Annexure III

UNIVERSITY OF DELHI SOUTH CAMPUS

Courses offered For M. Phil Biotechnology

UDSC

FACULTY OF INTERDISCIPLINARY & APPLIED SCIENCES

UNIVERSITY OF DELHI SOUTH CAMPUS
NEW DELHI-110021

Departments involved in M.Phil Biotechnology Programme

Each candidate is supposed to opt for any three papers available in various departments. Each paper carries 100 marks and pass percentage is minimum 50% marks.

DEPARTMENT OF BIOCHEMISTRY

Courses offered For M. Phil (Biotechnology)

	Title of papers
Semester 1	
BC I	Proteins – Structure, Folding and Engineering
BC II	Cell Biology – I
BC III	Membrane Biology
BC IV	Molecular Biology - I
BC V	**Recombinant DNA Technology and Applications - I**
BC VI	**Applications of Proteomics and Metabolomics**
BC VII	**Developmental Biology**
Semester 2	
BC VIII	Enzymes and Techniques in Biochemistry
BC IX	Cell Biology - II (Cellular Signalling)
BC X	Immunology and Immunotechniques
BC XI	**Molecular Biology – II**
BC XII	**Recombinant DNA Technology and Applications – II**

Note: Papers in bold will be available from 2010 session onwards

BC I
Proteins – Structure, Folding and Engineering

1. Introduction: Genesis; History; Importance and Significance of proteins; Functional diversity, Ubiquity, Classes and Dynamism; Structure-function relationship; Key Features.

2. Amino acids as constituents: Acid/Base properties, Bifunctional monomers, Polarity, Classification, Chirality & Stereochemistry, pK_a, Codes, Ways of representation, Essential, Non-essential, Non-standard & Non-proteinogenic amino acids.

3. Physico-chemical interactions in biological systems: Covalent & non-covalent interactions, Importance of water, Accessible surface area, Importance of weak interactions.

4. Levels of protein structure: *Primary structure*: Importance of amino acid sequence, Peptide bond and polypeptide – polarity, direction, backbone and side chains, Importance of H-bonding, Cross-linking in polypeptides, Flexibility and conformational restrictions, Characteristics of peptide bond, Trans- and cis-peptide bonds, Rotation of adjacent peptide bonds, Dihedral angles – phi and si, Ramachandran plot, Thermodynamic considerations. *Secondary structure*: H-bonding scheme, Alpha-helices, Screw sense, Diversity in alpha-helices, Alpha-helical wheel, Helix capping, Beta-stand and sheet, Types of beta-sheet, Ramachandran plots, Turns and loops, Importance of loops. *Tertiary structure*: General properties and characteristics, Myoglobin structure as model, Supersecondary structures, Protein Data Bank (PDB). *Quaternary structure*: Concept of subunits and protomers, Kinds of subunit association, Importance of quaternary structure, Various examples.

5. Fibrous and Globular proteins, Structural Features of Membrane proteins

6. Protein Classification and Structure Prediction: Importance, Assumptions, Classes and Databases; Terminologies like domains, motifs, folds, architecture, active site, Examples; Secondary structure prediction; Theories and tools; Tertiary structure prediction (Modeling).

7. Protein Folding: Genesis and definition; The "protein folding problem"; Terminologies; Denaturants and their mode of action; Anfinsen's classical experiment; Propensities of amino acids to form secondary structure; Folding curves and transitions; Cooperative protein folding; Equilibrium and kinetic intermediates; Models and Theories of protein folding; Assisted protein folding (Chaperones); Misfolding and diseases; Current status.

8. Protein Engineering: Basic principles; Types and Methods; Strategies in protein engineering (Directed evolution, Comparative design, Rational design); Applications.

9. Solvent Engineering, Solubility / stability of proteins in solutions: Interaction of protein, water and solvent; Importance of solvents; Factors affecting aqueous solubility; Physical basis for protein denaturation/ stability; Effect of primary structure on stabilization; Preferential binding and preferential hydration models; Thermodynamics of unfolding; Rationalizing stabilities of folded conformations; Various stabilizers.

10. Techniques to investigate protein conformation and folding: *Spectroscopic methods* : Absorbance, Fluorescence, Circular dichroism; *Electrophoretic methods* : Limited proteolysis and SDS-PAGE, Transverse Urea gradient gel electrophoresis; *Hydrodynamic methods* : gel filtration, analytical ultracentrifugation; Calorimetric methods – Differential Scanning Calorimetry (DSC); *Structural methods* : NMR; *Mass spectrometry*.

Suggested study material

1. D. Sheehan. 2009. Physical Biochemistry: Principles and Applications, John Wiley and Sons Ltd, Chichester, England.
2. C. Branden, T. Tooze. 1999. Introduction to Protein Structure, Garland Publishing, New York, USA.
3. T.E. Creighton. 2002. Proteins: Structures and Molecular Properties, W.H. Freeman and Company, New York, USA.
4. A. M. Lesk. 2004. Introduction to Protein Science: Architecture, Function and Genomics, Oxford University Press, Oxford, England.
5. R. Pain. 2000. Mechanisms of Protein Folding, Oxford University Press, Oxford, England.
6. M. Arai, K. Kuwajima. 2000. Advances in Protein Chemistry, Academic Press, New York, USA.

7. J. Cavanagh, W.J. Fairbrother, A.G. Palmer III, M. Rance, N. J. Skelton. 2007. Protein NMR Spectroscopy: Principles and Practice, Academic Press, San Diego, USA.

8. S. Lutz, U. W. Bornschesser. 2008. Protein Engineering Handbook, Wiley-VCH, Weinheim, Germany.

9. D. W. Mount. 2004. Bioinformatics: Sequence and Genome Analysis, Cold Spring Harbor Laboratory, Plainview, New York, USA.

10. V. N. Uversky, A.L. Fink. 2006. Protein Misfolding, Aggregation and Conformational Diseases: Part A: Protein Aggregation and Conformational Diseases (Protein Reviews), Springer, New York, USA.

BC II
Cell Biology – I

1. The Cell Theory of Life: Historical background, Difference between Prokaryotic and Eukaryotic cells.

2. Sub-Cellular organelles: Isolation and characterization of sub-cellular organelles. Structure and function of sub-cellular organelles.

3. Cell Culture: Primary culture and secondary culture, Monolayer and suspension culture, Preparation of primary culture from tissues or organs, counting of mammalian cells, cell freezing and reconstitution. Dye exclusion test for cell viability assay.

4. Cell lines, a clone of mammalian cells, cloning of mammalian cells- importance of cloning, Hybridization of mammalian cells, Application of hybrid cells. Marker proteins on mammalian cells.

5. Cytoskeleton: Role in control of cell shape and motility, role in intracellular transport, mitosis. Structure and movement of cilia and flagella. Microtubules, structure and dynamics.

6. Extracellular Matrix: Assembly of various extracellular matrix and their role in integrating cells into tissues and cell-cell interactions.

7. Cell cycles: G_0, G_1, S, G_2 and M-phases of cell cycles-Characteristics of each phase of cell cycles. Restriction point of cell cycle and Quiescent cells, Synchronization of mammalian cells-its importance. Determination of the length of each phase of cell cycle.

8. Control of cell cycle in yeast and mammalian cells. Role of various cycle-CDK complexes in the transition of various check point of cell cycle. Role of ubiquitin-protein ligase –SCF and APC/C in the control of cell cycle.

9. Mitosis: Different stages of mitosis- prophase, metaphase, anaphase and telophase and molecular mechanism of each stage of mitosis.

10. Transport across cell membranes: Understanding membrane transport phenomenon using artificial membrane (Liposomes). Preparation of liposomes –hand shaken and detergent dialysis methods for membrane transport studies, Passive and active transport, comparison of a carrier protein with membrane bound enzymes, Symport, uniport and antiport.

11. Endocytosis:-Classification of endocytosis, phagocytosis and pinocytosis, clathrin-independent endocytosis, receptor-mediated endocytosis. Mechanism of formation clathrin coated pits and vesicles, role of assembly particles in receptor-mediated endocytosis. Caveosomes and dynamics of caveolae and the kinases involved in regulation.

12. Endosome-endosome fusion assay. Identification and mechanism of action of various molecular factors (like Rab5, PI-3-Kinase) involved in endosome-endosome fusion.

13. Transport of cholesterol in mammalian cells: LDL-receptor structure adopted for its function. Signal/key for entry into clathrin coated pits. Regulation of cellular level of cholesterol in mammalian cells. Transport of iron into mammalian cells.

14. Polypeptide toxins: Source of polypeptide toxins, Structure and mechanism of action of plant and bacterial toxins. Retrograde transport of ricin from TGN to ER.

15. Protein targeting: Historical background, Protein translocation across ER-membrane. Modification and quality control of protein in ER: Golgi vesicular traffic, Biogenesis of sub-cellular organelles.

16. Glycosylation in mammalian cells, origin, nature and types of Glycosylation. Role of Glycosylation in protein stability and folding with reference to ER exit.

Suggested study materials

1. H. Lodish, A. Berk, C.A. Kaiser, M. Kreiger, M. P. Scott, A. Bretscher, H. Ploegh, P. Matsudaria. 2008. Molecular Cell Biology, W.H. Freeman and Company, New York., USA.

2. B. Alberts, A. Johnson, J. Lewis, M. Raff, K. Roberts, P Walter. 2002. Molecular Biology of the Cell, Garland Publishing, Inc. New York. USA.

3. G.M. Cooper. 2000. The Cell: Molecular Approach, ASM Press, Washington, D.C. USA.

4. M. Butler. 2004. Animal Cell Culture and Technology, BIOS Scientific Publishers, Taylor and Francis Group. U. K.

5. R.I. Freshney. 1989. Animal Cell Culture: A Practical Approach, IRL Press, Oxford. U.K.

6. J.M. Graham and R. Rickwood. 1997. Subcellular Fractionation: A Practical Approach, IRL Press, Oxford University Press. U.K.

7. D.L. Nelson, M.M. Cox. 2008. Lehninger Principles of Biochemistry, W.H. Freeman and Company, New York, USA.

8. J.M. Berg, J.L. Tymoczko, L. Stryer. 2008. Biochemistry, W.H. Freeman and Company, New York.

9. G. Zubey. 1993. Biochemistry, Wm. C. Brown Publishers, Oxford. U.K.

BC III
Membrane Biology

1. Historical development of the lipid bilayer model of biological membrane. Salient features of bio-membrane, comparison with model membrane/liposome. Detection of phospholipid bilayer microheterogenity and domains by fluorescence spectroscopy. Role of cholesterol and fatty acid composition in membrane fluidity. Supramolecular membrane structure. Live cell microscopy, FRAP and dynamics of cell surface receptors using TIRFM and confocal microscopy.

2. Liposome technology and its application in biotechnology. Preparation of liposomes. Charecterization of liposomes. Covalent attachment of protein/ligand to liposome surface. Biophysical study of methods of liposome membrane. Liposome in biological systems and its application in Biotechnology such as targeted drug delivery.

3. The molecular assembly of biomembranes. Structures of membrane proteins in normal and cancer cells. Interchange of proteins between membranes and their soluble environment. Studies on membrane fluidity. Membrane receptors and responses. Membranes in cancer. Membrane biology of glycolipids in normal and neoplastic cells.

4. Membrane permeability. Metabolite transport in normal and cancer cells. Bioenergetics of transport. Active transport by ATP-powered pumps. Membrane transport and tumor therapy. Electron transport in membranes with special emphasis in mitochondrial and chloroplast membranes. Cell contact and cell recognition.

5. Structure and function of various biological membranes. Lipid- protein and protein-protein interactions, dynamics of lipid-protein interactions, driving forces. Molecular and patch-clamp approaches to the structure function relationship of voltage gated channels. Ion channels in cancer cells. Membrane technology applied to laboratory diagnosis. Membrane rafts in normal and disease conditions. Detail of various classes of membrane proteins and their role in normal/abnormal cell physiology.

6. Structure and function of various enveloped animal viruses. Their entry mechanisms, use as a probe in cell biology. Use of fluorescence probes in membrane fusion. Detail studies on Influenza virus hemagglutinin (HA) and Sendai virus fusion (F) protein as a model. Kinetics of viral envelope protein-induced cell fusion by continuous monitoring of fluorescent dyes. Their applications in targeted drug/gene delivery.

7. Structure-function interplay of some typical membrane receptors like ASGP-R, LDL, Ferritin etc. Membrane biology of receptor-mediated endocytosis. Role of cytoskeletal components in membrane structure/organization.

8. Membrane asymmetry and its significance in membrane structure and function. Various techniques to determine asymmetry. Its implications in health and disease. Its role in membrane signalling.

9. The structural organization of Gap Junction. Role of complement proteins in making membrane pores. Mechanism of complement-mediated lysis of membrane. Structure and function of various hemolysins. Hemolysins and membrane active peptides in therapeutics.

Suggested study material

1. J.M. Berg, J.L. Tymoczko, L. Stryer. 2008. Biochemistry, WH Freeman and Company, New York and England.
2. R. Verna. 1989. Membrane Technology, Raven Press, New York., USA**.**
3. H. Lodish, A. Berk, S.L. Zipursky, P. Matsudaira, D. Baltimore, J. Darnell. 2000. Molecular Cell Biology, WH Freeman and Company, NY and England
4. H.R. Petty. 1993. Molecular Biology of Membranes Structure and Function, Plenum Press, New York, USA and London.
5. D.F.H. Wallach. 1975. Membrane Molecular Biology of Neoplastic Cells, Elsevier Scientific Publishing Company, Amsterdam, Oxford and New York., USA**.**
6. R.R.C. New. 1990. Liposomes a Practical Approach, IRL Press, Oxford, New York., USA**.** and Tokyo.
7. A.L. Lehninger, D.L. Nelson, M.M. Cox. 1993. Principles of Biochemistry, Worth Publisher, New York., USA**.**
8. A. Azzi, L. Masotti, A. Vecli. 1986. Membrane Proteins Isolation and Characterization, Spriger-Verlag, New York, USA**.**

BC IV
Molecular Biology - I

1. Introduction: Characteristics of living beings, brief historical review
2. Genetic code: Relationship between genes and proteins, concept of tRNA, triplet nature of genetic code, concept of mRNA, development of cell free system for protein synthesis by Nirenberg, discovery of 1st codon for phenyl alanine, discovery of codons for other amino acids.
3. Triplet binding assay, Hargobind Khorana's work on genetic code, discovery of initiation and termination codons, universality of genetic code, colinearity of genes and proteins, Wobble hypothesis and exceptions, degeneracy of genetic code, mitochondrial genetic code.
4. Protein synthesis in prokaryotes and eukaryotes: Complexity of protein synthesis and general features of the process, direction of protein synthesis, direction of mRNA translation, activation of amino acids, fidelity of protein synthesis.
5. Initiation: Special features of initiator tRNAs, RBS and its interactions with 16S rRNA in bacteria, initiation complex formation, role of bacterial and eukaryotic initiation factors, regulation at initiation.
6. Elongation: Elongation factors in prokaryotes and eukaryotes, entry of amino acyl tRNA to A site, peptide bond formation, nature of peptidyl transferase, translocation, translocation factors in prokaryotes and eukaryotes.
7. Role of antibiotics in understanding protein synthesis, recognition of cognate amino acyl tRNA, mechanism of action of elongation factors, allosteric control between A and E sites and its implications.
8. Termination: Recognition of termination codons by release factors, role of molecular mimicry, mechanism of peptidyl tRNA hydrolysis, ribosome release factors, differences between prokaryotes and eukaryotes
9. Mode of action of various antibiotics in the inhibition of protein synthesis.
10. Biosynthesis of RNA (Transcription) in prokaryotes: General features of the process, transience of bacterial mRNA, coupling of transcription and translation in prokaryotes, direction of transcription, various stages of the process.
11. Discovery and assay of RNA polymerase, Phage RNA polymerases – the minimal apparatus, Bacterial RNA polymerase - core and holoenzyme, Importance of sigma factor in initiation.
12. Isolation and characterization of promoters, consensus sequences, up and down mutations. Role of -10 and -35 sequences in open complex formation. Conserved regions of sigma factors and their role in DNA binding. Control of transcription by substitution of sigma factors
13. Elongation, RNA polymerase – structure and function
14. Termination of transcription, intrinsic and rho dependent termination, mechanism of action of rho. Anti-termination and gene regulation, role of anti-termination proteins and their interaction with RNA polymerase, mechanism of anti-termination.

