LEVIN LAB MEMBERS 2023–2024

CONTENTS

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DIRECTOR & ADMINISTRATOR

Simon A. Levin
Sandi Milburn
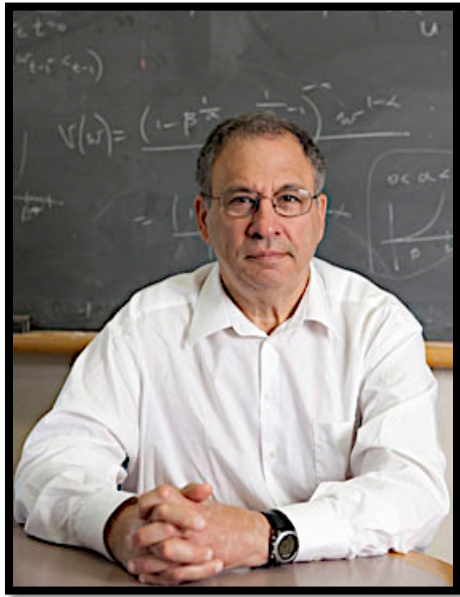
Simon A. Levin

Director, Levin Lab
James S. McDonnell Distinguished University Professor in Ecology &
Evolutionary Biology
Director, Center for BioComplexity in the High Meadows Environmental Institute

Simon A. Levin is the James S. McDonnell Distinguished University Professor in Ecology and Evolutionary Biology at Princeton University. He received his B.A. from Johns Hopkins University and his Ph.D. in Mathematics from the University of Maryland. Levin is a Fellow of the American Academy of Arts and Sciences and the American Association for the Advancement of Science, a Member of the National Academy of Sciences and the American Philosophical Society, and a Foreign Member of the Istituto Veneto and the Istituto Lombardo. He is a University Fellow of Resources for the Future, a Fellow of the Beijer Institute of Ecological Economics, a Fellow of the Society for Industrial and Applied Mathematics, a Fellow of the Society for Mathematical Biology, a Fellow of the American Mathematical Association, a Distinguished Fellow of the Luohan Academy, and a Fellow of the Academia Europaea. He is a former President of the Ecological Society of America and the Society for Mathematical Biology, Chair of the Council of IIASA, Chair of the Board of the Beijer Institute, and Chair of the Science Board of the Santa Fe Institute. He has received numerous awards including the Kyoto Prize in Basic Sciences, Heineken Prize for Environmental Sciences, Margalef Prize for Ecology, Tyler Prize for Environmental Achievement, the U.S. National Medal of Science, and the BBVA Foundation Frontiers of Knowledge Award in Ecology and Conservation Biology. He has mentored more than 150 Ph.D. students and Postdoctoral Fellows.
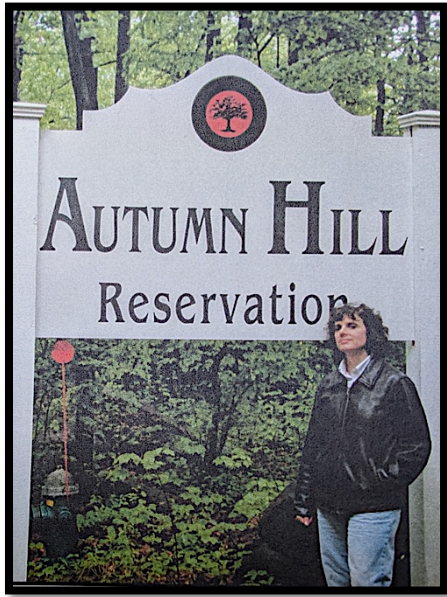
Sandi Milburn
Administrator, Levin Lab

Sandi Milburn is the administrator of the Levin Lab. She holds a degree in Anthropology, with substantial coursework in biological anthropology. Before joining the Levin Lab, she worked for Princeton's Programs in Creative Writing, Theater and Dance, and Visual Arts (now part of the Lewis Center for the Arts), where she designed posters and playbills, wrote press releases, and managed publicity for the Programs' events.

