Syllabus for M.Tech in Biotechnology (WBUT)

Semester – I

Code	Course Title	Contact Hrs./Wk	Credit
	Theory	L-T-P	
MBT-101	Microbial Biochemistry	3-0-0	3
MBT-102	Engineering Principles	3-0-0	3
MBT-103	Molecular Biology	3-0-0	3
MBT-104	Introductory Mathematics	3-0-0	3
MBT-105	Immunology	3-0-0	3
		15-0-0	15
	Practical		
MBT-191	Biochemistry & Analytical Techniques	0-0-6	3
MBT-192	Microbiology	0-0-6	3
MBT-193	Immunology	0-0-6	2
Semester Total			23

Semester – II

Code	Course Title	Contact Hrs./wk	Credit
	Theory	L-T-P	
MBT-201	Genetic Engineering	3-0-0	3
MBT-202	Bioprocess Engineering	3-0-0	3
MBT-203	Downstream Processing	3-0-0	3
MBT-204	Genetics & Cell Biology	3-0-0	3
MBT-205	Applied Bioinformatics	3-0-0	3
		15-0-0	15
	Practical		
MBT-291	Genetic Engineering	0-0-6	4
MBT-293	Downstream Processing	0-0-6	4
MBT-281	Comprehensive Viva Voce		2
	Communication Skills (Non-credit)		
Semester Total			25

Semester – III

Code	Course Title	Contact Hrs./wk	Credit
	Theory	L-T-P	
MBT-301	IPR & Biosafety	3-0-0	3
MBT-302	Bioprocess Plant Design	3-0-0	3
	Elective-I	3-0-0	3
	Elective-II	3-0-0	3
	Practical		
MBT-391	Bioreactor Operations	0-0-6	4
MBT-381	Project Proposal Presentation		7
MBT-382	Seminar/ Journal Club	1-0-0	1
Semester Total			24
Electives			
MBT-303	Bioentrepreneurship & Management	3-0-0	3
MBT-304	Plant Biotechnology	3-0-0	3
MBT-305	Environmental Biotechnology	3-0-0	3
MBT-306	Genoinformatics	3-0-0	3
MBT-307	Industrial & Food Biotechnology	3-0-0	3

Semester – IV

Code	Course Title	Contact Hrs./wk	Credit
		L-T-P	
MBT-481	Project Work		23

Detailed Syllabus for M.Tech in Biotechnology (WBUT)

Semester – I

Microbial Biochemistry- 3 Credits

Unit I

Cell Structure (Special emphasis on Cell Wall & Membrane) and Microbial Diversity

Structural differences between different microbial cell types and cellular organelles; Biochemical/Microscopic/Molecular methods used to differentiate between archae, eubacteria and eukaryotes; Cell wall of prokaryotes; Outer membrane of Gram -ve bacteria and control of its synthesis; Potential targets for drug design

Unit II

Biomolecules and Principles of Microbial Nutrition

Importance of non-covalent interactions in biological systems; Noninformational and Informational Macromolecules and their organization; Microbial nutrition; Different types of culture medium; C/N/P balance and making of culture medium.

Unit III

Bioenergetics and Catabolic Pathways

Oxidation-reduction reactions; Electron carriers and cellular metabolism; High energy compounds and their role in microbial fermentations; Enzymes as catalysts; Cellular metabolites and interconnectivity in biochemical pathways; Respiration and Electron Transport.

Unit IV

Metabolic diversity

Energy from oxidation of inorganic electron donors; Iron oxidation; Methanotrophy and methylotrophy; Nitrate and Sulfate reduction; Acetogenesis; Methanogenesis; Fermentation-energetics and redox constraints; Anaerobic respiration; Chlorophylls and other pigments involved in microbial photosynthesis; Anoxygenic and oxygenic photosynthesis; Autotrophic CO2 Fixation: Calvin cycle, Reverse Citric Acid cycle, Hydroxy-propionate cycle.

Unit V

Microbial Genetics and Genomics

Mutations and their chemical basis; Mutagens and their use in Biotechnology; Modes of recombination; Comparative prokaryotic genomics

Texts/References:

1. M.T. Madigan and J.M. Martinko, Brock Biology of Microorganisms, 11th Edition, Pearson Prentice-Hall, 2006.
2. L. Stryer, Biochemistry, 4th Edition, Freeman, 2002.
3. G. Gottschalk, Bacterial Metabolism, 2nd Edition, Springer-Verlag, New-York, Berlin. 1986.

Engineering Principles- 3 Credits

Unit I

Energy and Material Balances

Unit operations and unit processes: historical and more recent developments in chemical engineering; Process variables and degrees of freedom; Differential and integral balances; Lumped and distributed balances; Balances in systems involving physical changes.

Unit II

Steady state energy and material balances

Balances in reacting systems; Balances in systems involving recycle, purge, and bypass; Computer aided calculations; Generalization to unsteady state balances

Unit III

Properties of substances

Single component and multicomponent systems; Single and multiphase systems.

Unit IV

Introduction to transport phenomena: Momentum transfer

Viscosity; Molecular theory of Gases and Liquids; Shell balance: Falling film, Circular tube; Equations of Change for isothermal systems: Continuity, Motion, Energy, Substantial derivatives; Unidirectional flows: Pipe flow, Variable viscosity falling film, Couette viscometer, Rotating Sphere; Unsteady flows: Startup Plate flow, Parallel plates etc.

Unit V

Introduction to transport phenomena: Heat & Mass transfer

Thermal conductivity and mechanism of energy transport; Shell energy balances and temperature distributions in solids and laminar flow; Diffusivity and the mechanisms of mass transport; Concentration distributions in solids and laminar flow; Equations of

change for multicomponent systems; Introduction to the concept of heat and mass transfer coefficients; Dimensional Analysis (Buckingham Pi theorem).

Texts/References:

1. R.M. Felder and R.W. Rousseau, Elementary Principles of Chemical Processes, 3rd Edition, J. Wiley, New York, 2000.
2. D.M.Himmelblau, Basic Principles and Calculations in Chemical Engineering, 6th Edition, Prentice Hall of India. New Delhi, 1996.
3. B.I.Bhatt and S.M.Vora, Stoichiometry, 3rd Edition, Tata McGraw Hill. New Delhi. 1996.
4. R. B. Bird et al., Transport Phenomena, 2nd Edition, Wiley, 2006.

