10. SCHOOL OF BIOTECHNOLOGY

The pattern of JNUEE 2022-23 will be based on Multiple Choice Questions (MCQs) through Computer Based Test (CBT)

Ph.D.

Sl. No.	Name of School	Sub. Code & Sub. Code Number	Syllabus for Entrance Examination
1	School of Biotechnology	Biotechnology – SBTH (904)	**Biophysical Chemistry:** 1. **Interactions in Biological Systems:** Intra and inter molecular forces, electrostatic interactions and hydrogen bonding interactions; van der Waals and hydrophobic interactions; Disulfide bridges; Role of water and weak interactions 2. **Structure of Proteins:** Conformational properties of polypeptides; Primary and secondary structure (α-helix and β-sheet structures etc.); Tertiary and quaternary structure; Structural features of membrane proteins; Secondary and tertiary structure prediction of protein conformation 3. **Multiple equilibrium:** Titrations of proteins to evaluate net and total charge; Scatchard and Hill plots; Folding-unfolding equilibrium and denaturation of proteins; Effect of temperature and solvent conditions on the thermodynamics of protein folding-unfolding equilibrium and Kinetics of protein folding. 4. **Techniques for the study of Macromolecular structure:** Analytical Ultracentrifugation: Sedimentation velocity and equilibrium, determination of molecular weights; Microcalorimetry (DSC and ITC) and its applications; Circular Dichroism spectroscopy; UV, Visible and Fluorescence spectroscopy; X-ray diffraction; Nuclear Magnetic Resonance (NMR) and Mass Spectrometry. **Biochemistry & Enzymology** 1. **Enzyme Kinetics and Inhibition**: Introduction about enzymes, classification, activity, cofactors; Chemical Kinetics; Regulation of enzyme activity by various factors such as pH, temperature etc.; Enzyme Inhibition-various types with examples; Kinetics of enzyme inhibition; Enzyme activity and purification-subcellular fractionation and specific activity 2. **Enzymes: Mechanism, Structure and Regulation:** Substrate specificity of enzymes; Functional Groups Essential for Catalysis; Reaction Mechanism of Enzyme Active sites; Regulatory Enzymes; Allosteric Enzymes; Covalently modulated regulatory enzymes; Covalent Activation of Zymogens; Isozymes 3. **Regulatory Strategies of Enzymes:** Aspartate Transcarbomylase, Protein Kinase A, Myosin, Restriction Enzymes, Lactate Dehydrogenase, Ser/Thr Kinases, Tyr Kinases; Proteolysis Activation, Blood clotting Factors 4. **Glycobiology:** Sugars, glycoproteins, glycoconjugates, glycosylation of biomolecules, disorders associated with glycosylation defects 5. **Introduction to Metabolism:** Metabolic Pathways; Organic Reaction Mechanisms; Experimental Approaches to the study of Metabolism; Thermodynamics of Phosphate compounds; Oxidation-Reduction Reactions 6. **Carbohydrate Metabolism:** Glycolysis; Fermentation: The Anaerobic Fate of Pyruvate; Metabolism of Hexoses Other than Glucose; Glycogen; Breakdown & Synthesis; Gluconeogenesis; Pentose Phosphate Pathway; Metabolic Regulation and Control

			7. **Citric Acid Cycle:** Cyclic Overview; Metabolic Sources of Acetyl; Coenzyme A; Enzymes of the Citric Acid Cycle; Regulation of the Citric Acid Cycle 8. **Electron Transport and Oxidative Phosphorylation:** The Mitochondrion; Electron Transport; Oxidative Phosphorylation; Control of ATP Production 9. **Lipid metabolism:** Lipid Digestion, Absorption and Transport; Fatty Acid Oxidation& Biosynthesis; Ketone Bodies; Regulation of Fatty Acid Metabolism 10. **Amino Acid Metabolism:** Role of essential amino acids; Amino Acid Deamination; The Urea Cycle; Metabolic Breakdown of Individual Amino Acids; Amino Acids as Biosynthetic Precursors; Amino Acids Biosynthesis; Nitrogen Fixation 11. **Nucleotide Metabolism:** Synthesis of Purine Ribonucleotides; Synthesis of Pyrimidine Ribonucleotides; Formation of Deoxyribonucleotides; Nucleotide Degradation; Biosynthesis of Nucleotide Coenzymes **Bio-organic Chemistry:** 1. **Introduction to organic compounds:** **Classification of organic compounds** To familiarize the students with the basic notations used in organic chemistry to describe the name, structural representation, and orientation of organic compounds To familiarize the students with the basic understanding of the various functional groups those are present in many organic compounds, their synthesis and properties **Stereochemistry of organic compounds**: To understand the perspective and spatial orientation of atoms in an organic molecule, to compare and contrast the different arrangement of atoms or groups around carbon 2. **Reaction Mechanisms:** To understand the mechanistic pathways of organic reaction To understand the importance of steric and electronic influences of both reactant and reagents on the product formation or distribution The aim of this unit is to provide detailed exposure to some of the key areas of organic chemistry namely aliphatic and aromatic nucleophilic and electrophilic substitution reactions, elimination reactions and free radical reactions. The students will be able to recognize the direction of electron flow (use of curly arrows) in reaction mechanisms and knowledge of the relative stability of intermediates, prediction and/or explaining the products of reactions 3. **Name reactions and Spectroscopy:** To understand the importance of specific reagents for a specific transformation To understand how the organic compounds can be characterized To understand how to identify the various functional groups those are present in organic compounds To enhance the working knowledge and understanding of some of the synthetic reactions that are widely used in organic chemistry Name reactions will be very much useful to help them gain insights into the numerous approaches that are used in various complex synthetic transformations. 4. **Heterocyclic Chemistry of Bioorganic Compounds:** To identify and name the mono cyclic and bicyclic systems containing hetero atoms (atoms other than C and H); To understand how different heterocycles can be prepared from simple starting materials; To study how heterocycles can be interconverted. The study of heterocycles (their nomenclature, synthesis and reactions) will allow the students to learn the reactions that are useful for designing and interconverting therapeutically important compounds. 5. **Chemical Synthesis of Biomolecules:** To identify and draw the carbohydrates structure using Fischer, Haworth and chair projection and their inter conversions; To understand how glycosylation reactions occurs and neighbouring group participation effects; To study how Glucose structure was elucidated by Fisher (Kiliani-Fisher synthesis, Ruff degradation, osazone formation, oxidation); Nucleic acid synthesis

(phospho diester, triester methods, phospharamidite chemistry, protection-deprotection strategies, modification of 2' OH); Peptide synthesis (SPPS), Protein synthesis.