ASSOCIATE & VISITING RESEARCH SCHOLARS, PROFESSIONAL SPECIALISTS

Stefani Crabtree
George Hagstrom
Denis Patterson
Saverio Perri

Stefani Crabtree

Visiting Research Scholar, Utah State University

Stefani Crabtree is a Visiting Research Scholar to the Levin Lab, having joined in spring of 2020. She is currently Assistant Professor of Social-Environmental Modeling at Utah State University and External Faculty at the Santa Fe Institute. She completed a Ph.D. in Anthropology from Washington State University (2016) and a Ph.D. in Archéologie, Territoires et Environnements from the Université de Franche-Comté (2017). Her work uses complex adaptive systems modeling, such as agent-based models and network models, to understand the archaeological past and to leverage the archaeological record as a calibration dataset for sustainability challenges in the present and future.

Crabtree's recent work weaves together disparate strands of science to found a new field of 'archaeoecology' that acts as a bridge between paleoecology and modern ecology and explicitly includes humans as described in detail by her recent paper "Towards a Science of Archaeoecology" in the journal *Trends in Ecology and Evolution*. While studies of the abiotic environment are well established in archaeology (e.g., climate reconstruction from tree rings) examining full ecosystems from the archaeological past in a comprehensive and quantitative way—and assessing the human place within those ecosystems— is novel. She leads research projects in Western Australia, Northern Mongolia, and the American Southwest that combine fieldwork and computational modeling to query the past to be able to advance questions on sustainability into the future. Her work has impacted governmental policy on environmental management in arid ecosystems. She holds additional positions at the Australian Research Council Centre of Excellence for Australian Biodiversity and Heritage and at Crow Canyon Archaeological Center.

George Hagstrom
Professional Specialist, Department of Ecology & Evolutionary Biology

George Hagstrom studies emergent properties in complex adaptive systems, with particular focus on marine ecosystem function, biogeochemical cycles, and collective behavior in biological, social, and economic systems. One of Hagstrom's primary goals is to develop marine ecosystem models that capture biodiversity and adaptation, and to use these models to improve our understanding of key macroscale features of marine ecosystems and to predict how these ecosystem functions will respond to climate change and other anthropogenic perturbations. He uses a trait-space based description, rather than one based on species, to find a reduced-dimensionality representation of highly diverse marine ecosystems. He developed the trait-based ATOM model of marine phytoplankton and used it to show how dynamics in the elemental stoichiometry of phytoplankton induce novel couplings and feedbacks in marine biogeochemical cycles. He has implemented ATOM within an IPCC, CMIP6 grade Earth System Model, and is actively studying dynamic stoichiometry impacts nutrient limitation, primary productivity and carbon export, and nitrogen fixation. Hagstrom is working to extend the ATOM framework to incorporate genetic data, using quantitative systems biology, with the aim of better understanding the trade-offs between heterotrophic metabolic strategies and the relevance of genetic differences in *Prochlorococcus* and *Synechococcus* genetic differences across oligotroiphic ecosystems. Hagstrom is also actively working on a project to better understand how the microscopic dynamics of complex systems can be used to better anticipate or to manage critical transitions, using an approach directly inspired by statistical physics.

Denis Patterson

Visiting Research Scholar, Durham University, UK

Denis Patterson joined the Levin Lab in November 2020 as a Postdoctoral Researcher and is now an Assistant Professor in Applied Mathematics at Durham University. He previously received a Ph.D. in Applied Mathematics from Dublin City University under the supervision of Prof. John Appleby. His thesis employed techniques from nonlinear and stochastic analysis to study functional differential equations subject to random forcing. He then joined Professor Jonathan Touboul's group at Brandeis University where he began applying his mathematical training to problems in biology, ecology, and neuroscience.

