

1st SEMESTER

Sl. No.	Subject Type	Subject Code	Subject Name	Teaching Hours/Week			Credit	Maximum Marks			
				L	T	P		IA	EA	PA	Total
1	Basic Science Course	UBSCH101	CHEMISTRY	3	1	0	4	30	70	0	100
2	Basic Science Course	UBSMH102	MATHEMATICS -I	3	1	0	4	30	70	0	100
3	Engineering Science Course	UESCS103	PROGRAMMING FOR PROBLEM SOLVING	3	1	0	4	30	70	0	100
4	Basic Science Course	ULCCH101	CHEMISTRY LAB	0	0	3	1.5	0	0	100	100
5	Engineering Science Course	ULCCS103	PROGRAMMING FOR PROBLEM SOLVING LAB	0	0	2	1	0	0	100	100
6	Engineering Science Course	ULCME104	ENGINEERING GRAPHICS AND DESIGN LAB	1	0	4	3	0	0	100	100
7	Mandatory Course	INDUCTION TRAINING(21 DAYS)						0			
			Total				17.5				600

2nd SEMESTER

Sl. No.	Subject Type	Subject Code	Subject Name	Teaching Hours/Week			Credit	Maximum Marks			
				L	T	P		IA	EA	PA	Total
1	Basic Science Course	UBSPH111	PHYSICS	3	1	0	4	30	70	0	100
2	Basic Science Course	UBSMH202	MATHEMATICS-II	3	1	0	4	30	70	0	100
3	Engineering Science Course	UESEE113	BASIC ELECTRICAL ENGG.	3	0	0	3	30	70	0	100
4	Humanities & Social Sciences	UHSMH205	ENGLISH	2	0	0	2	30	70	0	100
5	Basic Science Course	ULCPH111	PHYSICS LAB	0	0	3	1.5	0	0	100	100
6	Engineering Science Course	ULCEE113	BASIC ELECTRICAL ENGG. LAB	0	0	4	2	0	0	100	100

7	Engineering Science Course	ULCME114	WORK SHOP/BASIC MANUFACTURING PROCESS LAB	1	0	4	3	0	0	100	100
8	HS	ULCMH204	ENGLISH LAB	0	0	2	1	0	0	100	100
			Total				20.5				800
9	Summer Internship programme (4 to 8 weeks) is mandatory as per AICTE rule										

3rd SEMESTER

Sl. No.	Subject Type	Subject Code	Subject Name	Teaching Hours/Week			Credit	Maximum Marks			
				L	T	P		IA	EA	PA	Total
1	Core Course	UPCBT301	Cell and Molecular Biology	3	0	0	3	30	70	0	100
2	Core Course	UPCBT302	Biochemistry	3	0	0	3	30	70	0	100
3	Core Course	UPCBT303	Biostatistics	3	1	0	4	30	70	0	100
4	Engg. Science Course	UESME304	Fluid Mechanics	3	0	0	3	30	70	0	100
5	Basic Science Course	UBSIT305	C++	3	1	0	4	30	70	0	100
6	Humanities Science Course	UHSMH212	Organizational Behavior	3	0	0	3	30	70	0	100
7	Lab Course	ULCBT301	Biosafety and Bioethics Lab	0	0	3	1.5	0	0	100	100
8	Lab Course	ULCBT302	Biochemistry Lab	0	0	3	1.5	0	0	100	100
			Total				23				800

4th SEMESTER

Sl. No.	Subject Type	Subject Code	Subject Name	Teaching Hours/WBTK			Credit	Maximum Marks			
				L	T	P		IA	EA	PA	Total
1	Core Course	UPCBT401	Microbiology	3	0	0	3	30	70	0	100
2	Core Course	UPCBT402	Genetics and Genetic	3	1	0	4	30	70	0	100

			Engineering								
3	Core Course	UPCBT403	Thermodynamics of Biological Systems	3	0	0	3	30	70	0	100
4	Basic Science Course	UBSMH301	Mathematics-III	3	0	0	3	30	70	0	100
5	Humanities Science Course	UHSMH211	Engineering Economics	3	0	0	3	30	70	0	100
6	Lab Course	ULCBT401	Microbiology Lab	0	0	3	1.5	0	0	100	100
7	Lab Course	ULCBT402	Cell and Molecular Biology Lab	0	0	3	1.5	0	0	100	100
8	Lab Course	ULCBT403	Genetic Engineering Lab	0	0	3	1.5	0	0	100	100
9	Mandatory Course	UMCCE401	Environmental Science	2	0	0	0	30	70	0	100
			Total				20.5				900
10	Summer Internship programme (4 to 8 weeks) is mandatory as per AICTE rule										

5th SEMESTER

Sl. No.	Subject Type	Subject Code	Subject Name	Teaching Hours/Week			Credit	Maximum Marks			
				L	T	P		IA	EA	PA	Total
1	Core Course	UPCBT501	Bioanalytical Techniques	3	0	0	3	30	70	0	100
2	Core Course	UPCBT502	Plant and Animal Biotechnology	3	0	0	3	30	70	0	100
3	Core Course	UPCBT503	Bioprocess Engineering	3	0	0	3	30	70	0	100
4	Core Course	UPCBT504	Immunotechnology	3	0	0	3	30	70	0	100
5	Programme Elective-I	UPEBT501 or UPEBT502	Industrial Microbiology and Enzyme Technology or Biophysics	3	0	0	3	30	70	0	100
6	Open Elective-I			3	0	0	3	30	70	0	100
7	Lab Course	ULCBT501	Bioprocess Engineering Lab	0	0	3	1.5	0	0	100	100

8	Lab Course	ULCBT502	Plant and Animal Biotechnology Lab	0	0	3	1.5	0	0	100	100
9	Lab Course	ULCBT503	Immunotechnology Lab	0	0	3	1.5	0	0	100	100
			Total				22.5				900

6th SEMESTER

Sl. No.	Subject Type	Subject Code	Subject Name	Teaching Hours/Week			Credit	Maximum Marks			
				L	T	P		IA	EA	PA	Total
1	Core Course	UPCBT601	Bioinformatics	3	0	0	3	30	70	0	100
2	Core Course	UPCBT602	Downstream process Engineering	3	0	0	3	30	70	0	100
3	Programme Elective-II	UPEBT601 Or UPEBT602	Environmental Biotechnology or Food process Engineering	3	0	0	3	30	70	0	100
4	Programme Elective-III	UPEBT603 or UPEBT604	Nanobiotechnology or Introduction to Biomedical Engineering	3	0	0	3	30	70	0	100
5	Open Elective-II			3	0	0	3	30	70	0	100
6	Lab Course	ULCBT601	Bioanalytical Methods Lab	0	0	3	1.5	0	0	100	100
7	Lab Course	ULCBT602	Downstream Processing Lab	0	0	3	1.5	0	0	100	100
8	Lab Course	ULCBT603	Bioinformatics Lab	0	0	4	2	0	0	100	100
			Total				20				800
9	Summer Internship programme (4 to 8 weeks) is mandatory as per AICTE rule										

7th SEMESTER

Sl. No.	Subject Type	Subject Code	Subject Name	Teaching Hours/Week			Credit	Maximum Marks			
				L	T	P		IA	EA	PA	Total
1	Programme Elective-IV	UPEBT701 or UPEBT702	Stem cell Engineering Or Biomaterial Engineering	3	0	0	3	30	70	0	100
2	Programme Elective-V	UPEBT703 Or UPEBT704	Genomics, Proteomics & Metabolomics Or Biosensors	3	0	0	3	30	70	0	100
3	Open Elective-III			3	0	0	3	30	70	0	100
4	Open Elective-IV			3	0	0	3	30	70	0	100
5	Humanities Science Course	UHSMH701	Entrepreneurship Development	3	0	0	3	30	70	0	100
6	Project Course	UPRBT701	Project Stage-1	0	0	6	3	0	0	100	100
7	Seminar	USEBT701	Internship Seminar	0	0	2	1	0	0	100	100
			Total				19				700

8th SEMESTER

Sl. No.	Subject Type	Subject Code	Subject Name	Teaching Hours/Week			Credit	Maximum Marks			
				L	T	P		IA	EA	PA	Total
1	Programme Elective-VI	UPEBT801 or UPEBT802	IPR, Bioethics and Biosafety or Molecular Modeling & Drug design	3	0	0	3	30	70	0	100
2	Open Elective-V			3	0	0	3	30	70	0	100
3	Open Elective-VI			3	0	0	3	30	70	0	100

4	Project Course	UPRBT801	Project Stage-2	0	0	14	7	0	0	100	100
5	Core Course	UPCBT801	Comprehensive Viva Voce	0	0	2	1	0	0	100	100
			Total				17				500

Open Electives offered by the Department of Biotechnology

1. Physiology for Engineers
2. Introduction to Biopharmaceutical Technology
3. Computational Biology
4. Industrial Biotechnology
5. Bioseparation Technology
6. Tissue Engineering

COURSE: B. Tech (Biotechnology) Duration: 4 years (Eight Semesters)

SEMESTER-III

CELL AND MOLECULAR BIOLOGY

Module-I

Introduction :Origin and evolution of cells, Cells as experimental models, Cell theory, tools of cell biology, chemistry of cells, molecular composition of cells, Central role of enzymes, metabolic energy, biosynthesis of cell constituents, Organization of Cell (Prokaryotic and Eukaryotic), Cell Wall & Cell Membrane, Nucleus, Endoplasmic reticulum, Golgi apparatus and Lysosomes, Bioenergetics and Metabolism – Mitochondria, chloroplasts, Peroxisomes, Cell Cycle, Cell Divisions- Mitosis and Meiosis, Programmed cell death, Membrane transport & trafficking, mechanisms of protein sorting and targeting, intercellular communication and associated signaling pathways.

