JGI JAIN DEEMED-TO-BE UNIVERSITY | FACULTY OF ENGINEERING AND TECHNOLOGY

Ph.D. Entrance Examination Syllabus – 2022

Biomolecules

Module I

Carbohydrates: Introduction**,** classification**,** configurational and conformational aspects of carbohydrates. Structure, properties and importance of monosaccharides, disaccharides, homo and hetero-polysaccharides including multiantenneary chains (Blood group substances) and bacterial polysaccharides. Glycosaminoglycans, Cardioglycosides. Glycoproteins- structure and functions, sequence analysis of oligosaccharides. Lectins- characteristics, functions in biological system, other uses.

Module II

Amino acids and Proteins: Introduction, classification and structural aspects of amino acids. Acid - base properties of amino acids. Non-protein amino acids and their significance. Peptide bond - structure and conformation. Naturally occurring peptides. Ionic properties of peptides and proteins. Methods of isolation and purification of proteins, salting in, salting out, criteria of protein purity. Chemical synthesis of polypeptides; protection and deprotection of N-terminal, C-terminal ends and functional groups of side chain. Merrifield solid phase synthesis**.** Primary structure; Elucidation of primary structure of proteins- Determination of aminoacid composition, end group analysis, cleavage by enzymes and chemicals, separation of fragments. Sequential degradation by Edman method and modern methods of sequencing. Assignment of disulfide bonds and interpretation of overlapping sequencing.

Module III

Secondary structure- Ramachandran plot, alpha-helical, pleated sheet, and triple helical structures. Fibrous proteins (Keratin, silk fibroin, collagen, elastin). Tertiary structure- forces involved in the stabilization of tertiary structure, denaturation and renaturation. Structure of Insulin, Ribonuclease, Lysozyme, Myoglobin, and Chymotrypsin. Quaternary structure – Hemoglobin, oxygen binding mechanism. Denaturation of proteins, Domain structure.

Module IV

Lipids: Classification, structure & biological role of Fatty acids, Acyl glycerols, Phospholipids, Sphingolipids, Glycolipids, Steroids, Prostaglandins, thromboxanes, and Leukotrienes. Bile acids; structure and physiological significance.

Nucleic Acids: Components of nucleic acids. Structure and properties of nucleosides and nucleotides. Isolation, fractionation and characterization of nucleic acids. Properties of nucleic acids in solution. Structure of nucleic acids - Primary, secondary and tertiary structure of DNA; Secondary structure of tRNA. DNA supercoiling, linking number, biological importance of DNA supercoiling, role of topoisomerase. Chemical synthesis of oligonucleotide (Khorana’s methods

of synthesis) (Maxam-Gilbert & Sanger's dideoxy method). Nucleic acid sequencing - rapid sequencing methods. Renaturation Kinetics-Cot curves and their significance.

Books for Reference

1. Lehninger et al. (2009), "Principles of Biochemistry", V Edition, Worth Publishers
2. Voet D & Voet J G (1999), "Biochemistry", III Edition, John Wiley & Sons
3. Rawn J (1989), "Biochemistry", Neil Patterson Publishers
4. Conn E E et al. (2006), "Outlines of Biochemistry", V Edition John Wiley & Sons
5. Zubay G (1998), "Biochemistry", McGarw Hill
6. Stryer L (1998), "Biochemistry", WH Freeman & Co
7. Devlin T (1999), "Text Book of Biochemistry with Clinical Correlations", Wiley – Liss
8. Mainwaring et al. (1982), "Nucleic acid Biochemistry & Molecular Biology", Oxford Blackwell Scientific
9. Sharon N (1975), "Complex Carbohydrates", Addison Wisely
10. Dickerson & Geis (1983), "Principles of Protein Structure", Function & Evolution, II Edition, Benjamin-Cummings
11. Scopes R (1993), "Protein purification: Principle and Practice II Edition, Springer-Verlag
12. Garrett R H & Grisham C M (1999), "Biochemistry", II Edition, Saunders College Publishing
13. Roe S (2001) Protein purification Techniques, Oxford University Press

Analytical Biochemistry

Module I

Spectrophotometry: Quantum mechanical description of atomic spectra, the chromophore concept, Principle – Beer & Lamberts Law, Single beam and Double beam spectrophotometer. Instrumentation, working and biochemical applications of UV-Vis spectrophotometry, Circular dichorism spectroscopy, ORD, IR, ESR, NMR and Mass-Spectroscopy Spectrofluorimetry – Fluorescence spectra, fluorescence and phosphorescence labeling, Instrumentation and application.

