Sabina J. Haque

PhD Candidate in Systems Biology, Harvard University

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Overview

I am an applied mathematician broadly compelled by explaining the cell with pure and applied math. Currently, I am a Systems Biology PhD candidate at Harvard University advised by Dr. Jeremy Gunawardena. My doctoral research involves using graph theory and stochastic processes to understand how cellular information processing tasks, such as those in eukaryotic gene regulation, depart from thermodynamic equilibrium. Previously, I graduated from Middlebury College in 2018 with a B.A. in Mathematics and Biochemistry.

Education

Harvard University — 2018 - present
PhD in Systems Biology
Advisor: Jeremy Gunawardena

Middlebury College — 2014 - 2018
B.A. in Mathematics (high honors),
Molecular Biology & Biochemistry

Research Interests

- Graph theory & stochastic processes
- Differential geometry & topology
- Spectra of Laplacian matrices
- Chemical reaction network theory
- Category theory & its applications
- Cellular information processing
- Non-equilibrium biophysics
- 3D structure of the genome
- Low Reynolds number fluid dynamics
- Active matter & collective cell behavior

Publications

1. **Haque, S. J.**, Satriano, M., Sorea, M. & Yu, P. Y. The Disguised Toric Locus and Affine Equivalence of Reaction Networks. *SIAM J. Appl. Dyn. Syst.* **22**, 1423–1444 (2023)

2. Chavez, A., Tuttle M, Pruitt B. W., Ewen-Campen B., Chari R., Ter-Ovanesyan D., **Haque S. J.** *et al.* Comparison of Cas9 activators in multiple species. *Nat. Methods* **13**, 563–567 (2016)

In Preparation

3. **Haque S. J.**, Cetiner U., Gunawardena J. Signature of non-equilibrium conditions exhibits non-monotonic response to increasing thermodynamic force. (In preparation).

4. **Haque S. J.**, Gunawardena J. An asymptotic transformation in finite directed graphs. (In preparation).

Fellowships and Awards

Lynch Foundation PhD Fellowship 2023 - 2024
Department of Systems Biology, Harvard University

NSF-Simons QBio PhD Fellowship 2021 - 2022
NSF-Simons Center for Mathematical & Statistical Analysis of Biology, Harvard University

Lynch Foundation PhD Fellowship 2019 - 2021
Department of Systems Biology, Harvard University

Graduation with high honors 2018
Department of Mathematics, Middlebury College

Outstanding Oral Presentation 2017
Graduate Program in Physical and Engineering Biology, Yale University

College Scholar (Dean's List equivalent, earned each eligible semester) 2014 - 2018
Middlebury College

Selected Talks

Following the energy: graph-theoretic models of broken detailed balance with biochemical applications. Apr 25 2023
NSF-Simons QBio Seminar, Harvard University, Cambridge MA

Following the energy: graph-theoretic models of broken detailed balance with biochemical applications. Mar 26 2023
Systems Biology Department Seminar, Harvard University, Cambridge MA

Graph-theoretic models of detecting broken detailed balance in molecular information processing. Jul 11 2022
2022 SIAM Annual Meeting MS 26: Trends and New Results in Deterministic Models of Biochemical Interaction Networks, Pittsburgh PA

Graph-theoretic models of non-equilibrium conditions in molecular information processing. May 17 2022
Systems Biology PhD Program retreat, Harvard University, Cambridge MA

Investigating mathematical properties of non-equilibrium signatures Mar 16 2022

in biological information processing systems.
Poster at 2022 American Physical Society Annual March Meeting, Chicago IL

Graph-theoretic models of non-equilibrium conditions in molecular information processing. Nov 10 2021
NSF-Simons QBio Seminar, Harvard University, Cambridge MA

Using the linear framework to analyze non-equilibrium behavior in biological systems. Dec 03 2019
Systems, Synthetic, and Quantitative Biology G2 Symposium, Harvard University, Cambridge MA

Stochasticity and magnetoreception in models of magneto-aerotaxis: an idea in-progress. May 15 2019
Poster at NSF-Simons Quantitative Biology Initiative Symposium, Harvard University, Cambridge MA