Module-II

Prokaryotes and Eukaryotes Genome Organization, Central dogma of molecular biology, Watson-Crick model of DNA, DNA as the genetic material, Kinetics of DNA-DNA hybridization- Genome complexity, C- value Paradox, Denaturation-renaturation, Cot curve analysis, Repetitive DNA, satellite DNA. Variants of genes- cryptic genes, pseudogenes and selfish DNA.

DNA Replication: Semi-conservative DNA replication, Origins of replication in prokaryotes and eukaryotes, DNA polymerases, Enzymes of DNA replication in prokaryotes and eukaryotes, Replication factors and the mechanism of replication, leading strand and lagging strand synthesis, DNA proofreading.

Module-III

Transcription: RNA types- general features, prokaryotic and eukaryotic genes-regulatory elements of genes (proximal or internal, including promoter, operator, activator and enhancers). Controlling factors of Transcription, RNA polymerases of prokaryotes and eukaryotes, Enzyme complexes and their assembly on the regulator region). Mechanism of transcriptional initiation, elongation and termination in prokaryotes and eukaryotes. Post transcriptional m-RNA processing- Capping and poly (A) tailing, m-RNA splicing, mRNA editing.

Translation: Genetic code, Codon & anticodon, Principle of protein synthesis, Translation machinery (Activation of t-RNA, Ribosome of prokaryotes and eukaryotes), Mechanism of Translation initiation, elongation and termination in prokaryotes and eukaryotes. Post translational modification of protein.

Recommended Books

1. Theory & Problems in Molecular & Cell Biology, Stansfield, Tata McGraw Hill.
2. The Cell Molecular approach, Geoffrey M. Cooper, ASM press Washington D.C. Sinauer Associates.
3. Gene IX, Benjamin Lewin (2004), Published by Pearson Prints Hall, Pearson.
4. Cell and Molecular Biology: Concepts and Experiments, Gerald Karp, 7th edition, Wiley Global Education .
5. Mol Bio of the Cell, Bruce Alberts, Lewis, Johnson, Garland Publisher Inc.
6. The cell: A molecular approach, Cooper, G M., ASM Press, Washington

BIOCHEMISTRY

Module-I

Amino acids: Classification and properties, Acid–base properties, The Peptide bond, ionization behaviour of peptides.

Proteins: Levels of protein structure, Determination of primary structure of protein. Secondary, tertiary and quaternary structures, structural patterns: motifs and domains. Ramachandran Plot

Carbohydrates: Classification, configuration and conformation of monosaccharides, sugar derivatives, important disaccharides. Structural and storage polysaccharides, glucosaminoglycans, proteoglycans, glycoproteins and glycolipids.

Lipids: Classification, storage lipids, structural lipids (glycerophospholipid and sphingolipids), signalling lipids.

Nucleic acid: Nucleosides, nucleotides, nucleic acids - structure, a historical perspective leading up to the proposition of DNA double helical structure; difference in RNA and DNA structure

Coenzymes and vitamins: Types and their function.

Module-II

Bioenergetics: Laws of Thermodynamics, entropy, enthalpy and free energy, standard free energy, chemical equilibrium. Phosphoryl group transfer and ATP.

Amino acid catabolism: (transamination, oxidative deamination and urea cycle) Protein degradation (proteosomal pathway) and Solid phase synthesis of peptides.

Carbohydrate metabolism: Glycolysis, TCA cycle, pentose-phosphate pathway. Gluconeogenesis, glycogen metabolism, regulation of carbohydrate metabolism, Oxidative phosphorylation, electron transport and ATP synthesis

Lipid metabolism: Biosynthesis and oxidation of fatty acids, regulation of fatty acid metabolism.

Module-III

Enzymes: General properties, nomenclature and classification, Michaelis- Menten kinetics and its significance, Brigg's-Halden modification, determination of V_{max} and K_m ,

Mechanism of enzyme action: general acid-base catalysis, covalent catalysis, metal catalysis

Enzyme inhibition: competitive, non-competitive inhibition, determination of K_i , allosteric regulation, covalent modification.

Recommended Books

1. Principle of Bio-Chemistry – Lehinger, Nelson and Cox
2. Biochemistry by L. Stryer
3. Fundamentals of Biochemistry – Voet & Voet
4. Biochemistry by Zubay.
5. Biochemistry, Rastogi, Tata McGraw Hill.

BIOSTATISTICS

Module-I

Introduction and definition of Biostatistics; Concept of variables in biological systems. Collection, Classification, tabulation graphical and diagrammatic representation of numerical data; Measures of central tendency: Mean, Median and Mode and their relationship; Measures of dispersion: Range, Quartile deviation, Mean deviation, Standard deviation, Concept of standard error, Coefficient of variation, Skewness and Kurtosis.

Module-II

Probability: Random experiment, events, sample space, mutually exclusive events, independent and dependent events; Various definitions of probability, addition and multiplication theorems of probability, Random variables (discrete and continuous), Probability density functions and its properties; Probability distributions: normal, Binomial, Poisson and their application.

Module-III

Concept of populations and sample. Simple random sampling without replacement. Definition of simple random sample; Designing of Experiments-Random block design and Split plot design; Correlation and Regression, linear and quadratic regression; Analysis of variance: One- way and two-way classifications with single observation per cell. Duncan's multiple range test; Tests of significance: Chi-square, student's t, z and f-distributions, their properties and uses.

Recommended Books

1. Biostatistics. By Rao KS, Himalaya Publishing House
2. Introduction to Biostatistics & Research Methods. By Sundar Rao PSS & Richard J, PHI learning Pvt. Ltd.
3. Biostatistics. By Arora and Mohan, Himalaya Publishing House
4. Principles and Practice of Biostatistics. By B Antonisamy, Prasanna S. Premkumar, Solomon Christopher, Elsevier India.
5. Methods in Biostatistics. By BK Mahajan, Jaypee Publications.

BIO SAFETY AND BIOETHICS LAB

1. Planning of establishing a hypothetical biotechnology industry in India
2. Practical aspects of sterilization and disinfection procedures.
3. Preparation and handling of different chemicals, acids, corrosive chemicals, buffers etc.
4. General safety aspects of different instrument handling.
5. Different biosafety level and types of biosafety cabinets.
6. Good Microbiological Techniques-Safe laboratory procedures
7. General issues related to Biomedical Waste Management.
8. Case study on Prevention and Management of Biological hazards.
9. Case study on handling and disposal of radioactive waste.
10. Ethical studies of use of animal in laboratory.
11. Case study on clinical trials of drugs in India with emphasis on ethical issues.
12. Case study on ethical aspects of Human Genome Project.

BIOCHEMISTRY LAB

1. Spectrophotometric/Colorimetric estimation of Protein using Lowry's Method
2. Spectrophotometric/Colorimetric estimation of carbohydrates
3. Spectrophotometric estimation of DNA using DPA method
4. Spectrophotometric estimation of RNA using Orcinol Method
5. Estimation of iodine Number and Saponification value of fatty acids
6. Separation of Amino acids by Paper Chromatography
7. Separation of Sugars by Thin Layer Chromatography
8. Separation of Proteins by Column Chromatography
9. Assay of Enzyme activity: Protease from bacteria
10. Assay of Enzyme activity: Amylase from Plant tissue & Saliva
11. Determination of K_m and V_{max} of an enzyme catalyzed reaction.

Organizational Behaviour (3-0-0)

Prerequisites:

1. English.

Module 1: (10 Hours)

The study of Organizational Behaviour: Definition, Meaning, Why study OB; Learning - Principles of learning and learning theories; Personality- Meaning, Determinants, Types, Personality and OB; Perception- Perceptual Process, perceptual errors, Importance of perception in organizations; Motivation- Nature and Importance, Theories of motivation (Herzberg, Maslow, McGregor).

Module 2: (10 Hours)

Group level: Groups in Organizations -Nature, Types, Reasons behind forming groups, Determinants, factors contributing to Group Cohesiveness, Group Decision Making- Process, advantages and disadvantages; Team- Effective Team Building; Types of Leadership- Effective Leadership, Styles of leadership, Leadership Theories-Trait Theory and Contingency Theory, Leadership and Followership; Conflict- Healthy Vs Unhealthy conflict, Conflict Resolution Techniques.

Module 3: (10 Hours)

Structural level: Organizational Culture: culture and organizational effectiveness; Organizational Change: Types of change, Reasons to change, Resistance to change and to manage resistance. Introduction to organizational development.

Text Books:

1. Stephens P. Robbins, Organizational Behaviour, PHI.
2. K. Aswathappa, Organizational Behaviour, HPH.

Reference Books:

1. Kavita Singh, Organizational Behaviour, Pearson.
2. D. K. Bhattacharya, Organizational Behaviour, OUP.
3. Pradeep Khandelwal, Organizational Behaviour, TMH.
4. Keith Davis, Organizational Behaviour, McGraw Hill.
5. Nelson Quick, ORGB, Cengage Learning.

MICROBIOLOGY

Module-I

Introduction to Microbial Kingdom- Bacteria, Fungi and Viruses; Classical and Modern approaches of microbial taxonomy. Classification, structural organization and multiplication of bacteria, fungi and Viruses; Methods of Microbiology- Culture media, Sterilization, Establishment of pure culture, Staining and its types, Micrometry, Microscopy & its types, Preservation of microbial (bacterial and fungal) cultures.

Module-II

Microbial growth and metabolism: Pattern of bacterial growth, Growth kinetics, Monod's Equation, Synchronous Growth and its Kinetics, Continuous culture and its growth kinetics, Growth inhibitory substances. Metabolism of carbohydrate in bacteria, Entner–Doudoroff pathway and Glyoxylate pathway, Energy transduction mechanism in bacteria, Cyanobacteria and nitrogen fixation, Anaerobic respiration.

