Manuel **Razo-Mejia**

Postdoctoral Scholar · Stanford University

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Education

California Institute of Technology (Caltech) — *Pasadena, California*

PhD Biochemistry & Molecular Biophysics — *2014 - 2021*

- Thesis Topic: Physical biology of cellular information processing
- Thesis Advisor: Rob Phillips.

Instituto Politecnico Nacional — *Silao, Guanajuato, Mexico*

BSc Biotechnological Engineering — *2009 - 2014*

Awards & Scholarships

Postdoc

2022 **Finalist**, HHMI Hanna Gray Fellowship — *HHMI*

PhD

2021 **Schmidt Science Fellowship**, Schmidt Science Fellows — *Schmidt Futures*

2019 **Caldwell CEMI graduate Fellowship**, Kim and Ginger Caldwell endowed fellowship — *Caltech*

2018 **Caltech's Breakthrough campaign featured story**, Caltech's Breakthrough campaign. Link: `https://breakthrough.caltech.edu/story/science-and-serendipity/` — *Caltech*

2015 **Amgen Graduate Fellowship**, Caltech-Amgen Research Collaboration — *Caltech*

2014 **Benjamin M. Rosen Graduate Fellowship**, Benjamin M. Rosen endowed fellowship for incoming students — *Caltech*

BSc

2014 **Valedictorian**, Class of 2014 — *IPN, Mexico*

2013 **Research Fellowship**, Summer Kupcinet-Getz International Science School — *WIS, Israel*

2012 **Research Fellowship**, Summer Undergraduate Research Fellowship — *Caltech*

Research Accomplishments

A Predictive Theory of Allosteric Induction — *Cell Systems*

with S. Barnes, N. Belliveau, T. Einav, G. Chure, M. Lewis, and R. Phillips — *2018*

- We wrote down a theoretical model, based on statistical physics, that predicts the expression level of a gene regulated by an allosteric transcription factor. We then tested the model experimentally by measuring the mean gene expression of a series of strains with different biophysical parameters, showing that the model was able to predict how changes to the regulation of the gene translate to changes in the cellular response.

Predictive shifts in free energy couple mutations to their phenotypic consequences — *PNAS*

with G. Chure, N. Belliveau, T. Einav, Z. Kaczmarek, S. Barnes, M. Lewis, and R. Phillips — *2019*

- We expanded our model of gene regulation by allosteric transcription factors to explore changes in biophysical parameters due to changes in the amino-acid sequence of the transcription factor. We mutated both the DNA-binding domain and the inducer-binding domain of the protein, and re-fit the corresponding parameters given new gene expression measurements. We then predicted the double-mutants by adding the corresponding free-energy changes for each of the mutations, and found great agreement with the corresponding experimental data.

First-principles prediction of the information processing capacity of a simple genetic circuit — *Physical Review E*

with S. Marzen, G. Chure, R. Taubman, M. Morrison, and R. Phillips — *2020*

- With the objective of predicting the amount of information (in bits) that a simple genetic circuit can gather from the state of the environment, we wrote down a non-equilibrium model for the full distribution of gene expression as a function of an external signal. We calibrated our model with previous information in order to perform parameter-free predictions. To test the model, we compared the predictions with experimental single-cell gene expression data finding great agreement.

Reconciling Kinetic and Equilibrium Models of Bacterial Transcription *PLoS Comp. Bio. (accepted)*

WITH M. MORRISON AND R. PHILLIPS *2020*

- We did an exhaustive analysis of the correspondence between equilibrium models of gene regulation –based on statistical mechanics– and equivalent kinetic models –based on the chemical master equation. We found that both frameworks make indistinguishable predictions at the level of mean gene expression. Only through accounting for higher moments of the distribution we can get mechanistic insights into which scheme better describes the regulation of the gene. We finally used Bayesian inference to show that "the best model" we found can predict single-molecule mRNA counts distributions.

Research interests

- I am interested in transitioning into evolutionary biology. Specifically, I find the parallels between population genetics and statistical physics extremely intriguing. I am therefore interested in using my background on theoretical modeling, Bayesian statistical inference, and molecular biology to explore questions on microbial evolution from a theory-experiment dialogue angle.

