Syllabus for Biochemistry and Biophysics

1. Molecular Interaction

Chemical bonds and stabilizing interactions: Structure of atoms, molecules and chemical bonds. Stabilizing interactions (Van der Waals, electrostatic, hydrogen bonding, hydrophobic interaction etc.)

Water: Properties, Structure, Ionization, pKw

Acids and Bases: pH, pKa , pKb , Handerson-Haselbach equation, buffer, measurement of pH.

2. Biomolecules

Carbohydrate: Structure and biological function of mono, polysaccharides (glycogen, starch, cellulose, Hetero polysaccharides: chondroitin sulphate, glycosamine, proteoglycan, glycoproteins).

Lipid: fatty acids, fats and oils, phospholipids, sphingolipids, glycolipids, cholesterol, gangliosides, lipoproteins, rancidity, acid value, saponification value, Iodine number, acetyl number, R.M. number.

Proteins: Amino acids and their physico-chemical properties, Peptide bond, Primary Secondary-(Ramachandran plot, α-helix, ß-strand, ß-sheet, turns and loops)-Tertiary (ion-ion, ion-dipole and dipole-dipole, interactions)-Quaternary structures of proteins, domains, motif and folds.

Nucleic acid: Nucleotides and their physico-chemical properties, double helical structure of DNA, A-B-Z forms of DNA, Repeat sequences and loops, RNA structure (primary, secondary and tertiary), ribozyme, denaturation and renaturation of DNA, chromosome structure.

Vitamins (Fat and water soluble): Structure and Biological functions.

Micronutrients: Physiological implications of Ca, Mg, Mn, Fe, Se, Co, Cr, Zn, Cu, Mo, sulfide and sulfate with special emphasis on Metalothionein, ceruloplasmin, ferritin, transferrin and their biological functions.

3. Molecular Biology

DNA replication (both prokaryotic and eukaryotic): Different modes of replication (semi-conservative, Bi-directional, Semi–discontinuous; Initiation (replication origin, associated proteins and enzymes, regulation of initiation); Elongation stage of replication (associated proteins and enzymes); Termination of replication (associated proteins and enzymes).

Transcription (both prokaryotic and eukaryotic): Prokaryotic transcription, transcription cycle (initiation, elongation and termination), bacterial promoters, different σ- factors, abortive initiation, processivity and editing functions of elongating polymerase, Rho-dependent and Rho-independent terminations. Eukaryotic transcription- RNA polymerases, transcription factors, processing of mRNA in eukaryotes.

Post-Transcriptional modification: RNA splicing, Spliceosome machinery, Splicing pathway, Alternative splicing, Exon shuffling, RNA editing, m-RNA transport.

Translation (both pro- and eukaryotic): m-RNA, t-RNA, Attachment of amino acids to t-RNA, Ribosome, Initiation, elongation and termination of translation, Post-translational modification.

Regulation of gene expression: Principles of transcriptional regulation, different operons and their regulation. Gene regulation at steps after transcription, Regulation of lambda phage. Eukaryotic gene regulation, Control of transcriptional regulator, Gene slicing, RNA in gene regulation, transcriptional control of gene expression, epigenetic regulation.

4. Microbiology & Virology

Micro-organisms: Microbiology in the 20th Century, Discovery of microorganisms, Classification of microorganisms, Microbial nutrition, Common nutrient requirements, Requirement for C, H and O, Requirement for N, P and S, Uptake of nutrients (Facilitated diffusion, Active transport) Group translocation, Synthetic or defined media, complex media, Types of media.

Microbial growth: Growth curve and equation, cell numbers (colony counts), cell mass., Environmental factors on growth (nutrient concentration, pH, temperature, oxygen concentration, pressure and radiation), Chemostat, Turbidostat.

Pro- & Eukaryotes: Prokaryotic cell structure (cell wall: Peptidoglycan, Gram positive and Gram negative cell walls), Mechanism of Gram staining, Bacterial surface charge, Capsules, Pili and Fimbriae, Flagella and Motility, Chemotaxis, eukaryotic cell structure (External cell coverings, Cilia and Flagella), Comparison of prokaryotic and eukaryotic cells.

Microbial spores: Endospores and exospores, their properties and germination.

Control of microorganisms: Physical methods (heat, filtration, radiation), Chemical methods (phenolics, alcohols, halogens, heavy metals, aldehydes and sterilizing gases), Antibiotics (definition and classification, basic mechanism of primary mode of action, Interaction between microbes (symbiosis, antibiosis and commensalism).

