

NIKITA SIVAKUMAR

I am a PhD candidate in biomedical engineering at Johns Hopkins University with a focus on building, validating, and exploring **data-driven, mathematical models to quantify how molecular and cellular processes drive tissue function**.

I am experienced in leveraging sparse or high-dimensional biological data to build agent-based, ODE, and machine learning models to gain mechanistic insights into physiological and disease processes. I am seeking an internship where I can apply my combined expertise in statistics and mathematical modeling to inform precision medicine.

Education

Johns Hopkins University

Ph.D. Biomedical Engineering

GPA: 4.0/4.0; **In progress**.

University of Virginia

B.S. Biomedical Engineering,

Minors in Computer Science & Engineering Business

GPA: 3.86/4.0; **May 2022**.

Thomas Jefferson High School for Science & Technology

GPA: 4.250; **June, 2018**.

Skills

Computational Systems Bioengineering

Mechanistic. Agent-based, Cellular Potts, ODE, signaling network, pharmacokinetic/dynamics, parameter optimization, sensitivity analysis.

Data science. Dimensionality reduction, unsupervised clustering, image analysis, machine learning, neural networks (convolutional & autoencoder)

Omics & Big Data

FastQC, STAR alignment, differential expression, single-cell and spatial transcriptomic analysis (cell type identification, cell-cell interaction analysis, community detection), metabolite set enrichment analysis

Programming

Python (*numpy, pandas, matplotlib, seaborn, scikit-learn, pytorch, scanpy*),

R (*tidyverse, ggplot, Shiny, Seurat*),

C++, Java, MatLab, Bash, HPC/SLURM, NetLogo

Computational Biology Experience

PhD Candidate

Johns Hopkins University

August, 2022-Present

PIs: Dr. Feilim Mac Gabhann &

Dr. Jude Phillip

Focus: Systems Immunology

- **Thesis:** Integrating **machine learning and mechanistic modeling to understand how single-cell lymphocyte motility and spatial organization drive the antibody response** to infection or vaccination.
- Built an unsupervised machine learning pipeline to quantify emergent single-cell motility behaviors from time-lapse, imaging data.
- Developed & validated agent-based simulation to simulate observed single-cell motility behaviors to predict their impact on cell-cell interaction.
- Developing mixed distribution statistical approaches to simulate observed single-cell behaviors.
- Developing statistical approaches to quantify cell spatial organization from sparse imaging data and applying simulations to understand how spatial context influences immune behavior.
- **Outcomes:** 3 contributed talks, 4 poster presentations, 2 manuscripts
- Applied unsupervised machine learning to identify novel tissue damage signatures from cell-free, methylated DNA in aging patients.
- Identified novel metabolic pathways enriched with each tissue damage signature to gain mechanistic insights.
- Found **predictive associations between cell-free DNA (liquid biopsies) and co-morbidities, including cardiovascular disease and frailty**.
- **Outcomes:** 1 conference abstract, 1 manuscript
- Led a multidisciplinary engineering team in applying unsupervised machine learning to **identify novel pressure-volume coupling phenotypes within pulmonary hypertension patients**. Applied supervised machine learning approaches to predict these phenotypes using standard multimodal measurements of the heart (hemodynamics, MRI).
- **Outcomes:** 2 contributed talks, 1 poster presentation, 1 manuscript

Computational Researcher

Johns Hopkins University

May, 2023-May, 2024

PIs: Dr. Jude Phillip, Dr. Peter Abadir, Dr. Lolita Nidadvolu

Focus: Computational Medicine

Precision Care Medicine Lead

Johns Hopkins University

August, 2022-May, 2023

PIs: Dr. Joe Greenstein, Dr. Casey Taylor, Dr. Catherine Simpson

Focus: Computational Medicine

Rotational PhD Student

Johns Hopkins University
August, 2022 - October, 2022
PIs: Dr. Jean Fan
Focus: Spatial transcriptomics

