

## EMPLOYMENT

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### Channing Division of Network Medicine (CDNM)

Brigham and Women's Hospital, Harvard Medical School

Postdoctoral Research Fellow in Prof. Yang-Yu Liu's lab

Boston, Massachusetts

06/2021–present

## EDUCATION

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### University of Illinois Urbana-Champaign (UIUC)

Ph.D. in Physics, GPA: 3.97/4.00, Advisor: Dr. Sergei Maslov

Urbana, Illinois

08/2014–05/2021

### University of Science and Technology of China (USTC)

B.S. in Applied Physics, GPA: 3.98/4.30, Rank: 1/67

Hefei, Anhui

09/2010–06/2014

## RESEARCH

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Inspired by concepts from statistical physics, mathematics, ecology, epidemiology, and machine learning, I am broadly interested in developing computational methods for complex biological systems, with a focus on modeling microbial communities with diverse interactions. My overarching goal is to merge ecological models with multi-omics data to unveil the assembly rules of microbial communities. Furthermore, my research investigates the ecological and evolutionary dynamics shaped by intricate interactions. On a practical note, I predict metabolomic profiles based on microbial compositions and dietary intakes via ecology-based models and machine-learning methods. Then, I leverage these predictive tools to infer the interplay between microbes, metabolites, and dietary compounds. I have previously worked in the following areas:

- The ecological model of microbial communities with trophic levels and the ecology-guided prediction of microbe-metabolite interactions.
- Modeling of microbial communities with cross-feeding interactions, exchange of essential nutrients, the diauxic shift, or thermodynamic constraints
- Network analysis of interactions between gut microbes, dietary compounds, and metabolites based on genomes.
- Personalized prediction of metabolite concentration and metabolic response to dietary interventions.
- Functional redundancy of microbial communities based on metagenome and metaproteome.
- Network structure of CRISPR-induced arms-race co-evolution between bacteria and viruses.
- Infection dynamics of viruses (such as phage P1<sub>vir</sub>) on the chemotactic bacteria (such as *E. coli*).
- Agent-based model for the COVID infection and data analysis of internal COVID case data for operational purposes.
- Multi-omics-based disease diagnostics.

## SCHOLARSHIPS AND AWARDS

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| • The Les Houches School of Physics “Evolution of Diversity” Program Scholarship | 2018 |
| • UCLA-CSST Summer Research Scholarship                                          | 2013 |
| • Guo Moruo Scholarship (the highest honor in USTC)                              | 2013 |
| • China National Scholarship                                                     | 2012 |
| • XinDi Scholarship                                                              | 2011 |

## PAST WORK EXPERIENCE

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<b>University of Ottawa</b> Visiting scholar in Prof. Daniel Figey's lab	Ottawa, Ontario, Canada 05/2022–05/2022
<b>University of Illinois at Urbana-Champaign (UIUC)</b> Research assistant in Prof. Sergei Maslov's lab	Urbana, Illinois 01/2017–05/2021
<b>Peking University</b> Exchange student in Prof. Chao Tang's lab	Beijing, China 07/2017–08/2017
<b>Niels Bohr Institute</b> Visiting scholar in Prof. Kim Sneppen's lab	Copenhagen, Denmark 06/2017–07/2017

## TEACHING EXPERIENCE

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- Guest lecture, “Application of Machine-Learning Methods in Biology and Medicine”. Summer School hosted by School of Medicine, Peking University, 2023
- Guest lecture, “Regression models – predicting metabolomic profiles of microbial communities as an example”. Microbiome Data Science, BIO/MIC 494/598, Arizona State University, 2023
- Teaching Assistant, Statistical Physics, UIUC PHYS 504, 2017
- Teaching Assistant, Relativity Math Applications, UIUC PHYS 225, 2016-2017
- Teaching Assistant, Classical Mechanics II, UIUC PHYS 326, 2016
- Teaching Assistant, Classical Mechanics II, UIUC PHYS 326, 2015-2016
- Teaching Assistant, Quantum Mechanics II, UIUC PHYS 581, 2015
- Teaching Assistant, Classical Mechanics II, UIUC PHYS 326, 2014-2015

