

Pre Ph.D. Subjects in Biotechnology

	Paper-II	Paper-III
Set 1	Metabolic Engineering	Stem cell Technology
Set 2	Bioprocess Engineering	Downstream processing in Biotechnology
Set 3	Advanced Immunology and Immunotechnology	Cancer Biology and Therapy
Set 4	Biochemistry and Metabolic Regulation	Nano Biotechnology and Nano Devices
Set 5	Molecular Biology & Virology	Bioinformatics

To select only one set of Paper-II and Paper-III from the above list related to your research

METABOLIC ENGINEERING

UNIT-I

INTRODUCTION

Basic concepts of Metabolic Engineering, Overview of cellular metabolism, Different models for cellular reactions, induction, Jacob Monod model and its regulation, Differential regulation by enzymes, Feed back regulation, Feed back repression, Catabolite Repression, optimization and control of metabolic activities. metabolic pathway manipulations to improve fermentation, The modification of existing or the introduction of entirely new metabolic pathways.

UNIT-II

PRIMARY METABOLITES

Amino acid synthesis pathways and its regulation at enzyme level and whole cell level, Alteration of feed back regulation, Limiting accumulation of end products. Engineering for L-Lysine Production by *Corynebacterium glutamicum* Metabolic Engineering of Pentose Metabolism for Ethanol Production

UNIT-III

SECONDARY METABOLITES

Regulation of secondary metabolite pathways, precursor effects, prophase, idiophase relationship, Catabolite regulation by passing control of secondary metabolism, producers of secondary metabolites, applications of secondary metabolites in pharmaceutical industries, food and agriculture.

UNIT-IV

MATERIAL BALANCES AND DATA CONSISTENCY

Material Balances and Data Consistency: Comprehensive models of cellular reactions; stoichiometry of cellular reactions, reaction rates, dynamic mass balances, yield coefficients and linear rate equations, analysis of over determined systems, identification of gross measurement errors

UNIT-V

METABOLIC FLUX

Metabolic Flux Analysis: Theory and applications - metabolic flux analysis of citric acid fermentation, Experimental determination method of flux distribution, optimization and control of metabolic flux, Integrating Methodologies of Molecular Breeding and bioprocess systems engineering, Fundamentals of Metabolic control analysis: Control coefficients and the Summation Theorems, Elasticity Coefficients and the Connectivity Theorems, Generalization of MCA Theorems.

TEXT BOOKS:

1. Wang.D.I.C Cooney C.L., Demain A.L., Dunnill.P. Humphrey A.E. Lilly M.D., Fermentation and Enzyme Technology, 1st edition John Wiley and sons 2000.
2. Stanbury P.F., and Whitaker A., Principles of Fermentation Technology, 2nded, Butterworth-Heinemann, 2003.

REFERENCES :

1. Yu Matsuoka and Kazuyuki Shimizu 13C-Metabolic Flux Analysis and Metabolic Regulation, Chemical Biology, 1st Ed, Woodhead Publishing 2013.
2. David T. Dennis, David B. Layzell, Daniel D. Lefebvre, David H. Turpin, Plant Metabolism 2nd edition Prentice Hall College .

BIOPROCESS ENGINEERING

UNIT –I

INTRODUCTION

An overview of traditional and modern applications of biotechnology industry, outline of an integrated bioprocess and the various (upstream and downstream) unit operations involved in bioprocesses, generalized process flow sheets. Characteristic properties of biological fluids, Principles and mechanisms of thermal stabilization by filtration, single and multiple bubbles aeration. On-ideality and RTD in Bioreactors, Analysis of multiple interacting microbial populations.

UNIT –II

MEDIA DESIGN & STERILIZATION

Medium requirements for fermentation processes, Carbon, nitrogen, minerals, vitamins and other complex nutrients, oxygen requirements, medium formulation for optimal growth and product formation, examples of simple and complex media, design and usage of various commercial media for industrial fermentations, surface methodology, response surface methodology, PlackettBurman Designs, Thermal death kinetics of microorganisms, batch and continuous heatsterilization, sterilization of liquid media, filter sterilization of liquid media, Air. Design of sterilization equipment.

UNIT -III

MONITORING OF BIOREACTORS

On and off-line sensors for a modern bioreactor, integrated systems of bioreaction, bioseparation biosensors, Characteristics of bio products; Flocculation and conditioning of broth.