Suggested study material

1. D.L. Nelson, M.M. Cox. 2008. Lehninger Principles of Biochemistry, W.H. Freeman and Company, New York, USA.
2. J.M. Berg, J.L. Tymoczko, L. Stryer. 2008. Biochemistry, W.H. Freeman and Company, New York, USA.
3. B. Lewin. 2007. Gene IX, Jones and Bartlett Publishers, Sudbury, Massachusetts, USA.
4. H. Lodish, A. Berk, C.A. Kaiser, M. Krieger, M.P. Scott, A. Bretscher, H. Ploegh, P. Matsudaira. 2007. Molecular Cell Biology, W.H. Freeman, New York, USA.
5. B. Alberts, A. Johnson, J. Lewis, M. Raff, K. Roberts, P. Walter. 2007. Molecular Biology of the Cell, Garland Science, New York and London.

6. J.D. Watson, T.A. Baker, S.P. Bell, A. Gann, M. Levin, R. Losick. 2007. Molecular Biology of the Gene, Benjamin Cummings, San Francisco, USA.

7. W.M. Becker, L.J. Kleinsmith, J. Hardin, G.P. Bertoni. 2008. The World of the Cell, Benjamin Cummings, San Francisco, USA.

8. R.F. Weaver. 2007. Molecular Biology, McGraw Hill. New York. USA.

BC V
Recombinant DNA Technology and Applications - I

1. Restriction and Modification systems in *E. coli* and their use in recombinant library constructions.
2. Restriction and Modification enzymes and their uses.
3. Basic techniques for RDT including Agarose gel electrophoresis, PAGE, Pulse field electrophoresis.
4. Basic Biology of plasmids including their replication, copy number, Incompatibility of Plasmids, and development of Plasmid Vectors. Vectors for making RNA probes.
5. Biology of filamentous phages, development of phage and phagemid vectors.
6. Biology of Bacteriophage lambda, Promoters and control circuits, phage assembly and In vitro packaging and development of vectors for different types of Libraries.
7. Vectors for cloning large fragments of DNA, (Cosmid, PAC, YAC and BAC) and strategies for cloning large DNA fragments.
8. Basic DNA sequencing methods, Maxam and Gilbert's chemical and Sanger's chain termination methods, and automated DNA sequencing, Pyrosequencing, Array based methods of DNA Sequencing, Base calling and sequencing accuracy.
9. Polymerase chain reaction and its application in research including cloning of PCR amplified fragments, mutagenesis and construction of Libraries. Real time/quantitative PCR
10. Oligonucleotide synthesis, purification, and its application in screening of libraries, cloning and mutagenesis.
11. Strategies for constructing cDNA libraries and screening using Nucleic acid and antibody probes. Subtractive Libraries, Expression based strategies for cloning of functional genes, Differential mRNA display.
12. Strategies for constructing Genomic libraries and screening using Nucleic acid probes.
13. Understanding of Operons Lac, Trp, Arabinose, Tetracycline and their applications in studying biological processes and development of Vectors. Use of Tags to aid solubility and Purification.
14. Vectors and strategies for expressing heterogonous proteins in *E. coli*, Yeast, Baculovirus, vaccinia virus and mammalian Cells.
15. DNA safety guidelines and regulatory aspects.

Suggested study material

1. F.M. Ausubel *et al.*, 2007. Current Protocols in Molecular Biology, John Wiley and Sons, Inc., USA.
2. J. Sambrooks, D.W. Russell. 2001. Molecular cloning, A Laboratory Manual Vol. I-III. Cold Spring Harbor Laboratory Press, USA
3. J.D. Watson, M. Gilman, J. Witkowski, M. Gilman, M. Zoller. 2008. Recombinant DNA, W.H. Freeman and Company, USA
4. J.D. Watson, R.M. Myers, A.A. Caudy, J. Witkowski. 1990. Recombinant DNA, Genes and Genomes – A Short Course, Cold Spring Harbor Laboratory Press, USA
5. R. Abe *et al.*, 2007. Current Protocols in Immunology, John Wiley and Sons, USA
6. S.B. Primrose, R.M. Twyman. 2003. Principles of Genome Analysis and Genomics, Blackwell Publishing, USA
7. S.B. Primrose, R.M. Twyman, R.W. Old. 2001. Principle of Gene Manipulation. Blackwell Science, USA T.A. Brown. 2007. Genomes 3. Garland Science, USA

BC VI
Applications of Proteomics and Metabolomics

1. Introduction to proteome, proteomics technology and importance of proteomics.

2. Principles and applications of the separation technology (Electrophoresis, Centrifugation, Chromatography etc) in proteomics. Mass spectrometry (Ionizers, analyzers and detectors) technology and its application in proteomics.

3. General workflow for the 2-D Gel Electrophoreses, sample preparation, evolution of D PAGE, experimental details for the 2-D gel and high throughput 2-D PAGE.

4. Application of two-dimension gel electrophoreses in proteomics. Importance of 2-D fluorescence difference gel electrophoresis for comparative proteomics. Two-dimensional gel electrophoresis for biomarker discovery

5. Proteomic profiling for host-pathogen interaction. Sample treatment for labeling, 2D LC-MS/MS analysis, database search and relative quantification, analysis and interpretation.

6. Protein-Protein Interaction (PPI) and its application in proteomics. Methods to study PPI.

7. Application of proteomics for drug discovery. Biomarkers and drug targets identification. Validation of drug targets and assessment of its toxicology

8. Introduction to metabolomics world. Highthroughput screening systems and utility. Lessons from metabolites, metabolic fingerprinting, and metabolic profiling. Biotechnological potentials of metabolomics.

9. Proteomics approaches in metabolomics. Analysis of differential protein expression, post-translational modifications and protein activity for metabolomics.

10. HPLC and FPLC based approaches in metabolomics. Criteria for the selection of chromatography methods and their importance in metabolomics.

11. Application for cellular metabolomics for metabolic pathway structure. Size of metabolome, metabolite identification, pathway identification and pathway integration.

12. Metabolite profiling for infectious disease.

13. Application of metabolite profiling in heart disease. Metabolic signature and metabolite profiling in heart disease.

14. Metabonomics in preclinical pharmaceutical discovery and development. Analytical considerations, and biological aspects and applications.

15. Prospects of metabolic profiling in plant science.

Suggested Study Material

1. T. Palzkill. 2002. Proteomics, Kluwer Academic Publishers, New York, USA.
2. E.D. Hoffmann, V. Stroobant. 2007. Mass Spectrometry: Principles and Applications, John Wiley & Sons Ltd. The Atrium, Southern Gate, Chichester, West Sussex PO19 8SQ, England.
3. D. Kambhampati. 2004. Protein Microarray Technology, WILEY-VCH Verlag GmbH & Co. KGaA, Weinheim, Germany.
4. E. Fung. Methods in Molecular Biology, Volume 264: Protein Arrays, Humana Press Inc., Totowa, NJ.
5. S.G. Villas-Boas. 2007. Metabolome Analysis: An Introduction, Wiley-Blackwell, USA.
6. B. J. Nikolau. 2007. Concepts in Plant Metabolomics, Wurtele, Eve Syrkin, Springer, USA.
7. J. Lindon, J. Nicholson, E. Holmes. 2006. The Handbook of Metabonomics and Metabolomics, Elsevier B.V., Netherlands.

BC VII

Developmental Biology

1. History and basic concepts of development, modification of development in evolution, identification of developmental genes.
2. Gametogenesis, fetilization, generation of multicellular embryo, formation of germ layers, patterning of vertebrate body plan.
3. Morphogenesis: Cell adhesion, cleavage and formation of blastula, ganstrulation, neural tube formation and cell migration.
4. Model systems
   - A. *C. elegans*: Study of cell lineage, mosaic development and organogenesis (vulva formation).
   - B. Drosophila: Pattern formation, polarily determination of embryo by maternal genes, formation of body segments, Homeotic genes.
   - C. Mouse: Vertebrate development, determining function of genes during development by generation of knockout and knock-in models.
5. Development of nervous system : Specification of cell identity in the nervous system, Axonal guidance, Neuronal survival, synapse formation, Neurotransmitters and Synaptic transmission. Psychological disorders like depression, bipolar disorder, Schizophrenia, Parkinson etc. Discussion about latest research interests in this field.
6. Cell-cell communication in development : Concepts of induction and competence, epithelial-mesenchymal interactions, role of FGF-RTK pathway, JAK-STAT, Hedgehog family, Wnt family, TGF-β superfamily, Notch pathway and developmental signals from extracellular matrix.
7. Stem cells in development : Definition, types and properties of stem cells, cultivation of stem cells, adult stem cells, cancer stem cells, stem cell markers, role of stem cells in development and applications of stem cells.
8. Medical implications of developmental biology : Genetic errors of human development, gene expression and human diseases, in-vitro fertilization, environmental assaults on human development, design of future medicines like gene therapy, therapeutic cloning and regeneration therapy.

Suggested study material

1. S. F. Gilbert. 2006. Developmental Biology, Sinauer Associates, Inc., MA, USA.
2. D.L. Riddle, T. Blumenthal, B.J. Meyer, J.R. Priess. 1997. *C. elegans* II. Cold Spring Harbor Laboratory Press, New York, USA.
3. Worm Book: The Online Review of *C. elegans* Biology. 2005. The *C. elegans* Research Community, Pasadena, USA. (www.wormbook.org)
4. G.J. Siegel, B.W. Agranoff, R.W. Alberts, S.K. Fisher, M.D. Uhler. 1999. Basic Neurochemistry: Molecular, Cellular, and Medical Aspects, Lippincott, Williams & Wilkins, New York, USA.
5. P.A. Lawrence. 1992. The making of a fly: the genetics of animal design, Blackwell Publishers, Oxford, UK.
6. L. Wolpert, R. Beddington, T. Jessell. 2001. Principles of Development, Oxford University Press, New York, USA.
7. H. Lodish, A. Berk, C.A. Kaiser, M. Krieger, M.P. Scott, A. Bretscher, H. Ploegh, P. Matsudaira. 2003. Molecular Cell Biology, W.H. Freeman, New York, USA.
8. A. Nagy, M. Gertsenstein, K Vintersten, R. Behringer. 2003. Manipulating the mouse embryo: a laboratory manual, Cold spring Harbor Press, New York, USA.

BC VIII
Enzymes and Techniques in Biochemistry

1. Enzymology: Introduction, General characteristics of enzymes, Activation energy, Coupled reactions, Active site and its importance, Factors influencing catalytic efficiency.
2. Enzyme kinetics: Rapid Equilibrium, Henry-Michaelis-Menten's equations, Steady State approach, Significance of K_m, Haldane equation, Velocity vs Substrate concentration curves.
3. Methods of plotting enzyme kinetics data: Lineweaver-Burk, Hanes-Woolf, Woolf-Augustinsson-Hofstee, Eadie-Scatchard; Advantages and disadvantages of the methods, Comparisons and applications; Integrated form of the Henry-Michaelis-Menten equation.
4. Equilibrium dialysis, Scatchard plot for equilibrium binding, Effect of pH on enzyme stability and activity, Effect of temperature on enzyme stability, Arrhenius equation.
5. Formation of E. S covalent intermediates, transient kinetics, flow techniques (cont., stopped, quenched), Temp-Jump.
6. General mechanistic principles: Role of proximity effect, bound distortion, multistep catalysis, bi-functional catalysis and solvent effects.
7. Regulation of enzyme activity: Feedback inhibition, reversible covalent modification, irreversible covalent modification, allosteric concept, Aspartate transcarbamylase, ligand-protein interaction, scatchard plot, Hill plot, cooperativity index, Models for allostery (MWC, KNF), Half site reactivity.
8. Enzyme Inhibition, Models and types of inhibition.
9. Applied enzymology: Application of enzymes in analytical labs. (Clin. And indust.), enzymes as industrial catalysts, Immobilized enzymes, enzyme electrodes, Assay of enzyme activities for diagnostic purposes, Abzymes, Recent developments.
10. Enzyme purification & Chromatography: Gel filtration, ion-exchange, hydrophobic interaction chromatography, hydroxyapatite and affinity chromatography, FPLC HPLC
11. Chemiluminescance & Phosphoresence
12. Hydrodynamic methods, Centrifugation Sedimentation, partial specific volume and diffusion co-efficient, Viscosity
13. Molecular spectroscopy, IR, ESR, FRET, Biomolecular fluorescence complementation assay
14. X-ray Crystallography: Methods of crystallization, X-ray diffraction and Bragg's Law, Crystallographic parameters; Phase problem; Electron Density Calculations; Model building.
15. Radioisotope and their use in biology, autoradiography, radioactive labeling of biological macromolecules.

Suggested study material

1. P. F. Cook, W.W. Cleland. 2007. Enzyme Kinetics and Mechanism, Garland Science Publishing, London, England and New York, USA.
2. K. Buchholz, V. Kasche, U.T. Bornscheuer. 2005. Biocatalysts and Enzyme Technology, Wiley-VCH, Weinheim, Germany.
3. Trevor Palmer. 2001. Enzymes: Biochemistry, Biotechnology, Clinical Chemistry, Horwood Publishing House, Chichester, England.
4. Irwin Segel. 2004. Biochemical Calculations, John Wiley and Sons, California, USA.
5. A.S. Bommarius, B.R. Riebel. 2004. Biocatalysis – Fundamentals and Applications, Wiley-VCH, Weinheim, Germany
6. P.C. Engel. 1996. Enzymology – LABFAX, BIOS Scientific Publishers, Academic Press, San Diego, USA.

7. U. Brodbeck. 1980. Enzyme Inhibitors, Verlag Chemie, Weinheim, Germany
8. M. P. Deutcher. 1993. Guide to Protein Purification, Academic Press, San Diego, USA.
9. David Sheehan. 2009. Physical Biochemistry: Principles and Applicatons, John Wiley and Sons Ltd, Chichester, England
10. Gale Rhodes. 2006. Crystallography Made Crystal Clear, Academic Press, Burlington, USA.