## INVITED TALKS

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- Predicting Metabolic Response to Dietary Intervention using Deep Learning. Oral presentation at AI in Biomedicine, Keystone Symposia, 05/2024
- Machine Learning for Precision Nutrition. Oral presentation at The Bio-Data Club Seminar, Moffitt Cancer Center, USA, 01/2024
- Machine Learning for Precision Nutrition. Oral presentation at Circulating Metabolic Intermediates as Fuels and Signals Conference, Keystone Symposia, Salt Lake City, USA, 10/2023
- Application of Machine-Learning Methods in Biology and Medicine. Oral presentation at School of Medicine, Peking University, China, 07/2023
- Machine Learning for Precision Nutrition. Oral presentation at MIT Center for the Physics of Living Systems, Department of Physics, Massachusetts Institute of Technology, Boston, USA, 04/2023
- Regression models – predicting metabolomic profiles of microbial communities as an example. Oral presentation at School of Life Sciences, Arizona State University, Phoenix, USA, 03/2023
- Pairing Metagenomics and Metaproteomics to Pinpoint Ecological Niches and Metabolic Essentiality of Microbial Communities. Oral virtual presentation at International workshop on Soft Matter and Biophysics theories, Institute of Theoretical Physics, Chinese Academy of Sciences, 11/2022
- Pinpoint ecological niches and metabolic essentiality of microbial communities using both metagenomics and metaproteomics. Oral presentation at MIT Center for the Physics of Living Systems, Department of Physics, Massachusetts Institute of Technology, Boston, USA, 05/2022
- Pinpoint ecological niches and metabolic essentiality of microbial communities using both metagenomics and metaproteomics. Oral presentation at School of Pharmaceutical Sciences, University of Ottawa, Ottawa, Canada, 05/2022

- Predicting metabolomic profiles from microbial composition through neural ordinary differential equations. Oral presentation at Center for Complex Network Research, Network Science Institute, Northeastern University, Boston, USA, 03/2022

## CONTRIBUTED PRESENTATIONS

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- Predicting metabolic response to dietary intervention using deep learning. Oral presentation at Microbial Communities, APS March Meeting, Minneapolis, USA, 03/2024
- Predicting metabolic response to dietary intervention using deep learning. Poster presentation at Microbial Ecology and Evolution Hub-based Conference 2024, Boston College, Boston, USA, 01/2024
- Machine Learning for Precision Nutrition. Poster presentation at Circulating Metabolic Intermediates as Fuels and Signals Conference, Keystone Symposia, Salt Lake City, USA, 10/2023
- Machine Learning for Precision Nutrition. Poster presentation at IAIFI Summer Workshop, Northeastern University, Boston, USA, 08/2023
- Microbiome-based correction of dietary assessment. Oral presentation at Health Professionals Follow-up Study (HPFS) meeting, Harvard Medical School, Boston, USA, 05/2023
- Predicting metabolomic profiles from microbial composition through neural ordinary differential equations. Poster presentation at MIT Microbiome Symposium, Massachusetts Institute of Technology, Boston, USA, 04/2023
- Predicting metabolomic profiles from microbial composition through neural ordinary differential equations. Oral presentation at Microbial Communities, APS March Meeting, Las Vegas, USA, 03/2023
- Pinpoint ecological niches and metabolic essentiality of microbial communities using both metagenomics and metaproteomics. Oral presentation at Ecological and Evolutionary Biology, APS March Meeting, Chicago, USA, 03/2022
- Predicting metabolomic profiles from microbial composition through neural ordinary differential equations. Oral presentation at Channing Microbiome Meeting, Harvard Medical School, Boston, USA, 02/2022
- Pinpoint ecological niches and metabolic essentiality of microbial communities using both metagenomics and metaproteomics. Oral presentation at Channing Network Science Meeting, Harvard Medical School, Boston, USA, 10/2021
- Hitchhiking, collapse, and contingency in phage infections of migrating bacterial populations. Poster presentation at Biocomplexity Theme Review, Carl R. Woese Institute for Genomic Biology, Urbana, USA, 10/2019
- CRISPR-induced Red Queen dynamics in the phage-microbial system. Poster presentation at Biocomplexity Theme Review, Carl R. Woese Institute for Genomic Biology, Urbana, USA, 10/2019
- Evidence for a multi-level trophic organization of the human gut microbiome. Poster presentation at IGB Fellows Symposium, Carl R. Woese Institute for Genomic Biology, Urbana, USA, 04/2019
- Thermodynamic constraints on cross-feeding in bacterial population. Oral presentation at Ecological and Evolutionary Biology, APS March Meeting, Boston, USA, 03/2019
- Hitchhiking, collapse, and contingency in phage infections of migrating bacterial populations. Poster presentation at “Evolution of Diversity” Program, Les Houches Physics School, Les Houches, France, 02/2018