Publications

2021

- Morrison, M. J., **Razo-Mejia, M.**, & Phillips, R. (2021). *Reconciling Kinetic and Equilibrium Models of Bacterial Transcription*. PLoS comp. bio. `GitHub repository`
  https://journals.plos.org/ploscompbiol/article?id=10.1371/journal.pcbi.1008572

2020

- **Razo-Mejia, M.**, et al. (2020). *First-principles prediction of the information processing capacity of a simple genetic circuit*. Phys. Rev. E 022404, 1–14. `Paper website` and `GitHub repository`
  http://doi.org/10.1103/PhysRevE.102.022404

2019

- Chure, G., **Razo-Mejia, M.**, Belliveau, N. M., Einav, T., Kaczmarek, Z. A., Barnes, S. L., Lewis, M., Phillips, R. (2019). *Predictive shifts in free energy couple mutations to their phenotypic consequences*. PNAS, 201907869. `Paper website` and `GitHub repository`
  https://doi.org/10.1073/pnas.1907869116
- Foster, P. J., **Razo-Mejia, M.**, Phillips, R. (2019). *Measuring the Energetic Costs of Embryonic Development*. Developmental Cell, 48(5), 591?592.
  http://doi.org/10.1016/j.devcel.2019.02.016
- Phillips, R., Belliveau, N. M., Chure, G., Garcia, H. G., **Razo-Mejia, M.**, Scholes, C. (2019). *Figure 1 Theory Meets Figure 2 Experiments in the Study of Gene Expression*. Annual Review of Biophysics, 48(1), 121?163.
  http://doi.org/10.1146/annurev-biophys-052118-115525

2018

- **Razo-Mejia, M.***, Barnes, S. L.*, Belliveau, N. M.*, Chure, G.,* Einav, T.*, Lewis, M., Phillips, R. (2018). *Tuning Transcriptional Regulation through Signaling : A Predictive Theory of Allosteric Induction*. Cell Systems, 1-14. * These authors contribute equally. `Paper website` and `GitHub repository`
  http://doi.org/10.1016/j.cels.2018.02.004.

2015

- Zelcbuch, L., **Razo-Mejia, M.**, Herz, E., Yahav S., Antonovsky N., Kroytoro H., Milo R., Bar-Even A. (2015). *An in vivo metabolic approach for deciphering the product specificity of glycerate kinase proves that both E. coli's glycerate kinases generate 2-phosphoglycerate*. Plos One, 10(3), e0122957.
  http://doi.org/10.1371/journal.pone.0122957

2014

- **Razo-Mejia, M.**, Boedicker, J. Q., Jones, D., DeLuna, a, Kinney, J. B., & Phillips, R. (2014). *Comparison of the theoretical and real-world evolutionary potential of a genetic circuit*. Physical Biology, 11(2), 026005.
  http://doi:10.1088/1478-3975/11/2/026005

Talks & Posters

Talks

***"From Molecular Basis to Predictability and Control of Evolution"*, NORDITA** *Stockholm, Sweden*

Invited speaker *2019*

- Title: Does evolution care about bits? Information as currency in nature's stock market

***"Stochastic Physics in Biology"*, Gordon Research Conference** *Santa Barbara, CA*

Invited speaker *2019*

- Title: Does evolution care about bits? Information as currency in nature's stock market

Posters

ASCB *San Diego, CA*

Presenter *2018*

- Title: The physics of information processing of a simple genetic circuit.

Personal References

Rob Phillips *Caltech*

Thesis advisor

- Email: phillips {at} pboc {dot} caltech {dot} edu

Dianne Newman *Caltech*

Thesis Committee

- Email: dkn {at} caltech {dot} edu

Justin Bois *Caltech*

Faculty Member

- Email: bois {at} caltech {dot} edu

Extracurricular Activity

Clubes de Ciencia Mexico (Science Clubs, Mexico) *Mexico*

Organization Committee *2011 - Present*

- The emerging non-profit association Clubes de Ciencia Mexico aims to expand the access of young Mexican students to high quality scientific education. For this we design and implement science, technology, engineering and math workshops for high school students and freshman undergrads. Our science clubs are the mechanism to establish a network of mentors that link the most prominent young scientists in Mexico and abroad with other Mexican students interested in science. This international network of mentors tries to catalyze three main objectives:
  (1) Increase the interest for science among the students.
  (2) Guide young students towards scientific careers.
  (3) Develop science-related technical and cognitive abilities.