

Revised M. Sc. Biophysics Semester III Running Batch Syllabus

(Admitted in July 2018)

Membrane Biophysics (MBP301)

Unit-I [12L]

Composition of biological membrane, function of primary components, hydrophobic effect, lipid-water systems, phase transition in lipid mixtures, critical fluctuations, lipid protein interactions, membrane rafts, correlation of physical properties of cell membrane and cell proteins, elastic properties of the membrane, spontaneous curvature, membrane melting, charge induced microstructures & domains.

Unit-II [12L]

Membrane transport, diffusion, electro-diffusion, types of transportation, thermodynamic model, chemical potential, osmotic pressure, water permeability, cellular mechanisms of volume regulation, structure, selectivity & permeability of ion channels, Voltage-gated channels, ligand-gated channels, stretch-activated channels, Na⁺, K⁺ and Ca²⁺ channels, pumps as channels.

Unit-III [12L]

Donnan equilibrium, the resting membrane potential, Nernst equation, Goldman equation, Nernst-Planck equation, Hodgkin-Huxley equation, Hodgkin-Katz experiment, Voltage clamp, transport by flux coupling, transport by phosphotransferase system, membrane impedance and capacitance, transmembrane potential, Zeta, Stern and total electrochemical potential, chemical synapse, post synaptic potential, action potential, properties of Action potential

Unit-IV [12L]

Conduction of the electrical activity, spread of electrical signals: passive vs. active, the action potential and its propagation through nerves, Saltatory conduction, propagation in a syncytium, membrane excitability, TRP channels as molecular sensors & integrators, channels and cell excitability, chloride channels and muscle excitability, synaptic integration

References

1. Membrane Biophysics, Authors: Mohammad Ashrafuzzaman, Jack A. Tuszynski, Springer Science & Business Media, 2012, ISBN 3642161057, 9783642161056.
2. Structure and dynamics of membranous interfaces, Kaushik Nag, Wiley, 2008, ISBN-0470116315, 9780470116319.
3. Mechanics of the Cell by David Boal, Publisher Cambridge University Press, 2012, ISBN-1139501771, 9781139501774.
4. Particles at Fluid Interfaces and Membranes: Editors P. Kralchevsky, K. Nagayama, Elsevier, 2001, ISBN-0080538479, 9780080538471.
5. The Structure of Biological Membranes, Editor Philip L. Yeagle, CRC Press, 2004, ISBN-1420040200, 9781420040203.
6. Methods in Membrane Lipids, Editor Alex DoPico, Humana Press, 2007, ISBN 1588296628, 9781588296627.

Quantum Physics & Chemistry (MBP302)

Unit-I

[12L]

de Broglie's wavelength, Bohr atom, Physical basis of quantum mechanics, Schrodinger equation (1D), Physical interpretation and conditions on the wave function, Stationary states and energy spectra, Particle in a square well potential, Tunnelling through potential barrier, Bound and unbound state.

Unit-II

[12L]

Spherically symmetric potentials in 3-dimensions, Hydrogen atom, Helium atom; singlet and triplet states, Observables, Quantum operators; position, momentum, energy and parity, Spectroscopic notations, L-S coupling, J-J coupling, Commutators; linear and angular momentum, Uncertainty principle, Zeeman and Stark effect, Linear harmonic oscillator

Unit-III

[12L]

Diatomic molecules, Molecular orbitals of the homo and heteronuclear diatomic molecules, Valance bond treatment of heteronuclear diatomic molecules, Molecular orbital and valence bond methods for the hydrogen molecule, charge distribution in molecular hydrogen, Born-Oppenheimer approximation and its breakdown, LCAO approximation, Vibrational and rotational energy levels in diatomic molecules

Unit-IV

[12L]

Chemical bond, Bonding and anti-bonding regions-formation of bonds, Polyatomic molecules, Directed valance (Introduction), Hybridization and geometry, Simple Huckel theory of the linear conjugated systems, Examples of simple Huckel calculations: Butadiene, Simple Huckel theory for the cyclic conjugated systems and aromaticity.

