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

Department of Biotechnology
Jamia Millia Islamia
New Delhi

M.Sc. Biotechnology (One Year/ Two Semester Program)
Course Structure

	Semester I					
Paper code	**Papers**	**Nature of course**	**Credit**	**Internal Assessments**	**Final Exams**	**Max Marks**
24-MBT-501	Molecular Biology	Core Paper	3	30	45	75
24-MBT-502	Cell Biology	Core Paper	3	30	45	75
24-MBT-503	Biochemistry & Biophysics	Core Paper	3	30	45	75
24-MBT-504	Immunology	Core Paper	3	30	45	75
24-MBT-505	Bioprocess Engineering and Technology	Core Paper (AECC)	4	40	60	100
24-MBT-506	Plant Biotechnology	Core Paper	3	30	45	75
24-MBT-507	Environmental Biotechnology	Core Paper	3	30	45	75
24-MBT-508	Molecular Medicine	Core Paper	3	30	45	75
*24-MBT-509	Lab Course		4	50	50	100
*24-MBT-510	Research Methodology	SWAYAM	4			100
*24-MBT-511	Critical analysis of classical papers /Seminar	VAC	3			75
Total			36			

***Compulsory Papers**

Note: Students may select from the list of Core Papers (501- 508) to accumulate minimum of 27 credits including the compulsory papers from the above mentioned papers. Lab Course will be based on the selection of their respective Core Papers. Students while choosing papers, must ensure that the total credits earned meet the minimum credit requirement.

The broad area of SWAYAM course should match with the subject mentioned above, however, the subject could be changed depending on the availability of the course on NPTEL.

Semester II (Without Research)					
Paper code	**Papers**	**Credit**	**Internal Assessments**	**Final Exams**	**Max Marks**
24-MBT-520	Microbiology	3	30	45	75
24-MBT-521	Enzymology and Enzyme Technology	3	30	45	75
24-MBT-522	Animal Biotechnology	3	30	45	75
24-MBT-523	Genetic Engineering	3	30	45	75
24-MBT-524	Elective-1*	2	20	30	50
24-MBT-525	Genomics and Proteomics (SEC)	3	30	45	75
24-MBT-526	Lab course	4	50	50	100
24-MBT-528	Seminar-1 (VAC)	1			25
Total		**22**			550

*****Elective-1: (i) Molecular Physiology, (ii)Vaccines, VAC- Value Added Course

Semester II (With Research)					
Paper code	**Papers**	**Credit**	**Internal Assessments**	**Final Exams**	**Max Marks**
24-MBT-529	Dissertation	14		350	350
	Thesis defense	3		75	75
	Thesis Evaluation	3		75	75
24-MBT-530	SWAYAM	2	As per the SWAYAM	As per the SWAYAM	50
Total		**22**			550

Code: 24-MBT-501

M.Sc. Biotechnology (Semester I)

Molecular Biology

Credit -3

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.

Code: 24-MBT-502

M.Sc. Biotechnology (Semester I)

Cell Biology

Credit -3

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. Freem

Code: 24-MBT-503

M.Sc. Biotechnology (Semester I)

Biochemistry & Biophysics

Credit -3

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 SinghNaro

Code: 24-MBT-504

M.Sc. Biotechnology (Semester I)

Immunology

Credit -3

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.

Code: 24-MBT -505

M.Sc. Biotechnology (Semester I)

Bioprocess Engineering & Technology

Credit -4

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.

Code: 24-MBT -506

M.Sc. Biotechnology (Semester I)

Plant Biotechnology

Credit -3

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.

Code: 24-MBT -507

M.Sc. Biotechnology (Semester I)

Environmental Biotechnology

Credit -3

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.

Code: 24-MBT -508

M.Sc. Biotechnology (Semester I)

Molecular Medicine

Credit -3

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