Syllabus for DBT-JRF BET examination

General Comments: Question paper will have two parts, Part-A (Aptitude & General Biotechnology) and Part-B (General plus specialized branches in Biotechnology). Part-A will have all compulsory 75 MCQ questions, out of which 25 will be of analytical aptitude, comprehension and quantitative reasoning type and 50 will be from General Biotechnology. There will be 200 questions in Part B, out of which only 50 questions need to be answered. Questions in Part B will also include general biotechnology in addition to the specialized areas listed below.

PART-A: Aptitude & General Biotechnology

Aptitude:

Questions may include Comprehension based, where a written paragraph is given for the students to read and then questions based on that paragraph is asked. They may be designed to test non-verbal reasoning capacity (e.g., by finding the odd one out in a series of abstract pictures), they may also be of quantitative type; designed to test the students ability to comprehend large numbers and do simple calculations.

General Biotechnology

1) **Biomolecular structure and function**
   a) Covalent structure of Amino acids, proteins, nucleic acids, carbohydrates and lipids.
   b) Forces that stabilize biomolecules: electrostatic and van der Waal's interaction, hydrogen bonding. Interactions with solvents, Hydrophobic effect.
   c) Protein Structure: Structural characteristics of α-helix, β-sheet and β-turn. Ramachandran plot. Protein domains and domain architecture. Quaternary structure of proteins.
   d) Conformation of Nucleic acids: Structural characteristics of A, B and Z-DNA. 3D structure of t-RNA, ribozymes and riboswitches
   e) Basic Thermodynamics: Laws of thermodynamics. Concepts of ΔG, ΔH and ΔS.
   f) Physical properties of water and their role in biology. Concepts of pH, ionic strength and buffers.

g) Chemical kinetics: Concepts of order and molecularity of a chemical reaction. Derivation of first and second order rate equation, measurement of rate constants. Concept of activation energy.
h) Enzymology: Introduction to enzymes. Types of enzymatic reaction mechanisms, Michaelis-Menten kinetics. Competitive, Non-competitive and Un-competitive inhibition. Bi-substrate reaction kinetics. Allostery.

2) Methods in Biotechnology

a) Concepts of precision and accuracy in experimental measurements. Concept of signal to noise ratio.
b) Biostatistics: Measures of Central Tendency. Fundamental ideas of probability and probability distributions: Binomial, Poisson and Gaussian distributions. Concept of the Central Limit Theorem. Hypothesis testing: Use of Student's t and χ^2 tests. Correlation and regression. Basic concepts of design of Experiments.
c) Biochemical Methods: Chromatography: Ion exchange, Gel Filtration and Affinity chromatography. Electrophoresis: Native and SDS-PAGE. Isoelectric focusing. 2D-PAGE and its applications.
d) UV/Vis spectrophotometry. Beer-Lambert's law and its use in determination of protein/ nucleic acid concentration.
e) Fluorescence Spectroscopy: Basic concepts of excitation and emission. Quenching, Stern-Volmer Plots. Theory and applications of FRET and fluorescence lifetime measurements.
f) Fundamentals of CD, IR and Raman spectroscopy and their use in the study of biomolecular conformation.
g) Centrifugation: Basic concepts of centrifugation. Calculation of g value from RPM. Density gradient centrifugation. Sedimentation velocity and Sedimentation equilibrium. Separation of sub-cellular components and macromolecules using high speed and ultracentrifugation.
h) Microscopy: Bright field, phase contrast, fluorescence, confocal, and electron microscopy.
i) Fundamentals of X-ray, NMR and cryo-electron microscopy for determination of biomolecular structure.

3) Organization of structure and functions of prokaryotic and eukaryotic cells

a) Cell wall and Cell Membrane: physical structure of model membranes in prokaryotes and eukaryotes, lipid bilayer, membrane proteins, other constituents; diffusion, osmosis, active transport, regulation of intracellular transport and electrical properties.

b) Structural organization and functions of cell organelles: nucleus, mitochondria, Golgi bodies, endoplasmic reticulum, lysosomes, Chloroplast, peroxisomes, vacuoles. Cytoskeletons structure and motility function.
c) Organization of genomes: genes and chromosomes, Operon, unique and repetitive DNA, interrupted genes, gene families, structure of chromatin and chromosomes, heterochromatin, euchromatin, transposons.
d) Cell division and cell cycle: Mitosis and meiosis, their regulation, Cell cycle and its regulation, Apoptosis, Necrosis and Autophagy.
e) Cell transformation and cancer, oncogenes and proto-oncogenes, tumor suppressor genes, metastasis. Therapeutic interventions of uncontrolled cell growth.

