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.