Tong Wang

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https://wt1005203.github.io/tongwang/
Google scholar

Employment

Channing Division of Network Medicine (CDNM)
Brigham and Women's Hospital, Harvard Medical School — Boston, Massachusetts
Postdoctoral Research Fellow in Prof. Yang-Yu Liu's lab — 2021/06–present

Education

University of Illinois Urbana-Champaign (UIUC) — Urbana, Illinois
Ph.D. in Physics, GPA: 3.97/4.00, Advisor: Sergei Maslov — 2014/08–2021/05

University of Science and Technology of China (USTC) — Hefei, Anhui
B.S. in Applied Physics, GPA: 3.98/4.30, Rank: 1/67 — 2010/09–2014/06

Research

Motivated by models in statistical physics, math, 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 such as cross-feeding interactions and predator-prey interactions. The primary goal of my current research is to combine ecological models and omics data to reveal the assembly rules of microbial communities, especially the human gut microbiome. Additionally, I investigate the ecological and evolutionary dynamics influenced by those interactions. I study the ecological and evolutionary dynamics influenced by those interactions. On the practical side, I focus on predicting metabolomic profiles based on microbiome compositions and dietary compositions via both ecology-based mechanistic models and machine learning methods and then leveraging those methods to infer interactions between microbes, metabolites, and dietary compounds. More specifically, I have worked on

- Prediction of gut fecal metabolite levels from microbial abundance using the ecological model with trophic levels.
- Ecology-guided prediction of experimentally untested microbe-metabolite metabolic interactions.
- Network analysis of interactions between gut microbes, dietary compounds, and metabolites based on genomes.
- Personalized prediction of metabolomic profiles of human gut microbiomes through deep learning.
- Personalized prediction of metabolomic profiles after the dietary intervention and personalized food recommendations.
- Functional redundancy of microbial communities based on metagenome and metaproteome and how the redundancy difference between two types of data reveals ecological niches and metabolic essentiality.
- Ecological models of microbial exchange of essential nutrients.
- Models of microbial cross-feeding at intermediate scale mediated by carbon sources like acetate and amino acids.
- Network structure of CRISPR-induced arms-race co-evolution between bacteria and viruses.
- Infection dynamics of viruses (such as phage P1*vir*) on the chemotactic bacteria (such as *E. colis*).
- The community assembly of microbial strains with the diauxic shift or thermodynamic constraints.
- Multi-omics-based disease diagnostics.
- Agent-based model for the University of Illinois at Urbana-Champaign.
- Data-analysis of internal COVID case data for operational purposes.

Experience

University of Ottawa — Ottawa, Ontario, Canada
Visiting postdoc in Prof. Daniel Figeys' lab — 2022/05–2022/05

University of Illinois at Urbana-Champaign (UIUC) — Urbana, Illinois
Research assistant in Prof. Sergei Maslov's lab — 2017/01–2021/05

Peking University — Beijing, China
Exchange student in Prof. Chao Tang's lab — 2017/07–2017/08

Niels Bohr Institute — Copenhagen, Denmark
Visiting scholar in Prof. Kim Sneppen's lab — 2017/06–2017/07

Publications (*: equal contribution)

Published (first or co-first author)

- Leyuan Li*, Tong Wang*, Zhibin Ning, Xu Zhang, James Butcher, Caitlin 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**, 2023*
- Tong Wang, Xu-Wen Wang, Augusto A. Litonjua, Kathleen Lee-Sarwar, Scott T. Weiss, Yizhou Sun, Sergei Maslov, Yang-Yu Liu, "Predicting metabolomic profiles from microbial composition through neural ordinary differential equations", ***Nature Machine Intelligence**, 2023*
- Akshit Goyal*, Tong Wang*, Veronika Dubinkina, and Sergei Maslov, "Ecology-guided prediction of cross-feeding interactions in the human gut microbiome", ***Nature Communication**, 2021*
- Derek Ping*, Tong Wang*, David T Fraebel, Sergei Maslov, Kim Sneppen, and Seppe Kuehn, "Hitchhiking, collapse, and contingency in phage infections of migrating bacterial populations", ***ISME J**, 2020*
- Tong Wang*, Akshit Goyal*, Veronika Dubinkina, and Sergei Maslov, "Evidence for a multi-level trophic organization of the human gut microbiome", ***PLoS Computational Biology**, 2019*

Published (other collaboration)

- 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**, 2023*
- Andrea Aparicio, Tong Wang, Serguei Saavedra, Yang-Yu Liu, "Feasibility in MacArthur's Consumer-Resource Model", ***Theoretical Ecology**, 2023*
- Ashish George, Tong Wang, Sergei Maslov, "Functional universality in slow-growing microbial communities arises from thermodynamic constraints", ***ISME J**, 2023*
- Xu-Wen Wang, Tong Wang, Darius Pascal 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**, 2023*
- Diana Rose Ranoa, Robin Holland, Fadi Alnaji, Kelsie Green, Leyi Wang, Richard Fredrickson, Tong Wang, George Wong, Johnny Uelmen, Sergei Maslov, et al, "Mitigation of SARS-CoV-2 Transmission at a Large Public University", ***Nature Communications**, 2022*
- Zihan Wang, Akshit Goyal, Veronika Dubinkina, Ashish George, Tong Wang, Yulia Fridman, and Sergei Maslov, "Complementary resource preferences spontaneously emerge in diauxic microbial communities", ***Nature Communications**, 2021*
- Alexei Tkachenko, Sergei Maslov, Tong Wang, Ahmed Elbanna, George Wong, and Nigel Goldenfeld, "Stochastic social behavior coupled to COVID-19 dynamics leads to waves, plateaus, and an endemic state", ***eLife**, 2021*

