Semester I [Core (CR)]

Course No: BT23101CR	Credits: 4
Course Title: Cell Biology	
Max.Marks: 100 [80 (SEE) + 20 (IA)]	

Course Objectives:

To introduce students to Cell Biology concepts and their significance in understanding and unraveling mechanistic aspects of cell Biology. Moreover, focus will be to understand the basics and advanced aspects of Cellular Communication, cytoskeleton networks and regulation of cell proliferation and apoptosis.

Unit I

Cellular diversity: An Overview. Structural features of Prokaryotic and Eukaryotic cells. Mycoplasmas. Viruses: Structure and types of viruses. Structural and functional details of Plasma membrane (different models), endoplasmic reticulum (smooth and rough endoplasmic reticulum), ribosomes (Prokaryotic and Eukaryotic) and Golgi complex, Lysosomes, Cell wall, Mitochondria, Chloroplast, Nucleus: organization of chromatin from nucleosomes to chromosomes, relationship between organization and function of chromatin, nuclear lamins, nuclear pores, nucleolus, cajal bodies, nuclear speckles and polycomb clusters.

Unit-II

Membranes. Various membrane models. Membrane lipids. Asymmetry of membranes. Membrane Proteins. Glycosylation of membrane Proteins.Transport of nutrients, ions and macromolecules across membranes.Mitochondrial membranes, TIM-TOM complexes, oxidative phosphorylation. Transmitter- gated ion channels. Electrical properties of membranes.Neurotransmission and its regulation. Facilitated diffusion through cell membrane. Concept of Ficks law. Active transport. Endocytosis. Exocytosis. Phagocytosis and pinocytosis.Vesicular transport and secretory pathways.Protein trafficking across organelles. Autophagy. Autophagy mechanisms.

Unit-III

Molecular signaling: Introduction. Scaffolding proteins. Modular proteins. Classes of receptors. G-proteins. Structure. Signaling through G-protein linked cell surface receptors.

Role of cAMP, Diacylglycerol and Inositol.Ca^{2+} in signaling.CaM Kinases. Signaling through Enzyme linked cell surface receptors. EGFR and PDGFR operated pathways. JAK-STAT

pathway. Notch and Wnt signaling pathways. MAP Kinases in signaling. Signaling through ion-channel linked receptors.. Signaling through regulated proteolysis. Ubiquitination.Cell cycle—Molecular events and regulatory controls, with emphasis on animal cells and yeast cell divisions. Role of different Cyclin-dependent Kinases.Regulation by cdc25 phosphatase.Cell cycle checkpoints.G1 and G2 checkpoints.Role of Rb and p53 proteins.Extracellular control of Cell division.

Unit-IV

Control of cell numbers in multi-cellular organisms. Programmed cell death. Caspases. Intrinsic and extrinsic pathways of apoptosis.Role of Bcl2 family of proteins. Cancer: Introduction. Types. Cancer Grades/Stages. Molecular basis of cell proliferation. Environmental, Chemical and Biological causes of Cancers. Oncogenes. Loss of Tumor suppressors.Cancer therapeutics and treatment.Cytoskeletal structures: Structure and function of Microtubules, Microfilaments and Intermediary filaments. Dynamic instability and Treadmilling.Regulation of cytoskeletal filaments. Higher order structures of Cytoskeletal filaments. Microtubule motor protein and their significance, microtubules and actin filaments, actin-myosin complex, Mechanism of muscle contraction and motor proteins. Cytoskeletal Structures and Cell behavior.Intercellular Junctions: Occluding Junctions, Anchoring Junctions and Communicating Junctions. Cell Adhesion Molecules: Types and Functions.

Learning Outcomes:

Students will get to know how Cellular Organelles function, different types of signaling mechanisms, cell cycle regulation and its links with cancers

Books Recommended:

1. Molecular Biology of the Cell by Alberts B., et al: Garland Science, Taylor and Francis, NY-USA.
2. Molecular Cell Biology by Lodish et al: W.W Freeman and Company, New York, USA.
3. Cell Biology: Organelle Structure and Function by David Sadava.
4. Selected Research/Review articles.

Semester I [Core (CR)]

Course No: BT23102CR	**Credits: 4**
Course Title: Molecular Biology-I	
Maximum Marks: 100 [80 (SEE) + 20 (IA)]	

Course Objectives:
To Introduce DNA as molecular component of life and to emphasize the importance of DNA by providing information on its chemical nature, structure, replication and maintenance.

Unit-I

General features of DNA replication: Semi-conservative versus conservative and dispersive mode of replication. Semi-discontinuous replication. Directionality of DNA replication Priming of DNA replication. Sigma and Rolling circle mode of replication with examples from M13 and lambda phage. Structure, function and experimental elucidation of various enzymes/proteins involved in DNA replication.: DNA helicases, Primases, Single stranded binding proteins (SSBs), Topoisomerases, DNA polymerases (Prokaryotic & eukaryotic). Molecular mechanism of DNA polymerization and Proofreading activity of DNA polymerases Molecular Components/events involved in initiation of DNA replication (Prokaryotic and eukaryotic). Regulatory mechanisms of prokaryotes and eukaryotes replication. Replication elongation: Processivity of DNA polymerases. Structure and function of beta-clamp and PCNA (proliferating cell nuclear antigen). Structure and function of DNA pol III gamma-complex as clamp loader and unloader. Model for leading and lagging strand synthesis. Replication Termination: Termination in prokaryotes and the molecular components involved. Decatenation of newly replicated circular genomes. End replication of linear genomes. Telomers: Function and structure. Telomerase: role in the formation of telomers and the molecular mechanism involved. Telomer binding proteins. t-loop formation and the proteins involved. Telomerase in ageing and cancer.

Unit-II

DNA Damage and Mutation: Physical and chemical DNA damaging agents. Spontaneous hydrolysis and deamination of DNA bases. Alkylating agents and radiation. Base analogs and intercalating agents.DNA Repair Systems:Direct reversal repair system (examples from prokaryotes and eukaryotes).

Excision Repair system: Base excision and nucleotide excision repair mechanisms (examples from prokaryotes and eukaryotes). Mismatch repair system. Double-strand DNA

breaksrepair system: Homologous recombination repair and non-homologous end-joining (NHEJ) repair systems.DNA damage bypass systems: Error-prone bypass in prokaryotes.

Molecular Recombination: Homologous recombination: General features.Alignment of homologous DNAs.Generation of double-stranded breaks.Strand invasion and heteroduplex formation.Holliday junctions and branch migration.Homologous recombination in eukaryotes.Molecular Mechanism of Meiotic Recombination and its Significance.Molecular mechanism of V(D)J recombination and antibody diversity.

Unit-III

Prokaryotic Transcription mechanisms and regulation:Transcription General Idea: Overview of the transcription process in prokaryotes. Promoters: Structure, function, and recognition by RNA polymerase RNA Polymerases: Molecular composition, structure, and function. Role of Sigma Factor and Alternative Sigma Factors: Importance of sigma factor in promoter recognition Diversity and biological role of alternative sigma factors. Single Subunit RNA Polymerases: T3 and T7 RNA polymerases: Structure and function. Molecular Events of Transcription: Initiation: Transcription initiation complex formation. Elongation: Structure and function of the elongation core complex. Proofreading during elongation. Transcription Termination: Molecular mechanism of Rho-dependent termination. Molecular mechanism of Rho-independent termination. Regulation of Bacterial Transcription: Operons: Definition and significance. Lac Operon: Basic features, regulation by Lac repressor, and CAP. Trp Operon: Structure and regulation, regulation by attenuation

Unit-IV

Eukaryotic Transcription mechanisms and regulation: Eukaryotic RNA Polymerases: Overview of eukaryotic RNA polymerases (RNA Pol I, RNA Pol II, and RNA Pol III). Roles and specific functions of each RNA polymerase.Class II Promoters: Structure and Function: Core promoter elements and their significance. Upstream elements and their roles in transcription regulation.Downstream elements and their impact on transcription initiation. Initiator elements and their involvement in transcription start site selection. Class II General Transcription Factors: Structure and functions of general transcription factors. Their role in assisting RNA polymerase II in transcription initiation.Mechanism of Transcription Initiation at Class II Promoters: Formation of the pre-initiation complex. Recruitment of RNA polymerase II and general transcription factors.The holoenzyme model of pre-initiation complex formation.Promoter Clearance and RNA Pol II CTD Phosphorylation: Clearing the promoter region for productive elongation. Phosphorylation of RNA Pol II C-terminal domain

(CTD) and its significance.Transcription Elongation: Molecular Mechanism. Overview of molecular events during transcription elongation. Proofreading mechanisms and RNA Pol II pausing.Transcription Termination: Termination signals and the process of transcription termination.

