Syllabus for Integrated Ph.D. in Molecular Biology (WBUT)

Semester – I

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

Semester – II

Code	Course Title	Contact Hrs./wk	Credit
A	Theory	L-T-P	
PHMB-201	rDNA Technology	3-0-0	3
PHMB-202	Neurobiology & Developmental Biology	3-0-0	3
PHMB-203	Genomics & Proteomics	3-0-0	3
PHMB-204	Genetics and Cell Biology	3-0-0	3
PHMB-205	Applied Bioinformatics	3-0-0	3
		15-0-0	15
B	Practical		
PHMB-291	rDNA Technology Lab	0-0-6	4
PHMB-292	Developmental Biology Lab	0-0-6	2
PHMB-295	Applied Bioinformatics	0-0-6	2
Semester Total			23

Semester – III

Code	Course Title	Contact Hrs./wk	Credit
A	Theory	L-T-P	
PHMB-301	Plant Biotechnology	3-0-0	3
PHMB-302	Immunotechnology	3-0-0	3
PHMB-303	Signal Transduction & Oncology	3-0-0	3
PHMB-304	IPR & Biosafety	3-0-0	3
PHMB-305	Human Physiology& Parasitology	3-0-0	3
B	Practical		
PHMB-391	Signal Transduction	0-0-6	4
C			
PHMB-381	Project Proposal Presentation		7
PHMC-382	Seminar/ Journal Club	1-0-0	1
Semester Total			27

Semester – IV

Code	Course Title	Contact Hrs./wk	Credit
		L-T-P	
PHMB-481	Project Work	0-0-0	23

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.

Lab Techniques- 3 Credits

Paper Chromatography, Thin-layer chromatography, Displacement chromatography, Gas chromatography, High performance / pressure liquid chromatography, Ion exchange chromatography, Size-exclusion chromatography, Affinity chromatography, Amino acid Analyser, Optical microscopy, Electron microscopy, Confocal microscopy, Agarose gel electrophoresis, Polyacrylamide gel electrophoresis, Western blot, Eastern blot, Southern blot, Northern blot, pH meter, Amino acid Sequencer, Autoradiography, DNA Sequence, Ultracentrifuge

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 & Virology 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 lymphoid 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 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 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.

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

SEMESTER II

Recombinant DNA Technology 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-based 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.

Neurobiology & Developmental Biology

Neurobiology

Unit I

Introduction to the Nervous system, cellular and molecular building blocks, the structure of nervous systems

Unit II

The Electrical Potential of a resting neuron, the nerve impulse, synaptic transmission, neurotransmitters and their release, integration of synaptic action

Unit III

Properties of sensory systems, coding and control of sensory information, motor systems: muscle and its control, reflexes and pattern generation, sensory influence on motor output, the brain and motor output.

Unit IV

Development, developmental plasticity, behavioral plasticity: learning, hormones and the nervous system

Unit V

The neural basis of behavior, gene regulation in the nervous system

Texts/References

1. Foundations of Neurobiology, Fred Delcomyn

2. From Neuron to Brain, Nicholls, Martin and Wallace: Sinauer Associates

Genomics & Proteomics 3 Credits

Unit I

Genomics

Whole genome analysis, Genome sequencing technology, Comparative genomics –paralogs and orthologs, Phylogeny, Human genetic disorders

Unit II

Candidate gene identification Target selection, customized microarray design,public microarray datasources

Unit III

Proteomics

Basics of protein structure, Introduction to basic proteomic technology, Bioinformatics in proteomics, Basics of proteome analysis.