Microbial genetics: Organization of bacterial and viral genome, Plasmids and Episomes, Genetic recombination in bacteria (Transformation, Conjugation and Transduction), Genetic analysis in bacteria, DNA repair mechanisms in bacteria, Transposons, Mutation in Microorganisms.

Module-III

Food Microbiology: Microbiology of foods, Types of microbes associated with food spoilage, Food preservation methods, Food poisoning, Microbiology of Milk and other dairy products.

Medical Microbiology: disease causing bacteria, virus and fungi; Antimicrobial agents, Antibiotics, Disinfectants and Vaccines, Health care associated infections- prevention and control

Environmental Microbiology: Microbiology of water, Microbiology of Air, Bacteriological analysis of water & water treatment, Microbiology of extreme environments (Halobacteria, Methanogens, Thermophiles), Microbiology of sewage and sludge.

Recommended Books

1. Prescott's Microbiology- Willey, Sherwood, Woolverton
2. Microbial Genetics- S.R. Maloy, J.E. Cronan, Jr., D. Freifelder
3. Brock Biology of Microorganisms- Madigan, Martinko, Bender, Buckley, Stahl
4. Microbiology- B.D. Davis, R. Dulbecco, H.N. Eisen, H.S. Ginsberg
5. Text book of Microbiology- R.Y.Stanier, J.L. Ingraham, M.L. Wheelis, P.R.Painter
6. Principles of Microbiology- G. Sumbali and R.S. Mehrotra, Tata McGraw Hill

GENETICS AND GENETIC ENGINEERING

Module-I

Mendelism and its principles, Non-Mendelian Gene Interactions (Co-dominance, Complete dominance, Incomplete dominance, Epistasis). Polygene and Multiple alleles, Linkage, crossing over- Chiasma type theory, Holiday model, Non-disjunction, inheritance of X-linked recessive genes and Y-linked genes,

Module-II

Enzymology of Genetic manipulation, Restriction endonuclease- exo & endo nucleases, Nomenclature, Types, Pattern of cleavage, Ligase and other modifying enzymes, Gene cloning vectors- Plasmid, bacteriophage, cosmid, BAC, YAC. Construction of cDNA library, genomic library. Basic concept of gene cloning, Polymerase chain reaction (PCR) and its applications, Variations in PCR- qPCR. Basics of Blotting Techniques, DNA micro arrays and Chips - principle and analysis, DNA finger printing and DNA foot printing. Yeast two-hybrid assay. DNA Sequencing- Chemical degradation and Sanger's Methods, Site directed mutagenesis. Gene knock out strategies; Gene targeting and silencing- RNA interference: Antisense RNA, si RNA and mi RNA. *In-vitro* transcription and translation.

Module-III

Molecular markers- Types (RFLP, RAPD, AFLP, SCAR, EST), Principle and methodology; Application of molecular markers, DNA typing, Single Nucleotide Polymorphisms, mapping, Gene therapy and gene replacement/augmentation; DNA vaccines and rDNA products- production of insulin; Genome projects: Human. Transgenic mice.

Books:

1. Gene cloning and DNA Analysis, T A Brown, Black well publishing
2. Principle of gene manipulation and genomics, Primerose and Old, Black well publishing.
3. Recombinant DNA, James D. Watson, Michael Gilman, W. H. Freeman Publisher
4. Principles and Techniques of Biochemistry and Molecular Biology- K. Wilson, J. Walker., Cambridge University Press.
5. Principles of Genetics, Robert Tamarin, Tata McGraw Hill
6. Concepts of Genetics, W.S. Klug and M.R. Cummings, Pearson

THERMODYNAMICS OF BIOLOGICAL SYSTEMS

Module-I

Statistical Thermodynamics – Boltzmann distribution and Entropy; Partition functions and Ensembles; calculations using protein and DNA molecules.

Estimation of thermodynamic properties using generalized equations of state.

Thermodynamics of multi-component mixtures– partial molar properties and excess properties; calculation of excess properties from local composition models.

Module-II

Phase equilibria – vapour-liquid and liquid-liquid equilibria with non-ideal solutions.

Chemical reaction equilibria – calculation of equilibrium conversions for single and multiple reactions in homogeneous and heterogeneous systems.

Module-III

Bioenergetics – energetics of metabolic pathways; coupled-reactions and role in catabolism and anabolism; analysis of photosynthesis and electron transport chain; Thermodynamic analysis of fermentation processes.

Introduction to Non-equilibrium thermodynamics; Onsager reciprocal relations for coupled flows; biological examples

Recommended Books

1. Molecular Driving Forces: Statistical Thermodynamics in Chemistry and Biology. By Ken A. Dill, Sarina Bromberg, , 2nd Edition, 2010, Garland Science.
2. Biochemical and Engineering Thermodynamics. By Stanley I. Sandler, Chemical, 4th Edition, 2006, John Wiley and Sons.
3. Thermodynamics of Biochemical Reactions. By Robert A. Alberty, 2003, John Wiley and Sons

Engineering Economics (3-0-0)

Prerequisites:

1. Mathematics.
2. Basic Economics.

Module 1: (10 Hours)

Engineering Economics: Nature, Scope, Basic problems of an economy, Micro Economics and Macro Economics.

Demand: Meaning of demand, Demand function, Law of Demand and its exceptions, Determinants of demand, Demand Estimation and Forecasting, Elasticity of demand & its measurement (Simple numerical problems to be solved), Supply-Meaning of supply, Law of supply and its exception, Determinants of supply, Elasticity of supply, Determination of market equilibrium (Simple numerical problems to be solved).

Production: Production function, Laws of returns: Law of variable proportion, Law of returns to scale.

Module 2: (10 Hours)

Cost and revenue concepts, Basic understanding of different market structures, Determination of equilibrium price under perfect competition (Simple numerical problems to be solved), Break Even Analysis-linear approach (Simple numerical problems to be solved).

Banking: Commercial bank, Functions of commercial bank, Central bank, Functions of Central Bank.

Inflation: Meaning of inflation, types, causes, measures to control inflation.

National Income: Definition, Concepts of national income, Method of measuring national income.

Module 3: (10 Hours)

Time value of money: Interest - Simple and compound, nominal and effective rate of interest, Cash flow diagrams, Principles of economic equivalence.

Evaluation of engineering projects: Present worth method, Future worth method, Annual worth method, Internal rate of return method, Cost benefit analysis for public projects.

Depreciation: Depreciation of capital asset, causes of depreciation, Methods of calculating depreciation (Straight line method, Declining balance method), After tax comparison of project.

Text Books:

1. Riggs, Bedworth and Randhwa, "Engineering Economics", McGraw Hill Education India.
2. Deviga Vengedasalam, "Principles of Economics", Oxford University Press.

3. William G. Sullivan, Elin M. Wicks, C. Patric Koelling," Engineering Economy", Pearson.
4. R. Paneer Selvam," Engineering Economics", PHI.
5. S. P. Gupta," Macro Economics", TMH.
6. S. B. Gupta," Monetary Economics", Sultan Chand and Co.

Mathematics-III (3-1-0)

Prerequisites:

1. Mathematics-I
2. Mathematics-II

Course Outcomes

On successful completion of this course, the students will be able to:

1. Have a fundamental knowledge of the concepts of probability theory.
2. Do correlation and regression and fitting of different types of curves.
3. Apply sampling theory and theory of estimation in various engineering problems and do various tests of hypothesis and significance.
4. Use calculators and tables to perform simple statistical analyses for small samples and use popular statistics packages, such as SAS, SPSS, S-Plus, R or MATLAB to perform simple and sophisticated analyses for large samples.

Module 1: (10 Hours)

Probability: Introduction, Probability of an event, additive rule & multiplication rule, conditional probability, Bayes' rule, random variable, discrete and continuous probability distribution, Joint probability distribution, Mathematical expectations, Variance and Co- variance of random variables, Mean and Co- variance of linear combination of random variables, Chebyshev theorem.

Module 2: (10 Hours)

Discrete Probability Distribution: Binomial & Multinomial, Hyper- geo- metric, Geometric, Poisson distribution.

Continuous Probability Distribution: Uniform, Normal, Exponential Distribution, Weibull's Distribution, Chi-square Distribution, Sampling Distribution: Sampling Distribution of S^2 , t Distribution, F Distribution.

Module 3: (10 Hours)

Estimation of parameter: methods of estimation, Estimating the mean of a single sample, Standard error, Prediction interval, Tolerance limits, Estimating the difference between means of two samples, estimating proportion and variance of single sample, Estimating the difference between two proportions and variances of two samples, maximum likelihood estimation.

Module 4: (10 Hours)

Testing of hypothesis: one and two tailed test, test on a single mean when variance is known & variance is unknown. Test on two means, test on single mean and two mean populations. One and two sample test for variance. χ^2 test for goodness of fit and test for independence.

Introduction to linear regression: Simple regression models, method of least squares, Properties of least square estimators, Inferences concerning the regression coefficients, Coefficients of determination and its application.

Statistical quality control (Simple Idea only)

Text Books:

1. Ronald E. Walpole, Raymond H. Myers, Sharon L. Myers & Keying Ye, "Probability & Statistics for Engineers & Scientists", Eighth Edition, 2007, Pearson Education Inc., New Delhi.
2. Jay L. Devore, "Probability and Statistics for Engineering and Sciences", Seventh Edition, Thomson/CENGAGE Learning India Pvt. Ltd.