Molecular Biology -3 Credits

Unit I

Genome organization

Organization of bacterial genome; Structure of eucaryotic chromosomes; Role of nuclear matrix in chromosome organization and function; Matrix binding proteins; Heterochromatin and Euchromatin; DNA reassociation kinetics(Cot curve analysis); Repetitive and unique sequences; Satellite DNA; DNA melting and buoyant density; Nucleosome phasing; DNase I hypersensitive regions; DNA methylation & Imprinting

.

Unit II

DNA Structure; Replication; Repair & Recombination

Structure of DNA - A-,B-, Z- and triplex DNA; Measurement of properties-Spectrophotometric, CD, AFM and Electron microscope analysis of DNA structure; Replication initiation, elongation and termination in prokaryotes and eukaryotes; Enzymes and accessory proteins; Fidelity; Replication of single stranded circular DNA; Gene stability and DNA repair- enzymes; Photoreactivation; Nucleotide excision repair; Mismatch correction; SOS repair; Recombination: Homologous and non-homologous; Site specific recombination; Chi sequences in prokaryotes; Gene targeting; Gene disruption; FLP/FRT and Cre/Lox recombination

.

Unit III

Prokaryotic & Eukaryotic Transcription

Prokaryotic Transcription; Transcription unit; Promoters-Constitutive and Inducible; Operators; Regulatory elements; Initiation; Attenuation; Termination-Rho-dependent and independent; Anti-termination; Transcriptional regulation-Positive and negative; Operon concept-lac, trp, ara, his, and gal operons; Transcriptional control in lambda phage; Transcript processing; Processing of tRNA and rRNA

Eucaryotic transcription and regulation; RNA polymerase structure and assembly; RNA polymerase I, II, III; Eukaryotic promoters and

enhancers; General Transcription factors; TATA binding proteins (TBP) and TBP associated factors (TAF); Activators and repressors; Transcriptional and post-transcriptional gene silencing

.

Unit IV

Post Transcriptional Modifications

Processing of hnRNA, tRNA, rRNA; 5'-Cap formation; 3'-end processing and polyadenylation; Splicing; RNA editing; Nuclear export of mRNA; mRNA stability; Catalytic RNA.

Translation & Transport

Translation machinery; Ribosomes; Composition and assembly; Universal genetic code; Degeneracy of codons; Termination codons; Isoaccepting tRNA; Wobble hypothesis; Mechanism of initiation, elongation and termination; Co- and post-translational modifications; Genetic code in mitochondria; Transport of proteins and molecular chaperones; Protein stability; Protein turnover and degradation

.

Unit V

Mutations; Oncogenes and Tumor suppressor genes

Nonsense, missense and point mutations; Intragenic and Intergenic suppression; Frameshift mutations; Physical, chemical and biological mutagens; Transposition - Transposable genetic elements in prokaryotes and eukaryotes; Mechanisms of transposition; Role of transposons in mutation; Viral and cellular oncogenes; Tumor suppressor genes from humans; Structure, function and mechanism of action of pRB and p53 tumor suppressor proteins; Activation of oncogenes and dominant negative effect;suppression of tumor suppressor genes; Oncogenes as transcriptional activators.

Text/References:

1. Benjamin Lewin, Gene IX, 9th Edition, Jones and Barlett Publishers, 2007.
2. J.D. Watson, N.H. Hopkins, J.W Roberts, J. A. Seitz & A.M. Weiner; Molecular Biology of the Gene, 6th Edition, Benjamin Cummings Publishing Company Inc, 2007.
3. Alberts et al; Molecular Biology of the Cell, 4th edition, Garland, 2002.

Introductory Mathematics -3 Credits

Unit I

Calculus review

Calculus (Quick review of concepts): Review of limits, continuity, differentiability; Mean value theorem, Taylor's Theorem, Maxima and Minima; Fundamental theorem of Calculus; Improper integrals; Applications to area, volume; Convergence of sequences and series; Power series; Partial Derivatives; Gradient and Directional derivatives; Chain rule; Maxima and Minima.

Unit II

Ordinary Differential Equations

First order differential equations: Exact equations, Integrating factors and Bernoulli equations.

Unit III

Second and higher order differential equations

Linear ODE's with constant coefficients: the characteristic equations; Cauchy-Euler equations; Linear dependence and Wronskians; Method of undetermined coefficients; Method of variation of parameters; Laplace transforms: Inverse theorem, shifting theorems, partial fractions.

Unit IV

Linear Algebra

Basics: Vectors, matrices, determinants; Matrix addition and multiplication; Systems of equations: Gauss elimination, Matrix rank, Linear independence, Cramer's rule; Inverse of a matrix: Gauss-Jordan elimination; Eigenvalues and Eigenvectors: characteristic polynomials, eigenvalues of special matrices(orthogonal, unitary, hermitian, symmetric, skew-symmetric, normal).

Unit V

Numerical methods

Solution of equations by iteration; Interpolation by polynomials; Piecewise linear and cubic splines; Numeric integration and differentiation; Linear systems: Gauss elimination, Gauss-Siedel, matrix inversion; LU factorization; Matrix eigenvalues; Numerical solution of ODEs: Euler and Runge-Kutta methods, Predictor-Corrector methods; Exposure to software packages like Matlab or Scilab.

Texts/References

1. G. B. Thomas and R. L. Finney, Calculus and Analytic Geometry, 9th Edition, ISE Reprint, Addison-Wesley, 1998.
2. E. Kreyszig, Advanced engineering mathematics, 8th Edition, John Wiley, 1999.
3. W. E. Boyce and R. DiPrima, Elementary Differential Equations, 8th Edition, John Wiley, 2005.