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Mathematics and Statistics:

1. **Basic study of Calculus:** Functions and Graphs, Limits and Continuity, Introduction to Differential equations and Integrations, definite and indefinite integrals, Integration by parts
2. **Basic Algebra and Trigonometry:** Determinant and Matrix, Arithmetic and geometric Progressions, Compound, Multiple and sub multiple angles
3. **Basic coordinate Geometry:** Straight line, circle, ellipse, parabola
4. **Basic concept of computer Programming:** Logical operations, Simple mathematical algorithms, Looping and Concept of rows and column operations
5. **Introduction to MATLAB:** Basic syntaxes, Analysis of Matrix using MATLAB, Analysis of the Data obtained from simple biological experiments using self-written programs (Data from UV-Vis spectra, Fluorescence spectra) Image analysis using simple microscopic images, analysis of basic mathematical models (radioactive decay functions, logistic growth etc.).

Bioinformatics:

1. **Biological data**: Nature of biological data and its structure; High-throughput data, it's generation and analysis basics.
2. **Biological database:** Bioinformatics basics, Introduction to Unix and Linux systems and basic commands; Database concepts; Protein and nucleic acid databases; Sequence file formats; databases and search tools: searching of databases similar sequence; NCBI; publicly available tools; resources at EBI; resources on web; database mining tools.
3. **Sequence Analysis:** Introduction to sequence alignment; substitution matrix; pairwise alignment; Scoring matrices, FASTA, BLAST; Statistical significance of alignment; motif discovery and gene prediction
4. **Multiple Sequence Alignment:** Multiple sequence alignment, CLUSTAL, MUSCLE, MAFFT, T-Coffee, distance matrix
5. **Phylogenetic Analysis:** Phylogenetic analysis; tree building methods, UPGMA, NJ; Maximum Parsimony; Maximum Likelihood; Software for phylogenetic analysis
6. **Structural Biology:** Structural databases; PDB File format; Peptide Bond, Phi-psi and chi torsion angles; Ramachandran Plot; Introduction to force field methods; Structural Classification; fundamental of protein modelling; homology modelling; ab initio modelling
7. **Biological Data security, privacy, safty and sharing:** Need for data security, Data privacy, Responsible sharing of biological data, Data ownership, Socio-legal issues around biological data.
8. **Future of Biological Data:** Where is the field going? Data size implications and its implications in future biological science research, New methods to deal with biological data complexity.

Molecular Biology of Prokaryotes:

Brief introduction to molecular biology & processes: Denaturation and renaturation of DNA. Tm. GC content from Tm. Renaturation kinetics of DNA and complexity of DNA. Cot curves. DNA-DNA hybridization-relatedness of difference genes and species.

Bacterial Genome organization: Evolution of genome, Genome content, C-value paradox, Packing ratio, density of genome. Bacterial genome. Short- and long range organization, Proteins associated with bacterial genome & their function.

Bacteriophages: Genome and infection and Biology: Bacteriophage T4: Unique properties of genome, Presence of modified bases. Terminal redundancy & Circular permutation. Genetic map of T4 is circular. T4 life Cycle; Transcription: Temporal expression of genes. Replication:

			Degradation of host genome and generation of modified cytosine for its own perpetuation in T even phages. Assembly of Phage particles. T4 DNA polymerase and regulation of transcription; Bacteriophage T7: Gene organization and Infection Controlled Injection of DNA; Transcriptional regulation; Classes of genes. Taking over cells & production of T7 Polymerase. Differential affinity with Class II and III promoters; Bacteriophage ϕX174: Genome. Circularity of genome. Infection and Growth. Conversion of single stranded circular DNA viruses into double stranded RF form. Synthesis of viral plus strand from RF DNA. Packaging of genome in phage head. Transcriptional regulation, Overlapping genes. **Plasmids**: Microscopic and Genetic-F plasmid first plasmid to be detected. Counter-selection, Transfer accompanied by replication, Purification of plasmids. Mobilizable and non-mobilizable plasmids. Incompatibility- reasons of incompatibility. Copy number control. Replication of Plasmids: Use of host and plasmid encoded proteins. Uni- and Bi directional replication, Butterfly mode of replication. Replicon. Control of plasmid replication- Iteron regulated and RNA regulated replication. Antisense RNA for primer RNA and replicase protein. Role of replication on incombatibility in Iteron regulated. Drug-resistance plasmid: R- and RTF determinant. Colicin plasmid: Types of plasmids. Action of colicins. Colicin genes. Immunity and Lysis proteins. Export and Action **Insertion sequences and Transposons:** Significance of moving elements of the genome. Bacterial transposable element: General organization of simple insertion sequence & transposable elements. Mechanisms of transposition: Non-Replicative and Replicative transposition, IS transposition a regulated event? Bacteriophage Mu: Replication by transposition. **Replication:** Elucidation of DNA structure and lead to copying mechanism. Models for DNA replication, Meselson and Stahl experiment 1957. Replication of the *E. coli* genome: John Cairns experiments: Single origin of replication, and bidirectional replication, Ross Inman's experiment- denaturation mapping studies, Mechanism of replication: Theta, rolling circle (sigma), D-loop, Semi discontinuous replication: Pulse chase experiment, Okazaki's experiment on T4 bacteriophage DNA, Use of T4 ligase mutants. Origin of replication– Commonality among E. coli, yeast and SV40 origin of replication Enzymes of DNA replication: DNA polymerases: DNA polymerase I not the primary enzyme: Its other role in maintenance of DNA integrity. Processivity, direction of DNA polymerization, fidelity, E. coli DNA polymerase I and its components, Klenow fragment and other domains. DNA polymerase II and its function in DNA replication and repair DNA polymerase III: subunit structure and function: core and holoenzyme. DNA polymerase IV and V. Stages of DNA replication: Initiation- role of DNA methylases, types of E. coli methylases; elongation and proteins involved in elongation, termination. Priming: Mechanisms of priming. RNA primed DNA synthesis – experimental evidences, E. coli primase, Types of primosomes *E. co*li type and PhiX174 type, PAS sequences, Prepriming proteins Endonucleolytic priming: PhiX 174 gene A protein dual activity. Terminal protein priming. Other proteins of replication. DNA helicase, SSB protein & its effect on replication, DNA ligase, topoisomerases Types I & II, Nick translation. **DNA recombination:** Definition, applications of natural recombination, Classification of recombination, Various possibilities of recombination, Models of homologous recombination, Steps involved in homologous recombination, Recombination events during Single and double strand breaks, Holliday Junction and resolution, Protein machinery of recombination, branch migration and resolution **Mutations and Repair:** Mutants, Mutations and Mutagenesis: definition, reasons, measuring mutagenicity. Classifications of mutations: On the basis of location, structure, function and phenotype. Conditional, spontaneous and induced mutations, Missense, nonsense, frameshift mutations, Reversions. Mutagenic agents_ high energy, chemical and natural, Suppressor tRNA, missense repressors, frameshift suppressors Repair: DNA repair: Mismatch repair, Base excision repair, nucleotide excision repair, direct repair, enzyme of repair, Error prone repair, SOS response **Transcription:** Flow of information from DNA to protein. Organization of genes in bacteria. Collinearity of genes and proteins. Operon concept. Process of transcription: RNA polymerase subunit structure and function role of sigma factor in differential expression of genes in bacteria. Transcription units and Cis elements. Promoter: Consensus sequences affecting the promoter function. Constitutive and inducible promoters. Operator sequences as regulatory *cis* sequences. Initiation: Interaction of polymerase with the promoter and control at initiation. Attenuation. Elongation. Termination: Rho dependent and Rho independent termination. Control at termination: Attenuation, Antitermination. Processing of