Reference Books:

1. William Mendenhall, Robert J. Beaver & Barbara M. Beaver, "Introduction to Probability and Statistics", 13th Edition, 2009, CENGAGE Learning India Pvt. Ltd., New Delhi.
2. T. Veerarajan, "Probability, Statistics and Random Processes", Tata McGraw Hill
3. Ronald Deep, "Probability and Statistics", Academic Press

MICROBIOLOGY LAB

1. Micrometry: Calibration of stage and ocular micrometer and measurement of microbial sample.
2. Staining of microbial sample (Gram's Staining, Capsule staining, Fungal staining)
3. Media preparation and sterilization (Slant, Stab and Broth culture)
4. Isolation of micro organisms from natural habitats (Air, Water, Soil & Milk)
5. Establishment of pure culture by streak plate and serial dilution method.
6. Study the bacterial growth curve using spectrophotometer and viability assessment.
7. Antibiotic assay and estimation of Zone of inhibition.
8. Chemical assay and MIC determination of antibiotics.
9. Biochemical assay of microorganisms (Starch Hydrolysis, Casein Hydrolysis and IMVIC test).
10. Microscopy: Study of Compound, Phase contrast and Fluorescence Microscopes.

CELL AND MOLECULAR BIOLOGY LAB

1. Mitosis and the Cell Cycle in Onion Root tip Cells.
2. Meiotic cell division in grasshopper testis.
3. Cell Counting.
4. Identification of blood cell types in human blood smear.
5. Identification of different types cells present in the leaf cross section.
6. Isolation of DNA from different biological sources (Bacterial, Plant, animal tissues).
7. Isolation of RNA from different biological sources (Bacterial, Plant, animal tissues).
8. Qualitative analysis of DNA and RNA by agarose gel electrophoresis.
9. Quantitative assessment of nucleic acid by using UV spectrophotometry.
10. DNA fragmentation assay.

GENETIC ENGINEERING LAB

1. Isolation of plasmid DNA and estimation its size using agarose gel electrophoresis.
2. Restriction enzyme digestion of bacterial genomic DNA.
3. Preparation of target DNA by linker/adapters/alkaline phosphatase treatment for cloning.
4. Ligation of DNA fragment with cloning vector.
5. Preparation of competent cells, Transformation in *E.coli* with recombinant vector.
6. Isolation of recombinants and confirmation of insert DNA in vector.
7. Amplification of DNA sample by PCR.
8. Blotting techniques (Southern Hybridization, Northern Hybridization).
9. DNA profiling by RAPD.
10. DNA finger printing assay using RFLP, SNP techniques.

BIOANALYTICAL TECHNIQUES

Module-I

Principle, instrumentation and applications of imaging techniques: light, electron, fluorescent, confocal, Atomic force microscopy, and Transmission and Scanning electron microscopy.

Principle, instrumentation, sampling and application of few spectroscopic techniques: UV, visible, Circular Dichromism, Infrared, Fourier transformation infrared, Mass spectroscopy, Nuclear magnetic resonance

Module-II

Electrophoretic Techniques: Principle, equipment and process, Agarose gel electrophoresis, horizontal and vertical gel electrophoresis, isoelectric focusing, capillary electrophoresis, native and SDS –PAGE. Blotting techniques: Western, Southern and Northern blotting. Visualization of agarose gel and PAGE. Microarray

Module-III

Centrifugation-: high speed and ultra. Principles and working techniques of chromatography- ion exchange, gel filtration, Gas Chromatography, High Performance Liquid Chromatography, Fast protein liquid chromatography, Thin Layer Chromatography, Paper chromatography. Radioisotope detection techniques: Introduction to radioisotopes, Fountain pen technique, Gieger-Muller monitor, Solid and liquid scintillation counting, Cerkenov counting, safety measures while handling radioactive elements.

Recommended Books

1. Biochemistry laboratory: modern theory and techniques. By R. F. Boyer. Prentice Hall, Boston.
2. Bioinstrumentation by L.Veerakumari, MJP Publishers.
3. Analytical techniques in biochemistry and molecular biology. By R. Katoch. Springer, New York.
4. Fundamentals of Bioanalytical Techniques and Instrumentation. By Sabari Ghosal, Anupama Sharma Awasthi. PHI Learning

PLANT AND ANIMAL BIOTECHNOLOGY

Module-I

Plant Biotechnology: Concept of totipotency, Tissue culture media- preparation, composition and plant growth regulators, Initiation and establishment of culture: Explant preparation, Callus culture, Single cell culture, Suspension culture, Microspore culture. Micropropagation, Organogenesis, Somatic embryogenesis, Artificial seed. Protoplast technology: Isolation and culture of protoplast, Somatic hybridization. Secondary metabolites of plant origin and its type; Production of secondary metabolites through tissue culture, Biotransformation with case studies.

Module-II

Animal Biotechnology: Equipments and materials for animal cell, culture technology, Brief discussion on the chemical, physical and metabolic functions of different constituents of culture medium, Development of primary culture. Development of cell line by enzymatic disaggregation. Cell growth characteristics and kinetics, Measurement of viability and cytotoxicity; Biology and characterization of the cultured cells.

Module-III

Techniques and applications: Concept of genetic transformation, direct transformation and indirect Transformation. Promoter tagging, activation tagging, herbicide resistance, insect resistance, disease resistance, molecular farming, terminator seed technology; Products of genetic transformation: Case studies for golden rice, Bt cotton and Flavr Savr tomato.

Application of animal cell culture: stem cell cultures, embryonic stem cells and their applications. Organ culture technology, Transfection of animal cells, tissue engineering, animal cloning.

Recommended Books

1. H S Chawla, Plant Biotechnology, Oxford University Press. K G Ramawat, Plant Biotechnology, S. Chand & Co.
2. A Kumar and SK Sopory, Recent advances in Plant Biotechnology, I.K. International. A Slater et al., Plant Biotechnology, Oxford Univ. Press
3. R. Ian Freshney, Culture of Animal Cells, 3rd Edition, Wiley-Liss publication Martin Clynes, (Eds) Animal Cell culture Techniques Springer Publication
4. Animal cell culture by R.I. Freshney
5. In vitro cultivation of Animal cells by C.K. Leach, Butterworth and Heinemann Ltd.1994.

BIOPROCESS ENGINEERING

Module I

Essential concept of Bioprocessing- structure and functions of various microorganisms, metabolic pathways, enzymes, microbial genetics, kinetics, stoichiometry of growth and product. Types of Bioreactors, Batch, Fed-batch and Continuous operation, Airlift, Fluidized bed, wave bioreactor, perfusion and microbioreactors. Development and Optimization of Bioreactor media.

Module II

Principle of bioreactor design, multiphase bioreactors, mass and heat transfer; Rheology of fermentation fluids, Aeration and agitation; Media formulation and optimization; Kinetics of microbial growth, substrate utilization and product formation; Sterilization of air and media; Concept of ideal and non-ideal reactors: residence time distribution, models of non-ideal reactors, Chemostat with immobilized cells, Chemostat with cell recycle.

Module III

Introduction to scale-up and scale-Down methodologies for Bioreactors, Modelling and Control of bioreactors- traditional and advanced measurement methods.

Recommended Books

1. Bioreactors: Design, Operation and Novel Applications; Carl-Fredrik Mandenius
2. Bioprocess Engineering: Basic Concepts. By Shuler. M.L and Kargi. F, 2nd Edition. Pearson.
3. Biochemical Engg. Bailly & Ollis, Academic Press
4. Bioprocess Engineering Principles. By P. M. Doran, 5th ed.
5. Introduction to Biochemical Engineering. By D. G. Rao. Tata McGraw Hill Education

IMMUNOTECHNOLOGY

Module-I

The origin of Immunology, types of immunity, humoral and cell mediated immunity, Primary and secondary lymphoid organ, antigen, cells of immune system, immunoglobulin and antibodies, Major Histocompatibility Complex (MHC), complement system,

Module-II

Antigen processing and presentation, synthesis of antibody and secretion, Molecular basis of Immunology, Molecular basis of antibody diversity, polyclonal and monoclonal antibody, Hybridoma Technology, antigen-antibody reaction,

Module-III

Immune response and tolerance: Regulation of immune response, immune tolerance, hyper sensitivity, autoimmunity; graft versus host reaction, Immuno- deficiency and immunoproliferate diseases. Dysfunctions of immune system and their modulation, Approaches for correcting immune dysfunction, Vaccinology,

Recommended Books

1. Immunology: Lydyard, P.M., Whelan, A., Fanger, M.W., 1st Ed., Viva Books.
2. Essential Immunology: Roitt, I.M., 9th Ed.(1997) Blackwell Scientific, Oxford, UK.
3. Immunology: Kuby, J. 3rd Ed. (1997) Freeman W. H., oxford.
4. Immunotechnology by A Khan.

INDUSTRIAL MICROBIOLOGY AND ENZYME TECHNOLOGY

Module-I

Microbial Processes and fermentation technology: Introduction to fermentation technology, Microbial growth and product formation kinetics in batch, continuous and fed batch fermentation, Large scale production: submerged, solid and semi-solid fermentation, Microbiological processes for production of organic acids; solvents; antibiotics, enzymes, polysaccharides; lipids; pigments and aromatic substances.

Module-II

Commercial media and strain development: Media selection and development for industrial production, Isolation, selection, characterization of microorganisms, stock culture, development inocula, strain improvement: induced mutation, over producing decontrolled mutants, genetically engineered strain and fermentation.

Module-III

Stability of enzyme: Enzyme stabilization by selection and genetic engineering, protein engineering. Application of enzymes in industry, analytical purpose and medical therapy. Application of Biocatalyst, Group transfer redox reaction, Elimination, isomerization and rearrangement, C-C bond cleavage, Reaction environment rebuilding, chemical modification, intramolecular cross linking and immobilization.

