Web Site Address: https://jmi.ac.in

M.Sc. Semester I

Molecular Biology

3 Credits

Unit 1: Structure and organization of genome (8 Hours)

Chromatin organization - histone and DNA interactome, the structure of chromatin, nucleosome, chromatin organization and remodeling, chromosome, heterochromatin, and euchromatin, torsional stress, DNA topology- linking number, twist, writhe, supercoiling, topoisomers.

Unit 2: DNA replication, repair and recombination (8 Hours)

DNA replication models, Meselson and Stahl experiment, DNA polymerases, DNA replication in viruses, bacteria and eukaryotes, replication fork, proofreading and fidelity of replication, end replication problem and telomerase, replication inhibiting drugs, DNA damaging agents, DNA repair mechanisms (nucleotide excision repair, base excision repair, mismatch repair, recombination repair, double strand break repair, transcriptional coupled repair, recombination- homologous, non-homologous and site-specific recombination)

Unit 3: Gene expression and regulation (8 Hours)

Structure of prokaryotic and eukaryotic genes, regulatory regions, transcription factors, transcription machinery, RNA polymerases, RNA processing structure and functions of different RNA types, initiation complex formation, elongation, termination,; operon concept- lac operon, trp operon, arb operon, λ-repressor, lexA repressor, lysogenic and lytic cycles of bacteriophages, riboswitches, inhibitors of transcription.

Unit 4: Protein synthesis, processing and transport (8 Hours)

protein translation machinery, ribosomes-composition and assembly; universal genetic codes, degeneracy of codons, Wobble hypothesis; Iso-accepting tRNA; mechanism of initiation, elongation and termination; co- and post-translational modifications, translational inhibitors.

Unit 5: Methods and techniques in molecular biology (8 Hours)

Methods of isolating DNA (genomic and plasmid) and RNA, DNA and RNA analysis by electrophoresis, agarose and polyacrylamide gels, DNA and RNA purity analysis, DNase I footprinting, EMSA, yeast-two hybrid system, PCR.

M.Sc. Semester I

Cell Biology

3 credits

Unit 1: Cellular structure and composition (8 Lectures)

Universal features of cells, compartmentalization of cells, structure and functional features of cellular organelles; nucleus and its components, endoplasmic reticulum, Golgi apparatus, mitochondria, chloroplast and cell energetic, lysosomes and peroxisomes, cellular cytoskeleton, general principles of cell communication, role of different adhesion molecules, cell junctions

Unit 2: Membrane structure and function (8 Lectures)

Plasma membranes, lipid bilayers, membrane models, structural and functional properties of the plasma membrane, transport across the plasma membrane, membrane electric potentials, sorting and regulation of intracellular transport, cytoplasmic membrane system, vesicular traffic, exocytosis, endocytosis, pinocytosis, protein trafficking.

Unit 3: Cell signaling (10 Lectures)

Extracellular and intracellular signaling, signal transduction receptors, ligands, structure and function of G-protein coupled receptors, receptor and non-receptor kinases, intracellular signaling transducers, kinases, phosphorylation, PI3K, MAPK and JAK-STAT pathways, signaling molecules, IP3/DAG, cAMP, secondary messengers, Wnt signaling. Hedgehog

signaling, Toll-like receptor signaling signaling pathways in apoptosis and cancer.

Unit 4: Cell differentiation, cell death, cell cycle and cancer (8 Lectures)
Cell differentiation, programmed cell death, necrosis, cell cycle and its regulation, role of hormones and growth factors in- regulation of differentiation, cell transformation and cancer, hallmarks of cancer, initiation and progression of cancer, oncogenes and tumour suppressor genes and their mutations, role of mutations in cancer.

Unit 5: Methods and techniques in cell biology (6 Lectures)
Confocal and immunofluorescence microscopy, sample staining and fixation for microscopy, Scanning and transmission microscopes, cell sorting (flowcytometry).

Suggested readings

1. The Cell: A Molecular Approach, 6th edition (2013)- Geoffrey M. Cooper, Robert E. Hausman, Sinauer Associates, Inc. USA
2. Molecular Biology of the Cell: 5th edition (2007)- Bruce Alberts, Alexander Johnson, Julian Lewis, Martin Raff, Keith Roberts, Peter Walter. Garland Science, USA.
3. Cell Biology: 6th edition, (2010)- Gerald Karp. John Wiley & Sons., USA
4. Molecular Cell Biology: 7th Edition, (2012)- Lodish H., Berk A, Kaiser C., KReiger M., Bretscher A., Ploegh H., Angelika Amon A., Matthew P. Scott M.P., W.H. Freeman

M.Sc. Semester I
Biochemistry and Biophysics **3 credits**

Unit1: Bioenergetics and Biophysical Chemistry (6 Lectures)
Concepts of Buffer, Reaction kinetics, Henderson-Hasselbalch equation, Thermodynamics, Enthalpy, Free energy, Entropy, Gibbs-Helmholtz equation, Spontaneous and non-spontaneous reaction, Endergonic and Exergonic reactions, Reversible and Irreversible reactions.

