

B. Tech. in BIOTECHNOLOGY

Syllabus of Paper – 1

TRANSPORT PROCESSES IN BIOLOGICAL SYSTEM

Introduction, revision of the basic principles of fluid mechanics, heat and mass transfer, Physiological properties of biological fluids and tissues; Non-Newtonian fluid flow.

Fluid flow in the circulation, Fluid flow in tissues, Mass transport in biological systems, Membrane transport processes in biological systems, Heat transfer in biological systems, Numerical modelling of blood flow and mass transport in the circulation (including demonstration of solving flow problems using computational fluid dynamics), Numerical modelling of drug delivery to solid tumour.

BIOPROCESS ENGINEERING

Basic concepts of process calculations, Fundamentals of material and energy balance for processes with/without chemical reaction. Simultaneous mass and energy balance in flow and without flow conditions. Microbial growth, batch, fed-batch and continuous growth, Nutritional requirements for growth and product formation. Medium design and optimization. Types of sterilization, thermal death kinetics of microorganism. Heat sterilization of liquid medium in batch and continuous mode. Air sterilization. Different types of bioreactors, configuration of Bioreactors and their main components. Modes of bioreactor operation. Fermentation definition, inoculum development. Various types of Fermentation, submerged fermentation, aerobic and anaerobic fermentation. Overview of biosynthetic mechanisms. Metabolic stoichiometry.

THERMODYNAMICS AND BIOCHEMICAL REACTION

Introduction, Energy Transformation, system and surroundings, Internal energy, Work, heat capacity, First law of thermodynamics, energy conservation in the living organisms. The second law of thermodynamics, entropy, isothermal systems, Protein denaturation, The third law and biology, Irreversibility and life. Gibbs free energy – reversible processes, phase transitions, chemical potential, effect of solutes on boiling points and freezing points, ionic solutions, equilibrium constant, chemical coupling, redox reactions. Applications of Gibbs free energy (photosynthesis, substrate cycling, osmosis, dialysis, membrane transport, enzyme substrate interaction, protein solubility, stability and dynamics, ELISA, non equilibrium thermodynamics etc). Statistical thermodynamics, binding equilibria. Reaction kinetics – Introduction, Rate of reaction, rate constant and order of reaction, First and second order reaction, temperature effects, collision theory, transition state theory, electron transfer kinetics, enzyme kinetics, inhibition, reaction mechanism of lysozyme, hydrogen exchange, protein folding and pathological misfolding, polymerization, muscle contraction and molecular motors. The frontier of biological thermodynamics.

BIOCHEMICAL ENGINEERING

Introduction, Enzyme and its applications, Enzyme Kinetics, Biokinetic parameters, enzyme reactor systems, Inhibition of enzyme reactions, Effects of pH, temperature and shear. enzyme immobilisation & kinetics, Immobilized enzyme reactors, Cell growth kinetics, batch, Plug Flow and Continuous stirred tank fermentors, multiple fermenter in series, fermenter with cell recycling. Sterilization methods, Thermal death kinetics, Batch and continuous sterilization.

Agitation and aeration- importance, correlation for mass transfer coefficient, interfacial area, mechanical agitation, Gas hold-up, power consumption, oxygen absorption rate, bioreactor scale-up, separation of bioproducts.

ENVIRONMENTAL BIOTECHNOLOGY

Basics of environmental biotechnology, Microbial growth and metabolism; Respiration and energy generation; Enzyme kinetics and regulation, microbial transformation reactions (aerobic and anaerobic biotransformations). Bioremediation technology and influencing factors, Types – phytoremediation, bioventing, bioleaching, land farming, bioreactor, composting, bioaugmentation, rhizofiltration, biostimulation. Bioremediation systems and processes (solid, liquid and slurry phase bioremediation); Microbial cleaning of gases (biofiltration and bioscrubbing); In situ bioremediation; Biotreatability studies. Microbial detoxification of persistent organic pollutants (POPs) and endocrine disruptors (insecticides, herbicides, fungicides, polychlorinated biphenyls, heavy metals). Environmental monitoring-bioreporter, biomarker and biosensor technology. Biological energy and biomass production from waste. Environmental impact assessment, Biodiversity and its conservation, GMOs and Biosafety. Ethical issues in environmental biotechnology.

DOWNSTREAM PROCESSING AND BIOSEPARATION

Introduction to downstream processing, principles, characteristics of biomolecules and bioprocesses. Pretreatment and stabilisation of bioproducts. Unit operations for solid -liquid separation insoluble products: Centrifugation and Filtration: basic principles, design characteristics; Ultracentrifuges: principles and applications; Sedimentation; Flocculation; Cell disruption: Sonication; Bead mills; Homogenizers; Chemical lysis; Enzymatic lysis; Separation of soluble products: Liquid-liquid extraction, aqueous two-phase extraction, Precipitation of proteins by different methods: salting in and salting out method, Adsorption. Membrane based purification: Ultrafiltration and Microfiltration; Reverse osmosis; Dialysis. Chromatography: principles, instruments and practice, adsorption, reverse phase, ion-exchange, size exclusion, hydrophobic interaction, bioaffinity and pseudo affinity chromatographic techniques. Electrophoresis. Final step: Drying, lyophilisation and crystallization in final product formulation.

Syllabus of Paper - 2

BASIC BIOCHEMISTRY

Introduction to Biomolecules – Chemical Composition and Reactivity, Macromolecules and their monomeric subunits, Amino Acids, Proteins, Lipids, Carbohydrates, Nucleic Acids, Enzyme and Metabolism. The concept of protein and nucleic acid sequencing. Macromolecular complexes, Hormones, Vitamins.

