Biochemistry Syllabus

for

PhD Entrance Test – 2024, UBKV

Basic Biochemistry

Fundamental principles governing life, supramolecular structures, significance of weak non-covalent interactions in biology. Structure of water, ionization of water, acid base concept, pH and buffers, significance of structure-function relationship. General introduction to physical techniques for determination of structure ofbiopolymers. Fundamentals of thermodynamic principles applicable to biological processes.

Structure, classification, properties and function of carbohydrates, amino acids, proteins, lipids and nucleic acids. Structure, formation and different forms of immunoglobulins, PR proteins and their classification.

Intermediary Metabolism

The living cell – a unique chemical system, biochemical reaction types, bioenergetics, bioavailability of nutrients, transport mechanism, signal transduction. Catabolism and anabolism, compartments of metabolic pathways, metabolic profiles of major organs.

Major catabolic and anabolic pathways of carbohydrate metabolism. Mechanisms of energy transduction, electron transport system, oxidative phosphorylation, control of ATP production. Fatty acid oxidation, ketone bodies, fatty acid biosynthesis, synthesis of triacylglycerols & cholesterol. General reactions of amino acid metabolism, degradative and biosynthetic pathways of amino acids, urea cycle, amino acids as metabolic precursors.

Synthesis and degradation of purine and pyrimidine nucleotides. Regulation of carbohydrate, lipid, protein, nucleotide metabolism and phosphorylation. Disorders of carbohydrates, lipids, amino acids and nucleic acid metabolism, inborn errors of metabolism. Metabolic pathway engineering.

Enzymology

Historical perspective, general properties of enzymes, enzyme compartmentalization in cell organelles, nomenclature and classification of enzymes, ribozymes, isozymes, abzymes. EXtraction of soluble and membrane-bound enzymes, purification of enzymes, measurement of enzyme activity. Enzyme specificity, monomeric and oligomeric enzymes, catalytic mechanism, mechanism of enzyme action, pseudoenzymes, enzyme promiscuity.

Chemical nature and involvement of cofactors and coenzymes in enzyme catalyzed reactions, metal activated enzymes and metalloenzymes, mechanism of enzymecatalyzed reactions without cofactors. Active site, identification of binding sites and catalytic sites. Relationship between initial velocity and substrate concentration, Michaelis-Menten equation, Lineweaver-Burk and Eadie-Hofstee plots, analysis of kinetic data, numerical exercises. Reversible and irreversible enzyme inhibition, uses of enzyme inhibition.

Nature of allosteric enzymes, sigmoidal kinetics, MWC model and allosteric regulation, KNF model and allosteric regulation. Feedback regulation, regulatory enzymes, control of enzymatic activity, symmetryand sequential model, reversible covalent modification of enzymes.

Industrial application of enzyme catalysis in sectors like food processing, detergents, biofuels, paper and pulp, biosensors and clinical applications of enzymes. Large scale production and purification of enzymes, immobilization of enzymes.

Molecular Biology

Historical development of molecular biology, nucleic acids as genetic material. Nucleic acid structure, chemical and physical properties of nucleic acids, spectroscopic and thermal properties of nucleic acids, DNA supercoiling.

Concept of genes and genome, genome complexity, genome organization in prokaryotes and eukaryotes, chromatin structure and function, repetitive and non-repetitive DNA, satellite DNA central dogma, genome editing.

Modes of replication, DNA polymerases, topoisomerases, DNA ligase, model of replisome, semi conservative replication in prokaryotes and eukaryotes, inhibitors of replication, DNA damage and repair. Basic principles of transcription, transcription initiation, elongation and termination, RNA processing, RNA interference, siRNAs, miRNAs and other ncRNAs, DNA/ RNA editing. Regulation of transcription, reverse transcription.

Ribosomes structure and function, organization of ribosomal proteins and RNA genes, genetic code, aminoacyl tRNA synthases. Initiation, chain elongation and termination of translation, energetics, inhibitors of translation. Post translational modifications of nascent polypeptide, protein targeting and turnover, regulation of gene expression in prokaryotes and eukaryotes, nucleases and restriction enzymes.

Importance, Sanger method, High-Throughput Sequencing (HTS) techniques, applications of DNA sequencing. Vectors, isolation of genes, recombinants vector, selection of recombinants, characterization and expression of cloned DNA, transformation, transgenesis, mutation, molecular mechanism of mutation, site directed mutagenesis, *in vitro* mutagenesis.

