

Benjamin Kuznets-Speck, Ph.D.

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Education

Ph.D. in Biophysics — University of California, Berkeley. September 2018 to May 2023

Thesis - Mountains and rivers: rare events in noisy systems and the forces that shape them

Batchelor of Science in Mathematics and Physics, summa cum laude, honors, 3.98 GPA

Case Western Reserve University. September 2014 to May 2018

Experience

Postdoctoral Research Fellow — Yogesh Goyal Lab

Northwestern University, Dept. of Cell and Developmental Biology - Evanston, IL.

September 2023 to present

I use a combination of machine learning and model selection on RNA sequencing data to build foundational models for transcriptomic perturbations, and apply them to study rare phenotypic events from cancer metastasis to drug resistance.

Postdoctoral Research Fellow — Adilson Motter Group

Center for Network Dynamics, Northwestern University, Dept. of Physics - Evanston, IL

August 2023 to September 2024

I leveraged machine learning on high-throughput next generation sequencing data to predict/classify disease states and infer pairs and tuples of significant causal genes associated with complex immune diseases. I developed a machine learning pipeline that learns groups of genes significant to classifying disease states from gene expression data. My pipeline uses a variety of modern machine learning techniques including variational auto-encoders (VAEs) to classify expression profiles and generate new ones with disease features, and a constrained optimization scheme to match transcriptional differences to changes in phenotype through the application of genetic perturbations. This work is currently in review in *PNAS*.

Postdoctoral Researcher — Michael DeWeese Group

University of California, Berkeley, Dept. of Physics - Berkeley, CA

May 2023 to August 2023

Counterdiabatic free energy estimation with optimal control for molecular dynamics simulations, controlling evolution with neural networks.

Kavli Graduate Research Fellow — Carlos Bustamante Lab

Kavli Energy Nano Science Institute, University of California, Berkeley- Berkeley, CA

March 2022 to May 2023

Experimental tests of speed limits on single molecule transitions; experiments, molecular dynamics simulations and data analysis pipeline development for single molecule force spectroscopy to study protein folding.

Graduate Researcher — David Limmer Group

University of California, Berkeley, Dept. of Chemistry - Berkeley, CA
August 2019 to March 2022

Speed limits on accelerating collective phenomena and the energetic cost to do so; generative design/control of noisy systems with reinforcement learning, model-free transition rate inference.

Research facilitator, Marine Biological Laboratory, Woods Hole MA, *Physical Biology of the Cell* summer course — supervisors: Rob Phillips & Hernan Garcia

Undergraduate Researcher, Goldwater Fellow — Michael Hinczewski Group

Case Western Reserve University, Dept. of Physics - Cleveland, OH
August 2015 to May 2018

Using non-equilibrium statistical mechanics to map trade-offs in speed, cost and information transfer in living cells; steering evolution in clonal populations, stochastic control of biophysical networks.

Skills

- Multi-scale Simulations and Sampling Algorithms
- Protein structure and dynamics
- Machine Learning for Biology and Physics
- Statistical and Nonequilibrium Physics
- Next Generation Sequencing and large scale omics datasets
- Python, PyTorch, NumPy, Pandas, R
- Statistical Analysis and Bayesian Inference
- Molecular Biology and Biophysics
- Optimal control theory

Awards

Kavli Energy Nano Science Institute Graduate Fellow, University of California, Berkeley - March 2022

Hertz Foundation Fellowship Finalist (1 of 40 nationwide), University of California, Berkeley - February 2019

Donald A. Glaser Award: for outstanding Sr. Math and Physics student, Case Western Reserve University - May 2018

Barry Goldwater Scholar (national award) Case Western Reserve University- March 2017

Albert A. Michelson Prize: for outstanding Jr. Math and Physics student, Case Western Reserve University - May 2017

Mentoring

In my time at UC Berkeley, I served as a mentor to multiple undergraduates and graduate students, including Aditya Singh and Joseph Slivka.

At Northwestern University, I mentored a graduate student, Buddha Ogonor, an undergraduate student, Caden Holcomb, and a high-school student Meghana Mandala. I am currently mentoring a masters student, Leon Schwartz, in the Goyal lab.

Publications

11. **B Kuznets-Speck**, E. Ilker & M Hinczewski, ‘Counterdiabatic driving for rapid force spectroscopy without nonequilibrium artifacts,’ in preparation for publication (manuscript available upon request), 2024.
10. **B Kuznets-Speck** & A.E. Motter, ‘Reactivity bounds negative transients in entropy production,’ in preparation for publication (manuscript available upon request), 2024.
9. **B. Kuznets-Speck**, B. K. Ogonor, T. P. Wytock & A. E. Motter ‘Generative prediction of causal gene sets responsible for complex traits,’ in review at Proc. Natl. Acad. Sci. (manuscript available upon request) 2024.
8. A. Zhong*, **B. Kuznets-Speck*** & M. R. DeWeese, ‘Time-Asymmetric Protocol Optimization for Efficient Free Energy Estimation,’ arXiv:2304.12287, accepted at Phys. Rev. E., 2024.
7. **B. Kuznets-Speck** & D. T. Limmer, ‘Inferring equilibrium transition rates from nonequilibrium protocols,’ Biophysical Journal, 2022.
6. A. Das*, **B. Kuznets-Speck*** & D. T. Limmer, ‘Direct evaluation of rare events in active matter from variational path sampling, Phys. Rev. Lett., 2022.
5. E. Ilker et al., ‘Shortcuts in Stochastic Systems and Control of Biophysical Processes,’ Phys. Rev. X, 2022.
4. **B. Kuznets-Speck** & D. T. Limmer, ‘Dissipation bounds the amplification of transition rates far from equilibrium’ Proc. Natl. Acad. Sci., 2021.
3. T. Wang, **B. Kuznets-Speck**, J. Broderick & M. Hinczewski, ‘The price of a bit: energetic costs and the evolution of cellular signaling,’ biorxiv. 2020. In revision at eLife.
2. S. Iram et al., ‘Controlling the speed and trajectory of evolution with counterdiabatic driving,’ Nature Physics, 2020.
1. A.W. Eckford, **B. Kuznets-Speck**, M. Hinczewski & P.J. Thomas, ‘Thermodynamic properties of molecular communication,’ IEEE, 2018.

Conferences and Public Speaking

- Workshop On Stochastic-thermodynamics (WOST), 2024.** — *The price of a bit: energetic costs and the evolution of cellular signaling.*
- American Physical Society Annual Meeting, 2022.** — *Shaping rare events away from equilibrium: bounds on transition rate enhancement and a new take on optimal control of reaction rates.*
- Berkeley Statistical mechanics meeting, 2022.** — *Beyond Bell's law: model free transition rate estimation from nonequilibrium trajectories.*
- Compass Physics Lecture, UC Berkeley, Fall 2021.** — *Bringing the heat: dissipation bounds transition rates far from equilibrium.*
- American Physical Society Annual Meeting, 2021.** — *Bringing the heat: dissipation bounds transition rates far from equilibrium.*
- Second Workshop On Stochastic-thermodynamics (WOSTII), Santa Fe Institute, 2021.** — *Bringing the heat: dissipation bounds transition rates far from equilibrium.*
- Berkeley Statistical mechanics meeting, 2020.** — *Taking transition state theory for a drive.*
- Biophysics graduate group retreat, Berkeley, CA, 2019.** — *Taking transition state theory for a drive.*
- Biophysical Society Annual Meeting, San Francisco, CA, 2018** — *The price of a bit: energetic costs and the evolution of cellular signaling.*