Denis has worked extensively on spatially explicit models of forest-savanna ecosystems, including rigorously deriving such models from microscale interaction rules and studying their dynamics in detail. The goal of this work is a better understanding of the implications of empirically observed forest-savanna bistability and of the resilience of these ecosystems more generally. He is also interested in mathematical models of malaria, both at the population and within-host scales, as well as problems in biological development. Dynamical systems, stochastic analysis and (nonlocal) PDEs, are common tools across his various projects.
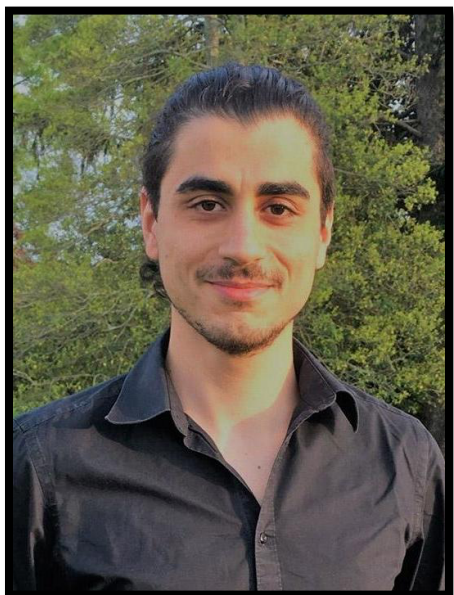
Saverio Perri
Visiting Research Scholar, Santa Fe Institute

Saverio Perri joined the Levin research group in September 2020 as part of the Earth Resilience and Sustainability Initiative (ERSI). In September 2023, he has joined the Santa Fe Institute (SFI) as an Applied Complexity Postdoctoral Fellow and continues to be part of the Levin group as a visiting scholar. Saverio completed a Ph.D. in Interdisciplinary Engineering at Masdar Institute (MI), Khalifa University, as part of the MI & MIT collaborative program. At MI, where he was advised by Professor Annalisa Molini (now at Tulane University), Saverio investigated the hydrological controls of soil salinization across a wide range of temporal and spatial scales – ranging from the plant to the catchment scale.

The focus of his current work has been on food systems and coupled human-natural systems. His project on food systems aims at characterizing the trade-offs and synergies within the global food system. The main goals consist of quantifying the extent to which global crop production is limited by biophysical constraints such as salinity and aridity, assessing the environmental consequences of these limitations, and ultimately identifying possible pathways of sustainable change.

Within the framework of coupled human-natural systems, he is investigating the socio-political feedback on climate change mitigation actions. In particular, Saverio is exploring the complex interactions between policy, technology, and societal norms that shape the adoption and diffusion of sustainable practices and technologies using a combination of quantitative and qualitative tools.

POSTDOCTORAL RESEARCH ASSOCIATES & FELLOWS

Talia Borofsky
Guillaume Falmagne
Giuseppe Ferro
Victoria Junquera
Nusrat Molla
Woi Sok Oh
Annie Stephenson
Emma Zajdela

Talia Borofsky

Postdoctoral Research Fellow, High Meadows Environmental Institute

Talia Borofsky joined the High Meadows Environmental Institute as a postdoctoral research fellow in August 2023 and is also affiliated with Hebrew University University's Ecology, Evolution, and Behavior Department. She received her Ph.D. in Biology from Stanford University, where she researched the evolution of social learning and cooperation by predators with advisor Professor Marcus Feldman.

She is now researching reciprocal niche construction between ecologically distinct types of cooperative traits. Her research will be conducted in collaboration with Princeton Professors Simon Levin, Daniel Rubenstein, and Naomi Leonard (Mechanical and Aerospace Engineering), as well as with Professor Erol Akçay (University of Pennsylvania) and Professor Gili Greenbaum (Hebrew University). Through this collaboration, she will use both theoretical modeling and data analysis to untangle the connections between ecology and the evolution of cooperation.

Guillaume Falmagne

Postdoctoral Research Associate, High Meadows Environmental Institute

Guillaume Falmagne joined Princeton's High Meadows Environmental Institute (HMEI) in September 2022. Before that, he worked at LLR (École Polytechnique, Palaiseau/Paris) where he received a Ph.D. in Physics. He investigated properties of the quark-gluon plasma using data from heavy ion collisions in the CMS detector at LHC (the 27-km particle accelerator at CERN, Geneva). In particular, he led the first observation of the Bc particle in that peculiar state of matter.