LearningOutcomes:

ImportanceofDNAinprokaryotesandeukaryotesbyprovidingbasicinformationinDNAreplication,keyproofreadingprocessesinDNAreplication, repair, recombination and transcription

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BooksRecommended:

1) MolecularBiologyby RobertF Weaver:McGraw-HillHigherEducation.
2) MolecularBiologyof theGeneby JamesD.Watson,etal:Pearson.
3) Latest research articles and reviews

Semester I [Core (CR)]

Course No: BT23103CR	**Credits: 4**
Course Title: Immune Biology	
Maximum Marks: 100 [80 (SEE) + 20 (IA)]	

Course Objectives:
The objectives of this course is know the structure and functions of immune system. The major emphasis of this course will be on the response of human body against the pathogens (bacterial viral and parasitic) and on the regulation of immune system

Unit I

Innate immune system: Recognition of Pathogen-associated molecular patterns (PAMPs) & Damage-associated molecular patterns (DAMPs) by Toll like receptors (TLRs) ,nucleotide-binding oligomerization domain (Nod) like receptors (NLRs), Retinoic acid inducible gene-I (RIG)-like receptor and C-type lectin receptors (CLRs).Cellular component of innate immune system: phagocytic cells (i.e., neutrophils, eosinophils, basophils, and mast cells), monocytes/macrophages, and dendritic cells, epithelial and endothelial cells, natural killer cells, innate lymphoid cells (ILC) and platelets. Destruction of microbes by phagocytosis and respiratory burst. Inflammation and inflammasome: Inflammatory rheostat, local inflammation and systemic inflammation. Complement system: classical, alternate and lectin pathway, Regulation of complement system.

Unit II

Adaptive Immune system: Lymph and lymphoid organs (primary& secondary). Detailed structure of lymph node. Cytokines and cytokine-receptors general characteristics, properties and their signaling pathways (JAKs and STATs).Chemokine properties and functions.Antigen,Immunogen, adjuvant, hapten and super antigen. Immunoglobulin structure and types.Cells of lymphoid system. T-cells CD4+ and its subsets (Th1,Th2, Th9, Th17, Tfh), CD8+ T cells.

Unit III

Antigen presentation and Immune Response: Genetic organization of human leukocyte antigen (HLA). Features of antigens recognized by T-cells. Antigen presenting cells.Structure and properties of MHC molecules. Processing pathways of protein antigens. T-cell activation and response.Role of co-stimulatory molecules.Humoral immune response (primary and secondary).T-dependent & T-independent antibody response. Effector functions of

antibodies (Neutralization of microbes & toxins, opsonization& phagocytosis of microbes, Antibody dependent cellular cytotoxicity, phagocytosis of microbes opsonised with complement fragments).

Unit IV

T-cell tolerance (central & peripheral).Mechanism of T-cell anergy. B-lymphocyte tolerance. Mechanism of Autoimmunity.Hypersensitivity reaction and its types. Cells, mediators & biochemical events of type I hypersensitivity reaction. Tumor antigens, Evasion of immune response by tumors.Vaccines- types and development.Hybridoma Technology.

Learning Outcomes:

On completion of this course, students should be able to Evaluate immunology in different areas including vaccine development, production of pharmaceutical drugs regulating immune system. Monoclonal antibodies for the immunological experiments.Able to conduct research on infectious diseases.

Recommended Books:

1 Abul K Abbas, Andrew H. Lichtman and Shiv pillai Cellular & molecular immunology Elsevier publications.
2. Kindt, T. J., Goldsby, R. A., Osborne, B. A., & Kuby, J. KubyImmunology.New York: W.H. Freeman.
3. Brostoff, J., Seaddin, J. K., Male, D., & Roitt, I. M. Clinical Immunology.London: Gower Medical Pub.
4. Murphy, K., Travers, P., Walport, M., &Janeway, C. Janeway'sImmunobiology. New York: GarlandScience.
5. Paul, W. E. Fundamental Immunology. New York: Raven Press.

Semester I [Core (CR)]

Course No: BT23104CR	**Credits: 2**
Course Title: Biomolecules	
Maximum Marks: 50 [40 (SEE) + 10 (IA)]	

Course objectives:
To understand the physical and chemical properties of biomolecules, like amino-acids, proteins, nucleic acids, carbohydrates and lipids.

Unit I

Amino acids, proteins and nucleic acids: Water and its properties, Physical and chemical properties of standard amino acids. Titration curves of amino acids.Peptide bond and its structure.Torsion angles and conformation of peptide bond groups.Ramachandran diagram and conformation of polypeptides.Protein secondary structures.Helical structures, beta structures and non-repetitive structures (beta bends, loops, random coils).Supersecondary structures (beta-hairpins, helix hairpins, beta-alpha-beta).Fibrious protein structure (a-keratin and collagen).Protein tertiary structures.Forces that stabilize the protein tertiary structures.Nucliec acid structure: Structure of DNA, forces stabilizing DNA helical structures and properties of A, B and Z forms of DNA

Unit-II

Carbohydrates, and lipids: Monosaccharides: Structures, classification, configuration and conformation (Hawrath projection formulas). Disaccharide and the glycosidic bond. Polysaccharides: Structural polysaccharide (cellulose) and storage polysaccharides (glycogen and starch). Fatty acids and lipids: Physical properties, classification and naming. Types of lipids.Triacylglycerides, phospholipids, sphingolipids and steroids (structure and function).

Learning Outcomes:
Will enable students to know the physical and chemical properties of cellular constituents of cells. and to understand how cell components function in the cell milieu.

Books Recommended:

1) Principles of Biochemistry by David Lee Nelson, Albert l. Lihninger, Michael M. Cox Publisher: w.h. freeman
2) Biochemistry by Donald Voet, Judith G. Voet
3) Biochemistry by Jeremy M. Berg, John l. Tymoczko, LubertStryer

Semester I [Discipline centric (DCE)]

Course No: BT23101DCE	**Credits: 3**
Course Title: Biotechniques	
Maximum Marks: 75 [60 (SEE) + 15 (IA)]	

Course Objectives: The course is aimed to acquaint the students with various techniques used in biological sciences and the emerging areas of biotechnology along with underlying principles.

Unit I

Electrophoresis:Basic principles & types of electrophoresis, Agarose gel electrophoresis. Polyacrylamide gel electrophoresis (PAGE), Native PAGE, SDS-PAGE, isoelectric focusing, 2D Gel electrophoresis, Pulse field gel electrophoresis, capillary electrophoresis. Electrophoresis in DNA sequencing, electrophoresis and single strand conformational polymorphism (SSCP), Blotting techniques: Southern, Northern, Western, Far-western, South-western and their applications.

Unit II

Chromatography:Theory of Chromatography; Gel exclusion chromatography; Principle, procedure and applications. Ion Exchange chromatography; cation-exchange and anion-exchange chromatography and its applications. Affinity based purifications of proteins; FLAG-, His-, Biotin- tag based. Tandem affinity purification (TAP) and its advantages.

Centrifugation: Basic principles of centrifugation. Types of centrifugation; differential centrifugation and density gradient centrifugation. Determination of Sedimentation Coefficient. Ultra-centrifugation.

Unit III

Spectroscopy and microscopy:UV-visible absorption spectroscopy. Principle and applications of Fluorescence spectroscopy; Jablonski diagram, Fluorophores; Intrinsic and extrinsic fluorophores, steady-state fluorescence,Fluorescence resonance energy transfer (FRET). Principle and applications of; bright-field microscopy, confocal microscopy, and super-resolution microscopy. Immunostaining procedure.

Learning Outcomes:

Understand the mechanics of common laboratory assays and how they can be applied to research. Perform basic biotechnical experiments and to enable the students to learn techniques like Nucleic acid isolation, Immunoprecipitation, SDS-PAGE ,Western blot analysis.

Books Recommended:

1) Principles & Techniques Biochemistry & Molecular Biology. Wilson & Walker. Cambridge University Press.
2) Principles of Radioactive Techniques, Use & Handling. BARC
3) Biological Centrifugation (The Basics) by Dr John Graham.
4) Chromatography: Basic Principles, Sample Preparations and Related Methods by Elsa Lundanes, Leon Reubsaet, TygeGreibrokk . WILEY.
5) Basics of Centrifugation. ThermoFisher

Semester I [Discipline Centric (DCE)]

Course No: BT23102DCE	**Credits: 2**
Course Title: Biostatistics	
Maximum Marks: 50 [40 (SEE) + 10 (IA)]	

Course Objectives: The objective of the course is to provide insight of methods for effective data collection, data representation, and data use so as to make inferences and conclusions about issues faced by biology students.

Unit-I

General Introduction to Statistics, Basic Concepts.Scope of Statistical methods in Biotechnology. Sampling methods/strategies: Sample Selection. Simple Random Sampling, Convenience Sampling, Systematic Sampling, Stratified Random Sampling, Cluster Sampling, etc. Data; types & Uses. Medical/Biological Uncertainties: Surveys and Cross-Sectional Studies. Retrospective Studies, Prospective Studies, Experimental Studies and Quality Control Clinical Trials, Epidemiological Studies. Measurement of central tendencies: Arithmetic Mean, Median, Mode, Geometric Mean, Harmonic Mean. Measures of Dispersion: Range, Mean Absolute Deviation, Population Variance and Standard Deviation, Sample Variance and Standard Deviation, Calculating the Variance and Standard Deviation from Grouped Data, Coefficient of Variation.

Unit-II

Presentation of variation by figures; data representation: Histogram, Stem-&-Leaf Plot, Line Diagram, Frequency Polygon, Frequency Curve, Pie Diagram, Bar Diagrams, Scatter Diagram, Box-&-Whisker Plot, Bubble Plot, Growth chart, Dendrogram, Nomogram, Partogram, Pedigree Chart, Cartogram. Confidence Intervals: Confidence Intervals, Confidence Intervals for a Single Population Mean, Z and t Statistics for Two Independent Samples. Paired t Test. Principles of test of significance: One-Tailed Versus Two-Tailed Tests, p-Values, Type I and Type II Errors, The Power Function, Two- Sample t Test (Independent Samples with a Common Variance). Students t-test, ANOVA: Comparison of means in one or two groups (student's t-test). Comparison of means in three or more groups (ANOVA), F- test.