Immunology -3 Credits

Unit I

Immunology- fundamental concepts and anatomy of the immune system

Components of innate and acquired immunity; Phagocytosis; Complement and Inflammatory responses; Haematopoesis; Organs

and cells of the immune system- primary and secondary lymphoidorgans; Lymphatic system; Lymphocyte circulation; Lymphocyte homing; Mucosal and Cutaneous associated Lymphoid tissue.(MALT&CALT); Mucosal Immunity; Antigens - immunogens,haptens; Major Histocompatibility Complex – MHC genes, MHC and immune responsiveness and disease susceptibility, HLA typing

Unit II

Immune responses generated by B and T lymphocytes

Immunoglobulins-basic structure, classes and subclasses of immunoglobulins, antigenic determinants; Multigene organization of immunoglobulin genes; B-cell receptor; Immunoglobulin superfamily; Principles of cell signaling; Immunological basis of self -non-self discrimination; Kinetics of immune response, memory; B cell maturation, activation and differentiation; Generation of antibody diversity; T-cell maturation, activation and differentiation and T-cell receptors; Functional T Cell Subsets; Cell-mediated immune responses, ADCC; Cytokines-properties, receptors and therapeutic uses; Antigen processing and presentation-endogenous antigens, exogenous antigens, non-peptide bacterial antigens and super-antigens; Cell-cell co-operation, Hapten-carrier system

.

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, Biosenor assays for assessing ligand -receptor interaction, CMI techniques- lymphoproliferation assay, Mixed lymphocyte reaction, Cell Cytotoxicity assays, Apoptotosis, Microarrays, Transgenic mice, Gene knock outs

Unit IV

Vaccinology

Active and passive immunization; Live, killed, attenuated, sub unit vaccines; Vaccine technology- Role and properties of adjuvants, recombinant DNA and protein based vaccines, plant-based vaccines, reverse vaccinology; Peptide 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.

Texts/References:

1. Kuby, RA Goldsby, Thomas J. Kindt, Barbara, A. Osborne Immunology, 6th Edition, Freeman, 2002.
2. Brostoff J, Seaddin JK, Male D, Roitt IM., Clinical Immunology, 6th Edition, Gower Medical Publishing, 2002.
3. Janeway et al., Immunobiology, 4th Edition, Current Biology publications., 1999.
4. Paul, Fundamental of Immunology, 4th edition, Lippencott Raven, 1999.

Lab on Biochemistry and Analytical Techniques -6 Credits

1. To prepare an Acetic-NaAcetate Buffer system and validate the Henderson-Hasselbach equation.
2. To determine an unknown protein concentration by plotting a standard graph of BSA using UV-Vis Spectrophotometer and validating the Beer- Lambert's Law.
3. Titration of Amino Acids and separation of aliphatic, aromatic and polar amino acids by TLC.
4. AN ENZYME PURIFICATION THEME (such as E.coli Alkaline phosphatase or any enzyme of the institutions choice).
   (a) Preparation of cell-free lysates
   (b) Ammonium Sulfate precipitation
   (c) Ion-exchange Chromatagraphy
   (d) Gel Filtration
   (e) Affinity Chromatography
   (f) Generating a Purification Table
   (g) Assessing purity by SDS-PAGE Gel Electrophoresis
   (h) Assessing purity by 2-D gel Electrophoresis
   (i) Enzyme Kinetic Parameters: Km, Vmax and Kcat.
5. Biophysical methods (Circular dichroism spectroscopy, fluorescence spectroscopy).
6. Determination of mass of small molecules and fragmentation patterns by Mass Spectrometry

Lab on Microbiology -6 Credits

1. Sterilization, disinfection, safety in microbiological laboratory.
2. Preparation of media for growth of various microorganisms.
3. Identification and culturing of various microorganisms.
4. Staining and enumeration of microorganisms.
5. Growth curve, measure of bacterial population by turbidometry

and studying the effect of temperature, pH, carbon and nitrogen.
6. Assay of antibiotics production and demonstration of antibiotic resistance.
7. Isolation and screening of industrially important microorganisms.
8. Determination of thermal death point and thermal death time of microorganisms.

Lab on Immunology -6 Credits

1. Selection of animals, Preparation of antigens, Immunization and methods of bleeding, Serum separation, Storage.
2. Antibody titre by ELISA method.
3. Double diffusion, Immuno-electrophoresis and Radial Immuno diffusion.
4. Complement fixation test.
5. Isolation and purification of IgG from serum or IgY from chicken egg.
6. SDS-PAGE, Immunoblotting, Dot blot assays
7. Blood smear identification of leucocytes by Giemsa stain
8. Separation of leucocytes by dextran method
9. Demonstration of Phagocytosis of latex beads
10. Separation of mononuclear cells by Ficoll-Hypaque
11. Flowcytometry, identification of T cells and their subsets
12. Lymphoproliferation by mitogen / antigen induced
13. Lympnode Immunohistochemistry (direct and indirect peroxidase assay)
14. Hybridoma technology and monoclonal antibody production.
15. Immunodiagnostics using commercial kits

Non-Credit Courses

Communication Skills

Process of Communication

Concept of effective communication-setting clear goals for communication; Determinining outcomes and results; Initiating communication; Avoiding breakdowns while communicating; Creating value in conversation; Barriers to effective communication; Non verbal communication-interpreting non verbal cues; Importance of body language,Power of effective listening; recognizing cultural differences.

Presentation Skills

Formal presentation skills; Preparing and presenting using Over Head Projector,Power Point; Defending Interrogation; Scientific poster preparation & presentation; Participating in group discussions.

Technical Writing Skills

Types of reports; Layout of a formal report; Scientific writing skills: Importance of communicating Science; Problems while writing a scientific document; Plagiarism; Scientific Publication Writing; Elements of scientific paper including Abstract,Introduction,Materials & Methods,Results,Discussion,References; Drafting titles and framing abstracts.

Computing Skills for Scientific Research

Web browsing for information search; Search engines and their mechanism of searching; Hidden web and its importance in scientific research; Internet as a medium of interaction between scientists; Effective email strategy using the right tone and conciseness.