He is now interested in collective phenomena in large groups through the lens of critical transitions and big data analysis. One project, together with postdoc Annie Stephenson, is based on data from a 10-million-user collaborative game on Reddit. He used machine learning techniques to build performant early warning signals for local transitions in the game. The collaborative nature of the game also allows to gain understanding of the organizational structures that favor cooperation at large scales, and of the dynamics of conflicts and group formation. In another project, he determines how the structure of the moisture network affects cascading transitions in the Amazon rainforest. He is also interested in complex systems that show feedback between their social and ecological components.

Giuseppe M. Ferro

Postdoctoral Research Fellow, High Meadows Environmental Institute

Giuseppe Ferro joined the High Meadows Environmental Institute in October 2022. Before that, he worked at ETH Zürich where he received a Ph.D. in Economics. He analyzed how real human beings make decisions under uncertainty, as opposed to what they should do. Specifically, he focused on developing operational models of individual decision-making in risky and ambiguous setups, representing the decision activity as a stochastic process, and working at different levels of abstraction (axiomatic models, low-dimensional stochastic processes, and computational models).

He is now interested in incorporating behavioral economics into climate models, adopting a complex systems approach. One of his projects aims to understand how recommendation algorithms on social media affect opinion dynamics on controversial issues such as climate change, analyzing the unintended consequences of an unregulated "attention" market. Another project involves studying how intra-firm multi-authority structures impact the pursuit of multiple conflicting goals (e.g., being profitable while being environmentally responsible).
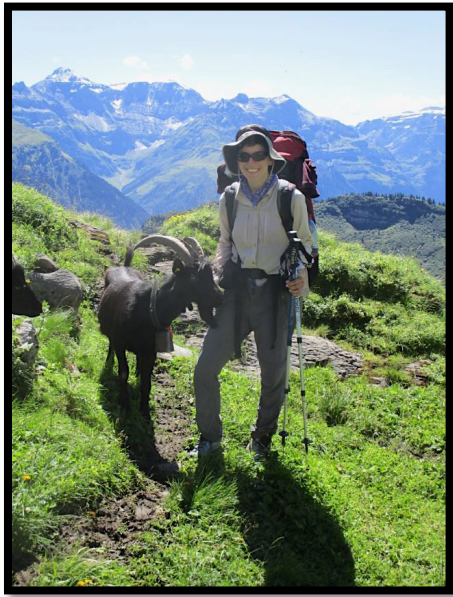
Victoria Junquera

Postdoctoral Research Associate, High Meadows Environmental Institute

Victoria Junquera joined HMEI and the research labs of Simon Levin and Daniel Rubenstein as a postdoc in September 2021 as a member of the Earth Resilience and Sustainability Initiative (ERSI). She completed her Ph.D. at the Group for Planning of Landscape and Urban Systems (PLUS) at ETH Zurich on the topic of crop booms in Lao PDR. Additional work focused on farmers' changing social networks in a Swiss mountain region. Her current work continues to pursue the topics of critical transitions in land systems and social networks in agriculture, while expanding case study areas and commodities to avocado growing regions in Spain and Israel. Her work is primarily based on mixed qualitative and quantitative analysis of empirical case-study data and focuses on three broad topics. First, theoretical work on land regime shifts based on empirical evidence of commodity crop expansion. Second, farmers' social relations and the interconnection between social and structural change in agriculture. And third, an in-depth analysis of water governance structures in arid agricultural regions and the impact of governance structures on water use and land-use dynamics. Victoria is also interested in the intersection between markets and land system changes.

Nusrat Molla

Distinguished Postdoctoral Research Fellow, The Andlinger Center

Nusrat Molla joined Simon A. Levin and Elke U. Weber's Labs in July 2023 as a Distinguished Postdoctoral Research Fellow at the Andlinger Center. She completed her Ph.D. at University of California, Davis, in which she focused on using dynamical systems modeling, sometimes coupled with qualitative analysis, to understand the social dynamics of resource extraction and governance. This work included, for example, exploring stabilizing and destabilizing factors in governance systems, and conducting a case study in California's San Joaquin Valley to understand how different water governance structures and management strategies shape different actors' influence and sensitivity to changes.