BASIC MICROBIOLOGY

Introduction to cell, Cell theory, Cell ultrastructure of Prokaryotes and Eukaryotes, Nucleus, Cell organelles, Cytoskeleton, Plasma membrane, Extracellular matrix, DNA and Chromosome, Euchromatin, Heterochromatin, Telomere, Prokaryotic and Eukaryotic Chromosomal organization, DNA replication – Semiconservative, Discontinuous and Bidirectional replication of circular and linear DNA, Central Dogma, Transcription, Translation, Gene regulation, Cell cycle, Cell division, Programmed cell death, Cellular Communication and Signalling.

CELL AND MOLECULAR BIOLOGY

Introduction to cell, Cell theory, Cell ultra structure of Prokaryotes and Eukaryotes, Nucleus, Cell organelles, Cytoskeleton, Plasma membrane, Extracellular matrix, DNA and Chromosome, Euchromatin, Heterochromatin, Telomere, Prokaryotic and Eukaryotic Chromosomal organization, DNA replication – Semi conservative, Discontinuous and Bidirectional replication of circular and linear DNA, Central Dogma, Transcription, Translation, Gene regulation, Cell cycle, Cell division, Programmed cell death, Cellular Communication and Signalling.

GENETIC ENGINEERING

Understanding the gene, genome and DNA. Gene cloning and Vector: Importance of gene cloning and DNA analysis. Isolation of DNA: Purification of DNA from living cells, preparation of plasmid and bacteriophage DNA. Gene handling: Manipulation of purified DNA with various enzymes. Restriction and modification enzymes. Gene transfer: Introduction of DNA into living cells, Transformation, Identification of recombinants. Cloning Vector: Cloning vectors for prokaryotes and eukaryotes. Plasmids, bacteriophages, phagemids, cosmids, Ti plasmid, yeast artificial chromosome, Obtaining gene-specific clones: PCR, RT-PCR, real-time PCR and their various applications. Applications of gene cloning: Gene location, expression and function in animals. DNA labelling, DNA sequencing, DNA fingerprinting, Southern and Northern blotting, In-situ hybridization, RAPD, RFLP, Site-directed mutagenesis. cDNA and genomic DNA library. Genome function: Gene annotation, transcriptome and proteome. Production of recombinant proteins: Foreign gene expression in various systems. Genetic modification of animals: Animal bioreactor system, Production of bioactive pharmaceutical proteins from animals. Gene targeting. Biopharmaceuticals and Gene Therapy. Ethics in Genetic Engineering.

IMMUNOLOGY

Overview of the mammalian immune system, Evolutionary perspective of immunity and self defense, Innate immunity, adaptive immunity and its characteristics, Antigen and immunogen, Antigen presenting cells and antigen presentation, MHC molecules, Humoral immunity: Structure and function of antibody, antibody diversity, B cell maturation, B cell receptor for antigen, Cell mediated immunity: T cell diversity and their function, maturation of T cell, T cell receptor for antigen, interdependence of humoral and cell mediated immunity, Complement system. Toll-like

receptors: structure, function and cellular expression, Transplantation immunology, Autoimmune disorder, Allergy and hypersensitivity, Immunopathology.

BIOINFORMATICS

Scope of bioinformatics, Major bioinformatics resources (NCBI, EBI, ExPASy), Sequence and structure databases, Data Mining, Understanding large scale DNA and protein sequencing and arrays, Sequence analysis, biomolecular sequence file formats, scoring matrices (PAM and BLOSUM), sequence alignment, gene prediction, phylogeny, knowledge discovery in biochemical databases, Molecular modelling and simulations.

PLANT BIOTECHNOLOGY

Special features and organization of plant cells; Concept of cellular totipotency: Nutritional requirements, single cell culture, micro-propagation, somaclonal variation, somatic embryogenesis and production of embryoids; Protoplast isolation and culture; Somatic hybridization and cybrid production and their applications in crop improvement. Productions of virus free plants using meristem culture. Regeneration of plants; Basis of tumor formation, hairy roots, features of Ti and Ri plasmids, mechanisms of DNA transfer, role of virulence genes, use of Ti and Ri as vectors, binary vectors, use of 35S and other promoters, genetic markers, use of reporter genes, methods of nuclear transfer, particle bombardment, electroporation, microinjection, transformation of monocots; Transgene stability and gene silencing. Herbicide and insect resistance; Plant Genetic Engineering: Transgenic plants, Genetically modified (GM) plants; Plant products of industrial importance; Biochemistry of major metabolic pathways and products; Autotrophic and heterotrophic growth; Plant growth regulators and elicitors; Cell suspension culture development: methodology, kinetics of growth and production formation, nutrient optimization; Production of secondary metabolites by plant suspension cultures; Hairy root cultures and their cultivation, Techniques in raising transgenics, Applications of Plant Biotechnology in Crop Improvement.

ENZYMOLGY AND PROTIEN ENGINEERING

Enzyme classification and co-factors; Kinetics of enzymatic reactions; Types of enzyme inhibitors and their mechanism of action; Enzyme immobilization and its application; Introduction and scope of Protein Engineering; Different approaches of protein engineering; Random mutagenesis; Mutagenesis by rational design; Protein sequencing; Effect of mutation on protein structure, stability and folding; Applications of protein engineering; Examples of commercially used engineered proteins.
