Biochem 440B, Physical Biochemistry-I

Fall 2009

Principles of Thermodynamics and Kinetics and their Applications to Biological Macromolecules

Classes on Tuesdays and Thursdays from 10:00 to 11:50 in 217 Noyes Lab

Help Sessions are scheduled each Wednesday at 7pm in room 217 Noyes Lab

PART 1: 5 LECTURES (Gennis) - Aug 25, 27; Sept 1, 3, 8 (Lectures 1-5)

A The Principles of Thermodynamics
1. First Law - System & surroundings; work & heat; mechanical energy and force;
2. Energy exchanges; enthalpy; bond energies
3. Entropy - probabilities & microscopic distributions
4. Approach to equilibrium - free energy and chemical work, ΔG, $\Delta G°$, K
5. Temperature & pressure dependence of equilibrium; non-bonding interactions
6. Chemical potentials; standard states - acid-base, pH, redox potentials
7. Coupling between reactions, and biological energy conversion

PART 2: 9 LECTURES (Nair): Sept 10, 15, 17, 22, 24, 29; Oct 1, 6, 8 (Lectures 6-14)

A. Water, Membranes and the Hydrophobic Force -
(Gennis text)
1. Structure of liquid water.
2. Hydrophobic effect
3. Amphiphiles, micelles and the phospholipid bilayer

B. Structural Hierarchy of Proteins and the Forces Involved
(Gennis text;Nair notes)
1. Proteins: Review Ramachandran + secondary structure; protein folds + motifs
2. Non-bonding forces - steric interactions, electrostatics;
3. Coulomb's Law and applications - ion-ion, ion-dipole, various dipoles
4. Dielectric properties, polarizability; van der Waals dispersion forces
5. Hydrophobicity and amphiphilicity of protein helices

C. Protein Stability -
(Nair notes, Gennis text)
1. Two state equilibrium treatment of protein folding; ΔH, ΔS, ΔC_p, etc
2. Hydration and solvent effects: osmotic pressure, denaturants, stabilizers, etc
3. Hydrophobicity, packing, mutagenesis - $\Delta\Delta G$

D. Nucleic Acid Structure/Topology/Stabilitiy -
(Nair notes, Gennis text)

1. Nucleic Acids: Phosphate torsions, ring conformers, base-pairing
2. Chain conformers, base pairing - Watson-Crick, Hoogstein; DNA polymorphism
3. DNA melting & renaturation; nearest neighbor analysis
4. DNA topology and supercoiling- twists, writhe, nicks & knots
5. RNA structures - stems, loops, tetraloops, etc

FIRST EXAMINATION: Tuesday, October 13

PART 3: 8 LECTURES (Gennis) Oct 15, 20, 22, 27, 29, Nov. 3, 5, 10 (Lectures 15-22)

A. Ligand binding and recognition

1. Affinity and kinetics; binding isotherms
2. Binding models - single vs. multiple sites, independent vs. cooperative binding
3. Binding & linkage - energetics of coupling
4. Allosteric regulation of proteins

B. 5. Isothermal titration calorimetry

C. Biochemistry of transport, bioenergetics

6. Biochemistry of transport
7. Coupling through linked transport processes

Part 4: 5 LECTURES (Nair) Nov. 12, 17

(Nov. 19 second exam)
(Nov 24-28, Thanksgiving)

Dec 1, 3, 8 (Lectures 23-27)

A. Principles of Chemical Kinetics -
1. Kinetic theory, diffusion and collision rates: Fick's laws
2. Reaction kinetics; order of reaction; diffusion control
3. Activation energy; the transition state and Marcus theory; the reaction coordinate
4. Rate constants and the equilibrium constant

B. Enzyme Kinetics and Catalysis -

1. Transition state complexes; binding, strain and catalysis
2. Steady state: M-M kinetics; competitive/non-competitive inhibition, etc
3. More complex kinetics - order of addition, etc.
4. Pre-steady state approach to enzyme kinetics; perturbation/relaxation methods

C. Protein Folding Kinetics -

FINAL EXAMINATION, 1:30 – 4:30 PM, Wednesday, December 16

GRADING:

2 EXAMINATIONS IN CLASS: 25% EACH

1 FINAL EXAM: 25%

10-12 PROBLEM SETS: 2 POINTS (MAX) EACH, ONLY IF TURNED IN ON TIME: 25%