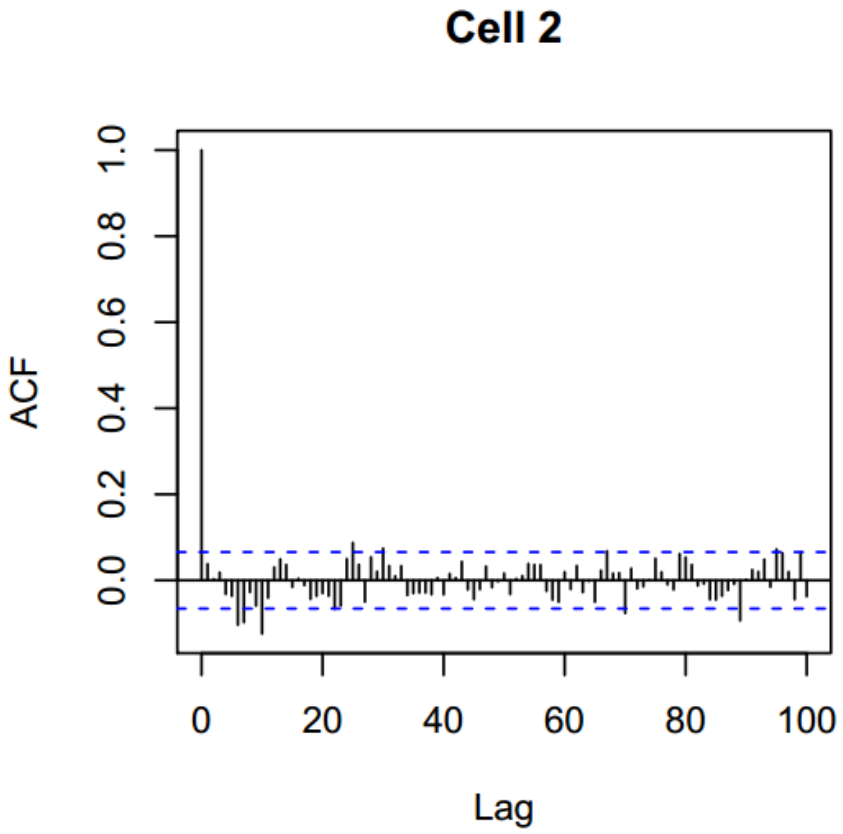
Power vs. Entropy correlation



Autocorrelation Function

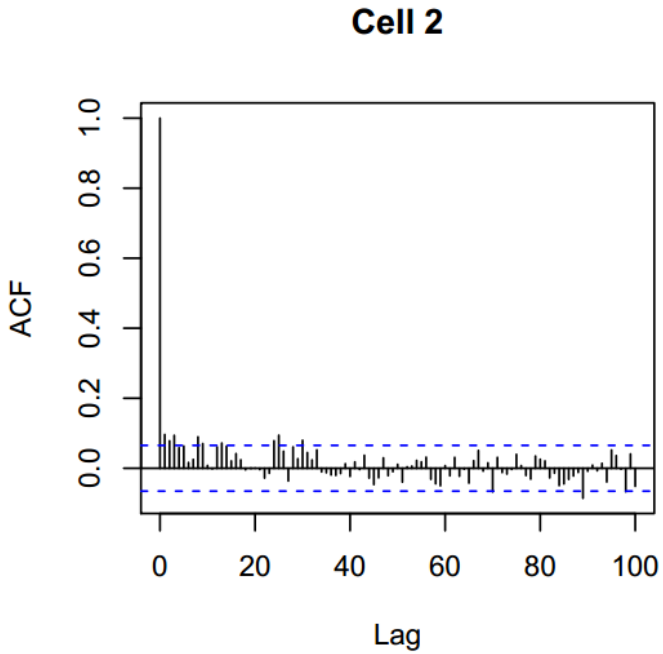


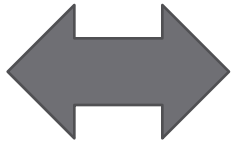
Raw Data

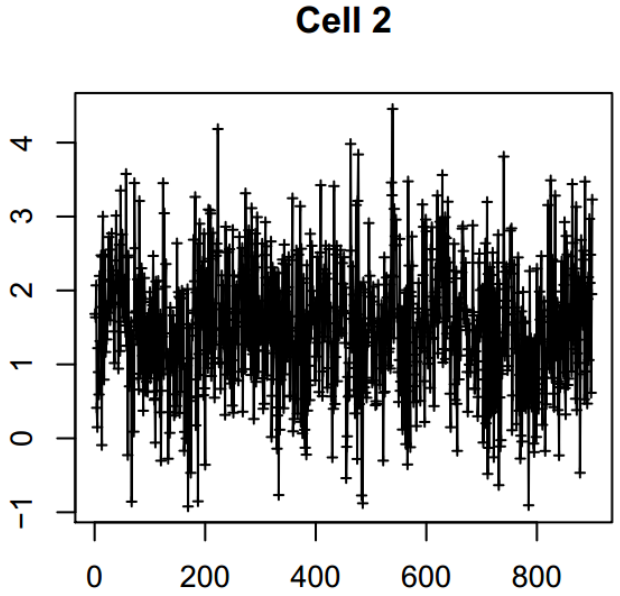


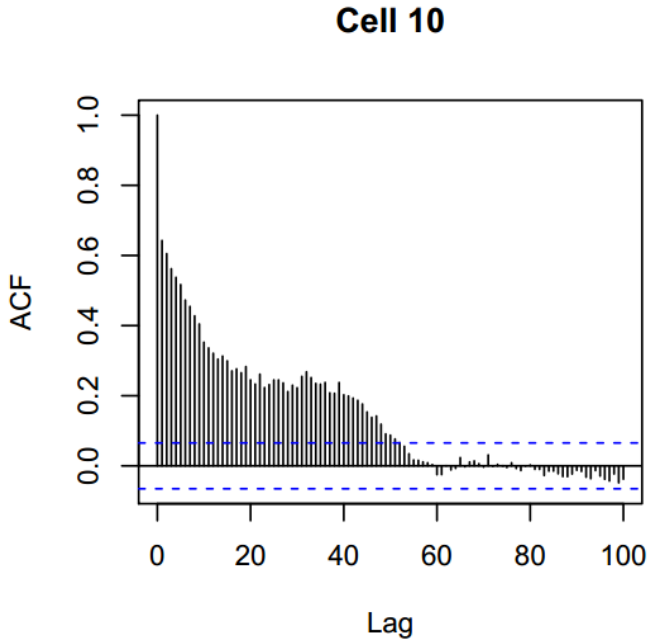
Moving Average

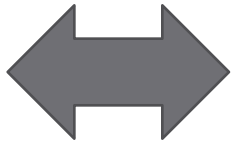
