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Ofer Kimchi

**Current**

**Branco Weiss Fellow**, postdoc-to-faculty transition fellowship October 2024 – 2029

**Lewis-Sigler Theory Scholar**,Princeton University *Princeton, NJ*

**Fellow**, Center for the Physics of Biological Function, City University of New York *New York, NY*

September 2021 – present

**Education**

**Harvard University** *Cambridge, MA*

Ph.D., Biophysics May 2021

Advised by Michael P. Brenner

National Defense Science and Engineering Graduate (NDSEG) Fellowship

**Princeton University** *Princeton, NJ*

A.B., Physics; Graduated with Highest Honors May 2016

Certificates: Quantitative & Computational Biology; Applied & Computational Mathematics

**Selected Fellowships, Honors and Awards**

**Branco Weiss Fellowship** *~$660K over 5 years to support postdoc-to-faculty transition* 2024 – 2029

*Awarded to 7/360 applicants worldwide across sciences, engineering, humanities*

**Lewis-Sigler Theory Scholar** *Princeton University; salary + $25K/year in research funding* 2021 – present

**Quantitative Biology Ph.D. Fellowship** *Harvard University* 2019 – 2021

**Certificates of Distinction in Teaching** *Harvard University*March 2018, September 2018

**DBIO Graduate Student Travel Award** *to present at APS March Meeting*January 2017

**National Defense Science and Engineering Graduate Fellowship** June 2016

**Princeton Kusaka Memorial Prize** *for outstanding 4th year research in physics ($5K honorarium)*June 2016

**Princeton Applied and Computational Mathematics Independent Project Prize** June 2016

**Princeton Quantitative and Computational Biology Award** June 2016

**Member, Phi Beta Kappa Society; Society of Sigma Xi** June 2016

**Princeton Allen G. Shenstone Prize** *for outstanding 3rd year research in physics ($1K honorarium)* May 2015

**2015 Education Committee Travel Award** *to present at Biophysical Society Meeting* February 2015

**Shapiro Prize for Academic Excellence** *awarded to top 3% of 1st/2nd year Princeton students* December 2014

**Presidential Scholar Semifinalist; National Merit Scholarship Finalist** January 2012

**Publications**

**O. Kimchi**, Y. Meir, N. S. Wingreen. [*Bacterial defense and phage counter-defense lead to coexistence in a modeled ecosystem*](https://www.biorxiv.org/content/10.1101/2024.07.17.603905v3.full.pdf)*.* Proceedings of the National Academy of Sciences, USA (in press) (2024).

**O. Kimchi**, Y. Meir, N. S. Wingreen. [*Lytic and temperate phage naturally coexist in a dynamic population model*](https://academic.oup.com/ismej/article/18/1/wrae093/7685662)*.* The ISME Journal 18(1), wrae093 (2024).

**O. Kimchi**\*, B. B. Larsen\*, O. R. S. Dunkley, A. J. W. te Velthuis, C. A. Myhrvold. [*RNA structure modulates Cas13 activity and enables mismatch detection*](https://www.ncbi.nlm.nih.gov/pmc/articles/PMC10659300/pdf/nihpp-2023.10.05.560533v2.pdf)*.* bioRxiv 560533 (2023). Under review at Nature (2nd round).

**O. Kimchi**†, E. M. King, M. P. Brenner. [*Uncovering the mechanism for aggregation in repeat expanded RNA reveals a reentrant transition*](https://www.nature.com/articles/s41467-023-35803-x)*.* Nature Communications 14 (2023).

A. I. Curatolo, **O. Kimchi**, C. P. Goodrich, R. K. Krueger, M. P. Brenner. [*A computational toolbox for the assembly yield of complex, heterogeneous structures*](https://www.nature.com/articles/s41467-023-43168-4)*.* Nature Communications 14 (2023).

T. Chiang, **O. Kimchi**, H. K. Dhaliwal, D. A. Villarreal, F. F. Vasquez, M. P. Brenner, V. Manoharan, R. Garmann. [*Measuring intramolecular connectivity in long RNA molecules using two-dimensional DNA patch-probe arrays*](https://www.biorxiv.org/content/10.1101/2023.03.12.532302v1.full.pdf)*.* bioRxiv 532302 (2023). Under review at Nucleic Acids Research (2nd round).

**O. Kimchi**†, M. P. Brenner, L. J. Colwell. [*RNA structure prediction including pseudoknots through direct enumeration of states: A user’s guide to the LandscapeFold algorithm*](https://link.springer.com/protocol/10.1007/978-1-0716-2768-6_4)*.* RNA structure prediction, Methods in Molecular Biology Springer (2022).

**O. Kimchi**†, C. P. Goodrich, A. Courbet, A. I. Curatolo, N. B. Woodall, D. Baker, M. P. Brenner.

[*Self-assembly based post-translational protein oscillators*](https://www.science.org/doi/10.1126/sciadv.abc1939). Science Advances 6(51) (2020).

