REVISED CURRICULUM M.Sc. BIOTECHNOLOGY COURSE

(2010-2011 Onwards)

INTERDISCIPLINARY BIOTECHNOLOGY UNIT
ALIGARH MUSLIM UNIVERSITY, ALIGARH

SEMESTER I

Biochemistry 3 Credits

Unit I
Chemical basis of life; Composition of living matter; Water – properties; pH; ionization and hydrophobicity; Emergent properties of biomolecules in water; Biomolecular hierarchy; Macromolecules; Molecular assemblies; Structure-function relationships Amino acids – structure and functional group properties; Peptides and covalent structure of proteins; Elucidation of primary and higher order structures; Evolution of protein structure; Structure-function relationships in model proteins like ribonuclease A; myoglobin; hemoglobin; chymotrypsin etc.; Tools to characterize expressed proteins.

Unit II
Enzyme catalysis – general principles of catalysis; Quantitation of enzyme activity and efficiency; Enzyme characterization and Michaelis-Menten kinetics; Relevance of enzymes in metabolic regulation; activation; inhibition and covalent modification; Single substrate enzymes

Unit III
Sugars - mono; di; and polysaccharides; Suitability in the context of their different functions- cellular structure; energy storage; signaling; Glycosylation of other biomolecules - glycoproteins and glycolipids; Lipids - structure and properties of important members of storage and membrane lipids; lipoproteins

Unit IV
Biomembrane organization - sidedness and function; Membrane bound proteins - structure; properties and function; Transport phenomena; Nucleosides; nucleotides; nucleic acids - structure; diversity and function; sequencing; Brief overview of central dogma.

Unit V
Bioenergetics-basic principles; Equilibria and concept of free energy; Coupled processes; Glycolytic pathway; Kreb's cycle; Oxidative phosphorylation; Photosynthesis; Elucidation of metabolic pathways; Logic and integration of central metabolism; entry/ exit of various biomolecules from central pathways; Principles of metabolic regulation; Regulatory steps; Signals and second messengers.

Texts/References:

1. *V.Voet and J.G.Voet; Biochemistry; 3rd edition; John Wiley; New York; 2004.*
2. *A.L. Lehninger; Principles of Biochemistry; 5th edition; W.H Freeman and Company; 2004.*
3. *L. Stryer; Biochemistry; 5th edition; W.H. Freeman and Company; 2002.*

Analytical Techniques 3 Credits

Unit I

Basic Techniques Buffers; Methods of cell disintegration; Enzyme assays and controls; Detergents and membrane proteins; Dialysis; Ultrafiltration and other membrane techniques Spectroscopy Techniques UV; Visible and Raman Spectroscopy; Theory and application of Circular Dichroism; Fluorescence; MS; NMR; PMR; ESR and Plasma Emission spectroscopy

Unit II

Chromatography Techniques TLC and Paper chromatography; Chromatographic methods for macromolecule separation -Gel permeation; Ion exchange; Hydrophobic; Reverse-phase and Affinity chromatography; HPLC and FPLC; Criteria of protein purity Electrophoretic techniques Theory and application of Polyacrylamide and Agarose gel electrophoresis; Capillary electrophoresis; 2D Electrophoresis; Disc gel electrophoresis; Gradient electrophoresis; Pulsed field gel electrophoresis

Unit III

Centrifugation Basic principles; Mathematics & theory (RCF; Sedimentation coefficient etc); Types of centrifuge - Microcentrifuge; High speed & Ultracentrifuges; Preparative centrifugation; Differential & density gradient centrifugation; Applications (Isolation of cell components); Analytical centrifugation; Determination of molecular weight by sedimentation velocity & sedimentation equilibrium methods

Unit IV

Radioactivity Radioactive & stable isotopes; Pattern and rate of radioactive decay; Units of radioactivity; Measurement of radioactivity; Geiger-Muller counter; Solid & Liquid scintillation counters (Basic principle; instrumentation & technique); Brief idea of radiation dosimetry; Cerenkov radiation; Autoradiography; Measurement of stable isotopes; Falling drop method; Applications of isotopes in biochemistry; Radiotracer techniques; Distribution studies; Isotope dilution technique; Metabolic studies; Clinical application; Radioimmunoassay

Unit V

Advanced Techniques: Protein crystallization; Theory and methods; API-electrospray and MADI-TOF; Mass spectrometry; Enzyme and cell immobilization techniques; DNA & Peptide Synthesis.

Texts/References:

1. *Freifelder D.; Physical Biochemistry; Application to Biochemistry and Molecular Biology; 2nd Edition; W.H. Freeman & Company; San Fransisco; 1982.*
2. *Keith Wilson and John Walker; Principles and Techniques of Practical Biochemistry; 5th Edition; Cambridge University Press; 2000.*
3. *D. Holme & H. Peck; Analytical Biochemistry; 3rd Edition; Longman; 1998.*

4. *R. Scopes; Protein Purification - Principles & Practices; 3rd Edition; Springer Verlag; 1994.*
5. *Selected readings from Methods in Enzymology; Academic Press*.

