Institute of Chemical Technology, Matunga, Mumbai
Syllabus for PhD (Tech) Bioprocess Technology Common Entrance Test

Section 1: DSP and Unit operaitons

Downstream Processing in Biotechnology, Selection of unit operation with due consideration of physical, chemical and biochemical aspect of biomolecules, basic review of bioprocess designing.

Primary separation and recovery processes: Cell disruption methods for intracellular products, removal of insolubles, biomass (and particulate debris) separation techniques, flocculation and sedimentation, centrifugation and filtration methods. Enrichment operations: Membrane – based separations (micro and ultrafiltration, precipitation methods, extractive separation, aqueous two-phase extraction, supercritical extraction, insitu product removal, integrated bioprocessing.

Product resolution / fractionation: Adsorptive and chromatographic separations processes, electrophoretic separations, hybrid separation technologies (electrochromatography).

Product finishing: precipitation/crystallization, mixing, dialysis, distillation and drying.

Ultracentrifugation as a separation technique for fractionation of cells and proteins.

Introduction to Process Analytical Technology (PAT) and Quality by Design (QbD).

Scale down, monitoring and Validation of bioprocesses

Section 2: Biological Sciences and fundamental processes

Biochemistry: Biochemical role of hormones, vitamins, proteins, enzymes, coenzymes,, nucleic acids and bioenergetics. Metabolism of lipids, proteins and carbohydrates, Principles of immunology. Protein structure, folding and function: Lysozyme, Ribonuclease A, Carboxypeptidase and Chymotrypsin. Enzyme kinetics including its regulation and inhibition. Glycolysis, TCA cycle, pentose phosphate pathway, oxidative phosphorylation, gluconeogenesis and glycogen metabolism. Photosynthesis: the Calvin cycle. Methods and applications of immobilization of cells and enzymes; kinetics of soluble and immobilized enzymes; biosensors.

Microbiology: Microbial Taxonomy and Diversity: Bacteria, Archea and their broad classification; Eukaryotic microbes: Yeasts, molds and protozoa; Viruses and their classification; Molecular approaches to microbial taxonomy. Prokaryotic and Eukaryotic Cells: Structure and Function: Prokaryotic Cells: cell walls, cell membranes, mechanisms of solute transport across membranes, Flagella and Pili, C. Pure culture techniques; Eukaryotic cell organelles: Endoplasmic reticulum, Golgi apparatus, mitochondria and chloroplasts. Microbial Growth: Definition of growth; Growth curve.

Molecular Biology: PCR and RT-PCR, microarray technology, DNA fingerprinting and recombinant DNA technology; prokaryotic and eukaryotic expression systems; Vectors: plasmids, phages and cosmids. Gene mutation: Types of mutation; UV and chemical mutagens; Selection of mutants; Ames test for mutagenesis; Bacterial genetic system:

transformation, conjugation, transduction, recombination, transposons; DNA repair and chromosomal aberrations.

Structure of atoms, molecules and chemical bonds.

Composition, structure and function of biomolecules (carbohydrates, lipids, proteins, nucleic acids and vitamins).

Section 3: Applied Biology and Biotechnology

Microbial fermentation and production of small and macro molecules. Application of immunological principles (vaccines, diagnostics). tissue and cell culture methods for plants and animals. Transgenic animals and plants, molecular approaches to diagnosis and strain identification. Genomics and its application to health and agriculture, including gene therapy. Bioresource and uses of biodiversity. Breeding in plants and animals, including marker assisted selection. Bioremediation and phytoremediation. Biosensors.

Section 4: Basic idea of Bioreaction engineering, system biology and synthetic biology

Section 5: Energy Biotechnology

Introduction to principles of generation of bioenergy. Classification of bioenergy. First, second and third generation Biofuels. Technologies for the three generation of Biofuels. Biomass to Liquid and Biomass to Gas fuel technologies, Biodiesel and Green Diesel, Algal Biotechnology for Bioenergy, Technologies for Biohydrogen, Biogas. Life cycle assessment of biofuels and biofuel technologies. Microbial fuel cells

Section 6: Basic Principles of Physics and Chemistry

Material and Energy Balances: Laws of mass conservation, chemical stoichiometry, heats of reactions, law of mass action

Numerical methods, Probability and Statistics: Numerical solutions of linear and non-linear algebraic equations Integration by trapezoidal and Simpsons rule, single and multi-step methods for differential equations.

Thermodynamics: Laws of conservation of mass and energy; degree of freedom analysis. First and Second laws of thermodynamics, reversible and irreversible processes, internal energy, enthalpy

Section 7: Fermentation and cell culture techniques

Nature of fermentation processes, Nutritional requirements in fermentation process, Strain Construction and Strain Improvement Modern Experimental Techniques: Batch, Fed-Batch, Continuous and extractive Fermentation, High cell-density and High-Performance Bioreactors, Quantitative Physiological Studies. Aerobic and anaerobic fermentation, surface, submerged and solid state fermentation technology, Statistical methods for fermentation optimization, Instrumentation and Control Systems, Improving the production of recombinant DNA proteins through fermentation development, Automation, optimization and Control of fermentation processes, Fermentor design and Cost, Design considerations for aseptic fermentation, Case studies with respect to antibiotic, enzymes and therapeutics. Cell culture engineering and technology: Plant and mammalian cell culture for production of bioproducts.