UNIT-IV

RHEOLOGY

Unit operation and process in the Chemical Industry, Fluid statics and Dynamics, Bernoulli's equation, Newtonian and Non-Newtonian fluids, materials and energy. Balance on reactive and non-reactive systems, principles of momentum, heat and mass transfer.

UNIT –V

STABILITY ANALYSIS

Stability analysis; Stability of recombinant cells; Physiology of immobilized cells; Packed-bed reactors; Fluidized-bed bioreactors; Air-lift bioreactors; Bubble-column bioreactors; Immobilized-enzyme bioreactors; Special reactors for animal and plant cells.

TEXTS BOOKS:

1. M. L Shuler and F. Kargi., Bioprocess Engineering, 2nd edition, Prentice Hall Inc., 2002.
2. P.M. Doran, Bioprocess Engineering Principles, 2nd edition, acadamic press, 2012.
3. P. B. Kaufman, L. J. Cseke, S. Warler, J. A. Duke, and H. L. Brielmann, Natural Products from Plants, CRC Press LLC, 2002.

REFERENCES:

1. H. J. Rehm and G. Reed, Biotechnology-A multi- Volume Comprehensive Treatise, 2/e, Vol 6, Wiley-VCH, 2002.
2. M. Moo-Young, Comprehensive Biotechnology, Vol. 4, 1st edition Pergamon Press, 2001.
3. F. Dicosmo and M. Missawa, Plant Cell Culture Secondary Metabolism: Towards Industrial Application. CRC LLC, 2004.

ADVANCED IMMUNOLOGY AND IMMUNOTECHNOLOGY

UNIT 1:

IMMUNOLOGY- FUNDAMENTAL CONCEPTS AND ANATOMY OF THE IMMUNE SYSTEM

Components of innate and acquired immunity; Phagocytosis; Complement and Inflammatory responses; Haematopoiesis; Organs and cells of the immune system- primary and secondary lymphoid organs; Lymphatic system; Lymphocyte circulation; Lymphocyte homing; Mucosal and Cutaneous associated Lymphoid tissue.(MALT&CALT);

UNIT -II

ANTIGENS AND ADAPTIVE IMMUNITY

Antigens and Immunogens, Factors affecting immunogenicity, Haptens and Adjuvants, B cell maturation, activation and differentiation, B-cell receptor, T-cell maturation, activation and differentiation and T-cell receptors. Major Histocompatibility Complex - MHC genes, Antigen processing and presentation- endogenous, antigens, exogenous antigens, non-peptide bacterial antigens and super-antigens.

UNIT-III

ANTIGEN-ANTIBODY INTERACTIONS

Precipitation, agglutination and complement mediated immune reactions; Advanced immunological techniques - RIA, ELISA, Western blotting, ELISPOT assay, immunofluorescence, flow cytometry and immunoelectron microscopy; Surface plasmon resonance, Biosensor assays for assessing ligand –receptor interaction, CMI techniques- lymphoproliferation assay.

UNIT-IV

VACCINE TECHNOLOGY

properties of adjuvants, recombinant DNA and protein based vaccines, plant-based vaccines, reverse vaccinology; Peptide vaccines, Live,Killed,Attenuated,sub unit vaccines,conjugate vaccines; Antibody genes and antibody engineering, chimeric and hybrid monoclonal antibodies; Catalytic antibodies and generation of immunoglobulin gene libraries.

UNIT-V

CLINICAL IMMUNOLOGY:

Immunity to Infection : Bacteria, viral, fungal and parasitic infections (with examples from each group); Hypersensitivity – Type I-IV; Autoimmunity; Types of autoimmune diseases; Mechanism and role of CD4+ T cells; MHC and TCR in autoimmunity; Treatment of autoimmune diseases; Transplantation – Immunological basis of graft rejection; Clinical transplantation and immunosuppressive therapy; Tumor immunology – Tumor antigens; Immune

response to tumors and tumor evasion of the immune system, Cancer immunotherapy; Immunodeficiency-Primary immunodeficiencies, Acquired or secondary immunodeficiencies.

