

# COLLOQUIUM

## Thursday March 27, 2025

Refreshments at 3:15PM outside PSF 101 Colloquium from 3:30PM – 4:30PM in PSF 101

Nonequilibrium Thermodynamics in Living Systems: The Free Energy Cost of Biological Functions Dr. Yuhai Tu

### IBM T.J. Watson Research Center



#### Abstract:

Inspired by Erwin Schrödinger's seminal question, "What is Life?", this talk explores how living systems utilize free energy (negative entropy) to sustain life and perform vital biological functions. By examining specific examples—from John Hopfield's kinetic proofreading mechanism to bacterial flagellar motor switches and molecular clock synchronization—we address key questions: How do biological systems optimize free energy to enhance performance? What thermodynamic constraints shape biochemical networks? And what design principles enable highly efficient biological functions? Nearly a century after Schrödinger's work, modern molecular biology offers new insights into these timeless questions, revealing the intricate balance between energy, entropy, and life.

#### **Biography:**

Yuhai Tu is a distinguished physicist with expertise in physics, biology, and machine learning. He graduated from the University of Science and Technology of China in 1987 and earned his PhD in Theoretical Physics from UCSD in 1991. After a postdoctoral fellowship at Caltech, he joined IBM Research in 1994. His early work on nonequilibrium statistical physics and flocking dynamics earned him the APS Lars Onsager Prize in 2020. Since 2000, he has focused on biological physics, contributing to transcriptome data analysis, bacterial chemotaxis modeling, and thermodynamics of biochemical networks. Currently, he studies biological network dynamics, information processing thermodynamics, and the statistical physics of machine learning, bridging physics, biology, and computation.