Bioreactor design and control

Background of bioreactors, Modeling and Design of bioreactors: batch, fed-batch, and continuous flow types (Airlift bioreactors, Airlift pressure cycle bioreactors, Loop bioreactor, Stirred tank bioreactors, Fluidized bed bioreactor, Packed-bed reactors, Trickle bed bioreactor, Bubble column fermenter, Multiphase bioreactors, Disposable bioreactors and Wave bioreactor). Design of Stirrers and impellers. Design, development and scale up of bioreactors and photobioreactors for production of antibiotics, enzymes, vaccines, therapeutic products and biofuels. Reactors with non ideal mixing. Immobilized enzyme/cell reactors. Mass and Heat Transfer, Shear effects in cell cultures, Pontryagin maximum principle for the determination of optimal flow rate to fed batch reactors, optimization for the production of primary and secondary biological products.

Sections 8: Biopharmaceuticals: characterization, applications and IPR

Biologicals and Biopharmaceuticals: Antibodies: polyclonal and monoclonal antibodies, catalytic antibodies, diagnostic antibodies; production of antibodies, vaccines: types, production and applications; Therapeutic proteins, hormones and peptides: Insulin, erythropoietin, interleukins, hormones, sterilization methods for biopharmaceuticals.

Bioanalyticals and related analytical methods: Absorption spectroscopy (UV, Visible and IR), fluorimetry, conductometry, potentiometery, principles of mass, NMR and ESR spectroscopy, X-ray diffraction and analytical chromatographic methods, hyphenated techniques in bioanalysis, Pharmacopoeial assay, LAL-Test, BET Test, Principles and methods of microbial assay of pharmacopoeia, filter integrity test, sterility testing of biopharmaceuticals, methods of analysis of for proteins. Electrophoresis (PAGE, SDS-PAGE); Immunological techniques: Immunodiffusion, immunoelectrophoresis, RIA and ELISA.

Applications of Biotechnology in Food and Pharmaceutical Technology areas: Use of biologicals and biotechnological processes to make food and pharma products including microbial and enzymatic biotransformations; Biological sciences involved in action of bioactives in health care in food and pharma products.

Types of IP, Patent filing in India and in abroad, Successful research and commercialization of biotechnological inventions

Section 9: Proteins and Enzyme Engineering, and Green Technology

Protein structure and chemistry, Protein database analysis, methods to alter primary structure of protein, examples of engineered proteins, protein design, principles and examples. Thermodynamics of peptide/protein folding and substrate binding. Tools for the manipulation of DNA. Biocatalysis versus chemical catalysis; Understanding when to use a biocatalyst for a chemical problem; Advantages/disadvantages of biocatalysts compared to traditional chemical reactions and heterogeneous/ homogeneous catalysis; Mild reaction conditions, excellent stereo- chemo- and regio- selectivity versus substrate specificity, product inhibition, lack of catalysts robustness, cofactor recycling; Isolated enzyme systems and whole cell systems. Free and immobilized enzymes for biocatalysis. Biocatalyst recycling and recovery; Enzyme immobilization. Enzyme Immobilization:

Physical and Chemical techniques for enzyme immobilization – adsorption, matrix entrapment, encapsulation, cross linking, covalent binding etc. Characterization of immobilized biocatalysts. Advantages and disadvantages of different immobilization techniques, overview of application of immobilized enzyme systems. Whole cells as catalysts; Energetically unfavourable reactions at low temperatures and in unfavourable solvents; The Michaelis-Menten model and modes of inhibition; Kinetics of enzyme catalysed reaction; Regulation mechanisms; Mechanisn of enzyme action; Multienzyme systems; Selection and screening of biocatalysts for activity, stability and substrate or product selectivity; Extremozymes – protein catalysts for reactions at extremes of temperature, pressure and pH. Principles of green chemistry (e.g. prevention of waste, less hazardous methods, safer chemicals and solvents, energy efficiency, atom economy, use of catalysis, etc.)

Section 10: Environmental Biotechnology

Bioremediation and Waste treatment, activated sludge, aerobic and anaerobic granulation and factors affecting on it. Environmental Policy & Legislation; Sampling of air and water pollutants; Monitoring techniques and methodology, pH, Dissolved Oxygen (DO); Chemical oxygen demand (COD); Biological Oxygen Demand (BOD); Speculation of metals, monitoring & analysis of CO, NO_2, CO_2, SO_2; Pesticide residue; Phenols and petrochemicals. Bioaugmentation and Biostimulation; Biofilms in treatment of waste water; Biofilm development and biofilm Kinetics; Aerobic Biofilms; Bioreactors for waste water treatments

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