Learning outcomes:

The student will be able to recognize the importance of data collection and its role in determining scope of inference. The students will be able to Interpret statistical results correctly, effectively, and in context.

Books Recommended:

1) Introduction to Biostatistics and Research Methods by Sunder Rao and J Richards
2) Medical Statistics by David Machin, Michael J Campbell and Stephen J Walters.

Semester I [Discipline Centric (DCE)]

Course No: BT23103DCE	**Credits: 3**
Course Title: laboratory Course-I	
Maximum Marks: 75 [60 (SEE) + 15(IA)]	

Course Objective:

The objective of the course is to provide hands on training of basic experiments related to protein chemistry, viz., preparation, estimation, visualization, separation and analysis using different techniques.

Practical

- Concept of molarity, molality, concentration. Preparation of solution and buffers.
- Titration of Amino Acids and determination of pKa values
- Determination of an unknown protein concentration by various methods
- Protein isolation from bacterial cells, their separation by SDS-Polyacrylamide gel electrophoresis and visualization by Coomassie and silver staining.
- Protein separation by gel-filtration chromatography
- ELISA

Learning Outcomes:

The course will expose students to different concepts related to solutes, solvents, solutions, and buffers. Students will be able to understand Titrate different amino acids for pKa determination. **To** estimate and analyze protein mixture and to separate bygel-filtration chromatographic techniques**.**

Books Recommended:

Sambrook, J., Fritsch, E. R., &Maniatis, T. (1989). Molecular Cloning: A Laboratory Manual (2nd ed.). Cold Spring Harbor, NY: Cold Spring Harbor Laboratory Press.

Semester I [Generic Elective (GE)]

Course No: BT23001GE	**Credits: 2**
Course Title: Biochemical techniques	
Maximum Marks: 50 [40 (SEE) + 10(IA)]	

Course Objectives:

The course is aimed to acquaint the students with various techniques used in biological sciences and the emerging areas of biotechnology along with underlying principles. The course also aims to make students learn about modern instruments for various analytical works.

Unit I

Electrophoresis and Radioactivity: Basic principles & types of electrophoresis, Agarose gel electrophoresis, PAGE, SDS-PAGE and isoelectric focusing. Blotting techniques: Southern, Northern, Western, Far-western, South- western and their applications. Determination of antigen antibody concentration by immunodiffusion, immunoelectrophoresis, ELISA.Isotopes, modes of radioactive disintegration, Radioactive decay, Radiation quantitation and units.Applications of radioactive isotopes in biochemical assays.Radiation hazards and protection.

Unit II

Chromatography and Centrifugation: Theory of Chromatography; Migration. Dispersion. Chromatographic Resolution. Types: Gel filtration, Paper, thin-layer and partition chromatography. Affinity Chromatography: Ion Exchange chromatography, Purification of specific groups of molecules (Immunoglobulins, GST fusion proteins, Poly (His) fusion proteins, Protein A fusion proteins). Gas Chromatography. Basic principles of centrifugation.Types of centrifugation; differential centrifugation and density gradient centrifugation.

Learning Outcomes:

- Understand the mechanics of common laboratory assays and how they can be applies to research.
- Perform basic biotechnical experiments
- To enable the students to learn techniques like Nucleic acid isolation, Immunoprecipitation, SDS-PAGE western blot analysis.

Books Recommended:

1) Principles & Techniques Biochemistry & Molecular Biology. Wilson & Walker. Cambridge University Press.
2) Principles of Radioactive Techniques, Use & Handling. BARC
3) Biological Centrifugation (The Basics) by Dr John Graham

Semester I [Open Elective (OE)]

Course No: BT23001OE	**Credits: 2**
Course Title: Introduction to cancer Biology	
Maximum Marks: 50 [40 (SEE) + 10(IA)]	

Objectives:
This course will introduce students to central concepts of cancer biology, including causes and precautions aimed at its prevention.

Unit I

Basic Introduction to Cell Structure, Cell Organization, Cell division and Cell Death. Introduction to Cancers: Definition, Cancer types and Cancer Stages. Causes of Cancer: Environmental, Chemical and Biological causes, Oncogenes and Tumor suppressors. Hallmarks of Cancers.

Unit II

Cancer Progression, Cancer Detection: Detection using Biochemical assays, Tools for early diagnosis of Cancer. Cancer prevention: Preventing Cancer through Diet and Lifestyle. Cancer Therapy: Chemotherapy, Radiotherapy, Immunotherapy and Gene therapy.

Learning Outcomes:
By the end of this course students will have knowledge about, what cancers are, the types of cancers and molecular biology involved therein. Students will understand the predisposition and progression of cancers and the therapeutic interventions currently in vogue.

Books/Readings recommended:

1) Albers, Bruce et al., Molecular Biology of the cell, 6th Edition, Garland Science, 2015.
2) Mc Donald F et al., Molecular Biology of Cancer, 2nd Edition, Taylor Francis, 2004.
3) King Roger J.B., Cancer Biology, Addison Wesley Longman, 1996.
4) Internet/Online resources.

Semester II [Core (CR)]

Course No: BT23201CR	**Credits: 4**
Course Title: Animal cell Science and Technology	
Maximum Marks: 100 [80 (SEE) + 20 (IA)]	

Course Objectives:
This Course will help students to familiarize themselves with animal cell, their culturing and maintaining them as *in vitro* cultures. The aim is to provide theoretical knowledge on animal cells for in vitro studies, manipulation of animal cells in vitro and application of molecular techniques to in vitro situations.

Unit I

Structure and organization of Animal Cell, Primary and established Cell lines, Setting up of Tissue culture facility; Equipment and facilities needed. Contaminations in cell culture; Types and their eradication/contamination control, Precautions in handling of cell lines. Introduction to balanced salt solutions and simple/complete growth medium, Role of CO2, serum and supplements. Serum components necessary for growth of cells in culture. Serum and serum free defined media. Limitations and applications of serum and serum free media.

Unit II

Cell Lines: Biology and characterizations of the cultured cells. Cryopreservation. Basic techniques of mammalian cell culture in vitro: Disaggregating of tissue and primary culture. Transfection of cell lines.Types and Methods of Transfection. Transfection applications. Scaling-up of animal cell culture.Equipment and reagents.Advantages and Disadvantages of Scale-up techniques. Cell synchronization, cell cloning and micromanipulation. Application of animal cell culture.

Unit III

Cell transformation: Properties of transformed cells. Methods of cell Transformation. Immortalization: Introduction. Methods used to immortalize cells. Mechanisms involved in cell immortalization. Measurements of viability and cytotoxicity assay: Cell viability assays using dye exclusion or dye uptake, MTT, TUNNEL and ELISA based assays. Fluorescence based cell viability assays. Cell culture based vaccines: Introduction to Subunit vaccines, peptide vaccines, recombinant vaccines, genetic vaccines and attenuated vaccines. Advantages and disadvantages of all the types of vaccines.

Unit IV

Three dimensional culture: Introduction. Multicellular tumour spheroids (MCTS).Spheroid culturing techniques. Tissue engineering: Introduction. Tissue Engineering of Skin, Nerve implants. Tissue engineered Urothelium implants. Design criterion for tissue engineering. Cell substrates and support material. Organ and Histotypic cultures: Introduction. Advantages and limitations.Differences between Organotypic and Histotypic cultures.Factors affecting the growth of Organotypic and Histotypic cultures.

Cloning of Animals. Strategies for Transgenic animal production using Microinjection, Somatic cell nuclear transfer technique, embryonic stem cells and using Viruses. Legal and ethical aspects of Animal Cloning.Application of Transgenic animals.

Learning Outcomes:

By the end of this course students will be able to comprehend the fundamental concepts of animal cell culture and its importance. Have knowledge for carrying out various assays and experiments in cultured cells.

Books Recommended:

1) Culture of Animal Cells: A Manual of Basic Technique and Specialized Applications, by, R. Ian Freshney, published by Wiley-Blackwell, UK.
2) Animal Cell Culture: A Practical Approach by JRW Masters, published by Oxford University Press, UK.
3) Basic Cell Culture: A Practical Approach by John M. Davis, published by Oxford University Press, UK.
4) Transgenic Animal Technology, 3rd Edition, A Laboratory Handbook by Carl Pinkert, Elsevier Press.
5) Selected Research and Review articles.

Semester II [Core (CR)]

Course No: BT23202CR	**Credits: 4**
Course Title: Molecular Biology II	
Maximum Marks: 100 [80 (SEE) + 20 (IA)]	

Course Objectives:
To emphasize on advanced concepts of molecular processes involved in expression of genetic information in eukaryotic cells, including transcription, splicing, translation and post-translational modification, and how these processes are regulated.