Extreme environment microbes: Anaerobes, Halophiles, Thermophiles, Acidophiles and Alkylophiles.

Biogeochemical roles of microbes: Carbon, nitrogen and sulfur cycles; Nitrogen fixation and its mechanism.

Microbiology of water, air, soil and milk.

Microbial diseases : The epidemiology of infectious disease, Human diseases cause by Gram positive and Gram negative Bacteria - Airborne diseases, Direct contact Diseases, Food-borne and water borne diseases with names of infecting microorganisms ,Human diseases caused by other bacteria and Human diseases caused by Fungi and Protozoa.

Bacteriophages: Discovery, Structures, Plaques, Host specificity, Life cycles of bacteriophages: Virulent phages (T4, T7, ϕX174, RNA phage), Lysogenic phages (λ, P1), Chronic phage (M13).

Eukaryotic Virus: Basic structures, Life cycles of RNA viruses (Vesicular Stomatitis Virus, Poliovirus, Reovirus, Retrovirus) and DNA viruses (Simian Virus 40, Adenovirus).

Viral Diseases: Human viral pathogens, Factors behind incidence and severity, Acute infection (gastrointestinal, respiratory, liver), Systemic spread, HIV and Aids, Viral oncogenes.

Diagnosis, Vaccines and Antivirals

5. Human Physiology
General anatomical interrelationship of organs

Nutrition: Autotrophy, Digestion of food, BMR

Excretion: Nephron, Urine formation, Micturition, Electrolyte balance.

Respiration: Transport of oxygen and carbon dioxide in blood, regulation of acid-base balance.

Cardiovascular system: Cardiac cycle, neural and chemical regulation

Blood circulation: Blood composition and functions, Blood corpuscles, haemopoiesis, plasma function, blood volume, blood group, hemoglobin, Mechanism of blood clotting, formation and maturation of WBC and RBC, Different haematological parameters.

Endocrine glands and their functions
Reproduction

6. Cell Biology

Origin and evolution of Cell: Prokaryotes, eukaryotes, development of multicellular organisms

Structural organization and function of intracellular organelles: Cell wall, nucleus, mitochondria, Golgi bodies, lysosomes, endoplasmic reticulum, peroxisomes, plastids, vacuoles, chloroplast, structure & function of cytoskeleton and its role in motility.

Endoplasmic reticulum (ER): Protein secretion from ER, target of proteins to ER, insertion of proteins into the ER membrane, protein folding and processing in ER, quality control in the ER, the smooth muscle ER and lipid synthesis, export of proteins and lipids from the ER, the signal hypothesis.

Golgi apparatus: Organization of Golgi, protein glycosylation within the Golgi, Lipid and polysaccharide metabolism in the Golgi, protein sorting and export from the Golgi apparatus.

Lysosomes: Lysosomal acid hydrolases, endocytosis and lysosome formation, phagocytosis and autophagy. Disorders resulting from defects in lysosomal function.

Peroxysomes: Functions of peroxysomes, peroxysome assembly. Diseases that result from abnormal mitochondrial and peroxysomal function.

Extracellular matrix and adhesion molecules: Cytoskeletal proteins and their functions**,** myofibrillar and their junction in cell shape and contraction, mechanism of muscle contraction.

Cell membrane:
Membrane lipids & proteins, matrix adhesion proteins, glycoproteins, receptors. Lipid mobility. Phospholipids, glycolipids and spingolipids in membranes. Membrane carbohydrate, liposome.

Transport of small molecules: Passive-facilitated-carrier mediated diffusion, symport, antiport and co-transport, ion channels, ionophores, , transport processes, P-type, V-type, F type and drug transport ATPases - their mechanism of actions and regulation. Multi drug transport protein, ATP dependent Cl^- channel, cystic fibrosis.

Cytoskeleton: Structure and organization of actin filaments, actin, myosin and cell movement, sarcoplasmic reticulum in muscle contraction, intermediate filaments, microtubules, microtubule motor and movement

Signaling by growth factors—epidermal growth factor, nerve growth factor, platelet derived growth factor, insulin growth factor and fibroblast growth factor.

Glycogen synthase kinase (GSK), AMP kinase, PI-3 kinase, Akt and mTOR pathways in signal transduction and their relevance in different disease pathogenesis.