Text/References

1. Mohan Krishna and N.P. Singh, Speaking English effectively,Macmillan,2003.

Semester - II

Genetic Engineering -3 Credits

Unit I

Basics Concepts

DNA Structure and properties; Restriction Enzymes; DNA ligase Klenow enzyme, T4 DNA polymerase, Polynucleotide Kinase,Alkaline phosphatase; Cohesive and blunt end ligation; Linkers;Adaptors; Homopolymeric tailing; Labeling of DNA: Nick translation, Random priming, Radioactive and non-radioactive probes, Hybridization techniques: Northern, Southern and Colony hybridization, Fluorescence in situ hybridization; Chromatin Immunoprecipitation; DNA-Protein Interactions-Electromobility shift assay; DNaseI footprinting; Methyl interference assay

Unit II

Cloning Vectors

Plasmids; Bacteriophages; M13 mp vectors; PUC19 and Bluescript vectors, Phagemids; Lambda vectors; Insertion and Replacement vectors; EMBL; Cosmids; Artificial chromosome vectors (YACs; BACs); Animal Virus derived vectors-SV-40; vaccinia/bacculo & retroviral vectors; Expression vectors; pMal; GST; pET-can be omitted vectors; Protein purification; His-tag; GST-tag; MBP-tag etc.; Intein-based vectors; Inclusion bodies; Methodologies to reduce formation of inclusion bodies; Baculovirus and pichia vectors system, Plant based vectors, Ti and Ri as vectors, Yeast vectors, Shuttle vectors

Unit III

Cloning Methodologies

Insertion of Foreign DNA into Host Cells; Transformation; Construction of libraries; Isolation of mRNA and total RNA; cDNA and genomic libraries; cDNA and genomic cloning; Expression cloning; Jumping and hopping libraries; Southwestern and Farwestern cloning; Protein-protein interactive cloning and Yeast two hybrid system; Phage display; Principles in maximizing gene expression

Unit IV

PCR and Its Applications

Primer design; Fidelity of thermostable enzymes; DNA polymerases; Types of PCR - multiplex, nested, reverse transcriptase, real time PCR, touchdown PCR, hot start PCR, colony PCR, cloning of PCR products; T-vectors; Proof reading enzymes; PCR in gene

recombination; Deletion; addition; Overlap extension; and SOEing; Site specific mutagenesis; PCR in molecular diagnostics; Viral and bacterial detection; PCR based mutagenesis, Mutation detection: SSCP, DGGE, RFLP, Oligo Ligation Assay (OLA), MCC (Mismatch Chemical Cleavage, ASA (Allele-Specific Amplification), PTT (Protein Truncation Test)

Unit V

Sequencing methods; Enzymatic DNA sequencing; Chemical sequencing of DNA; Automated DNA sequencing; RNA sequencing; Chemical Synthesis of oligonucleotides; Introduction of DNA into mammalian cells; Transfection techniques; Gene silencing techniques; Introduction to siRNA; siRNA technology; Micro RNA; Construction of siRNA vectors; Principle and application of gene silencing; Gene knockouts and Gene Therapy; Creation of knock out mice; Disease model; Somatic and germ-line therapy- in vivo and ex-vivo; Suicide gene therapy; Gene replacement; Gene targeting; Transgenics; cDNA and intragenic arrays; Differential gene expression and protein array.

Text/References:

1. S.B. Primrose, R.M. Twyman and R.W.Old; Principles of Gene Manipulation. 6th Edition, S.B.University Press, 2001.
2. J. Sambrook and D.W. Russel; Molecular Cloning: A Laboratory Manual, Vols 1-3, CSHL, 2001.
3. Brown TA, Genomes, 3rd ed. Garland Science 2006
4. Selected papers from scientific journals.
5. Technical Literature from Stratagene, Promega, Novagen, New England Biolab etc.

Bioprocess Engineering & Technology - 3 Credits

Unit I

Principles of enzyme catalysis

Proteins as enzymes; Michaelis-Menten kinetics; Kinetics and Statistics; Inhibition; Effect of pH and temperature; Enzymology; Immobilized enzymes: methods, mass transfer considerations; Industrial enzymes

Unit II

Microbial growth

Introduction to metabolism; Nutrient transport; Glycolysis; TCA cycle and other pathways; Control of metabolism; Factors affecting microbial growth; Stoichiometry: mass balances; Stoichiometry: energy balances; Growth kinetics; Measurement of growth.

Unit III

Bioreactors

Introduction to bioreactors; Batch and Fed-batch bioreactors, Continuous bioreactors; Immobilized cells; Bioreactor operation;

Sterilization; Aeration; Sensors; Instrumentation; Culture-specific design aspects: plant/mammalian cell culture reactors.

Unit IV

Bioseparations

Biomass removal; Biomass disruption; Membrane-based techniques; Extraction; Adsorption and Chromatography

Unit V

Industrial Processes and Process economics

Description of industrial processes; Process flow sheeting; Process economics

Texts/References

1.Michael Shuler and Fikret Kargi, Bioprocess Engineering: Basic Concepts, 2nd Edition, Prentice Hall, Englewood Cliffs, NJ, 2002.

2. Pauline Doran, Bioprocess engineering principles, 1 Edition, Academic Press, 1995.

3. Colin Ratledge, Bjorn Kristiansen, Basic Biotechnology, 2nd Edition, Cambridge University Press, 2001.

4.Roger Harrison et al., Bioseparations Science and Engineering, Oxford University Press, 2003.

Downstream Processing in Biotechnology -3 Credits

Unit I

Biomass removal and disruption: Centrifugation; Sedimentation; Flocculation; Microfiltration; Sonication; Bead mills; Homogenizers; Chemical lysis; Enzymatic lysis

Unit II

Membrane based purification: Ultrafiltration ; Reverse osmosis; Dialysis ; Diafiltration ; Pervaporation; Perstraction

Unit III

Adsorption and chromatography: size, charge, shape, hydrophobic interactions, Biological affinity; Process configurations (packed bed, expanded bed, simulated moving beds)

Unit IV

Precipitation (Ammonium Sulfate, solvent); Electrophoresis(capillary); Crystallization; Extraction(solvent, aqueous two phase, super critical), Drying

Unit V

Case studies

Texts/References:

1. E L V Harris and S. Angal, Protein Purification Methods, Ed.IRL Press at Oxford University Press, 1989.
2. P.A. Belter, E.L. Cussler and Wei-Shou Hu., Bioseparations-Downstream Processing for Biotechnology, Wiley-Interscience Publication, 1988.
3. J. E. Bailey and D. F. Ollis, Biochemical Engineering Fundamentals, 2nd Edition, Mc-Graw Hill, Inc., 1986.
4. R. K. Scopes, Berlin, Protein Purification: Principles and Practice,Springer, 1982.