- Shai Pilosof, Sergio A. Alcala-Corona, Tong Wang, Ted Kim, Sergei Maslov, Rachel Whitaker, and Mercedes Pascual, "The network structure and eco-evolutionary dynamics of CRISPR-induced immune diversification", ***Nature Ecology and Evolution****, 2020*
- Chen Liao, Tong Wang, Sergei Maslov, and Joao Xavier, "Modeling microbial cross-feeding at intermediate scale portrays community dynamics and species coexistence", ***PLoS Computational Biology****, 2020*

In Review

- Tong Wang, Hannah Holscher, Sergei Maslov, Frank B. Hu, Scott T. Weiss, Yang-Yu Liu, "Predicting metabolic response to dietary intervention using deep learning", ***In Review, Nature Communications***
- Tong Wang*, Leyuan Li*, Daniel Figeys, Yang-Yu Liu, "Pairing Metagenomics and Metaproteomics to Pinpoint Ecological Niches and Metabolic Essentiality of Microbial Communities", ***In Review, ISME J***
- 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", ***In Review, Nature Communications***

In preparation

- Tong Wang, Ashish George, Sergei Maslov, "A graphically interpretable ecological model with overflow of multiple essential nutrients can accurately predict community assembly", ***In Prep***
- Tong Wang, Yuanqing Fu, Menglei Shuai, Ju-Sheng Zheng, Lu Zhu, Qi Sun, Frank B. Hu, Scott T. Weiss, Yang-Yu Liu, "Microbiome-based correction of nutrient profiles derived from self-reported dietary assessments", ***In Prep***
- Tong Wang, Giulia Menichetti, Scott T. Weiss, Yang-Yu Liu, "Assessing the interactions between microbes and dietary compounds based on microbial genomes", ***In Prep***
- Pu-Ting Dong, Tong Wang, Yang-Yu Liu, Xuesong He, "Differentiation of microbial interaction at single-cell level through unconventional utilization of expansion microscopy", ***In Prep***

Scholarships and Awards

- 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

Funding in application

- K99/R00, Pathway to Independence Award, NIH, submitted on Oct 2023 and waiting for review

Invited talks

- Machine Learning for Precision Nutrition. Oral presentation at Circulating Metabolic Intermediates as Fuels and Signals Conference, Keystone Symposia, Salt Lake City, USA, 2023/10
- Application of Machine-Learning Methods in Biology and Medicine. Oral presentation at School of Medicine, Peking University, China, 2023/07
- 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, 2023/04
- Applying regression models in microbial communities. Oral presentation at School of Life Sciences, Arizona State University, Phoenix, USA, 2023/03

- 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, 2022/11
- 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, 2022/05
- 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, 2022/05
- 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, 2022/03

Contributed presentations

- Machine Learning for Precision Nutrition. Poster presentation at Circulating Metabolic Intermediates as Fuels and Signals Conference, Keystone Symposia, Salt Lake City, USA, 2023/10
- Machine Learning for Precision Nutrition. Poster presentation at IAIFI Summer Workshop, Northeastern University, Boston, USA, 2023/08
- Microbiome-based correction of dietary assessment. Oral presentation at Health Professionals Follow-up Study (HPFS) meeting, Harvard Medical School, Boston, USA, 2023/05
- Predicting metabolomic profiles from microbial composition through neural ordinary differential equations. Poster presentation at MIT Microbiome Symposium, Massachusetts Institute of Technology, Boston, USA, 2023/04
- Predicting metabolomic profiles from microbial composition through neural ordinary differential equations. Oral presentation at Microbial Communities, APS March Meeting, Las Vegas, USA, 2023/03
- 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, 2022/03
- Predicting metabolomic profiles from microbial composition through neural ordinary differential equations. Oral presentation at Channing Microbiome Meeting, Harvard Medical School, Boston, USA, 2022/02
- 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, 2021/10
- 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, 2019/10
- 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, 2019/10
- 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, 2019/04
- Thermodynamic constraints on cross-feeding in bacterial population. Oral presentation at Ecological and evolutionary biology, APS March Meeting, Boston, USA, 2019/03
- 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, 2018/02

Teaching experience

- Guest lecture, "Application of Machine-Learning Methods in Biology and Medicine", Summer School hosted by School of Medicine, Peking University, 2023
- Guest lecture, "Applying regression models in microbial communities", Microbiome Data Science, ASU 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

Peer review

Nature Communications, PNAS, eLife, Biophysical Journal, Microbiology Spectrum, PloS One

Skills

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