Unit IV

Implications of Human Genome Project, Basic human inheritance patterns,Basics of SNP detection and its application

Unit V

Bioinformatics

Introduction of Genomic Data and Data Organization: Sequence Data Bank – Introduction to sequence data banks – protein sequence data bank,NBRF-PIR, SWISSPROT, Signal peptide data bank, Nucleic acid sequencedata bank-GenBank, EMBL, nucleotide sequence data bank, AIDS Virus sequence data bank, rRNA data bank. Structural data banks – protein Data Bank (PDB), The Cambridge Structural Database (CSD); Genome data bank – Metabolic pathway data; Microbial and Cellular Data Banks,Introduction to MSDN (Microbial Strain Data Network), Numerical Coding Systems of microbes, Hybridoma Data bank structure, Virus Information System, Cell line information system; other important Data banks in the area of Biotechnology/life sciences/ biodiversity. Sequence analysis – Analysis Tools for Sequence Data Banks; Pair-wise alignment – NEEDLEMAN and Wunsch algorithm, Smith Waterman,Multiple alignment – CLUSTAL, PRAS; BLAST, FASTA algorithms to analyze sequence data; Sequence pattern, motifs and profiles.Secondary Structure predictions; prediction algorithms; Chao -Fasman algorithm, Hidden-Markov model.

Recommended Texts

Branden and Tooze “Introduction to Protein Structure”

R. R. Sinden, “DNA Structure & Function”

A. R. Leach “Molecular Modelling- Principles & Function”

Mount “Bioinformatics” Cold Spring Harbour

ArthurLesk “Introduction to Bioinformatics

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 deleteriousn 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 exterior 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 cellwall The Cytoskeleton-the self-assembly and dynamic structure of cyto-skeletal filaments, how cells regulate their cyto-skeletal filaments, molecularmotors, the cyto-skeleton and cell behaviorCell Communication-generalprinciples 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 analys

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

Lab on Genetic Engineering

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 Developmental Biology

1. Cell separation by ficoll -hypaque method.
2. Isolatiion and characterization of haematopoietic stem cell.
3. Lymphocyte culture
4. Embryonic stem cell.

Lab on Applied Bioinformatics

Downloading macromolecular sequences from the NCBI database in different file formats.

Creating a non-redundant database of sequences using CD-HIT.

Identification of relatives from the database using BLAST search. Creation of a data-set on the basis of the E-value.

Using EMBOSS for local and global alignment of proteins.

Determination of domains present in proteins and comparison of domain architecture (DA) across different proteins.

Identification of repeats in proteins using Pfam.

Further identification of repeats left undetected by Pfam using multiple sequence analysis.

Construction of phylogenetic tree using PHYLIP.

Semester – III

Plant Biotechnology

Unit I

Plant tissue culture

Plasticity and Totipotency, The culture environment, Plant Cell culture media, Plant growth regulators and function, Culture types- Callus, Cell-suspension culture, Protoplast culture, Root culture, Shoot tip and Meristem culture, Mmbryo culture, M icrospore culture, Somaclonal variation, Somatic Embryogenesis, Polyploidy, Androgenesis, Artificial Seed, Germplasm Conservation and Cryopreservation

Plant Genome : Organization and expression of plant genes

Gene structure and expression, regulation of gene expression, Implication of plant transformations, Plant signal transduction, G Protein, Role of Calcium in signaling, Protein kinases, Plant promoters, terminators, reporters, selectable markers, Clean Gene Technology, Gene Silencing

Unit II

Genetic Transformation

Direct gene Transfer Techniques, Agrobacterium mediated gene transfer- Biology and molecular basis of Agrobacterium mediated plant transformation and its application, Plant vectors, Ri and Ti Plasmids, Opines and their significance

Mutagenesis and Cloning of Genes

Mendelian genetics, Concept of forward and reverse genetics, Molecular polymorphism, RFLP, RAPD, DNA Microsatellite, Linkage analysis, DNA polymorphic markers, QTL

Unit III

Seed Science & Technology

Seed structure, Molecular aspects of seed germination, seed growth, seed quality assessment, seed architecture, crop cultivar fingerprinting, RFLP, RAPD, Image Analysis, SEM

Post Harvest Technology

Classification of ripening fruits, Physiological and biochemical changes of fruit ripening, Molecular mechanism of fruit ripening, Role of Ethylene in fruit ripening, Ripening specific genes