TEXT BOOKS:

1. Peter J. Delves , Seamus J. Martin, Dennis R. Burton, Ivan M. Roitt Essential Immunology, 12 edition , Wiley-Blackwell, 2011.
2. Judy Owen , Jenni Punt , Sharon Stranford , Kuby Immunology, 7th Edition, W. H. Freeman, 2013.
3. Kuby, RA Goldsby, Thomas J. Kindt, Barbara, A. Osborne Immunology, 6thEdition, Freeman, 2002.
4. Brostoff J, Seaddin JK, Male D, Roitt IM., Clinical Immunology, 6thEdition, Gower Medical Publishing, 2002.
5. Janeway et al., Immunobiology; 8thedition, Garland Science, 2011.
6. William E. Paul, Fundamental of Immunology, 7thedition, Lippincott Williams & Wilkins, 2012.
7. A. K. Chakravarthy, Immunology&Immunotechnology, 1st edition, Oxford University Press, 2006.

REFERENCES:

1. Benjamin E and Leskowitz S, ELISA Immunological Techniques, 5thedition, Wiley-Liss, 2003.
2. Abul Abbas and Lichman , Cellular Molecular Immunology; 1st edition; Saunders, 2011.

BIOCHEMISTRY AND METABOLIC REGULATION

UNIT I:

ENZYMES

Nomenclature and classification of enzymes. Factors affecting on enzymes. Enzyme specificity. Enzymes assay. Enzyme inhibition. Applications

UNIT II:

METABOLISM AND REGULATION OF MACROMOLECULES

Carbohydrates- Glycolysis, aerobic and anaerobic fate of pyruvate, Oxidative phosphorylation, Gluconogenesis, pentose phosphate pathway, glycogen metabolism. Nucleic acids- Purine synthesis and catabolism. Pyrimidine synthesis and catabolism. Proteins- Transamination, Deamination, Oxidative deamination, Urea cycle. Aminoacids- Biosynthesis of non-essential aminoacids, catabolism of aminoacids. Lipids- Fatty acid synthesis, β -oxidation of fatty acids

UNIT III:

PHOTOSYNTHESIS

Light reaction and Dark reaction, photosynthesis in plants , bacteria and algae.

UNIT IV:

TRANSPORTATION IN BIOMEMBRANES, SIGNAL TRANSDUCTION

Structure of plasma membranes. Transportation of molecules across plasma membrane. Modes of cell signaling, Types of receptors used for cell signaling, pathway of intracellular signal transduction using secondary messengers, Apoptosis

UNIT V:

PROTEIN TARGETING

Protein synthesis, Cotranslation and post translation of proteins. Protein targeting

TEXT BOOKS

1. William H. Elliott and Daphne C. Elliott, Biochemistry and Molecular Biology 3rd edition Oxford University press 2005.
2. Jeremy M. Berg, John L. Tymoczko, Lubert Stryer, Biochemistry, 3rd Edition, W H Freeman & Co, 2006.

REFERENCES:

1. Albert L. Lehninger, Michael M. Cox, David L. Nelson Principles of Biochemistry 5th edition W H Freeman & Co 2008.
2. J.L. Jain, Sunjay Jain AND Nitin Jain. Fundamentals of Biochemistry 1st edition S. Chand and Company LTD 2007

MOLECULAR BIOLOGY AND VIROLOGY

UNIT I:

DNA & RNA:

DNA Structure, Replication and repair. Genes arrangement. Eukaryotic chromosome Structure and replication. Repetitive DNA. CpG islands, Gene amplification.

Different classes of RNA and their functions. RNA synthesis and other post transcriptional modifications.

UNIT II:

REGULATION OF GENE EXPRESSION IN PROKARYOTES & EUKARYOTES:

Protein synthesis and translational modifications. translational controls and inhibitors of polypeptide synthesis

Control of gene expression in prokaryotes. Transcriptional control in Eukaryotes. Regulation at Post-transcriptional level.

UNIT III:

PLASMIDS & TRANSPOSONS:

Types of plasmids, Ecological advantage, applications including as vectors in gene therapy and genetic transformation.

Molecular mechanism of antisense molecules, inhibition of splicing, polyadenylation and translation, disruption of RNA structure and capping.