Biostatistics & Computer Applications 3 Credits

Unit I
Fundamental concepts in applied probability; Exploratory data analysis and statistical inference; Probability and analysis of one and two way samples; discrete and continuous probability models; Expectation and variance; Central limit theorem; Inference; Hypothesis; Critical region and error probabilities; Tests for proportion; Equality of proportions; equality of means of normal populations(variance known; variance unknown); Chi-square test for independence; P-value of the statistic; Confidence limits; Introduction to one way and two-way analysis of variance; Data transformations

Unit II
Elements of programming languages - C and PERL; Data base concept; Database management system; Database browsing and Data retrieval; Sequence database and genome database; Data Structures and Databases; Databases such as GeneBank; EMBL; DDBJ; Swissplot; PIR; MIPS; TIGR; Hovergen; TAIR; PlasmoDB; ECDC; Searching for sequence database like FASTA and Blast algorithm.

Unit III
Cluster analysis; Phylogenetic clustering by simple matching coefficients; Sequence Comparison; Sequence pattern; Regular expression based pattern; Theory of profiles and their use in sequence analysis; Markov models; Concept of HMMS; Baum-Welch algorithm; Use of profile HMM for protein family classification; Pattern recognition methods

Unit IV
Goals of a Microarray experiment; Normalization of Miroarray data; Detecting differential gene expression; Principle component analysis; Clustering of microarray data; Structure determination by X-ray crystallography; NMR spectroscopy; PDB(Protein Data Bank) and NDB(Nucleic Acid Data Bank); File formats for storage and dissemination of molecular structure.

Unit V
Methods for modeling; Homology modeling; Threading and protein structure prediction; Structure-structure comparison of macromolecules with reference to proteins; Force fields; Molecular energy minimization; Monte Carlo and molecular dynamics simulation

Practicals:

Introduction to MSEXCEL-Use of worksheet to enter data; edit data; copy data; move data. Use of in-built statistical functions for computations of Mean; S.D.; Correlation; regression coefficients etc. Use of bar diagram; histogram; scatter plots; etc. graphical tools in EXCEL for presentation of data. Introduction to SYSTAT package. Searching PubMed ; Introduction to NCBI; NCBI data bases; BLAST BLASTn; BLASTp; PSI-BLAST; Sequence manipulation Suite; Multiple sequence alignment; Primer designing; Phylogenetic Analysis. Protein Modeling; Protein structure Analysis; Docking; Ligplot interactions.

Texts/References:

1. *Wayne W. Daniel; Biostatistics : A foundation for Analysis in the Health Sciences; 8th Edition; Wiley; 2004.*
2. *Prem S. Mann; Introductory Statistics; 6th Edition; Wiley; 2006.*
3. *John A. Rice; Mathematical Statistics and Data Analysis; 3rd Edition; John A. Rice; Duxbury Press; 2006.*
4. *Campbell and Heyer; Discovering Genomics; Proteomics; & Bioinformatics; 2nd Edition; Benjamin Cummings; 2002.*
5. *Cynthia Gibas and Per Jambeck; Developing Bioinformatics Computer Skill; 1st Edition; O'Reilly Publication; 2001.*

Cellular & Molecular Biology 3 Credits

Unit I

Cell diversity: Chemical equilibrium and energetics; Cell theory; Cell organelles- endo-membrane systems; Golgi apparatus; lysosomes; endoplasmic reticulum; nucleus and chromatin organization; Extracellular matrix - basal lamina; connective and other tissues; Cell-cell junctions; Cell wall- structural organization and functions; Cellular energy transactions- Role of mitochondria and chloroplast; Co- and post-translational modification of Proteins; Intracellular protein trafficking; Quality control in ER and Golgi; secretary pathway and vesicular trafficking; Import into mitochondria; chloroplast; peroxisome; lysosomes; Receptor-mediated endocytosis; Cytoskeleton- actin; myosin; microfilaments; microtubules and their dynamics; Intermediate filaments; Cell motility; Cilia and flagella; Motor proteins- kinesin and dynein; Differentiation of specialized cells-stem cells differentiation; blood cell formation.

Unit II

Basic techniques of cell biology; Light and electron microscopy; Confocal microscopy; atomic force microscopy; Sub-cellular fractionation; Culturing of metazoan cells; Protein-DNA Interactions; Footprinting and gel-shift asays; Yeast two hybrid and Phage display; Structure determination: Application of X-Rays; NMR; cryoelectron microscopy; RNA interference; hybridization techniques; Membrane transport- Passive and active transport; diffusion and osmosis; ion channels (gated & non-gated); Symport and Antiport; Uniport and Co-transport; Trans-epithelial transport; Transport of proteins and molecular chaperones.

