

**Course title:** Quantitative principles in biological systems  
**Course number:** PHY 4807 (Spring 2026)  
**Class hours:** Friday 13:30-15:55 (3 credit hours)  
**Class location:** E10-211

**Course instructor:** Po-Yi Ho  
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**Office hours:** TBD  
**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 an actionable, interdisciplinary approach to quantify and understand biological systems.

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

Week	Topic	Assignment
	<b>Sensing molecules</b>	Problem set #1
1 (03/06)	Chemotaxis and random walks	
2 (03/13)	Chemotaxis and chemical reaction networks	
3 (03/20)	Problem solving session #1	Problem set #2
	<b>Optimizing functions</b>	
4 (03/27)	Bacterial growth and optimization	
5 (04/03)	Gene regulation and statistical mechanics	
6 (04/10)	Problem solving session #2	Problem set #3 & Final project assigned
	<b>Representing information</b>	
7 (04/17)	Morphogenesis and information theory	
8 (04/24)	Sequences and spin glass models	Problem set #4
9 (05/08)	Problem solving session #3	
	<b>Evolving diversity</b>	
10 (05/09)	Evolution and evolutionary dynamics	Problem set #4
11 (05/15)	Microbiomes and random matrices	
12 (05/22)	Final project discussions	
	<b>Searching for principles</b>	
13 (05/29)	Problem solving session #4	
14 (06/05)	Neural networks / Searching for principles	
15 (06/12)	Final project presentations	
16 (06/24)	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.
- *Thinking Probabilistically*. Ariel Amir.
- *Physical Biology of the Cell*. Rob Phillips, Jane Kondev, Julie Theriot, and Hernan Garcia.
- *Quantitative Biosciences*. Joshua Weitz.
- Caltech's "Biological Circuit Design" course notes.
- Ben Good's course notes.
- Bingkan Xue's course notes.
- Yuansheng Cao's course notes.
- ... and more to be listed.