Molecular and cellular basis of oxidants-mediated cardiovascular, pulmonary and neuronal systems. Protective role of Mg^{2+} in cardiovascular diseases. the competition between sympathetic and parasympathetic signals. Alpha-adrenergic and beta-adrenergic receptors. Muscarinic acetylcholine receptor, Cytokine receptors associated
tyrosine kinase in JAK/STAT and TGF/Smad pathways. Hedgehog, Wnt and Notch pathways

Protein acetylation and protein ubiquitinylation. Integrins sensors of signals for the extracellular matrix. Transcription factors as hormone receptor, The nuclear receptor family and activation of gene transcription. Ligand controlled transcription factor Xenosomes of the toxic stress response. Peroxysome proliferator activated receptors. Antioxidant response element. Activation of steroid hormone receptors by HSP70 and HSP 90. eiF2 kinase. Ras subfamily of G proteins. Control of gene transcription by Ca^{2+}.

The cell cycle: Phases of cell cycle, M-phase: mitosis and cytokinesis, prophase, metaphase, anaphase, telophase. Regulation of the cell cycle by growth factors and extracellular signals, Cyclins and CDKs in cell cycle regulation. Cell cycle Checkpoints and its activation. Apoptosis; Caspases, pro and anti-apoptotic genes, Mitochondria dependent and independent pathways, regulation of apoptosis, senescence.

Cancer: Defective control of cell death and differentiation, metastasis, communication of cancer cells with normal cells.

Vesicular transport: Understanding of vesicular transport, cargo selection, cont proteins and vesicle budding, vesicle fusion.

7. Bioenergetics

Bioenergetics : Organization and function of mitochondria, endosymbioant hypothesis for the biogenesis of mitochondria, electron transport chain, mechanism of oxidative phosphorylation, chemiosmotic hypothesis, respiratory chain inhibitors, coupled reaction, uncouplers, biological energy transducers.

8. Enzymology

Overview of enzymes: Classification and nomenclature and enzymes, properties of enzymes and the use of cofactors. Enzyme units and turnover of enzymes.

Catalytic site: Lock and key or template model, induced fit model, Role of metal ions, metalloenzymes and metal activated enzymes; ternary enzyme-metal substrate complexes, enzyme bridge complexes (M-Enz-S), substrate bridge complexes (Enz-S.M), metal-bridge-complexes (Enz-S.M), role of metal ions in catalysis, Vitamins as coenzymes.

Catalysis: Factors affecting catalytic efficiency of enzymes (pH, Temperature etc.) Michaelis-Menten equation, activators, inhibitors, inhibition reactions and their kinetics, allosteric and feedback inhibition, competitive, non-competitive, un-competitive and mixed type inhibition, kcat/km – a measure of catalytic efficiency.

Specialized Enzymes: Isoenzymes, regulatory enzymes, regulation of enzyme activity trypsinogen –chymotrypsinogen – pepsinogen. Carboxyanhydrase.

9. Metabolism

Energy exchange, energy rich compounds.

Metabolism of:
Carbohydrate: Mechanism and regulation of glycolysis and TCA cycle pentose phosphate pathways, glycogenesis and glycogenolysis and their regulation, glyoxylate pathway, uronic acid pathway, R.L. cycle, metabolism of fructose, galactose etc. Entner Doudoroff pathway. Gluconeogenesis, Futile cycle. Regulation of blood glucose homeostasis. Hormonal regulation of carbohydrate metabolism.

Lipids: Lipid biosynthesis, biosynthesis of Triglycerides, phosphoglycerides and sphingolopids. Fatty acid synthesis, desaturase and elongase. Fatty acid oxidation and lipid peroxidation. Ketone bodies- formation and utilization. Degradation of lipid and role of phopholipase.

Amino acids: Catabolic fate of alpha-amino acids and their regulation, urea cycle and its regulation. Amino acid biosynthesis.

Nucleotides: Biosynthesis of purines and pyrimidines- De novo and salvage pathways and their regulation. Catabolism of purines and pyrimidines. Structure and regulation of ribonucleotide reductase, Biosynthesis of ribonucleotides and deoxyribonucleotides.

Integration of different metabolic pathways. Organ specialization. Metabolism under different stress conditions.

10. Medical Biochemistry

Metabolic disorders of –
Carbohydrates: Galactosemia, glycogen storage disease, deficiency of glucose-6phosphate dehydrogenase, Hypoglycemia, Diabetes mellitus.

Lipids: Tay-Sachs disease, Nieman Pick disease.

Amino acids: Phenylketonuria, alkaptonuria, Maple syrup urine disease.