References

1. Elementary Quantum Chemistry, F. Pilar, McGraw Hill book company, New York, 1968
2. Quantum Chemistry, N.V. Riggs, Macmillan Company London, Oxford and IBH publishing, 1975
3. Molecular Orbital theory, A. Streitwiser, John Willey, New York, 1961
4. Quantum Chemistry, Ira N Levine, Fourth Edition, Prentice Hall of India, New Delhi, 1994
5. Quantum Mechanics Concepts and Applications Second Edition, NouredineZettili Jacksonville State University, Jacksonville, USA
6. Concepts of Modern Physics, Arthur Beiser, McGraw Hill, 2003

Biophysical Techniques (MBP303)

Unit-I **[12L]**

Reflection, absorption, emission, scattering in spectroscopy, UV-Visible absorption, fluorescence and phosphorescence spectroscopy, Circular Dichroism, dynamic light scattering, rotational and vibrational spectroscopy, study of diatomic vibrations and rotational modes, advantages of Raman spectroscopy, applications, advantages and disadvantages of these techniques to biology.

Unit-II **[12L]**

General principles of NMR spectroscopy, resonance condition, relaxation phenomena and measurements, chemical shifts, coupling constants, proton decoupling (broad band), NOE effects, ¹H, ¹³C, solid state NMR, Basic principle and application of ESR, spin-labeling. Basic principle of Mass spectroscopy, analysis and its application, importance and principle of MALDI-TOF spectroscopy and its applications.

Unit-III **[12L]**

General principles of electrophoresis, Factors affecting electrophoresis, Electrophoresis of proteins, SDS-PAGE, Support media for SDS-PAGE, Native gel, Gradient gel, Isoelectric focussing gel, Molecular mass determination by electrophoresis, Two-dimensional electrophoresis, Detection of proteins in gel, Wester Blotting, Electrophoresis of nucleic acid, Agarose gel electrophoresis, Support media for agarose gel electrophoresis, Electrophoresis of RNA, Capillary electrophoresis, Microchip electrophoresis, application of electrophoresis.

Unit-IV **[12L]**

Basic principles of chromatography, paper chromatography, TLC, column chromatography, gas, liquid chromatography, ion exchange chromatography, exclusion chromatography, affinity chromatography, high performance liquid chromatography, fast protein liquid chromatography, their applications to macromolecules.

References

1. Fundamentals of Molecular Spectroscopy, 5th Edn, McGraw Hill, ISBN-10 1259062597, ISBN-13 9781259062599, 2013 May
2. Introductory Raman Spectroscopy by John R. Ferraro, Kazuo Nakamoto and Chris W. Brown, Second Edition, ISBN: 978-0-12-254105-63, Elsevier Science Publishing, 2003
3. Infrared and Raman Spectroscopy; Principles and Spectral Interpretation, by Peter Larkin, Elsevier Science Publishing Co Inc (13 July 2011), ISBN-10: 0123869846, ISBN-13: 978-0123869845
4. Introduction to Magnetic Resonance Spectroscopy ESR, NMR, NQR by D.N. Sathyanarayana (Second Edition), I K Int. Publ. House; Second Edition ISBN-10: 9382332529, ISBN-13: 978-93823325278 Nov 2013
5. Physical Biochemistry, D. Freifelder, W.H. Freeman & Co. San Francisco, 1976
6. NMR Spectroscopy: Basic Principles, Concepts and Applications in Chemistry, Wiley India Pvt Ltd; Second edition ISBN-10: 8126528443, ISBN-13: 978-8126528448, 12 October 2010
7. Biomolecular NMR Spectroscopy, by Jeremy N. S. Evans, OUP Oxford (11 May 1995)

ISBN-10: 0198547668, ISBN-13: 978-0198547662

8. Govil G. & Hosur R. V. NMR – Conformation of Biological Molecules, Springer- Verlag.
9. Modern Optical Spectroscopy: With Exercises and Examples from Biophysics and Biochemistry, by William W. Parson, Springer; 2007 edition (12 December 2006), ISBN-10: 354037535X, ISBN-13: 978-3540375357
10. Handbook of Fluorescence Spectroscopy and Imaging: From Single Molecules to Ensembles, Prof. Dr. Markus Sauer, Prof. Dr. Johan Hofkens, Dr. Jörg Enderlein, 2011 Wiley-VCH Verlag GmbH & Co. KGaA, Print ISBN: 9783527316694
11. Principles of Fluorescence Spectroscopy, Lakowicz, Joseph R. 5rd ed. 2006, XXVI, Springer, ISBN-10: 0387312781, ISBN-13: 978-0387312781, June 2010
12. Electrospray and MALDI Mass Spectrometry: Fundamentals, Instrumentation, Practicalities, and Biological Applications, by Richard B. Cole (Editor), Wiley-Blackwell; 2nd Edition edition
ISBN-10: 0471741078, ISBN-13: 978-0471741077, 18 May 2010
13. Friefelder D. Physical biochemistry W.H. Freeman & Co.
14. Stout G.H. & Jensen L.H. X-ray structure determination, Macmillan.
15. Slayter E.M. Optical methods in Biology, John Wiley
16. Blundell T. L. and Johnson L.N. Protein crystallography, Academic Press.
17. Wuthrich K. NMR of proteins and nucleic Acids, Wiley Interscience, Publications.