Unit I

Mechanism of Gene Regulation: Regulatory Elements and Transcription Factors: Enhancers, Silencer Elements, and Methods of Studying Transcription Factors. Recent Advances: Enhancer-promoter interactions and 3D genome organization in gene regulation.Domain Structure of Transcription Factors: DNA Binding Domains: Zinc Finger, Leucine Zipper, Homeodomains, Basic Domains. Transcription Activation Domains and Mechanism of Activator Function. Recent Advances: Discovery of novel transcription factor domains and interactions.Transcriptional Coactivators and Repressors: Activation Bypass, Mediator Complex, and Role in Transcriptional Regulation. Recent Advances: Insights into coactivator and corepressor functions.Gene Regulation During Development: Transcription Factors in Developmental Gene Expression and Homeobox Genes: Recent Advances: Epigenetic regulation and non-coding RNAs in developmental gene regulation

Unit II

Chromatin Structure and Epigenetic Regulation:Overview of Chromatin, Histones, and Nucleosomes: Euchromatin and Heterochromatin. Chromatin Remodeling and Nucleosome Positioning. Histone Modifications and the Histone Code Hypothesis: Histone Acetylation, Methylation, Phosphorylation, and Ubiquitination. Genome-Wide Analysis and Crosstalk between Histone Modifications

DNA Methylation and Epigenetic Control: Role of DNA Methylation in Gene Regulation. Epigenetic Reprogramming in Development and Diseases.Gene Regulation during Drosophila Development.

Unit III

Post-transcriptional RNA Processing:RNA splicing and spliceosome: Heteronuclear RNA (hnRNA), Exons, Introns, and Splicing Signals. Molecular Mechanism of RNA Splicing and Alternative Splicing

rRNA and tRNA Processing, RNA Editing, and Modifications: Ribosomal rRNA Processing in Eukaryotes and Prokaryotes. tRNA Processing and Modifications. RNA Editing Mechanism and Self-Splicing RNAs

Post-transcriptional Modifications of mRNA: Capping at the 5' End and Polyadenylation: Structure and Types of Caps: Function of 5' End Capping and Poly(A) Tail

Unit IV

Protein Translation and Translational Regulation:Translational Machinery and tRNA Charging: Structural Features of mRNA in Prokaryotes and Eukaryotes. Ribosome Structure and AminoacyltRNASynthetases. Genetic Code and tRNA Charging with Specific Amino Acids. Translational Initiation and Elongation: Prokaryotic and Eukaryotic Initiation Complex Formation. Mechanism of Translation Initiation and Cap-Dependent/Cap-Independent Translation. Translation Elongation, Proofreading, and Translocation Translation Termination and Translational Regulation: Termination Codons and Release Factors. Ribosome Dissociation and Factors Involved.Aberrant termination and molecular mechanism to deal with aberrant termination.Prokaryotic and Eukaryotic Translational Regulation.Role of mircoRNAs (miRNAs) in translation regulation.

Learning Outcomes:

Will enable students to understand different types, structure, and function of different types of eukaryotic polymerases, RNA polymerases, transcription factors and associated factors and the mechanism of their functioning. Besides students will be acquitted about posttrasncriptional events like splicing, capping and polyadenylation.

Books Recommended:

1) Transcriptional Regulation in Eukaryotes: Concepts, Strategies, and Techniques by Michael F Carey, Stephen T Smale and Craig L Peterson.
2) Gene Regulation by David S. Latchman fifth edition.
3) Molecular Biology by Robert F Weaver: McGraw-Hill Higher Education.
4) Molecular Biology of the Gene by James D. Watson, et al: Pearson.

Semester II [Core (CR)]

Course No: BT23203CR	**Credits: 4**
Course Title: Advanced Enzymology	
Maximum Marks: 100 [80 (SEE) + 20 (IA)]	

Course Objectives:
The objective of the course is to provide a deeper insight into the fundamentals of enzyme structure and function and kinetics enzymes. Also it deals with current applications and future potential of enzymes.

Unit I

Enzyme definition and characteristics, mechanism of enzyme action, activation energy, collision & transition state theories, lock and key model, induced fit hypothesis, active site - structure, substrate binding, role of catalytic amino acid residues. Derivation of MichaelisMenten equation using steady state and equilibrium assumptions, enzyme kinetics parameters (K_m, V_{max}, K_{cat}, K_{cat}/K_m). Transformation of Michaelis – Menten plot to linear forms. Lineweaver-Burk, Eadie-Hofstee, Hanes plots, Eisenthal and Cornish-Bowden plots.Merits and demerits of linear plots.Kinetics of bi-substrate reaction, ping-pong reaction, multi-substrate reaction.

Unit II

Enzyme Inhibition: irreversible and reversible inhibition: mechanism and kinetics of competitive, noncompetitive and uncompetitive inhibition. Methods of examining enzymes-complexes, trapping E-S complex, use of substrate analogs. Type of enzymatic catalysis; acid-base, nucleophilic-electrophilic, covalent catalysis.Mechanisms of action of chymotrypsin, ribonuclease, lysozyme; ribozymes, synthetic artificial enzymes.

Unit III

Enzyme regulation and feedback control, phosphorylation, regulation of aspartic transcarbamylase and metalloenzymes, carboxypeptidase-A, isozymes and their significance.Protein-Ligand binding including measurement, analysis of binding isotherm. Cooperatively phenomenon. Hill and Scatchard plots. Hemoglobin as a model for cooperativity.Allosteric enzymes, sigmodial kinetics and their physiological significance.Symmetric and sequential modes for action of allosteric enzymes and their significance.

Unit IV

Industrial enzymes: Sales value and manufacturers, Sources and engineering, Environmental benefits, Enzyme detection and quantification, Immobilized enzymes, Extremophiles, Enzymes in organic solvents.

Proteases and Carbohydrases: Proteolytic enzymes, Carbohydrases, Lipases, Penicillin acylase, Amino acylase and amino acid production, Cyclodextrins and cyclodextringlycosyltransferase, Enzymes and animal nutrition, Enzymes in molecular biology

Non-catalytic industrial proteins: Functional properties of proteins, Milk and milk proteins, Animal-derived proteins, Plant-derived proteins, Sweet and taste-modifying proteins.

Learning outcomes:

The student will be able to describe structure, regulation, functions and the mechanisms of action of enzymes. The student will get exposure to wide applications of enzymes and their future potential, and will learn the basics of drug designing, through ligand binding examples.

Books Recommended:

1. Enzymes: Biochemistry, Biotechnology, Clinical Chemistry by Trevor Palmer, Horwood Publishing
2. Fundamentals of Enzyme kinetics by Athel Cornish-Bowden, Portland press
3. Fundamentals of Enzymology by Nicholas Price and Lewis Stevens, Oxford University Press
4. Enzyme Structure and Mechanism by Alan Fersht, W. H. Freeman
5. Enzymology by T. Devasena , Oxford University Press

Semester II [Core (CR)]

Course No: BT23204CR	**Credits: 2**
Course Title: Environmental Biotechnology	
Maximum Marks: 50 [40 (SEE) + 10 (IA)]	

Course Objectives:

The aim of the course is to introduce the biotechnological tools and microorganisms both native and genetically modified to address the problems of environment. The biotechnological approaches to provide alternatives to compounds, which are sources of pollution, will be presented in detail.

Unit I

Basic components of environment, Concept of ecosystem, abiotic and biotic components. Environmental pollution: Air, water, and soil pollution. Microbial regulation of global biogeochemical cycles.Biomarkers and biosensors as environmental monitors. Biosurfactants and their application in environmental clean-up.Bioinsecticides: Bacillus thuringiensis, Baculoviruses, uses, genetic modificationsand aspects of safety in their use; Biofungicides: Description of mode of actions andmechanisms (e.g., Trichoderma, Pseudomonas fluorescens)

Unit II

Bioremediation: Fundamentals, methods and strategies of application (biostimulation, bioventing bioaugmentation). Technological aspects ofbioremediation (in situ, ex situ). Bioremediation of metals, organic pollutants (PAHs, PCBs, Pesticides etc.). Application of bacteria and fungi in bioremediation: White rot fungi vs specializeddegrading bacteria.Phytoremediation:Fundamentals and description of major methods of application (phytoaccumulation, phytovolatilization, rhizofiltrationphytostabilization).Microorganisms and biotechnologicalinterventions for optimization of production of biofuels.

Learning Outcome:

After completion of course, students will be able to understand how biotechnological methods like microbial gene modification, biotransformations, etc are used to environmental quality evaluation, monitoring and remediation of contaminated environments.

Books Recommended:

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.

Semester II [Discipline Centric (DCE)]

Course No: BT23201DCE	**Credits: 2**
Course Title: Microbiology	
Maximum Marks: 50 [40 (SEE) + 10 (IA)]	

Course Objectives:
The aim of this course is to give fundamental concepts of bacterial growth, mechanism of toxins, retroviral replication, mode of action of antimicrobial agent.

Unit I

Bacteria: Structure, functions & biosynthesis of Cell wall (Peptidoglycan), Outer membrane of Gram Negative bacteria; structure and formation of endospore; Bacterial growth phases & Kinetics. Toxins: Endo & Exotoxins and their mode of action. Antimicrobial agents & their mode of action; Anti-bacterial & anti-Fungal antibiotics, Mechanism of drug resistance.Structure & replication of retroviruses (HIV),General concept of pararetro viruses, Structure & function of viroids and Prions.

Unit II

Bacteriophage:, Life cycle of lambda phage, Regulation of gene expression in lambda phage (Lysogenic & lytic options). Transformation: Molecular mechanism of natural transformation. Conjugation: formation of F,HFr and F-prime. Transduction: Mechanism of specialized and generalized transduction. Structure of transposons (Composite & non Composite)

Learning Outcomes:
The course will enable students to understand the basics of microbial structure and microbial growth requirements and equipped with various methods of growth parameters. They can comprehend the mechanism of gene transfer and endmapping of bacteria.