Unit IV

Plant Disease Resistance

Types of pathogen and their mode of action, Plant defence system, Constitutive and inducible defence, Genetic basis of plant pathogen interaction, R genes and R gene mediated resistance, Biochemistry and Molecular biology of defence reactions, Systemic acquired resistance, Role of Salicylic, Jasmonic acid and ethylene in plant defence

Plant Stress Response

Abiotic and biotic stress, Drought, salinity, heat, cold, nutrient, submergence stress, Pathogen stress, Osmotic adjustment and its role in drought and salinity tolerance, ABA in stress tolerance, Strategies for genetic engineering of stress tolerance

Unit V

Plant as Biofactories

Bioferfentation, Production of industrial enzymes, pigments, biofertilizers, biopesticides, cell culture for secondary metabolites production. Biogas, Bioplastic,

Biofules, Biosensors

Eco-biotechnology

Plant genetic resources, Crop gene bank, Plant breeders right and farmers right, patenting of biological materials

Immunotechnology 3 Credits

Unit I

Drugs

Antimetabolites, corticosteroids, anti-inflammatory agents

Cytokinins

Cytokinins regulating immune inflammation: interleukin-4, interleukin-10, interleukin-12 The interferons: Basic biology and therapeutic potential Treatment of inflammatory diseases

Unit II

Macromolecules

Intravenous immunoglobulin therapy, Treatment of angioedema resulting from CI inhibitor deficiency

Antibodies and antibody based therapy

Characteristics of animal cells and their implication on process design, Nutritional requirements and serum free culture of mammalian cells, Kinetics of growth and product formation.Reactor systems for large-scale production using animal cells. Production of Polyclonal antibodies with different types of antigens :antigen preparation and modification, adjuvant, dose and route of antigen administration,collection of sera, purification of antibodies.Inhibitors of tumor necrosis factor, targeting the IL2 receptor with antibodies or chimeric toxins, monoclonal antibodies to CD3 Hybridome technology – production and applications of monoclonal antibodies for diagnosis and therapy.

Unit III

Immunotherapy for allergic diseases

Specific and nonspecific immunotherapy for Asthma and allergic diseases, insect stings etc Vaccine and peptide therapy

Unit IV

Transplantation

Renal, pancreas, cardiac, lung, liver transplantation, xenotransplantation

Cellular therapy, Drug therapy in HIV

Tumor Immunology, AIDS and other Immunodeficiencies.

References

Therapeutic Immunology, authors.. K Frank Austen, Steven J Burakoff,

Fred Rosen, Terry B Strom

Publisher.Blackwell Science

Signal Transduction & Oncology 3 Credits

Unit I

Cell communication

Concepts of signal molecules, Receptors- G protein linked receptors and G protein mediated signaling, Second messengers, Role of Calcium, lipid signaling- Phospholipase and Phosphoinocitides signaling, Signaling through enzyme linked cell surface receptors- Cytokine receptors and JAK-STAT pathway, Receptor tyrosine kinases, Map kinase pathways, Down modulation of a signal

Integration of Signals and Gene controls

Experimental approaches for building a comprehensive view of signal induced responses, responses of cells to environmental influences

Unit II

The cell cycle and programmed cell death

Overview of cell cycle, Components of the cell cycle control system- the checkpoints and Cdks, Intracellular control of cell cycle, Programmed cell death, Extracellular control of cell division, cell growth and apoptosis

The mechanics of cell division

Mitosis and cytokinesis

Cell junction, Cell adhesion and the extracellular matrix

Cell junction, cell cell adhesion, the extracelluylar matrix of animals, integrins

Unit III

The cell cycle and programmed cell death

Overview of cell cycle, Components of the cell cycle control system- the checkpoints and Cdks, Intracellular control of cell cycle, Programmed cell death,Extracellular control of cell division, cell growth and apoptosis

The mechanics of cell division

Mitosis and cytokinesis

Cell junction, Cell adhesion and the extracellular matrix

Cell junction, cell cell adhesion, the extracelluylar matrix of animals, integrins