Unit 2: Methods and Techniques (6 Lectures)
Electrophoresis- SDS and native Polyacrylamide gel electrophoresis, 1- and 2-dimensional electrophoresis, Isotachophoresis, Isoelectric focusing, Protein purification, Dialysis, Salting-in and salting-out, Affinity chromatography, Size-exclusion chromatography, Ion-exchange chromatography, UV-Visible spectroscopy, Fluorescence spectroscopy, Circular Dichroism (CD), protein quantitation, and detection- Bradford method, Lowry method.

Unit 3: Carbohydrate Metabolism (8 Lectures)
Glycolysis; Fermentation: The Anaerobic Fate of Pyruvate; Metabolism of Hexoses Other than Glucose; Glycogen; Breakdown & Synthesis; Gluconeogenesis; Pentose Phosphate Pathway; Glyoxylate cycle; Metabolic Regulation and Control

Unit 4: Citric Acid Cycle, Electron Transport, Oxidative Phosphorylation (6 Lectures)
Cyclic Overview; Metabolic Sources of Acetyl; Coenzyme A; Enzymes of the Citric Acid Cycle; Regulation of the Citric Acid Cycle; The Mitochondrion; Electron Transport; Oxidative Phosphorylation; Control of ATP Production

Unit 5: Lipid, Amino acids metabolism and Nucleotide metabolism (14 Lectures)
Lipids, transport of lipids, fatty acid activation and transport into mitochondria, Fatty Acid Oxidation & Biosynthesis; Regulation of Fatty Acid Metabolism; **Amino acid metabolism:** transamination reactions, transport of amino groups, urea cycle, metabolic breakdown of individual amino acids, Amino Acids as Biosynthetic Precursors; **Nucleotide metabolism:** Structures of nucleotides, synthesis of purines and pyrimidines- de novo and salvage pathways, catabolism of purine & pyrimidines, Formation of Deoxyribonucleotides

Suggested readings:

1. Lehninger, Principles of Biochemistry. David Nelson & Michael Cox,W.H. Freeman and company, NY.
2. Fundamentals of Biochemistry. Donald Voet & Judith Voet , JohnWiley and Sons, Inc. USA
3. Physical Biochemistry by David Freifelder
4. Biochemistry: 7th Edition, (2012), Jeremy Berg, Lubert Stryer, W.H.Freeman and company, NY
5. Introduction to Practical Biochemistry, S. K. Sawhney, Randhir SinghNarosa,

M.Sc. Semester I
Immunology

3 credits

Unit I: Immunology: fundamental concepts and overview of the immune system (8 lectures)

Components of innate and acquired immunity; phagocytosis; complement and inflammatory responses; pathogen recognition receptors (PRR) and pathogen associated molecular pattern (PAMP); innate immune response; mucosal immunity; antigens: immunogens, haptens; Major Histocompatibility Complex: MHC genes, Organs of immune system, primary and secondary lymphoid organs.

Unit II: Immune responses generated by T lymphocytes (8 lectures)

Antigen processing and presentation- endogenous antigens, exogenous antigens, Self MHC restriction, importance of Thymus in T-cell maturation, role of TCR-MHC interaction in T cell activation, T-cell maturation, activation and differentiation, organization of TCR genes; and T-cell receptors; functional T Cell subsets; cell-mediated immune responses.

Unit III: Immune responses generated by B lymphocytes (8 lectures)

Immunoglobulins - basic structure, classes & subclasses of immunoglobulins, antigenic determinants; multigene organization of immunoglobulin genes; B-cell receptor; Immunoglobulin superfamily; kinetics of immune response, memory; B cell maturation, activation and differentiation; generation of antibody diversity; ADCC; non-peptide bacterial antigens and super-antigens;

Unit IV: Vaccinology (8 lectures)

Active and passive immunization; live, killed, attenuated, subunit vaccines; vaccine technology: role and properties of adjuvants, recombinant DNA and protein based vaccines, plant-based vaccines, reverse vaccinology; peptide vaccines, conjugate vaccines; antibody genes and antibody engineering:chimeric, generation of monoclonal antibodies, hybrid monoclonal antibodies; catalytic antibodies and generation of immunoglobulin gene libraries, idiotypic vaccines and marker vaccines, viral-like particles (VLPs), dendritic cell based vaccines, vaccine against cancer, T cell based vaccine, edible vaccine and therapeutic vaccine.

Unit V: Clinical immunology and Immunogenetics (8 lectures)

Immunity to infections, Hypersensitivity: Type I-IV; autoimmunity; types of autoimmune diseases; mechanism and role of CD4+ T cells; MHC and TCR in autoimmunity; treatment of autoimmune diseases; transplantation: immunological basis of graft rejection; clinical transplantation and immunosuppressive therapy; tumor immunology: tumor antigens; immune response to tumors and tumor evasion of the immune system, cancer immunotherapy; immunodeficiency: primary immunodeficiencies, acquired or secondary immunodeficiencies, autoimmune disorder, anaphylactic shock, immunofluroscence, immune exhaustion in chronic viral infection, immune tolerance, NK cells in chronic viral infection and malignancy. Major histocompatibility complex genes and their role in autoimmune and infectious diseases, HLA typing, human major histocompatibility complex (MHC), Complement genes of the human

major histocompatibility complex and disease associations, genetic studies of rheumatoid arthritis, systemic lupus erythematosus and multiple sclerosis, genetics of human immunoglobulin.