Recommended Books

1. Principle of Fermentation Technology , P.F. Stanbury, A. Whitaker and S.J. Hall, Elsevier
2. Industrial Microbiology, Prescott and Dunn,
3. Biochemical Engineering and Biotechnology Handbook, Atkinson, B and Marituna, F., The Nature Press, Macmillan Publ. Ltd.
4. Biochemical Engineering Fundamentals, Bailey & Olis. MGH

BIOPHYSICS

Module-I

Length force and time scales in living systems, chemical bonding and stability of molecules, forces and energies at nanometer scale: Intermolecular interactions, electrostatic screening, chemical composition of living systems. Heat, temperature, chemical equilibrium, thermodynamic equilibrium, types of energies and laws of thermodynamics, Applications: Brownian motion, chemical kinetics and catalysis, protein folding and unfolding, metabolism in animals. Entropy, Entropic forces, Applications: Electrostatics in water, melting of DNA, phase transitions in membranes, Diffusion and its applications in biological systems.

Module-II

Spectroscopic methods in biophysics, conformational changes in biological processes, biological energy conservation and transduction, photosynthesis, Cell membrane transport system- active transport, passive and facilitated diffusion, co-transport across membrane, concentration gradient, membrane potential, electrochemical gradient, carrier transport, ion transport, ion pumps, water transport, use of liposomes for membrane models and drug delivery systems

Module-III

Friction in fluids, Reynold number, significance of low Reynolds numbers, The time reversal properties of a dynamical law, Applications: Swimming and pumping - Bacterial motion, vascular networks. Molecular motors and nerve impulses: Electro-osmotic effects, ion pumping, Biophysics of motility: the biophysics of the nerve impulse, nerve impulses and their electrical network equivalence, mechanism of the action potential, Applications: synapses in nerves and muscles, neuromuscular junctions.

Recommended Books

1. Molecular Biophysics by Daune, M, Oxford University Press.
2. Biophysics by Glaser, R, Springer.
3. Lehninger's Principles of Biochemistry by Nelson, D.L., Cox, M.M., McMillan Publishers.
4. Biological Physics: Energy, information, life. By P. Nelson, Freeman, 1st edition.
5. Biophysics: An Introduction. By Rodney M.J. Cotterill, Wiley, 1st Edition.

BIOPROCESS ENGINEERING LAB

1. Bioreactor operation – Demonstration
2. Batch, fed batch and continuous cultures a) Estimation of Monod parameters b) Pure and mixed cultures.
3. Temperature effect on growth-estimation of energy of activation and Arrhenius constant for micro-organisms.
4. Production of secondary metabolites by feed batch culture.
5. Kinetic Studies in C.S.T.R
6. Kinetic Studies in P.F.R
7. Kinetic Studies in Combined Reactor
8. Kinetic Studies in Batch Reactor
9. R.T.D Studies in C.S.T.R
10. R T D Studies in C.S.T.R's in Series R.T.D Studies in Plug Flow Reactor

CELL CULTURE LAB

1. Media preparation, sterilization for plant tissue culture.
2. Explant preparation and establishment of meristem culture
3. Callus culture
4. Anther culture of Datura
5. Establishment of suspension culture
6. Agrobacterium mediated transformation (Co-cultivation & GUS expression)
7. Preparation of animal tissue culture media and sterilization
8. Establishment of Primary culture and Primary explants technique.
9. MTT Assay
10. Cell viability study
11. Maintenance and characterization of cell line.
12. Cryopreservation technique

IMMUNOTECHNOLOGY LAB

1. Ag-Ab reaction by agglutination assay.
2. Latex agglutination
3. Ouchterlony double diffusion
4. Single Radial Immunodiffusion
5. Immuno-electrophoresis
6. Rocket immuno-electrophoresis
7. Counter current Immuno-electrophoresis
8. ELISA technique
9. Polyclonal antibody production
10. Purification of IgG antibody.
11. Antibody conjugation with enzyme.
12. ELISPOT assay

BIOINFORMATICS**Module I**

Introduction and Applications of Bioinformatics; Databases: Importance of databases; DNA, Protein sequence and structure databases (NCBI, EMBL, DDBJ, Uniprot, PDB, CSD, PIR, GENBANK, SWISSPROT, TrEMBL, SNP, CATH, SCOP, Pfam); Metabolic pathway databases (KEGG, MetaCyc); Specialized Genomic resources; Database retrieval tools and analysis packages.

Module II

Sequence Alignment: Local, Global and Multiple sequence Alignment; Dynamic programming, Needleman-Wunch algorithm, Smith-Waterman algorithm; PAM, BLOSUM matrices; Predictive Methods Using DNA And Protein Sequences (Algorithms to predict ORF, promoters, splicesites)

Module III

Molecular Modelling and Drug Designing: Protein secondary and tertiary structure prediction methods. *Ab initio* and Homology modeling; Molecular Mechanics and force fields; Molecular Dynamics simulations; Computer aided drug design (CADD); Molecular Docking, QSAR analysis (Molecular Descriptors, ADMET properties)

Recommended Books:

1. Bioinformatics: Sequence and Genome Analysis. By Mount DW. Spring Harbor Press
2. Introduction to Bioinformatics. By Arthur Lesk, Oxford University Press.
3. Bioinformatics: A Practical Guide to the Analysis of Genes and Proteins. By Baxevanis AS and Ouellette BF, Wiley International Science.
4. Bioinformatics computing. By Bryan Bergeron, Prentice Hall Inc
5. Introduction to computational biology: an Evolutionary approach. By Bernhard Houbold, Thomas Wiehe. Blkhauser Verlag press.
6. Current Topics in Computational Molecular Biology. By Tao Jiang, Ying Xu, Michael Q. Zhang, MIT press.
7. Bioinformatics from genome to drug. By Thomas lengauer WILLEY-VCH press.

DOWNSTREAM PROCESS ENGINEERING

Module-I

Basic concepts of Bio-separation Process: Importance of downstream processing in biotechnology, Characteristics of biological molecules, Characteristics of different bio-products. Physico-chemical basis of separation: Physico-chemical basis of different bioseparation processes; Purification strategies and methodologies.

Module-II

Unit operation in Downstream processing: Filtration: Theory of filtration, Darcy's law, derivation, Filtration at constant pressure and at constant rate; empirical equations for batch and continuous. Centrifugation: Basic principles, design characteristics; ultracentrifuges: principles and applications. Membrane based bioseparation methods: Separation of intracellular, extra-cellular, heat and photosensitive materials, filtration membrane, cross flow system, micro-filtration, reverse osmosis, Ultra filtration.

Downstream Processes: Cell disruption methods (mechanical, chemical and biological methods); precipitation of protein (solvent and salting out methods); solvent extraction of bioprocesses (liquid-liquid, aqueous two phase and super critical fluid extraction); adsorption and absorption process; Dialysis, Electrodialysis

Module-III

Chromatographic based separation: Theory, Principle, Types of various chromatography techniques; chromatographic separation based on size, charge, hydrophobic interaction and biological affinity.

Crystallization and Drying: Theory, Principle, instrumentation and application.

Recommended Books

1. Principle of Fermentation Technology. By P.F. Stanbury, A. Whitaker and S.J. Hall, Butterworth and Heinemann., Elsevier
2. Bioprocess Engineering Principles (Second Edition), By by Pauline M Doran, Academic Press.
3. Introduction to Biochemical Engineering. By D.G. Rao, Tata McGraw-Hill Education.
4. Fundamentals of Biochemical Engineering. By Rajiv Dutta, Ane Books India, Springer.
5. Bioprocess Engineering Basic Concepts. By Michael L. Shuler and Fikret Kargi. Prentice Hall PTR
6. Biochemical Engineering and Biotechnology. By GHASEM D. NAJAFPOUR, Elsevier.

ENVIRONMENTAL BIOTECHNOLOGY

Module-I

Introduction to environmental biotechnology, Environmental monitoring bioreporter, biomarker. Bioprospecting, Biomicroelectronics and biosensor technology Introduction to environmental pollutants: their sources and effects. Removal of Specific Pollutants: Sources of Heavy Metal Pollution, Microbial Systems for Heavy Metal Accumulation, Biosorption & detoxification mechanisms. Microbiology and biochemistry of waste water treatment: Biological Treatment of anaerobic and aerobic; methanogenesis, methanogenic, acetogenic, and fermentative bacteria-technical process and conditions;

Module-II

Biodegradation of xenobiotic compounds (Aliphatic, Aromatics, Polyaromatic Hydrocarbons, Polycyclic aromatic compounds, Pesticides, Surfactants and microbial treatment of oil pollution). Biotransformations and biocatalysts: Basic organic reaction mechanism. Isolated Enzymes versus whole cell systems. Use of Genetically Engineered Organisms. emerging biotechnological processes in waste - water treatment; Applications include treatment of municipal and industrial wastewaters.

Module-III

Biooxidation & microbial leaching: Biooxidation – Direct and Indirect Mechanisms, Recovery of metals from solutions; Microbes in petroleum extraction; Microbial desulfurization of coal. Clean technologies: Composting Technology and Organic farming, biofertilizers, biopesticides, microbial polymer production and bio plastic technology. Biotechnology of fossil fuels: desulfurization of coal, oil shales, microbial enhanced oil recovery (MEOR). Introduction to Biofuels, Biotechnology of mineral processing. Ethical issues in environmental biotechnology.

Recommended Books

1. Environmental Biotechnology Principles and Applications. Rittmann B and McCarty P, McGraw Hill 2001
2. Environmental Biotechnology- Theory and application. Evans, G.M., Furlong, J C., John Wiley & Sons, Ltd, USA. 2003
3. Environmental Biotechnology. By Scragg Alan, Oxford University Press, 2005
4. Environmental Microbiology. By W.D. Grant & P.E. Long, Blakie, Glasgow and London.

FOOD PROCESS ENGINEERING

Module- I

Introduction to food process engineering, General aspects of food industry, Analysis of food, major ingredients present in different food & food products, Food additives color, flavor, vitamins;; preliminary operations. Different Food processing methods: Blanching- pasteurization – sterilization- extrusion cooking- micro wave processing.

Module- II

Food Preservation; by Drying, Refrigeration. Food conversion operation: Size reduction- Solid foods and liquid foods. Methods for improved food processing: Enzymes in bakery, fat/oil industries, beverage production, sugar syrup.