## PEER REVIEW

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Scientific journals: Science, Cell, Nature Communications, PNAS, eLife, PloS Computational Biology, Biophysical Journal, Microbiology Spectrum, PloS One, Nutrients, Computational and Structural Biotechnology Journal

Grants: UKRI (United Kingdom Research and Innovation)

## SKILLS

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Python (including Data Science, Machine learning, and Deep Learning tools), R, Matlab, Julia, C, C++, OpenMPI, Latex, Markdown

## First or Co-first

- [Tong Wang](#), Ashish B. George, Sergei Maslov. Higher-Order Interactions in Auxotroph Communities Enhance Their Resilience to Resource Fluctuations. *Will be submitted soon*. DOI: 10.1101/2024.05.22.595348
- [Tong Wang](#), Yuanqing Fu, Menglei Shuai, Ju-Sheng Zheng, Lu Zhu, Andrew T. Chan, Qi Sun, Frank B. Hu, Scott T. Weiss, Yang-Yu Liu. Microbiome-based correction for random errors in nutrient profiles derived from self-reported dietary assessments. *Under Review at Nature Communications*. DOI: 10.1101/2023.11.21.568102
- [Tong Wang](#), Hannah D. Holscher, Sergei Maslov, Frank B. Hu, Scott T. Weiss, Yang-Yu Liu. Predicting metabolic response to dietary intervention using deep learning. *In Press at Nature Communications*. DOI: 10.1101/2023.03.14.532589
- [Tong Wang\\*](#), Leyuan Li\*, Daniel Figeys, Yang-Yu Liu. Pairing Metagenomics and Metaproteomics to Characterize Ecological Niches and Metabolic Essentiality of gut microbiomes. *ISME Communications*. DOI: 10.1093/ismeco/ycae063
- Leyuan Li\*, [Tong Wang\\*](#), Zhibin Ning, Xu Zhang, James Butcher, Joeselle M. Serrana, Caitlin M. A. Simopoulos, Janice Mayne, Alain Stintzi, David R. Mack, Yang-Yu Liu, Daniel Figeys. Revealing Protein-Level Functional Redundancy in the Human Gut Microbiome using Ultra-deep Metaproteomics. *Nature Communications* 14, 3428 (2023). DOI: 10.1038/s41467-023-39149-2
- [Tong Wang](#), Xu-Wen Wang, Kathleen A. Lee-Sarwar, Augusto A. Litonjua, Scott T. Weiss, Yizhou Sun, Sergei Maslov, Yang-Yu Liu. Predicting metabolomic profiles from microbial composition through neural ordinary differential equations. *Nature Machine Intelligence* 5, 284–293 (2023). DOI: 10.1038/s42256-023-00627-3 — highlighted in IGB Newsletter
- Akshit Goyal\*, [Tong Wang\\*](#), Veronika Dubinkina, Sergei Maslov. Ecology-guided prediction of cross-feeding interactions in the human gut microbiome. *Nature Communications* 12, 1335 (2021). DOI: 10.1038/s41467-021-21586-6 — highlighted in EurekAlert!; Bik's Picks
- Derek Ping\*, [Tong Wang\\*](#), David T. Fraebel, Sergei Maslov, Kim Sneppen, Seppe Kuehn. Hitchhiking, collapse, and contingency in phage infections of migrating bacterial populations. *The ISME Journal* 14, 2007–2018 (2020). DOI: 10.1038/s41396-020-0664-9 — highlighted in Nature Research Microbiology Community; Bik's Picks
- [Tong Wang\\*](#), Akshit Goyal\*, Veronika Dubinkina, Sergei Maslov. Evidence for a multi-level trophic organization of the human gut microbiome. *PLoS Computational Biology* 15(12): e1007524 (2019). DOI: 10.1371/journal.pcbi.1007524 — highlighted in EurekAlert!; Phys; Bik's Picks