Recommended Textbooks and References:

1. Kindt, T. J., Goldsby, R. A., Osborne, B. A., & Kuby, J. (2006). Kuby Immunology. New York: W.H. Freeman.
2. Brostoff, J., Seaddin, J. K., Male, D., & Roitt, I. M. (2002). Clinical Immunology. London: Gower Medical Pub.
3. Murphy, K., Travers, P., Walport, M., & Janeway, C. (2012). Janeway's Immunobiology. New York: Garland Science.
4. Paul, W. E. (2012). Fundamental Immunology. New York: Raven Press.
5. Goding, J. W. (1996). Monoclonal Antibodies: Principles and Practice: Production and Application of Monoclonal Antibodies in Cell Biology, Biochemistry, and Immunology. London: Academic Press. 6. Parham, P. (2005). The Immune System. New York: Garland Science.

M.Sc. Semester II
Microbiology **3 Credits**

Unit I Microbial characteristics (9 lectures)

Introduction to microbiology and microbes, history & scope of microbiology, morphology, structure, growth and nutrition of bacteria, bacterial growth curve, bacterial culture methods; bacterial genetics: mutation and recombination in bacteria, plasmids, transformation, transduction and conjugation; antimicrobial resistance.

Unit II Microbial diversity (12 lectures)
Microbial taxonomy and evolution of diversity, classification of microorganisms, criteria for classification; classification of bacteria; Cyanobacteria, acetic acid bacteria, Pseudomonads, lactic and propionic acid bacteria, endospore forming bacteria, Mycobacteria and Mycoplasma. Archaea: Halophiles, Methanogens, Hyperthermophilic archae, Thermoplasm; eukarya: algae, fungi, slime molds and protozoa; extremophiles and unculturable microbes.

Unit III Control of microorganisms (5 lectures)
Sterilization, disinfection and antisepsis: physical and chemical methods for control of microorganisms, antibiotics, antiviral and antifungal drugs, biological control of microorganisms.

Unit IV Virology (5 lectures)
Virus and bacteriophages, general properties of viruses, viral structure, taxonomy of virus, viral replication, cultivation and identification of viruses; sub-viral particles – viroids and prions.

Unit V Host-microbes interaction (8 lectures)
Host-pathogen interaction, ecological impact of microbes; symbiosis (Nitrogen fixation and ruminant symbiosis); microbes and nutrient cycles; microbial communication system; bacterial quorum sensing; microbial fuel cells; prebiotics and probiotics.

Recommended Textbooks and References:

1. Pelczar, M. J., Reid, R. D., & Chan, E. C. (2001). *Microbiology* (5th ed.).New York: McGraw-Hill.
2. Willey, J. M., Sherwood, L., Woolverton, C. J., Prescott, L. M., & Willey, J. M. (2011). *Prescott's Microbiology*. New York: McGraw-Hill.
3. Matthai, W., Berg, C. Y., & Black, J. G. (2005). *Microbiology, Principles and Explorations*. Boston, MA: John Wiley & Sons.

M.Sc. Semester II
Enzymology and Enzyme Technology

3 credits

Unit 1: Protein Structure (8 Lectures)
Primary and higher-order structures, Ramachandran plot, Protein folding: Anfinsen's Dogma, Levinthal paradox, cooperativity in protein folding, free energy landscape of protein folding and pathways of protein folding, Molten globule state, Chaperones in protein folding, diseases associated with protein folding, Effect of denaturants and reducing agents on protein folding and structure

Unit 2: Enzymes and Catalysis (6 Lectures)
Introduction about enzymes; History; General characteristics of enzymes; Classification of enzymes; Activation energy and catalysis; Enzyme catalytic power; Factors affecting enzyme activity (pH, temperature, substrate, product concentrations); Feedback and feed-forward regulation of enzymes

Unit 3: Enzyme Kinetics and Inhibition (9 Lectures)

Concepts of enzyme kinetics; Michaelis - Menten, Lineweaver-Burke, Eadie-Hofstee and Hanes-Woolf equations and Km value plot; Steady-state and Pre-steady state kinetics; Enzyme inhibition and activation; Immobilization of enzymes and its applications; Specific activity of enzymes; Concept of Isozymes; Allosteric enzymes and their regulation; T and R states in proteins; Haemoglobin and myoglobin kinetics

Unit 4: Enzyme immobilization (7 Lectures)

Methods – adsorption, matrix entrapment, encapsulation, cross-linking, covalent binding; advantages and disadvantages of different immobilization techniques, immobilized enzyme kinetics

Unit 5: Protein Engineering and Applications (10 Lectures)

Protein engineering – definition, applications; Features or characteristics of proteins that can be engineered (definition and methods of study); Protein engineering with unnatural amino acids and its applications; Coenzyme; Ribozymes; Enzymatic bioconversions e.g., starch and sugar conversion processes, hydrolyzed protein processes; Applications of protein engineering-devices with bacteriorhodopsin as an example, engineering antibody affinity by yeast surface display, applications in vaccines, peptidomimetics, and drug discovery