Module-III

Production and utilization of food products - soft and alcoholic beverages, dairy products, meat, poultry and fish products, treatment and disposal of food processing wastes for value added products. Microbial and Chemical safety of food products: heavy metal, fungal toxins, pesticide and herbicide contamination, Food preservatives and additives, Post-harvest technology for food preservation: canning, dehydration, ultrafiltration, sterilization, irradiation etc. Food standards and quality maintenance: FPO, PFA, Agmark, ISI, HACCP, FSSAI food plant sanitation and cleaning in place (CIP).

Recommended Books

1. Modern Food Microbiology. By J. M. Jay, M.J. Loessner, D.A. Golden. CBS Publishers, 1987
2. Food Microbiology. Frazier,
3. Prescott and Dunn's Microbiology. By G.Reed, CBS publishers, 1987
4. Technology of food preservation, Desrosier CBS publishers
5. Introduction to food engineering. R.P. Singh and D.R. Headman, Academic Press

NANOBIOTECHNOLOGY

Module-I

The world of small dimensions. The nanoscale dimension and paradigm. Effects on Nanomaterials: size, shape, density, melting point, wet ability and specific surface area. Fundamental sciences of Nanobiotechnology. Nano-biomimicry, Biological building blocks. biology at the nano-interface. Cell nano structure interaction.

Module-II

Nanoscale visualization techniques: Electron Microscopy, Scanning probe Microscopy (AFM, STM). Carbon nanomaterials- fullerenes, graphene, nanotubes, Quantum Dots and Metal-based nanoparticles. Micro- Nano-fabrication- Approaches & methods (photolithography, soft lithography, etching). Structural and functional principles of nanobiotechnology (self-assembly & self Organisation). Protein-based & DNA- based Nanostructures. Synthesis of Nanomaterials- Sol-Gel synthesis; Microemulsions synthesis. Biological nanoparticles synthesis- plants and microbial. magnetosomes, Bio-Nanomachines.

Module-III

Micromachines- MEMS; BioMEMS, microarray, Lab-on-a-chip devices and their potential in nanobiotechnology. Nanoanalysis and nanobiosensors- Different classes, molecular recognition elements, transducing elements. Application of various transducing elements as part of nanobiosensors. Medical Applications of Nanobiotechnology- Polymeric & metal nano-particles for drug delivery, Nano-technology in Cancer Diagnosis, Nanoparticles' Cytotoxicity. Nanotechnology safety and the environment, Impact of nanotechnology on society and industry

Reference Books

1. Nanobiotechnology: Concepts, Applications and Perspectives, Vol I and II, CM Niemeyer and CA Mirkin, Wiley VCH.
2. Bionanotechnology by David S. Goodsell, 2004, Wiley Publications.
3. Nanoscience and Nanotechnology, KK Chattopadhyaya and AN Banerjee, PHI learning, Pvt. Ltd.

INTRODUCTION TO BIOMEDICAL ENGINEERING

BIOANALYTICAL METHODS LAB

1. UV-Visible spectroscopy: UV – spectrophotometric analysis of DNA and protein samples/
Determine λ_{max} of DNA, protein, bromophenol blue solutions by wavelength scan
2. Determination of secondary structure of protein by Circular dichroism (CD) spectroscopy.
3. 2D-TLC analysis of amino acids
4. Use of viscometer in protein analysis
5. 2 D-PAGE
6. Fluorescence spectroscopy
7. HPLC (demonstration)
8. GC (demonstration)
9. Differential scanning calorimetry (DSC)
10. FTIR
11. Electron microscopy

DOWNSTREAM PROCESSING LAB

1. Harvesting of cells using filtration, centrifugation
2. Cell disruption techniques
3. Precipitation of protein
4. Dialysis Techniques
5. Column chromatography
6. Protein separation by chromatography e.g. Gel chromatography
7. Membrane filtration
8. Membrane based separation
9. Extraction techniques (like liquid-liquid and Aqueous two phase extraction)
10. Drying

BIOINFORMATICS LAB

1. Retrieving Human genome data, OMIM, SNP databases to understand genetic and metabolic disorders.
2. Mining genomic data to identify genomic features: codon usage, repeats, Homologous sequences etc.
3. Making Phylogenetic tree of given sequences by using ClustalW and PHYLIP.
4. Gene and promoter prediction for Prokaryotes and eukaryotes (comparative analysis by using different tools.
5. Learning about molecule visualisation software like Rasmol, Pymol etc.
6. Primary Structural databases: pdb, ndb, csd and Derived databases of structures: DSSP, FSSP, CATH & SCOP.
7. Prediction of secondary structures of proteins.
8. Prediction of Tertiary structure of proteins and Validation of model protein structure: Energy minimization, Procheck, verify 3D, Prosa II, ERRAT etc.
9. Molecule drawing. Conversion of 2D structure to 3D structure.
10. Molecular docking and analysis of receptor with ligand
11. Molecular Dynamics simulation

STEM CELL ENGINEERING**Module-I**

Properties of stem cells: pluripotency, totipotency, adult stem cells, umbilical cord stem cells. Embryonic stem cell: Germinal stem cells, General methods of characterization of stem cells, molecular mechanisms Cell cycle regulation in stem cells. Stem cell niches, Stem cell lineage tracing, cell signalling in stem cell. Embryonic stem (ES) cells: Isolation of ES cells, Salient features and application of ES cells. Maintenance of ES in undifferentiated state. *In vitro* fertilization, culturing of embryos-isolation of human embryonic stem cells, blastocyst, inner cell mass, growing ES cells in lab, laboratory tests to identify ES cells, stimulation ES cells for differentiation.

Hematopoietic Stem Cells (HSC): Identification and Characterization of HSCs, Sources of HSC Mouse Assay of HSC, HSC in leukemia and lymphoma, Clinical use of HSC. Mesenchymal and Neural Stem Cell: Embryonic origin of MSC's, Harvesting, Isolation and Characterization, Differentiation studies of MSC's, Neural stem cell and Neural crest stem cell.

Module-II

Adult stem cells: Somatic stem cells, test for identification of adult stem cells, adult stem cell differentiation, trans differentiation, plasticity, different types of adult stem cells. Screening stem cell techniques: fluorescence activated cell sorting (FACS), time lapse video, green fluorescent protein tagging, stem cell based drug discovery, drug screening and toxicology.

Module-III

Genetic engineering and therapeutic application of stem cells: Gene therapy, genetically engineered stem cells. Therapeutic applications in Parkinson disease, Neurological disorder, limb amputation, heart disease, spinal cord injuries, diabetes, burns, HLA typing, Alzheimer's disease, tissue engineering application. Stem cell regulations, debate, social and ethical concerns. Regulatory considerations and FDA requirements for stem cell therapy.

Recommended Books

1. Embryonic Stem cells by Kursad and Turksen. 2002.Humana Press.
2. Stem cell and future of regenerative medicine. By committee on the Biological and Biomedical applications of Stem cell Research.2002.National Academic press
3. Hematopietic Stem Cell Transplantation by Treleaven, J., first edition 2009
4. Essentials of Stem Cell Biology by Lanza, R., second Edition, 2009 Academic Press
5. Molecular Cell Biology by Lodish et al., sixth Ed., W.H. Freeman & Co. 2008
6. Stem Cells: From Bench to Bedside by Bongso and Ariff BTBT903 Nanobi

BIOMATERIAL ENGINEERING

Module-I

Introduction to biomaterials, Concept of biocompatibility. Structural properties (mechanical, thermal, optical, electrical and surface properties) of biomaterials, Characterization of Materials: Mechanical properties: Stress-Strain Behavior, Mechanical Failure: Static & Dynamic Failure, Friction & wear failure, Visco-Elastic material behavior. Assessment of biocompatibility of biomaterials,

Module-II

Properties of Biomaterials: Electrical Properties & Piezoelectricity, Optical Properties, X-ray Absorption, Acoustic Properties, Density & Porosity Diffusion Properties. Metallic Biomaterials: Introduction & Implants materials, metallic implants, stainless steels, CoCr Alloys, Ti Alloys, hydroxyapatite glass, Corrosion of metallic Implants. Hydrogels, self-assembling peptides, 2D and 3D matrices (scaffolds) of biomaterials for tissue engineering, Soft tissue and hard tissue replacement, cardiovascular implants, Biomaterials for ophthalmology, orthopaedic and dental implants.

Module- III

Ceramic Biomaterials- Introduction, Non-absorbable materials like Alumina, Carbons & Zirconia, Biodegradable Ceramics like Calcium phosphate, Aluminum-Calcium-Phosphate (ALCAP) Ceramics. Bioactive ceramics like Glass ceramics. Polymeric Biomaterials- Introduction, Polymerization & Basic structure, physicochemical properties of polymers, Polymers used as Biomaterials: Polyvinylchloride (PVC), Polyethylene (PE), Polymethylmetacrylate (PMMA). Polymers for drug delivery. Composite Biomaterials- Structure, Bounds & Properties, Anisotropy of Composites, Particulate Composites, Fibrous Composites & Porous Materials. Design concept of developing new materials for bio-implant applications

Recommended Books

1. Biomaterials –An Introduction, 3 Ed– Joon Park & R.S.Lakes- Springer
2. Biomaterials- Joyce Y.Wong & Joseph D. Bronzino – CRC Press
3. Buddy D. Ratner Allan S. Hoffman Frederick J. Schoen Jack E. Lemons. Biomaterials Science, Second Edition: Wiley Science 2004.
4. Biomaterial. By Bhatt SV, Narosa publishing house
5. Biomaterials: An Introduction. Park J and Lakes RS. Springer 2009

GENOMICS, PROTEOMICS AND METABOLOMICS

Module-I

Introduction to genomics: Orientation and structure of genomes ;Genome mapping: Physical and Genetic Map, Genome Sequencing, Next generation sequencing methods,Genome Annotation. Structure, organization and composition of prokaryotic and eukaryotic genomes,Genome sequencing projects- Microbes, plants and animals; Human genome sequencing; Accessing and retrieving genome project; Reverse genetics, Structural genomics, Functional genomics and Comparative genomics; High throughput screening in genome for drug discovery-identification of gene targets, Pharmacogenomics.