Baseline Correction

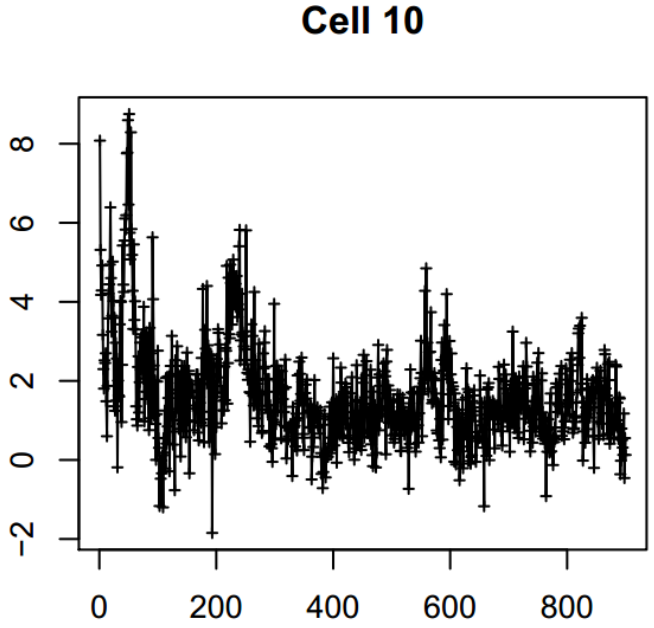






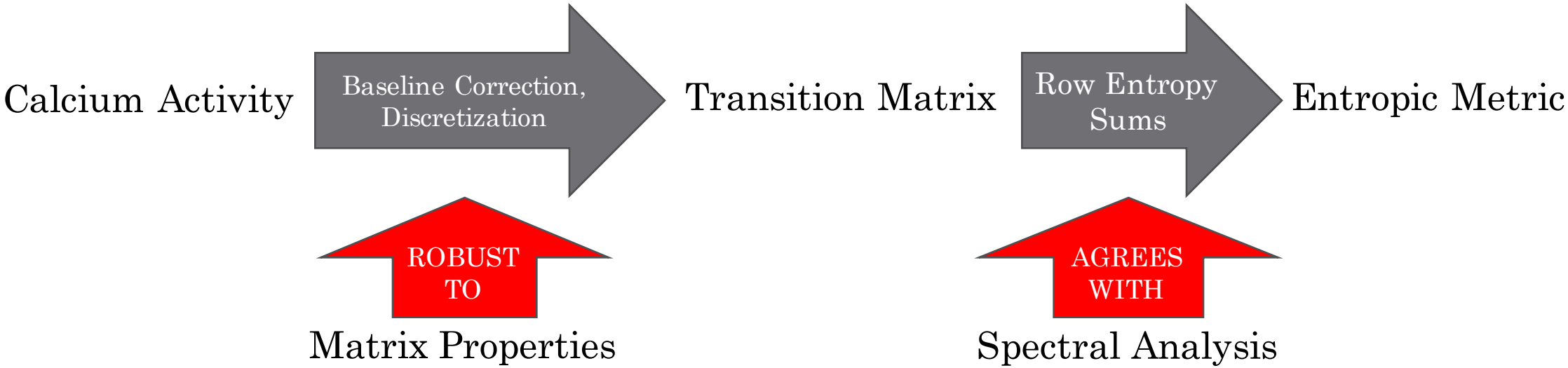






Conclusions

Conclusions



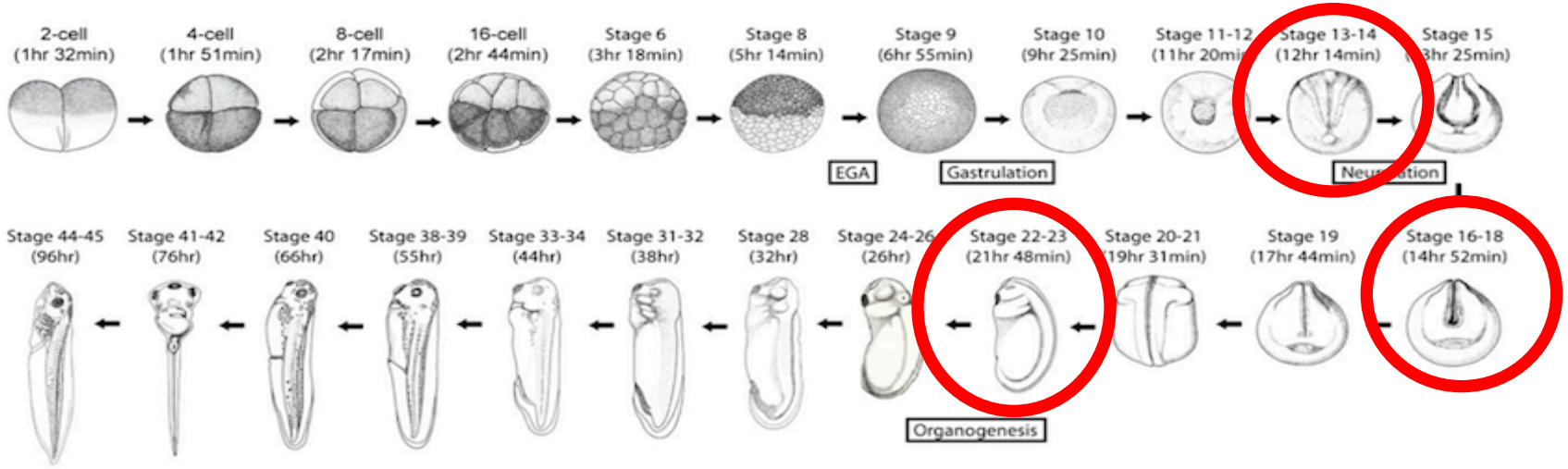
Conclusions

Calcium Activity → Baseline Correction, Discretization → Transition Matrix → Row Entropy Sums → Entropic Metric

ROBUST TO → Matrix Properties

AGREES WITH → Spectral Analysis

Distinct Calcium Activity Modes



Future Directions for the Saha Lab

This Project

- Apply to many datasets
- Compare against feature-dependent methods

Future Projects

- Predicting Neuronal Phenotype
- *in vivo* Spatial Effects

Acknowledgments

Insights and Discussions:

Greg Smith

John Delos

Attendees of the W&M Biomath Journal Club

Saha Lab Calcium Group

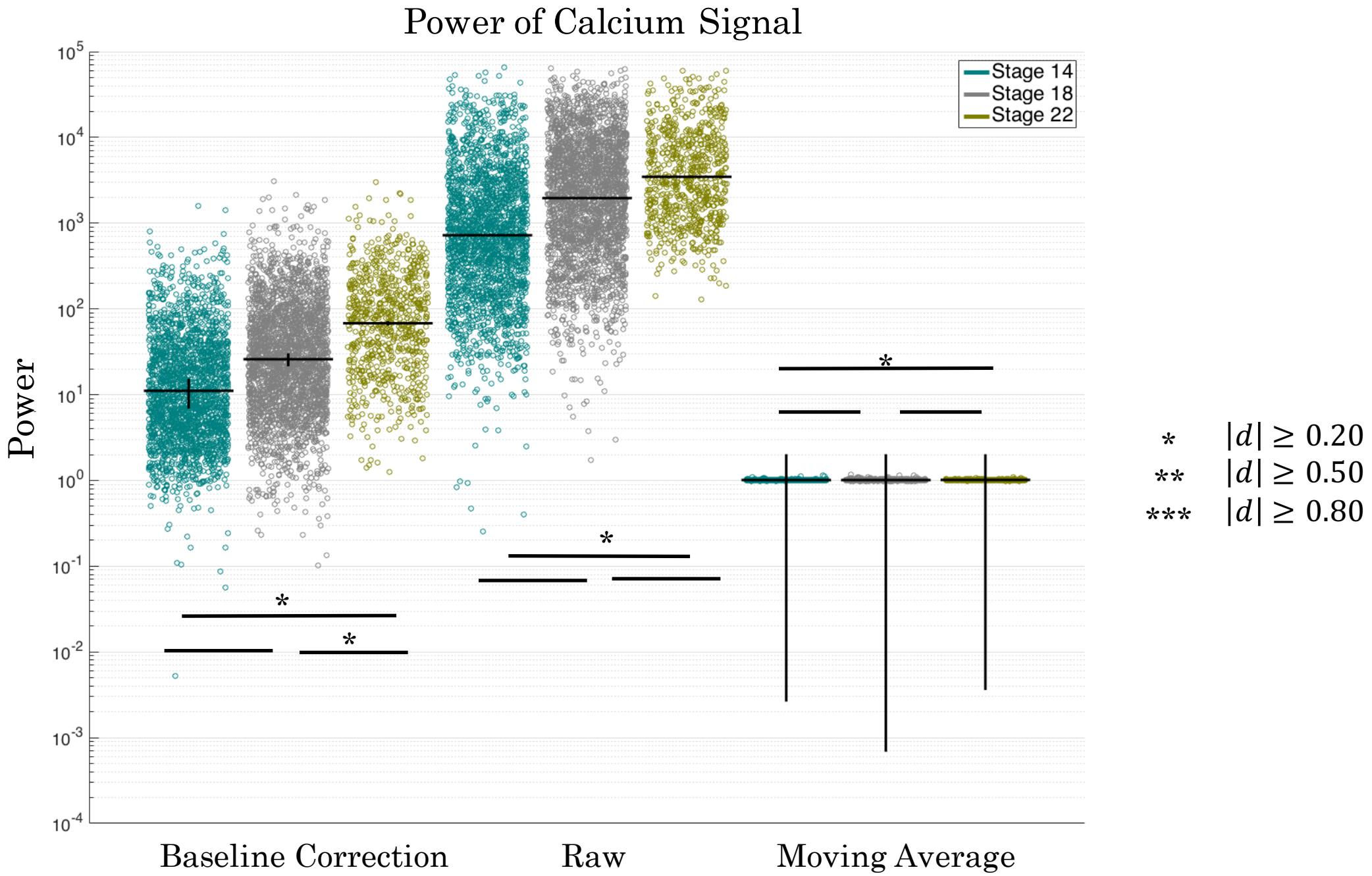
Funding:

NSF IOS-1257895

NIH-1R15HD077624-01

Thank you!

Questions?



* $|d| \geq 0.20$

** $|d| \geq 0.50$

*** $|d| \geq 0.80$