Suggested readings:

1. Lehninger Principles of Biochemistry, David L. Nelson, David L. Nelson, Albert L. Lehninger, Michael M. Cox,
2. Biochemistry, LubertStryer, John L. Tymoczko, Jeremy Mark Berg, Pub.W. H. Freeman Company,
3. Harper's Illustrated Biochemistry by Robert K. Murray, Darryl K. Granner, Peter A. Mayes, Victor W. RodwellPub:McGraw-Hill Medical
4. Proteins: Structure and Molecular Properties by T.E. Creighton
5. Fundamentals of Biochemistry. Donald Voet & Judith Voet , JohnWiley and Sons, Inc.
6. Enzymes: Biochemistry, Biotechnology & Clinical chemistry Palmer Trevor,Publisher: Horwood Pub. Co., England
7. Practical Enzymology, 2nd edition (2011), Hans BissWanger, Wiley-Blackwell,USA
8. Introduction to Practical Biochemistry, S. K. Sawhney, Randhir SinghNarosa

M.Sc. Semester II
Animal Biotechnology

3 credits

Unit 1: Introduction to animal tissue culture (8 Lectures)

Tissue culture- definition, concept and significance, maintenance of sterility and use of antibiotics, detection of various biological contamination, cross-contamination, formulation of tissue culture media- serum and synthetic media, sterilization of culture media and reagents, introduction to the balance salt solutions, simple growth media, culture conditions, role of temperature, pH, carbon dioxide and oxygen in animal cell culture, role of different media components in cell culture.

Unit 2: Tissue culture characteristics (8 Lectures)

Primary culture, the establishment of cell lines, immortalization of cell lines, maintenance and passaging, cryo-preservation, and revival of cells in culture, freezing, and storage of culture cells, cell growth curve, adherent and suspension culture, the role of growth factors in cell culture, various methods of cell separation

Unit 3: Organ culture (8 Lectures)

3D culture and spheroid formation, applications of 3D culture, organ explant and utility of

organ culture, histotypic and organotypic cultures, organ transplants, regenerative medicine, tissue engineering and its application.

Unit 4: Tissue culture applications (8 Lectures)

Experimental applications- cell proliferation assays, cell synchronization, measurement of viability and cytotoxicity. transformation, transfection,micro-manipulation, nuclear transplantation, cell hybridization, in vitro drug testing in cell culture, production of vaccines and proteins of pharmaceutical relevance, recombinant protein production, harvesting and purification.

Unit 5: Applied animal biotechnology (8 Lectures)

Artificial breeding – in vitro fertilization, cloning and embryo transfer technology, artificial insemination, germ cell storage, transgenic animals- fish, mice and sheep, gene targeting and transfer, mouse models for human genetic disorder and diseases, knock-out and knock-in mice.

Suggested readings

1. R. Ian Freshney. Culture of Animal cells, 5th Edition, 2010. A John Wiley & Sons, Inc., Publications, USA
2. Gene Transfer to Animal Cells, 1st edition (2005), R. M. Twyman, Taylor & Francis USA.
3. Molecular Biotechnology: 4 edition. (2010), Glick B.R., Pasternak J.J., Patten C. L., ASM press, USA

M.Sc. Semester II
Genetic Engineering

credits

Unit 1: Introduction and tools for genetic engineering [6 lectures]

General requirements for performing a genetic engineering experiment; restriction endonucleases and methylases; DNA ligase, Klenow enzyme, T4 DNA polymerase, polynucleotide kinase, alkaline phosphatase; cohesive and blunt end ligation; linkers; adaptors; homopolymeric tailing; labelling of DNA: nick translation, random priming, radioactive and non-radioactive probes, hybridization techniques: northern, southern, south-western and far-western and colony hybridization, fluorescence *in situ* hybridization.

Unit 2: Different types of vectors [7 lectures]

Plasmids; Bacteriophages; M13 mp vectors; PUC19 and Bluescript vectors, phagemids; Lambda vectors; Insertion and Replacement vectors; Cosmids; Artificial chromosome vectors (YACs; BACs); Principles for maximizing gene expression expression vectors; mammalian expression and replicating vectors; Baculovirus and *Pichia* vectors system, plant-based vectors, Ti and Ri as vectors, yeast vectors, shuttle vectors.

Unit 3: Different types of PCR techniques [8 lectures]

Principles of PCR: primer design; fidelity of thermostable enzymes; DNA polymerases; types of PCR – multiplex, nested; reverse-transcription PCR, real-time PCR, touchdown PCR, hot start PCR, colony PCR, asymmetric PCR, cloning of PCR products proof reading enzymes; PCR based site specific mutagenesis; PCR in molecular diagnostics; viral and bacterial detection; sequencing methods; enzymatic DNA sequencing; chemical sequencing of DNA; automated DNA sequencing; RNA sequencing; chemical synthesis of oligonucleotides.

Unit 4: Gene manipulation and protein-DNA interaction [7 lectures]

Insertion of foreign DNA into host cells; transformation, electroporation, transfection; construction of libraries; cDNA and genomic libraries; construction of microarrays – genomic arrays, cDNA arrays and oligo arrays; study of protein-DNA interactions: electrophoretic mobility shift assay; DNase footprinting; methyl interference assay, chromatin immunoprecipitation; protein-protein interactions using yeast two-hybrid system; phage display.