BC IX

Cell Biology (Cellular Signaling) - II

1. Cellular Signaling: General principles of signaling by cell surface receptors, endocrine, paracrine and autocrine signaling, types of cellular responses induced by signaling molecules, components of intracellular signal-transudation pathways.
2. Short Term Signaling: G-protein coupled receptor system, General mechanism of the activation of effectors molecules associated with G-protein-coupled receptors, G-protein coupled receptors that activate or inhibit adenylate cyclase, G-protein coupled receptors that activate phospholipase C, and G-protein coupled receptors that regulate ion channels.
3. Long Term Signaling: Signaling of growth factors (EGF and Insulin) via activation of receptor tyrosine kinases. Signaling of TGFβ by direct activating Smad proteins. Cytokine signaling via JAK/STAT pathway.
4. Cell Survival and Death Signal: Programmed cell death and role of Caspase protein in apoptosis. Various pro-apoptotic and anti-apoptotic regulators and pathways.
5. Signal for Protein Sorting: Road map of biosynthetic protein traffic. Dynamics of protein trafficking. Experimental evidences of protein translocation across ER-membrane.
6. Signal Recognition Particles: Characteristics and importance of SRP. Characterization and function of SRP-receptor, signal peptide and signal peptidase. Mechanism of movement of polypeptide through ER-membrane into the ER lumen.
7. Protein Modification in ER: GRP, PERK, Unfolded response pathway, eiF2a, PDI roles in survival and death. Role of PDI and Bip in protein maturation in ER. Biosynthesis of O-linked and N-linked sugars, Golgi antiport. Role of Dolicol-phosphate in the biosynthesis of precursor N-linked oligosaccharides.
8. Sorting of protein in Golgi: Evidences for three compartments for Golgi stack, Mapping of Golgi enzymes in stack, Sorting of resident ER-protein from other proteins, targeting of lysosomal enzymes and specificity of lysosomal enzymes phosphorylation.
9. Golgi vesicular Transport: Coated and uncoated vesicle, Composition of coated vesicles, Role of ARF and coatomer in the formation of coated bud and vesicles. Mechanisms of targeting and fusion of Golgi-derived transport vesicles to the correct target site. Role of NSF, SNAPs and SNAREs.
10. Protein Import in Mitochondria: Characteristics of signal sequences, nature of receptors, accessories proteins, co-receptors for import of mitochondrial proteins, mechanism.
11. Protein Import in Peroxisomes: Characteristics of signal sequences, nature of receptors, accessories proteins, co-receptors. Mechanism of entry of proteins into the peroxisomal matrix and insertion into peroxisomal membranes.
12. Signal for Import and Export of Macromolecules from Nucleus: Characteristics of signal sequences, nature of importins and exportins. Mechanism of entry and exit of macromolecules from nucleus. Mechanism of entry of large and small molecules into nucleus via Nucler-Pore-Complex.

Suggested Study Material

1. L. Harvey, B. Arnold, Z.S. Lawrence, M. Paul, D. Baltimore, J.E. Darnell. 1999. Molecular Cell Biology, W. H. Freeman & Co, New York, USA.
2. G.M. Cooper. 2000. The Cell - A Molecular Approach, Sunderland (MA), Sinauer Associates, Inc. USA.
3. B. Alberts, A. Johnson, J. Lewis, M. Raff, K. Roberts, P. Walter. 2000. Molecular Biology of The Cell, Garland Science, New York and London.
4. J.G. Siegel, B. W. Agranoff, A. R. Wayne, S.K. Fisher, M.D. Uhler. 1999. Basic Neurochemistry: Molecular, Cellular, and Medical Aspects, Lippincott,Williams & Wilkins, Philadelphia, USA.
5. A. Varki, R.D. Cummings, J.D Esko, H.H. Freeze, P. Stanley, C.R. Bertozzi, G.W Hart, M.E. Etzler. 2008. Essentials Of Glycobiology, Cold Spring Harbor Laboratory Press. Plainview, New York, USA.
6. J.M. Coffin, S.H. Hughes, H.E. Varmus. 1997. Retroviruses, Cold Spring Harbor Laboratory Press, Plainview, New York, USA.
7. T. Strachan, A. P. Andrew. 1999. Human Molecular Genetics, Garland Science, New York and London.
8. D. W. Kufe, R.E Pollock, R. R. Weichselbaum, R.C.J. Bast, S.H. Gansler, J. F. F. Ted, Emil. 2003. Cancer Medicine, BC Decker Inc,Hamilton,Canada

BC X
Immunology and Immunotechniques

1. Historical development of the branch "Immunology". Integration of all disciplines of modern biology in full understanding of Immunology.
2. Overview of the immune system. Cells and organs involved in immunity. Hematopoiesis, Concepts of vaccines.
3. Discovery of immunoglobulins, blood group substances. Structure and function of various classes of immunoglobulins. Humoral immune response, Concept of neutralizing antibodies. Epitope mapping, Development of monoclonal antibodies, single chain antibodies. Applications of antibodies in diagnostics and routine laboratory assay systems. Agglutination reaction, principles of western blots, radioimmunoassay, ELISA, immunohistochemistry, immunoelectron microscopy, Flow cytometry.
4. Generation of B and T cells Responses. Antigens, Immunogens, Haptens, Epitopes. Antigen-Antibody interactions.
5. T-cell receptors, maturation, activation and differentiation. B-cell activation and differentiation, B-cell receptor and the immunoglobulin superfamily.
6. Immune response to infectious diseases, AIDS, Transplantation immunology.
7. Various immunocytes, their identification/purification and function, cell mediated immunity, MHC restriction and mechanism of antigen presentation.
8. Allergy, Cell biology of hypersensitivity reactions, development of vaccines against various infectious diseases with special emphasis on tuberculosis, malaria, leishmania etc.
9. Immunogenetics, Generation of antibody diversity, class switching among constant-region genes
10. Immune effector mechanisms. Properties of cytokines, receptors, secretion by T_{H1} and T_{H2} subsets.
11. The complement systems, mechanism of complement activation, pathology related to complement proteins.
12. Regulatory T cells and its role in immune response. Immunological memory.
13. Designing vaccines for active immunization, whole-organism vaccines, recombinant vaccines, DNA vaccine, synthetic peptide and multivalent sub unit vaccines. Vaccine delivery.
14. Tumor antigens and cancer immunotherapy.
15. Mechanisms of induction of autoimmunity, treatment of autoimmune diseases

Suggested study material

1. R.A. Goldsby, T.J. Kindt, B.A. Osborne. 2007. Kuby Immunology, W.H. Freeman and Company, New York.
2. J.M. Berg, J.L. Tymoczko, L. Stryer. 2008. Biochemistry, W.H. Freeman and Company, New York and England**.**
3. F. Loor, G.E. Roelants. 1977. B and T cells in Immune Recognition, John Wiley & Sons, London, New York, Sydney, Toronto.
4. I. Roitt, J. Brostoff, D.M. Mosby. 1993. Immunology, St. Louis, Baltimore, Toronto.
5. D. Male, B. Champion, A. Cooke. 1987. Advanced Immunology, JB Lippincott Company, Philadelphia.
6. C.A. Janeway, P. Travers. 1994. Immunobiology, Blackwell Scientific Publications, Oxford.
7. S. Pathak, U. Palan. 2005. Immunology Essential and Fundamental, Capital Publishing Company, New Delhi, Kolkata and Bangalore.
8. I.R. Tizard. 1995. Immunology and Introduction, Saunders College Publishing, Harcourt Brace College Publishers, New York, Tokyo.
9. K. Landsteiner. 1962. The Specificity of Serological Reactions, Dover Publications, Inc. New York.

BC XI

Molecular Biology - II

1. DNA Replication in prokaryote and eukaryotic systems : Semiconservative nature of replication, classic experiments of Meselson and Stahl, origin of replication, types of replicons, isolation and mapping of replication origins, relationship between genome size and number of origins. Regulation of replication initiation by methylation and licensing factors. Various modes of replication, mode of action of reverse transcriptase, discovery, properties and general structure of DNA polymerases, synthesis of leading and lagging strands, role of okazaki fragments and termination of replication.
2. DNA Repair : Different types of DNA damages, requirement of repair systems, recognition of DNA damage, types of DNA repair systems including excision repair, base flipping, mismatch repair, recombination repair, conserved repair systems in eukaryotes and diseases associated with DNA repair problems.
3. Eukaryotic Transcription : General introduction, characteristics of promoters and enhancer elements. Activators and repressors of transcription, different DNA binding domains like zinc finger, helix-turn-helix, leucine zipper, helix-loop-helix. Properties of eukaryotic RNA polymerases and their mode of action, assembly of basal transcription apparatus at the promoter, initiation, elongation and termination of transcription. General techniques used to study binding and activity of transcription factors and coactivators in eukaryotes.
4. RNA Splicing and Processing : Splice junctions, Lariat structure, role of sn RNA in splicing, Spliceosome formation, Alternative splicing and tRNA splicing. Processing and maturation of RNA.
5. Catalytic roles of RNA : Self splicing introns , catalytic activities of Ribozymes, RnaseP, Viroids and mechanisms of RNA editing.
6. Gene Silencing : Mechanism of action of RNAi and micro-RNA. Role of DNA-Methylation, Acetylation and Deacetylation in gene expression. Recent advances and applications of gene silencing.

Suggested study material

1. J.M. Berg, J.L. Tymoczko, L. Stryer. 2008. Biochemistry, W.H. Freeman and Company, New York, USA.
2. B. Alberts, A. Johnson, J. Lewis, M. Raff, K. Roberts, P.Walter. 2008. Molecular Biology of the Cell, Garland Science, New York, USA.
3. H. Lodish, B. Harvey, Arnold, S. Zipursky, S.Lawrence, P. Matsudaira, D. Baltimore, J. Darnell, E. James. 2003. Molecular Cell Biology, W.H. Freeman and Company, New York, USA.
4. G. M.Cooper. 2000. The Cell: A Molecular Approach, Sinauer Associates, Inc. Massachusetts, USA.
5. M.M. Cox, D.L. Nelson. 2008. Lehninger's Principles of Biochemistry, W.H. Freeman and Company, New York, USA.
6. B. Lewin. 2006. Genes, Jones and Bartlett Publishers, Massachusetts, USA.
7. J.D. Watson, T.A. Baker, S.P. Bell, A. Bann, M. Levine, R. Losick. 2004. Molecular Biology of the Gene, Benjamin Cummings, California, USA.
8. R.H. Garrett, C.M. Grisham. 2000. Biochemistry, Saunders College Publishers, Texas, USA.

BC XII

Recombinant DNA Technology and Application - II

1. Mutagenesis: Chemical, random, site-directed and Newer methods and strategies for protein engineering such as DNA shuffling to produce better variants and to study their functions.
2. Regulated vectors for controlled expression of multiple genes to study gene function in different hosts.
3. Determining the Function of Individual genes. Gene deletion, over-expression and complementation. Genome-wide Insertional mutagenesis.
4. Recombinant DNA strategies to study protein interactions. Yeast 2-hybrid system, Bacterial-2 hybrid system, Phage display, Ribosome Display, Cell Display, Protein fragment complementation.
5. Gene transfer and expression in plant.
6. Gene transfer in animals and human and applications.
7. Fundamentals of Whole-Genome Sequencing. Sequencing of Phage, Viral and Bacterial Genomes, Human Genome sequencing, and comparative genomics.
8. High throughput genome-wide cloning and protein expression strategies and applications.
9. Antibody gene cloning and Engineering, Humanization and Human antibodies.
10. Strategies for large-scale expression of recombinant proteins in heterogonous hosts. Purification and downstream processing to produce Therapeutic grade recombinant proteins and regulatory aspects.
11. Micro/si RNA technology and applications in studying gene functions.
12. Microarray techniques for DNA, Proteins and Antibodies. Global expression profiling

Suggested study material

1. E. Golemis. 2002. Proteins–Protein Interaction. A Molecular Cloning Manual, Cold Spring Harbor Laboratory Press, USA
2. F.M. Ausubel *et al.*, 2007. Current Protocols in Molecular Biology, John Wiley and Sons, Inc., USA
3. J. Sambrooks, D.W. Russell. 2001. Molecular cloning, A Laboratory Manual Vol. I-III. Cold Spring Harbor Laboratory Press, USA
4. J.D. Watson, M. Gilman, J. Witkowski, M. Gilman, M. Zoller. 1992. Recombinant DNA, W.H. Freeman and Company, USA
5. J.D. Watson, R.M. Myers, A.A. Caudy, J. Witkowski. 2008. Recombinant DNA, Genes and Genomes – A Short Course, Cold Spring Harbor Laboratory Press, US
6. J.E. Coligan *et al.*, 2007. Current Protocols in Current Protocols in Protein Science, John Wiley and Sons, USA
7. R. Abe *et al*., 2007. Current Protocols in Immunology, John Wiley and Sons, USA
8. S.B. Primrose, R.M. Twyman. 2003. Principles of Genome Analysis and Genomics, Blackwell Publishing, USA
9. S.B. Primrose, R.M. Twyman. 2005. Genomics-Applications in Human Biology, Blackwell Publishing, USA
10. T.A. Brown. 2007. Genomes 3, Garland Science, USA

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DEPARTMENT OF BIOPHYSICS

Courses offered under M. Phil (Biotechnology)

	Title of papers
Semester 1	
BP I	Physical Methods In Biology
Semester 2	
BP II	Information Processing and the Brain

BP I
Physical Methods in Biology

SPECTROSCOPY

Historical background of development of optics. Corpuscular theory of light, wave theory of light, Electromagnetic theory of light, Planck's concept and modern theory of light.
Electronic structures of atoms & molecules, theory of chemical bonding.

Scattering of Light.
UV & Visible absorption spetrophotometry, Lambert Beer's Law, molar extinction coefficient and its determination, instrumentation & applications
Fluorescence Spectroscopy: principles and applications, fluorescence polarisation
Polarisation of light, CD and ORD spectroscopy,
Fundamentals of X-ray crystallography, instrumentation and biological applications.
Principles of magnetic resonance, Nuclear Magnetic Resonance (NMR) & Electron Spin Resonance (ESR) and biological applications, Relaxation studies.
Electron Microscopy: Principles of transmission & scanning electron microscope

HYDRODYNAMIC METHODS

Viscosity,
Sedimentation equilibrium and velocity centrifugation,
Density gradient method, applications.

CHROMATOGRAPHY

Partition and Absorption Chromatography, paper and thin layer chromatography, gel filtration, ion-exchange and affinity chromatography. GLC, HPLC and FPLC. Emerging trends in chromatography

ELECTROPHORESIS

Behavior of biomacromolecules in electric fields, PAGE, Agarose Gel Electrophoresis, 2D Electrophoresis, Dialectrophoresis.

RADIOACTIVE METHODS

Radioactive isotopes, nature of radioactive decay, sample preparation and counting, G.M. and Scintillation counters. Precautions in radio isotope handling. Autoradiography and its biological applications.