primary transcripts in prokarytoes:
Processing of tRNA & rRNA. Cleavage of T7 early mRNAs by RNase III. Control at processing level. Regulation of transcription in bacteria: Introduction and repression. Represser as a regulatory molecule. Coordinated control of gene clusters. Positive and negative regulation: Regulation of transcription of *lac, trp, ara, his*, & *gal* operons. Regulation through catabolite repression. CAP protein as a positive control factor. Transcriptional regulation in bacteriophage Lambda: Lytic and Lysogenic switch. role of various regulatory proteins.

Translation: Genetic code. Origin of genetic code. Essential components of translation. Ribosome: the site for translation, subunit composition and assembly. Role of ribosomal RNA in translation. tRNA: Salient features of tRNA. Aminoacyl tRNA synthetases. Difference between initiator fmet-tRNA and met-tRNA, Suppressor tRNAs, frameshift suppression. Codon-Anticodon recognition: Wobble hypothesis. Process of translation: Activation, Initiation, elongation translocation and termination. Factors involved in various steps. Peptidyl transferases. Co-translational and Post – translational mechanisms. Control of gene expression at translational level.

Immunology:

1. **Introduction to the Immune System:** Historical background, cellular and molecular components of immune system
2. **Innate Immunity:** Innate immune cells, Pathogen associated molecular pattern (PAMP), Pathogen recognition receptors (PRR), Type 1 IFN, Interferon Stimulated Genes (ISGs), Complement system.
3. **The Recognition of Antigen:** Structure of a typical antibody molecule, Antigen recognition by T cell and B cells, Generation of lymphocyte antigen receptors, TCR gene rearrangement, Antigen presentation to lymphocytes, MHC/HLA complex.
4. **The Development and Survival of Lymphocyte:**
   The development of T lymphocytes in the thymus, Development of B lymphocytes, Positive and negative selection of T cells, Maturation of lymphocytes in peripheral lymphoid tissue
5. **The Adaptive Immune Response:** T cell mediated immunity, Entry of naïve T cells and APCs into peripheral lymphoid organs, Naïve T cells priming by pathogen-activated dendritic cells, T cell-mediated toxicity, Macrophage activation by TH1 cells, humoral immune response, Immunological memory, Cytokines.
6. **Immune system in Disease:** Self-tolerance, autoimmune diseases, transplant rejection, allergy and anaphylactic shock, AIDS immunology
7. **Immune aging:** Immunosenescence, Immune-exhaustion during aging and chronic infection, Mucosal Immunology
8. **NK cells and Cancer:** Inhibitory receptors, KIR receptors, CTL responses in cancer, Immunotherapy
9. **Characterization of lymphocytes specificity, frequency and function:** Lymphocyte isolation, ELISPOT assay, Multicolor flow cytometry, HLA-tetramer assay
10. **Vaccines:** History of vaccinology, attenuated vaccine, heat killed vaccine, subunit vaccine, recombinant vaccine, DNA vaccine, dendritic cell based vaccine, VLPs, T-cell based vaccine, edible and therapeutic vaccines. Vaccine against cancer, Adjuvants and their role in vaccine.

Plant biotechnology:

1. **Prologue to Plant's World:** Plant and human society; Growth and development; Plant hormones; Photosynthesis
2. **An Introduction to Plant Genetics:** Plant genome organisation; Organellar Genome, Polyploidy; Genetic diversity; Molecular markers and mapping; Phylogenetics and genomics; Breeding and methods; Forward vs. reverse genetics; Discussion;
3. **Basic Aspects/Techniques of Plant Tissue Culture:** Introduction; Totipotency and Regeneration; Nutritional media and growth regulators; Haploid production,

Problems in plant tissue culture; Discussion.

4. **Transgenic Crops:** Plant Transformation methods, Agrobacterium Biology, Molecular characterization of transgenic plants, Global status of transgenic crops; Traits under development; Case Studies; Challenges; Discussion
5. **Applications:** Crop improvement; Plant Molecular farming (Bioreactors); Renewable energy; Bio-fortification for Human Health; Discussion
6. ***Safety and Regulations:*** Understanding issues encountered in plant biotechnology; Risk assessment; Environmental impact and gene flow; Regulation and labelling; Discussion.

Microbiology:

1. **Bacterial diversity**
   How to classify Bacteria; Chemical/Biochemical reactions; Nutrient preference and other biochemical properties; 16s rRNA base classification; Three domains of microorganisms.
2. **Diversity of bacterial flora in humans**
   Diversity of microorganisms associated with different anatomical areas in humans; Alterations in microbiome diversity with diseases.
3. **Structure and functions of the prokaryotic cells**
   Peptidoglycan structure and biosynthesis; Cell surface proteins and their role in bacterial pathogenesis; Structure and biosynthesis of cell surface organelles; Chaperone –usher pili in gram negative bacterial; Covalent anchorage of cells surface proteins in gram positive bacteria.
4. **Bacterial host pathogen interaction**
   Mechanisms of bacterial pathogenesis; Bacterial structure in relation to pathogenicity; Bacterial proteins toxins/endotoxins.
5. **Antimicrobial agents used in the treatment of infectious diseases**
   Mechanism of antibiotic actions; Antibiotic resistance.
6. **Basic concepts of virus structure**
   Helical Symmetry; Icosahedral Symmetry.
7. **Origin of viruses**
   Different hypothesis; Viral eukaryogenesis.
8. **Emerging and re-emerging viral diseases**
   Emerging viral infections as public health threats; Factors effecting re-emergence of viruses.
9. **Viral genome replication**
   Double stranded DNA virus; Single stranded DNA virus; Single stranded RNA virus; Double stranded RNA virus; Retrovirus.
10. **Molecular genetics of viruses**
    Mutation rates and outcomes; Phenotypic variations by mutations; Recombination
11. **Molecular pathogenesis**
    Animal models; Methods for the study of viral pathogenesis
12. **Viral immune evasion strategies**
    Innate immunity; Adaptive immunity.
13. **Antiviral chemotherapy- Mechanism of action**
    Viral genome replication inhibitors; Viral entry, exit and maturation inhibitors
14. **Modern approaches to virus control**
    Antisense RNA, siRNA, ribozymes and miRNA
15. **Construction of recombinant viruses for therapeutic purpose**
    Replication incompetent virus; Replication competent virus.