Dynamics and perturbations in laminar flows: an analytical approach. May 09 2018
Mathematics Department senior thesis talk, Middlebury College, Middlebury VT

Analysis of endocytic protein dynamics by stochastic modeling of fluorescent signal lifetimes. Sep 09 2017
Mathematics Department seminar, Middlebury College, Middlebury VT

Analysis of endocytic protein dynamics by stochastic modeling of fluorescent signal lifetimes. July 18 2017
Physical and Engineering Biology (PEB) REU Symposium, Yale University, New Haven CT

Modeling neurodegenerative diseases in S. cerevisiae of fluorescent signal lifetimes. Aug 01 2016
Church lab meeting, Harvard University, Cambridge MA

Teaching

Harvard University
AM 50: Introduction to Applied Mathematics — Spring 2020

Middlebury College (STEM Peer Tutor)
MATH 0223: Multivariable Calculus — Spring 2018
CHEM 0322: Biochemistry of Macromolecules — Spring 2018
MATH 0122: Calculus II — Fall 2017
MATH 0121: Calculus I — Fall 2017
MATH 0200: Linear Algebra — Spring 2017
Precalculus (private tutoring) — Spring 2016

Middlebury College (Peer Writing Tutor for First Year Writing Seminars)
Head First Year Seminar Mentor — 2017 - 2018
FYSE 1259: Science and Science Fiction — Fall 2017

FYSE 1483: The Magic of Numbers — Fall 2016
FYSE 1167: Shakespeare's Characters — Fall 2015

Conferences and workshops attended

Simons-NSF MathBioSys Annual Meeting 2023 — Apr 2023
Simons Foundation, New York NY

2022 SIAM Annual Meeting — Jul 2022
David L. Lawrence Convention Center, Pittsburgh PA

APS Annual March Meeting 2022 — Mar 2022
McCormick Place - West Building, Chicago IL

Quantitative Approaches in Biology (virtual) — Nov 2020
Northwestern University NSF-Simons Center

Mathematical Models in Biology: From Information Theory to Thermodynamics (virtual) — Jul 2020
Banff International Research Station (BIRS)

Workshop on Dynamics, Randomness, and Control in Molecular and Cellular Networks — Nov 2019
Center for Mathematical Sciences and Applications, Harvard University, Cambridge MA

Quantitative Biology Initiative Symposium — May 2019
Harvard University, Cambridge MA

Outreach

"**How Does Math Explain the Cell?" outreach event creator/coordinator** — Sep 2023
Cambridge Science Festival, Cambridge MA

Guest speaker for summer class on Physics of Biological Function — Jun 2023
Wentworth Institute of Technology, Boston MA

Cambridge Science Festival volunteer — Oct 2022
Cambridge, MA

Graduate research assistant in Quantitative Biology grant preparation — May-Jul 2022
NSF-Simons Center for Quantitive Biology, Harvard University, Cambridge MA

Diversity, equity, and inclusion contributor, recruiter, and mentor — 2020-present
Systems Biology Department/PhD Program, Harvard University, Cambridge MA

"What is Systems Biology?" outreach event creator/coordinator — Apr 2019
Cambridge Science Festival, Cambridge MA

Writing

Guest speaker at Teen Cafe in Biotechnology Apr 2019
MIT Museum, Cambridge MA

Cellular mathematics: how does math enhance our understanding of life at the molecular level? 2022-present
https://sabinahaque.substack.com/

Graph Theory 101 Jun-Aug 2021
Science in the News Special Edition: Networks, Harvard University, Cambridge MA
https://sitn.hms.harvard.edu/flash/2021/graph-theory-101/

Challenging an epidemic of systemic racism in America Jun 2020
https://medium.com/@sjhaque14/challenging-an-epidemic-of-systemic-racism-in-america-26c419744fb9

References

Jeremy Gunawardena PhD
Associate Professor of Systems Biology, Harvard Medical School
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Chris Rycroft PhD
Professor of Mathematics, University of Wisconsin-Madison
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Polly Yu PhD
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Assistant Professor of Mathematics, University of Illinois Urbana-Champaign
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