Advanced Biochemistry Lecture (CHEM-UA 890): Spring 2017

Course Instructor: Dr. Somdeb Mitra
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Course Consultant: Dr. Nicholas Geacintov;
Guest Lecturers: Dr. Nate Traaseth and Dr. Nadrian Seeman
Recitation Instructors: Mr. Haotian Li (Wednesday) and Dr. Somdeb Mitra (Friday)

Date	No.	Lecture Topic
1/23		Introduction, Course Motivation and Overview
Module I: *Structural Stability and Folding of Proteins and Nucleic Acids*		
1/25	1	Review of Structural Features of Proteins and Nucleic Acids
1/30	2	Overview of Protein Engineering: Cloning, Recombineering, Expression
2/1	3	Basic Principles of Protein Purification and Analysis by Mass Spectrometry
2/6	4	Thermal Measurements of Stability (Protein: DSC; DNA/RNA: UV- melting)
2/8	5	Detecting Structure Content by Optical Rotation (Linear & Circular Dichroism)
2/13	6	Energetics of Protein Folding: Theory, Folding Landscape, Disorder, Amyloids
2/15	7	Ensemble Equilibrium Measurements of Protein Folding
2/20		Holiday (President's Day)
2/22	8	Protein Folding Kinetics & Folding Pathways: Theory & Ensemble Measurements
2/27	9	RNA Folding and Conformational Dynamics: Theory & Ensemble Measurements
3/1	10	Single-molecule Fluorescence Measurements of Folding: (smFRET)
3/6	11	Single-molecule Force Measurements of Folding: (AFM, Optical Tweezers)
3/8		**Midterm**
313		Spring Break
3/15		Spring Break
Module II: *Reversible Association Reactions of Macromolecules*		
3/20	12	General Theory and Quantitative Analysis of Equilibrium Binding Reactions
3/22	13	Thermal Measurements of Binding Interactions (ITC)
3/27	14	Hydrodynamic Measurements of Binding Interactions (AUC)
3/29	15	Ensemble Fluorescence Measurements of Binding Interactions (Anisotropy/FRET)
4/3	16	Binding Kinetics: Significance of Association and Dissociation Rate Constants
4/5	17	Stopped Flow Fluorescence and Ensemble Binding Kinetics (Anisotropy/FRET)
4/10	18	Kinetic Analysis by Surface Plasmon Resonance & High-throughput Screening
4/12	19	Single-molecule Fluorescence Detection of Binding (DNA curtains, smFRET)
Module III: *Atomic Resolution Analysis of Structure, Dynamics & Interactions*		
4/17	20	X-ray Crystallography: Lecture I - Seeman
4/19	21	X-ray Crystallography: Lecture II - Seeman
4/24	22	X-ray Crystallography: Lecture III - Seeman
4/26	23	Structure & Dynamics of Biomolecules by NMR (NOSEY, HSQC) - Traaseth
5/1	24	NMR Analysis of Larger Biomolecules and Complexes (TROSY, RDC) - Traaseth
5/3	25	Macromolecular Interactions by NMR (CSP, Saturation transfer) - Traaseth
5/8	26	Cryogenic Electron Microscopy (CryoEM) and its applications - Mitra
		Final Exam

Lecture and Recitation Information

Lecture Times: Mondays and Wednesdays: 11 am to 12:15 pm; Bldg/Room: Silver/411
Recitations: Wednesday (Haotian Li) 12:30 pm-1:45 pm, 4:45 pm-6:15 pm; Bldg/Room: (TBA)
Friday (Dr. Mitra) 11 am-12:15 pm; Bldg/Room: 194M/209 (**likely to be cancelled**)

Study resources:

Since this is an Advanced Course, there is no single designated text book. Please find below a list of Reference Books and Scientific Reviews. Students are especially encouraged to follow Reference Books A.1, A.2 and A.3 to clarify important concepts and master approaches towards solving analytical problems.

A. Suggested Text or General Reference Books:

1. The Molecules of Life: Physical and Chemical Principles. Kuriyan, J., Konforti, B. and Wemmer, D. (1st Edition, 2013). Garland Science Publication. ISBN: 978-0-8153-4188-8
2. Principles of Physical Biochemistry. Van Holde, K.E., Johnson, C.W., Ho, P.S. (2nd Edition, 2006). Prentice Hall Publication. ISBN: 0-13-046427-9
3. Physical Chemistry: Principles and Applications in Biological sciences. Tinoco, I., Sauer, K., Wang. J.C., and Puglisi, J.D. (4th Edition, 2002). Prentice Hall Publication. ISBN: 013095943X

B. Additional Reference Books and Scientific Series:

1. Structure and Mechanism in Protein Science. Fersht, A. (1999). W.H. Freeman Publication. ISBN-13: 978-0716732686
2. Biophysical Chemistry: Parts I and II. Cantor, C. and Schimmel, P. (1980). W.H. Freeman Publication. ISBN: 0716711885and 0716711907.

C. Topic-specific selected Scientific Reviews will be updated periodically

Evaluation

Midterm (40%): Lectures 1 to 12

Final (non-cumulative) (50%): Lectures 13 to 27

Quizzes during recitation (10%): Either an online quiz or a paper-based quiz will be conducted during every recitation, typically for 20-30 minutes. Online quizzes will be Multiple Choice or True/False type questions, using the free software Socrative. All students must download Socrative on their smart phones or laptop computers and bring these devices to the recitations. For the paper-based quizzes, students will answer the quizzes directly on the booklets and hand them in to the recitation instructor.

[Note: The remaining time of the recitation sections will be dedicated to reviewing specific numerical problems and clarifying important concepts.]

Problem Sets: Problem sets comprising of analytical and numerical problems will be periodically uploaded on the course website. These will not be graded, students should work on the problem sets at home. Numerical or analytical problems, similar to the ones in the problem sets, will be included in the Midterms and Finals. Therefore, adequate knowledge to solve such problems is essential for performing well in the examinations. As mentioned above, some of the most challenging problems from the problem sets and lecture concepts will be reviewed during the recitation sessions.

No requests for additional assignments/make-up term papers will be granted. Students are responsible for all the study materials prescribed for the course and will be evaluated based on course materials covered both during the Lectures and the Recitations.

Evaluation Philosophy: While some memorization is essential in any course in biochemistry, students will be primarily tested on their understanding of important concepts and their ability to apply those concepts for solving analytical problems.

Additional Information

Course Objective: This course is designed with the intent of providing an overview, at sufficient depth, of the energetic principles underlying structural stability, folding, conformational dynamics and interactions of biological macromolecules, as well as some of the most important biophysical and biochemical techniques used to characterize these crucial biological phenomenon. Designed for advanced-level undergraduate students and a mandatory requirement for Biochemistry Majors.

Prerequisites / Co-requisites: Physical Chemistry: Quantum Mechanics and Spectroscopy (CHEM-UA 651) and Physical Chemistry: Thermodynamics and Kinetics (CHEM-UA 652) with grades of C or better.

Attendance: Mandatory for both Lectures and Recitations.