Genetics & Cell Biology - 3 Credits

GENETICS

Unit I

Basic Genetics-genetic code and chromosome theory of inheritance Prokaryotic Genetics–conjugation, transduction and transformation, Host cell restriction (restriction endonucleases), Complementation, Molecular recombination,Mapping of bacterial genes

Unit II

Fungal Genetics-life cycle of yeast, recombination and linkage in yeast, tetrad analysis, genetic map vs. physical map, yeast vectors, mutant hunts (forward and reverse genetics) selection and screening strategies,mating type switching, yeast two-hybrid system

Unit III

Mammalian genetics-Mendel's experiments, monohybrid and dihybrid cross, sexual reproduction applications of chi square test, deviation from Mendelian segregation,linkage, genetic map, Mendelism in human genetics: pedigree analysis,dosage compensation and sex determination, inheritance characteristics of sex-linked and autosomal traits, chromosome discovery, chromosomes as physical basis of inheritance, Polytene and lampbrush chromosomes,chromosomal aberrations and genetic load, sex-linked deleterious genes, extrachromosomal/non-Mendelian inheritance(episomes,mitochondria and chloroplasts), parental imprinting

Unit IV

Population Genetics-Variation and its modulation, effect of sexual reproduction on variation (Hardy-Weinberg Equilibrium), sources of variation, selection balanced polymorphism, random events

CELL BIOLOGY

Unit I

DNA and Chromosomes-The structure and function of DNA, Chromosomal DNA and its packaging in the chromatin fiber, the global structure of chromosomes Visualizing Cells-looking at cell structures with microscopes,visualizing molecules in living cells

Unit II

Membrane Structure-lipid bilayer, membrane proteins Membrane Transport of Small Molecules and the Electrical Properties of Membranes-principles of membrane transport, carrier proteins and active membrane transport

Unit III

Intracellular Compartments and Protein Sorting-compartmentalization of cells, transport of molecules between the nucleus and cytosol, transport of proteins into mitochondria and choloroplasts, peroxisomes, the endoplasmic reticulum Intracellular Vesicular Traffic-molecular mechanisms of membrane transport and the maintenance of compartmental diversity,transport from the ER through the Golgi apparatus, transport from the trans-Golgi network to lysosomes, transport into the cell from the plasma membrane via endocytosis, transport from the trans-Golgi network to the cell exterio r via exocytosis Energy Conversion in Mitochondria and Chloroplasts-the mitochondria, electron-transport chains and their proton pumps, chloroplasts and photosynthesis, the genetic systems of mitochondria and plastids, the evolution of electron-transport chains

Unit IV

Cell Junctions, Cell Adhesion, and the Extracellular Matrix-cell junctions, cell-cell adhesion, the extra-cellular matrix of animals, integrins, plant cell wall The Cytoskeleton-the self-assembly and dynamic structure of cyto-skeletal filaments, how cells regulate their cyto-skeletal filaments, molecular motors,the cyto-skeleton and cell behaviour Cell Communication-general principles of cell communication, signaling through G-protein-linked cell-surface receptors,signaling through enzyme-linked cell-surface receptors, signaling pathways that depend on regulated proteolysis

Unit V

The Cell Cycle and Programmed Cell Death-an overview of the cell cycle,components of the cell cycle control system, intracellular control of cell cycle events, apoptosis, extra-cellular control of cell division and cell growth

Text Books

CELL BIOLOGY

Class Text: Molecular Biology of the Cell
Alberts, Johnson, Lewis, Raff, Roberts and Walter
Recommended Readings:
Molecular Cell Biology by Lodish, Berk, Matsudaira, Kaiser, Krieger, Scott,Zipursky & Darnell; Freeman, 5th Edition Karp

GENETICS

Recommended texts:

Text: An Introduction to Genetic Analysis
Griffiths, Miller Suzuki, Lewontin and Gelbart
Eighth Edition
Publisher: W. H. Freeman & Co.

References:
Instant Notes In Genetics
P.C. Winter, G.I. Hickey and H.L. Fletcher
Viva Books Pvt. Ltd.

Applied Bioinformatics -3 Credits

Unit I

Sequence-alignment related problems.

Sequence databases; Similarity matrices; Pairwise alignment; BLAST; Statistical significance of alignment; Sequence assembly; Multiple sequence alignment; Clustal; Phylogenetics: distance based approaches, maximum parsimony.

Unit II

Pattern analysis in sequences

Motif representation: consensus, regular expressions; PSSMs; Markov models; Regulatory sequence identification using Meme; Gene finding: composition based finding, sequence motif-based finding.

Units III and IV

Structure-related problems

Representation of molecular structures (DNA, mRNA, protein), secondary structures, domains and motifs; Structure classification (SCOP, CATH); Visualization software (Pymol, Rasmol etc.); Experimental determination of structures (X-ray crystallography, NMR); Structure databases; Secondary structure prediction; RNA structure prediction; Mfold; Protein structure prediction by comparative modelling approaches(homology modelling, threading); Ab initio structure prediction: force fields, backbone conformer

generation by Monte Carlo approaches, side-chain packing; Energy minimization; Molecular dynamics; Rosetta; Structure comparison (DALI, VAST etc.); CASP; Protein-ligand docking; Computer-aided drug design (pharmacophore identification); QSAR; Protein-Protein interactions

Unit V

System-wide analyses:

Transcriptomics: Microarray technology, expression profiles, data analysis; SAGE; Proteomics: 2D gel electrophoresis; Mass Spectrometry; Protein arrays; Metabolomics: 13C NMR based metabolic flux analysis

Texts/References:

1. David W. Mount. Bioinformatics: Sequence and Genome Analysis 2nd Edition, CSHL Press, 2004.

2. A. Baxevanis and F. B. F. Ouellette, Bioinformatics: a practical guide to the analysis of genes and proteins, 2nd Edition, John Wiley, 2001.