Books Recommended:

1) Molecular Genetics of Bacteria. Jeremy W. Dale, Simon F. Park: Wiley-Blackwell.
2) Microbiology by Prescott, Joanne M. Willey, Linda M. Sherwood, Christopher J. Woolverton: McGraw-Hill.
3) Fundamental Bacterial Genetics. Nancy Trun, Janine Trempy: Wiley- Blackwell.

Semester II [Discipline Centric (DCE)]

Course No: BT23202DCE	**Credits: 3**
Course Title: Intermediary Metabolism	
Maximum Marks: 75 [60 (SEE) + 15 (IA)]	

Course Objectives:

The objective of intermediary metabolism course is to provide fundamental knowledge regarding the various metabolic pathways and their regulation with reference to human cells and tissue.

Unit I

Carbohydrate Metabolism:Bioengertics and Thermodynamics.Glycolysis, fermentation, gluconeogenesis and their reciprocal regulation. Glycogen synthesis/degradation and their regulation. TCA cycle and oxidative phosphorylation. Pentose phosphate pathway and glyoxylate cycle. Carbohydrate related disorders.

Unit II

Protein and Nucleotide metabolism: Transamination and deamination reactions and their clinical significance. Urea cycle. Nucleotide metabolism: purine and pyrimidine synthesis (de novo and salv age pathway). synthesis of deoxyribonucleotides from ribonucleotides. Formation of uric acid and its clinical significance. Nucleotide synthesis inhibitors and their clinical significance. Protein and Nucleotide releated disorders.

Unit III

Fatty-acid Metabolism and metabolic syndrome:Beta-oxidation of saturated and unsaturated fatty acids. Fatty acid synthesis. Triglyceride systhesis. Ketone-body synthesis and degredation and their significance. Prostaglandin synthesis and their significance. Brown adipose and thermogenesis. Obesity and body mass. Role of adipose tissue. Leptin and obesity. genes that regulate body mass. Metabolic deregulation and type-2 diabetes. Mechanism and pathways involved in diabetic complications. Role of diet, medication and exercise in managing type-2 diabetes.

Learning outcomes:

By the end of the course, the students get holistic view of the human metabolism and its regulation. The students get to know the role of various food components in metabolism and the molecular mechanism of various metabolic disorders, like diabetes, obesity, etc.

Recommended Books:

1) Principles of biochemistry by david lee nelson, albert l. lehninger, michael m. cox publisher: w.h. freeman.
2) Biochemistry by Donald voet, Judith G. voet

Semester II [Discipline Centric (DCE)]

Course No: BT23203DCE	**Credits: 3**
Course Title: Laboratory Course-II	
Maximum Marks: 75 [60 (SEE) + 15 (IA)]	

Course Objectives:

The course is aimed to provide basic lab training in techniques like DNA/RNA isolation, protein-protein interactions, SDS-PAGE, western blot and enzyme assay. The students are also provided training in handling of plant tissue culture.

Practicals

- Isolation of Genomic DNA and total RNA by various methods. Quantification of DNA and RNA.
- Separation of DNA and total RNA by agarose gel electrophoresis.
- SDS-PAGE and Western blotting.
- Immunoprecipitation (IP).
- Enzyme Assay
- Effect of temperature and pH on enzyme activity
- Determination of Kinetic constants Km and V max.
- Bacterial growth curve and culture techniques.

Learning Outcomes:

Will enable the students to learn techniques like Nucleic acid isolation, Immunoprecipitation, SDS-PAGE western blot analysis, basic enzyme assays and Plant tissue culture.

Books Recommended:

1. Sambrook, J., Fritsch, E. R., &Maniatis, T. (1989). Molecular Cloning: A Laboratory Manual (2nd ed.). Cold Spring Harbor, NY: Cold Spring Harbor Laboratory Press.

Semester II [Generic Elective (GE)]

Course No: BT23002GE	**Credits: 2**
Course Title: Redox Biology	
Maximum Marks: 50 [40 (SEE) + 10 (IA)]	

Course Objective:
The goal of this course is to let students understand the basics of Oxidant molecules their production and their harmful effects.

Unit I

Reactive Oxygen Species.Origin, Production, Enzymatic and Non-enzymatic sources of reactive oxygen Species (ROS) production.Mitochondria as a source of ROS.Involvement of cytochrome complexes, Xanthine oxidase and NADPH oxidase.Effects on cell and biomolecules. Lipid peroxidation. Protein oxidation. Inactivation of different proteins.ROS as a secondary messenger.Regulation of signal transduction.Role in cancers.ROS detection in the cells. □

Unit II

Antioxidants. Enzymatic antioxidants. Glutathione Peroxidase. Superoxide dismutase. Catalase. Non- enzymatic antioxidants.Mechanistic involvement of Vitamin C, Vitamin A. Vitamin E. Protective effects on the cell. Aging. Mechanistic players in aging.ROS in aging.Yeast and C. elegansas a model to study aging. Pathways involved in aging. Role of ROS regulating protein in aging including p53 and p66shc. □

Learning Outcome:
Students will have clear concepts on basics of oxidants, Oxidative stress, oxidant production and possible effects on cellular systems.Students will know on different types of antioxidants and mechanism of their action.Students will know about the physiological role of oxidants.

Books/Readings Recommended:

1) Selected Research and Review Journals like Antioxidant Redox Signaling and Free Radical Biology Medicine.
2) Internet Resources: Pubmed, Google, Google Scholar.

Semester II [Open Elective (OE)]

Course No: BT23002OE	**Credits: 2**
Course Title: Nutritional Biotechnology	
Maximum Marks: 50 [40 (SEE) + 10 (IA)]	

Course Objectives:

This course will enable the student to learn about various food components, their nutritional aspects, diet management and biotechnological applications in agriculture and food production

Unit I

Nutrition, Energy requirements of the body, Recommended Dietary Intakes (RDI) and its uses.Factors affecting nutritional requirement of an individual, Malnutrition. Balanced diet and basic food components

Carbohydrates: Occurrence and physiological functions, Lactose intolerance. Dental caries. Sugar alternatives. Role of dietary fiber in health and disease. Disorders related to carbohydrate metabolism. Glycemic index and Glycemic load of foods and their uses.

Lipids – Classification and Functions, Concepts of visible and invisible fats, EFA, SFA, MUFA, PUFA – sources and physiological functions. Role of lipoproteins (Chylomicrons, VLDL, IDL, LDL, and HDL), cholesterol, triglycerides in health and disease.

Unit II

Proteins: Classification and Functions, Concepts of essential and non-essential amino acids – their role in growth and development. Physiological functions of proteins.Protein malnutrition and muscle wasting disorders.

Vitamins: Role of vitamins in health. Deficiency and toxicity and nutrient claims in food and dietary Supplement.

Genetically Modified Organisms and their role in modern nutrition, resistance to insects, diseases, etc

Learning Outcome:

By the end of this course, the students will have a clear understanding about the relationship between food, nutrition and health.

Books Recommended:

Biochemistry by Donald Voet and Judith G Voet, John Wiley & Sons Biochemistry by U. Satyanarayana.

Semester III [Core (CR)]

Course No: BT23301CR	**Credits: 4**
Course Title: Genetic engineering	
Maximum Marks: 100 [80 (SEE) + 20 (IA)]	

Course Objective: The objective of genetic engineering course is to familiarise students with fundamentals of DNA recombinant technology and advanced aspects of genetic engineering.

Unit I

Recombinant DNA Technology Tools: Restriction endonucleases: Historical perspective. Nomenclature. Different types of restriction-modification systems and their characteristic features.Blunt end and cohesive end cutters with examples.Isochizomers, neoisoschizomers and isocaudemers.Restriction modification enzymes and their importance in DNA recombinant technology (Dam, DCM methylases). DNA ligases: E.coli and T4 DNA ligases. Chemistry of T4 DNA ligase reaction.DNA Phosphatases and their role in recombinant DNA technology.DNA Pol I and Klenow fragment and their role in recombinant DNA technology. Vectors: Plasmids: General features of plasmid vectors. Molecular regulation of high and low copy number plasmids. Characteristics features of pBR322, pUC series of plasmid vectors.General scheme of cloning in plasmid vectors. Selectable marker genes used in plasmid vectors and their mechanism of action. Molecular details of blue-white selection. Expression plasmid vectors: transcriptional and translation regulatory elements in expression plasmids. Characteristics feature of inducible plasmid expression vectors.yeast plasmid vectors: General features and mode of selection. Transformation of plasmid DNA in bacterial cells (Physical and chemical methods). Bacteriophages as cloning vectors: lambda-phage vectors: General characteristics features. Insertional lambda phage vectors and replacement lambda phage vectors .General scheme of cloning in lambda phage vectors. In-vitro packaging and its importance. M13 vectors: General features and scheme of cloning in M13 phage. Phagemid vectors: General features and their importance. Cosmid vectors: General characteristics and scheme of cloning in cosmid vectors. YACs: General characteristic features and scheme of cloning in YACs. BACs: General characteristic features and their importance.

Unit II

Genetic engineering techniques: Polymerase chain reaction: Principle and methodology. Source of template DNA (genomic DNA, Plasmid DNA and RNA). Features of an ideal primer.Primer design with restriction sites at the ends. Degenerate primers and their importance. DNA polymerases for PCR: characteristic features of error prone (Taq) and high fidelity DNA polymerases. Different types of PCR (nested, asymmetric, multiplex). Applications of PCR. Reverse Transcription PCR (RT- PCR): Principle and methodology. Different methods of first strand and second strand cDNA synthesis and cDNA library sysnthesis. Characteristic features of different reverse transcriptases (RT) used in RT-PCR. Real-Time PCR: Principle and methodology. Ct value and its importance.Different methods of fluorescent detection and probes (SYBER green, Taqmann probe, Molecular beacon probes, Scorpion probes). Melting curves and their importance. Quantification and normalization of raw data.Applications of Real-Time PCR.