Nucleotides: Gout, Lesch -Nyhan Syndrome.

Function of liver in health and disease: Jaundice, Hepatitis; liver function test.

Evaluation of organ function test: Assessment and clinical manifestation of renal, hepatic, pancreatic, gastric & intestinal function, enzyme of pancreatic origin and biliary tract, test of myocardial infarction.

Enzymes as clinical diagnostic tools.

Endocrinal disturbance: Protein hormones and hormones of hypothalamus, pituitary, thyroid and steroid hormones.

Different types of anemia and mechanisms of their pathogenesis
Antibiotics: Classification: Primary mode of action of penicillin, streptomycin, chloramphenicol, tetracycline, actinomycin D, mitomycin C, polyenes, mechanism of antibiotics resistance, multiple drug resistance.

11. Medical Biophysics

Mechanical properties of muscles: Muscle contractility & motility, mechanical properties of muscles, biomechanics of cardiovascular systems, respiratory pressure, , eye and ear pressures (tonometry), rheology of blood.

Medical Acoustics: Physical aspects of hearing, pressure amplification in the ear, the cochlea and basilar membrane as sound frequency analyzer. Hearing defects and aids. Audiometry.

Neurobiology: Mechanism of nerve conduction, resting and action potential, generator potential, biophysics of neural spikes, voltage clamp experiments, synaptic conduction. Electrical events in a cardiac cycle, electrical potential of the brain. Neural aspects of vision, colour vision.

Medical Optics: Principles of optics, aberration of optical images, eye, vision, physical mechanism of image formation in retina, optical defects of the eye and their corrections. Fiber optics, principles of endoscopy and other uses of fiber optics in medical science. LASERS and Cryotopes, colonoscopy, Biometry.

Nuclear Medicine: Application in diagnostic studies, dynamic function studies, use of radioisotopes and tracers, imaging and autoradiography in cardiology, neurology, thyroid imaging. Radiopharmaceuticals.

Non-ionizing Electromagnetic Radiations: Low frequency and high frequency effects, effects of microwaves, physiological effects of electricity Electrical properties of cells and tissues, dielectric properties of biological materials.

Medical Imaging Techniques: Basic principles and uses: X-rays, CT, USG, Eco cardiograph, MRI, PET, SPET.

12. Radiation Biology

Principles of Radiological Physics: Properties and production of radiation-corpuscular and electromagnetic radiation, elementary process involving radiation and free particles, interaction of particulate radiation and EM radiation with matter.

Dose: Exposure dose, absorbed dos e, effectiveness of different radiation LET, RBE.

Effect of Radiation on Water: Direct and indirect action of radiation, chemical dosimetry.

General Biological Effect of Ionizing Radiation and Epigenetic effect: Effect on whole organism, on cells, biomolecules, factors that modulate radiation response –temperature, oxygen effect, LET cell age, cell cycle, role of radiation protector and sensitizers , Bystander effect (Epigenetic effect).

Survival Curve and its Interpretation: Target theory and its validity its limitation determination of target size, explanation of shoulder of survival curve, implication of repair. Sub-lethal damage and potentially lethal damage.

Radiation Protection and Tumor Radio Therapy.

Interaction of Non-ionizing Radiation with Matter: Ozone depletion**,** UV and visible light sources, action spectra, effects on cells, biomolecules.

13. Genetics

Mendelian Genetics, Population Genetics, Evolution, speciation Organization of Human chromosome, banding, karyotyping, chromosomal disorders, screening of human genetic disorder.

Gene Mutation and Polymorphism: Spontaneous mutation, Luria –Delbruck fluctuation test, origin of spontaneous mutation, different types of mutants, induced mutation, physical and chemical mutagens, mutator gene, mutational hot spots, selection– screening–enrichment of mutants (auxotroph, ts etc.), reversion, Ames test, suppression, hyper mutation, programmed mutation, SNP, length polymorphism and disease.

DNA Repair: Different types of DNA damages, repair processes –damage reversal-photo-reactivation, repair of alkylation damage, damage removal-nucleotide excision repair, base excision repair, mismatch repair, inducible repair pathways. Genetic diseases due to error in DNA repair**.**

Recombination: Generalized homologous recombination, models (Holliday, Meselson Radding, double- stranded break), proteins involved in homologous recombination in *E.coli*, homologous recombination of circular DNAs, site–specific recombination, transposition, IS and Tn elements, replicative and non-replicative transposition, Composite transposons.