Module II

Chromatography: Introduction, principle, procedure and applications of – Paper, Thin Layer Chromatography (TLC), Adsorption Chromatography, Ion-exchange Chromatography, Molecular Sieve Chromatography, Chromatofocussing. Affinity Chromatography – Hydrophobic Interaction Chromatography, Metal Chelate Chromatography, Covalent Chromatography.

Gas Liquid Chromatography (GLC), High Performance Liquid Chromatography (HPLC) and Fast Protein Liquid Chromatography (FPLC). Special chromatographic techniques for nucleic acids – DNA Cellulose Chromatography, Hydroxyl-Apatite Chromatography.

Module III

Electrophoresis: Principle, types, moving boundary electrophoresis, zone electrophoresis. Principle, procedure and applications of - Paper, Cellulose acetate, High – Voltage, Starch, Agarose, PAGE, SDS-PAGE, IEF, Pulsed Field - Electrophoresis and Capillary Electrophoresis. Blotting techniques - Western, northern and southern blotting. Detection methods- General and specific methods.

Biosensors in bioanalysis- Principle- Instrumental design- Types of biosensors- Applications Electrodes- Types of electrodes- Nernst equation- Redox reactions- Applications**.**

Module IV

Centrifugation: Principle of sedimentation, Svedberg constant, concepts of RCF, factors affecting sedimentation velocity, Safety aspects in centrifugation. different types of centrifuges and rotors. Table top centrifuge, Microfuge and its application.

Cytometry: Hemocytometer, Coulter counter, Flow cytometry, Fluorescence-activated flow cytometry (FACS).

Preparative and analytical ultracentrifugation: Differential, continuous and density gradient centrifugation. Sedimentation velocity, equilibrium analysis and its applications. Analysis of subcellular fractions - assessment of homogeneity.

Books for Reference:

1. Holme D J & Pick H (1998), “Analytical Biochemistry”, III Edition, Longman
2. Segel I H (1976), “Biochemical Calculations”, II Edition, John Wiley & sons
3. Wilson K & Walker J (2000), “Practical Biochemistry Principles and Techniques”, V Edition Cambridge University Press
4. Williams &Wilson (1981), “Principles and Techniques of Practical Biochemistry”, III Edition, Edward Arnold
5. Harris and Angal (1990), “Protein Purification Applications”, IRL Press
6. Scopes R (1993), “Protein purification: Principle and Practice II Edition, Springer-Verlag
7. Walker & Gastra (1983), “Techniques in Molecular Biology”, Croom Helm
8. Wilson K & Walker J (2005), “Principles and Techniques of Biochemistry and Molecular Biology”, VI Edition, Cambridge University Press
9. Van Holde K E (1998), “*Principles of Physical Biochemistry”, Prentice Hall*

Enzymology

Module I

Introduction to enzymes: Nomenclature and classification of enzymes. Enzyme assay-enzymeunits. Active site and specificity. Enzyme localization and purification. Applications of enzymes.

Kinetics of enzyme catalyzed reactions: Concept of ES complex, derivation of Michaelis-Menten equation for uni- substrate reactions. Different plots for the determination of K_m & V_{max} and their physiological significances. Importance of K_{cat}/K_m. Kinetics of zero & first order reactions.

Significance and evaluation of energy of activation. Collision & transition state theories. Effect of pH and temperature Michaelis theory, steady state theory, linear transformation of Michaelis-Menten equation. King-Altman procedure for deriving the rate equation.

8 Hours

Module II

Classification of multi substrate reactions with examples of each class: Ping Pong, random & ordered Bi-Bi mechanisms. Investigation of reaction mechanisms using isotopic-exchange at equilibrium.

Inhibition studies: Reversible and irreversible inhibition. Competitive, non-competitive, uncompetitive, linear-mixed type inhibitions and their kinetics, determination of K_i. Suicide inhibitor.

