Course title: **Quantitative principles in biological systems**
Course number: CST 5022 (Spring 2025)
Class hours: Friday 14:20-16:55 (3 credit hours)
Class location: E10-212

Course instructor: **Po-Yi Ho**
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Office hours: Monday 14:00-15:00
Office location: E3-211

Course description

This course presents an integrated introduction to quantitative principles in biological systems. We explore four themes – randomness, optimization, information, and diversity – and analyze examples across a wide range of contexts. Problem sets involve the application of mathematical models and computational tools to test candidate principles and search for new ones. We aim to provide a unified approach to understand and engineer biological systems.

Prerequisites – basic working knowledge of calculus, linear algebra, statistics, and programming; basic physics, chemistry, and biology.

Week	Topic	Assignment
	Sensing molecules	Problem set #1
1	Chemotaxis and random walks	
2	Chemotaxis and chemical reaction networks	
3	Problem solving session #1	
	Optimizing functions	Problem set #2
4	Bacterial growth and optimization	
5	Gene regulation and statistical mechanics	
6	Problem solving session #2	
	Representing information	Problem set #3
7	Morphogenesis and information theory	
8	Sequences and spin glass models	
9	Problem solving session #3	
	Evolving diversity	Problem set #4 & Final project
10	Evolution and evolutionary dynamics	
11	Microbiomes and random matrices	
12	Problem solving session #4	
	Searching for principles	
13	Final project discussions	
14	Neural networks	
15	Final project presentations	
16	Searching for principles	

Learning objectives

- Develop numerical and physical intuition for biological systems.
- Analyze data to test and formulate quantitative principles.
- Communicate research effectively across fields and disciplines.

Course policies

- We follow a zero-tolerance policy for cheating and plagiarism.
- We expect active participation during lectures, problem sessions, and project presentations.

Assessments and grading

- Active participation 10%
- Problem sets 15% x 4
- Project report 15%
- Project presentation 15%

Learning resources

- *Biophysics: Searching for Principles*. William Bialek.
- *Physical Biology of the Cell*. Rob Phillips, Jane Kondev, Julie Theriot, and Hernan Garcia.
- … and more to be listed.