Genetics and Recombinant DNA Techniques (MBP304)

Unit-I: Genetics I

[12L]

Mendelian principles: dominance, segregation, independent assortment, Concept of gene: Allele, multiple alleles, pseudoallele, complementation tests, deviation from mendelian inheritance, codominance, incomplete dominance, gene interactions, pleiotropy, genomic imprinting, penetrance and expressivity, phenocopy, Linkage & crossing over.

Unit-II: Genetics II

[12L]

Sex determination, Chromosomal and molecular basis of sex determination, Gene dosage compensation, Gene expression, copy number variation, Mutation, Mutational load assessment, Introduction to human genetic disease, Mitochondrial genome and associated diseases, Monogenic and Polygenic diseases, Conventional and modern approach of diagnosis.

Unit III: Tools and Techniques in Molecular Biology Part I:

Enzymes used in recombinant DNA technology: DNA and RNA polymerases, ligases, methylases, endonucleases and exonucleases. DNAases and RNAases. Sterilization and disinfection. Radioimmunoassay (RIA) and Enzyme Linked Immunosorbant Assay (ELISA). Western blotting techniques.

Unit IV: Tools and Techniques in Molecular Biology Part II:

Nucleic acid isolation methods; Nucleic acid separation techniques: Agarose gel electrophoresis of DNA. Blottings: Southern and Northern blotting techniques. Nucleic acid amplification protocols; DNA sequencing. Vectors: Basic requirements for a suitable cloning vector. Recombinant DNA. Competent cell preparation and transformation protocols. Cloning and selection transformants and recombinants.

References

1. Human genetics, A.Gardner, R.T.Howell and T.Davies, Published by VinodVasishtha for Viva Books private limited, 2008.
2. Fundamentals of Genetics by S.S. Gahalain, Publisher Anmol Publications Pvt. Limited, 2004, ISBN8126120029, 9788126120024.
3. Genetics, Authors Daniel L. Hartl, Maryellen Ruvolo, Publisher Jones & Bartlett Publishers, 2011, ISBN 1449626114, 9781449626112.

Lab Course (MBP305)

1. Determination of molar absorption coefficient of the native proteins (RNase-A, α -lactalbumin and lysozyme) from the spectra of model compounds (Try and Trp).
2. Determination of no. of Tryptophan and Tyrosine residues in an unknown protein (Lysozyme) by Edelhoch's method.
3. Determination of conformational stability from the guanidine hydrochloride-induced denaturation of a protein.
4. Determination of thermal stability from heat-induced transition curves of a protein (RNase-A).
5. Determination of secondary structure elements of proteins (RNase-A, α -lactalbumin and lysozyme) from their CD spectra.
6. Estimation of hydrodynamic radius of a protein using Dynamic Light Scattering System (DLS).
7. Estimation of molecular weight and purity of a protein using SDS-Gel electrophoresis.

Enzymology (MBP306) (CBCS)

Unit-I: Introduction to Enzymes

[12L]

General concept and background, Nomenclature and Classification of Enzymes. Enzyme activity- chemical nature of enzymes, Mechanism of enzyme catalysis: Acid-base catalysis, covalent catalysis, Metal ion catalysis, Proximity and orientation effects, etc, Lock and key, Induced fit and Transition state Hypotheses, Concept of active site and energetics of enzyme substrate complex formation, Transition-state stabilization, Enzyme catalysis – general principles of catalysis; Quantitation of enzyme activity and efficiency; Enzyme Kinetic Parameters: K_m , V_{max} and K_{cat} , Enzyme characterization and Michaelis-Menten kinetics; Kinetics of single and bi-substrate enzyme catalysed reactions. Mechanism of Serine proteases-Chymotrypsin, Coenzymes and Cofactors- Prosthetic group, Metalloenzymes and metal activated enzymes, Proenzymes, Isozymes, Abzymes, Synzyme.