Investigation of active site structure: Trapping E-S Complex, use of substrate analogs, Chemical modification of amino acid side chain, proteolytic enzyme treatment, site directed mutagenesis. Metal activated and metalloenzymes-kinetic mechanism of pyruvate kinase, creatine kinase and carboxy peptidase A.

Module III

Chemical nature of enzyme catalysis: General acid base catalysis, electrostatic catalysis, covalent catalysis, intramolecular catalysis and enzyme catalysis. Reactions catalyzed by enzymes chymotrypsin, lysozyme and ribonuclease.

Coenzymes: Mechanistic role of Nicotinamide nucleotides, flavin nucleotides, pyridoxal phosphate, Coenzyme A, lipoic acid, Thiamine pyrophosphate, biotin, tetrahydro folate and Vit B_{12}.

Module IV

Multienzyme system: Occurrence, isolation & their properties: Mechanism of action and regulation of pyruvate dehydrogenase & fatty acid synthase complexes. Enzyme-enzyme interaction, multiple forms of enzymes with special reference to lactate dehydrogenase.

Allostery of enzyme action: Binding of ligands to proteins, Co-operativity, Hill equation, Adair equation, Scatchard plot.

Sigmoidal kinetics: MWC and KNF models, Allosteric enzymes metabolic regulation. Study of ATCase as allosteric enzyme.

Books for Reference

1. Roberts D V (1977), “Enzyme kinetics”, Cambridge University Press
2. Colowick S P et al. (2006), Vol I “Methods in Enzymology”, Academic Press
3. Segel I H (1976), “Biochemical Calculations”, II Edition, John Wiley & Sons
4. Palmer T (1994), 3rd Edn “Understanding Enzymes”, Ellis Horwood Ltd.
5. Jack R C (1995), “Basic Biochemical Laboratory Procedures & Computing”, Oxford University Press
6. Harris S L V & Angal (1989), “Protein Purification Methods”, IRL Press
7. Engel P C (1981), “Enzyme Kinetics the Steady state approach”, II Edition, Champman & Hall
8. Whitaker M D (1972), “Principles of Enzymology for Food Sciences”, Academic Press
9. Price & Lewis (1989), “Fundamentals of Enzymology”, Oxford University Press
10. Bugg T B (2000), “Introduction to Enzyme and Coenzyme Chemistry” Blackwell Science
11. Copeland R A (2000) “Enzymes”, 2nd edition Wiley-VCH

Metabolism

Module I

Carbohydrate metabolism: Glycolysis-regulation and energetics- PDH complex-citric acid cycle, Pentose phosphate pathway. Gluconeogenesis – glycogenesis & glycogenolysis metabolism - regulation, glyoxylate cycle, glucose alanine cycle and Gamma aminobutyrate shunt pathways, Cori cycle, anapleurotic reactions, glucuronate pathway. Hormonal regulation of carbohydrate metabolism.

Module II

Amino acid Metabolism: General metabolic reaction of amino acids – transamination, deamination Assimilation of ammonia, glutamine transport-urea cycle –energetics and its regulation. Degradation of the individual amino acids– Amino acids forming pyruvate (alanine, glycine, threonine, serine, cystine and cysteine) oxaloacetate (aspartic acid and asparagine), α-ketoglutarate (glutamic acid, glutamine, arginine, histidine and proline), succinyl CoA (valine, isoleucine and methionine), acetoacetate and/or acetyl CoA (leucine and lysine), pyruvate, formaldehyde, acetoacetate and/or acetyl CoA (tryptophan), and fumarate, acetoaetate and/or acetyl CoA (phenylalanine and tyrosine).

Module III

Lipid metabolism: Fatty acid Biosynthesis-Acetyl CoA carboxylase, fatty acid synthase complex, biosynthesis and degradation pathway for tri-acylglycerols and phosphoglycerides. Oxidation of even and odd numbered fatty acids, α-, β-, ω- oxidation of fatty acids. Oxidation of unsaturated fatty acids -Energetics of fatty acid oxidation -biosynthesis and degradation of ketone bodies. Cholesterol biosynthesis and regulation.