3. Jonathan Pevsner, Bioinformatics and Functional Genomics, 1st Edition, Wiley-Liss, 2003.

4. P. E. Bourne and H. Weissig. Structural Bioinformatics.Wiley.2003.

5. C. Branden and J. Tooze, Introduction to Protein Structure,2nd Edition, Garland Publishing, 1999.

Practical

Lab On Genetic Engineering- 4 credits

1.Isolation of genomic DNA from Bacillus subtilis* genome.
2.PCR amplification of scoC gene and analysis by agarose gel electrophoresis.
3.Preparation of plasmid,pET-28a from E.coli DH5α and gel analysis.
4. Restriction digestion of vector (gel analysis) and insert with NcoI and XhoI
5. a. Vector and Insert ligation
b. Transformation in E.coli DH5α.
6.Plasmid isolation and confirming recombinant by PCR and RE digestion.
7.Transformation of recombinant plasmid in E.coli BL21 (DE3)strain.
8.Induction of ScoC protein with IPTG and analysis on SDS-PAGE.
9. Purification of protein on Ni-NTA column and analysis of purification by SDS-PAGE
10. a. Random Primer labeling of scoC with Dig-11-dUTP
b. Southern hybridisation of B.subtilis genome with probe and non-radioactive detection.
* Any other bacterial Strain can be used.

Lab On Downstream Processing-4 credits

1. Conventional filtration
2. Centrifugation in batch and continuous centrifuge
3. Cell disruption
4. Protein precipitation and its recovery
5. Ion-exchange chromatography
6. Membrane based filtration-ultra filtration in cross flow modules and micro filtration
7. Adsorption process in batch and continuous mode.

Comprehensive Viva-2 Credits

Semester - III

IPR & Biosafety -3 Credits

Unit I

Introduction to Intellectual Property
Types of IP: Patents, Trademarks,Copyright & Related rights,Industrial Design,Traditional Knowledge,Geographical Indications,Protection of New GMOs; International framework for the protection of IP
IP as a factor in R & D; IPs of relevance to Biotechnology and few case studies; Introduction to history of GATT,WTO,WIPO and TRIPS

Unit II

Concept of 'prior art'
Invention in context of "prior art" ; Patent databases; Searching International Databases; Country-wise patent searches(USPTO,EPO,India etc.); Analysis and report formation.

Units III
Basics of Patents
Types of patents; Indian Patent Act 1970; Recent Amendments; Filling of a patent application; Precautions before patenting-disclosure/non-disclosure; WIPO Treaties; Budapest Treaty;PCT and Implications; Role of a Country Patent Office; Procedure for filing a PCT application

Unit IV

Patent filing and Infringement
Patent application-forms and guidelines,fee structure,time frames; Types of patent applications; provisional and complete specifications;PCT and convention patent applications; International patenting-requirement,procedures and costs; Financial assistance for patenting-introduction to existing schemes; Publication of patent-gazette of India,status in Europe and US
Patenting by research students,lecturers and scientists-university/organizational rules in India and abroad,credit sharing by workers,financial incentives
Patent infringement-meaning,scope,litigation,case studies and examples

Unit V

Biosafety
Introduction;Historical background; Introduction to Biological safety cabinets; Primary containment for Biohazards; Biosafety Levels; Biosafety Levels of specific Microorganisms; Recommended Biosafety Levels for Infectious Agents and Infected Animals; Biosafety guidelines-

Government of India; Definition of GMOs & LMOs; Roles of Institutional Biosafety Committee,RCGM,GEAC etc. for GMO applications in food and agriculture; Environmental release of GMOs; Risk Analysis; Risk Assessment; Risk Management and Communication;Overview of National Regulations and relevant International Agreements including Cartagena Protocol.

Bioprocess Plant Design-3Credits

Unit I

Introduction; General design information; Material and energy balance calculations; Process Flowsheeting.

Unit II

Scale up and scale down issues: Effect of scale on oxygenation, mixing, sterilization, pH, temperature, inoculum development, nutrient availability and supply; Bioreactor scale-up based on constant power consumption per volume, mixing time, impeller tip speed (shear), mass transfer coefficients. Scaleup of downstream processes: Adsorption (LUB method);Chromatography (constant resolution etc.); Filtration(constantresistance etc.); Centrifugation (equivalent times etc.); Extractors(goemetry based rules).Scale-down related aspects.

Unit III

Selection of bioprocess equipment (upstream and downstream); Specifications of bioprocess equipment; Mechanical design of reactors, heat transfer and mass transfer equipment; Design considerations for maintaining sterility of process streams and process equipment; Piping and instrumentation; Materials of construction for bioprocess plants.

Unit IV

Facility design aspects; Utility supply aspects; Equipment cleaning aspects; Culture cell banks; cGMP guidelines; Validation; Safety.

Unit V

Process economics; Case studies.

Texts/References:

1. Robert H. Perry and Don W. Green (eds.), Perry's Chemical Engineers' Handbook, 7th Edition, McGraw Hill Book Co., 1997.

2. Michael Shuler and Fikret Kargi, Bioprocess Engineering: Basic Concepts, 2nd Edition, Prentice Hall, Englewood Cliffs, NJ, 2002.

3. Roger Harrison et al., Bioseparations Science and Engineering, Oxford University Press, 2003.

4. J. M. Coulson and J. F. Richardson (Eds.) R.K.Sinnott, Chemical Engineering Volume 6: An introduction to Chemical Engineering Design, 2nd Edition, Butterworth-Heinemann Ltd., UK. (Indian

Edition: Asian Books Private Limited, New Delhi)

5. Max S. Peters and Klaus, D. Timmerhaus, Plant Design and Economics for Chemical Engineers, 4th Edition, McGrawHill Book Co., 1991.

6. M. V. Joshi and V.V.Mahajani, Process Equipment Design, 3rd Edition, Macmillan India Ltd., 2000.

7. Michael R. Ladisch, Bioseparations Engineering: Principles, Practice and Economics, 1st Edition, Wiley, 2001.

8. Relevant articles from Bioprocess journals.

Lab on Bioreactor Operation- 6 Credits

1. Microbial growth and product formation kinetics
2. Enzyme kinetics
3. Effects of inhibitor on microbial growth
4. Enzyme immobilization techniques
5. Bioconversion using immobilized enzyme preparation
6. Bioconversion in batch
7. Fedbatch and continuous bioreactors
8. Oxygen transfer studies in fermentation
9. Mixing and agitation in fermenters
10. RTD studies
11. Mass transfer in immobilized cell/enzyme reactor

Project Proposal Presentations – 7 Credits

Electives

Bioentrepreneurship & Management – 3 credits

Accounting and Finance

Taking decision on starting a venture; Assessment of feasibility of a given venture/new venture; Approach a bank for a loan; Sources of financial assistance; Making a business proposal/Plan for seeking loans from financial Institution and Banks; Funds from bank for capital expenditure and for working;Statutory and legal requirements for starting a company/venture; Budget planning and cash flow management; Basics in accounting practices: concepts of balance sheet, P&L account, and double entry bookkeeping; Estimation of income, expenditure, profit, income tax etc.