Unit 5: Gene silencing and genome editing techniques [12 lectures]

Gene silencing techniques; introduction to siRNA; micro RNA; principle and application of gene silencing; gene knockouts and gene therapy; creation of transgenic plants; debate over GM crops; introduction to methods of genetic manipulation in different model systems *e.g.* fruit flies (*Drosophila*), worms (*C. elegans*), frogs (*Xenopus*), fish (zebra fish) and chick; Transgenics - gene replacement; gene targeting; creation of transgenic and knock-out mice; introduction to genome editing by CRISPR-CAS.

Recommended Textbooks and References:

1. From Genes to Genomes, 2nd edition, (2008), J.Dale and M.Schantz, John Wiley & SonLtd.USA
2. Gene Cloning and DNA Analysis: an introduction, 6th edition, (2010) T. A. Brown,Wiley- Blackwell Publisher, UK
3. From Gene to Clones ; Introduction to gene technology, 4th edition, (2003), E. Winnacker,Panima Publisher, India
4. Principles of Gene Manipulation & Genomics, 7th Edition (2006), Primrose and Twyman,Blackwell Publishing, USA.
5. Green, M. R., & Sambrook, J. (2012). Molecular Cloning: a Laboratory Manual. Cold Spring Harbor, NY: Cold Spring Harbor Laboratory Press.
6. Brown, T. A. (2006). Genomes (3rd ed.). New York: Garland Science Pub.
7. Selected papers from scientific journals, particularly Nature & Science.

M.Sc. Semester II
Molecular Physiology

3 credits

Unit 1: Blood physiology (8 lectures)

Blood and circulation- blood corpuscles, hematopoiesis and formed elements, plasma function, blood volume, blood volume regulation, blood groups, hemoglobin, carbon dioxide and oxygen transport, Bohr effect, homeostasis.

Unit 2: Vascular and respiratory physiology (8 lectures)

Heart structure, myogenic heart, specialized tissue, ECG – its principle and significance, cardiac cycle, blood pressure, neural and chemical regulation. Respiratory system- transport of gases, exchange of gases, waste elimination, neural and chemical regulation of respiration.

Unit 3: Endocrinology (8 lectures)

Endocrine glands, basic mechanism of hormone action, hormones and diseases, different types of hormones, classes of hormones, hormone receptors, function of different hormones, regulation of hormone secretion and feedback mechanism, reproductive processes and its hormonal regulation

Unit 4: Nervous system and sense organs (8 lectures)

Neurons, synapse, action potential, nerve impulses and excitation, neurotransmitters, gross neuroanatomy of the brain and spinal cord, central and peripheral nervous system, neural motor plates and neuromuscular junctions. Vision, hearing and tactile response.

Unit 5: Excretory and thermoregulatory system (8 lectures)

Comparative physiology of excretion, kidney, urine formation, urine concentration, waste elimination, regulation of water balance, blood volume, electrolyte balance, acid-base balance.Comfort zone, body temperature – physical, chemical, neural regulation.

M.Sc. Semester II

Genomics and Proteomics **4 credits**

Unit 1: Basics of Genomics (07 Lectures)

Brief overview of prokaryotic and eukaryotic genome organization; extra-chromosomal DNA: bacterial plasmids, mitochondria and chloroplast

Unit 2: Genome Mapping (07 Lectures)

Genetic and physical maps; markers for genetic mapping; methods and techniques used for gene mapping, physical mapping, linkage analysis, cytogenetic techniques, FISH technique in gene mapping, somatic cell hybridization, radiation hybrid maps, in situ hybridization, comparative gene mapping.

Unit 3: Genome Sequencing Project (06 Lectures)

Human Genome Project, genome sequencing projects for microbes, plants and animals, accessing and retrieving genome project information from the web. Fetching the information of gene, cds and primers. Phylogenetics trees – introduction and applications,

Unit 4: Genomics and Transcriptomics (10 Lectures)

Identification and classification of organisms using molecular markers: 16S rRNA typing/sequencing, SNPs; use of genomes to understand evolution of eukaryotes, determining gene location in genome sequence. Transcriptome analysis for identification and functional annotation of gene, Contig assembly, chromosome walking and characterization of chromosomes, mining functional genes in genome, gene function: forward and reverse genetics, and gene ethics. RNA-Seq., microarrays.

Unit 5: Proteomics (10 Lectures)

Introduction to proteome and proteomics: concept and applications, structural and functional proteomics, tools and techniques in proteomics- IEF, 2D & 3D PAGE and mass spectrometry, Gel-free proteomics analytical chromatography (HPLC, UPLC, nano-HPLC) and working principle, types and use of mass-spectrometry in proteomics, proteomics in PTM analysis, Clinical proteomics: diagnostics and biomarker discovery.

Unit 6: Other omics (08 lectures)

Introduction, concept and applications of metabolomics, lipidomics, and interactomics. Chips in omics: protein chips and lab-on-chip.