Eukaryotic Molecular biology and Genetics:

1. **Introduction to molecular genetics:** Basic concepts for gene, gene analysis,

			gene-function and genome of different model organisms (Archaea to Human). General genome characteristics of the model organisms, Comparative genome structure analysis of the prokaryotes and eukaryotes. 2. **Fundamentals of human genetics:** Physical structure of the gene, Mendel's laws, alleles & genotypes, Segregation patterns, Deviations from mendelian principles, Penetrance and Expressivity, Statistical methods used in genetics, Organization of the human genome, Techniques to study human chromosomes, DNA methylation and histone code. 3. **Modern tools of Human Molecular Genetics:** Concepts in the molecular genetics, Basic knowledge of the mammalian transcriptomics, Transcriptomic analysis of mammalian cell and its importance in human physiology, Basic nucleic acid hybridization assay, Factors affecting nucleic acid hybridization, Common hybridization probes and methods of probe labelling, Microarray hybridization, Applications of microarray hybridization in functional genomics and biotechnology. 4. **Genes in pedigrees and population:** General concepts of the genetics and gene inheritance, interdisciplinary (e.g. Mathematical, statistical, computational approaches etc). Inherited disease symptoms to genetic analysis. Early days of gene hunting: Use of microsatellite markers for identifying disease genes for monogenetic diseases such as haemophilia and cystic fibrosis, Mendelian pedigree patterns, Factors affecting gene frequencies, Hard-Weinberg relationship. 5. **Genomics: The mapping and sequencing of genomes**: Approaches and milestones in genetic and physical mapping of the human genome, Disadvantages of advantageous previous gene hunting methods for complex disorders such as type 2 diabetes, Human genome project, HapMap project 1000 genome project, linkage disequilibrium, Role of genome wide association studies (GWAS) in understanding complex disease genomics, Advantages and limitations of association studies, Genomic libraries, DNA sequencing and analysis of DNA, Comparative genomics: Tools and applications. 6. **Genetic models for studying mammalian development and diseases:** Study of model organisms, comparative genomics and evolution, Concept of G-value paradox. Selection. Invertebrate model & vertebrate model (one each example). 7. **Basics human epigenetics and its applications:** Basic concepts, Chromatin conformations: DNA methylation and the histone code, Epigenetic memory & Imprinting in humans, ENCODE project, Different available methods and their comparisons. 8. **Pharmacogenetics, personalized medicine and population screening:** Pharmacogenetics, Pharmacogenomics, Genetic differences affecting metabolism of drugs taking warfarin as an example, Personalized medicine, Testing for susceptibility to complex diseases, Population screening. 9. **Introduction to Eukaryotic Molecular Biology:** How to read a paper. The evolution of a Cell with Nucleus, Hypothesis vs speculation in science, Rationalization of hypothesis, Experimental tools, Eukaryotic genome, gene expression and cell fate. 10. **Dynamic genome** – 3 D cell, dynamic genome architecture in nuclear space, chromatin movement, microscopes, microarrays and chromosome capture assays chromatin mobility and principle of nuclear organization, Nuclear architecture and gene-gene interaction, gene kissing, transcription factories, structural constraints on chromatin mobility (5L) 11. **Nuclear Matrix and gene regulation**: Nuclear matrix, nuclear matrix proteins, nuclear-matrix, structure and function, DNA Binding Properties of the Nuclear Matrix and Individual Matrix Prose. 12. **Association of chromosome territories with the nuclear matrix**: Disruption of

			human chromosome territories correlates with the release of a subset of nuclear matrix proteins, nuclear matrix targeting, signal, higher order chromatin structure and unclear matrix, transcriptional repression & nuclear lamina, nuclear matrix & expression of globin gene. 13. **Principle of eukaryotic Gene regulation:** gene regulating sequences, promoter, enhancers, regulatory elements, locus control region, gene activation and gene repression, transcription activators and repressors, TBP,GTFs, TBP associated factors (TAFs),RNA polymerases I,II,III, structure and function, mediators, general transcription factors, classes of transcription factors, structure and function, DNA-protein recognition in genome, Transcriptional regulatory networking, gene expression and Cancer progression 14. **Programmed cell death:** Apoptotic and necrotic cell death, apoptotic and anti-apoptotic genes, tumour suppressor genes, cell fate through decision between cell cycle arrest and apoptosis. 15. **Gene regulation and disease**: Order vs disorder in transcriptional regulation, network disfunction and disease, transcriptional therapeutics in diseases control. **Cell Biology:** **1. Composition and organization of biological membranes:** Membrane lipids: Types, properties and how they affect the curvature and fluidity of the membrane; lipid rafts: composition, a platform for organization of signalling complexes Membrane proteins: Properties and orientation in biological membranes; membrane composition and curvature, Membrane asymmetry, methods to study diffusion in membranes **2. Cellular transport mechanisms:** Principles of transport of small molecules across membrane: Organization and functioning of carriers and channels, membrane potential, action potential and membrane excitability Protein transport across membranes: Transport across the nuclear pore; Transport across ER and from ER to other organelles by vesicular transport; Post-translational modifications of proteins and their role in protein transport; Endocytosis, phagocytosis, exocytosis **3. Cell Cycle:** Components of cell cycle regulatory mechanisms: Cyclin-CDK complexes, CKIs and ubiquitin ligases in cell cycle regulation; Cell Cycle control mechanisms: Checkpoints, Regulation and maintenance of G1, control of genome replication, DNA damage and cell cycle regulation; Cell cycle defects and cancer: Key defects in cell cycle regulation and transformation) **4. Cell Signaling and Crosstalk:** Introduction: General Principles of cell communication, cell surface receptors and nuclear receptors, intracellular signalling and mechanisms. Cell Surface Receptors: regulation and signaling of G-protein-coupled receptors, G-proteins, cAMP dependent & c-GMP dependent pathways. Receptor Tyrosine kinase mediated signalling pathways- EGFR and IGFR mediated cell signalling and effects to cell apoptosis and cell proliferation. The pathway involving Ras and MAPK will be discussed in detail. Phosphoinositide & PI3Kinase- AKT signalling pathway, Ser/Thr Kinase mediated signalling, His-Kinase mediated signalling pathway and two component signalling pathway. Proteolysis based signaling (Wnt, Notch, Hedgehog): Structural and functional basis for normal and abnormal signalling. Cross-Talk Between Different Intracellular Pathways: Interactions between GPCRs and tyrosine kinase receptors; cross-cascade signaling of proteins involved in gene transcription. (Example: Cross talk between pattern-recognition receptors and Toll-like receptors. **5. Cytoskeletal Network:** Cytoskeletal network Proteins and their role: actin, microtubules and intermediate filaments. Extracellular Matrix components Cytoskeletal Protein Signaling network affecting cell adhesion and migration phenomenon of the cell.