Unit III

Cell cycle and cancer biology; Mitosis- role of cyclins; CDK; MPF and control of mitosis; Nuclear decondensation; Control of S-phase; Cell cycle control in mammalian cells; Check points and restriction points; Meiosis- asymmetric cell division; Gametogenesis and fertilization; Cell death and its regulation; Tumor cells and onset of cancer; Oncogenes; proto-oncogenes; Viral and cellular oncogenes; tumour suppressor genes from humans; Structure; function and mechanism of action of pRb and p53 tumour suppressor proteins; Types of cancer and metastasis; Genetic basis of cancer; Mutations as cause of cancer; Nonsense; missense and point mutations; Intragenic and Intergenic suppression; Frameshift mutations; Physical; chemical and biological mutagens; Carcinogens; Viruses and cancer; Cell signaling- surface receptors; Signal

transduction; Role of GPCR; Cytokine receptors; Receptor tyrosine kinase; MAPK pathways; Secondary messengers; Gene activation by cell surface receptors.

Unit IV

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; Overlapping genes; Split genes; Eukaryotic Gene structure; mobile genetic elements (transposons and retroposons) in Prokaryotes and Eukaryotes; Organelle DNAs; Organization and morphology of chromosomes; DNA replication- mechanism; enzymes and accessory proteins involved; control; Replication of single stranded circular DNA; gene stability and DNA repair enzymes; Photoreactivation; Nucleotide excision repair; mismatch correction; SOS repair; Homologous and non-homologous recombinations; Site specific recombinations; Chi sequences in prokaryotes; Gene targeting; Gene disruption; FLP/FRT and Cre/Lox recombination.

Unit V

Prokaryotic and Eukaryotic transcription; RNA polymerases; General and specific transcription factors; Regulatory elements- TATA box and TATA binding proteins; activators; repressors; Mechanisms of transcription regulation at initiation; elongation and Termination (Rho dependant and rho dependant); Attenuation and anti-termination; Regulation of transcription factor activity; Chromation remodelling and histone modification; Regulation of transcription in eukaryotes- regulatory sequences (Promoters and enhancers); Gene expression in bacteria; Operon Concept (lac; trp; ara; his operons); Transcriptional control in lambda phage; Pre mRNA Modifications- 5'- cap formation; 3'- end processing and polyadenylation; splicing; mRNA stability; Processing of hnRNA; RNA editing; Nuclear export of mRNA and its regulation; tRNA modification; cytoplasmic mechanism of post transcriptional control; Genetic code- degeneracy of codons; Wobble hypothesis; Genetic code in mitochondria; Translation- Procaryotic and eukaryotic translation; the translation machinery; Mechanism of initiation; elongation and Termination; regulation of translation; 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.*
4. *Lodish et al.; Molecular cell Biology; 4th Edition; W.H. Freeman & Company; 2000.*
5. *Smith & Wood; Cell Biology; 2nd Edition; Chapman & Hall; London;1996.*
6. *B. M. Turner; Chromatin & Gene regulation; 1st Edition; Wiley-Blackwell; 2002.*
7. *Watson et al.; Molecular Biology of the gene; 5th Edition; Pearson Prentice Hall. USA; 2003*

SEMESTER II

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 ymphoid organs; 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 & subclasses of immunoglobulins; antigenic determinants; Multigene organization of immunoglobulin genes; B-cell receptor; Immunoglobulin superfamily; Principles of cell signaling;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 plasma 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.*
5. *Goding; Monoclonal antibodies; Academic Press. 1985.*

Microbiology & Industrial Applications 3 Credits

Unit I

Microbial Diversity & Systematics Classical and modern methods and concepts; Domain and Kingdom concepts in classification of microorganisms; Criteria for classification; Classification of Bacteria according to Bergey's manual; Molecular methods such as Denaturing Gradient Gel Electrophoresis (DGGE); Temperature Gradient Gel Electrophoresis (TGGE); Amplified rDNA Restriction Analysis and Terminal Restriction Fragment Length Polymorphism (T-RFLP) in assessing microbial diversity; 16S rDNA sequencing and Ribosomal Database Project.

Unit II

Microbial Growth & Physiology Ultrastructure of Archaea (Methanococcus); Eubacteria (E.coli); Unicellular Eukaryotes (Yeast) and viruses (Bacterial; Plant; Animal and Tumor viruses); Microbial growth: Batch; fed-batch; continuous kinetics; synchronous growth; yield constants; methods of growth estimation; stringent response; death of a bacterial cell. Microbial physiology: Physiological adoption and life style of Prokaryotes; Unicellular Eukaryotes and the Extremophiles (with classical example from each group)

Unit III

Microbial Interactions and Infection Host–Pathogen interactions; Microbes infecting humans; veterinary animals and plants; Pathogenicity islands and their role in bacterial virulence

Unit IV

Microbes and Environment Role of microorganisms in natural system and artificial system; Influence of Microbes on the Earth's Environment and Inhabitants; Ecological impacts of microbes; Symbiosis (Nitrogen fixation and ruminant symbiosis); Microbes and Nutrient cycles; Microbial communication system; Quorum sensing; Microbial fuel cells; Prebiotics and Probiotics; Vaccines

Unit V

Industrial Applications Basic principles in bioprocess technology; Media Formulation; Sterilization; Thermal death kinetics; Batch and continuous sterilization systems; Primary and secondary metabolites; Extracellular enzymes; Biotechnologically important intracellular products; exopolymers; Bioprocess control and monitoring variables such as temperature; agitation; pressure; pH Microbial processes-production; optimization;

screening; strain improvement; factors affecting down stream processing and recovery; Representative examples of ethanol; organic acids; antibiotics etc. Enzyme Technology-production; recovery; stability and formulation of bacterial and fungal enzymes-amylase; protease; penicillin acylase; glucose isomerase; Immobilised Enzyme and Cell based biotransformations-steroids; antibiotics; alkaloids; enzyme/cell electrodes.