Undergraduate researcher

University of Virginia
January, 2019 - August, 2022
PIs: Dr. Shayn Peirce-Cottler &
Dr. Matthew Lazzara
Focus: Systems biology

Undergraduate researcher

University of Virginia
August, 2020 - December, 2020
PI: Mete Civelek, Ph.D. (BME)
Focus: Single-cell transcriptomics

Undergraduate researcher

University of Virginia
October, 2020 - January, 2021
PIs: Dr. Gianluca Guadagni
Focus: Epidemiological
simulation

- Developed a novel algorithm to identify distinct multi-cellular spatial patterns from spatially-resolved, single-cell transcriptomic data.
- Integrated superpixelation, connected components, and graph-based clustering algorithms to identify distinct cell-type spatial patterns from *CODEX* and *MERFISH* datasets.
- Developed and validated agent-based model of synthetic gene circuits that induce differential adhesion between cell types to drive multicell spheroid patterning. Performed sensitivity analysis on this model to **identify time- and space- dependent cell-cell behaviors that regulate multicell patterning in development and disease processes**.
- Created and implemented a novel sensitivity analysis pipeline that utilizes unsupervised machine learning to identify how combinations of cell-to-cell signaling parameters drive the formation of distinct multicell patterns.
- **Outcomes:** 3 contributed talks, 3 poster presentations, 1 manuscript, 2 review articles
- Analyzed single-cell RNAseq data from primary, circulating, and secondary pancreatic cancer tumor samples to explore intra-tumoral heterogeneity.
- Quantified cell-type specific variation in expression of epithelial-mesenchymal transition markers.
- Performed single-cell RNAseq quality control, alignment, cell-type identification, and differential gene expression analyses.
- Developed an agent-based simulation framework to simulate the spread of Covid-19 across the UVa campus.
- Implemented student specific movement patterns on a spatially-accurate map along with interventions including masking, social distancing, hybrid courses, and quarantining.
- Quantitatively identified public measures that could contain the spread of the disease.
- **Outcomes:** 1 contributed talk

Teaching Experience

Graduate Student Professor- Introduction to Data-Driven Computational Modeling ¹, Mechanistic and Data-Driven Insights into Disease², Data Science-Driven Simulations³

Johns Hopkins University
September, 2023 - January, 2025

Teaching Assistant - Precision Care Medicine

Johns Hopkins University
September, 2023 - May, 2024

- ¹Designed and taught two-credit fall semester course that explored applying data-driven methods to develop and parameterize agent-based simulations of complex, real-world systems. Mentored students on semester-long team projects that spanned topics including cancer metastasis, supply chain management, and information dissemination.
- ²Designed and taught two-credit intersession course that explored deterministic, stochastic, and data-driven modeling to understanding biological diseases from a multiscale perspective.
- ³Designed and taught two sections of 1-credit undergraduate fall course that introduced students to building mathematical simulations to answer multi-disciplinary research questions.
- Mentored student teams on data-driven research projects in collaboration with clinicians at the Johns Hopkins School of Medicine. Met weekly with student teams and clinicians to guide the development of machine learning applications to improve patient care.
- Notable projects included deep learning models to predict eye torsional movements, convolutional neural networks to improve pulse oximetry measurements in darker skin tones, and unsupervised approaches to improve skin allergy subtype identifications.

**Undergraduate Student Professor-
Introduction to Agent-Based Modeling¹,
Introduction to Data-Driven Computational Modeling²**

University of Virginia

¹August, 2019 - May, 2020

²August, 2021 - December, 2021

- Designed curriculum for one-credit course on agent-based modeling to undergraduate- and graduate- level students. Taught course for two semesters to a total of 20 students.¹
- Refined this curriculum to offer a new course on integrating stochastic modeling and data-driven techniques to explore real-world systems. Taught course for one semester to 14 enrolled students.²
- Wrote and delivered 10 weekly lectures, created student assessments, and mentored students on team-based, semester-long modeling projects of their choice. Modeling projects have included embryonic stem cell differentiation, Covid-19 transmission, and fake news spread.