Emerging topics in Biophysical methods

BP II
Information Processing and the Brain

1. Electrical behavior of the biological membrane. (4L)

2. Introduction to Nervous System with a special reference to Sensory Receptors and Perception. (3L)
3. Origin of the concept of Computability, Turing Machines. (2L)

4. Synaptic Transmission: Physicochemical Principles, Resting Potential, Action Potential, Membrane Theory of Action Potential, Hodgkin Huxley Model, Mathematical solutions of H-H Equations (6L)

5. Models of Neurons: Artificial neurons, Physiological Neuronal Network versus Artificial Neural Network. (4L)

6. Mathematical tools to deal with Spiking Neurons. (2L)

7. Neural Basis of Cognition: Principles of Learning & Memory, Cellular Mechanism of Learning & Memory, and Comparison with Machine Learning. (4L)

8. Open discussions on the Interface of Artificial Neural Net and the Brain. (1L)

Suggested study material

1. Scott, A. (2002) Neuroscience: A Mathematical Primer, Springer
2. Churchland, P.S. & Sejnowski, T.J. (1999). The Computational Brain, MIT Press.
3. Nelson, P. C. (2004). Biological Physics, W.H. Freeman & Co., Chapter 12.
4. Gazzaniga, M.S. et al. (2002). Cognitive Neuroscience: The Biology of the Mind, W.W. Norton & Co.
5. Rosenzweig et.al. (2005). Biological Psychology, Sinauer Associates, Inc.
6. Kendel, (2002). Principles of Neural Science.
7. Lytton, W.W. (2002). From Computers to Brain, Springer.
8. Haken, H. (2002). Brain Dynamics, Springer.
9. Kluwe, R.H. et al. (2003). Birkhauser.
10. Landau, L.J. & Taylor, J.G. (1998) Concepts for Neural Networks, Springer.

DEPARTMENT OF GENETICS

Courses offered under M. Phil (Biotechnology)

Semester I	
GEN I	Concepts of Genetics
GEN II	Chromosomes, Genes and Genomes
GEN III	Population Genetics
GEN IV	Concepts in Cell and Molecular Biology
GEN V	**Plant-Microbe Interactions**
GEN VI	**Medical Genomics**
GEN VII	**RNAi: Biology And Application**
GEN VIII	**Plant Genetic Engineering**
Semester II	
GEN IX	Gene Expression and Regulation
GEN X	Human Genetics
GEN XI	Molecular Plant Breeding
GEN XII	**Developmental Biology**
GEN XIII	***Drosophila* Genetics**
GEN XIV	**Genetics of Bacteria and Their Viruses**
GEN XV	**Fungal Genetics**

Note: Papers in bold will be available from 2010 session onwards

GEN I
CONCEPTS OF GENETICS

The science of Genetics has come to occupy a pivotal position in the entire field of Biology, as it is central to numerous aspects of human affairs. Deeply rooted in strong concepts, it has provided the unifying themes for all living organisms. While on one hand, the science centers around a phrase "like begets like", it also explains the

inherent variability that differentiates one individual from the other. Though the discipline of Genetics has moved far ahead from simple inheritance of the characters, it is absolutely essential to have a clear understanding of the underlying concepts. This paper deals with these basic concepts that form the building block for any further understanding of Genetics.

Model systems in Genetic Analysis: Bacteriophage, *E. coli*, *Neurospora crassa*, yeast, *Arabidopsis*, maize, *Drosophila*, *C. elegans*, Zebra fish, *Homo sapiens* - General outline of life cycle, importance in Genetic analysis. [6]

Laws of inheritance – Mendel's Laws, concept of dominance, segregation, independent assortment; Chromosome theory of inheritance. [10]

Allelic and non-allelic interactions – Concept of alleles, types of dominance, lethal alleles, multiple alleles, test of allelism, complementation; Epistasis. [12]

Linkage – Concepts, recombination, gene mapping in prokaryotes and eukaryotes, fine structure mapping. [12]

Sex-linked inheritance – Conceptual basis, sex influenced traits, mechanism of sex determination. [4]

Quantitative inheritance – Concept, Genes and Environment - heritability, penetrance and expressivity. [4]

Cytoplasmic inheritance – Basis and mechanism, role of organellar genes. [4]

Mutation – Classification, mechanism, repair, role in genetic analysis and evolution. [6]

Changes in Chromosome number and structure: Polyploidy, aneuploidy, chromosomal rearrangements - deletion, duplication, inversion, and translocation. Meiotic consequences in structural heterozygotes, role in speciation and evolution. [6]

Suggested study material

Concepts of Genetics	Klug W. S. and Cummings M. R	Prentice-Hall	2003
Genetics-a Conceptual Approach	Pierce B. A.	Freeman	2003
Genetics- Analysis of Genes and Genomes	Hartle D. L. and Jones E. W.	Jones & Bartlett	2001
An Introduction to Genetic Analysis	Griffith A. F. et al	Freeman	1993,2008
Principles of Genetics	Snustad D. P. and Simmons M. J.	John Wiley & Sons.	1997,2002
Genetics	Strickberger M. W.	Prentice-Hall	1990

GEN II

CHROMOSOMES, GENES AND GENOMES

The students are expected to have basic knowledge of chromosome structure, genome organization and cell division. Therefore, the syllabus includes advanced aspects of chromosome biology, genome organization and genetics of cell cycle regulation. Emphasis would be given to explain the topics with the help of classical experimental strategies, examples from different model organisms and contemporary genetic approaches and methods.

Chromatin structure: Histones, DNA, nucleosome morphology and higher level organization; Functional states of chromatin and alterations in chromatin organization. [8]

Chromosome organization: Metaphase chromosomes**:** centromere and kinetochore, telomere and its maintenance; Holocentric chromosomes; Heterochromatin and euchromatin, position effect variegation; Chromosomal domains (matrix, loop domains) and their functional significance. [12]

Giant chromosomes: Polytene and lampbrush chromosomes. [2]

Cytogenetic aspects of cell division: Chromosome labeling and cell cycle analysis, Overview of mitosis and meiosis, sister chromatid cohesion remodeling, regulation of exit from metaphase, chromosome movement at anaphase. Genetic control of meiosis with examples from yeast. [10]

Chromosomal anomalies: Numerical and structural alterations, induced chromosomal aberrations in somatic cells. [6]

Techniques in the study of chromosomes and their applications: Short term (lymphocyte) and long term (fibroblast) cultures, chromosome preparations, karyotyping, banding, chromosome labeling, *in situ* hybridization, chromosome painting, comparative genome hybridization (CGH), somatic cell hybrids and gene mapping, premature chromosome condensation. [8]

Genome organization in viruses, prokaryotes and eukaryotes: Organization of nuclear and organellar genomes; C-value paradox, Repetitive DNA-satellite DNAs and interspersed repeated DNAs, Transposable elements, LINES, SINES, Alu family and their application in genome mapping. [14]

Concept of gene: Conventional and modern views. Fine structure of gene, split genes, pseudogenes, non-coding genes, overlapping genes and multi-gene families. [2]

Genome mapping: Physical maps -an overview and approaches. [1]

Genome evolution [1]

Suggested study material

1.	Essential Cell Biology	Alberts B. et al.	Garland	2009
2.	Molecular Biology of The Cell	Alberts B et al.	Garland	2008
3.	The Eukaryotic Chromosome	TBostock C. J. & Summer A. T.T	Elsevier	1978
4	The Chromosome	Hamsew and Flavell	Bios	2003
5.	Advanced Genetic Analysis	Hawley & Walker	Blackwell	2003
6.	Structure & Function of Eukaryotic Chromosomes	Hennig	Springer	1987
7.	Genes IX	Lewin B.	Pearson	2008
8.	Molecular Cell Biology	Lodish, H. et al.	Freeman	2007
9.	Cell and Molecular Biology	De Robertis & De Robertis	Lippincott & Wilkins	2004
10.	Genomes 3	Brown T. A.	Garland	2007

GEN III
POPULATION GENETICS

A thorough understanding of the population genetics is necessary to comprehend the evolutionary processes. This course will make the students familiar with different types of DNA markers and the range of tools for their detection to enable advanced studies on molecular population genetics. It will also make them understand the forces that have an impact on levels of genetic variations in natural and/or experimental populations for both qualitative and quantitative traits.

General background [1]

Variation at the genetic level: DNA markers -VNTR, STR, microsatellite, SNP and their detection techniques - RFLP, genotyping, RAPD, AFLP etc. [7]

Organization and measure of genetic variation: Random mating population, Hardy-Weinberg principle, complications of dominance, special cases of random mating – multiple alleles, different frequencies between sexes (autosomal and X-linked). [10]

Linkage and linkage disequilibrium [2]

Sources responsible for changes in gene frequencies: Mutation, selection, migration and isolation; random genetic drift; insights into human migration, natural selection and evolution. [4]

Population substructure: Hierarchical population, Isolate breaking, Inbreeding, Assortative mating. [2]

Quantitative Genetics: Johannsen pure-line theory, multiple factor hypothesis, types of quantitative traits, components of phenotypic variation and genetic models for quantitative traits, concept of heritability, artificial selection and realized heritability. [6]

Suggested study material

1.	DNA markers Protocols, applications and overviews	Anolles G. C. & Gresshoff P. M.	Wiley-Liss	1998
2.	Molecular markers in Plant Genetics and Biotechnology	Vienne De. D.	Science Publishers	2003
3.	Genetics of Population	Hedrick P.W.	Jones & Bartlett	2005
4	Principle of Population Genetics	Hartl D. L. and Clark A. G.	Sinauer Associates	2007
5.	Biostatistics	Danial, W. W	Wiley	2004
6.	Statistical methods in Biology	Bailey, N.T.J	Cambridge Univ. Press	1995

GEN IV
CONCEPTS IN CELL AND MOLECULAR BIOLOGY

Life on this earth has evolved through a set of simple biochemical reactions, which has subsequently given rise to specific cell types. Cells are made out of some building blocks which when bonded together produce the various structural and functional constituents. From a geneticist's point of view, the understanding of informational molecules, such as DNA, RNA, and proteins is central as they provide information on life and its processes. This paper deals with the structural and informational molecules, and their role in information transfer. While tracing the origin of life and its subsequent evolution, special emphasis has been given to proteins as biocatalysts, in cellular reactions.

Origin of life: Origin of biomolecules, primitive life forms, RNA world, biological evolution. [8]

Tree of life: rRNA as a chronological marker, Woese's concept of molecular taxonomy. [4]

Cellular organization: An overview, endosymbiotic origin of mitochondria and chloroplast. [3]

Biomolecules: Chemical bonds, building blocks: carbohydrates, lipids, fats, proteins, nucleic acids. [8]

Informational molecules: DNA as genetic material, DNA structure and replication. RNA as genetic material, types of RNA, role of RNA in information transfer, concept of central dogma, Genetic code, codon usage, protein structure: primary, secondary and tertiary, processing, and transport; versatility of the proteins in biological processes. [14]

Enzymes: As biocatalysts, specificity and kinetics, assay and inhibition of enzyme activity, mechanism of action, regulation of enzyme activity; Allosteric enzymes. [11]

Cellular energetics: Energy rich compounds, ATP synthesis, thermodynamics of cellular reactions, metabolic networks-an overview. [8]

Cell cycle and its regulation [4]

Cell signaling [4]

Suggested study material

1.	Principles of Biochemistry	Lehninger et al.	Freeman	2008
2.	Biochemistry	Devlin, T.M.	Wiley-Liss	2005
3.	Biochemical Calculation	Sehgal I. H.	Wiley	1975
4	Fundamentals of Enzymology	TPrice N. C. and Lewis S.T	Oxford University Press	1999
5.	Biochemistry	TBerg, J. M. Tymoczko, J. L and Stryer L.T	W. H. Freeman	2006
6.	Molecular Biology of the Gene	Watson, J. et al.	Benjamin Cummings	2008
7.	Molecular Cell Biology	Lodish,H. et al.	W. H. Freeman	2007
8.	The World of the Cell	Becker, W.M. et al.	Benjamin Cummings	2009

GEN V

PLANT-MICROBE INTERACTIONS

The course is designed to provide the genetic and molecular principles underlying plant- microbe interactions. Tutorials would be in form of discussion and student presentations based on recent reviews available for each topic, highlighting the advances made in the respective field.

History of Plant pathology and recent developments: Significance of plant diseases, and pathology, types of plant-microbe associations (pathogenic– bacteria, virus, fungi, and symbiotic). [3]

Beneficial Plant - Microbe interactions (molecular aspects): [5]

a. Nitrogen fixing bacteria and cyanobacteria

b. Mycorrhizal association

c. Phytohormones and Biocontrol antibiotics

Parasitism and disease development: Pathogenecity, host range of pathogens, disease cycle and epidemics. [5]

Molecular biology of pathogenicity: Mechanisms of variability in pathogens, pathogenicity genes and mechanisms in pathogenic bacteria, biotrophic and necrotrophic fungi, Virus and Viroid genes involved in pathogenicity, *Agrobacterium* and plant interaction-a model system. [10]

Molecular genetics of plant disease susceptibility and resistance: Types of plant resistance to pathogens (R gene resistance, quantitative and monogenic), basal and induced defense mechanisms, pre-formed inhibitors of pathogens, gene for gene interaction in plant defense, Systemic Acquired Resistance (SAR) and Induced Systemic Resistance (ISR), Recognition mechanism and signal transduction during plant - pathogen interaction. [10]

Suggested study material

1.	Plant Pathology	Agrios G. N.	Academic Press	2005
2.	Molecular Plant pathology	Dickinson M.	BIOS Scientific Press	2003
3.	Plant Pathogenesis and Resistance: Biochemistry and Physiology of Plant-Microbe Interactions	Jeng-Sheng H.	TKluwer Academic Pubs.T	2001

GEN VI

MEDICAL GENOMICS

This era in time is the most exciting period in medical practice and research due to unprecedented technical advances in genetics and genomics research. An effective weaving together of previously separate strands of cytogenetics / biochemical genetics/ immunogenetics/ molecular genetics/ statistical, functional and population genetics is evident in this area. Conventional tools such as pedigree analysis still remain to be a powerful starting tool for new gene identification and study of inheritance genetics. Functional genomics and understanding mechanisms underlying genetic observations together with in- silico approaches to unravel nuances in genome architecture are the contemporary tools. Introduction to new methodologies to study genetics of single gene disorders as well as the enigmatic common complex traits; variety of tools to unravel the function of genes and their variants; and finally translation of this exciting new knowledge to medical practice by diagnostic and therapeutic innovations are the contents of this paper. Genetic counseling is emerging as an area of utmost importance in this translational research era and this would also be dealt with. A didactic approach and problem based tutorial exercises which seem to be the most effective method of introducing and training students in this branch of applied genetics would be followed.

