

Biophysical Principles of Molecular and Cellular Systems 2024-2025

Monday/Wednesday/Friday 9 – 11 am
Room LC504

Course Directors

Alessio Accardi
Jeremy Dittman

TAs

Abdul Vehab Dozic
Anna Peczak

Textbooks

The course does not follow a specific textbook. Elements from multiple sources are used but the principal sources are:

Jackson Molecular and Cellular Biophysics
Kuriyan The Molecules of Life

Course Description

This core course offers an introduction to fundamental biophysical principles applicable to a broad range of systems, from molecules to cell signaling pathways. The curriculum will combine lectures, group problem sets, paper discussions, and grant writing. The course is articulated in 6 modules, 3 in each semester. Each module is centered around a specific biological question and aims to provide the students with the conceptual (i.e., theoretical basis, mathematical approaches) and practical (i.e., experimental techniques, computational approaches, analysis strategies) tools to approach it. Modules 1-3 (which take place in the Fall semester) will cover the core biophysical principles of molecular mechanisms and cellular processes. In Modules 4-6 (which take place in the spring semester) the foundational concepts introduced in the first three modules are integrated to describe fundamental cellular processes at multiple scales. Grading is based on class participation, problem sets, and grant writing exercises.

Module 1: Thinking at the Nanoscale Level: Proteins, Membranes, and Electricity

Module 2: Thermodynamic Principles of Molecular Interactions

Module 3: Kinetics and Signaling in Cellular Processes

Module 4: Introduction to Signal Transmission

Module 5: Metabolism and Signaling Associated with Decisions on Cell State

Module 6: Integration of Signaling for Information Transmission

Lecturers

Alessio Accardi
Jeremy Dittman
Simon Scheuring
Richard Hite
Crina Nimigean
Olga Boudker
George Khelashvili
Joshua Levitz
Paul Riegelhaupt
Tobias Meyer
Stephen Long

		Class topic	Lecturer (take2)	Confirmed					
August (3 classes)									
M	26	Course Intro --Thinking at the nanoscale level	AA, JD	Yes	AA=Alessio Accardi				
W	28	Membranes and lipids I	SS	Yes	JD=Jeremy Dittman				
F	30	Math bootcamp (functions, diffEQ, probability, dimensions v units, etc...)	AA, JD, TAS		RH=Richard Hite				
September (12 classes)									
W	4	Membranes and lipids II	SS	Yes	MD=Melinda Diver				
F	6	JC #1: Faculty-led journal club	AA		SL=Steve Long				
M	9	Intro to protein structure	RH	Yes	PR=Paul Riegelhaupt				
W	11	Energy & Coulomb	SL	Yes	GK=George Khelashvili				
F	13	Introduction to Grant Writing and Specific Aims	AA		OB=Olga Boudker				
M	16	Protein conformational changes --intro to gating	SL	Yes	JL=Josh Levitz				
W	18	Membrane potential and ionic gradients & Nernst	PR	Yes	TR=Tim Ryan				
F	20	PBL #1:	SS/SL/PR		SS=Simon Scheuring				
M	23	Microscopic view of entropy and energy	JD	Yes	TM=Tobias Meyer				
W	25	Boltzmann distribution	JD	Yes	DE= David Eliezer				
F	27	Intro to 2-state model and DiffEq basics	AA	Yes					
M	30	JC#2	MD	Yes					
October (13 classes)									
W	2	State models and ion channel gating	AA	Yes					
F	4	Ligand-gated ion channels	CN	Yes					
M	7	PBL #2	AA/JD						
W	9	Intro to MD simulations --looking at molecules gate	GK	Yes					
F	11	Discussion on SA pages on JC#2	MD						
M	14	No Class --Columbus Day							
W	16	JC#3	GK						
F	18	Intro to thermodynamics #1	OB	Yes					
M	21	Intro to thermodynamics #2	OB	Yes					
W	23	Ligand binding --Entropy, Enthalpy and the molecular forces driving bindi	JL	Yes					
F	25	Diffusion #1	JD	Yes					
M	28	Intro to enzyme kinetics (Michaelis-Menten, steady-state, equilibrium)	OB	Yes					
W	30	PBL #3	GK/OB/JL						
November (11 classes)									
F	1	Protein Folding	DE	Yes					
M	4	IDRs	DE	Yes					
W	6	Discussion on SA pages on JC#3	GK						
F	8	No Class -PBSB Retreat							
M	11	PBL #4	OB/JL/DE						
W	13	Diffusion #2	JD	Yes					
F	15	JC#4 Protein folding/Diffusion	JD/DE						
M	18	Ca2+ signaling #1	JD						
W	20	Ca2+ signaling #2	TR	Yes					
F	22	Discussion on SA pages on JC#4. Assignment of Grant topics	JD/DE						
M	25	Work on grant proposal/Meet with PIs							
W	27	No Class --Thanksgiving							
F	29	No Class --Thanksgiving							
December (9 classes)									
M	2	Work on grant proposal/Meet with PIs							
W	4	Ca2+ signaling #4	TM	Yes					
F	6	PBL #4	JD/TR/TM						
M	9	In class discussion on grant proposal							
W	11	Work on grant proposal							
F	13	Mock Study Section --The end (of the first semester)	AA/JD/GK/MD						