Module-II

Introduction and tools of proteomics: Proteomics and Proteomes, Various tools used inproteomics (N-terminal sequencing of proteins, 2-D electrophoresis Differential displayproteomics, Yeast two hybrid and three hybrid system, phage display, isoelectrofocusing,Peptide fingerprinting. Chromatography, LC/MS-MS for identification of proteins and modified proteins, SAGE, Protein micro array).Applications of proteomics: Mining proteomes, protein expressionprofiling, identifying protein – protein Interactions and protein complexes, mapping- proteinidentification, new directions in proteomics, structural proteomics; Proteomics and Drugdelivery. Transcriptomics.

Module-III

Metabolomics-an overview, Metabolite isolation and analysis by Mass Spectrometry, Sample preparation (fractionation, enrichment, derivatization), metabolite library, Profiling based on NMR, LIF, LC-UV, 2-D and high (spatial) resolution metabolite profiling, Quantitative metabolomics Metabolite analysis and biochemical pathways: Carbon pathway, Secondary metabolism, amino acid metabolism, Engineered metabolism, Systems biology: Databases (Metabolic pathwaysresources) and pathway reconstruction.

Recommended Books

1. Fundamentals of Biochemistry, Voet D, Voet JG & Pratt CW, 2nd Edition. Wiley
2. Genomes, Brown TA, 3rd Edition. Garland Science
3. Discovering Genomics, Proteomics and Bioinformatics, Campbell AM & Heyer LJ, 2nd Edition. Benjamin Cummings
4. Molecular Biotechnology, Glick BR & Pasternak JJ, 3rd Edition, ASM Press
5. Proteomics, Pennington SR & Dunn MJ, Viva publications
6. Molecular Biology H.D.Kumar,, 2nd edition, Vikas Publishing House Pvt. Lt.

BIOSENSORS

Module-I

Sensors: Brief historical background-Sensor characteristics-calibration curves, linearity, dynamic range, signal to noise ratio, selectivity, sensitivity, interference, response time. Introduction to biosensors and classification. Components of Biosensor.

Module-II

Different transduction mechanism in sensors, Basics, Classification, Characteristics and Choice, Primary sensing elements. Immobilization on transducers: adsorption, encapsulation, covalent attachment, enzyme sensors affinity sensors: antibodies, oligo-nucleotide. Examples and functioning of different types of biosensors including optical, mechanical, electrochemical, FET, thermal, etc.

Module-III

Applications: Biosensors in health care, agriculture, environment and food processing. Biosensors/ Physiological receptors: Working Principle, Types and applications of Chemoreceptors, Baroreceptors and Touch receptors.

Referred Books

1. Advances in Biosensors, B.D. Malhotra, A.P.F.Turner, Elsevier JAI, 2003
2. Electrochemical Sensors, Biosensors and their Biomedical applications, X.Zhang, H.Zu, J. Wang, Elsevier Science and Technology Books, 2008
3. Biosensors for environmental monitoring, Bilitewski, U.Turner, A.P.F. Harwood, Amsterdam. 2000
4. Chemical Sensors and Biosensors for Medical and Biological Applications, SpichigerKeller, U. E., Wiley-VCH, 1998.

Entrepreneurship Development (3-0-0)

Prerequisites:

1. Organizational Behaviour.
2. English.

Module 1: (06 Hours)

Entrepreneurship: Concept of Entrepreneurship and Intrapreneurship, Types of Entrepreneur, Nature and Importance, Entrepreneurial Motivation and Achievement, Entrepreneurial Personality & Traits and Entrepreneurial Skills.

Module 2: (08 Hours)

Entrepreneurial Environment, Identification of Opportunities, Converting Business, Opportunities into reality. Start-ups and business incubation, Skill Development. Setting up a Small Enterprise. Issues relating to location, Environmental Problems and Industrial Policies and Regulations.

Module 3: (08 Hours)

Basics of Accounting, Terms: Assets, Liabilities, Equity, Revenue, Expense, Working capital, Marketing Mix and STP.

HRM: Concepts and Function, Labour Laws- Factories Act, Organizational support services - Central and State Government, Incentives and Subsidies.

Module 4: (08 Hours)

Sickness of Small-Scale Industries, Causes and symptoms of sickness, cures of sickness, Role of Banks and Government in reviving sick industries.

Text Books:

1. Entrepreneurship Development and Management, Vasant Desai, HPH.
2. Entrepreneurship Management, Bholanath Dutta, Excel Books.
3. Entrepreneurial Development, Sangeeta Sharma, PHI.
4. Entrepreneurship, Rajeev Roy, Oxford University Press.

IPR, BIOETHICS AND BIOSAFETY

Module-I

Introduction to intellectual property rights (IPR): IPR laws and its Scope, types of IP, Role of international institutions e.g. GATT, WTO, WIPO and TRIPS in IPR,

Basics of patents: Patentability Criteria, types of patents; Rights of a patentee, Indian Patent Act 1970; recent amendments; Patent filing procedures: types of patent applications: filing of a patent application; provisional and complete specifications; PCT and conventional patent applications: International patenting-requirement, procedures: National & PCT filing procedure,

Module-II

Introduction to Copy right (Conceptual Basis, International Convention/Treaties on Copyright); Trademarks (Introduction, subject matter of protection, Kinds of Trademarks, International Legal Instruments on Trademarks and Indian Trademarks Law); Geographical Indications (Concept, Indication of Source, International Conventions/Agreements); Industrial Designs (Introduction, need for Protection of Industrial Designs, The Designs Act, 2000); Layout Designs of Integrated Circuits (Conditions and Procedure for Registration, The Semiconductor Integrated Circuits Layout-Design Act, 2000); Trade secret (Concept, requirements); Protection of Plant Varieties and Farmers' Rights: (Rights Authority, Effect of Registration and Benefit Sharing, The Protection of Plant Varieties and Farmer's Rights Act, 2001)

Module-III

Principles of bioethics and Biosafety-Social and ethical issues in biotechnology: interference with nature, unequal distribution of risk and benefits of biotechnology. Ethics related to human cloning, human genome project.

Concepts and importance of Classification of Biosafety Levels, Good laboratory practice (GLP) and Good manufacturing practice (GMP), Risk Assessment and containment levels; GMOs & LMOs.

Recommended Books

1. IPR, Biosafety and Bioethics. By Deepa Goel and Shmini Parashar, Pearson India Publications.
2. Intellectual Property Rights. By Neeraj Pandey and Khusdeep Dharni, PHI Publications.
3. Intellectual Property Rights Laws. By S. K. Singh. Central Law Agency (CLA).
4. Bioethics. By Stanley SA. Wisdom educational services.
5. Bioethics and Biosafety. By Sateesh MK. IK International Pvt. Ltd.

MOLECULAR MODELLING & DRUG DESIGNING

Module-I

Introduction to Molecular Modelling and its applications: Biomolecular modeling problems: protein folding, protein misfolding, nucleic acid/protein interactions, and RNA folding. Basic concepts of quantum mechanics, *ab initio*, semi-empirical and density functional theory calculations, Molecular size versus accuracy. Approximate molecular orbital theories. Molecular mechanics and force fields.

Module-II

Introduction to molecular dynamics and simulations; Molecular Dynamics using simple models; Dynamics with continuous potentials, Constant temperature and constant dynamics; Conformation searching and systematic search; Monte-carlo simulation of biomolecules and biopolymers. Comparative modeling of protein: by homology- the alignment, construction of framework, selecting variable regions, side chain placement and refinement, validation of protein models – Ramchandran plot, threading and *ab initio* modeling.

Module-III

Analog based drug designing: Introduction to QSAR, physicochemical parameter and molecular descriptors, molecular modelling in drug discovery. Structure based drug designing: 3D pharmacophores, molecular docking, De novo Ligand design. Structural features of RNA: Primary, Secondary, Tertiary. Introduction to RNA Secondary structure prediction, Methods for RNA Secondary structure prediction, Limitation of RNA Secondary structure prediction

Recommended Books

1. Principles and applications of modeling, A R Leach, Prentice Hall.
2. Molecular Modeling, Hans Pieter, Heltje & Gerd Folkens, VCH.
3. Guide book on Molecular modeling and Drug Designing. N Claude Cohen. Elsevier.
4. Molecular modeling and Drug Designing. K Anand Solomon. MJP Publishers.

OPEN ELECTIVES

PHYSIOLOGY FOR ENGINEERS

Module I

Basics of Biology; Need to study biology, comparison between eye and camera, Bird flying and aircraft, Biological observations lead to major discoveries (Brownian motion and the origin of thermodynamics), Overview of Cell, Animal, plant and Microbial Cells, Classification- Unicellular or multicellular, prokaryotes or eukaryotes, Autotrophs, heterotrophs, lithotropes. Model organisms- *Escherichia coli*, *Saccharomyces cerevisiae*, *Drosophila melanogaster*, *Arabidopsis thaliana*, *Mus musculus*.

Module II

Cells and Cell theory, Cell Structure and Function, Homoeostasis, Cell growth, reproduction, Macromolecules in cell; water, carbohydrates, Lipids, Classification of amino acid and proteins, Nucleotides, Genetic information, Central dogma of life, Chemical nature & broad classification of enzymes, Cell cycle; mitosis and meiosis.