Module IV

Nucleotide Metabolism: Biosynthesis of purine nucleotides and pyrimidine nucleotides. Regulation. Degradation of purine and pyrimidine nucleotide. Heme Metabolism: Biosynthesis and degradation. Biosynthesis of coenzymes NAD^+ / $NADP^+$ and FAD^+.

Books for Reference:

1. Biochemistry; Voet, D. and Voet, J.G. [Eds.] (1999) 3 Ed. Jhon Wiley and sons
2. Biochemistry; David Rawn, J. (1989) Neil Patterson Publishers
3. Text Book of Biochemistry with Clinical correlations; Thomas Devlin [Ed.] (1997), Wiley - Liss
4. Lehninger et al. (2009), “Principles of Biochemistry”, V Edition, WorthPublishers
5. Principles of Biochemistry; Smith et al., [Ed.] (1986) McGarw Hill
6. Biochemistry; Geoffrey Zubey, (1998), WCB Publishers
7. Biochemistry; David Rawn, J. (1989) Neil Patterson Publishers

Molecular Biology - I

Module I

Conceptual Background of DNA: Chemical composition of DNA, DNA structure-single stranded DNA, detailed account of double stranded DNA-BDNA, Z.DNA, and other structural forms. Central dogma of molecular biology. Identification of DNA as the genetic material - experimental proofs. RNA as genetic material. Repetitive DNA content of genomes; tandemly repeated DNA (VNTRs), mini-, micro- satellites and interspersed genome-wide repeats and their significance. C-value paradox. Organization of prokaryotic, eukaryotic and organelle-genomes (Chloroplast and mitochondria).

Experimental proofs for semi-conservative replication, discontinuous replication. Chemistry of nucleotide polymerization. Basics of DNA Replication: Enzymes involved, chemistry, mechanism of action and role in replication of topoisomerases, helicases, ligases, telomerase. Prokaryotic and eukaryotic DNA polymerases and its regulatory mechanism. Primosome & replisomes.

Module II

Replication of bacterial genomes – Bi-directional replication in E. coli, origins of replication, trombone model of replication, termination. Mechanism of replication in yeast and higher eukaryotes- Initiation, events at the replication fork, synthesis of leading and lagging strand. Difference between prokaryotic and eukaryotic replication.

Replication of Viruses: λ phage, T7 bacteriophage, SV 40 virus. Chloroplast and mitochondrial replication.

Module III

Post replication actions: Recombination- Crossing over, Homologous recombination, formation of Hetroduplexes, Holliday junction structure, Site-specific recombination, Transposons, model of transposition. Inhibitors of DNA replication.

DNA repair: Existence of repair systems, direct repair systems, excision repair- base excision and nucleotide excision repair, photo reactivation. Post replication repair; mismatch repair, SOS repair and recombination repair.

Module IV

Mechanisms of Transcription: Prokaryotic transcription; promoters, bacterial RNA polymerase, steps- initiation, elongation and termination. Eukaryotic transcription; Structure and functions of RNA polymerase I, II and III. Transcription of mRNA; promoters, extra promoter elements, transcription factors, accessory proteins of transcription. Stages of mRNA transcription –

initiation, elongation, termination. Post transcriptional processing; 5' capping, polyadenylation, splicing, different types of splicing, alternate splicing. RNA editing. Inhibitors of transcription. Biosynthesis of rRNA; promoter structure, transcription and processing of prokaryotic and eukaryotic rRNA.

Biosynthesis of tRNA; promoter structure, transcription and maturation of prokaryotic and eukaryotic tRNA.