4) Cellular processes

a) DNA replication, repair and recombination (Unit of replication, enzymes involved, replication origin and replication fork, fidelity of replication, extrachromosomal replicons, DNA damage and repair mechanisms, homologous and site-specific recombination).

b) Transcription of various types of RNAs and their processing and modifications. Transcription factors and machinery including RNA polymerases, formation of initiation complex, elongation and termination of transcription. Regulation of transcription: activators (enhancers) and repressors, Locus control regions. Structure and function of different types of RNA and mRNPs. RNA transport, localization and function.

c) Protein synthesis, processing and transport of proteins: Ribosome, mRNA structure, genetic code, aminoacylation of tRNA, aminoacyl tRNA synthetase. Mechanism of translation: Initiation, elongation and termination factors and translational proof-reading. Regulation of Translation- global vs mRNA-specific. Translation inhibitors, Post-translational modifications of proteins. Protein trafficking and transport.

d) Control of gene expression at transcription and translation level: Regulation of gene expression in viruses, prokaryotes and eukaryotes, role of chromatin, chromatin remodelling and gene silencing, Epigenetic regulation.

e) Host-pathogen interaction: Recognition and entry processes of different pathogens like bacteria, viruses and protozoans into animal and plant host cells, alteration of host cell behavior by pathogens, virus-induced cell transformation, pathogen-induced diseases in animals and plants, cell-cell fusion in both normal and abnormal cells.

f) Cell signaling: Hormones and their receptors, cell surface receptor, signaling through G-protein coupled receptors, signal transduction pathways, second messengers, regulation of signaling pathways, bacterial and plant two-component systems, light signaling in plants, bacterial chemotaxis and quorum sensing.

g) Cellular communication: General principles of cell communication, cell adhesion and roles of different adhesion molecules, tight junctions, communicating junctions, extracellular matrix, integrins, neurotransmission and its regulation. Regulation of hematopoiesis, differentiation and development.

h) Innate and adaptive immune system: Cells and molecules involved in innate and adaptive immunity, antigens, antigenicity and immunogenicity. B and T cell epitopes, structure and function of antibody molecules. generation of antibody diversity, monoclonal antibodies, antibody engineering, antigen-antibody interactions, MHC molecules, antigen processing and presentation, activation and differentiation of B and T cells, B and T cell receptors, humoral and cell-mediated immune responses, primary and secondary immune modulation, the complement system, Toll-like receptors, cell-mediated effector functions, inflammation, hypersensitivity and autoimmunity, immune response during bacterial (tuberculosis), parasitic (malaria) and viral (HIV) infections, congenital and acquired immunodeficiencies, vaccines.

5) **Recombinant DNA Technology**

a) Enzymes used in Recombinant DNA technology.

b) Isolation and purification of DNA (genomic and plasmid) and RNA. Various methods of separation, characterization of nucleic acids including Southern and Northern hybridizations.

b) Molecular cloning of DNA or RNA fragments in bacterial and eukaryotic systems. Expression of recombinant proteins using bacterial, animal and plant vectors and their purification. Western blotting.

c) Generation of genomic and cDNA libraries. Plasmid, phage, cosmid, BAC and YAC vectors. In vitro mutagenesis and deletion techniques, gene knock out in bacterial and eukaryotic organisms.

d) Isolation and amplification of specific nucleic acid sequences, PCR, RT PCR and qRT PCR

e) DNA sequencing methods, strategies for genome sequencing.

f) Methods for analysis of gene expression at RNA and protein level, large scale expression, such as micro array based techniques.

g) Analysis of DNA polymorphism: RFLP, RAPD and AFLP techniques.

h) Biosafety regulations and IPR.