Identification and Isolation of disease genes: Single gene disorders- conventional and contemporary methods: Pedigree analysis, Linkage mapping, Positional/structural and functional cloning; Bioinformatic analysis; Characterisation; Mutation detection, diagnosis and therapy (with examples from autosomal dominant, autosomal recessive, X-linked dominant, X-linked recessive and complex disease conditions); Multifactorial disorders: Familial forms- Linkage analysis, Candidate gene identification; Genetic polymorphism and disease susceptibility; Sporadic cases- Association studies- markers from candidate gene/pathways; whole genome association (Single nucleotide polymorphism, CNVs); Statistical methods used; Common examples. [16]

Functional genomics and animal models in human disease: An overview; cDNA/gene cloning; site-directed mutagenesis; mammalian tissue culture; cell line transfections; functional assays; Use of model organisms, methods for generation of transgenic animals/ knock-in, knock-out models (microinjection, ES cell transformation); ENumutagenesis; RNAi approach; Some examples. [4]

Pharmacogenetics: History, Early evidence; Clinical determinants; Molecular insights (genes involved in pharmacokinetics and pharmacodynamics of drugs); Applications in pre-prescription testing. [2]

Diagnostic genetics: Cytogenetics/ Molecular Cytogenetics/Biochemical/Molecular methods; Screening for mutation/ chromosomal anomaly - Adult/Prenatal/Newborn screening; Pre-implatation screening (Assisted reproductive technology- *in vitro* fertilization and Embryo transfer); Forensic testing - DNA fingerprinting, paternity testing, individual identification. [6]

Treatment of genetic disorders: Methods of therapy - Drug (recombinant proteins); Diet; Gene (Viral vectors, delivery methods, efficacy); Some examples (Thalassemia, Phenylketonuria, Cystic fibrosis, DMD etc). [2]

Genetic counseling: Prenatal/adult diagnosis of genetic disorders; Risks and benefits; Informed consent; Right of choice; Dilemmas faced by counselors. Case studies. [2]

Suggested study material

1.	Human Molecular Genetics	Strachan T. & Read A.	Garland Science	2003
2.	An introduction to Human Molecular Genetics: Mechanism of Inherited Diseases	Pasternak J.	Fitzgerald Science Press	2005
3.	Thompson and Thompson Genetics in Medicine	Robert et al.	Saunders	2007
4	Landmarks in Medical Genetics	(Ed.) Harper P. S.	Oxford University Press	2004
5.	Chromosome Banding	Sumner A.T.	Unwin Hyman	1990
6.	Human Genetics: Problems and Approaches	Vogel F. and Motulsky A. G.	Springer Verlag	2009

GEN VII

RNAI: BIOLOGY AND APPLICATIONS

In the postgenomic era, the elucidation of physiological function of genes is extremely important and RNAi has rapidly become one of the key methods used in functional genomics since its discovery in 1998. RNAi is also involved in defense and the regulation of chromatin structure and gene expression. In fact, this elegant and revolutionary reverse genetics approach has tremendous commercial promise with regard to developing new drugs and therapeutics for human diseases as well as the improvement of crop yield and quality. This course covers the basic aspects of RNAi biology, use of siRNA and microRNAs for gene silencing, RNAi vectors and generation of transgenic animals and plants expressing dsRNA. The current and potential applications of RNAi in healthcare and agriculture is also covered.

Discovery of RNA interference (RNAi): PTGS, RNAi and related phenomena. [2]

Categories of small non-coding RNAs: dsRNAs, siRNAs, shRNAs, piRNAs and miRNAs, Detection of small RNAs. [2]

Mechanism of RNAi: Different components of RNAi pathway and their evolutionary conservation and role in gene silencing, RNAi-like pathway in bacteria, Molecular basis of RNAi /siRNA /miRNA mediated gene silencing. RNAi in defense and the regulation of chromatin structure and gene expression; RNAi suppressors. [6]

Large-scale genetic analysis using RNAi: Genome-wide RNAi screens in *C. elegans*, and other systems, High-throughput small RNA profiling, RNAi microarrays. [4]

miRNAs and siRNAs: Pathways, expression and functions of microRNAs, High-throughput analysis of miRNA gene expression; siRNA vectors, siRNA delivery *in vitro* and *in vivo*; RNA informatics - Computational tools for miRNA discovery, siRNA and miRNA design. [8]

Expression of dsRNA in animals and plants, and its applications: RNAi vectors and generation of transgenic animals and plants, Analysis of expression of dsRNA and gene silencing; The use of RNAi in the prevention of diseases in animal models and crop improvement; RNAi therapy; Future prospects of RNAi in biology, medicine and agriculture. [10]

Suggested study material

1.	The RNA World	TEds. TGesteland et al.	CSHL Press	2006
2.	RNA Interference Technology: From Basic Science to Drug Development.	Eds. Fire et. al.	Cambridge University Press,	2005
3.	RNAi: A Guide to Gene Silencing.	Ed. Gregory J. Hannon	CSHL Press	2003
4	RNA Silencing: Methods and Protocols	Ed. Gordon G. Carmichael	CSHL Press	2005
5.	RNA Interference in Practice	Ed. Ute Schepers,	Wiley-VCH GmbH & Co. KGaA.	2006
6.	Genes IX.	Lewin B	Jones and Barlett	2008

GEN VIII
PLANT GENETIC ENGINEERING

Human society is confronted with a multitude of challenges, including the rapid loss of phytodiversity, environmental perturbations, and the ever-increasing human population. Needless to highlight, food security for the ever-increasing population will be a major challenge in present and future times. In fact, it would be necessary to produce more and more in the coming years. Although conventional breeding has contributed its share, we need to adopt newer technologies, particularly biotechnological strategies to boost the yield and quality of our crop plants. The course is designed to provide students with specialized knowledge of the theory and practical skills of plant tissue culture, somatic cell genetics and genetic engineering relevant to crop improvement. It deals with the various cell and tissue culture systems and their applications, plant transformation vectors and methods, and potential applications of transgenic technology in agriculture and healthcare.

Plant tissue culture and somatic cell genetics: Historical developments; Nutrient media; Role of phytohormones in plant development *in vitro*; Plant regeneration pathways - Organogenesis and Somatic embryogenesis; Organ culture, Root culture, Embryo culture - Embryo rescue, Breakdown of seed dormancy; Endosperm culture and triploid production; Anther and pollen culture, and production of haploid and doubled haploid plants; Callus culture; Cell culture and production of secondary metabolites; Protoplast culture and fusion, Somatic hybrids; Organelle transfer and cybrids; *In vitro* fertilization for production of novel hybrids; Micropropagation, artificial seed and bioreactor technology, Virus-free plants by meristem culture; Use of somaclonal and gametoclonal variation for crop improvement; *In vitro* mutagenesis and mutant selection; Preservation of plant germplasm *in vitro*. [26]

Plant transformation vectors and methods: Plant transformation vectors - T-DNA and viral vectors, direct gene transfer vectors; Selectable marker and reporter genes, Plant transformation by *Agrobacterium* sp., non-*Agrobacterium* sp., and *in planta* transformation, Molecular mechanism of T-DNA transfer; Direct gene transfer methods in plants - Gene gun and other methods; Chloroplast transformation; Transgene analysis, silencing and targeting; Marker-free and novel selection strategies; Multigene engineering; Gene knock-down by ribozymes, antisense RNA and RNA interference. [18]

Applications of plant transgenic technology: Transgenic crops for resistance against biotic and abiotic stresses; Engineering crops for male sterility and modification of flower colour, flowering, fruit ripening and senescence; GM crops for nutritional quality and quantity; RNAi-mediated crop improvement; Molecular pharming; Metabolic engineering and hairy root culture for secondary plant products; Other applications; Global status and biosafety of transgenic plants.

[20]

Suggested study material

1.	Plant Tissue Culture: Theory and Practice	Bhojwani S. S. & Razdan M. K.	Elsevier	1996
2.	Plant Biotechnology: The Genetic Manipulation of Plants	Slater A. Scott N. & Fowler M.	Oxford University Press Inc.	2003
3.	Plants, Genes and Crop Biotechnology	Chrispeels M. J. & Sadava D. E.	Jones and Barlett Publishers	2003
4	Principles of Gene Manipulation and Genomics	Primrose S. B. & Twyman R. M.	Blackwell Publishing.	2006
5.	Plant Cell, Tissue and Organ Culture: Fundamental Methods.	(Eds). Gamborg O. L & Phillips G. C.	Springer-Verlag.	1995
6.	Plant Biotechnology	B. D. Singh	Kalyani Publishers.	2005

GEN IX
GENE EXPRESSION AND REGULATION

These topics would be taught with emphasis on discoveries, examples and experimental designs for studies. After being introduced to the topics highlighting experiments leading to seminal discoveries the students will cover 'Gene expression: basic processes' mainly through self-study. The students are expected to read, research and discuss papers related to the topics.

Gene expression: Basic processes

Gene as a unit of function. [1]

Transcription (prokaryotic and eukaryotic) – RNA polymerase, DNA sequences, transcription factors, process of initiation, elongation and termination. [13]

Post transcriptional modifications – capping, poly-adenylation, splicing (*cis*- and *trans*-), editing. [9]

Translation – genetic code, ribosome structure, the process of translation. [6]

Gene regulation:

Introduction, levels of regulation, evidences and experimental designs/methodologies, role of genetic analysis in understanding gene function and regulation. [6]

Lessons from bacteria: regulation at *lac* (including reading of Jacob and Monod's seminal paper) [8], *trp* [2] and *ara* operons [2]; control of lysis and lysogeny in λ phage [6]. [18]

Yeast: Gene regulation in a single celled eukaryote using a model case of GAL gene. [4]

Regulation in higher eukaryotes:

a. Perceiving signals. [2]
b. Transcriptional control – Changes in chromatin structure, epigenetic controls. [14]
c. Transcriptional control - DNA sequence elements and transcription factors. [6]
d. Post-transcriptional regulation – Alternative RNA splicing, RNA editing, RNA transport and localization, RNA stability [6], Regulation of translation – RNA structure, control at initiation, codon usage [4], Post-translational modifications [3] [13]
e. RNA-mediated control of gene regulation. [4]

Suggested study material

1.	Genes and Signals	Mark Ptashne and Alexander Gann	CSHL Press	2002
2.	A Genetic Switch	Mark Ptashne	CSHL Press	2004
3.	Gene Regulation	David S Latchman	Chapman & Hall	2005
4	Genes IX	Benjamin Lewin	Prentice Hall	2008
5.	Molecular Cell Biology	Lodish, H. et al.	W. H. Freeman	2007
6.	Molecular Biology	Weaver R F	McGrawHill	1999
6.	Selected papers on gene function and regulation (a compilation)			

GEN X
HUMAN GENETICS

Human Genetics is a very wide as well as a rapidly advancing subject and one which interests even a layman. Last two decades have revolutionized our early understanding of the basic concepts of Genetics, genome organization, gene structure and function. This introductory course attempts to walk the students through classical genetics and molecular genetics with a cautionary endnote on range of ethical, legal and social issues which are also the logical consequences of such unparalleled scientific progress. Beginning with constructing genetic hypothesis from pedigree data and population sampling, application of a variety of conventional and modern tools to test such hypothesis, constraints/ limitations of genetic methodology when applied to humans would be discussed in the early part of the paper. Application of mapping tools and cloning strategies culminating in the successful completion of the Human genome project and exciting, unimagined areas of research which have emerged in the post-sequencing era would be covered next. New/ current knowledge on genetic variations in health and disease across populations and their clinical/diagnostic implications would be dealt subsequently. Considering that purview of medical genetics is now all of medicine and involves ethical issues, this study will remain incomplete without serious discussion on these issues.

Introduction to Human Genetics: History; Early perception, development and documentation; Genome organization; Chromosome structure, function and implications for disease. [4]

Study tools in Human Genetics: Pedigree analysis- Mendelian inheritance and exceptions; Chromosomal analysis (*in vitro, in vivo*), Biochemical analysis; Somatic cell genetics (somatic cell hybrids, monochromosome hybrid panels, gene mapping); Molecular genetic analysis. [12]

Human genome mapping methods: Physical mapping: Introduction to physical map markers- Chromosomal, G/Q- banding, radiation hybrid, Fluorescence *in situ* hybridization, comparative genome hybridization, long range restriction mapping, high resolution mapping- STS/EST/MS/SNP/sequencing; Genetic mapping: Linkage analysis (RFLP/MS/SNP); Applications of mapping in normal and disease genome analysis; Gene identification using positional and functional cloning approach. [16]

Human genome analysis: Conception, mapping, cloning and sequencing, Outcome- Generation of 'OMICS' era, significant leads. [8]

Genetic variation in health and disease: Human genetic diversity- Methods of study – Biochemical/molecular genetic markers; some examples. Tracing human migrations with autosomal, Y-chromosomal and mitochondrial markers. [4]

Diseases and disorders: Chromosomal disorders: Structural and numerical; Autosomal/sex chromosomal/sex reversal; Mechanisms – mitotic/meiotic non-disjunction/ chromosomal rearrangements; Some examples (Syndromes/Cancer/Infertility); Single gene and disease: Inborn errors of metabolism, Haemoglobinopathies; Multifactorial disorders: Introduction; Methods of study (Epidemiological, Twin/ adoption and Family studies); Etiology - genetic and non-genetic determinants; Common examples. Epigenetics and disease: Mechanisms (Imprinting/methylation; chromatin remodeling); Current understanding; examples. Mitochondrial myopathies. [10]

Ethical, legal and social issues in Human genetics: Prenatal/adult (individual/family/population) screening of mutation/risk factor for genetic diseases; Confidentiality/privacy, Discrimination, Ethical dilemma, Human rights, Surrogate mothers; Human cloning and eugenics; Organ banking and transplantation; Research ethics; Medical ethics in India. [2]

Classical papers in Human genetics [8]

Suggested study material

1.	Human Genetics: Problems and Approaches	TVogel F. and. Motulsky A. GT	Springer Verlag	2009
2.	Human Molecular Genetics	Strachan T & Read A	Garland Science	2003
3.	An Introduction to Human Molecular Genetics: Mechanism of Inherited Diseases	Pasternak J	Fitzgerald Science Press	2005
4	Chromosome Structural analysis: A Practical Approach	(Ed.) W.A. Bickmore	Oxford University Press	1999
5.	The AGT Cytogenetics Lab Manual	Barch, Knutsen and Spurbeck,	Lippincott Raven publ	2000
6.	Human Cytogenetics: Constitutional analysis	(Ed) D.E. Rooney	Oxford University Press	1992
7.	Human Chromosomes	Miller O. J. and Therman E.	Springer-Verlag	2000
8.	The 1P^{stP} Years of the Human Chromosome	Harper P. S.	Scion Publishing	2006
9.	Analyzing Chromosomes	Czepulkowski B.	BIOS Scientific Publ	2001

GEN XI
MOLECULAR PLANT BREEDING

This is a course on applied plant genetics. This course primarily deals with how to undertake plant genome analysis and gene mapping through the use of DNA markers and how this information could be utilized in bringing the efficiencies in selection methods of plant breeding and gene isolation through forward genetics approach.

Plant Breeding: History, genetic diversity in plant breeding. [4]

Natural breeding systems in plants and their application in plant breeding. [8]

Conventional breeding methods for self, cross-pollinated and vegetatively propagated crop plants. [6]

Heterosis breeding [4]

Polyploidy and haploids in plant breeding [2]

Cytogenetic tools in Plant breeding [4]

Seed production and variety development [2]

Molecular plant breeding: Introduction - molecular markers as new efficient tools in breeding. [4]

Molecular markers for genome mapping: Principles of genetic linkage, concept of genetic distance, development and choice of mapping populations, linkage map construction – relational, integrated and comparative maps. [10]

Dissection of quantitative traits: Principles and methods of QTL mapping, fine mapping of QTL [6]

Marker assisted breeding: Gene tagging, marker aided selection – foreground and background selection, concept of graphical genotypes, elimination of linkage drags. [10]

Cloning plant genes: Comparative genomics and cloning, positional cloning. [4]

Suggested study material

(GEN 0803 Molecular Plant Breeding):

1.	Principles of Plant Breeding	Allard R. W.	Wiley & Sons	1999
2.	Plant Breeding Theory and Practice	Stoskopf N. C., Tomes D. T. & Christie, B. R.	Westview Press	1993
3.	Principle of Crop Improvement	Simmonds N. W. & Smart J.	Blackwell Science	1999
4	Plant Cytogenetics	Singh R. J.	CRC Press	2003
5.	Genome mapping in Plants	Paterson A. H.	Academic Press	1996
6.	Molecular markers in Plant Genetics and Biotechnology	Vienne D.	INRA	2003
7.	Quantitative Genetics, Genomics and Plant Breeding	Kang M. S.	CABI Publishing	2002
8.	Plant Molecular Breeding	Newbury H. J.	CRC press	2003

GEN XII

DEVELOPMENTAL BIOLOGY

There are proximal and ultimate explanations for development. Importantly, today for the first time one can begin to see how they might link up. These are based on molecular biology, genetics, biochemistry and mechanical properties of cells on the one hand, and evolutionary arguments on the other, with much of interplay between the two. Keeping this in mind, the course envisages giving an insight into how developmental patterns arise using examples from different model systems and highlighting regulatory networks involved in these processes. The students are however expected to have studied the basic processes of development (animal and plant embryology). The emphasis would be on experiments done which led to various concepts. The students are urged to read: "The art of the genes –How organisms make themselves by Enrico Coen".