Texts/References:

1. *Pelczar MJ Jr.; Chan ECS and Kreig NR.; Microbiology; 5th Edition; Tata McGraw Hill; 1993.*
2. *Maloy SR; Cronan JE Jr.; and Freifelder D; Microbial Genetics; Jones Bartlett Publishers; Sudbury; Massachusetts; 2006.*
3. *Crueger and A Crueger; (English Ed.; TDW Brock); Biotechnology: A textbook of Industrial Microbiology; Sinaeur Associates; 1990.*
4. *G Reed; Prescott and Dunn's; Industrial Microbiology; 4th Edition; CBS Publishers; 1987.*
5. *M.T. Madigan and J.M. Martinko; Biology of Microorganisms; 11th Edition; Pearson Prentice Hall; USA; 2006.*

Genetics & 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;

Unit II

Cloning Vectors and methodology; Plasmids; Bacteriophages; M13 mp vectors; PUC19 and Bluescript vectors; Phagemids; Lambda vectors; Cosmids; Artificial chromosome vectors (YACs; BACs); Animal Virus derived vectors-SV-40; Expression vectors; pMal; GST; pET-based vectors; Protein purification; His-tag; GST-tag; MBP-tag etc.; Intein-based vectors; Inclusion bodies; Methodologies to reduce formation of inclusion bodies; Plant based vectors; Ti and Ri as vectors; Yeast vectors; Shuttle vectors. 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 Far-western cloning; Protein-protein interactive cloning and Yeast two hybrid system; Phage display; Principles in maximizing gene expression

Unit III

PCR the basics; application and sequencing**:** 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; Site specific mutagenesis; PCR in molecular diagnostics; Viral and bacterial detection; PCR based mutagenesis; Mutation detection: SSCP; RFLP; Oligo Ligation Assay (OLA): 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; Suicide gene therapy; Gene replacement; Gene targeting;

Unit IV

Gene transfer in bacteria; History; Transduction – generalized and specialized; Conjugation – F; F'; Hfr; F transfer; Hfr-mediated chromosome transfer; Transformation – natural and artificial transformation; Merodiploid generation; Gene mapping; Transposable genetic elements; Insertion sequences; Composite and Complex transposons; Replicative and non-replicative transposition; Genetic analysis using transposons. Genetic variation Mutations; kinds of mutation; agents of mutation; genome polymorphism; uses of polymorphism. Gene mapping and human genome project Physical mapping; linkage and association Population genetics and evolution Phenotype; Genotype; Gene frequency;

Unit V

Mendelian Genetics Introduction to human genetics; Background and history; Types of genetic diseases; Role of genetics in medicine; Human pedigrees; Patterns of single gene inheritance-autosomal recessive; Autosomal dominant; X linked inheritance; Hemoglobinopathies - Genetic disorders of hemoglobin and their diseases.

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.*
6. *S.R. Maloy; J.E. Cronan; D. Friefelder; Microbial Genetics; 2nd Edition; Jones and Bartlett Publishers; 1994.*
7. *N. Trun and J. Trempy; Fundamental Bacterial Genetics; Blackwell publishing; 2004.*
8. *Strachan T and Read A P; Human molecular genetics; 3rd Edition Wiley Bios; 2006.*
9. *Mange E J and Mange A. P.; Human genetics; 2nd Edition; Sinauer Associates publications; 1999.*
10. *Hartl L D and Jones B; Analysis of genes and genomes; 3rd Edition; Jones and Bartlett Publishers; 1994.*

Proteins & Enzymes 3 Credits

Unit I

Peptides & proteins- Peptide bond conformation; dihedral angles; Ionization behaviour of peptides; Peptide diversity in terms of size and composition; Peptides with biological activities; Primary: secondary and tertiary structure of proteins; Ramachandran plot; Fibrous and globular proteins; Forces stabilizing native protein conformation; Super-

secondary structure: quaternary structure; Prediction of secondary structure; Chemical modification of Proteins.

Unit II

Determination of protein structure**-** Sequence determination of proteins; N- and C-terminal amino acid analysis; Edman's degradation: classical and automated procedures; Use of mass spectrometry in primary structure determination; secondary structure determination with the help of CD; Tertiary structure study with the help of X-ray diffraction

Unit III

Protein function**-** Protein ligand interactions; Qualitative and quantitative studies on cooperative and non-cooperative (Sigmoidal) binding of ligands; Hill equation; Sequential and concerted model for cooperative binding.

Unit IV

Protein denaturation and folding; Models of protein folding and association of proteins; Anfinsen's experiment: Thermodynamics of protein folding- Leventhal Paradox; Role of chaperons in folding; Protein misfolding disorders: Amlyloid fiber formation; Protein evolution.