She plans to build on this work by modeling the conditions under which rural communities reliant on extractive industries can transition to other livelihoods and forms of production, with a focus on understanding the roles of institutions, attitudes towards adaptation, and building of social capital within communities. She will use coal mining-reliant communities in Appalachia as a case study, using surveys and interviews with stakeholders to inform model development.
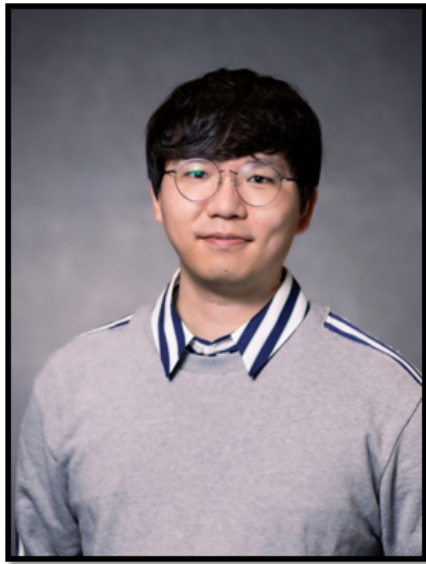
Woi Sok Oh

Postdoctoral Research Associate, High Meadows Environmental Institute

Woi Sok Oh started working with Simon Levin and Daniel Rubenstein in Fall 2021. Before coming to Princeton, he received a Ph.D. degree in Agricultural and Biological Engineering at the University of Florida, mentored by Rachata Muneepeerakul. He was trained in complex system modeling (dynamical system modeling and agent-based modeling) in the problems of coupled natural-human systems such as resource management, urban evacuation, and environmentally-induced migration.

At Princeton, he focuses on understanding forced migration from the network perspective. He works on network analysis and modeling of internal displacement in Somalia to (1) detect systematic network patterns hidden behind complex movements and (2) find significant drivers of forced migration. From complex systems approaches, he ultimately aims to solve the puzzling interactions between climate, conflict, and migration. In addition, he is interested in other human-nature interactions such as food trade, flood insurance, and climate negotiations.

Annie Stephenson

Postdoctoral Research Associate, High Meadows Environmental Institute

Annie Stephenson joined the High Meadows Environmental Institute in September 2022 and is also affiliated with the Stockholm Resilience Center and the Potsdam Institute for Climate Impact Research. She completed her Ph.D. at Harvard University in Applied Physics. Her Ph.D. work combined experimental measurements and theoretical models to understand and tune light scattering in correlated, disordered systems for applications in structural color. Through her work with agent-based models for light scattering and data-informed model-building, she developed an interest in understanding other complex systems with large numbers of interacting components.

As a postdoctoral researcher at Princeton, Annie is studying human collective behavior. In particular, she is interested in the dynamics of cooperation and conflict and collective action. In one project, in collaboration with postdoc Guillaume Falmagne, she is working to characterize patterns, including critical transitions and early warning signals of those transitions, using data from a collaborative game on the discussion website Reddit. In this same Reddit dataset, she is also investigating scaling laws in organizations using techniques borrowed from urban scaling theory, aiming to develop an understanding of why some communities can successfully mobilize individuals to reach a common goal, while others cannot. Annie and Guillaume have begun collaborating with a group of researchers at the Santa Fe Institute to further study the Reddit community structure. In another project, Annie is using social media data to understand the dynamics of fashion trends—why some spread quickly but are soon forgotten and why others can remain popular for much longer. In a project in collaboration with Professors Naomi Leonard (Princeton, Mechanical and Aerospace Engineering) and Scott Althaus (University of Illinois, Urbana-Champaign), she plans to examine data collected as part of the Social, Political, and Economic Event Database Project (SPEED) to understand the growth dynamics of social movements. Additionally, Annie attended the Complex Systems Summer School at the Santa Fe Institute, where she formed several group projects that are still active, and she has since been back to the Santa Fe Institute for two other workshops.