			6. **Cellular Mechanisms:** Pathways of cell apoptosis, intrinsic and extrinsic, pathways for cell proliferation; Pathways for autophagy; ER stress and UPR pathways; Effect of glycosylated proteins on cellular Mechanisms of cell. **Genetic Engineering and its Applications:** 1. **Methods, Tools and Molecular Strategies in Genetic Engineering:** Introduction to genetic engineering, general work flow, potentials and its limitations; Host, vector and steps in cloning. Cloning of cDNA, and construction of cDNA library; Analysis of a cloned DNA fragment using restriction digestion and DNA sequencing; Concept, strategies, general workflow and variant of the PCR; The use of PCR in gene recombination, deletion, insertion and site directed mutagenesis; PCR in molecular diagnostics: Defection of the pathogens, and its potentials; PCR based diagnostics of the minimum residual disease (MRD) with case study; Application of real time (RT) PCR in the study of gene expression; Use of genetic engineering for recombinant protein technology; Expression of foreign gene in E. coli, Baculovirus and Pichia expression systems; Strategies for the production of soluble proteins; Role of integrated OMICS in the genetic engineering; Importance of computational tools and system biology for genetic engineering. 2. **Animal Genetic Engineering:** Methods of introduction of DNA into mammalian cells and Cell synchronization and its importance in the genetic engineering; Transient and stable integration of foreign DNA into mammalian cells; The viral vectors and their use in gene delivery and packaging of retroviral vectors and helper cells for gene therapy; The Adeno viral vector, unarmed Herpes and vaccinia viral vectors and their importance; Principles and methods of the gene targeting for model organism; Strategies for Gene knockouts in animals; Gene disorder and Gene therapy; Development of animal models for gene therapy; Detection of mutations in neoplastic diseases; Immuno - Suicide gene therapy in neoplastic diseases; Somatic and germ line gene therapy in vivo and ex-vivo experiments, Bioethics; Use of genome wide screening in the functional genomics; Recent breakthrough and advances in the genome engineering; Recent trends and development in the gene therapy. 3. **Plant Genetic Engineering**: Introduction to plant tissues culture, Plant transformation (Agrobacterium-mediated, Microprojectile bombardment-mediated and Floral-dip method of plant transformation), cointegrate and binary vector system, CRISPR/Cas9-based precise genome engineering, Transgenic Selection and Regeneration, optimization of transgenic expression, Applications of plant genetic engineering, understanding issues encountered in plant biotechnology, Discussion. **Downstream Processing:** 1. **Thermodynamic requirements of separation:** Classification of separation processes-equilibrium and non-equilibrium processes. Chief characteristics of bio-separation processes. RIPP: removal of in-solubles, isolation of products, purification and polishing. 2. **Cell harvesting:** Cell disruption – ball mill, chemical lysis, homogenization, selection of unit operation for insoluble removal. Centrifugation – general theory of centrifugation-final settling velocity, critical particle diameter, sigma factor. Types of centrifuges: tubular bowl, disc stack, basket, Sharples super-centrifuge. Theory of disc-stack centrifuges. Filtration. Types of filtration –rotary vacuum drum, plate and frame, leaf filters. Compressible cakes and filter aids. Theory of filtration. 3. **Product isolation:** Extraction, principle of extraction, partition coefficient, extraction factor, batch extraction, cascades, idealized stage operation, differential extraction, height of a transfer unit, number of transfer units, adsorption, adsorption isotherms, batch adsorption, adsorption in a CSTR. Aqueous Two Phase Extraction, Supercritical extraction, Foam based separation. 4. **Product Purification:** Chromatography, yield and purity and resolution, Principles of elution chromatography, ion-exchange, hydrophobic interaction, reverse-phase chromatography, gel-filtration chromatography. The concept of resolution, plate height. Protein purification. Synthesis of chromatography trains. Scaling-up chromatography using PAT/QbD approach.

			5. **Membrane filtration:**Tangential flow filtration, micro-filtration, ultra-filtration, reverse o 6. **Polishing:** Crystallization – separation, purity, nucleation, crystal growth, characteristic length, crystal size distribution, dominant crystal length. 7. **Lyophilisation and drying** 8. **Case study of Monoclonal antibody purification** **Bioprocess Engineering:** 1. **Basics of bioprocess engineering:** Introduction to bioprocess engineering, Microbial growth and death kinetics; Strain improvement strategies; Ideal and non-ideal reactors; Residence Time Distribution; Elements in bioreactor design-overview of bioreactor, specialised bioreactors, Construction materials, types of bioreactors, components of bioreactors and importance 2. **Stoichiometry and Models:** Stoichiometry of cellular reactions, reaction rates, dynamic mass balance, yield coefficient and linear rate equations; Material balances and data consistency (the Black box model, elemental balances, heat balance, over determined systems); Metabolic Flux Analysis and Metabolic control analysis: concept and applications. 3. **Bioreactor design and analysis:** Upstream processing: media formulation and optimization; sterilization (medium and air)-thermal death kinetics of microorganisms; aeration, agitation in bioprocess; Analysis of batch and continuous culture; Multiphase bioreactor system; Scale-up, scale-down. Developments using microbial processes (SmF and SSF), mammalian cell culture, plant cell culture, photobioreactor and CART-cell culture; Gas fermentation: Overview of conversion of gasified biomass and industrial gaseous into value added chemicals. 4. **Monitoring of Bioprocesses:** On line data analysis for measurement and control of important physicochemical and biochemical parameters, parameter estimation techniques for biochemical processes, Techno-economic feasibility of bioprocess. Challenges in biotherapeutics manufacturing. **Emerging Technologies:** 1. **Systems Biology:** Bimolecular network models, virtual cells, cytoscape 2. **Synthetic Biology:** Standards in biology, logic gates, oscillators, synthetic genes & proteins, synthetic cells 3. **Neurosciences:** Brain computer interface and consciousness: basic concepts & technological review 4. **Photoreceptor Biotechnology:** Development of climate-smart crops with photoreceptor biotechnology, Photoreceptor biotechnology for carbon sequestration and biorefinery, value added products, Artificial illumination for increasing yield and nutritional index of the crops 5. **Optobiology:** Photoimmunology, Photodynamic therapy, optogenetics therapy, opto-pharmacology and optogenetics for controlling neural networks, behavioral and neuropathies 6. **Genome Biology:** Introduction to Next Generation Sequencing technologies, Whole Genome Assembly and challenges, Sequencing and analysis of large genomes, Gene prediction, Functional annotation, Comparative genomics, Human genome project, Human Genomics Databases, Functional genomics case studies 7. **Data in biology:** Usefulness of data in biology, emerging technology like machine learning and artificial intelligenc 8. **Introduction to Microfluidics:** Importance of low volume measurement, Design and fabrication of microfluidic devices, Applications in biomedical sciences 9. **Biosensors and Bioelectronics:** Different types of sensors, optical and electronic biosensor, Nanoparticle plasmonic based optical sensing, fabrication of electronic sensors for impedimetric detection of biomolecules, cyclic voltammetry and immobilization of biomolecules on electrodes for electronic sensing