Polymerase chain reaction (PCR), expression cloning, gel electrophoresis, molecular markers, macromolecule blotting and probing, arrays (DNA array and protein array) – principles and application.

Techniques in Biochemistry

Principles and applications of paper, thin layer, column, gel filtration, ion-exchange, and affinity chromatography, HPTLC, GC, HPLC and FPLC. General principles of paper and gel electrophoresis, native and SDS-PAGE, 2D-PAGE, capillary electrophoresis.

Hydrodynamic methods of separation of biomolecules such as viscosity and sedimentation velocity – their principles. Basic principles of sedimentation, type, care and safety aspects of centrifuge, preparative and analytical centrifugation.

Principles and applications of UV-VIS, Fluorescence, IR and FTIR, Raman, NMR and FTNMR, ESR and X-Ray spectroscopy. MS/MS, LC-MS, GC-MS, MALDI-TOF, applications of mass spectrometry inbiochemistry.

Principle, function and instrumentation of atomic absorption spectrophotometry. Principles and applications of light, UV, phase contrast, fluorescence and electron microscopy, flow cytometry.

Tracer techniques in biology: concept of radioactivity, radioactivity counting methods with principles of different types of counters, concept of α, β and γ emitters, scintillation counters, γ-ray spectrometers, autoradiography, applications of radioactive tracers in biology.

Production of antibodies, immune-precipitation, immune-blotting, immunoassays, RIA and ELISA. Cryopreservation, polymerase chain reaction (PCR).

Plant Biochemistry

Structure and function of plant cell and its organelles, phytochromes, chloroplast morphology, structure and chemistry of photosynthetic pigments, light reaction of photosynthesis.

Carbon reduction in C_3, C_4 and CAM plants, photorespiration, sucrose-starch interconversion. Biosynthesis of structural carbohydrates, storage proteins and lipids.

Biochemistry of seed germination – stages, requirements, metabolism and mobilization of storage material. Biochemistry of fruit ripening – ripening process, cell wall degrading enzymes, role of ethylene and regulation of ethylene production.

Different classes of phytohormones, their biosynthesis and mode of action. Biochemistry and significance of plant secondary metabolites – phenolics, terpenoids, alkaloids, cyanogenic glycosides

and glucosinolates. Effect of biotic and abiotic factors on plant metabolism and plant defense system.

Nutritional Biochemistry

Fundamentals of human nutrition, concept of balanced diet, biochemical composition, energy and food value of various food grains (including cereals, pulses, oilseeds), fruits and vegetables. Physico-chemical, functional and nutritional characteristics of carbohydrates, proteins and fats and their interactions (emulsions, gelation, browning etc.). Digestion and absorption, digestive secretions, their characteristic features and control, microflora of the GI tract.

Biochemical functions of nutrients, macro- and micronutrients – carbohydrates, fats and proteins, vitamins, water soluble and fat soluble vitamins, mineral and phytonutrients, prebiotics and probiotics, enzymes and metabolic protein factors, cofactor role, electrolytic function, constituents of skeletal tissues, interrelationship in nutrient functions, mineral deficiency diseases; nutraceuticals, antinutritional factors, biochemistry of postharvest storage.

Factors affecting bioavailability of nutrients, biological value of proteins; effect of cooking, processing and preservation of different food products on nutrients, energy and micronutrient malnutrition, deficiency diseases due to macro- and micronutrients.

Nitrogen and Sulphur Metabolism

Nitrogen cycle, assimilation of inorganic nitrogen, nitrate uptake and transporters, enzymology of nitrate reduction – Nitrate reductase (NR) and Nitrite reductase (NiR), NR regulation, nitrate signaling.

Assimilation of inorganic nitrogen and N-transport amino acids – glutamine synthetase (GS), glutamate synthase (GOGAT), glutamate dehydrogenase (GDH), aspartate amino transferase (AspT) and asparagine synthetase (AS), interaction between carbon metabolism and amino acid synthesis.

Nitrogen fixation – an overview, enzymology of nitrogen fixation – nitrogenase, *nif* genes and their regulation, symbiotic nitrogen fixation - biochemical basis of rhizobial infection, nodule development. Mechanism of creation of microaerobic environment for nitrogen fixation. Metabolic exchange between host plant and bacteroids.

Overview of sulfate assimilation, sulfur chemistry and function, sulfate uptake and transport, reductive sulfate assimilation pathway, synthesis and function of sulfur containing amino acids, glutathione and its derivatives, role of sulfated compounds in metabolism.