UNIT IV:

ANTISENSE TECHNOLOGY & RHIBOZYMES

Biochemistry of ribozyme; hammer- head, hairpin and other ribozymes, strategies for designing ribozymes, Applications and challenges of antisense strategies (antisense oligo nucleotides, ribozyme technologies and RNAi) in gene silencing

UNIT V:

STRUCTURE & REPLICATION OF VIRUSES

Structure and classification of viruses and Replication of bacteriophages. Animal DNA and RNA viruses, Life cycles of viruses, Infectious DNA.

TEXT BOOKS :

1. "Molecular Biology of the gene" by Waston et al 4th ed.
2. "Genes VI" by Benjamin Lewis
3. Biochemistry and Molecular biology, William H. Elliott and Daphne C. Elliott, Third Edition, Indian edition, Oxford University press, 2005.

REFERENCES:

1. "Genetics" by Ursula Goodenough
2. "Cytogenetics" by IGarl P. Swanson, Mertz & Young
3. "General Virology" by Luria & Darnell
4. "Biochemistry" by Stryer.

STEM CELL TECHNOLOGY

UNIT –I

STEM CELLS INTRODUCTION

Definition and basics of stem cells, Classification of stem cells different types of stem cells- Human embryonic stem cells, Adult stem cells. Sources of stem cells - Fetus and various adult tissues – Advantages of stem cells. Blastocyst culture- Various stages of embryonic development. Properties of stem cells - self renewel, clonality and plasticity, Pluripotent nature of stem cells - Extrinsic and Intrinsic factors, Characterization of human embryonic stem cells – Expression of cell surface marker, Karyotyping.

UNIT –II

STEM CELLS AND THEIR DEVELOPMENTAL POTENTIAL

Sub cloning and controlled differentiation of human embryonic stem cells, In vitro and in vivo differentiation of human embryonic stem cells, Feeder free culture of human embryonic stem cells, Application of stem cells.

UNIT -III

THERAPEUTIC CLONING STRATEGIES

Derivation and propagation of human embryonic stem cells, Reproductive cloning by SCNT, Use of SCNT, Limitations of cloning – Hurdles to improve the efficiency of therapeutic cloning, Stem cell research and ethics – translational medicine ethics.

UNIT –IV

HAEMATOPOIETIC STEM CELLS

Basics, Development and Regulation of HSC, Clinical Application of HSC – Gene Therapy – using hematopoietic stem cells HSC for Leukemia, Mesenchymal stem cells (MSC) - Differentiation and Identification, Characteristics of mesenchymal stem cells, Clinical applications of stem cells, Stem cells and regenerative medicine, Ips – induced pluripotent stem cells.

UNIT -V

SKELETAL MUSCLE STEM CELLS

Development and functions, Liver stem cells – Organization and functions, Tumor stem cells – Basics differences and Similarities of cancer stem cells and stem cells, Cancer stem cell signaling – NOTCH pathway, wnt signaling pathways in hematopoietic stem cells, Stem cell therapies in animal models, Use and benefits of stem cell for human beings.

TEXT BOOKS:

1. AriffBongso, EngHin Lee -Stem Cells: From Bench to Bedside, 2nd Edition, World Scientific Publishing Company, 2010.
2. C S Potten - Stem Cells; 1st edition; Academic Press, 2002.

REFERENCES:

1. Nagy A, Gertenstein M, Vintersten K, Behringer R- Manipulating the Mouse Embryo , 1st edition, New York: Cold Spring Harbor Press, 2003.
2. Scott F. Gilbert, Susan Singer- Developmental biology, 8th edition, Sinauer Associates Inc, 2006.

DOWNSTREAM PROCESSING IN BIOTECHNOLOGY

UNIT-I

INTRODUCTION TO BIOPRODUCTS:

Regular characteristics of Biomolecules, Problems and requirements of bioproduct purification. Economics of downstream processing in Biotechnology, cost-cutting strategies, characteristics of biological fluids.

UNIT –II

CELL DISRUPTION METHODS

Various cell disruption methods, need for cell disruption for intracellular products, cell disruption equipment. Applications in bio-processing.

UNIT-III

SOLID- LIQUID SEPARATION

Centrifugation: Principles of centrifugation, centrifuge effect, various centrifuges viz; basket centrifuge, tabular centrifuge, disc-bowl centrifuge, scale –up of centrifuges. Extraction methods.