Approaches to developmental biology: Anatomical, genetic, evolutionary, teratology, mathematical modeling and experimental approaches. [4]

Life cycles and evolution of developmental patterns. [2]

Introduction to model organisms: *Dictyostelium*, *Caenorhabditis elegans*, *Drosophila*, Zebrafish, Xenopus, Chick, Mouse, *Arabidopsis* and Rice. [8]

Basic concepts of development: Potency, commitment, specification, induction, competence, determination and differentiation, morphogenetic gradients, pattern formation, cell fate and cell lineages; mosaic versus regulative development. [6]

Fertilization and early development in animals: Cleavage, gastrulation, cell specification; axis and pattern formation with examples from *C. elegans*, *Drosophila*, amphibians, chick and mammals. [20]

Morphogenesis and organogenesis in animals: Cell aggregation and differentiation in *Dictyostelium*, formation of vulva in *C. elegans*, induction of development of compound eye in *Drosophila*, limb development and regeneration in vertebrates. [12]

Environmental regulation of animal development [4]

Developmental process in plants: Gametophyte development and fertilization, post-fertilization changes, organization of shoot and root apical meristem, shoot and root development; leaf development and phyllotaxy; transition to flowering, floral meristems and floral development in *Arabidopsis* and Rice.

Developmental mechanisms of evolutionary change [2]

Suggested study material

1.	Developmental Biology	Gilbert S. F	Sinauer Asso.	1994. 1997, 2006
2.	Principles of Development	Wolpert L et al.	Oxford University Press	1998
3.	The Art of the Genes: How Organisms Make Themselves	Coen E.	Oxford University Press	1999
4	Genetic Analysis of Animal Development	Wilkins A. S.	Wiley-Liss	1993
5.	Biological Physics of the Developing Embryo	Forgacs G. & Newman S. A.	Cambridge University Press	2005

GEN XIII

DROSOPHILA GENETICS

The course has been designed to provide advanced understanding of Drosophila genetics. The teaching will include both knowledge-based sessions (to facilitate understanding of concepts) and skill-based sessions (application of knowledge and skills in practical activities).

Life cycle and advantages of *Drosophila* as a model organism for genetic analysis [4]

***Drosophila* development:** [12]

(a) Embryonic development

(b) Maternal genes and formation of body axes

(c) Segmentation genes

(d) Homeotic genes and their functions

(e) Larval stages and tissue types

(f) Imaginal discs: development and differentiation

(g) Pupa and metamorphosis

(h) Adult morphology and internal organs

(i) Spermatogenesis and oogenesis

(j) Stem cells in *Drosophila*

Polytene chromosome: Maps, puffing and utility. [4]

Basics of setting up *Drosophila* crosses [6]

Nomenclature of gene mutations, balancer chromosomes [3]

Mutagenesis and isolation of new variants: [7]

(a) X-ray and chemical mutagenesis

(b) P-element and insertional mutagenesis

(c) Mapping of new mutations by recombination, deletion and complementation mapping

Generation of Transgenic *Drosophila* : [6]

(a) Germ-line transformation and selection of vectors.

(b) Application of P-element based vectors in transgenic generation

Advanced *Drosophila* genetics: [10]

(a) Mitotic recombination

(b) Generation and analysis of somatic clones

(c) Generation and analysis of germ-line clones

(d) Conditional and /or targeted expression/ablation of genes/transcripts (e.g. UAS/GAL4 system)

(e) RNAi based screening of gene functions

***Drosophila* model for human genetic disorders** (e.g. Parkinson's, Huntington's, Alzheimer's diseases etc.). [6]

Overview of *Drosophila* genome project: Online databases and other resources for *Drosophila* genetics.[6]

Suggested study material

1.	Developmental Biology	Gilbert S. F.	Sinauer	2006
2.	Development of *Drosophila melanogaster* (Vol I & II)	Bates and Arias	CSHL Press	1993
3.	*Drosophila* Guide	Demerec and Kaufmann	Carnegie	1986
4.	*D. melanogaste:* Practical Uses in Cell and Molecular Biology	Goldstein and Fyrberg	Academic	1993
5.	The making of a fly: The genetics of animal design	Lawerence	Blackwell	1992
6.	*Drosophila*: Methods and Protocols	TDahmann C.TTT	Humana	2008
7.	Fly Pushing: The Theory and Practice of *Drosophila* Genetics	Greenspan R. J.	CSHL Press	1997
8.	*Drosophila*: A Practical Approach	Roberts D. B.	CSHL Press	1998
9.	Compiled reviews and research papers			

GEN XIV
GENETICS OF BACTERIA AND THEIR VIRUSES

Though microorganisms have had a late entry in the field of genetics, once that happened, they quickly occupied the centre stage. Combining the structural simplicity with the unifying genetic basis, they offered immediate advantages in studying all the three aspects of heredity: the generation, expression, and transmission of biological variation. Bacteria and their viruses have been extensively exploited for genetic analyses providing important leads on gene function and gene manipulations. This paper deals with the strength of bacterial and phage genetics in terms of transmission of the genetic information, as the other two aspects are dealt with separately other courses. In phage systems, their interaction with the host both under lytic and lysogenic as well as transpositional mode with the subsequent impact on the host are also included. Some topics of general interest where these systems have contributed significantly are also covered.

Bacteria as model systems in genetic analysis: Mutation, recombination, test of allelism, gene mapping. [6]

Methods of gene transfer in bacteria:

Conjugation: Discovery, nature of donor strains and compatibility, interrupted mating and temporal mapping, Hfr, F', map of F plasmid, mechanism of chromosome transfer, molecular pathway of recombination. Chromosome transfer in other bacteria. [12]

Transformation: Natural transformation systems, Biology and mechanism of transformation, transformation and gene mapping, Chemical-mediated and electrotransformation. [8]

Transduction: Discovery, generalized and specialized or restricted transduction, Phage P1 and P22-mediated transduction, mechanism of generalized transduction, abortive transduction. Temperate phage lambda and mechanism of specialized transduction, gene mapping, fine-structure mapping. [8]

Techniques for studying bacteriophages: Virulent phage (TB_{4B}) and Temperate phage (phage lambda). Important aspects of lytic and lysogenic cycles, phage-host relationships, immunity and repression.,site-specific recombination (lambda and P1). [16]

Transposable phage (phage Mu): Genetic organization, and transposition, Mu as a genetic tool. [5]

Plasmids: Types, detection, replication, incompatibility, partitioning, copy-number control and transfer. Properties of some known plasmids. [6]

Genetic rearrangements and their evolutionary significance: Phase variation in *Salmonella*. [3]

Suggested study material **(Gen 1003 Genetics of Bacteria and their Viruses):**

1.	Microbial Genetics	Maloy S., Cronan J., Freifelder D	Jones and Bertlett	1994
2.	Fundamental Bacterial Genetics	Trun N and Trempy J	Blackwell Publ.	2004
3.	Modern Microbial Genetics	Streips U. N. and Yasbin R. E.	Wiley-Liss	2003
4	Molecular Genetics of Bacteria	Sneider L. and Champness W.	ASM Publishers	2007
5.	Genetics of Bacteria	Scaife J.	Academic Press	1985
6.	Genetics of Bacteria and Viruses	Birge E. A.	Springer	2006
7.	Molecular Genetics of Bacteria	Dale J.W. and Park S	Wiley	2004
8.	Others books on Genetics, Molecular biology, and Molecular Genetics.			
9.	Several Research papers, reviews, and Articles.			

GEN XV
FUNGAL GENETICS

The course is designed to provide some fundamental, theoretical principles on which to form an integrated view of various genetic and molecular processes using Fungi as model system. Tutorials would be in form of discussion based on recent reviews available related to each topic, highlighting the advances made in each field.

Overview of Fungal Biology: Fungal life cycle and various phases, Fungi in nature, fungi in biotechnology, and as experimental tools, Special fields of interest: metabolic studies and biotechnology, plant-pathogenic relationship. [6]

Fungi as model systems: Mutants and wild types: Isolation of various kinds of mutants, functional mutants (auxotrophs, conditional lethals, resistance mutants, reverse mutants) Characterization of mutants: complementation and functional allelism. [6]

Parasexual analysis: Parasexual cycle, heterokaryosis and protoplast fusion, haploidisation, mitotic crossover and recombination, genetic analysis. [6]

Meiotic Recombination: Methods of analysis, linkage: tetrad analysis, gene mapping gene conversion. [8]

Extra-chromosomal elements: Mitochondrial genome, mitochondrial plasmids, 2-micron plasmid, killer plasmid, linear plasmids. [4]

Epigenetic gene silencing in filamentous fungi:

a) RIP
b) MIP
c) Quelling
d) Heterothallism and mating type switch [16]

Transposable genetic elements in filamentous fungi retroposons, reterotransposons (transposon trapping) in fungi. [8]

Genetic transformation and vector development in fungi. [4]

Genetic engineering: Yeast 2-hybrid system and its variations - one-, and three- hybrid system in the study of nucleic acid-protein interaction. [8]

Suggested study material

1.	Fungal Genetics: Principles and Practice	Bos C J.	CRC	1996
2.	The Mycota	Ed. Esser K. &. Lemke P. A.	Springer	1995
3.	Essential Fungal Genetics	Moore D.& Frazer N.	Springer	2002
4	Fungal Genetics	Fincham	Springer	1965

DEPARTMENT OF MICROBIOLOGY

Courses offered under M. Phil (Biotechnology)

Semester I	
MIC I	Diversity of Prokaryotic and Eukaryotic Microbes
MIC II	Microbial Physiology and Metabolism
MIC III	Virology
MIC IV	Immunology
MIC V	**Molecular Biology**
MIC VI	**Recombinant DNA Technology**
MIC VII	**Microbial Genetics**
MIC VIII	**Industrial and Food Microbiology**
Semester II	
MIC IX	Environmental Microbiology
MIC X	Plant - Pathogen Interaction
MIC XI	Microbial Pathogenicity

Note: Papers in bold will be available from 2010 session onwards

MIC I

DIVERSITY OF PROKARYOTIC AND EUKARYOTIC MICROBES

Archaea: Systematics, and occurrence, diversity, characteristic features, significance and potential applications (eg. biochips, methane generation, ultrafiltation membranes, production of PHB and PHA, desulphurization of coal and crude oil, bioleaching of metals, enzymes, compatible solutes and others) of different groups of archaebacteria (Crenarchaeota, Euarchaeota, Korarchaeota, Nanoarchaeota).

Bacteria: Conventional and molecular systematics, and general discussion on the occurrence, diversity, characteristic features, significance and potential applications of various groups of bacteria according to Bergey's Manual of Systematic Bacteriology.

Fungal Systematics and diversity: Implications of molecular and biochemical methods including rDNA analysis, RFLP, RAPD and other fingerprinting techniques, fatty acids, polysaccharides and lipids and role of secondary metabolites in systematics.

Fungal endophytes of tropical plants and their applications: Endophytic fungi, colonization and adaptation of endophytes. Endophytes as latent pathogens and biocontrol agents.

Mycorrhizal fungi: Diversity of endo and ecto mycorrhizal fungi. Biology of arbuscular mycorrhizal fungi: signaling, penetration and colonization inside roots, culturing and benefits, recent advances in the field of mycorrhiza.

Agriculturally important toxigenic fungi: Biodiversity, Chemical and biological characterization of toxic metabolites, toxigenic fungi in sustainable agriculture with special emphasis on biopesticides.

Secondary metabolites from fungi: Terpenes, Non-ribosomal peptides, hydrophobins, peptaibols, indole alkaloids, detailed emphasis on polyketides.

Genomics and Biodiversity of yeast: Gene duplication leading to adaptation and biodiversity, functional evolution, diversity in central metabolism, case of aerobiosis/anaerobiosis, changes in regulatory circuits for adaptation to new environments and physiology.

Antagonistic interactions in yeasts: Mycocinogeny and diversity of mycogenic yeast strains, characteristics of mycocins, mode of action, genetic basis of mycocinogeny, important mycocins, applications of antagonistic yeasts.

Biotechnological applications of yeasts: Yeasts as producers of bioactive molecules such as pigments, lipids, organic acids and EPS, yeasts as probiotics, yeasts in bioremediation, yeasts in alcoholic fermentations.

Algal diversity from morphology to molecules: Importance of algae in production of algal pigments, biofuels, hydrogen production, important bioactive molecules, role of algae in sustainable environment.

Suggested study material

1. The Prokaryotes. A handbook on the biology of bacteria: ecophysiology, isolation, identification, applications. Volumes I-IV by Balows, A., Trüper, H. G., Dworkin, M., Harder, W., Schleifer, K. H. Springer-Verlag, New York; 1992
2. Bacterial Systematics, by Logan, A., Niall A. Logan, Wiley-blackwell; 1994
3. Principles of Microbiology by R.M. Atlas , Mosby publishers, St. Louis; 1995
4. Brock Biology of Microorganisms (12th edition) by Madigan and John M. Martinko, Paul V. Dunlap, David P. Clark Benjamin Cummings; 2008.
5. Microbiology : An Introduction by Gerard J Tortora, Berdell R Funke, Christine L Case Benjamin-Cummings Publishing Company ; 2008.

6. Fundamentals of the fungi by Elizabeth Moore, Fourth edition, Benjamin Cummings; Landecker; 1996.

7. Mycotechnology: Present status and future prospects. Edited by Mahendra Rai. I.K., International Publishing House Pvt. Ltd.; 2007.

8. The Yeast Handbook: Biodiversity and Ecophysiology of yeasts by Carlos A. Rosa and Gabor Peter. Springer- Verlag Berlin Heidelberg; 2006.

9. Algae: Anatomy, Biochemistry and Biotechnology by Laura Barsanti and Paolo Gualtieri. Taylor and Francis Group, LLC; 2006.

MIC II

MICROBIAL PHYSIOLOGY AND METABOLISM

Growth and cell division: Measurement of growth, growth physiology, cell division, growth yields, growth kinetics, steady state growth and continuous growth.

Solute Transport: Primary and Secondary transport: Introduction, Kinetics,
ABC transporters, Phosphotransferase system, Drug export systems, amino acid transport.

Central Metabolic Pathways and Regulation: Glycolysis, PPP, ED pathway, Citric acid cycle: Branched TCA and Reverse TCA, glyoxylate cycle.
Utilization of sugars other than glucose and complex polysaccharides
.
Nitrogen metabolism: Metabolism of amino acids: Amino acid biosynthesis and utilisation, lysine and glutamine overproduction, stringent response, polyamine biosynthesis and regulation.

Metabolism of lipids and hydrocarbons: Lipid composition of microorganisms, biosynthesis and degradation of lipids, lipid accumulation in yeasts, hydrocarbon utilization, PHA synthesis and degradation.