Unit V

Enzymes**-** History; Features of enzyme catalyzed reaction; Properties and study of enzyme active sites; Kinetics of single and multi-substrate reactions; Enzyme inhibition-irreversible and reversible (competitive: noncompetitive and uncompetitive inhibition); Allosteric enzymes (sequential and concerted model).

Artificial enzymes- Synthetic and semi-synthetic enzymes: Catalytic antibodies; Molecular imprinting: Non-aqueous enzymology- Behaviour of enzymes in non aqueous media: application in synthesis and industry.

Texts/ References:

1. *M.M. Cox and D.L.Nelson, Lehninger; Principles of Biochemistry;(2008) 5th edition; W.H Freeman and Company;*
2. *J.M. Berg, J.L. Tymoczko and L. Stryer; Biochemistry; 5th edition; (2007) W.H. Freeman and Company..*
3. *H.W. Blank & D.S, Clark; Applied Biocatalysis, Vol I (1991) Marcel Dekkar Inc. N.Y.*
4. *D. Whitford; Proteins, Structure and Function (2001) John Wiley & Sons Ltd.*
5. *R. Guerois and Lopez de la Paz; Protein Design Methods and Applicatios (2006) Humana Press*

SEMESTER III

Bioprocess Engineering & Technology 3 Credits

Unit I

Basic principle of Biochemical engineering Isolation; screening and maintenance of industrially important microbes; Microbial growth and death kinetics (an example from

each group; particularly with reference to industrially useful microorganisms); Strain improvement for increased yield and other desirable characteristics.

Unit II

Concepts of basic mode of fermentation processes Bioreactor designs; Types of fermentation and fermenters; Concepts of basic modes of fermentation - Batch; fed batch and continuous; Conventional fermentation v/s biotransformation; Solid substrate; surface and submerged fermentation; Fermentation economics; Fermentation media; Fermenter design-mechanically agitated; Pneumatic and hydrodynamic fermenters; Large scale animal and plant cell cultivation and air sterilization; Upstream processing: Media formulation; Sterilization; Aeration and agitation in bioprocess; Measurement and control of bioprocess parameters; Scale up and scale down process.

Unit III

Downstream processing Bioseparation -filtration; centrifugation; sedimentation; flocculation; Cell disruption; Liquid-liquid extraction; Purification by chromatographic techniques; Reverse osmosis and ultra filtration; Drying; Crystallization; Storage and packaging; Treatment of effluent and its disposal.

Unit IV

Applications of enzymes in food processing Mechanism of enzyme function and reactions in process techniques; Enzymic bioconversions e.g. starch and sugar conversion processes; High-Fructose Corn Syrup; Interesterified fat; Hydrolyzed protein etc. and their downstream processing; baking by amylases; deoxygenation and desugaring by glucoses oxidase; beer mashing and chill proofing; cheese making by proteases and various other enzyme catalytic actions in food processing. Applications of Microbes in food process operations and production Fermented foods and beverages; Food ingredients and additives prepared by fermentation and their purification; fermentation as a method of preparing and preserving foods; Microbes and their use in pickling; producing colours and flavours; alcoholic beverages and other products; Process wastes-whey; molasses; starch substrates and other food wastes for bioconversion to useful products; Bacteriocins from lactic acid bacteria – Production and applications in food preservation.

Unit V

Enzyme kinetics; Two-substrate kinetics and pre-steady state kinetics; Allosteric enzymes; Enzyme mechanism; Enzyme inhibitors and active site determination Production; recovery and scaling up of enzymes and their role in food and other industries; Immobilization of enzymes and their industrial applications.

Texts/ References:

1. *Jackson AT.; Bioprocess Engineering in Biotechnology; Prentice Hall; Engelwood Cliffs; 1991.*
2. *Shuler ML and Kargi F.; Bioprocess Engineering: Basic concepts; 2nd Edition; Prentice Hall; Engelwood Cliffs; 2002.*
3. *Stanbury RF and Whitaker A.; Principles of Fermentation Technology; Pergamon press; Oxford; 1997.*

4. *Baily JE and Ollis DF.; Biochemical Engineering fundamentals; 2nd Edition; McGraw-Hill Book Co.; New York; 1986.*
5. *Aiba S; Humphrey AE and Millis NF; Biochemical Engineering; 2nd Edition; University of Tokyo press; Tokyo; 1973.*
6. *Comprehensive Biotechnology: The Principles; Applications and Regulations of Biotechnology in Industry; Agriculture and Medicine; Vol 1; 2; 3 and 4. Young M.M.; Reed Elsevier India Private Ltd; India; 2004.*
7. *Mansi EMTEL; Bryle CFA. Fermentation Microbiology and Biotechnology; 2nd Edition; Taylor & Francis Ltd; UK; 2007.*