			10. **Nanotechnology and its Application:** What is Nanotechnology? Different types of Nano materials; their synthesis and characterization; applications in biotechnology and other fields. **Bioentrepreneurship:** 1. **Innovation and entrepreneurship in bio-business:** Introduction and scope in Bio-entrepreneurship, Types of bio-industries and competitive dynamics between the sub-industries of the bio-sector (e.g. pharmaceuticals vs. Industrial biotech), Strategy and operations of bio-sector firms: Factors shaping opportunities for innovation and entrepreneurship in bio-sectors, and the business implications of those opportunities, Alternatives faced by emerging bio-firms and the relevant tools for strategic decision, Entrepreneurship development programs of public and private agencies (MSME, DBT, BIRAC, Make In India), strategic dimensions of patenting & commercialization strategies. 2. **Bio markets - business strategy and marketing:** Negotiating the road from lab to the market (strategies and processes of negotiation with financiers, government and regulatory authorities), Pricing strategy, Challenges in marketing in bio business (market conditions & segments; developing distribution channels, the nature, analysis and management of customer needs), Basic contract principles, different types of agreement and contract terms typically found in joint venture and development agreements, Dispute resolution skills. 3. **Finance and accounting:** Business plan preparation including statutory and legal requirements, Business feasibility study, financial management issues of procurement of capital and management of costs, Collaborations & partnership, Information technology. 4. **Technology management:** Technology – assessment, development & upgradation, managing technology transfer, Quality control & transfer of foreign technologies, Knowledge centers and Technology transfer agencies, Understanding of regulatory compliances and procedures (CDSCO, NBA, GCP, GLA, GMP). 5. **India, Asian and Global Status of Bioentrepreneurship:** Challenges in the entrepreneurship training, Mentoring and nurturing the business of biotechnology, Current status of Bioentrepreneurship in India, State of the Asian Bioentrepreneurship, An emerging and re-emerging model of European Bioentrepreneurship. Standard models strategies of Bioentrepreneurship around the world, Policies and rights for Bioentrepreneurs, surviving in the valley of death for Bioentrepreneurs. **Intellectual Property Rights, Bioethics and Biosafety:** 1. **Introduction to IPR:** Introduction to intellectual property; types of IP: patents, trademarks, copyright & related rights, industrial design, traditional knowledge, geographical indications, protection of new GMOs; International framework for the protection of IP; IP as a factor in R&D; IPs of relevance to biotechnology and few case studies; introduction to history of GATT, WTO, WIPO and TRIPS; concept of 'prior art': invention in context of "prior art"; patent databases - country-wise patent searches (USPTO, EPO, India); analysis and report formation. 2. **Patenting:** Basics of patents: types of patents; Indian Patent Act 1970; recent amendments; WIPO Treaties; Budapest Treaty; Patent Cooperation Treaty (PCT) and implications; procedure for filing a PCT application; role of a Country Patent Office; filing of a patent application; precautions before patenting-disclosure/non-disclosure - patent application- forms and guidelines including those of National Bio-diversity Authority (NBA) and other regulatory bodies, fee structure, time frames; types of patent applications: provisional and complete specifications; PCT and conventional patent applications; international patenting-requirement, procedures and costs; financial assistance for patenting introduction to existing schemes; publication of patents-gazette of India, status in Europe and US; patent infringement- meaning, scope, litigation, case studies and examples; commercialization of patented innovations; licensing – outright sale, licensing, royalty; patenting by research students and scientists-university/organizational rules in India and abroad, collaborative research - backward and forward IP; benefit/credit sharing among parties/community, commercial (financial) and non-commercial incentives

3. **National & International Regulatories:** International regulations – Cartagena protocol, OECD consensus documents and Codex Alimentarius; Indian regulations – EPA act and rules, guidance documents, regulatory framework – RCGM, GEAC, IBSC and other regulatory bodies. Draft bill of Biotechnology Regulatory authority of India - containments – biosafety levels and category of rDNA experiments; field trails – biosafety research trials – standard operating procedures - guidelines of state governments; GM labelling – Food Safety and Standards Authority of India (FSSAI)
4. **Biosafety:** Biosafety and Biosecurity - introduction; historical background; introduction to biological safety cabinets; primary containment for biohazards; biosafety levels; GRAS organisms, biosafety levels of specific microorganisms; recommended biosafety levels for infectious agents and infected animals; definition of GMOs & LMOs; risk – environmental risk assessment and food safety assessment; problem formulation, risk characterization and development of analysis plan; risk assessment of products derived from RNAi, genome editing tools
5. **Bioethics:** Introduction, ethical conflicts in biological sciences - interference with nature, bioethics in health care - patient confidentiality, informed consent, euthanasia, artificial reproductive technologies, prenatal diagnosis, genetic screening, gene therapy, transplantation. Bioethics in research – cloning and stem cell research, Human and animal experimentation, animal rights/welfare

Animal Biotechnology:

1. **Culture media for animal cell culture:** Media and supplements, serum, serum free media, natural media, feeder layer on substrate, Gas Phase for tissue culture, source of tissue, primary culture; Stages of commitment and differentiation, proliferation and malignancy
2. **Subculture and cell lines:** Cross contamination, terminology, naming and choosing cell line and its maintenance. Criteria for subculture, growth cycle and split ratio, propagation in suspension and attached culture.
3. **Cloning and Hybridoma technology:** Vectors and cloning, somatic cell fusion, hybridomas, HAT selection, Medium suspension fusion, selection of hybrid clones, organ culture
4. **Cell separation and quantitation:** Separation techniques based on density, size, sedimentation velocity, antibody based techniques- immuno panning, magnetic sorting, fluorescence activated cell sorting;
   Quantitation-cell counting, cell weight, DNA content, protein, rate of synthesis, measurement of cell proliferation.
5. **Cell characterization and differentiation:** Lineage and tissue markers, cell morphology, karyotyping, chromosome banding; Differentiation-commitment, terminal differentiation; Lineage selection, proliferation
   and differentiation, commitment and lineage, markers of differentiation, induction of differentiation, cell interaction-homotypic and heterotypic; Cell-matrix interaction.
6. **Application of animal biotechnology:** Artificial animal breeding, cloning and transgenic animals, medicines, vaccines, diagnosis of diseases and disorders, gene therapy, forensic application.