Unit III

Site-Directed mutageneis: M13 vector based methods, plasmid vector based methods (single primer and double primer methods), PCR based methods. Protein engineering: Different methods and application of protein engineering. Hetrologous protein expression systems: Expression in bacterial systems: Promoters and translation elements used in expression vectors. Inducible promoter systems.Expression and purification of GST fusion proteins. Expression in yeast: Various promoters elements used in expression vectors. Inducible expression systems in yeast (Gal and CUP1 system).Pichiapastroris as yeast expression systems. Expression in Insect cell line (Sf9/21): Baculovirus expression vectors. structure and construction of recombinant Basmid vectors and expression of protein in baculoviral vectors.Expression in mammalian cells.Mammalian expression vectors. Viral and cellular promoter used in expression vectors. Importnace of kozak in expression vectors and codon optimization. Tet- Off/On Inducible systems.Expression of proteins with fusion tags (HA, His, Myc, Flag, GFP) and their significance. In- vitro transcription and translation and its application

Unit IV

Studying protein-protein interaction: Yeast Hybrid systems: Two hybrids based on split transcriptional activation, Split ubiquitin system, SOS recruitment system. Reverse two hybrid. Yeast three hybrid systems for protein-protein, protein-RNA interactions and protein ligand interaction. Transfections: Transient and stable transfection in animal cell.Physical, chemical and biological transfection agents.Repoter assays: Repoter genes and applications (Chlorophenicolacetytransferase (CAT), Luciferase (Firefly and Renilla), living colours (Green fluorescent, yellow fluorescent and their application in co- localization studies). Dual luciferase assay and its application. Gene knock-downs: Antisence RNA technology with examples from animals. RNA interference: Methodology and applications. Transgenics: Gene knock-in: Various methods of making transgenics (animals). Gene knock outs: Methodology based on Cre-LoXp system. Conditional and specific knock-outs. Gene editing: CRISPR-Cas9 system: Biology and mechanism. Re-engineering of CRISPR-Cas9 tools for Gene expression, repression, epigenome editing, etc. CRISPR-Cas9 and Base editing: Adenosine Base editing (ABEs) and cytosine base editing (CBEs).

Learning Outcomes:

After successful completion of the course, the students are expected to gain knowledge in genetic engineering concepts. The academic knowledge provides them a strong platform for performing various research-based endeavours in genetic engineering

Books Recommended:

1) Principles of Gene Manipulation and Genomics by Sandy B. Primrose, Richard Twyman: Blackwell Publishing Professional.
2) Analysis of Genes and Genomes by Richard J. Reece: Wiley.
3) Molecular Biotechnology - Principles and Applications of Recombinant DNA by Glick, Bernard R.; Pasternak, Jack J.; Patten, Cheryl L: ASM Press..

Semester III [Core (CR)]

Course No: BT23302CR	**Credits: 4**
Course Title: Plant Biotechnology	
Maximum Marks: 100 [80 (SEE) + 20 (IA)]	

Course Objectives:

The aim of this course is to provide skilled knowledge of biotechnology for the improvement of plants. The course deals with the concept of plant totipotency and its regulation .How to propagate plants in vitro by using tissue culture, Understanding the mechanism of genetic transformation of plants using agrobacterium system for the production of disease resistant, stress tolerant and to have altered nutrient content.

Unit I

General structure, organization & Molecular basis of Shoot Apical Meristem(SAM) & Root Apical meristem (RAM).Totipotency of Plant cell, Plant cell cycle, Role of various hormones in regulating plant cell cycle, Micropropagation (Seed V/S Soma), Stages & methods of micropropagation.Production of virus free plants. Tissue culture media (Composition & preparation),Role of micro, macro nutrients & other components present in tissue culture media, Commonly used media (Murashige and Skoogetc) Initiation and Maintenance of callus and suspension culture, Single cell clones Organogenesis: Basis, applications & control of Somaclonal variation. Somatic embryogenesis- acquisition of embryogenic competency, factors & genes influencing the embryogenic competency of cell during somatic embryogenesis, Synthetic seeds. Embryo rescue.

Unit II

Protoplast isolation (mechanical & enzymatic methods), maintenance, purification, viability, Culture and fusion (Spontaneous & induced fusion, sodium nitrate, calcium ion, PEG, electrofusion).Identification & Selection of hybrid cells and regeneration of hybrid plants; Symmetric & Asymmetric hybrids, Cybrids-formation and applications. Anther, pollen and ovary culture for the production of haploid homozygous lines, Molecular mapping, Introduction to genetic and physical maps, physical mapping

Unit III

Plant Transformation Technology; Morphology of Agrobacterium tumefaciens, Features of Ti Plasmids, Opines and its Types, Basis of tumor formation, Factors influencing binding of Agrobacterium to plant, Mechanism of T-DNA transfer & Role of virulent proteins in (Formation of T-DNA strand, movement of T-Complex & Integration of T-DNA into Plant

genome), Features of Binary vectors & its Types (pBIN19, pGreen, pCAMBIA, etc), Promoters used in Ti vectors (CaMV 35S and other promoters), Use of reporter genes(Opine synthase, CAT, GUS, LUX, GFP) and selectable markers (antibiotic & herbicide resistant genes, Metabolic intermediates etc) Generation of marker free plants (using Cre- Lox & other Excision techniques), Vector less or direct DNA transfer (Particle bombardment, Electroporation, WHISKERS, Pollen tube entry, Floral dip, Liposome mediated,etc). Plant transformation for productivity and performance with special example of Herbicide resistance (Glyphosate &Phosphinothricin resistance), Insect resistance (Bt based plants), Disease resistance (Role of R-proteins & other molecules), long shelf fruit and flowers, Stress tolerance (water deficit stress, Role of osmoprotectants and other molecules).

Unit IV

Molecular farming: Methodology involved in the production of Golden rice, Metabolic engineering of carbohydrates (Starch and fructan production), lipids (production of shorter & longer chain fatty acids, Modification of the degree of saturation). Production of Biodegradable plastic, Production Therapeutic protein in plants (Hirudin, Glucocerebrosidase, etc), Purification strategies for proteins-Oleosin partitioning Technology, Plantibodies (full length, scFv, Minibody, Diabody, Bispecific) Edible Vaccines, Manipulation of Shikimate pathway for the production of Vitamin E, Chloroplast Transformation (Mechanism & Advantages), Principle & applications of Gene termination technology, Concerns about Genetically modified plants.

Learning Outcomes:

Concepts of molecular mechanism involved in dedifferentiation & re- differentiation of plant cell using plant hormones to alter cell cycle. Core methodology involved in tissue culture for micropropagation of plants. Applied knowledge how plant can be used as an expression system for production of bioactive compounds at industrial scale. How to address the social and scientific concerns of genetically modified plants

Books Recommended:

1) Plant Biotechnology: The Genetic Manipulation of Plants Adrian Slater Nigel W. Scott Fowler: Oxford University Press.
2) Introduction to Plant Biotechnology: H S Chawla: Science Publishers, Inc.
3) Plant propagation by Tissue Culture : Edwin F. George,Michael A Hall: Springer-verlag.
4) Agrobacterium: From Biology to Biotechnology: Tzfira,Tzvi,Citovsky,Vitaly: Springer verla

Semester III [Core (CR)]

Course No: BT23303CR	**Credits: 4**
Course Title: Bioprocess engineering and Fermentation Technology	
Maximum Marks: 100 [80 (SEE) + 20 (IA)]	

Course Objectives: The objective of the course is to provide students with the knowledge of fermentation, bioreactor technology, and thus applications of the chemical engineering principles in biological systems.

Unit I

Sterilization: Types of sterilization. Thermal death kinetics of microorganism. Heat sterilization of liquid medium, Batch mode, Continuous mode, Problems & Examples. Air sterilization. Fermentation overview: Inoculum development. Various types of Fermentation: submerged fermentation, aerobic and anaerobic fermentation. Bioreactor operations: Different types of bioreactors, Configuration of Bioreactors and their main components. Modes of bioreactor operation.Important bioreactor accessories.

Unit II

Basic concepts, Kinetics of Cell Growth: Kinetics of batch culture, Growth kinetics for continuous culture, Material balance for CSTR. Fundamentals of material and energy balance for processes with/without chemical reaction: Biomass Balances (Cells) in a Bioreactor, Material Balance in Terms of Substrate in a Chemostat, Modified Chemostat. Problems & Examples. Metabolic stoichiometry: Biomass and Product Yields, YX/S and YP/S .Overview of biosynthetic mechanisms.

Unit III

Whole cell immobilization and their applications.Single cell protein. Cell disruption: mechanical, enzymatic, and chemical methods. Pre-treatment strategies. Solid-liquid separation: filtration, centrifugation, Adsorption, Problems/Examples. Liquid-liquid extraction, Solvent selection, Operating Conditions, Mode of Operation, Extractor Type Design Criteria. Membrane separation: ultrafiltration (Theory, Experimental set-up) reverse osmosis, dialysis, lyophilization. Precipitation of proteins by salting out, isoionic& semisynthetic polyelectrolyte methods.