Emma Zajdela

Postdoctoral Research Associate, High Meadows Environmental Institute, C-PREE; ORISE IC Postdoctoral Research Fellowship at Princeton University for Modeling the Dynamics of Complex Socio-Ecological Systems at the Nexus of Environmental Challenges, Scientific Collaboration, and Conflict

Emma Zajdela will join Princeton and the Levin Lab in October 2023. Previously, she completed her Ph.D. in the Department of Engineering Sciences and Applied Mathematics at Northwestern University, where she was a recipient of the National Science Foundation Graduate Research Fellowship, Buffett Institute Global Impacts Fellowship, and NICO Intersection Science Fellowship. Her research focuses on developing mathematical models to understand and predict complex social phenomena with real-world applications. She has worked on topics ranging from the mathematics of poker, autonomous vehicles, scientific collaboration at virtual and in-person conferences, and fashion trends. Since 2015, she has worked with the Malta Conferences Foundation, a non-profit organization that uses science diplomacy in the Middle East and currently serves as Treasurer and Member of the Board of Directors.

At Princeton, Emma's research will focus on modeling the dynamics of complex socio-ecological systems at the nexus of environmental challenges, scientific collaboration, and conflict. In human societies, environmental, historical, and cultural factors interplay to drive conflict. Therefore, to understand the dynamics of human systems, we must understand the environment in which they reside. A focus of the project will be to apply and test the model in the context of water scarcity, conflict, and science diplomacy in the Middle East. In collaboration with Professor Michael Oppenheimer (Princeton, School of Public and International Affairs, Department of Geosciences and HMEI), she will investigate the role of scientists in creating change in the public sphere particularly on shared environmental challenges including climate change.

GRADUATE STUDENTS

Matthew Cheung
Ari Freedman
Theo Gibbs
Anna Jacobson
Jiayu Li
Yimei Li
Maximilian Nguyen

Matthew Cheung
Ph.D. Student, Program in Applied and Computational Mathematics (PACM)

Matthew Cheung is a fourth-year Ph.D. student in the Levin Lab and the Program for Applied and Computational Mathematics at Princeton University. Before starting graduate school, he graduated from the University of California, Los Angeles with a B.S. in Applied Mathematics and a Specialization in Computing.

Matthew is interested in the interplay between human behavior/opinions and the dynamics of wealth in socioeconomic systems. This involves incorporating heterogeneity and aspects of human behavior, such as pro-social preferences and discounting, into models in ecological economics. His current research explores a dynastic model for intergenerational resource transfers under uncertain conditions, and the implications for inequality. Future work will look to integrate the dynamics of information and opinions regarding redistribution and pro-sociality, and the feedback from the dynamics of wealth.
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Ari Freedman

Ph.D. Student, Department of Ecology & Evolutionary Biology

Ari Freedman joined the Levin group in 2020 as a Ph.D. student in the Ecology and Evolutionary Biology department. He is primarily interested in developing new ways to measure and model the effects of various human behaviors on disease transmission dynamics, through both data-driven and theoretical approaches. Before joining the group, he worked in the Dwyer group at the University of Chicago studying the disease ecology of the Douglas fir tussock moth. He continues to work on problems in disease ecology centered around anthropogenic disturbance and the evolution of virulence.

Theo Gibbs
Ph.D. Student, Program in Quantitative and Computational Biology (QCB)

Theo Gibbs received a B.S. in Mathematics with Honors from the University of Chicago, where he characterized how population abundances affect the stability of large random ecosystems. He then spent a year at the University of Illinois at Urbana-Champaign, working on theory for microbial communities.

As a QCB graduate student at Princeton advised by Simon Levin and Jonathan Levine, Theo is interested in how higher-order interactions affect species coexistence in diverse ecological communities. Higher-order interactions emerge when the direct effect of one species on another changes in the presence of a third species. Although these kinds of interactions are likely frequent in nature, they are missing from most classical ecological models. Theo combines ecological theory and experimental data from annual plant communities to understand whether or not higher-order interactions can explain the coexistence we observe in nature. Aside from research, Theo likes to play soccer and discover new music.

