

BE505

Molecular Bioengineering

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1. *Introduction.* Brief history of molecular biology. Chirality as an inherent property of biological molecules. Asymmetric carbon atom. Optical activity. Molecular structure. Atomic and molecular orbitals, hybridization. The nature of chemical bond. Chemical structure of proteins and nucleic acids. Amino acids and nucleotides.

2. *Transduction, transmission, storage and retrieval of biological information by macromolecules.* DNA double helix. DNA melting and hybridization. RNA transcription, protein synthesis and the central dogma. Genetic code. Genomes of prokaryotes and eukaryotes. Junk DNA. Splicing. Alternative splicing.

3. *Biological pathways for synthesis of DNA, RNA and proteins.* DNA replication in prokaryotes and eukaryotes. DNA polymerases. Telomeres and telomerase. The role of telomeres. Polymerase chain reaction. Restriction enzymes. DNA sequencing. RNA polymerases. Ribosome. Posttranslational modification and cellular transport.

4. *Structure of DNA and RNA.* Sugar conformation. Conformations of nucleoside. B-DNA. Alternative duplex structures: A, B', Z. Structure of duplex RNA. Dependence of DNA structure on sequence and ambient conditions (temperature, pH, counterions, solvent, etc.). Antisense and antigene strategies of modulation of gene activity. RNAi pathway.

5. *Protein structure.* The peptide bond and the polypeptide chain, degrees of freedom (external and internal coordinates), observed 1-2-3-D structure hierarchies. Ramachandran plot, α -helix, β -strands, type I and type II turns. The energetic contribution into folding of peptide chains, hydrogen bonding and hydrophobicity patterns. All- α , all- β and $\alpha\beta$ protein structures. Protein folding in vitro and in vivo. Chaperons.

6. *Methods to study biomolecular structure* Finding molecular structure as an ill-posed mathematical problem. Direct and indirect methods. X-ray analysis of fibers and crystals. Structural databases. Nuclear magnetic resonance. Nuclear Overhauser effect. 2-D NMR and its structural applications.

7. *Structural transitions in nucleic acids and proteins and their applications.* Absorption spectra and their changes with conformation. Luminescence and fluorescence in modern biotechnology. Molecular beacons. Real Time PCR. Recent advances in rapid DNA sequencing. Pyrosequencing. Fluorescence *in situ* hybridization (FISH). Pathogen detection based of nucleic acids. PNA FISH. Detection of antibiotic-resistant strains. DNA chips. Protein folding and unfolding. Energy landscapes and folding funnels.

Conformational changes associated with binding.

8. *Molecular interactions*. The origin and calculation of binding free energy. Proteins in the immune system: immunoglobulins and the Major Histocompatibility Complex. Equilibrium expressions for single and multiple binding sites. Receptor-ligand binding. The Adair equation. Scatchard plot. The Hill equation. Allostery as regulatory element.

9. *DNA-protein interactions*. DNA recognition in prokaryotes. The helix-turn-helix motif. Lambda Cro and repressor. Lambda phage regulation.

10. *Mechanisms of enzymatic catalysis and receptor-ligand binding*. Energetics of enzyme catalysis. Serine proteinases. Substrate specificity. Affecting specificity and stability by protein engineering.

11. *Biomolecular motors*. Difference between manmade motors and biomolecular motors. Inertia in the viscous medium. The Brownian motion. The rectified thermal diffusion as the mechanism of action of biomolecular motors. Allosteric transitions in proteins. Muscle contraction. Actin-kinesin movement. Single-molecule experiments on biomolecular motors.

12. *Metabolic and signal transduction networks*. Basic theory of metabolism. Metabolic steady states. Thermodynamics of metabolic pathways. Methods for studying metabolism and its regulation. Regulation by covalent modification. The Goldberger-Koshland model of a molecular switch. Flux balance analysis. Signal transduction pathways.

Textbooks:

Peter Atkins and Julio de Paula "Physical Chemistry for Life Sciences" Freeman, 2005.

Branden and Tooze "Introduction to Protein Structure" 1999.

Maxim D. Frank-Kamenetskii "Unraveling DNA" Addison -Wesley, 1997.

Available online: <http://www.questia.com/PM.qst?a=o&docId=85769631>