UNIT-IV

CONCENTRATION OF PRODUCTS

Membrane separation processes: Basic principles of membrane separation, membrane characteristics, different types of membranes, criteria for selection of membranes.

UNIT-V

CHROMATOGRAPHIC SEPARATION AND ELECTROPHORESIS METHODS

Principles of chromatographic separation methods, different types of chromatographic methods, viz; adsorption chromatography, ion – exchange chromatography, gel chromatography, affinity chromatography etc. Applications in bio-processing. Principles of electrophoresis and electrophoresis mobility, Applications. **Drying:** Various types of drying methods, Freeze drying technique and its advantages over other methods. Applications in bio-processing.

TEXT BOOKS

- 1) Product Recovery in Bioprocess technology, BIOTOL series, Butterworth –Heinemann, 2006
- 2) Principles of fermentation technology by Peter F Stan bury, Allan Whitaker and Stephen J Hall, Pergamon Publications.2007
- 3) Comprehensive Biotechnology Vol 2 Ed: M.Moo –young 2003

REFERANCE BOOK:

1. Principles of Downstream processing, by Ronald & J.Lee, 2nd edition Wiley Publications, 2007

CANCER BIOLOGY AND THERAPY

UNIT I:

FUNDAMENTALS OF CANCER BIOLOGY:

Regulation of cell cycle, mutations that cause changes in signal molecules, effects on receptor, signal switches, tumour suppressor genes, modulation of cell cycle in cancer, different forms of cancers, diet and cancer. Cancer screening and early detection, Detection using biochemical assays, tumour markers, molecular tools for early diagnosis of cancer.

UNIT II :

PRINCIPLES OF CARCINOGENESIS:

Theory of carcinogenesis, Chemical carcinogenesis, metabolism of carcinogenesis, principles of physical carcinogenesis, x-ray radiation-mechanisms of radiation carcinogenesis.

UNIT III :

PRINCIPLES OF MOLECULAR CELL BIOLOGY OF CANCER:

Signal targets and cancer, activation of kinases; Oncogenes, identification of oncogenes, retroviruses and oncogenes, detection of oncogenes. Oncogenes/proto oncogene activity. Growth factors related to transformation. Telomerases.

UNIT IV :

PRINCIPLES OF CANCER METASTASIS:

Clinical significances of invasion, heterogeneity of metastatic phenotype, metastatic cascade, basement membrane disruption, three step theory of invasion, proteinases and tumour cell invasion.

UNIT V :

NEW MOLECULES FOR CANCER THERAPY :

Different forms of therapy, chemotherapy, radiation therapy, detection of cancers, prediction of aggressiveness of cancer, advances in cancer detection. Use of signal targets towards therapy of cancer; Gene therapy.

TEXT BOOKS:

1. Maly B.W.J, "Virology A Practical Approach", IRL Press, Oxford, 1987.
2. Lodish et al, Cell and Molecular Biology, 7th edition, W. H. Freeman, 2012.
3. Margaret Knowles and Peter Selby, Cellular and Molecular Biology of Cancer, 4th edition, Oxford University Press, 2005.
4. Dunmock N.J And Primrose S.B., "Introduction to Modern Virology", Blackwell Scientific Publications, Oxford, 1988.

REFERENCES

1. Weinberg, Biology of Cancer, 1st edition, Garland Publication, 2006.

2. Devita, Hellman, and Rosenberg's Cancer: Principles and Practice of Oncology.9th edition
Lippincott Williams and Wilkins 2011.

NANO BIOTECHNOLOGY AND NANO DEVICES

UNIT-I

INTRODUCTION

Introduction to Nano Biotechnology: Background and Definition of Nano biotechnology-Significance. Supramolecular Chemistry: Definition and examples of main intermolecular forces used in supramolecular chemistry. Self-assembly processes in organic systems. Main supra molecular structures.

UNIT –II

NANOSCALED BIOMOLECULES

Chemical approaches to nano structured materials-Molecular Building Blocks to Nanostructures. Nano scaled Biomolecules-Nucleic Acids and Proteins. Chemical Synthesis of Artificial Nanostructures. Structural Control to Designed Properties and Functions. Molecular nano scale engineered devices.

UNIT-III

NANOFABRICATION

Nanofabrication: Introduction, Basic techniques, MEMS fabrication techniques, nanofabrication techniques-Equipment and processes needed to fabricate nano devices and structures such as bio-chips.