Metabolism of nucleotides: Purine and pyrimidine biosynthesis, regulation of purine and pyrimidine biosynthesis, inhibitors of nucleotide synthesis.

Physiological Adaptations and Intercellular signaling: Introduction to two component system, regulatory systems during aerobic- anaerobic shifts: Arc, Fnr, Nar, FhlA regulon, response to phosphate supply: The Pho regulon
Quorum sensing: A and C signaling system, sporulation in *Bacillus subtilis*, control of competence in *Bacillus subtilis.*
Heat-Shock responses
pH homeostasis, osmotic homeostasis.

Suggested study material

1. Biochemistry by Geoffrey L. Zubay. Fourth Edition, Addison-Wesley educational publishers Inc., 2008
2. Lehninger Principles of Biochemistry by David L. Nelson and Michael M. Cox. Fifth Edition, W.H. Freeman and Company; 2008.
3. Microbial lipids edited by C. Ratledge and SG Wilkinson, second edition, Academic Press; 1988.
4. Microbial Physiology by Albert G. Moat and John W. Foster. Third edition, John Wiley and Sons; 2002
5. The Physiology and Biochemistry of Prokaryotes by David White. Second Edition, Oxford University Press; 2000.

MIC III

VIROLOGY

Section A: Animal Viruses

Classification, Morphology and Chemistry of Viruses: Virus evolution and classification, properties of viruses, virus structure

Working with viruses: Techniques for visualisation and enumeration of viral particles, measuring biological activity of viruses, assays for virus estimation and manipulation, characterization of viral products expressed in infected cells, Diagnostic virology, Physical and chemical manipulation of viruses.

Virus replication Strategies: Principal events involved in replication: Adsorption, penetration, uncoating nucleic acid and protein synthesis, intracellular trafficking, assembly, maturation and release, viral-host interaction, Host response to viral infection.

Replication patterns of specific viruses: Replicative strategies employed by animal DNA viruses. Replicative strategies employed by animal RNA viruses. Identification of virus prototypes associated with different virus replication schemes; Details on important viruses namely Herpesvirus, Poliovirus, Influenza virus, VSV, SV40 and Adeno Virus, Poxviruses, Hepatitis Viruses, coronaviruses, Retroviruses.

Subviral pathogens: HDV, Prions, Viroids

Pathogenesis of viral infection: Stages of infection, Patterns of some viral diseases- epidemiology, transmission, infection, symptoms, risk, transformation and oncogenesis, emerging viruses.

Anti-viral strategies-prevention and control of viral diseases: Host specific and nonspecific defense mechanisms involved in resistance to and recovery from virus infections. Role of interferon in viral infections. Contributions of various host defense mechanisms in viral infections; Viral Chemotherapy: Nucleoside analogs, reverse transcriptase inhibitors, protease inhibitors, History of vaccines especially smallpox and polio. New methods: subunit vaccines, anti-idiotype and DNA vaccines.

Section B: plant and microbial viruses

History and development of plant virology, cryptograms, and classification of plant viruses and viroids:
Brief history of virology highlighting the significant contributions of scientists to the development of plant virology; significance of plant virology and modern classification of plant viruses and viroids according to ICTV; and cryptograms of various plant viruses and virus groups

Propagation, purification, characterization and identification and genomics of plant viruses: **General methods of propagation of plant viruses; purification of plant viruses using centrifugation, chromatography and electrophoresis techniques, their assay and comparison of the sensitivity of assay methods; methods employed in identification of plant viruses and structural and functional genomics**

Symptoms of plant virus diseases, transmission of plant viruses, viral and viroid diseases and their control: General discussion on symptoms caused by viruses and viroids in diseased economically important trees and agricultural crops, and their control including development of virus disease resistant transgenetics

Microbial viruses: Diversity, classification, characteristics and applications of bacteriophages, and general account on algal, fungal and protozoan viruses.

Suggested study material

1. Principles of Virology: Molecular Biology, Pathogenesis and Control of Animal Viruses by S.J. Flint, L.W. Enquist, V.R. Racaniello, and A.M. Skalka 2nd edition, ASM Press, Washington, DC, 2004.

2. Introduction to Modern Virology EPZ by Nigel Dimmock, Andrew Easton and Keith Leppard, 5th edition, Blackwell Publishing, 2005

3. Basic Virology by Edward K. Wanger, Martinez Hewiett, David Bloom and David Camerini, 3rd edition, Blackwell Publishing, 2007.

4. Principles of Molecular Virology by Alan J. Cann, 3rd edition, Elsevier Academic Press, 2001.

5. Plant Virology by Roger Hull, 4th edition, Academic press, 2002.

MIC IV

IMMUNOLOGY

Three fundamental concepts in immunology: Specificity, discrimination of self from non-self and memory.

Immune cell receptors: Detailed structure and development of B cell (Ig) and T cell (TcR) receptors; Structure of CD4, CD8, MHC-I, MHC-II molecules, cellular adhesion molecules (ICAM, VCAM, MadCAM, selectins, integrins); Pattern Recognition Receptors (PRRs) and Toll-like receptors (TLR); Markers of suppressor / regulatory cells - $CD4^+$ $CD25^+$ $Foxp3^+$ T_{reg} , iNKT

Genetic organization: Organization of the genes for B and T cell receptors. Genetic organization of MHC-I and MHC-II complex (both HLA and H-2). Molecular mechanisms r
esponsible for generating diversity of antibodies and T cell receptors. Peptide loading and expression of MHC-I and MHC-II molecules; Hybridoma technology and monoclonal antibodies, antibody engineering.

Immune response and signaling: Humoral and cell-mediated immune response; Innate immune response and pattern recognition; Recent advances in innate immune response especially NK-DC interactions; Major cytokines and their role in immune mechanisms: TNF, IFN, IL-1, IL-2, IL-4, 1L-6, 1L-10, 1L-12, IL-17, TGFβ; Cell signaling through MAP kinases and NF-κB.

Tolerance and autoimmunity: Central and peripheral tolerance, and their mechanism; Mechanisms of autoimmunity; Autoimmune components of diabetes mellitus (DM), multiple sclerosis (MS), experimental autoimmune encephalitis (EAE); Infections leading to autoimmune diseases.

Immunological disorders and hypersensitivity: Deficiencies / defects of T cells, B cells, complement and phagocytic cells; Comparative study of Type I-V hypersensitivities with examples.

Transplantation and tumor immunology: Alloreactive response; Graft rejection and GVHD; HLA-matching; Transgenic animals for xenotransplantation; Tumor antigens, immune response to tumors and immunotherapy of tumors.

Suggested study material

1. Kuby Immunology by Kindt TJ, Goldsby RA, Osborne BA, Kuby J: 6th edition. New York. WH Freeman; 2006.
2. Cellular and Molecular Immunology by Abbas AK, Lichtman AH, Pillai S: Saunders Elsevier; 2007.
3. Immunobiology: The immune system in health and disease by Janeway CA,Travers P,Walport M, Shlomchik MJ: 6th edition. New York. Garland Science Publishing; 2005.
4. Medical Microbiology and Immunology by Levinson W, Jawetz E: Lange publication; 2001.
5. Fundamental Immunology by Paul WE: 4th edition. New York. Raven Press; 2000.
6. Roitt's Essential Immunology by Delves PJ, Martin SJ, Burton DR, Roitt IM; 11th edition. Blackwell Publishing/Oxford Univ. Press; 2006.

MIC V

MOLECULAR BIOLOGY

The nature of Genetic material: The structure of DNA and RNA; Melting of DNA, Superhelicity, Organization of Microbial Genomes, Organization of Eukaryotic Genomes, Chromatin arrangement, nucleosome formation.

DNA replication: Arrangement of replicons in a genome, Various modes of replication, continuous, discontinuous synthesis, various replication Enzymes, Replication Fork and priming, leading and lagging strand, elongation, termination, specific features of replication in Prokaryotes and Eukaryotes, action of topoisomerases, Telomere maintenance and Chromatin Assembly, Single stranded DNA replication, Relationship between DNA replication and cell cycle, DNA copy number maintenance.

Recombination and Repair of DNA: DNA repair and recombination, DNA Mismatch Repair, Double Strand Break Repair, Recombination as a molecular biology tool.

Transcription: Transcription machinery of prokaryotes, various transcription enzymes and cofactors, initiation, elongation and termination, sigma factors, Transcription machinery of eukaryotes, various forms of RNA polymerase and cofactors, initiation, elongation and termination, promoters, enhancers, silencers, activators, effect of chromatin structure, regulation of transcription.

Post-transcriptional processes: RNA processing, splicing, capping and polyadenylation, rRNA and tRNA processing, RNA Editing; RNAi and miRNAs, Antisense RNA, Post-transcriptional gene regulation.

Translation: The genetic code and protein structure, Mechanisms of translation in prokaryotes, Mechanisms of translation in eukaryotes, initiation complex, ribosomes and tRNA, factors, elongation and termination, *in vitro* translation systems, polycistronic/ monocistronic synthesis, Regulation of translation, RNA instability, inhibitors of translation, stringent response in bacteria,

Post-translational processes: Protein modification, folding, chaperones, transportation; The Signal Hypothesis, protein degradation.

Molecular basis of cell physiology: Signals and cacades in organism development, Molecular mechanisms of dormancy, persistence and drug tolerance and drug resistance Molecular mechanisms of Oncogenesis and cancer, genetic disorders, aging, mitochondrial inheritance. Approaches for treatment of same Genetically modified organisms. Use in basic and applied research. Implications of genome organization, Genes and behavior, Genome analysis, DNA typing, Genomics and beyond.

Suggested study material

1. Gene IX by Benjamin Lewin, Jones and Bartlett Publishers, Sudbury, Massachusetts, 2007.
2. Molecular Biology by R.F. Weaver , 4th edition, McGraw Hill. New York. USA, 2007.
3. Molecular Biology of the Gene by J.D. Watson, T.A. Baker, S.P. Bell, A. Gann, M. Levin, R. Losick, 6th edition, Benjamin Cummings, San Francisco, USA, 2007.
4. Molecular Biology of the Cell by B. Alberts, A. Johnson, J. Lewis, M. Raff, K. Roberts, P. Walter, 5th edition, Garland Science, New York and London, 2007.
5. Biochemistry (5th edition) by J.M. Berg, J.L. Tymoczko, L. Stryer, W.H. Freeman and Company, New York, USA, 2008.
6. Current Protocols in Molecular Biology Edited by: Fred M. Ausubel; Roger Brent; Robert E. Kingston; David D. Moore; John A. Smith; Kevin Struhl, John Wiley and Sons, Inc. 2007

MIC VI

RECOMBINANT DNA TECHNOLOGY

Basics of DNA cloning: Simple cloning and cloning using linkers and adaptors. Cloning into various kinds of vectors – plasmids, phages lambda and M13, phagemids, cosmids, P1 phage, PACs, BACs and YACs. Selection and screening of clones.

Methods of DNA and protein analysis: Agarose, polyacrylamide and pulsed field gel electrophoresis of DNA. Southern and Northern Blotting. Radiolabelling probes. Isolation and purification of DNA. RFLP analysis. DNA fingerprinting and its application in forensics, in disease diagnosis and in identification of strains. Native PAGE, SDS-PAGE and two-dimensional PAGE analysis of proteins. Western Blotting analysis.

Polymerase Chain Reaction: Concept of PCR and various thermophilic enzymes used in PCR. Gradient PCR versus Touchdown PCR. Designing primers. Cloning PCR products. Long PCR, Inverse PRC, Vectorette PCR, RT-PCR, 5' and 3' RACE, qPCR, Real Time PCR using SYBR Green, Scorpion primers and TaqMan probes, MOPAC, Multiplex PCR, Differential Display PCR, RAPD fingerprinting of micro-organisms, Ligation Chain Reaction, Overlap PCR, Rolling Circle Amplification Technology.

Construction of cDNA and genomic DNA libraries: Vectors used in the construction of cDNA versus genomic DNA libraries. Steps and enzymes involved in the construction of cDNA versus genomic DNA libraries. Screening libraries by colony hybridization and colony PCR. Screening expression libraries. Enriching for clones in cDNA libraries by positive selection and subtractive hybridization. Identifying genes in complex genomes by direct selection of cDNA and exon trapping.

Genome sequencing: DNA sequencing by Sanger's method – traditional and cycle sequencing. Physical mapping by restriction fragment fingerprinting of BAC clones and STS mapping. E-PCR. Whole genome shotgun sequencing. Clone-by-clone shotgun sequencing of genome – preparation of BAC/YAC library, map construction, clone selection, subclone library construction, random shotgun phase, finishing phase and sequence authentication. Genome annotation at the nucleotide level, protein level and process level. Comparative genome sequencing of micro-organisms to identify and categorize SNPs. Array CGH.

Transcriptional analysis of gene expression and transcriptomics: Gene expression analysis by Northern Blotting, RT-PCR, EST analysis and the use of reporter genes. Enzymatic and bioluminescent reporters. Reporters used in protein localization and trafficking studies. Promoter analysis – deletion analysis and linker scanning analysis coupled to reporter assays, mapping transcriptional start sites by S1 nuclease mapping, primer extension studies or 5' RACE.
Transcriptome analysis by DD-PCR and EST analysis, DNA microarrays (cDNA arrays and oligo arrays), Serial Analysis of Gene Expresion (SAGE).

Overexpression of recombinant proteins: Overexpression and tagging of recombinant proteins in *E.coli,* driven by lac, T7 and Tet-regulatable promoters, Expression in *B. subtilis*. Overexpression systems in *S.cerevisiae*, *P.pastoris, S.pombe* and *K.lactis*. Baculovirus overexpression system. Mammalian cell overexpression system.

Analysis of protein-DNA and protein-protein interactions: Gel retardation assay, DNA footprinting by DNase I and chemical methods, yeast one-hybrid assay, ChIP- chips. Yeast two hybrids, three-hybrids, split hybrids and reverse hybrids. Co-immunoprecipitations, pull-downs and Far-Westerns. GFP and FRET. Phage display.

Protein engineering and proteome analysis: Insertional and deletion mutagenesis. Site directed mutagenesis by conventional and PCR-based methods. Proteome analysis by 2D gel electrophoresis coupled to mass spectrometric analysis. Protein arrays and their applications.

Pharmaceutical products of DNA technology: Human protein replacements – insulin, hGH and Factor VIII. Human therapies – TPA, interferon, antisense molecules. Vaccines – Hepatitis B, AIDS, and DNA vaccines.

Transgenics and animal cloning: Creating transgenic animals and plants**.** Animal cloning.

Suggested study material

1. Molecular Biology by David P. Clarke, 1st edition; Elsevier Academic Press; 2005.
2. Molecular Cloning: A laboratory manual by Joseph Sambrook & David Russell, 3rd edition; CSHL press; 2001.
3. DNA Technology : The Awesome Skill by I. Edward Alcamo, 2nd edition; Hardcourt Academic Press; 2001.
4. Molecular Biology of the Gene by James Watson, Tania Baker, Stephen Bell, Alexander Gann, Michael Levine & Richard Losick , 6th Edition; CSHL Press; 2007.

MIC VII

MICROBIAL GENETICS

Genetic analysis of bacteria: Importance and uses of mutation analysis. Inheritance in bacteria, types of mutations, spontaneous and induced mutagenesis, isolating mutants, selecting mutants, mutant enrichment. Reversions versus suppression. Complementation tests, recombination tests and gene replacements. Cloning genes by complementation. Cloning genes by marker rescue.