Advances in Protein Chemistry:

1. Protein Engineering
2. Thermodynamics of protein stability using calorimetry
3. Protein-ligand interaction
4. Mechanisms of protein folding
5. Protein aggregation and amyloid fibril formation.
6. Protein dynamics by Hydrogen-Deuterium(H-D) exchange
7. Fluorescence polarization and fluorescent probes for conformational studies
8. Application of mass spectrometry in sequencing and conformation
9. Protein structure determination by NMR spectroscopy

Advances in Human Molecular Genomics:

			1. **Introduction to Concepts of Genomics:** Basic concepts of Genetics & Genomics and their similarities and differences. Basic Epigenetics. Genetic counselling & risk assessment. Ethics in Medical Genetics. 2. **Human Disease Genomics:** Genetics of common and complex human diseases with their complex inheritance pattern. Molecular, biochemical & cellular basis of human genetic diseases. Advanced tools of human molecular genetics. Disease gene identification. Epigenetic basis of human diseases. 3. **Human Population Genomics:** Genetic variation in individuals & populations; Mutations & polymorphisms. Human Genome Project. HapMap Project. ENCODE Project. Pharmacogenetics & pharmacogenomics. **Chemical Biology:** 1. **Design of molecules:** Rational Design- Principles of rational design of small molecules for therapeutic and biotechnological purposes; Principles of rational and combinatorial design of macro molecules like designer enzymes/aptamers/DNA origami. Combinatorial design- Design of small molecule libraries (organic compounds, peptides) through scaffold design, bio-isostere searching and fragment-based approaches**;** Design of macromolecular libraries, random mutagenesis and combichem approaches. 2. **Mechanistic enzymology:** Enzymatic red-ox reactions, Baeyer-Villiger oxidation; Polyketide synthesis; Stereo chemical aspects of the conversion of oxaloacetate to citrate Protease (any two); Enzymatic epimerization/racemization reactions (PLP). **Computational Biology:** 1. **Computational biology basics and biological databases:** Computers in biology and medicine; Overview of biological databases, nucleic acid & protein databases, primary, secondary, functional, composite, structural classification database, Sequence formats & storage, Access databases, Extract and create sub databases, limitations of existing databases 2. **Pairwise and multiple sequence alignments:** Local alignment, Global alignment, Scoring matrices - PAM, BLOSUM, Gaps and penalties, Dot plots. Dynamic programming approach: Needleman and Wunsch Algorithm, Smith and Waterman Algorithm, Hidden Markov Model: Viterbi Algorithm. Heuristic approach: BLAST, FASTA. Building Profiles, Profile based functional identification 3. **Genome analysis:** Polymorphisms in DNA sequence, Introduction to Next Generation Sequencing technologies, Whole Genome Assembly and challenges, Sequencing and analysis of large genomes, Gene prediction, Functional annotation, Comparative genomics, Probabilistic functional gene networks, Human genome project, Genomics and crop improvement. Study available GWAS, ENCODE, HUGO projects, extract and build sub databases; Visualization tools including Artemis and Vista for genome comparison; Functional genomics case studies. 4. **Molecular modelling:** Significance and need, force field methods, energy, buried and exposed residues; side chains and neighbours; fixed regions; hydrogen bonds; mapping properties onto surfaces; RMS fit of conformers and protein chains, assigning secondary structures; sequence alignment: methods, evaluation, scoring; protein curation: backbone construction and side chain addition; different types of protein chain modelling: ab initio, homology, hybrid, loop; Template recognition and alignments; Modelling parameters and considerations; Model analysis and validation; Model optimization; Substructure manipulations, annealing, protein folding and model generation; loop generating methods; loop analysis; Analysis of active sites using different methods in studying protein–protein interactions 5. **Structure-based drug development:** Molecular docking: Types and principles, Semi-flexible docking, Flexible docking; Ligand and protein preparation, Macromolecule and ligand optimization, Ligand conformations, Clustering, Analysis of docking results and validation with known information. Extraprecision docking platforms, Use of Small-molecule libraries, Natural compound libraries for virtual

high throughput screenings.

Environmental Biotechnology:

1. **Introduction to Environment:** Introduction to environment; pollution & pollution indicators; waste management: domestic, industrial, solid and hazardous wastes; Biodiversity and its conservation; microbiology of water, air and soil: types, importance and diseases; microorganisms and biogeochemical cycles; Role of microbes in biogeochemical cycles - Carbon cycle; Sulphur cycle; Nitrogen cycle and Phosphorus cycle.
2. **Bioremediation:** Bioremediation: Fundamentals, methods and application; bio stimulation & bioaugmentation; bioremediation of heavy metals & organic pollutants like pesticides, Polycyclic aromatic hydrocarbons etc. Biodegradation: types, microbial basis and role in environment.
3. **Role of microorganisms in bioremediation:** Application of bacteria & fungi in bioremediation: White rot fungi vs specialized degrading bacteria: examples, uses and advantages vs disadvantages; Phytoremediation: Fundamentals, methods (phytoaccumulation, phytovolatilization, rhizofiltration, phytostabilization) & applications.
4. **Biotechnology and Agriculture:** Bioinsecticides: Bacillus thuringiensis, Baculoviruses, etc; genetic modifications, applications and safety in their use; Biofertilizers: Symbiotic systems between plants – microorganisms (nitrogen fixing symbiosis, mycorrhiza fungi symbiosis), Plant growth promoting rhizobacteria (PGPR) – classification, PGPR and plant root interactions; mechanism of action, applications & challenges; Biofungicides: Description of mode of actions and mechanisms.
5. **Biofuels:** Environmental Biotechnology and biofuels: biogas, bioethanol, biodiesel, biohydrogen; Biomass resources: lignocellulosic and algae; genetic engineering for feedstock improvement; microorganisms and biotechnological interventions; Improvement of biological strains,

Infectious Disease Biology:

1. **Microbial mechanisms of establishment and persistence (Strategies of pathogens to establish acute and chronic infections):** Role of key microbial proteins and metabolic functions in persistence (bacterial toxins, secretion systems and virulence), Microbial variability and persistence: sub-typing of pathogens (including WGS), genetic regulation and exchange of virulence determinants, emerging infections, the microbiome, antibiotics and resistance, Biofilm formation and microbial intercellular communication
2. **Principles of Molecular Biology, Pathogenesis, & Control of Human Viruses:** Basic principles of infection, transmission, tropism of human viruses, Biology of individual pathogenic human viruses, including influenza, HIV, Herpes, Polio, Hepatitis, RSV and Dengue viruses. Evolution of viruses and viral strategies for the evasion of the natural and adaptive immune system.
3. **Host response to infection and microbial modulation of host responses:** Host genetic susceptibility (Coevolution and coadaptation), Cellular responses to persistent infection (interaction with array of host receptor), Escape of pathogens from innate and adaptive immunity (microbial manipulation of host inflammatory responses)
4. **Virus-host interaction in Infectious diseases:** Co-evolution and adaptation between viruses and hosts. (post-entry viral inhibitors, natural versus non-natural hosts), Resident viruses and their interaction with host immune system: Significance of “host-virobiota” interaction and “Virome” study., Early Virus-Host Interaction: How they predict the course of a persistent infection.
5. **Epigenetic modifications and viral infection:** Epigenetic remodelling of host genes in human viral infection., Methods of Epigenetic Analysis (DNA methylation, Amplification of Inter-Methylated Sites, Methylated DNA Immunoprecipitation (MeDIP), NSG., Endogenous retroviruses and their association with diseases: PERV and Xenotransplanation. Host epigenetic/cellular responses to control the