Recommended Text Books and Readings

1. Genes IX by Benjamin Lewin, Johns and Bartlett Publisher, 2006.
2. Modern Biotechnology, 2nd Edition, S.B. Primrose, Blackwell Publishing, 1987.
3. Molecular Biotechnology: Principles and Applications of Recombinant DNA, 4th Edition, B.R. Glick, J.J. Pasternak and C.L. Patten, 2010.
4. Molecular Cloning: A Laboratory Manual (3rd Edition) Sambrook and Russell Vol. I to III, 1989.
5. Principles of Gene Manipulation 6th Edition, S.B. Primrose, R.M. Twyman and R.W. Old. Blackwell Science, 2001.

6. Snustad, D.P., Simmons, M.J. (2009). Principles of Genetics. V Edition. John Wiley and Sons Inc.
7. Klug, W.S., Cummings, M.R., Spencer, C.A. (2009). Concepts of Genetics. IX Edition. Benjamin Cummings.
8. Russell, P. J. (2009). iGenetics- A Molecular Approach. III Edition. Benjamin Cummings.
9. Glick, B.R., Pasternak, J.J. (2003). Molecular Biotechnology- Principles and Applications of recombinant DNA. ASM Press, Washington.
10. Pevsner, J. (2009). Bioinformatics and Functional Genomics. II Edition. John Wiley & Sons.

4 credits

M.Sc. Semester III
Bioprocess Engineering & Technology

Unit I: Basic principles of biochemical engineering (6 Lectures)
Isolation, screening and maintenance of industrially important microbes; microbial growth and death kinetics (an example from each group, particularly with reference to industrially useful microorganisms); strain improvement for increased yield and other desirable characteristics.

Unit II: Stoichiometry and models of microbial growth (5 Lectures)
Elemental balance equations; metabolic coupling – ATP and NAD+; yield coefficients; unstructured models of microbial growth; structured models of microbial growth.

Unit III: Bioreactor design and analysis (10 Lectures)
Batch and continuous fermenters; modifying batch and continuous reactors: chemostat with recycle, multistage chemostat systems, fed-batch operations; conventional fermentation v/s biotransformation; immobilized cell systems; large scale animal and plant cell cultivation; fermentation economics; upstream processing: media formulation and optimization; sterilization; aeration, agitation and heat transfer in bioprocess; scale up and scale down; measurement and control of bioprocess parameters.

Unit IV: Downstream processing and product recovery (10 Lectures)
Separation of insoluble products - filtration, centrifugation, sedimentation, flocculation; Cell disruption; separation of soluble products: liquid-liquid extraction, precipitation, chromatographic techniques, reverse osmosis, ultra and microfiltration, electrophoresis; final purification: drying; crystallization; storage and packaging.

Unit V: Fermentation economics (5 Lectures)
Isolation of micro-organisms of potential industrial interest; strain improvement; market analysis; equipment and plant costs; media; sterilization, heating and cooling; aeration and agitation; bath-process cycle times and continuous cultures; recovery costs; water usage and recycling; effluent treatment and disposal.

Unit VI: Applications (12 Lectures)
Mechanism of enzyme function and reactions in process techniques; enzymatic bioconversions *e.g.* starch and sugar conversion processes; high-fructose corn syrup; interesterified fat; hydrolyzed protein *etc.* and their downstream processing; baking by amylases, deoxygenation and desugaring by glucoses oxidase, beer mashing and chill proofing; cheese making by proteases and various other enzyme catalytic actions in food processing. Fermented foods and beverages; food ingredients and additives prepared by fermentation and their purification; fermentation as a method of preparing and preserving foods; microbes and their use in pickling, producing colours and flavours, alcoholic beverages and other products; process wastes-whey, molasses, starch substrates and other food wastes for bioconversion to useful products; bacteriocins from lactic acid bacteria – production and applications in food preservation; biofuels and biorefinery

Recommended Textbooks and References:

1. Shuler, M. L., & Kargi, F. (2002). Bioprocess Engineering: Basic Concepts. Upper Saddle River, NJ: Prentice Hall.
2. Stanbury, P. F., & Whitaker, A. (2010). *Principles of Fermentation Technology*.

Oxford: Pergamon Press.

3. Blanch, H. W., & Clark, D. S. (1997). *Biochemical Engineering.* New York: M. Dekker.
4. Bailey, J. E., & Ollis, D. F. (1986). *Biochemical Engineering Fundamentals*. New York: McGraw-Hill.
5. El-Mansi, M., & Bryce, C. F. (2007). *Fermentation Microbiology and Biotechnology*. Boca Raton: CRC/Taylor & Francis.

M.Sc. Semester III
Plant Biotechnology

3 credits

Unit-1 Plant Tissue Culture (08 Lectures)

Plant tissue culture: historical perspective; media preparation – nutrients and plant hormones; sterilization techniques; organogenesis; totipotency; Somatic embryogenesis; establishment of cultures – callus culture, cell suspension culture, applications of tissue culture - micropropagation; somaclonal variations; germplasm conservation and cryopreservation; synthetic seed production; protoplast culture and somatic hybridization - protoplast isolation; culture and usage; somatic hybridization - methods and applications; cybrids and their applications; plant cell cultures for secondary metabolite production.