Marketing

Assessment of market demand for potential product(s) of interest; Market conditions, segments; Predictionof market changes; Identifying needs of customers including gaps in the market, packaging the product;Market linkages,branding issues; Developing distribution channels; Pricing/Policies/Competition;Promotion/Advertising; Services Marketing

Negotiations/Strategy

With financiers, bankers etc.; With government/law enforcement authorities;With companies/Institutions for technology transfer; Dispute resolution skills;External environment/changes;Crisis/Avoiding/ Managing; Broader vision–Global thinking

Information Technology

How to use IT for business administration; Use of IT in improving business performance; Available software for better financial management; E-business setup, management.

Human Resource Development (HRD)

Leadership skills; Managerial skills; Organization structure, pros & cons of different structures; Team building, teamwork; Appraisal; Rewards in small scale set up.

Fundamentals of Entrepreneurship

Support mechanism for entrepreneurship in India

Role of knowledge centre and R&D

Knowledge centres like universities and research institutions; Role of technology and upgradation; Assessment of scale of development of Technology; Managing Technology Transfer; Regulations for transfer of foreign technologies; Technology transfer agencies.

Case Study

1. Candidates should be made to start a 'mock paper company', systematically following all the procedures.

- The market analysis developed by them will be used to choose the product or services.

- A product or service is created in paper and positioned in the market. As a product or services available only in paper to be sold in the market through the existing links. At this juncture, the pricing of the product or the service needs to be finalized, linking the distribution system until the product or services reaches the end consumer.

- Candidates who have developed such product or service could present the same as a project work to the Panel of Experts, including representatives from industry sector. If the presented product or service is found to have real potential, the candidates would be exposed to the next level of actual implementation of the project.

2. Go to any venture capital website (like sequoiacap.com) and prepare a proposal for funding from venture capital.

Plant Biotechnology – 3Credits

Unit I

Plant Tissue Culture

Historical perspective; Totipotency; Organogenesis; Somatic embryogenesis; Regulation and applications; Artificial seed production; Micropropagation; Somaclonal variation; Androgenesis and its applications in genetics and plant breeding; Germplasm conservation and cryopreservation.

Protoplast Culture and Somatic Hybridization

Protoplast isolation; Culture and usage; Somatic hybridization- methods and applications ; Cybrids and somatic cell genetics.

Unit II

Agrobiology

Agrobacterium-plant interaction ; Virulence; Ti and Ri plasmids; Opines and their significance; T-DNA transfer; Disarming the Ti plasmid.

Genetic Transformation

Agrobacterium-mediated gene delivery; Cointegrate and binary vectors and their utility; Direct gene transfer-PEG-mediated,electroporation,particle bombardment and alternative methods; Screenable and selectable markers; Characterization of transgenics; Chloroplast transformation; Marker-free methodologies; Gene targeting.

Unit III

Molecular Mapping & Marker Assisted Selection (MAS)

Quantitative and Qualitative traits; MAS for genes of agronomic importance, e.g. Insect resistance, grain quality and grain yield; Molecular plymorphism,RFLP,RAPD,STS,AFLP,SNP markers; Construction of genetic and physical map; Gene mapping and cloning; QTL mapping and cloning.

Strategies for Introducing Biotic and Abiotic Stress Resistance/Tolerance

Bacterial resistance; Viral resistance; Fungal resistance; Insects and pathogens resistance; Herbicide resistance; Drought, salinity, thermal stress, flooding and submergence tolerance.

Unit IV

Genetic Engineering for Plant Architecture and metabolism

Seed storage proteins; Protein engineering; Vitamins and other value addition compounds; Source-sink relationships for yield increase; Post-harvest bioengineering; Plant architecture; Flowering behaviour

Plant as Biofactories

Concept of biofactories; Fermentation and production of industrial enzymes,vitamins and antibiotics and other biomolecules; Cell cultures for secondary metabolite production; Production of pharmaceutically important compounds; Bioenergy generation

Unit V

Plant Genomics

Identification of candidate genes using genetic information(positional cloning),using biochemical and expression analysis(micro array analysis,proteomics,metabolomics); Characterisation and functional analysis of candidate genes: transformation,mutant populations,knockout systems; Heterologous expression systems; Protein analysis; Bioinformatics and databases; Genoinformatics.

Eco-biotechnology

Biosensors; Biofuels; Marine biofarming; Plant genetic resources; Patenting of biological material; Plant breeders rights (PBRs) and farmers rights; Biosafety and containment practices

Text/References

1. Adrian Slater, Nigel Scott and Mark Fowler,Plant Biotechnology: The genetic manipulation of Plants,1st Edition, Oxford University Press,2003
2. Edited by BR Jordan,2nd Edition,The Molecular Biology and Biotechnology of Flowering,CABI,2006.
3. Neil Wille,Phytoremediation; Methods and Reviews,1st Edition, Humana Press,2007.
4. Denis Murphy,Plant Breeding and Biotechnology: Societal Context and the Future of Agriculture, Cambridge University Press,2007.

Environmental Biotechnology - 3Credits

Unit I

Introduction

Environment; Basic Concepts; Resources; Eco system: plants,animals,microbes; Ecosystem management; Renewable sources; Sustainability; Microbiology of degradation and decay; Role of Biotech in environmental protection; Control and management of biological processes

Unit II

Pollution

Environmental pollution; Source of pollution; Air, Water as a source of natural resource; Hydrocarbons,substituted hydrocarbons; Oil pollution; Surfactants; Pesticides; Measurement of pollution; Water pollution; Biofilm; Soil pollution; Radioactive pollution; Radiation; Ozone depletion; Green house effect; Impact of pollutants; Measurement techniques; Pollution of milk and aquatic animals.