Immunotechnology & Molecular Virology 3 Credits

Unit I

Introduction to Immunotechnology Kinetics of immune response: memory; Principles of Immunization; Techniques for analysis of Immune response ; Antibody Related Techniques Immuno-chemistry of Antigens - immunogenecity: Antigenecity: haptens: Toxins-Toxoids: Hapten-carrier system; Genetic basis of immune response; Role and properties of adjuvants: Immune modulators; B cell epitopes; Hybridoma Rabbit: human; Antigen – Antibody interaction: affinity: cross reactivity: specificity: epitope mapping; Immuno assays: RIA: ELISA: Western blotting: ELISPOT assay: immunofluorescence: Surface plasma resonance: Biosensor assays for assessing ligand –receptor interaction
New Generation Antibodies Multigene organization of immunoglobulin genes: Ab diversity; Antibody engineering; Phage display libraries; Antibodies as in vitro and in vivo probes

Unit II

CMI and Imaging techniques CD nomenclature: Identification of immune Cells; Principle of Immunofluorescence Microscopy: Flurochromes; Staining techniques for live cell imaging and fixed cells; Flow cytometry: Instrumentation: Applications; Cell Functional Assays –lymphoproliferation: Cell Cytotoxicity: Mixed Lymphocyte Reaction: Apoptotosis: Cytokine expression; Cell cloning: Reporter Assays: In–situ gene expression techniques; Cell imaging Techniques- In vitro and In vivo; Immuno-electron microscopy; In vivo cell tracking techniques; Microarrays; Transgenic mice: gene knock outs

Unit III

Classification of animal and plant viruses; Satellite viruses; Viroids; Virusoids etc.; Diseases causes by animal viruses and plant viruses; Economic loss due to important viruses : Genome organization of animal viruses; Replication of RNA viruses; Replication of DNA viruses ; Structure of animal viruses and plant viruses;
Genome organization of DNA and RNA plant viruses; Replication of DNA and RNA plant viruses

Unit IV

Methods to diagnose animal virus infections: Electron microscopy: Tissue culture growth of viruses : Virus quantitation assays: Viral serology: ELISA: neutralization assays; Molecular methods: hybridization: PCR: real time PCR: sequencing: microarray : gene silencing and antiviral assays

Unit V

Methods to study plant viruses; Infectivity assays – Sap transmission: insect vector transmission: agroinfection (using Agrobacterium); serological methods: immunelectrophoresis in gels: direct double-antibody sandwich method: Dot ELISA: Immunosorbent electron microscopy (ISEM): Decoration technique: Gene silencing: PTGS & TGS: viral suppressors of gene silencing.

Texts/References:

1. *Voet D; Voet JG & Pratt CW; Fundamentals of Biochemistry; 2nd Edition. Wiley 2006*
2. *Brown TA; Genomes; 3rd Edition. Garland Science 2006*
3. *Campbell AM & Heyer LJ; Discovering Genomics; Proteomics and Bioinformatics; 2nd Edition. Benjamin Cummings 2007*
4. *Primrose S & Twyman R; Principles of Gene Manipulation and Genomics; 7th Edition; Blackwell; 2006.*
5. *Glick BR & Pasternak JJ; Molecular Biotechnology; 3rd Edition; ASM Press; 1998.*

Genomics & Proteomics 3 Credits

Unit I

Introduction Structural organization of genome in Prokaryotes and Eukaryotes; Organelle DNA-mitochondrial; chloroplast; DNA sequencing-principles and translation to large scale projects; Recognition of coding and non-coding sequences and gene annotation; Tools for genome analysis-RFLP; DNA fingerprinting; RAPD; PCR; Linkage and Pedigree analysis-physical and genetic mapping.

Unit II

Genome sequencing projects Microbes; plants and animals; Accessing and retrieving genome project information from web; Comparative genomics; Identification and classification using molecular markers-16S rRNA typing/sequencing; EST's and SNP's.

Unit III

Proteomics Protein analysis (includes measurement of concentration; amino-acid composition; N-terminal sequencing); 2-D electrophoresis of proteins; Microscale solution isoelectricfocusing; Peptide fingerprinting; LC/MS-MS for identification of proteins and modified proteins; MALDI-TOF; SAGE and Differential display proteomics; Protein-protein interactions; Yeast two hybrid system.

Unit IV

Pharmacogenetics High throughput screening in genome for drug discovery-identification of gene targets; Pharmacogenetics and drug development

Unit V

Functional genomics and proteomics Analysis of microarray data; Protein and peptide microarray-based technology; PCR-directed protein in situ arrays; Structural proteomics

Texts/References:

1. *Voet D; Voet JG & Pratt CW; Fundamentals of Biochemistry; 2nd Edition. Wiley 2006*
2. *Brown TA; Genomes; 3rd Edition. Garland Science 2006*

3. *Campbell AM & Heyer LJ; Discovering Genomics; Proteomics and Bioinformatics; 2nd Edition. Benjamin Cummings 2007*
4. *Primrose S & Twyman R; Principles of Gene Manipulation and Genomics; 7th Edition; Blackwell; 2006.*
5. *Glick BR & Pasternak JJ; Molecular Biotechnology; 3rd Edition; ASM Press; 1998.*

Plant Biotechnology Credit: 3

Unit I

Conventional plant breeding. Introduction to cell and tissue culture; tissue culture as a technique to produce novel plant and hybrids. Tissue culture media (composition and preparation). Initiation and maintenance of callus and suspension culture; single cell clones. Organogenesis; somatic embryogenesis; transfer and establishment of whole plants in soil.