Unit-2 Plant Genetic Manipulation (08 Lectures)

Genetic engineering: Agrobacterium-plant interaction; virulence; Ti and Ri plasmids; opines and their significance; T-DNA transfer; disarmed Ti plasmid; Genetic transformation - Agrobacterium-mediated gene delivery; cointegrate and binary vectors and their utility; direct gene transfer - PEG-mediated, electroporation, particle bombardment and alternative methods

Unit-3 Molecular Characterization of Transgenic Plants (08 Lectures)

Screenable and selectable markers; characterization of putative transgenics; chloroplast transformation; marker-free methodologies; Hardening of in vitro raised plants.

Unit-4 Translational Plant Biotechnology (08 Lectures)

Genome editing and crop improvement: ZFNs, TALENs, CRISPR/Cas9 tool; molecular pharming - concept of plants as biofactories, production of industrial enzymes, plantibodies and pharmaceutically important compounds. Cisgenesis and intragenesis, Green Revolution: Concept and significance. Major GMOs: Glyphosate resistance, Golden rice, Bt crops, etc.

Unit-5 Molecular Mapping and Marker Assisted Selection (08 Lectures)

Molecular markers - hybridization and PCR based markers RFLP, RAPD, STS, SSR, AFLP, SNP markers; DNA fingerprinting-principles and applications; introduction to mapping of genes/QTLs; marker- assisted selection - strategies for introducing genes of biotic and abiotic stress resistance in plants: molecular diagnostics of pathogens in plants.

Recommended Textbooks and Readings

1. Altman A, Hasegawa PM (Ed) (2012) – Plant Biotechnology and agriculture. Prospects for the 21st century (Academic press)
2. Bhojwani SS. & Razdan MK (1996). - Plant Tissue Culture: Theory & Practice (Elsevier)
3. Chawla HC (2004) – Introduction to plant biotechnology (Science Publ.)
4. Slater A, Scott NW, Fowler MR (2008) – Plant Biotechnology: the genetic manipulation of plants (Oxford Press)
5. Rai M (2009) – Fungal Biotechnology (IK International)
6. Vasil IK, Thorpe TA (1994) – Plant cell and tissue culture (Springer)
7. H K Das Textbook of Biotechnology 4th Edition
8. Plants Cell Culture 1994, Chrispeds, M.J. and Sadana, D.E., Bios Sceintific Publishers, Oxford, UK.
9. Plant Cell and Tissue Culture, 1994, Vasit, I.K. and Thorpe, T.A., Klmeer Academic Press, The Netherlands.
10. An Introduction to Plant Tissue Culture, 1993, Razdan, M.K., Published by Oxford and I.B.H.Publishing Co. Pvt. Ltd. New Delhi.
11. Applied and Fundamental Aspects of Plant Cell, Tissue and Organ Culture, 3rd Ed 1992, Rienert,J. and Bajaj Y.P.S.; Narosa Publishing House, New Delhi.
12. aniBiotechnology and Plant Genetic Resources, 1997, Callom, J.A., Ford – Lloyd, B.V. andNewbury, H.J., Conservation and use, CAB International, Oxon, UK.

M.Sc. Semester III
Environmental Biotechnology

3 credits

Unit 1: Introduction to environment (7 lectures)

Environmental and ecosystem process; pollution and its control; pollution indicators and monitoring (bio indicators and biomarkers); determination of dissolved oxygen, biological oxygen demand(BOD), chemical oxygen demand (COD); waste management: domestic, industrial, solid and hazardous wastes; function of the waste treatment system, sewage-treatment methods; Biodiversity and its conservation; Role of microorganisms in geochemical cycles; microbial energy metabolism, relevant microbiological processes, use of recombinant DNA technology for the study of bacterial community.

Unit 2: Bioremediation (7 lectures)

Fundamentals, methods and strategies of application (biostimulation, bioaugmentation) – examples, bioremediation of metals (Cr, As, Se, Hg), radionuclides (U, Te), organic pollutants (PAHs, PCBs, Pesticides, TNT *etc*.), technological aspects of bioremediation (*in situ*, *ex situ*), metals and gaseous bioremediation; biocatalyst; Factors affecting process of biodegradation, Biochemical pathway of biodegradation , Xenobiotics; Persistence and bio magnification of xenobiotic molecules.

Unit 3: Role of microorganisms in bioremediation (6 lectures)

Application of bacteria and fungi in bioremediation: White rot fungi *vs* specialized degrading bacteria: examples, uses and advantages *vs* disadvantages; Phytoremediation: Fundamentals and description of major methods of application (phytoaccumulation, phytovolatilization, rhizofiltration, phytostabilization).

Unit 4: Biotechnology and Agriculture (10 lectures)

Bioinsecticides: *Bacillus thuringiensis*, Baculoviruses, uses, genetic modifications and aspects of safety in their use; Biofungicides: Description of mode of actions and mechanisms (*e.g. Trichoderma, Pseudomonas fluorescens*); Biofertilizers: Symbiotic systems between plants – microorganisms (nitrogen fixing symbiosis, mycorrhiza fungi symbiosis), Plant growth promoting rhizobacteria (PGPR) – uses, practical aspects and problems in application.