Unit-II: Enzyme Inhibition and Regulation

[12L]

Enzyme specificity: Types of specificity, Identification of binding site & catalytic site, 3-D structure of active site. Inhibition & its kinetics, Reversible Inhibition- Competitive, Non-Competitive, Uncompetitive, Mixed, Substrate, Allosteric and Product Inhibition. Analysis of enzyme kinetic data. Michaelis-Menten, Lineweaver-Burk and the direct linear plot. Irreversible Inhibition- Suicide inhibition. Examples and Mechanism of various Inhibitions like Penicillin, Iodoacetamide and DIPF. Feedback Regulation, Allosteric enzymes, Allosteric Regulation, Reversible Covalent Modification and Proteolytic Activation. Organisation of enzymes in the cell. Enzymes in the cell, localization, compartmentation of metabolic pathways, enzymes in membranes, Mechanisms of enzyme degradation, lysosomal and nonlysosomal pathways, examples.

Unit-III: Enzyme immobilization

[12L]

Enzyme immobilization: Methods of immobilization of enzymes, Physical and chemical techniques for enzyme immobilization, Kinetics of immobilized enzyme, Effect of external mass transfer & intra-particle diffusion, limitation & applications of immobilized enzymes, Bioreactors using immobilized enzyme. Support and medium used for enzyme immobilization: Adsorption, matrix entrapment, encapsulation, cross-linking, covalent binding and suitable examples, Advantages and disadvantages, Enzyme based biosensor: Design of enzyme electrodes and their application as biosensors in industry, healthcare and environment.

Unit-IV: Industrial and Clinical uses of Enzymes

[12L]

Production and purification of crude enzyme extracts from plant, animal and microbial sources, Methods of characterization of enzymes, Enzyme Engineering and site directed mutagenesis: Introduction, aim, principle & steps of enzyme engineering, design and construction of novel enzymes, Bifunctional and polyfunctional enzyme, Enzyme in organic solvents. Industrial Enzymes- Thermophilic enzymes, enzymes used in various fermentation processes, Metal degrading enzymes. Clinical enzymes, Enzyme Structure activity

Relationship (SAR) and Drug Discovery, Biotransformation Applications of Enzymes and Industrial enzymes

References

1. Buchholz, K., Kasche, V. and Bornscheuer, U., “Biocatalysts and Enzyme Technology”, WILEY–VCH, 2005.
2. L. Lehninger, d.L. Nelson, M.M Cox- “Principle of Biochemistry by Werth publishers, 2000.
3. L. Stryer, J.M. Berge, J.L. Tymoezko- “Biochemistry” W.H. freeman & Co. 2002.
4. Introduction to protein structure by B randen and Tooze (1998): Garland publishing group.
5. Enzyme by Palmer (2001); Horwood publishing series.
6. Fundamental of Enzymology by Price and Stevens (2002): Oxford University Press.
7. Bailey J.E. & Ollis, D.F. Biochemical Engineering Fundamentals, 2nd Ed., McGraw Hill, 1986

Measurement and Data presentation (PGAE301) (Ability Enhancement)

Unit 1: Measurement [12L]

Block diagram of Measuring Systems: Performance characteristics, Static characteristics, Accuracy, Precision, Resolution, Types of Errors, Repeatability, Reproducibility, Fidelity, Lag; Specifications of Instruments. Standards and calibration.

Unit 11: Data Acquisition [12L]

Classification of transducers – Selection of transducers – Resistive, capacitive & inductive transducers – Piezoelectric, Hall effect, optical and digital transducers – Elements of data acquisition system – A/D, D/A converters – Smart sensors.

Unit III: Presentation skills [12L]

Elements of an effective presentation, Structure of a presentation, Presentation tools, Data types, The graph Abstract Data Type, Data Structures for Graphs, Graph Traversals Directed Graphs, Weighted Graphs, Shortest Paths, Minimum spanning Trees. Data Graphing/Plotting using Microsoft Excel, Origin

Unit IV: Advanced technical writing [12L]

Report writing: Definition and importance of reports, qualities of reports, language and style in reports, types of reports, formats (letter, memo, project-reports). Methods of compiling data for preparing report. A computer-aided presentation of a technical project report based on survey-based or reference based topic. Technical paper-writing.

TEXT BOOKS:

1. A.K. Sawhney, 'A Course in Electrical & Electronic Measurements & Instrumentation', Dhanpat Rai and Co, 2004.
2. J. B. Gupta, 'A Course in Electronic and Electrical Measurements', S. K. Kataria & Sons, Delhi, 2003.
3. Doebelin E.O. and Manik D.N., Measurement Systems – Applications and Design, Special Indian Edition, Tata McGraw Hill Education Pvt. Ltd., 2007.