Unit IV

Cancer

Tumor Cells and Onset of Cancer, Chemical carcinogenesis Biochemistry and molecular biology of cancer,Genetic basis of cancer, Oncogenes and Oncogenic

Mutations and Growth Promoting Proteins, Mutations causing loss of growth inhibiting and cell cycle controls, Role of carcinogens and DNA repair in cancer,viral and cellular oncogenes, tumor suppressor genes

IPR & Biosafety 3 Credits

Unit I

Why IPR is necessary, Various forms of IPR, TRIPS and IPR, IPR- National and International scenario, Issues related to IPR protection of software and database, IPR protection of life forms

Unit II

Necessity of bioethics, Origin and Evolution of ethics into bioethics, Different paradigms of bioethics- National and International

Unit III

Microbiological quality of food and water, Treatment of municipal waste and industrial effluents; Degradation of pesticides and other toxic chemicals by micro-organisms; Thuringiensis toxin as a natural pesticide; Biological control of other insects swarming the agricultural fields; Enrichment of ores by micro-organisms; Biofertilizers, Nitrogen fixing micro-organisms enrich the soil with assimilable nitrogen.Sources and characteristics of industrial wastes; effects on environment, waste volume reduction, waste strength reduction, Neutralisation, Equalization and Proportioning Removal of suspended and colloidal solids, Removal of inorganic and organic dissolved solids of water quality systems, Streams and Estuarine models for pollution control, waste treatment methodologies, for specific industries

Human Physiology & Parasitology 3 Credits

Human Physiology

Unit I

Tissues of human body (Epithelial tissue, Connective tissue, Muscular Tissue, Nervous tissue), Circulation (open and closed circulation, lymphatic systems,blood composition and function), Cardiovascular system (Heart, ECG, Blood Pressure, SinoAortic Mechanism),

Unit II

Endocrine Systems (Endocrine glands and hormones), Nerve conduction and neurotransmitters, Response to stress and homeostasis, Reproductive system (Male and female Reproductive system)

Unit III

Skeletal system and Muscular Contraction, Respiratory system (Respiratory organs, Mechanism and Regulation of respiration), Digestive system (Alimentary canal, Digestive juices and enzymes, Liver), Excretion and osmoregulation (Physiology of kidney, skin, sweat, sebum)

Recommended Text:

1. Text Book of Medical Physiology by Guyton AC and Hall JE

2. Best and Taylor's Physiological Basis of Medical Practice, ed West JB et al
3. Review of Medical Physiology by WF Ganong

4. Harper's Illustrated Biochemistry by Robert K Murray, et al

5. William's Textbook of Endocrinology, eds JD Wilson and DW Froster

Parasitology

Unit I

Protozoa : Classification, General Biology, Process of reproduction in common protozoal class, Importance of protozoa in soil and water eco system

Unit II

Host-parasite interaction; Drug therapy

Unit III

Malaria & Toxoplasmosis; Leishamaniasis & Trypanosomiasis; Classification of Helminths, Intestinal helminthic diseases; Filariasis, Dracanculosis; Biology of Entamobea, Wuchereria, Fasciola, Schitosoma; Diagonistic approach to parasitic diseases; Hospital Acquired infection control program & biological waste management program.

Lab on Signal Transduction 6 credits

1) Tissue Culture Methods: Growth and maintenance of human neuroblastoma SH-SY5Y cells/ human liver carcinoma Hep G2 cells including safety measures.
2) Generation of oxidative stress by Thyroid hormone / H_2O_2 treatment; lipid peroxidation assays (TBARS) and Reactive oxygen species (ROS) generation assays.
3) H_2O_2 induced DNA fragmentation assays.
4) Thyroid hormone induced gene expression: transfection of luciferase reporter constructs of Thyroid hormone response element (TRE) and

subsequent luciferase assays.

REFERENCES:

R. Ian Freshney, *Culture of Animal cells: A manual of basic techniques,* Wiley-Liss, 1987.