Gene transfer: Transformation, Conjugation, Transduction

14. Cellular Signaling

Introduction of cell signaling**:** cAMP pathway: second messenger and protein phosphorylation. InsP3 and protein kinase C. InsP3 receptor and ryanodine receptors. Hormones and their receptors. Cell surface receptors, signaling through G-protein coupled receptors. Receptor tyrosine kinases, cytokine receptors and non-receptor tyrosine kinases.

Mechanisms of action of cholera toxin and pertussis toxin. cGMP and nitric oxide. Crosstalk between different signaling systems. Redox and nitrosylation switches in signal transduction. Phosphodiesterases and phosphatases as regulators of signal transduction. Protein kinase families in vertebrates: an overview. Steroid hormones and nuclear receptor superfamily.

Regulation of phospholipase A2, phospholipase C and phospholipase D activity. Role of ADP ribosylationm factor, guanine nucleotide exchange factor and guaninine nucleotide activating protein in regulating phospholipase D activity.

Cellular Ca^{2+} regulation**.** Ca^{2+} as intracellular messenger, Integration of receptor, non-receptor and store operated Ca^{2+} entry mechanism. Cellular Ca^{2+} entry and efflux mechanisms involving plasma membrane Na/K-ATPase, plasma membrane Ca^{2+} ATPase, sarco (endo) plasmic reticular Ca^{2+} ATPase, $Na^{+/}H^{+}$ exchanger, Na^{+}/Ca^{2+}
exchanger and voltage gated Na^{+}, K^{+} and Ca^{2+} channels in regulating intracellular Ca^{2+} dynamics. Regulation of mitochondrial Ca^{2+} dynamics. Concepts of redox regulation and pore formation in mitochondrial Ca^{2+} dynamics. Regulation of intracellular Ca^{2+} by cADP ribose.
Signaling by growth factors—epidermal growth factor, nerve growth factor, platelet derived growth factor, insulin growth factor and fibroblast growth factor.

Glycogen synthase kinase (GSK), AMP kinase, PI-3 kinase, Akt and mTOR pathways in signal transduction and their relevance in different disease pathogenesis.

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Antioxidant response element. Activation of steroid hormone receptors by HSP70 and HSP 90. eiF2 kinase. Ras subfamily of G proteins. Control of gene transcription by Ca^{2+}

15. Developmental Biology

Features of Development: Gametogenesis (Meiosis, Oogenesis, Spermatogenesis), Early Development (Cleavage, Gastrulation, Axes & Symmetry), Morphogenic processes (Cell movement, cell adhesion, classification of morphogenetic processes).

Developmental commitment: Fate map, specification, determination, cytoplasmic determinant, homeotic genes.

Techniques for study of Development: Study of gene expression by Biochemical and In Situ Methods, Cell labeling.

Development of model organisms: Drosophila, Xenopus, Mouse, C. elegans

Organogenesis: Tissue organization, Stem Cells.

16. Immunology

Introduction of immune systems: Cells and organs of immune system.

Lymphocytes: Differentiation, lymphocyte-sub-populations. T and B cells and their antigens

APC cells, Phagocytic cells, macrophage, dendritic cells, K and NK cells . Macrophage activation, pattern recognition molecules (TLR, NLR, RlRs)

Types of immunity: Innate-adaptive-passive-active immunity, self vs. non-self-discrimination. An overview

Antigenicity of molecules: Immunogen vs. antigen, characteristics and types of antigens, Epitope.

Immunoglobulins: Molecular structure, Classification and function, Antigen-antibody reactions.

MHC molecules: Structure, function, MHC polymorphism

Active and passive immunization: Types of vaccines, Attenuated and killed vaccines, macromolecular with reference to subunit vaccines, recombinant and DNA vaccines, strategies for new vaccine development, difficulties in vaccination of AIDS and malaria

B cell development, activation, differentiation
Antibody gene expression and antibody diversity, B cell receptor, monoclonal and polyclonal antibody, abzymes.
T-cell development, activation and differentiation, T-cell receptor expression and gene rearrangement, T- cell selection in thymus, T-cell receptor function, TCR-Antigenic peptide interaction, super antigens.

Antigen processing and presentation: Antigen presenting cells, MHC class I processing pathway and MHC class II processing pathway, Antigen presentation to T Cells.

