Chem 752: Biophysical Chemistry

Total Credit: Three

Schedule: Monday: 6.00 – 7.20 p.m. Wednesday 7.30-8.50

Room: Curtis 351

Lecturer: Reinhard Schweitzer-Stenner; RSchweitzer-Stenner@drexel.edu, Disque Hall 218, phone: 215-895-2268

Textbook: van Holde, Johnson, Ho: Principles of Physical Biochemistry, Prentice Hall. **Chang:** Physical Chemistry for the Chemical and Biological Science, University Science Books. **K.A. Dill and S. Bromberg** Molecular Driving Force, Garland Science. **J.N. Omuchic, Z. Luthey-Schulten and P.G. Wolynes:** Theory of Protein Folding: The Energy Landscape Perspective. *Annu. Rev. Phys. Chem.* 48, 545-600, 1997. **N. Sutin** Theory of Electron Transfer Reactions: Insights and Hindsights. *Inorg. Chem.* 30, 441-497, 1983. **R. Schweitzer-Stenner and Jonathan B. Soffer:** Optical Spectroscopy in: Comprehensive Biophysics. Vol 1, Biophysical Techniques for Structural Characterization of Macromolecules, H. Jane Dyson. Oxford: Academic Press, 2012. pp. 533-591 (copy can be provided). **R. Schweitzer-Stenner (editor):** Protein and Peptide Folding, Misfolding and Non-Folding, Wiley, 2012. Research paper literature will be cited during the lecture. **Thomas Heimburg:** Thermal Biophysics of Membranes. Tutorials in Biophysics. Wiley& Sons, 2007.

Course objectives:

1. Developing of general understanding how physical laws govern biological processes.
2. Acquire basic knowledge about how physical methods can be applied to understand biological processes.
3. Developing an understanding of the relation between structure, function and dynamics of biological macromolecules.
4. Developing an understanding of the forces governing protein folding and misfolding.
5. Developing an understanding on how statistical mechanics can be applied to understand the properties of biological membranes.

Assignments: Two or three set of home assignments will be provided. The assignments will be graded and count 33%.

Exams and Homework: Besides the final there will be a written midterm, open book exams. Students are allowed to bring along with themselves all types of textbooks and class notes. Homework assignments will be given on a regular basis. A short seminar

will have to be presented and a one page paper detailing its content will have to be submitted for the final exam. Extra points can be earned in class by solving in-class problems. The final grade will be obtained on the basis of the total score, i.e. 0.33*(assignment points+extra points) + 0.33*mid-term-exam points+0.33*final exam points. The grading scheme is A: 100-80 P, B: 79.99-60 P, C: 59.99 P-45 P, D: 44.99-35 P, F; less than 35 P.

Complaints: Complaints about the grading of assignments and exams have to be brought to the attention of the lecturer within 48 hours after their return. All grades are considered final afterwards.

Office hour: To comply with Drexel policy I officially offer office hours on Monday from 4.30 through 6.00 p.m. **However, students are urged to see me in my office in the case of any problems and questions**.

Principal philosophy: The course will emphasize conceptual thinking instead of memorizing. Students shall be prepared to employ concepts introduced in class to a variety of problems. Exams will frequently contain question, which check the understanding of the subject. It is assumed that the participating students have a solid working knowledge of pre-calculus and calculus. I will sometimes employ concepts from Statistical Mechanics. Help will be given to students who do not have a background on this. Basic knowledge of quantum mechanics is assumed. The course is an attempt of the instructor to create a course, which is dedicated to introduce basic research concepts rather than textbook teaching. Therefore textbooks, review articles and research papers will be used. Students may buy the van Holde textbook, but it is not really necessary. The bio-part of the Dill-Bromberg textbook will be used for chapter 2. It is expected instead that the participating students do their own literature searches

Behavior in class: Students are asked to appear on time for the class and to switch off their cellular phones. Cheating will lead to an F for the entire course. I am encouraging discussions, but not chattering while I am lecturing. For the final exam, texts from other sources have to be explicitly quoted. It is expected that students use their own words for writing the final paper.

Student learning information

A. Course description and calendar

A successful completion of this class requires some knowledge of quantum mechanics, thermodynamics, statistical mechanics and kinetics. The mathematical level if this class is moderate, but students are expected to know how to differentiate and integrate as well as elementary vector and matrix algebra

1. **General Introduction: Biophysical Systems (1. week)**

    - amino acids
    - forces and stability
    - secondary structure
    - structural propensities
    - tertiary and secondary structures
    - DNA and RNA
    - lipid membranes

2. **Forces in Proteins (1. and 2. week)**

    - Basics
    - Molecular potentials
    - Van der Waals interactions
    - Hydrogen bonding
    - Stability of protein structures

3. **Biophysical techniques (3rd week and 1 lecture of 4th week)**

    - X-ray crystallography
    - NMR spectroscopy
    - UV-vis absorption spectroscopy
    - Circular dichroism (CD) spectroscopy
    - Fluorescence spectroscopy
    - Vibrational spectroscopy

4. **Conformational transitions in peptides and proteins (1 lecture of 4th week and 5th week)**

    - Landau theory
    - Helix-coil transition
    - Ising model
    - Two site model of cooperativity
    - The hemoglobin case

Midterm Exam is on Monday of the sixth week

5. **Protein folding and unfolding (1 lecture of 6th week and 7th week)**

- The Anfinsen experiment
- Simple thermodynamics of folding (Kauzmann and Tanford)
- The landscape funnel model (Wolynes and Onuchic)
- The unfolded state
- Intrinsically disordered peptides and proteins

6. **Enzyme kinetics (8th week)**

    - Catalysis
    - Kinetics
    - Chymotrypsin
    - Multisubstrate systems
    - Inhibition
    - Allosteric Interactions

7. **Membrane biophysics (9 and 10th week)**
    - Membrane compositions
    - Membrane electrostatics: Double-layer theory and beyond
    - Phase transitions
    - Diffusion
    - Adsorption, binding and insertion of proteins
    - Protein-lipid interactions
    - Mechanics of membranes

8. **Electron transfer processes (11th week)**

    - The respiratory chain
    - Photoreaction center
    - Potential energy and surfaces
    - Ultrafast spectroscopy