J. Kames, D.D. Holcomb, **O. Kimchi**, M. DiCuccio, N. Hamasaki-Katagiri, T. Wang, A. A. Komar, A. Alexaki, C. Kimchi-Sarfaty. [*Sequence analysis of SARS-CoV-2 genome reveals features important for vaccine design*](https://www.nature.com/articles/s41598-020-72533-2). Scientific Reports 10, 15643 (2020).

**O. Kimchi**†, T. Cragnolini, M. P. Brenner, L. J. Colwell†. [*A polymer physics framework for the entropy of arbitrary pseudoknots*](https://www.cell.com/biophysj/fulltext/S0006-3495(19)30560-0?_returnURL=https%3A%2F%2Flinkinghub.elsevier.com%2Fretrieve%2Fpii%2FS0006349519305600%3Fshowall%3Dtrue)*.* Biophysical Journal 117(3):520-532 (2019).

**O. Kimchi**, S. L. Veatch, B. B. Machta**.** [*Ion channels can be allosterically regulated by membrane domains near a de-mixing critical point*](https://rupress.org/jgp/article/150/12/1769/43712/Ion-channels-can-be-allosterically-regulated-by). Journal of General Physiology 150(12):1769-1777 (2018). Accepted for cover.

M. Watts, J. Ha, **O. Kimchi**, A. Sherman. [*Paracrine Regulation of Glucagon Secretion: The -- Model*](https://journals.physiology.org/doi/full/10.1152/ajpendo.00415.2015)*.* American Journal of Physiology—Endocrinology & Metabolism 310(8):E597-E611 (2016).

\*Co-first authors  †Corresponding author

**Patent Applications**

Method of determining secondary structure of a nucleic acid. U.S. Patent Application No. 17/482,765, March 31, 2022. R. F. Garmann, T. K. Chiang, V. N. Manoharan, **O. Kimchi,** M.P. Brenner.

Enhanced nucleic acid detection using Cas13 and designed secondary structure. U.S. Patent Application No. 63/542,704, October 5, 2023. C. Myhrvold, B. Larsen, **O. Kimchi**, O. Dunkley, A. te Velthuis.

**Selected Presentations**

**RNA structure affects RNA-RNA interactions: From RNA condensates to CRISPR-Cas13**2024

*Invited speaker, Flatiron Institute*

**Competition and coexistence in phage and bacteria**2024

*Invited speaker, APS March Meeting*

**RNA structure modulates Cas13 activity and enables mismatch detection**2024

*Presentation, Aspen Center for Physics Workshop on the Physics of Biological Data Analysis*

*Posters, CSHL Meeting: Genome Engineering—CRISPR Frontiers; Winter Q-Bio conference*

**RNA structure can inhibit Cas13 activity and enables SNP detection**2023

*Posters, Soft Matter Physics Gordon Research Conference; Biophysical Society Annual Meeting*

**A reentrant transition in RNA aggregation**2023

*Speaker & session chair, APS March Meeting*

**RNA hybridization in and out of equilibrium**2021

*Invited speaker, Boston College Biology Seminar*

**Towards a synthetic post-translational protein oscillator**2020

*Selected oral presentation, 1st Annual Biodesign Research Conference*

*Speaker & session chair, APS March Meeting; Speaker & poster, Harvard QBio symposium*

**RNA structure and kinetics including pseudoknots through complete landscape enumeration** 2019

*Speaker, APS March Meeting; Poster, Stochastic Physics in Biology GRC*

**A complete free energy landscape for RNA structure** 2018

*Speaker, APS March Meeting; Poster, Cargèse summer school*

**Regulation by a Critical Membrane**  2017

*Speaker, APS March Meeting; Poster, Intracellular Phase Transitions Meeting*

**Research Experience**

**Princeton University Lewis-Sigler Institute for Integrative Genomics** *Princeton, NJ*

Independent postdoctoral fellow Fall 2021 – Present

*How does RNA secondary structure affect Cas13 activity?* with Cameron Myhrvold

Initiated experimental collaboration to probe effects of RNA structure on Cas13

Designed experiments and developed model to interpret results, driving new experimental directions

Developed model-driven method to improve Cas13 specificity by 1-2 orders of magnitude

*Why are homotypic RNA clusters so prevalent?* with Liz Gavis and Ned Wingreen

Formulated hypothesis for the ubiquity of RNA homotypic clusters in *Drosophila* embryogenesis

Designed experiments to test hypothesis, currently being carried out by Gavis lab

*How do diverse phage and bacteria coexist?* with Ned Wingreen

Coded and analyzed ODE-based model for ecological dynamics of diverse phage and bacteria

Developed analytical dynamical systems theory framework to predict dynamical features

*Are homo- or hetero-polymers more prone to phase separation?* with Ned Wingreen

Worked with student to write molecular dynamics simulations for polymeric phase separation

*What drives phase separation for repeat RNA?* with Michael Brenner

Constructed new analytical framework for RNA condensates based on multimer enumeration