UNIT-IV

APPLICATIONS OF NANO MATERIALS

Multilayer films, Applications to NEMS, Bio and other applications to Nano devices.

UNIT V:

MEDICAL NANO TECHNOLOGY

Nano technology for Immune system, clinical imaging, nano robots, Nano Fibres for Tissue Engineering.

TEXT BOOKS:

1. David S. Goodsel Bionanotechnology: Lessons from Nature 1st edition Wiley Liss 2004
2. Vinod Labhasetwar, Diandra L. Leslie-Pelecky Biomedical Applications of Nanotechnology 1st edition Wiley-Interscience 2007.
3. Introduction to Nano Technology by Charles. P. Poole Jr and Frank J. Owens. Wiley India Pvt Ltd.

REFERENCE BOOKS:

1. Hand book of Nano structured materials Vol I to V
2. Encyclopaedia of Nano Technology by M. Balakrishnarao and K. Krishna Reddy, Vol I to X Campus books.

BIOINFORMATICS

UNIT I :

INTRODUCTION AND BIOINFORMATICS AND BIOLOGICAL DATABASES :

Introduction to Bioinformatics- History, overview, Applications, Emerging areas of Genomics and Proteomics. Biological databases and their management – Protein Sequence databases, Protein structure databases, DNA databases, drug databases

UNIT II :

NUCLEOTIDE SEQUENCE ANALYSIS AND RNA STRUCTURES

Nucleotide sequence analysis. DNA Sequence Analysis- Nucleic acid codes, Introduction to whole genome analysis, restriction site checks, Sequence assembly, finding overlaps and contigs, shotgun projects, walking primers, ORF analysis, Identification of transcription signals and other sequence patterns, Restriction enzyme databases, Coding region identification, EST analysis, SNP analysis, RNA Sequence and structure Analysis - Different types of RNA, si-RNA design and development, micro RNA identification strategies, RNA secondary structure, RNA structure Prediction Methods, Introduction to Small nuclear RNAs, Applications of Small nuclear RNADNA/Protein Sequence alignments

UNIT III:

STATISTICAL METHODS IN BIOINFORMATICS:

Dynamic programming methods- derivation and algorithms. Sequence Alignment concepts, Pair-wise alignment, Heuristic alignments, Multiple alignment, Matrices (PAM, BLOSUM) Statistics and Scoring systems

UNIT IV :

STRUCTURE AND MODELING OF PROTEINS:

Protein sequence analysis. Protein Physical properties- Molecular weight and amino acid composition, Iso-electric point, extinction coefft, Studies of protein hydrophobicity on kyte and Doolittle scale and other physico-chemical properties of primary protein sequences. Structural properties- Secondary structures, Hydrophobic patterns, structural motifs, Post translational modifications, Folding domain motifs, protein families. Principles of Protein Structure, Secondary Structure prediction methodologies, Threading methods. Protein Folds, protein domains, Tertiary structure prediction. Homology Modeling of proteins- methodology and applications Ab initio protein structure prediction Energy minimization - concept, applications and methodology Molecular Dynamics simulations – concept and methodology

UNIT V:

BIOINFORMATICS APPLICATIONS AND DRUG MODELLING.

QSAR and Drug Designing Concepts, 2D descriptors, 3D descriptors. Drug Discovery: Drug Discovery Overview, Stages of drug discovery, Introduction to drug discovery tools– MoE and Accelrys suite. Bioinformatics applications in experimental biotechnology. Automatic 2D Gel analysis- Tools, Principles and methodology, Restriction analysis of DNA sequences, *Insilico*Primer Design, Micro-array image and data analysis, Protein Interaction Mapping (Yeast 2 Hybrids)Functional genomics tools, Functional proteomics tools

TEXT BOOKS:

1. Bioinformatics by Zoe Lacroix and Terence Critchlow, Morgan Kaufmann Publishers, 2003.
2. Bioinformatics by OrpitaBosu, Oxford University press, 2007.

REFERENCE BOOKS:

1. Bioinformatics : Genome and sequence analysis by David W Mount.
2. Bioinformatics : A practical guide to analysis of genes and proteins by Baxevanis, Andreas D Wiley – Interscience publishers.