## Co-author

- Lu Wu, Xu-Wen Wang, Zining Tao, [Tong Wang](#), Wenlong Zuo, Yu Zeng, Yang-Yu Liu, Lei Dai. Data-driven prediction of colonization outcomes for complex microbial communities. *Nature Communications*. 15, 2406 (2024). DOI: 10.1038/s41467-024-46766-y
- Zheng Sun, Jiang Liu, Meng Zhang, [Tong Wang](#), Shi Huang, Scott T. Weiss, Yang-Yu Liu. Removal of false positives in metagenomics-based taxonomy profiling via targeting Type IIB restriction sites. *Nature Communications* 14, 5321 (2023). DOI: 10.1038/s41467-023-41099-8
- Andrea Aparicio, [Tong Wang](#), Serguei Saavedra, Yang-Yu Liu. Feasibility in MacArthur's Consumer-Resource Model. *Theoretical Ecology* 16, 225–238 (2023). DOI: 10.1007/s12080-023-00566-0
- Ashish B. George, [Tong Wang](#), Sergei Maslov. Functional universality in slow-growing microbial communities arises from thermodynamic constraints. *The ISME Journal* 17, 1482–1494 (2023). DOI: 10.1038/s41396-023-01455-4
- Xu-Wen Wang, [Tong Wang](#), Darius P. Schaub, Can Chen, Zheng Sun, Shanlin Ke, Julian Hecker, Anna Maaser-Hecker, Oana A. Zeleznik, Roman Zeleznik, Augusto A. Litonjua, Dawn L. DeMeo, Jessica Lasky-Su, Edwin K. Silverman, Yang-Yu Liu, Scott T. Weiss. Benchmarking omics-based prediction of asthma development in children. *Respiratory Research* 24, 63 (2023). DOI: 10.1186/s12931-023-02368-8
- Diana Rose E. Ranoa, Robin L. Holland, Fadi G. Alnaji, Kelsie J. Green, Leyi Wang, Richard L. Fredrickson, [Tong Wang](#), George N. Wong, Johnny Uelmen, Sergei Maslov, et al. Mitigation of SARS-CoV-2 Transmission at a Large Public University. *Nature Communications* 13, 3207 (2022). DOI: 10.1038/s41467-022-30833-3 — highlighted in EurekAlert!; MedicalXpress; Chicago Tribune; ScienMag

- Zihan Wang, Akshit Goyal, Veronika Dubinkina, Ashish B. George, [Tong Wang](#), Yulia Fridman, Sergei Maslov. Complementary resource preferences spontaneously emerge in diauxic microbial communities. *Nature Communications* 12, 6661 (2021). DOI: 10.1038/s41467-021-27023-y — highlighted in EurekAlert!; Phys
- Alexei V. Tkachenko, Sergei Maslov, [Tong Wang](#), Ahmed Elbanna, George N. Wong, Nigel Goldenfeld. Stochastic social behavior coupled to COVID-19 dynamics leads to waves, plateaus, and an endemic state. *Elife* 10, e68341 (2021). DOI: 10.7554/eLife.68341 — highlighted in UIUC Physics news; BNL News
- Shai Pilosof, Sergio A. Alcalá-Corona, [Tong Wang](#), Ted Kim, Sergei Maslov, Rachel Whitaker, Mercedes Pascual. The network structure and eco-evolutionary dynamics of CRISPR-induced immune diversification. *Nature Ecology & Evolution* 4, 1650–1660 (2020). DOI: 10.1038/s41559-020-01312-z — highlighted in EurekAlert!; Phys
- Chen Liao, [Tong Wang](#), Sergei Maslov, Joao B. Xavier. Modeling microbial cross-feeding at intermediate scale portrays community dynamics and species coexistence. *PLoS Computational Biology* 16(8): e1008135 (2020). DOI: 10.1371/journal.pcbi.1008135