Unit IV

Microbial fermentation and production of small and macromolecules: Antibiotics and Pharmaceuticals (Penicillin, Streptomycin), Microbial Production of Organic Acid (Citric Acid, Lactic Acid, Vinegar), Microbial Production of Vitamins. Production of Amino Acids (L-Glutamate, Lysine), Industrial Production of Ethanol by fermentation. Bakers yeast fermentation. Spirulina production. Alpha-amylase production, High Fructose corn syrup production. Cheese Production. Biodiesel production. Butanol production. Biopesticides. Biopolymer. Hepatitis B vaccine. Insulin. Biofertilizer. Biomethanation process.

Learning outcomes:

After completing this course, the students will be able to analyze the kinetics of cell and product formation under different types of culture conditions. The students will be able to develop control strategies for bioprocess operations, and will be able to select the appropriate methods for product purification.

Books Recommended:

1. M.L.Shuler and F.Kargi, "Bioprocess Engineering--basic Concepts", 2nd Edn. Prentice-hall of India Pvt Ltd
2. P.M.Doran, "Bioprocess Engineering Calculations", Elsevier India Pvt Ltd (2008).
3. C. Ratledge& B. Kristiansen, "Basic Biotechnology" 3rd Edn. Cambridge University Press
4. Peter F. Stanbury, Stephen J. Hall & A. Whitaker, "Principles of Fermentation Technology", Elsevier India Pvt Ltd.(2007).

Semester III [Core (CR)]

Course No: BT23304CR	**Credits: 2**
Course Title: Human Genetics	
Maximum Marks: 50 [40 (SEE) + 10 (IA)]	

Course Objective:

Provide deep understanding of complex genetic principles and their human genetics applications. Equip students to analyze inheritance patterns, interpret genomic data, and grasp advanced techniques in genetics research

Unit I

Inheritance Patterns and Genetic Variation:Mendelian Inheritance and Single-Gene Patterns: Overview of Mendel's laws. Autosomal recessive and dominant disorders: inheritance patterns and examples.Non-Mendelian Inheritance: Sex-linked recessive and dominant disorders. Mitochondrial inheritance. Genomic imprinting and its impact on gene expression.Population Genetics: Sources of genetic variation, Hardy-Weinberg equilibrium, population structure, genetic drift, migration, and natural selection.

Unit II

Advanced in Human Genetics:Complex Trait Genetics and Genomics: Polygenic inheritance, heritability, genome-wide association studies (GWAS), and their applications.Disease-Causing Variants and Personalized Medicine: Genetic basis of rare and common diseases, cancer genomics, and personalized medicine.Cutting-Edge Techniques in Human Genetics: Emerging genomics technologies (long-read sequencing, single-cell genomics), gene editing techniques and their applications.Genetic Models and Traits: Use of animal models in human genetics research, induced pluripotent stem cells and their role in genetic studies.

Learning Outcome:

Grasp Mendel's laws, inheritance patterns, and exceptions.Understand sex-linked, mitochondrial inheritance, and genomic imprinting.Analyze genetic variation, assess Hardy-Weinberg equilibrium, comprehend evolutionary forces.Interpret polygenic inheritance, heritability, conduct GWAS.Evaluate disease genetics, explore personalized medicine, assess cancer genomics.Comprehend cutting-edge genomics like long-read sequencing, gene editing.Recognize animal models, understand induced pluripotent stem cells in genetics.

Books Recommended:

1) Thompsan and Thompsan: Genetics in Medicine, Elsevier publications.
2) Emery’s Elements of Medical Genetics. Elsevier

Semester III [Discipline Centric (DCE)]

Course No: BT23301DCE	**Credits: 2**
Course Title: Bioethics, Biosafety and Intellectual Property Rights	
Maximum Marks: 50 [40 (SEE)+10 (IA)]	

Course Objective:

The main aim is to introduce students to Bioethics, its meaning, its philosophical foundations and bioethics principles.Imparting knowledge and skills that will enable students to develop ethical answers to these various issues especially related to research discoveries made in the field of biology.Identify the basic concepts of modern biology and explain how recent advancements in these areas have influenced current bioethical issues.

Unit I

Introduction to Bioethics.Ethics and Morality.Introduction to subject areas of Bioethics (Poverty, Birth control, ethics and religion, euthanasia, Environmental ethics). Bioethical Principles. Bioethics in Research. Conflicts of interest, Publication misconduct: definition, concept, problems that lead to unethical behavior and vice versa, types, Violation of publication ethics, authorship and contributor ship.Plagiarism and similarity index concepts.Laboratory Biosafety: Importance, Biosafety levels, Biosafety Guidelines.

Unit II

Bioethical and Biosafety issues concerning Stem cells and Cloning. Animal cloning. Controversies regarding Designer babies. Gene therapy. Ethical controversies on Organ Transplantation. Surrogacy. Ethical regulations on Surrogacy. Genetically modified crops. Ethical and Bio safety issues involved in GMO,s. Advantages and Disadvantages. Ethical Limits of Animal use. Animal experiments in light of Bioethics.

Intellectual property rights: Introduction, Categories, Examples and Importance. Entrepreneurship: Meaning, Types and its Importance.

Learning Outcome:

Students will be able to understand basics of bioethics, importance of this course, its relevance in research, publishing field and healthcare.Students will be able to understand the goal behind transgenic plants and animals, Ethical concerns and analysis. .

Books & Referencesrecommended:

1) Title: Bioethics, an introduction for the biosciences Author: Ben Mepham. Publisher: Oxford University, UKYear: 2013Edition: 2nd.
2) Title: Bioethics: An Anthology (Blackwell Philosophy Anthologies) Paperback..Authors: Helga Kuhse, UdoSchüklenk and Peter Singer. Publisher: John Wiley & Sons; Year: 2015. Edition: 3rd Revised edition.
3) Title: The International Law of Biotechnology: Human Rights, Trade, Patents, Health and the Environment (Principles of International Law series) .Author: Mathias

Semester III [Discipline Centric (DCE)]

Course No: BT23302DCE	**Credits: 3**
Course Title: Systems and computational Biology	
Maximum Marks: 75 [60 (SEE)+15 (IA)]	

Course Objectives:

To introduce the concepts of systems biology to student. To expose the students to high through put methods like proteomics and next generation sequencing based methods

Unit I

Introduction to systems biology, Networks-definition, Representation of networks, Graph theory.Properties of networks, Degree, Degree distribution, Clustering coefficient, shortest-pathlength.Structure of biological networks.Types of networks- Random, Scale-free and Hierarchical networks.Emergent properties of networks.Cellular networks; genetic and molecular interaction networks. Significance of cellular networks (combinatorial-out puts, multitasking), Synthetic networks. Systems biology and future medicine

Unit II

Noise-noise and robustness of cellular processes, Sources of biological noise; Intrinsic and Extrinsic noise, Noise in gene expression; stochastic gene expression, cell-to-cell variation in gene expression (cell-to-cell variation in number of RNA and protein molecules). Single cell measurements -Methods to study cell-to-cell variability of RNA and proteins.Noise and cellular decision-making (microbes to mammals).Non-genetic cellular heterogeneity and response.

Unit III

Protein-Protein Interaction Networks (PPINs); Mass spectrometry LC-MS/MS, identification, generation, and computational analysis of PPINs.Genome sequencing; library preparations, barcoding and Next Generation Sequencing (NGS), reference genome alignment and de novo assembly.Transcriptomics; microarray, RNA-seq (including computational pipelines for data analysis (determination of RPKM values) and applications. Chromosome conformation capture; (3C, 4C, 5C and HiC) and computational pipelines for data analysis and visualization (HiC-Pro, HiGlass, Juice-box). Chromatin-immuno precipitation coupled to NGS (ChIP-seq) and computational pipelines for data analysis. Introduction to Galaxy platform for analysis of different omics and large data sets. Applications of Machine Learning (ML) and Artificial Intelligence (AI) in Biology; AlphaFold, prediction and subtyping of cancers

Learning Outcome: This advanced course will enable the students to think in terms of systemic/holistic perspective and understand the biological processes in a more realistic context. The students will also get familiar with proteomics and genomics based methods**.**

Books Recommended:

Introduction to Systems Biology, Edited by Sangdun Choi, HUMANA Press

Semester III [Discipline Centric (DCE)]

Course No: BT23303DCE	**Credits: 3**
Course Title: Laboratory Course-III	
Maximum Marks: 75 [60 (SEE)+15 (IA)]	

Course Objectives:
To acquaint students with the principles and applications of genetic engineering techniques.

Practicals

- Restriction enzymes, cohesive and blunt end digestion of plasmid DNA,
- DH5-Alpha Competent cell preparation and competance calculation,
- Bacterial Transformation using plasmid DNA.
- Plasmid Isolation and purification,
- Polymerase chain Reaction (PCR): Primer design and PCR amplication of known DNA using plasmid template.
- Cloning DNA fragments in pUC vectors and selection of recombinant by blue-white selection.
- GST-fusion protein expression in E.coli and their affinity purification using GST tag.
- Basic idea of animal Cell Culture.

Learning Outcomes:
Students will acquire the knowledge on different techniques related to gene cloning, PCR amplification, Protein Purification and basic culture handling. Development of an ability to design and conduct genetic engineering experiments, as well as to analyze and interpret data.

Books Recommended:
Sambrook, J. and Russell, D.W. Molecular Cloning: A Laboratory Manual. Cold Spring Harbor Laboratory Press, New York.