Complement vs. cell mediated lysis: Complement pathways, biologic consequence of complement activation, regulatory mechanisms cell mediated cytotoxicity, necrosis, apoptosis, Cytokines and cell mediated immunity, Th subsets, immediate hypersensitivity, allergic response, Type I to Type IV hypersensitivity, Delayed type hypersensitivity; Cell mediated immunity, T cell subsets, antigen specific components of DTH, regulation of DTH

Microbial Immunity and immunoparasitology, Non-specific immunity and specific immunity, bacterial, viral and parasitic infection, development of new treatments for human diseases related to immune dysfunction.

Autoimmunity & Transplantation Immunology: B cell tolerance, T cell tolerance, clonal deletion, clonal anargy, B cell associated autoimmune diseases, mechanism of breaking B cell

tolerance, molecular mimicry, Transplantation, Transplant rejection, tissue compatibility, histocompatibility antigens in transplantation, Graft vs host rejection, mediators of rejection, immune suppression.

Tumor immunobiology: Cancer and immune system, tumor specific antigens, immnuosuppresion in tumor microenvironments, immunotherapy of cancer using monoclonal antibody and cytokines, NK and dendrdritic cells in cancer

Immune deficiency disorder – Phagocytic cell defects, B and T cell deficiency disorder, combined B and T cell deficiency disorder, secondary immunodeficiency conditions, complement deficiency.

17. Structural Biology

DNA Topology: Thermodynamics of DNA supercoiling, Theoretical approaches to DNA supercoiling, Knots and catenanes, DNA Bending.

Protein analysis by mass spectrometry: Mass spectrometry (general and technical), Sample preparation, Interpretation of mass spectra, Mass analysis of intact proteins and peptides.

Peptide mapping: Cleavage of peptide bonds, Separation of peptide fragments, Electroblotting procedure, Peptide sequencing strategies and tandem mass spectrometry.

Protein folding: Protein folding patterns, Thermodynamics of protein folding, Molten globule, Folding funnel, Molecular chaperones.

Protein-protein and Protein-DNA interactions: Protein-protein interfaces and their properties, Structural themes in proteins-DNA binding, Protein-DNA complexes and genes regulation.

Determination of DNA-ligand interactions by: Fluorescence correlation spectroscopy (principle, instrumentation and method), Time-resolved fluorescence spectroscopy, Microcalorimetry (both DSC and ITC), Scanning force microscopy, Surface Plasmon resonance spectroscopy.

18. Neurochemistry

Nervous system: Different parts of neuron and its function, types of glia and their function, chemical composition of myelin and differences in myelinated and unmyelinated neurons, blood brain barrier, different nerve fibers in mammalian system. Brain organization -CNS, PNS.

Neurotransmitters, neuromediater, neuromodulators and their molecular aspects, pharmacology of receptors, biochemical aspects of learning and memory, memory loss, biochemistry of mental disorder, biochemistry of aging and age related disorders (Parkinson's, schizophrenia, Huntington's, Alzheimer's), Cerebrovascular disease (stroke).

Meninges, carbohydrate and energy metabolism in brain, transport of amino acid, protein, nucleic acids, metabolites in brain, biochemistry of synaptic junctions, influence of different factors (growth factors, hormones, cytokines) in brain functions.

Reflexes and Sensation pain & temperature

CNS active drugs -Their classifications and modes of action**.**

19. Plant Biochemistry

Photosynthesis: Structures of organelles involved in photosynthesis in plants and bacteria, Proton gradients and electron transfer in chloroplasts of plants and in purple bacteria-differences from mitochondria. Light receptors-chlorophyll, light harvesting complexes, bacteriorhodopsin, photosystems I and II, energy transfer between photosystems-ferridoxin, plastocyanin, plastoquinone, carotenoid. The Hill reaction, photo-photophosphorylation and reduction of CO_2, C3, C4 and CAM metabolism, light and dark reactions. Light activation of enzymes regulation of photosynthesis, photorespiration.

Biological nitrogen fixation and ammonia assimilation: Mechanism of biological nitrogen fixation, Nitrogen fixing enzyme and its structure , Nif gene and Fix gene and its regulation in nitrogen fixation, ammonia assimilation.

Translocation of inorganic and organic substances

Plant hormones: Growth regulation substances and their mode of action. Molecular effects of auxin in regulation of cell extension. Molecular effects of gibberellic, abscisic acids and Cytokinins in the regulation of seed dormancy, germination, growth and development, and embryogenesis.

Defense systems in plants.

Sensory photobiology: Structure, function and mechanisms of action of phytochromes, cryptochromes and phototropins; stomatal movement; photoperiodism and biological clocks.