Books for Reference

1. Buchanan B B Gruissum & Jones (2000), "Biochemistry and Molecular Biology of Plant", 2nd Edition ASPP, USA
2. Rawn J (1989), "Biochemistry", 1st Edition, Neil Patterson Publishers
3. Wagner & Hewlett (2008), "Basic Virology", 3rd edition, Blackwell Science
4. Blow J J (1996), "Eukaryotic DNA Replication", Oxford University Press
5. Benzamin L (2008), "Genes X", 10th Edition Oxford University Press
6. Watson J D et al. (2007), "Molecular Biology of Gene", 6th Edition, Benzamin Cummins
7. Alberts et al. (2002), "Molecular Biology of the Cell", 4th Garland Publications
8. Freifelder D (1996), "Molecular Biology", 2nd Edition, Narosa Publishers
9. Harley & Klein (2008), "Microbiology", 7th Edition, Prescott McGraw-Hill
10. Maloy et al (1994), "Microbial Genetics", 2nd Edition, Jones & Bartlett Publishers
11. Walker & Rapley (2000), "Molecular Biology and Biotechnology", 4th Edition, R S C Press
12. Watson J D (2004), "Molecular Biology of Gene", 5th Edition, Pearson Education
13. Flint et al (2003), "Principles of Virology", 2nd Edition, ASM Press

Developmental Biology and Neurochemistry

Module I

Cellular Basis of Development: Cleavage- Patterns of embryonic cleavage- Holoblastic cleavage (Isolecithal, Mesolecithal); Meroblastic Cleavage - Telolecithal (Bilateral, discoid), Centrolecithal. Gastrulation- Types of cell movements during gastrulation- Cell Specification and axis formation- Blastulation- Blastula formation, Neurulation- Primary and Secondary neurulation, Somite formation.

Gametogenesis: Origin of germ cells- Spermatogenesis-Sperm morphology- Primitive and modified spermatozoa- Spermatids - activators and inhibitors of sperm function. Oogenesis- Meiotic maturation of oocytes - mechanism of ovulation, fertilization and implantation, control of ovulation- role of hormones and drugs in gametogenesis.

Module II

Development of model organisms: *Coenohabditis elegans* - early embryonic development: Cleavage and axis formation, Gastrulation. Chick - early embryonic development, regional specification. Human - early embryonic development, neurulation.

Morphogenic processes: cell movement, cell adhesion, classification of morphogenetic processes.

Module III

Neuromorphology: Neurons: Introduction to neurons, components of neurons, classification and types of neurons, Cytology of neurons, structure and function- Dendrites and Axons, myelination and synapses. Glial cells: Structure and function of glial cells, Different types of glial cells: astrocytes, oligodendrocytes and Schwann cells, Types of astrocytes – type I & II astrocytes, fibrous and protoplasmic astrocytes, Importance of astrocytes in glutamate metabolism and blood brain barrier, Functions of other glial cells: oligodendrocyte and microglial cells.
10 Hours

Nerve fiber types and functions: Resting membrane and action potential, Nernst and Goldman equations. Mechanism of initiation and propagation of action potential. Design and use of Patch-Clamp in measuring membrane potential.

Module IV

Neurophysiology: Ion channels and transport of ions. Synaptic transmission, Neurotransmittors and Neurohormone chemistry- Synthesis, storage and release. Blood brain and CSF barrier characteristics, transport systems. Trafficking proteins of synaptic vesicles, vesicle cycle – exo and endocytosis of synaptic vesicles.

Receptors: Structure, subtypes and functions - Acetyl Choline (Ach), GABA, Glycine, Signal transduction in vision. Role of agonists & antagonists of neurotransmitters. Biochemical basis of neurological diseases.

Books for Reference

- Balinsky, B.L. (1971). “Introduction to Embryology”, Saunders College Pub.
- Gilbert, S.F. (2003). “Developmental Biology “, 7th Edition, Sinauer Associates Pub.
- Beril, N.J. and Karpotata, G. (1972). “Development”, Mc Graw Hill Pub.
- Browder, L.W. Erickson, A and Jeffery N.R. (1991). “Developmental Biology”, Saunders College Pub.
- Carlson, B.M. (1998). “Pattern’s foundations of Embryology”, Mc Graw Hill Pub.
- Helmreich, E. (2001), “The Biochemistry of Cell Signalling”, Oxford University Press
- Siegel, J et al. (1999), “Basic Neurochemistry”, Wippincott, Williams & Wilkins
- Sadava (1993), “Cell Biology”, Jones & Bartlett Publishers
- Lodish et al. (1999), “Molecular Cell Biology”, WH Freeman & Co.
- Baltimore et al. (1995), “Molecular Cell Biology”, Scientific American Publication
- Dale et al. (2001), “Neuroscience”, 2nd Edition, Sinauer Associates Inc.