Module III

Bioenergetics, Glucose Metabolism, glycolysis, ATP synthesis, oxidation and degradation of fatty acid, Nervous system, Muscle system, Immune system- General principles of cell signaling, Bioelectricity, Bioelectric potentials, Ion channels, Action potentials, Neuromuscular junction, signaling between cells, Molecular Machines/Motors- Cytoskeleton, overview of replication, transcription, protein synthesis.

Recommended Books:

1. S. ThyagaRajan, N. Selvamurugan, M. P. Rajesh, R. A. Nazeer, Richard, W. Thilagaraj, S. Barathi, and M. K. Jaganathan, “*Biology for, Engineers,*” Tata McGraw-Hill, New Delhi, 2012.
2. Robert Weaver, “*Molecular Biology,*” MCGraw-Hill, 5th Edition, 2012.
3. Eric R. Kandel, James H. Schwartz, Thomas M. Jessell, “*Principles of Neural Science,*” McGraw-Hill, 5th Edition, 2012.

INTRODUCTION TO BIOPHARMACEUTICAL TECHNOLOGY

Module-I

Introduction to biopharmaceuticals, historical perspective of pharmaceutical biotechnology, process of transforming new molecular entities into drugs. Biopharmaceuticals: current status and future prospects, generic and branded biopharmaceuticals.

Drug discovery approaches, modulatory effects, binding strength, effective and inhibitory concentration, side effects, Introduction to pharmacokinetics and Pharmacodynamics, ADME. Pre-clinical toxicity assessment, Clinical trial phases and design, clinical data management, concept of Pharmacovigilance.

Module-II

Biopharmaceutical technologies: Role of manufacturing process, process evaluation, drug substance manufacturing, drug product manufacturing, batch and continuous processes, sterility and sterile technology, purification of product, formulation and filling, labelling and packaging techniques.

Module-III

Quality assurance and quality control: Fundamental of quality assurance, benefits, structure of quality management. Basic principles, GMP compliant design.

Documentation and Reporting Documentation - Documentation of activities in the production process, Reporting – Following of approved guidelines of respective Drug Administration Body (MHRA, USFDA, CDSCO, etc.), Standard Operating Procedures and other statutory requirements

Recommended Books:

1. Biopharmaceuticals: Biochemistry and Biotechnology by Gary Walsh, Publisher: Wiley-Blackwell.
2. Manufacturing of Pharmaceutical Proteins (from technology to Economy) by Dr.-Ing. Stefan Behme, Wiley-VCH Verlag GmbH & Co.
3. Pharmaceutical Biotechnology: Drug Discovery and Clinical Applications. By Oliver Kayser, Heribert Warzecha (2012), 2nd Edition. John Wiley & Sons, Inc.
4. Pharmaceutical Biotechnology: Concepts and Applications. By Gary Walsh (2007) John Wiley & Sons, Inc.
5. Biotechnology and Biopharmaceuticals: Transforming Proteins and Genes into Drugs. By Rodney J. Y. Ho (2013) 2nd Edition, John Wiley & Sons, Inc.

TRANSPORT PHENOMENA IN BIOLOGICAL SYSTEMS

Module-I

Mass conservation: Useful form of the mass balance equation; applications of mass balance equation to biological systems.

Mass flux: Primary driving force for mass flux; Fick's first law; Solution approaches – shell balance and conservation equation; Steady state diffusion, across a membrane; Unsteady state diffusion – , concentration profiles in protein sorption; Pseudo-steady state approximation.

Module-II

Momentum flux: Basic rheology; Types of flows; Shell momentum balances; Equation of motion and its applications to flow in a falling film, flow in a pipe, capillary flow, tangential annular flow; Non-dimensional analysis; Pulsatile flow; Turbulent flow; Macroscopic aspects – Engineering Bernoulli equation and its application; friction factors.

Module-III

Energy flux: Modes of heat flux; Equation of energy; Steady state conduction – say, to find the temperature profile in a tissue; Unsteady state heat conduction.

Charge flux: Reason to study charge flux; Charge density and flux; Maxwell's relations; An expression for charge conservation; Ions in solution – electro-neutrality, charge relaxation time, Debye length.

Fluxes under the action of simultaneous forces: Simultaneous concentration gradient and electrical potential gradient – say, electrophoresis; simultaneous concentration gradient and velocity gradient – say, $k_L a$ in bioreactors, blood oxygenators; simultaneous temperature gradient and velocity gradient – say, heat exchangers.

Recommended Books

1. Continuum Analysis of Biological Systems: Conserved Quantities, Forces and Fluxes. By Suraish kumar GK. Springer-Verlag GmbH, Heidelberg
2. *Transport Phenomena in Biological Systems*. Truskey, GA, Yuan F, Katz DF. 2009. II ed. Prentice Hall, New Jersey.
3. Transport Phenomena. By Bird, RB, Stewart, WE, Lightfoot, EN. 2001. II edition, John Wiley and Sons, New York.

INDUSTRIAL BIOTECHNOLOGY

Module I

Introduction to Industrial Biotechnology, Scopes, Perspectives and Biobased economy. Fermentation processes: Principles and general requirements, instrumentation and control system of fermenter and ancillaries, Medium formulation for optimal growth and product formation, nutrients and other requirements Media and its types, design of various commercial media for industrial fermentations, Strain improvement, Mutations and over producing decontrolled mutants, Safety aspects of industrial biotechnology processes.

Module II

Stoichiometry of cell growth and product formation, elemental balances, degrees of reduction of substrate and biomass, available electron balances, yield coefficients of biomass and product formation, Maintenance coefficients, Energetic analysis of microbial growth and product formation, Microbial Experimentation in the Fermentation Industry. Thermodynamic efficiency of growth, Batch cultivation and continuous cultivation, Simple unstructured models for microbial growth, Monod model, growth of filamentous organisms, product formation kinetics – Leudeking-Piret models, substrate and product inhibition on cell growth and product formation,

Module III

Fermentation using genetically engineered microbes, Single Cell Protein production, Yeast Production, Production of industrial alcohol and alcohol bases products, Organic acids, Antibiotics, vaccines, Production of industrial enzymes (proteases, amylases, lipases, cellulases etc.), recombinant proteins, vaccines, amino acids, exopolysaccharides, pigments, fermented foods. Extraction of Fermentation products and Treatment of Wastes in Industry

Recommended Books

1. Modern Industrial Microbiology and Biotechnology, 2nd Edition, 2017, Nduka Okafor, Benedict C. Okeke. CRC Press, Boca Raton, USA.
2. Biotechnology: Industrial Microbiology A Textbook, 1st edition, 2016. CBS Publishers and Distributors Pvt. Ltd.
3. Fermentation Microbiology and Biotechnology. 3rd Edition, El-Mansi et al., 2011. CRC Press, Boca Raton, USA.

BIOSEPARATION TECHNOLOGY

Module -I

Introduction; An overview of bioseparation. Separation of cells and other insolubles from fermented broth. Centrifugation; Differential, density and continuous centrifugation. Sedimentation, Flocculation.

Module-II

Separation of soluble bio-products: Liquid-liquid extraction, aqueous two-phase extraction, precipitation, adsorption. Precipitation Methods and Membrane based Purification: Precipitation with salts, organic solvents and polymers, Reverse osmosis, Dialysis, Diafiltration, Pervaporation Fractionation of fat; Thermal and separation processes.

Module -III

Chromatography techniques for bioseparation: Adsorption chromatography, Ion- exchange chromatography, gel-filtration chromatography, affinity,high pressure / performance liquid chromatography (HPLC), hydrophobic chromatography. Reverse phase (RP) and thin layer chromatography (TLC).

Recommended Books

1. M.R. Ladisch, Bioseparations Engineering, Wiley Interscience 2001
2. Kennedy and Cabral, Recovery processes for biological materials.
3. Heinemann, Product Recovery in Bioprocess Technology, Butterworth Publication.
4. Roger G. Harrison, Paul W. Todd, Scott R. Rudge, and Demetri Petrides, Bioseparations Science and Engineering, Oxford University Press, USA (October 31, 2002)

TISSUE ENGINEERING

Module-I

Introduction to tissue engineering: Basic definition, Measurement of tissue characteristics, appearance. Tissue types and Tissue components, Functional subunits, Tissue dynamics, Homeostasis in prolific tissues, Tissue repair, angiogenesis.

Cell numbers and growth rates, measurement of cell characteristics morphology, Cell differentiation, motility and functions, cellular component, ECM component, mechanical measurements and physical properties, cell-matrix interactions.

Module II

Cell-Matrix & Cell-Cell Interactions, telomeres and Self-renewal, Control of cell migration in tissue engineering. Bioreactors for Tissue Engineering. Basic wound healing, Engineering of wound healing and sequence of events.

Culture environment and maintenance of cells *in vitro* for tissue engineering

In vivo cell & tissue engineering case studies: Artificial skin, Artificial blood vessels, Regeneration of bone, muscle.

Module III

Biomaterial in tissue engineering: Properties of Biomaterials (Surface, bulk, mechanical and biological properties), Types of biomaterials, biological and synthetic materials, Biopolymers, Scaffolds & tissue engineering

Recommended Books:

1. Bernhard O.Palsson,Sangeeta N.Bhatia,"Tissue Engineering" Pearson Publishers 2009.
2. Meyer, U.; Meyer, Th.; Handschel, J.; Wiesmann, H.P. Fundamentals of Tissue Engineering and Regenerative Medicine.2009.
3. Blitterswijk CV, Tissue Engineering, Academic Press (2008)
4. Saltzman WM, Tissue Engineering, Oxford University Press (2004).
5. Lanza RP, Langer R, Vacanti JP, Principles of Tissue Engineering, Academic Press,
6. 3 rd Edition (2007). Palsson B and Bhatia SN, Tissue Engineering, Pearson Prentice Hall (2003).
7. Nanotechnology and Tissue engineering - The Scaffold", Cato T. Laurencin, Lakshmi S. Nair, CRC Press.