Anna Jacobson
Ph.D. Student, Program in Quantitative and Computational Biology (QCB)

Anna Jacobson is a fifth-year graduate student with the program in Quantitative and Computational Biology. She joined the Levin Lab in 2020. A New York native, Anna attended Tufts University for her undergraduate degree, where she got a joint B.S. in Computer Science and Biology.

Anna's primary research interests involve climate and environmental policy. How can scientists perform meaningful work that maximally supports decisionmakers in D.C. and beyond? The start of her thesis work involved using mathematical decomposition to improve the runtime and accuracy of models used to inform capacity expansion decisions for energy systems in the continental United States. For the remainder of her work, she aims to study how abstraction and model design decisions impact real-world investment decisions and policy recommendations.

Jiayu Li

Ph.D. Student, Program in Applied and Computational Mathematics (PACM)

Jiayu Li is a first-year graduate student in Applied Math (PACM) at Princeton. She graduated from UCLA with a B.S. degree in Applied Math and Computational and Systems Biology. She is interested in understanding ecosystems with mathematical models. .She is currently exploring the possibilities to decide what to do in the next few years.
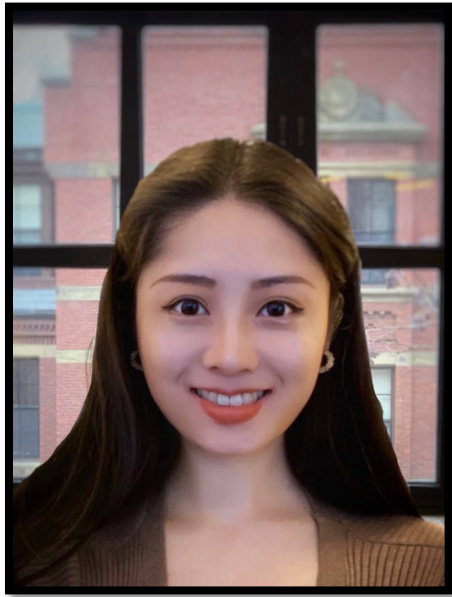
Yimei Li

Ph.D. Student, Program in Quantitative and Computational Biology (QCB)

Yimei Li is a second-year Ph.D. student in Quantitative and Computational Biology at Princeton University. She joined Levin Lab in May 2022, where she studied mathematical models for the ecology and evolution of infectious diseases, especially the dynamics at cross-scales. Before that, she worked on the dynamical modeling of dengue incidence.

Now, she works at the interface between theoretical models and empirical data, focusing on the population dynamics of infectious diseases. She is particularly interested in examining pathogens across multiple scales, from individual host interactions to broader population-level dynamics, with a special focus on the influence of human behavior. Additionally, she investigates in vivo biological data to deepen her understanding of disease mechanisms.

Maximilian Nguyen
Ph.D. Student, Program in Quantitative and Computational Biology (QCB)

Maximilian Nguyen is a fifth-year Ph.D. student in the Princeton QCB program and joined the Levin Lab as a graduate student in Summer 2020. He received a B.S. and M.S. in Chemical & Biological Engineering at Georgia Tech and Cornell University respectively. He was then a research assistant at Harvard Medical School and Dana-Farber Cancer Institute working on various problems in systems biology and the physics of life. Previously, he studied aspects of the information processing problem of how cells transcribe the genome, the decision problem of how stem cells decide what type of cell to differentiate into, and how the memory of the adaptive immune system changes over a human lifetime.

Motivated by the on-going pandemic, he started working on topics in epidemiology. His current research is focused on investigating the effectiveness of centralized versus decentralized control of human behavior during epidemic mitigation and analyzing the social and economic determinants of COVID-19 outcomes in rural settings. Beyond epidemiology, he is also developing a game theoretic framework for studying situations where players interact in multiple concurrent games on mixed timescales.