Gene transfer and mapping by conjugation: Basis of fertility in bacteria. Self-transmissable and mobilizable plasmids. Molecular mechanism of gene transfer by conjugation – genes and proteins involved. Regulation of gene transfer by conjugation. Hfr strains. Mapping bacterial genomes using Hfr strains. Chromosomal DNA transfer by plasmids – by integrated plasmids, by chromosome mobilization and by creation of prime factors. Transfer systems in gram positive bacteria. Ti plasmid transfer system and its application in creating transgenics.

Lytic bacteriophages: Lytic development cycle using phages T4 and T7 as models. Regulation of expression of genes in phage T4 – transcriptional activators, antitermination, a new sigma factor and replication-coupled transcription. Regulation of gene expression in phage T7 – a phage-encoded RNA polymerase. Replication of T4 versus T7 phages – recent advances. Replication and packaging of filamentous phages M13 and f1 – recent advances. Genetic analysis of phages – complementation and recombination tests with phages. Genetic experiments with the rII genes of phage T4. Deciphering the genetic code using rII mutants. Constructing phage genetic linkage maps using two-factor and three factor crosses.

Gene transfer by transformation and transduction: Natural transformation and competence. Molecular basis of natural transformation – DNA uptake competence systems in gram positive and gram negative bacteria. Regulation of competence in *B.subtilis*. Importance of natural transformation. Artificially induced competence. Generalized versus specialized transduction - T4 and lambda phage. Mapping bacterial genes by transduction.

Lysogenic phages: Lambda phage – gene and promoter organization. Lambda lytic cyle – regulation of gene expression – very early, early and late genes. Establishment and maintenance of lysogeny. Regulation of gene expression in lysogenic phase - role of cI, cII and cIII proteins. Lambda immunity region and immunity to superinfection. Events leading to induction – role of cI and cro repressors in regulating the events. Other lysogenic phages – P2 and P4. Lysogenic phages and bacterial pathogenesis.

Transposons: Discovery of transposition. Classes of bacterial transposons. Regulation of transposition activity. Effects of transposition in bacteria. Genetic requirements for transposition. Assays to analyze transposition events – suicide vectors and mating out assays. Molecular mechanisms of transposition – genetic evidence supporting the mechanisms. Conjugative transposons. Transposon mutagenesis. Cloning out genes by transposon mutagenesis. Mu transposon, Mu*d* transposons and gene fusions, mini-Mu elements and their use in *in vivo* cloning. Yeast Ty-1 transposon. Site-specific recombination – *loxP*-Cre system, phase variation system in *Salmonella*.

Gene regulation: Control of gene expression. Positive gene regulation, negative gene regulation and attenuation, using the *lac*, *gal*, *trp*, *ara* and *tol* operons, with emphasis on recent advances.

Suggested study material

1. Molecular Genetics of Bacteria by Larry Snyder and Wendy Champness, 3rd edition; ASM press; 2007.
2. Fundamental Bacterial Genetics by Nancy Trun and Janine Trempy, 1st edition; Blackwell Science Publishers; 2004.
3. Modern Microbial Genetics by U.N. Streips and R.E. Yasbin, 2nd edition; Wiley Publishers; 2002.
4. Microbial Genetics by Stanly R. Maloy, John E. Cronan, Jr. & David Freifelder, 2nd edition; Narosa Publishing House; 1987.

MIC VIII

INDUSTRIAL AND FOOD MICROBIOLOGY

Section A

Introduction to industrial microbiology: Sources of industrially important microbes, strain development, types of fermentation and fermenters, process optimization, and recent developments in fermentation technology.

Downstream processing of microbial products: Filtration, centrifugation, cell disruption, liquid-liquid extraction, chromatography, membrane processes, drying (lyophilization and spray drying), and crystallization

Fermentation economics: Basic objective for successful economically viable fermentation process, cost break down for well established fermentation processes, market potential of the products, cost aspects of various stages in the processes development including effluent treatment

Production aspects: Microbial strains, substrates, strain improvement, flow diagrams, product optimization, and applications of industrial alcohol (ethanol and butanol), amino acids (lysine, phenylalanine, tryptophan), antibiotics (cephalosporins, tetracyclines, polyenes), enzymes and immobilized enzymes, SCP, microbial polyesters, biosurfactants, and recombinant products (insulin, somatostatin, thaumatin).

Section B

Microbiology of foods: Vegetables, fruits, milk, fermented and non-fermented milk products, fresh meats, poultry and non-dairy fermented foods.

Microbial spoilage of foods

Food preservation: Chemical, physical and biological methods.

Fermentation processes: Production of milk and milk products, plant based products, fish products, meat products and food beverages.

Food-borne diseases

Suggested study material

1. Biotechnology: A Text Book of Industrial Microbiology by W. Crueger & A. Crueger, Panima Publishing Corporation, New Delhi/Bangalore, 2000.
2. Principles of Fermentation Technology by P.F. Stanbury, W. Whitaker &S.J. Hall, Aditya Books (P) Ltd., New Delhi, 1997.
3. Modern Industrial Microbiology & Biotechnology by N. Okafer, Scientific Publishers, Enfield, USA., 2007.
4. Fermentation Microbiology and Biotechnology by El Mansi & Bryce, Taylor & Francis, London, Philadelphia, 1999.
5. Fermentation Biotechnology by O.P. Ward, Open University Press, Milton Keynes, U.K., 1989
6. Industrial Microbiology: An Introduction by Waites, Morgan, Rockey & Highton, Blackwell Science, 2001.
7. Biochemical Engineering and Biotechnology by B. Atkinson & F. Mavituna , The Nature Press, 1982
8. Microbial Biotechnology: Fundamentals of Applied Microbiology by Glazer & Nikaido , W.H. Freeman and Co., New York, 1995.
9. Modern Food Microbiology, 4th edition by J.M. Jay, Springer, 2006.
10. Fundamental Food Microbiology , 3rd edition by B. Ray., CRC press, 2006.
11. Food Microbiology: Fundamentals and Frontiers, 2nd edition by Michael P. Doyle, Larry R. Beuchat, Thomas J. Montville, ASM press, 2001.
12. Food Microbiology by M.R. Adams & M.O. Moss., Royal Society of Chemistry, 2000.
13. Food Microbiology by M.R. Adams, Royal Society of Chemistry, 2008.

MIC IX

ENVIRONMENTAL MICROBIOLOGY

Section A

Brief history and development of environmental microbiology: History and development of microbial ecology highlighting significant contributions of microbiologists and emergence of environmental microbiology, and significant applications of microbes in solving environmental pollution problems

Culture-dependent and culture-independent approaches for understanding microbial diversity in the environment: Understanding microbial diversity in the environment by culture-dependent approaches and their limitations, and by culture-independent molecular approaches (DNA heterogeneity by reannealing denatured environmental DNA, ARDRA, analysis of FAME profiles, measuring metabolic capabilities using BIOLOG microtitre plates, using DNA probes and PCR primers, G+C analysis, slot-blot hybridization of community DNA, and fluorescent *in situ* hybridization of intact cells)

Microbial diversity in normal environments: Diversity of microbes in terrestrial (agricultural and desert soils), aquatic (fresh water and marine), atmospheric (stratosphere) and animal (cattle, termites, pests such as cockroach and nematodes, and human being) and their potential applications

Microbial diversity in extreme environments: Occurrence, diversity, adaptations and potential applications of oligotrophs, thermophiles, psychrophiles, barophiles, organic solvent and radiation tolerants, metallophiles, acidophiles, alkaliphiles and halophiles

Global warming: The source and variety of gases which contribute to global warming, effects of global warming and remedial measures

Section B

Lignin degradation: Lignocellulolytic microorganisms, enzymes and their biotechnological applications in: (i) biopulping, (ii) biobleaching, (iii) textiles (iv) biofules, (v) animal feed production.

Liquid waste management: Treatment of sewage (Primary, Secondary and Tertiary treatments) and Treatment of Industrial effluents (distillery, textile, pulp and paper).

Solid waste management: Waste types & their possible usages, landfill development and composting.

Bioremediation of environmental pollutants: Petroleum hydrocarbons and pesticides.

Microbes and mineral recovery: Bioleaching of copper, gold and uranium.

Suggested study material

1. Microbial Ecology By Atlas R.M., Bartha R., Benjamin Cummings Publishing Co, Redwood City, CA., 1993.
2. Environmental Microbiology by A.H. Varnam & M.G. Evans, Manson Publishing Ltd., 2000.
3. Manual of Environmental Microbiology by Christon J. Hurst, Ronald L. Crawford, Jay L. Garland, David A. Lipson, Aaron L. Mills, ASM Press, 2007.
4. Environmental Microbiology by W.D. Grant & P.E. Long, Kluwer Academic Publishers, 1981.
5. Environmental Microbiology by R. Mitchel (2nd edition), Wiley-Blackwell, 2009.
6. Microbiology: An environmental Perspective by P. Edmonds, Macmillan, New York, 1978.
7. Environmental Microbiology by Raina Maier, Ian Pepper, & Charles Gerba, Academic Press, 2008.
8. Environmental Microbiology: Principles And Applications by Patrick K. Jjemba, Science Publishing Inc., 2004.

9. Encyclopedia of Microbiology, Six-Volume Set, 1-6 by Moselio Schaechter, Academic press, 2009.

10. Lignocellulose Biotechnology: Future Prospects by R.C. Kuhad and A. Singh, I.K. International, 2007.

11. Applied Bioremediation and Phytoremediation by A. Singh and O.P. ward, Springer, 2004.

12. Microbial and Enzymatic Degradation of Wood and Wood components, by K-E.L. Eriksson, R.A. Blanchettee and P. Ander, Springer, 1990.

13. Advances in Applied Bioremediation by A. Singh, R.C. Kuhad and O.P. Ward, Springer, 2009.

MIC X

PLANT – PATHOGEN INTERACTION

Concepts and physiology of plant diseases: What is a disease and what causes disease, pathogenesis, pathogenesis in relation to environment, effect of microbial infections on plant physiology, photosynthesis, respiration, transpiration, translocation.

Biochemical basis of plant diseases: Enzymes and toxins in plant diseases, phytoalexins.

Some important plant diseases and their etiological studies: Crown gall, symptoms of viral diseases and their control, diseases of some important cereals, vegetables and crops.

Genetical basis of plant diseases: Genetics of host-pathogen interactions, resistance genes, resistance mechanism in plants.

Disease control: Principles of plant disease control, physical and chemical methods of disease control, biocontrol, biocontrol agents - concepts and practices, fungal agents, *Trichoderma* as biocontrol agent, biocontrol agents – uses and practical constraints.

Molecular approach: Molecular diagnosis, transgenic approach for plant protection, futuristic vision of molecular diagnosis, applications and constraints.

Disease forecasting: History and important milestones in disease control, disease forecasting and its relevance in Indian farming.

Suggested study material

1. Plant pathology by George N. Agrios: 4th ed., Academic press, New York, 1969.
2. Plant pathology by R.S. Mehrotra: Tata McGraw –Hill publishing company limited. New Delhi.
3. Bacterial plant pathology, cell and molecular aspects by David C. Sigee, Cambridge University Press, 1993.
4. Molecular plant pathology by M. Dickinson: BIOS Scientific Publishers, London, 2003.
5. The essentials of Viruses, Vectors and Plant diseases by A.N. Basu & B.K. Giri: Wiley Eastern Limited, 1993.
6. Biocontrol of Plant Diseases (Vol. I) by K.G. Mukerji & K.L. Garg: CRC Press, Inc., Boca Raton, Florida, 1988.
7. Molecular Biology of Filamentous Fungi by U. Stahl & P. Tudzyski: VCH Verlagsgesellschaft mbH, D-6940 Weinheim (Federal Republic of Germany), 1992.

MIC XI

MICROBIAL PATHOGENICITY

Classical view of microbial pathogenicity: Define pathogenicity and virulence; Quantitative measures of virulence: minimal lethal dose (MLD), LD_{50}, $ID_{50,}$ $TCID_{50.}$ Virulence determinants: colonization, toxins, enzymes and invasiveness. Facultative / obligate intracellular pathogens.

Molecular microbial pathogenicity: Molecular Koch's postulates, multiplicity of virulence features, coordinated regulation of virulence genes, two component signal transudation systems and environmental regulation of virulence determinants, antigenic variation; clonal and panmictic nature of microbial pathogens, type 1-IV secretion systems, biofilms and quorum sensing.

Emerging and re-emerging pathogens: Illustrate emerging and re-emerging pathogens using *V. cholerae* O: 139, X-MDR *M. tuberculosis, Helicobacter pylori,* Enterohaemorrhagic *E. coli* (EHEC), *Cryptosporidium parvum*, Lyme disease, SARS virus, Bird flu, prions, AIDS, Dengue Hemorrhagic Fever, and *Chlamydiae*, opportunistic fungal pathogens. Mechanisms of emergence of new pathogens: microbial change and adaptation, horizontal gene transfer (HGT), pathogenicity islands (PAI), role of integrons.

Molecular microbial epidemiology: Objectives of microbial epidemiology. Biochemical and Immunological tools - biotyping, serotyping, phage typing, FAME, Curie Point PyMS, protein profiling, multilocus enzyme electrophoresis (MLEE); Molecular typing: RFLP (ribotyping, IS based), RAPD, 16S-23S IGS, ARDRA, rep (REP, ERIC, BOX)-PCR, PFGE, AFLP, MLST, MVLST, VNTR, SNP, Microarry and whole genome sequence; GIS

Environmental change and infectious diseases: Global warming lead increase in vector-borne and water-borne infectious diseases; Impact of increasing urbanization, international travel and trade on infectious diseases.

Antimicrobial resistance: Recent concepts – Multidrug efflux pumps, extended spectrum β-lactamases (ESBL), X-MDR *M. tuberculosis*, Methacillin-resistant *S. aureus* (MRSA).

Newer vaccines: Recombinant vaccines, subunit vaccines, DNA vaccines, Vaccinia, BCG and HIV– vector based vaccines

Rapid diagnostic principles: Nucleic acid probes in diagnostic microbiology, nucleic acid amplification methods, Real-time PCR, diagnostic sequencing and mutation detection, molecular typing methods, array technology.

Suggested study material

1. Jawetz, Melnick, & Adelberg's Medical Microbiology by Brooks GF, Butel JS, Morse SA, Melnick JL, Jawetz E, Adelberg EA . 23rd edition. Lange Publication. 2004.

2. Cellular Microbiology by Cossart P, Boquet P, Normark S, Rappuoli R eds. 2nd edition. American Society for Microbiology Press. 2005.

3. Bacterial Pathogenesis: A molecular approach by Salyers AA and Whitt DD eds. American Society for Microbiology Press, Washington, DC USA. 2002.

4. Pathogenomics: Genome analysis of pathogenic microbes by Hacker J and Dorbindt U. ed. Wiley-VCH. 2006.

5. Molecular Microbiology: Diagnostic Principles and Practice by Persing DH, Tenover FC, Versalovic J, Tang Y, Unger ER, Relman DA, White TJ eds. American Society for Microbiology Press, 2004.

6. Infectious Disease Epidemiology: Theory and Practice by Nelson KE, Williams CM, Graham NMH eds. An Aspen Publication. 2001

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