Coded dynamic programming model to complement statistical mechanics theory

**Google Research** *Palo Alto, CA*

Summer Intern Summer 2019

*What information is encoded by continuous glucose monitors?*

Analyzed large time-series datasets of patient continuous glucose monitoring data

Employed machine learning, neural networks (LSTMs, CNNs, FCNs)

*Are correlations in language truly long-range?* Advisor: Bill Bialek

Conducted large-scale dataset analysis on English text documents

Used information theory approaches to compare correlations to those expected by chance

**Harvard University Departments of Applied Mathematics and Physics** *Cambridge, MA*

Ph.D. Researcher; Advisor: Michael Brenner Fall 2016 – May 2021

*How can we leverage hybridization to improve structure prediction for large RNA?*

Developed new collaborations on DNA/RNA hybridization with Manoharan lab (Harvard)

Worked closely with collaborators to design high throughput microarray-based hybridization experiments

Developed novel analysis method employing automatic differentiation of microarray data

*How can we optimize the yields of* de novo *designed protein assemblies?*

Formulated equilibrium statistical mechanics theory for yield of asymmetric protein self-assembly

Worked in team of 6 students/postdocs to develop theory, simulations, and experiments concurrently

*Can current protein design tools enable the construction of a synthetic post-translational protein oscillator?*

Developed new collaborations on protein self-assembly with Baker lab (UW)

Constructed differential equation-based models for experimentally realizable protein oscillators

*Enumerating RNA free energy landscapes including pseudoknots*

Constructed Feynman diagram formalism for entropies of complex RNA structures (pseudoknots)

Developed algorithm to predict complete energy landscape of arbitrary RNA sequences

*The epistatic landscape of compensatory evolution in* S. cerevisiae; Advisor: Michael Desai Winter 2017

Conducted collaborative experimental rotation project

Techniques used include: PCR, gel electrophoresis, cell culturing, transfections, Illumina sequencing

**Princeton University Lewis-Sigler Institute for Integrative Genomics and Dept. of Physics** *Princeton, NJ*

Undergraduate Researcher Summer 2014 – Spring 2016

*How are ion channels affected by the nearly-critical cell membrane?* Advisor: Ben Machta

Developed large-scale algorithm to simulate Ising model dynamics with embedded lattice channel

Analyzed results using statistical mechanics scaling laws to demonstrate biological relevance of model

*How does a 30S ribosome find its target on an mRNA?* Advisor: Ned Wingreen

Formulated and probed feasibility of testable quantitative theories for ribosome search

*Monte Carlo analysis of the Potts Model phase transition.* Advisor: David Huse

Performed Monte Carlo simulations on fractal-dimensional lattice to probe phase transition order

**National Institutes of Health Laboratory of Biological Modeling** *Bethesda, MD*

Summer Intern Summer 2013

*What leads to anti-synchronous pancreatic insulin/glucagon oscillations?* Advisor: Arthur Sherman

Developed and numerically solved large ODE system predicting biological 𝛼/𝛽 cell coupling

**Teaching, Mentorship, and Community Activities**

**Peer reviewer**

*Physical Review Letters*; *PNAS; Nature Communications*; *PLOS Computational Biology*

**Conference organizer** January 2024

Co-organized workshop “Bacteria vs. Phage: The Main Event” at Princeton Center for Theoretical Science.

Recruited speakers, emphasizing diversity across different axes; led discussions throughout workshop

**DEI community service** Winter 2024 – present

Member, LSI Climate Committee, Princeton University

**Preceptor and course instructor**Fall 2021, Summer 2022

Co-led precepts for Integrated Science, an intensive Freshman course

Organized discussion group for Princeton Summer Undergraduate Program about scientific presentations

**Research advisor**Summer 2020 – present

Mentored high school student on project relating to CRISPR-based methods to treat Huntington’s disease

Mentored post-bac student on project relating to analysis of large RNA-DNA hybridization dataset

Provided mentorship on experimental design and presentations to graduate and post-bac students

Provided thought leadership and technical mentorship to undergraduate researchers on covid-19 modeling

Wrote recommendation letter for post-bac student, who started graduate school at Stanford in Fall 2023

**Course developer and instructor**Summer 2020

Developed and taught quantitative biology course about how to read and understand scientific papers

Course aimed at 12 minority and underrepresented students performing summer research at Harvard

**Seminar leader** Fall 2019-Spring 2021

Ran Kavli seminar: weekly seminar series with diverse speakers fostering intra-Harvard collaborations

Shepherded seminar into virtual space in March 2020, maintaining high attendance and engagement

**Teaching fellow**

Graduate student teaching fellowFall 2017, Spring 2018, Fall 2020

Constructed problem sets, led recitations, and mentored students in independent projects

Courses were at both graduate and undergraduate level in mathematical modeling

QuantLab tutor at Princeton University Freshman Scholars InstituteSummers 2014-2015

Mentored students in problem sets and labs to make quantitative majors more accessible

Program was for incoming freshmen to Princeton from minority, low-income backgrounds