Unit 5: Biofuels (10 lectures)

Biogas, bioethanol, biodiesel, biohydrogen; Description of the industrial processes involved,

microorganisms and biotechnological interventions for optimization of production; Microbiologically enhanced oil recovery (MEOR); Bioleaching of metals; Production of bioplastics; Production of biosurfactants: bioemulsifiers; Paper production: use of xylanases and white rot fungi.

Recommended Textbooks and References:

1. G. M. Evans and J. C. Furlong (2003), Environmental Biotechnology: Theory and Applications, Wiley Publishers.
2. B. Ritmann and P. L. McCarty, (2000), Environmental Biotechnology: Principle & Applications, 2nd Ed., McGraw Hill Science.
3. Scragg A., (2005) Environmental Biotechnology. Pearson Education Limited.
4. Thakur I.S. (2016) Environmental Biotechnology, Ik InternationalPublishing house
5. Sharma P.D.(2007) Ecology and Environment, Rastogi publications
6. Bartha A.(2009) Microbial Ecology,Dorling Kindersley
7. Gupta M. (20180 Fundamentals of Environmental Biology,Ik International Publishing house
8. H. J. Rehm and G. Reed, (2001), Biotechnology – A Multi-volume Comprehensive Treatise, Vol. 11, 2nd Ed., VCH Publishers Inc.

M.Sc. Semester III
Molecular Medicine

3Credits

Unit 1: Molecular Diagnostics (8 Hours)

Diagnosis of biochemical disorders and inherited disorders, antibody-based diagnosis: diagnosis of various diseases using ELISA, Western Blot, q-PCR, etc. Homogeneous and Heterogeneous enzyme immunoassays. Enzyme immunoassays, Immunohistochemical technique. Use of polyclonal or monoclonal antibodies in diagnosis. Immuno florescence. PCR and array-based diagnosis of diseases, Methods for diagnosis of specific diseases like tuberculosis, malaria, AIDS, CML, etc.

Unit 2: Prenatal Diagnosis & Neonatal Screening (8 Hours)

Prenatal diagnosis- Risk Factors and indications for prenatal diagnosis; pre-implantation genetic diagnosis; invasive techniques- amniocentesis, fetoscopy, chorionic villi sampling (CVS); non-invasive techniques- ultrasonography, Nuchal Translucency scan, maternal serum screening and fetal cells in maternal blood, NIPT, Double markers, Tripple markers, Quadruple markers, Diagnosis using protein and enzyme markers (PKU- Guthrie test etc.), Karyotyping, Diagnosis through genome sequencing, neonatal screening.

Unit 3: Cancer Biology (8 Hours)

Introduction to Cancer Biology: Understanding the hallmarks of cancer, Historical perspectives on cancer research, Grading and staging of cancers: Anaplasia, Metaplasia, Dysplasia. Molecular and Cellular Basis of Carcinogenesis, Genetic mutations and carcinogenesis, Apoptosis, Autophagy, dysregulation in the cell death mechanisms and its role in the development and progression of cancer, Tumor Microenvironment, Tumor angiogenesis, Metastasis and Invasion, Molecular mechanisms of metastasis, Current Therapeutic regimes. Problems of reoccurrence and resistance to therapies and development of novel therapeutic approaches.

Unit 4. Gene Therapy (8 Hours)

Gene Therapy Strategies: History and scope of gene therapy, Types of gene therapies; Somatic and germ lines, Gene replacement and gene addition, *Gene therapy vectors*: Viral vectors: Retrovirus, Adenovirus, Adeno-associated virus, Lentivirus, Nonviral vectors; Naked DNA, Liposomes and lipoplexes, Transposons and their significance. *Gene editing methods:* CRISPR-Cas9 tools etc. *Gene Therapy for Human Diseases:* Gene therapies for Hemophilia B, B-thalassemia, Sickle cell disease, Cystic fibrosis, Duchene Muscular Dystrophy, Tyrosinemia, Severe Combined Immunodeficiency Syndrome (SCID).

Unit 5: Therapeutics and Regenerative Medicine (8 Hours)

Stem cells: definition, properties, and potency of stem cells, embryonic and adult stem cells, the concept of tissue engineering, hematopoietic stem cell therapy, cancer stem cells, potential uses of stem cells in cell-based therapies. Chromosomal Abnormalities: Monosomy, Trisomy, Turner syndrome, Kleinfelter syndromes, Cri-du-Chat Syndrome, Triple X Syndrome, Williams Syndrome, DiGeorge Syndrome, Bartter Syndrome. Clinical trials and FDAapproval process.

Suggested readings:

1. Principles of Genetics in Medicine by Thompson and Thompson
2. Introduction to Human Molecular Genetics- J.J Pasternak, John Wiley Publishers
3. Human Molecular Genetics- Tom Strachan and A P Read, Bios Scientific Publishers
4. Human Genetics Molecular Evolution- Mc Conkey
5. Recombinant DNA Technology- AEH Emery
6. Principles and Practice of Medical Genetics, I, II, III Volumes by AEH Edts. Emery
7. Medical Biotechnology- Pratibha Nallari, V. Venugopal Rao- Oxford Press