Unit III

Control,remediation and management

Waste water collection; Control and management; Waste water treatment ; Sewage treatment through chemical,microbial and biotech techniques; Anaerobic processes; Anaerobic filters; Anaerobic sludge blanket reactors; Bioremediation of organic pollutants and odorous compounds; Use of bacteria,fungi,plants,enzymes,and GE organisms; Plasmid borne metabolic treatment; Biougmentation; Bioremediation of contaminated soils and waste land; Bioremediation of contaminated ground water; Microphytes in water treatment; Phytoremediation of soil metals; Treatment for waste water from dairy,distillery,tannery,sugar and antibiotic industries.

Unit IV

Alternate source of energy

Biomass as a source of energy; Bioreactors; Rural biotechnology; Biocomposting; Biofertilizers; Vermiculture; Organic farming; Bio-mineralization; Biofuels; Bioethanol and biohydrogen; Solid waste management.

Unit V

Environment and health in respect to genetics

Gene and environment; Effect of carbon and other nanoparticles upon health; Gene mutation; Genetic testing; Genetic sensors; Environmental pollution and children; Human biomonitoring

Text/References

1. Metcalfe and Eddy Inc., Waste water Engineering: Treatment,Disposal and Reuse",4th Edition,McGraw Hill Book Co.,2003
2. Mackenzie L. Davis and David A. Cornwell,Introduction to Environmental Engineering,4th Edition,McGraw Hill Book Co.,2006.
3. R.M.Maier,I.L.Pepper and C.P.Gerba,Elsevier,Environmental Microbiology: A Laboratory Manual,2nd Edition,Academic Press,2004.

4. B.C.Bhattacharyya and R.Banerjee,Environmental Biotechnology,Oxford University Press
5. I.S.Thakur, Environmental Biotechnology: Basic concepts and Applications, I.K.International

Genoinformatics - 3 Credits

Unit I
Overview of genomes
Diversity of Genomes: Prokaryotic and Eukaryotic Genomes: Structure, Organization, Evolution of Genome: Lateral or Horizontal Transfer among Genomes

Unit II
Genome analysis
Introduction; Gene mapping and applications- Genetic and Physical Mapping; Integrated map; Sequence assembly; Completed Genomes: Bacterium, Nematode, Plant and Human

Unit III
Genome annotation
Genome Annotation- Introduction, Structural and functional annotation; Automated and manual approaches; Structural annotation – prediction and homology based; Genes – Orthologs – Paralogs - Families – Functional annotation - GO, EC number and metabolic pathways, putative, expressed and hypothetical protein

Unit IV
Phylogenetics
Phylogenetic analysis: Evolutionary Change in Nucleotide Sequences; Rates and Patterns of Nucleotide Substitution; Models for Nucleotide Substitution and Methods for Phylogenetic analysis: Sequence Alignment, Softwares (SSearch, BLAST, FASTA, CLUSTAL); Construction of Phylogenetic Tree

Unit V
Genome Expression
Gene expression; Transcriptome and Proteome- General Account, Assigning function for a gene–mutagenesis screening, over expression, knock-out mutants

Texts/References
1. Wilkins, M.R., Williams, K.L., Appel, R.D., Hochstrasser, D.F. (Editors), Proteome Research: New Frontiers in
Functional Genomics. Springer Verlag Berlin Heidelberg. 1997
2. Baxevanis, A. and Ouellette, F.B.F (Editors), Bioinformatics: A Practical Guide to the Analysis of Genes and Proteins, 2nd Revised Edition, John Wiley and Sons, New York. 2001
3. Dale and Schartz, From Genes to Genomes, Humana. 2003
4. Hawley and Mori, The Human Genome, Academic, 1999
5. Primrose and Twyman, Principles of Genome Analysis & Genomics, 3rd Edition, Blackwell, 2003.
6. Liebler, D., Introduction to Proteomics: Tools for New Biology. Human Press, Totowa, 2002
7. Campbell, A.M. & Heyer, L.J., Discovering Genomics, Proteomics and Bioinformatics, 2nd Edition, Benjamin/
Cummings, 2006

8. Jerome, P.E. Mathematics for Genome Analysis, Cambridge, 2002.
9. Hall, B.G., Phylogenetic Tress Made Easy: A How to Manual for Molecular Biologists. Sinauer Ass., USA. 2001
10. Nei, M. and Kumar, S., Molecular Evolution and Phylogenetics, Oxford University Press. 2000.

Industrial & Food Biotechnology - 3 Credits

Unit I
Industrial and Food Biotechnology; Introduction; History; Importance; Applications of biotechnology in food processing; Significant advances; Recent developments; Risk factors; Safety regulations etc.

Unit II
Bioprocessing – Industrial use of micro organisms; Microbes exploited commercially- Saccharomyces, Lactobacillus, Penicillium, Acetobactor, Bifidobacterium, Lactococcus, Streptococcus etc; Fermentation-process, media and systems; Upstream and down stream processing; Product development; Dairy fermentation and fermented products

Unit III
Microbial enzymes in food processing; Industrial production of enzymes - proteases and cellulases; Food and beverage fermentation- alcoholic and non alcoholic beverages; Food additives and supplements – probiotics, health care products, vitamins and antibiotics; Fuels and industrial chemicals- Alkanes, industrial ethanol etc.

Unit IV
Modification of microbes/enzymes – Strain improvement, enzyme/ cofactor engineering; Technologies for microbial inactivation; Applications in product development/improvement.

Unit V
Cell immobilization for product enhancement – Classic examples; Biosensors and Bioprocess monitoring; Model systems and process control

Texts/References

1. Gautam, N. C., Food Biotechnology in Comprehensive Biotechnology, Vol. 6., Shree Publishers,
New Delhi, 2007
2. Gutierrez – Lopez, G. F. et. al., Food Science and Food Biotechnology. CRC Publishers, Washington, 2003
3. Maheshwari, D. K. et. al., Biotechnological applications of microorganisms, IK . International, New Delhi, 2006
4. Stanbury, P. F. et. al., Principles of Fermentation Technology, 2nd Edition, Elsevier, UK, 1995.
5. Waites, M. J. et. al., Industrial Biotechnology: An Introduction, Blackwell publishing, UK, 2007.

Semester - IV

Project Work- 23 credits

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