			expression of endogenous retroviruses in the cell. 6. **New Threats: Emerging Viral Diseases:** Epidemiology and cross species viral infection, Virus fitness and host switching., Virus and Nervous system: Debut of Zika virus in the Medical science., Computational approach to predict virus resistance, immunogenic epitopes, and vaccine design. (Introduction to Los Alamos HIV Database, and NetCtl), Severe Acute Respiratory Syndrome (SARS) and Human Coronaviruses (HCoVs): Transmission and disease pathogenesis. 7. **Systems analysis of host-pathogen interactions (introduction to PHI database):** Host - Pathogen Interaction Database, Hi-Jack: A novel computational framework for pathway-based inference of host-pathogen interactions, Host-Pathogen Interactions Alignment (HPIA) algorithm 8. **Viruses and Human Cancers:** Viral mechanisms of transformation and tumorigenicity, Interactions between human cancer viruses and the immune system, Use of high-throughput genomics in Tumour virology. Oncolytic viruses (OVs) and car **Molecular and Cell Biology of Viral Oncohenesis:** 1. **Genomic Integrity and development of cancer:** Replication errors, mutagens, inherited defects in DNA repair mechanisms, alterations in chromosomal structure 2. **Oncogenes:** Activation by endogenous retroviruses, changes in structure and expression leading to oncogene activation 3. **Tumor suppressor genes:** Role in cancer development and prevention, epigenetic regulation of expression of TSGs 4. **Hallmarks of cancer:** Different cell types in cancer, progression, characteristics of cancer cells 5. **Signaling receptors and cancer:** Growth factors and signaling proteins as oncogenes (e.g. Src, EGFR, Integrin receptors), alteration of cell signaling in cancer (Ras, Akt/PKB, JAK-STAT, Wnt/β- 6. **Cell cycle and cancer:** Role of p53 and retinoblastoma in cell cycle regulation, interplay between phosphorylation, dephosphorylation and ubiquitylation in regulation of cell cycle and aberrations in these mechanisms 7. **Cell Biology of invasion and metastasis:** Epithelial to mesenchymal transition (ETM), TFs in ETM, role of Ras-like GTPases in cell adhesion, shape and motility, factors affecting metastasis 8. **Viral carcinogenesis:** Discovery of oncogenic viruses; The origin and nature of transforming gene; Functions of viral transforming genes 9. **Molecular biology of RNA and DNA tumor viruses:** Direct acting and indirect acting tumor viruses 10. **Activation of cellular signal transduction pathways by viral oncogene:** Viral mimics cellular signaling molecules; Altering the activity of signal transduction proteins 11. **Disruption of cell cycle control pathway by viral oncogene products:** Abrogation of restriction point control exerted by Rb proteins; Production of virus specific cyclins; Inactivation of CDK inhibitors 12. **How viruses counteract the barriers of tumor growth:** Telomerase activity; Cell polarity and attachment; Epigenetic control 13. **Viruses as novel cancer therapeutic agents:** Generation of recombinant viruses to selectively target and lyse the cancer cells; Various strategies to arm the recombinant virus to enhance its oncolytic ability. **Nanobiotechnology:** 1. **Introduction to Nanotechnology:** Current status, Different types of nano materials their importance and applications, Different methods for the synthesis of nanomaterials and characterization processes including basic instrumentation. 2. **Nano Biotechnology:** Role in nanomedicine including toxicity, ethical & regulatory issues, nanoparticle-based drug delivery strategies, advantages & disadvantages of

			different nano-materials used for drug delivery 3. **Nanotechnology for diagnostics:** Optical diagnostics, Fabrication of electrodes, Applications of Biosensor, role of nanomaterials and nanostructures in the enhancement of sensitivity 4. **Light induced nanostructures:** Light induced nanostructures formation and their biomedical applications 5. **Biosynthesis of nanoparticles:** Molecular machinery of biosynthesis of metal Nanoparticles by microorganisms and their use. Green biosynthesis of nanoparticle and sustainable development. Bio-Inspired nanotechnology and its importance.

11. SCHOOL OF SANSKRIT AND INDIC STUDIES

The pattern of JNUEE 2022-23 will be based on Multiple Choice Questions (MCQs) through Computer Based Test (CBT)

Ph.D.

Sl. No.	Name of School	Sub. Code & Sub. Code Number	Syllabus for Entrance Examination
1	School of Sanskrit and Indic Studies (SSIS)	Sanskrit Studies – SANH (906)	**Syllabus:** The test will cover the following areas: Indian Philosophical Systems; Traditions of Yoga & Sādhanā, Sanskrit literature and Poetics; Sanskrit Grammar and Grammatical Theory; Modes of Disputation and Interpretation of Texts; Sanskrit Linguistics including Computational Linguistics; Vedic, Agamic and Purānic Studies; Pali and Prakrit Studies; Indian Social Thought, Religious Studies; Sanskrit Manuscriptology; Issues in Sanskrit Studies and Researches; Research Methodology & Research Aptitude.

12. School of Engineering

The pattern of JNUEE 2022-23 will be based on Multiple Choice Questions (MCQs) through Computer Based Test (CBT)

S. No	Program	Branch	Syllabus
1.	Ph.D.	Computer Science and Engineering	**Syllabus:** 50% of the questions will be from research methodology and remaining 50% from bachelor's/master's level computer science engineering **Research Methodology:** Experimental design; fundamentals of sampling; data types, quality measurement; processing and analysis of data; hypothesis testing (parametric, nonparametric), theory of probability. **Computer Science:** Engineering mathematics, Digital logic, Computer organisation and architecture, Programming and data structure, Algorithms, Theory of computation, Compiler design, Operating system, Database, Computer networks.
2.	Ph.D.	Electronics and Communication Engineering	**Syllabus:** 50% of the questions will be from research methodology and remaining 50% from bachelor's/master's level electronics and communication engineering **Research Methodology:** Experimental design; fundamentals of sampling; data types, quality measurement; processing and analysis of data; hypothesis testing (parametric, nonparametric), theory of probability. **Electronics and Communication:** Engineering mathematics, Networks, Signal and systems, Electronic device, Analog circuits, Digital circuit, Control systems, Communications, Electromagnetics