Leadership & Outreach

Co-president of Women of Whiting

Johns Hopkins University

June, 2024- Present

Co-presidency started in 2025

- Leads the primary women advocacy student group for Johns Hopkins engineering graduate students.
- Spearheading the implementation of a monthly lunch series with women professors at Hopkins to create a space for graduate students to learn about the unique nuances of navigating academia as a woman in STEM.
- Organizes an annual Women of Whiting conferences (100+ registrants) that brings together women in industry and academia from the local DMV area for a series of professional development activities.

Lab Manager for the Phillip Lab

Johns Hopkins University

June, 2023- June, 2024

- Coordinated logistics for lab maintenance, purchases, and social events for the Phillip Lab.
- Advocated for the Phillip Lab at monthly meetings with the Institute for NanoBiotechnology administration.

Data Team Lead, Dysphagaid

Engineering Going Global (EGG)

September, 2018 - May, 2022

- Led the data-driven modeling group at Dysphagaid, a student team of biomedical engineers that focused on creating a drinking aid for patients with the swallowing disorder, dysphagia.
- Guided team in applying web scraping and natural language processing to assess patient sentiment towards current dysphagia products and used this data to define new design requirements.

Teaching Design Engineer

Clark Elementary School

August, 2018 - December, 2018

- Collaborated with team of engineers to create a hands-on fraction math game to aid in student learning.
- Worked with local third grade class to understand difficulties young students face with grasping math concepts in the classroom.

Girl Scout Senior

Girl Scouts for America

September, 2008 - August, 2018

- Earned the **Girl Scout Gold Award**, the highest honor a girl scout can receive, for developing and implementing a program for learning effective study strategies for local high schoolers.
- Logged 1000+ hours of local, national and global service through consistent activities such as volunteering at local soup kitchens, tutoring students in the local community, honoring veterans, and volunteering at a deaf and dumb school in Chennai, India.

Awards

Achievement Rewards for College Scientists Fellowship (October, 2025)

Named an ARCS scholar by the Metropolitan Washington DC chapter for her thesis work in identifying tunable immune cell behaviors that shape an effective antibody response. Awarded \$15,000 by the Global Autoimmune Institute.

INBT Symposium Best Poster Award (May, 2025)

Won \$500 best graduate poster award at the Annual Institute for NanoBiotechnology Symposium for her poster on multi-scale modeling of immune interactions.

BME Distinguished Teaching Award (October, 2024)

Awarded the JHU departmental distinguished teaching award for her contribution to designing and teaching three successful undergraduate courses and serving as a teaching assistant for Precision Care Medicine.

National Science Foundation Graduate Research Fellowship (August, 2023 - August, 2026)

Awarded the NSF GRFP award as an undergraduate in April, 2022 which provides a \$34,500 stipend for three years of PhD studies at any institution.

Johns Hopkins University Biomedical Engineering Rotational Fellowship (August, 2022 - August, 2023)

Received fellowship to conduct first-year PhD studies in several labs at the John Hopkins BME program.

UVa School of Engineering and Applied Sciences Outstanding Student Award (April, 2022)

Recognized as an outstanding student in the school of engineering at UVa and presented with an engraved Revere Bowl.

Global Infectious Disease Institute Undergraduate Excellence In Research Award (January, 2021)

Team of two recognized with \$500 award for developing a computational model that predicted Covid-19 spread at UVa.

Arnold & Mabel Beckman Scholarship (March, 2020 - August, 2021)

This scholarship is one of the top national research awards for undergraduates. Received \$21,000 to continue predictive modeling of multicellular pattern formation over two summers and one academic year.

NanoStar Summer Undergraduate Research Program Fellowship (June, 2019 - August, 2019)

Awarded \$3,000 to conduct summer undergraduate research aimed on applying agent-based modeling to identify cell-cell behaviors that impact pattern formation in development and disease.

Peer-reviewed publications

N. Sivakumar, C. Min, L. Choe, W. Beguelin, F. Mac Gabhann, J.M. Phillip. "A computational platform to predict how lymphocyte motility drives germinal center B-T interactions." *Biorxiv*. 2025.