Unit II

Shoot-tip culture: Rapid clonal propagation and production of virus-free plants. Embryo culture and embryo rescue. Protoplast isolation; culture and fusion; selection of hybrids cells and regeneration of hybrid plants; symmetric and asymmetric hybrids; hybrid biotransformation. Anther; pollen; and ovary culture for production of haploid plants and homozygous lines. Cryopreservation; slow growth and DNA banking for germ plasm conservation.

Unit III

Plant transformation technology: Basis of tumor formation; hairy root; features of T1 and R1 plasmids; mechanisms of DNA transfer; role of virulence genes; use of T1 and R1 as vectors; binary vectors; use of 35S and other promoters; genetic markers; use of reporter genes; reporter genes with introns; use of scaffold attachment regions; methods of nuclear transformation; viral vectors and their applications; multiple gene transfers; vectorless or direct DNA transfer; particle bombardment; electroporation; microinjection transformation of monocots. Transgene stabilityand gene silencing/ plant transformation. Application of plant transformation for productivity and performance promoter trapping; activation tagging. Herbicide resistance; phosphoinothricin;glyphosate; sulfonyl urea; atrazine; insect resistance; Bt. Genes; non-Bt like protease inhibitors; alpha amylase inhibitor; virus resistance; coat protein mediated; nucleocaspid gene; disease resistance; chitinase; 1 – 3 beta glucanase; RIP antifungal proteins; thionines; PR proteins; nematode resistance abiotic stress post-harvest losses; long shelf life of fruits and flowers; use of ACC synthase; poly- galactrunase; ACC oxidase; male sterile lines; bar and barnase systems; carbohydrate composition and storage; ADP glucose pyrophosphatase; terminator gene technology. Chloroplast transformation: Advantages; vectors; success with tobacco and potato plants.

Unit IV

An introduction to plant conservation biotechnology, Molecular approaches to assessing plant diversity; molecular marker system; molecular markers in germ plasm characterization; population genetics; biodiversity characterization, plant germplasm acquisition; plant genetic resource conservation; acquisition procedures; planning methods involved, Phytosanitary aspects of plant germplasm conservation; safe movement of germplasm; quarantine; virus detection; production of pathogen free plants, Cryopreservation; principle; preparation and pretreatment, cryoprotection

procedure, Stability assessment; natural variation; techniques; morphological variation; cytological, biochemical and molecular analysis, biotechnological advances in conservation of root and tuber crops; economical important plants; endangered plants; rain forest conservation.

Unit V

Metabolic engineering and industrial products: Plant secondary metabolites; control mechanisms and manipulation of phenylpropanoid pathway; alkaloids; industrial enzymes; biodegradable plastics; polyhydroxybutyrate; therapeutic proteins; lysosomal enzymes; antibodies; edible vaccines; purification strategies; oleosin partitioning technology. Molecular marker-aided breeding: RFLP maps; linkage analysis; RAPD markers; STS; microsatellites; SCAR (sequence characterized amplified regions); SSCP (single strand conformational polymorphism); AFLP; QTL; map-based cloning. Molecular marker-assisted selection. Arid and semi-arid plant biotechnology; Green house and Green-home technology.

References:

1) *Plant cell & tissue culture Ed: Pollard JW & Walker JM. (1990) Humana Press*
2) *Principles of Plant Biotechnology Ed: Mantell, Mckee RA, Matthews JA. (1987) Blackwell Scientific Publications*
3) *Plant Biotechnology & Transgenic Plants, Ed: Oksman, CKM & Barz WH. (1999) Kluwer Academic/Plenum*
4) *Plant Conservation Biotechnology by Benson EE (1999) CRC*
5) *Fundamentals of Plant Biotechnology by Amla Batra. (2006) Capital Publishing House*

IPR & Biosafety — Non-Credit

Unit I

Introduction to Intellectual Property Types of IP: Patents; Trademarks; Copyright & Related Rights; Industrial Design; Traditional Knowledge; Geographical Indications; Protection of GMOs IP as a factor in R&D; IPs of relevance to Biotechnology and few Case Studies

Unit II

Agreements and Treaties History of GATT & TRIPS Agreement; Madrid Agreement; Hague Agreement; WIPO Treaties; Budapest Treaty; PCT; Indian Patent Act 1970 & recent amendments

Unit III

Basics of Patents and Concept of Prior Art Introduction to Patents; Types of patent applications: Ordinary; PCT; Conventional; Divisional and Patent of Addition; Specifications: Provisional and complete; Forms and fees Invention in context of “prior art”; Patent databases; Searching International Databases; Country-wise patent searches (USPTO; esp@cenet(EPO); PATENTScope(WIPO); IPO; etc.)

Unit IV

Patent filing procedures National & PCT filing procedure; Time frame and cost; Status of the patent applications filed; Precautions while patenting – disclosure/non-disclosure; Financial assistance for patenting introduction to existing schemes Patent licensing and agreement Patent infringement- meaning; scope; litigation; case studies

Unit V

Biosafety Introduction; Historical Backround; 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 Cartegana Protocol.