Semester III [Generic Elective (GE)]

Course No: BT23003GE	**Credits: 2**
Course Title: Molecular Mechanism of Plant life	
Maximum Marks: 50 [40 (SEE)+10 (IA)]	

Course Objectives:
The aim of this course is to study the organization root apical meristem and shoot apical meristem, floral development, mode of action of new plant hormones.

Unit I

Organization of Shoot & Root apical Meristem. Molecular mechanism of shoot, Root & Leaf development. Phyllotaxy. Transition of flowering: Induction of flowering, Regulatory Pathways of Flowering. Floral meristem & floral development (Arabidopsis &Antirrhium)

Unit II

Plant hormones (Auxin, Gibberellin, Cytokinin, Ethylene, Brassinosteroids, Abscisic acid, Strigolactones, Jasmonates, polyamines, Salicyclic acid, Nitric oxide) biosynthesis storage, breakdown and transport: physiological effects and mechanism of action. Changing the genome of plants-transgenic plants (methods, advantages & concerns).

Learning Outcomes:
Demonstrate the molecular mechanism of regulating the stem cells in plant meristems.Elucidates the role new hormones in plants

Books recommended:

1) Handbook of Plant Science by Keith Roberts (Volume I &II), Wiley-Interscience.
2) Molecular life of plants by Russel Jones, Helen Ougham, Howard Thomas, Susan Waaland, Wiley- Blackwell

Semester III [Generic Elective (GE)]

Course No: BT23004GE	**Credits: 2**
Course Title: Cancer Immunology	
Maximum Marks: 50 [40 (SEE)+10 (IA)]	

Course Objectives:

The objective of this course is to introduce current concepts and advances in the area of cancer biology. The Students will understand the role of oncogenes and suppressor genes and get knowledge on cancer related mutagens and pathways and cancer therapy

Unit I

Oncogenes: Historical aspects, provirus, protovirus and oncogene hypothesis. Functional class of oncogenes (proto-oncogenes) Mechanism of carcinogenic transformation by oncogenes, viral oncogenes.Tumor suppressor genes- properties, mechanism of tumor suppressor genes in cancer induction with special reference to P53 gene. Inherited cancers.

Unit II

Tumor immunology and cancer diagnostics & therapy: Tumor immunology –Introduction, Mechanism of immune response to cancer, natural killer cells and cell mediated cytotoxicity. Biochemical, histological and radiological methods for cancer diagnosis Chemotherapy and radiotherapy strategies for cancer treatment.Cancer chemotherapeutic drugs.Types of radiation therapy.Immunotherapy of cancer – Rationale of immunotherapy, Tumor necrosis factor, interleukins, cytokines, interferons, vaccines, monoclonal antibodies.

Learning Outcomes:

Comprehend pathogenesis, molecular mechanisms and identification of cancerExplain cancer metastasis microenvironment and cancer therapy

Books Recommended:

1) Basic Immunology: Abul K. Abbas, Andrew H. Lichtman.
2) Janeway'sImmunobiology, Garland Sciernce
3) Essential Immunology by Delvis, Martin , Burton and Roitt

Semester IV [Core (CR)]

Course No: BT23401CR	**Credits: 1**
Course Title: Proposal writing	
Maximum Marks: 25 [25(SEE)]	

The students in consultation with their faculty advisor will prepare a synopsis of the project to be pursued. In the following months, the synopsis should include the rationale, objectives, proposed methodology and significance of the study. The students shall make an open presentation of the synopsis during the fourth week of the semester.

Semester IV [Core (CR)]

Course No: BT23402CR	**Credits: 14**
Course Title: Research Based Project	
Maximum Marks: 350 [280 (SEE)+ 70 (IA)]	

The project will be based upon research and actual bench work, carried under the guidance of faculty supervisor and in close collaboration with other research groups. The students are expected to put in at least six working hours daily for a maximum of six months. The students will participate in Journal club and Lab meetings of the research group. Project report will be submitted and will be evaluated at the end of 4th semester.

Part 1 of the project will be based upon introduction to the subject and a general review of the literature pertaining to the project. The students should be encouraged to write a review of the problem or on a related topic.

Part 2 of the project will be based on the actual experimental work, presentation and analysis of the data generated. The project report should consist of Abstract, Rationale, Review of literature, Methodology, Results and discussion, and bibliography. Two examiners will evaluate the project reports of the students. The examiners will be nominated by the Head of the department from the panel of examiners proposed by the Project advisor; one of them will be the advisor. The examiners should be either from the department or from allied

Semester IV [Core (CR)]

Course No: BT23403CR	**Credits: 2**
Course Title: Seminar and Journal Club	
Maximum Marks: 50 [40(SEE)+ 10 (IA)]	

Each student under the supervision of a faculty advisor will deliver a seminar on a topic related to his/her Project work. Two faculty members nominated by the Head of the department will evaluate the seminars. The journal club will consist of a research paper presentation to be assigned and evaluated by the Project advisor.

Semester IV [Core (CR)]

Course No: BT23404CR	**Credits: 3**
Course Title: Project presentation	
Maximum Marks: 75 [60(SEE)+ 15(IA)]	

The students should make an open presentation defending their project work. One external expert and two faculty members nominated by the Head of the department will evaluate the presentation. The presentation will be open to all the students, scholars and teachers of the department and other allied departments.

Semester IV [Core (CR)]

Course No: BT23405CR	**Credits: 2**
Course Title: Project viva	
Maximum Marks: 50 [40(SEE)+ 10 (IA)]	

One expert and all the faculty members of the department will conduct project viva.

Semester IV [Generic Elective (GE)]

Course No: BT23005GE	**Credits: 2**
Course Title: Basic Recombinant DNA Technology	
Maximum Marks: 50 [40(SEE)+ 10 (IA)]	

Course Objective:
Recombinant DNA Technology course aim is to provide general and basic information of recombinant DNA to the students so that they can apply it in their own respective subjects.

Unit I

Historical background of Recombinant DNA technology. Tools for making Recombinant DNA: Restriction enzymes: Nomenclature, types, properties. DNA ligases: Mechanism and types of DNA ligation .DNA phosphatases and their role in recombinant DNA technology.DNA Pol I and Klenow fragment and their role in recombinant DNA technology. Vectors: Plasmid: General features, copy Number and its regulation. Selection marker genes in plasmid vector.Bacterophages : Lambda phage as vector. General features of Cosmids and Phagemids

Unit II

DNA cloning in Plasmid vectors.General features of expression plasmid vector.Expression in bacterial systems using Inducible promoter systems.Expression in yeast using Gal Inducible systems.Expression in mammalian cells.Mammalian expression vectors. Viral and cellular promoter used in expression vectors. Expression and purification of *GST* and *His* tagged fusion proteins.

Learning Outcome:
After successful completion of the course, the students are expected to gain knowledge in Recombinant DNA Technology concepts. The academic knowledge will orient them to take some skill-based entrepreneurship in biotech companies.

Books Recommended:

1) Analysis of Genes and Genomes by Richard J. Reece: Wiley.
2) Molecular Biotechnology - Principles and Applications of Recombinant DNA by Glick, Bernard R.; Pasternak, Jack J.; Patten, Cheryl L: ASM Press.
3) DNA recombinant Technology and molecular techniques by M U Hussain: Black Prints India INC

Semester IV [Open Elective (OE)]

Course No: BT23003 OE	**Credits: 2**
Course Title: Bioethics	
Maximum Marks: 50 [40(SEE)+ 10 (IA)]	

Course Objectives:

Course aim is to introduce students to Bioethics, its meaning, its philosophical foundations and bioethics principles. Imparting knowledge and skills that will enable students to develop ethical answers to these various issues especially related to research discoveries made in the field of biology. Identify the basic concepts of modern biology and explain how recent advancements in these areas have influenced current bioethical issues.

Unit I

Introduction to Bioethics.Ethics and Morality.Introduction to subject areas of Bioethics (Poverty, Birth control, ethics and religion, euthanasia, Environmental ethics). Bioethical Principles. Bioethics and boundaries of public and private. Bioethics and conflict of interest.Bioethics in Research.

Unit II

Ethical issues concerning Embryonic Stem cells and Cloning. Animal cloning. Controversies regarding Designer babies. Gene therapy. Ethical controversies on Organ Transplantation. Surrogacy. Ethical regulations on Surrogacy. Genetically modified crops. Political and ethical issues involved in GMO,s. Advantages and Disadvantages. Ethical Limits of Animal use. Animal experiments in light of Bioethics.

Learning Outcomes:

Students will be able to understand basics of bioethics, importance of this course, its relevance in research, publishing field and healthcare.Students will be able to understand the goal behind transgenic plants and animals, Ethical concerns and analysis.Students will understand various ethical issues pertaining to animal use in research, growth hormone usage, Surrogacy and cloning.Students will understand the tools and approaches needed to make a bioethical decision and to communicate that decision in rationally informed way.

Books Recommended:

1) Title: Bioethics, an introduction for the biosciences Author: Ben Mepham Publisher: Oxford University, UK Year: 2013 Edition: 2nd
2) Title: Bioethics: An Anthology (Blackwell Philosophy Anthologies) Paperback. Authors: Helga Kuhse, UdoSchüklenk and Peter Singer Publisher: John Wiley & Sons; Year: 2015 Edition: 3rd Revised edition
3) Title: The Biological Foundations of Bioethics Author: Tim Lewens Publisher: OUP, Oxford Year: 2015 Edition