<https://doi.org/10.1101/2025.08.05.668700>

N. Sivakumar, C. Zhang, C. Chang-Chien, ..., C.O. Taylor, J. Greenstein, S. Hsu, P.M. Hassoun, C.E. Simpson. "A machine learning approach to predict emergent right ventricular pressure-volume phenotypes in pulmonary hypertension." *Pulmonary Circulation*. 2025. <https://doi.org/10.1002/pul2.70057>

L.S. Nidadavolu*, D. Sosnowski*, **N. Sivakumar***, D.A. Bennett, J.M. Phillip, B. Maher, J.D. Walston, E.S. Oh, P.M. Abadir. "Cardiovascular-Derived Cell-Free DNA: Associations With Frailty and Aging-Related Comorbidities." *Journal of Gerontology: Biological Sciences*. 2025. <https://doi.org/10.1093/gerona/glaf081>

D. Maity*, **N. Sivakumar***, P. Kamat, ..., J.M. Phillip. "Profiling emergent patterns of single-cell motility." *Advanced Science*. 2024. <https://doi.org/10.1002/adv.202400918>

N. Sivakumar*, C. Mura*, S.M. Peirce. "Innovations in Integrating Machine Learning and Agent-Based Modeling of Biomedical Systems." *Frontiers in Systems Biology | Multiscale Mechanistic Modeling*. 2022. <https://doi.org/10.3389/fsysb.2022.959665>

N. Sivakumar, H.V. Warner, S.M. Peirce, M.J. Lazzara. "A computational modeling approach for predicting multicell patterns based on signaling-induced differential adhesion." *PLOS Computational Biology*. 2022. <https://doi.org/10.1371/journal.pcbi.1010701>

H.V. Warner, **N. Sivakumar**, S.M. Peirce, M.J. Lazzara. "Multiscale computational models of cancer." *Current Opinion in Biomedical Engineering*. 2019. <https://doi.org/10.1016/j.cobme.2019.11.002>

*indicates co-first authorship

Abstracts & Presentations

N. Sivakumar, C. Min, K. Choe, W. Beguelin, J.M. Phillip, F. Mac Gabhann. "Data-driven simulations elucidate how lymphocyte motility drives cell-cell interactions during the antibody response." ARCS Scholar Reception. October 23, 2025. DC. (Poster presentation).

N. Sivakumar, C. Min, K. Choe, W. Beguelin, J.M. Phillip, F. Mac Gabhann. "Multi-Scale Modeling Elucidates How Different Motility Impacts Germinal Center B-T Interactions." ARCS Scholar Reception. May 5, 2025. Baltimore, MD. (Poster presentation).

N. Sivakumar, C. Min, K. Choe, W. Beguelin, J.M. Phillip, F. Mac Gabhann. "Data-driven simulation to quantify the effect of lymphocyte motility on germinal center B-cell:T-cell interactions." Institute for Computational Medicine Retreat.

December 10, 2024. Baltimore, MD. (Oral presentation).