Texts/References:

1. *BAREACT; Indian Patent Act 1970 Acts & Rules; Universal Law Publishing Co. Pvt. Ltd.; 2007*
2. *Kankanala C.; Genetic Patent Law & Strategy; 1st Edition; Manupatra Information Solution Pvt. Ltd.; 2007*

Important Links:

- *http://www.w3.org/IPR/*
- *http://www.wipo.int/portal/index.html.en*
- *http://www.ipr.co.uk/IP_conventions/patent_cooperation_treaty.html*
- *www.patentoffice.nic.in*
- *www.iprlawindia.org/ - 31k - Cached - Similar page*
- *http://www.cbd.int/biosafety/background.shtml*
- *http://www.cdc.gov/OD/ohs/symp5/jyrtext.htm*
- *http://web.princeton.edu/sites/ehs/biosafety/biosafetypage/section 3.html*

SEMESTER IV

Bio-entrepreneurship 3 Credits

Unit I:

Accounting and Finance

Forms of Business Organizations; Statutory and legal requirements for starting specific Organisation; Special provisions for Venture Capital Financing; Basics of accounting conventions; Difference between receipts and income; payment and expenses; Concept Profit and Loss Account; Understanding Balance Sheet related concepts; Preparation of Project for Bank Finance

Unit II

Marketing

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

Unit III

Negotiations Strategies

With financiers, bankers, government, law enforcement authorities and companies & Institutions; Technology transfer and dispute resolution skills; Changes in External environment; Crisis Management; Use IT for business administration and financial management; E-business setup and management

Unit IV

Human Resource Development (HRD):

Different types of Organizational structures; Leadership and Managerial skills;Team building, teamwork, performance appraisal, rewards system; Fundamentals of Entrepreneurship: Support mechanism for entrepreneurship in India

Unit V

Role of knowledge centre and R&D:

Knowledge centers 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.

Note: Names of specific cases to be discussed in the class shall be specified from time to time

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LABS

Semester I

Lab I: Biochemistry and Analytical Techniques **4 Credits**

1. Preparation of Acetic-NaAcetate Buffer system and validation of the Henderson-Hasselbach equation.
2. Determination of protein concentration in unknown solution/biological sample plotting a standard graph of BSA using UV-Vis Spectrophotometer and validating the Beer-Lambert's Law.
3. pH meter 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 other enzyme).
    (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 gel electrophoresis
    (i) Enzyme Kinetic Parameters: Km, Vmax and Kcat.
5. Biophysical methods (Circular dichroism spectroscopy, fluorescence spectroscopy).

Lab II: Molecular Biology **4 Credits**

1. Plasmid DNA isolation and DNA quantitation: Plasmid minipreps
2. Restriction digestion
3. Preparation of competent cells.
4. Agarose gel electrophoresis
5. Transformation of E.coli with standard plasmids, calculation of transformation efficiency
6. Polymerase chain reaction (PCR), using standard 16srRNA eubacterial primers
7. RFLP analysis of the PCR product
8. Transformation of the yeast *Saccharomyces cerevisiae*

Semester II

Lab I: Immunology **4 Credits**

1. Selection of animals, preparation of antigens, immunization and methods of bleeding, serum separation, storage.
2. Antibody titre by ELISA.
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 density gradient method
9. Demonstration of Phagocytosis of latex beads
10. Separation of mononuclear cells by Ficoll-Hypaque

Lab II: Microbiology and Industrial Applications **4 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.

Semester III

Lab I: Genetic Engineering and Immunology 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 Nco I and Xho I
5. (a) Vector and Insert ligation
   (b) Transformation in E.coli DH5a.
6. Plasmid isolation and confirming recombinant by PCR and RE digestion.
7. Transformation of recombinant plasmid in BL21 (DE3).
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 hybridization of B. subtilis genome with probe and non-r radioactive detection.
11. Antibody titre against model against model antigen by Sandwich Elisa method
12. Lymph node Immunohistochemistry (direct and indirect peroxidase assay)
13. Antibody isotype determination
14. SDS-PAGE profile of IgG, IgM and IgA class of antibodies
15. Western blotting using anti-sera from *Candida albicans* infected animals.

Lab II: Bioprocess Engineering and Technology 4 Credits

1. Determination of oxygen transfer rate and volumetric oxygen mass transfer coefficient (KLa) under variety of operating conditions in shake flask and bioreactor.
2. Determination of mixing time and fluid flow behaviour in bioreactor under variety of operating conditions.
3. Rheology of microbial cultures and biopolymers and determination of various rheological constants.
4. Production of microbial products in bioreactors.
5. Study of the kinetics of enzymatic reaction by microorganisms.
6. Production and purification of various enzymes from microbes.
7. Comparative studies of ethanol production using different substrates.
8. Microbial production and downstream processing of an enzyme, e.g. amylase.
9. Various immobilization techniques of cells/enzymes, use of alginate for cell immobilization.