- L.S. Nidadavolu, D. Sosnowski, **N. Sivakumar**, D.A. Bennett, J.M. Phillip, B. Maher, J.D. Walston, E.S. Oh, P.M. Abadir. "Cardiovascular-Derived Cell-Free DNA: Associations With Frailty and Aging-Related Comorbidities. Gerontological Society of America Annual Scientific Meeting. November 13-16, 2024. Seattle, WA. (Conference abstract). <https://doi.org/10.1093/geroni/igae098.1722>
- N. Sivakumar**, C. Min, K. Choe, W. Beguelin, J.M. Phillip, F. Mac Gabhann. "Multi-cellular simulations predict motility-driven B- and T-cell germinal center interactions." Annual Biomedical Engineering Society Conference. October 23-26, 2024. Baltimore, MD. (Oral presentation).
- C. Min, K. Choe, **N. Sivakumar**, C. Xu, W. Beguelin, J.M. Phillip. "Dynamic behaviors of Ezh2 mutant B cell and interaction with follicular dendritic cell and T follicular helper cell within germinal centers." Annual Biomedical Engineering Society Conference. October 23-26, 2024. Baltimore, MD. (Poster presentation).
- N. Sivakumar**, C. Min, K. Choe, W. Beguelin, F. Mac Gabhann, J.M. Phillip. "Data-driven simulation elucidates role of lymphocyte motility in driving germinal center cell-cell interactions." Johns Hopkins Department of Medicine Research Retreat. February, 14, 2024. Baltimore, MD. (Poster presentation).
- N. Sivakumar**, C. Min, K. Choe, W. Beguelin, F. Mac Gabhann, J.M. Phillip. "Identification of differential motility patterns in germinal center light zone lymphocytes." Annual Biomedical Engineering Society Conference. October 11-14, 2023. Seattle, WA. (Poster presentation).
- N. Sivakumar**, D. Maity, C. Min, ..., J.M. Phillip. "CaMI: A data-driven tool to analyze emergent spatiotemporal differences in single-cell motility." Annual Biomedical Engineering Society Conference. October 11-14, 2023. Seattle, WA. (Oral presentation).
- N. Sivakumar**, C. Chang-Chien, C. Zhang, P. Gu, Y. Li, Y. Yang, C.O. Taylor, J. Greenstein, C.E. Simpson. "A data-driven approach to improve patient risk stratification in pulmonary hypertension." Biomedical Engineering Design Day. May 1st, 2023. Baltimore, MD. (Oral presentation and poster).
- N. Sivakumar**, C. Chang-Chien, C. Zhang, P. Gu, Y. Li, Y. Yang, C.O. Taylor, J. Greenstein, C.E. Simpson. "A data-driven approach to define pathobiological classifications of pulmonary hypertension." Computational Medicine Night. March 27, 2023. Baltimore, MD. (Oral presentation).
- N. Sivakumar**, M. J. Lazzara, S.M. Peirce. "Hybrid, Multiscale Modeling of Signaling-Induced Pattern Formation in Multicell Spheroids." Annual Biomedical Engineering Society Conference. October 12-15, 2023. San Antonio, TX. (Oral presentation).
- N. Sivakumar**, M. J. Lazzara, S.M. Peirce. "A Computational Framework to Explore Multi-cell Spheroid Patterning with Synthetic Gene Circuits." World Congress of Biomechanics. July 10-14, 2023. Taipei, Taiwan. (Oral virtual presentation).
- N. Sivakumar**, M. J. Lazzara, S.M. Peirce. "Agent-Based Modeling of Multi-cell Spheroid Patterning using Synthetic Gene Circuits." Annual Biomedical Engineering Society Conference. October 6-9, 2021. Orlando, FL. (Poster presentation).
- N. Sivakumar**, S. M. Peirce. "Agent-Based Modeling and Machine Learning to Explore Multi-cell Spheroid Patterning." Beckman Symposium. August 5-7, 2021. Virtual Meeting. (Oral and poster presentation).
- N. Sivakumar**, J. Lipowski, G. Guadagni. "ABM of Covid-19 Spread at UVA." Global Infectious Diseases Institute Excellence in Undergraduate Research Award Symposium. January 21st, 2021. Virtual Meeting. (Oral presentation).
- N. Sivakumar**, Shayn M. Peirce, Matthew J. Lazzara. "Agent-Based Modeling for Designing Multi-Cell Patterns Using Synthetically-Engineered Gene Circuits." Annual Biomedical Engineering Society Conference. October 14-17, 2020. Virtual Meeting. (Poster presentation).
- N. Sivakumar**, H. V. Warner, M. J. Lazzara, S. M. Peirce. "Agent-Based Modeling of Self-Sorting Behaviors in Heterogeneous N-Cadherin and P-Cadherin Spheroids." Annual Biomedical Engineering Society Conference. October 16-19, 2019. Philadelphia, PA. (Poster presentation).