6. Genetics, Phylogeny & Evolution

a) Chromosomal inheritance: Principles of Mendelian inheritance, codominance, incomplete dominance, gene interactions, pleiotropy, genomic imprinting, linkage and cross-over, sex-linked inheritance, Population Genetics and Hardy-Weinberg equilibrium.

b) Extrachromosomal inheritance: Maternal inheritance (mitochondria and chloroplast)

c) Gene concept: Allele, multiple alleles, pseudoalleles.

d) Genetic analysis: Linkage maps, mapping with molecular markers, tetrad analysis, gene transfer in bacteria: transformation, conjugation, transduction, sex-duction, fine structure analysis of gene.

e) Mutation: Spontaneous, induced, lethal, conditional, reversion, mutagenic suppression, germinal and somatic mutation, insertion, deletion, duplication, translocation, transposition, ploidy.

f) DNA finger printing and its applications, DNA bar coding, marker assisted selection and QTL mapping.

g) Species concept in archaea, bacteria and eukarya.

h) Phylogenetic analysis and evolutionary relationship among taxa, MLST.

7. Genomics and Proteomics

a) Introduction to Genomics: Structure and organization of prokaryotic and eukaryotic genomes - nuclear, mitochondrial and chloroplast genomes; Computational analysis of sequences- finding genes and regulatory regions; Gene annotation; Similarity searches; Pairwise and multiple alignments; Alignment statistics; Prediction of gene function using homology, context, structures, networks; Genetic variation-polymorphism, deleterious mutation; Phylogenetics; Tools for genome analysis– PCR, RFLP, DNA fingerprinting, RAPD, Automated DNA sequencing; Linkage and pedigree analysis; Construction of genetic maps; Physical maps, FISH to identify chromosome landmarks.

b) Genome sequencing: Human genome project-landmarks on chromosomes generated by various mapping methods; BAC libraries and shotgun libraries preparation; Physical map-cytogenetic map, contig map, restriction map, DNA sequence; DNA sequencing and sequence assembly; Model organisms and other genome projects; Comparative genomics of relevant organisms such as pathogens and non-pathogens; Evolution of a pathogen. Taxonomic classification of organisms using molecular markers -16S rRNA typing/sequencing.

c) DNA Microarray technology: Basic principles and design: cDNA and oligonucleotide arrays; Applications: Global gene expression analysis, Comparative transcriptomics,

Differential gene expression; Genotyping/SNP detection; Detection technology; Computational analysis of microarray data.

d) Proteomics: Outline of a typical proteomics experiment; Identification and analysis of proteins by 2D analysis; Spot visualization and picking; Tryptic digestion of protein and peptide fingerprinting; Mass spectrometry; ion source (MALDI, spray sources); analyzer (ToF, quadrupole, quadrupole ion trap) and detector; clinical proteomics and disease biomarkers; Prions; proteins in disease; Protein-protein interactions: Solid phase ELISA, pull-down assays (using GST-tagged protein), far western analysis, by surface plasmon resonance technique, Yeast two hybrid system, Phage display; Protein interaction maps; Protein arrays-definition, applications- diagnostics, expression profiling.

8. IPR, Biosafety & Bioethics

a) 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

b) Invention in context of “prior art”; Patent databases; Searching International Databases; Country-wise patent searches (USPTO, EPO, India etc.); Analysis and report formation

c) Types of patents; Indian Patent Act 1970; Recent Amendments; Filing of a patent application; Precautions before patenting-disclosure/non-disclosure; WIPO Treaties; Budapest Treaty; PCT and Implications; Role of a Country Patent Office; Procedure for filing a PCT application

d) Patent application- forms and guidelines, fee structure, time frames; Types of patent applications: provisional and complete specifications; PCT and convention 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 Patenting by research students, lecturers and scientists-University/organizational rules in India and abroad, credit sharing by workers, financial incentives, Patent infringement- meaning, scope, litigation, case studies and examples.

e) Biosafety: Introduction; Historical Background; Introduction to Biological Safety Cabinets; Primary Containment for Biohazards; Biosafety Levels; Biosafety Levels of Specific Microorganisms; Recommended Biosafety Levels for Infectious Agents and Infected Animals; Biosafety guidelines - Government of India; Definition of GMOs & LMOs; Roles of Institutional Biosafety Committee, RCGM, GEAC etc. for GMO applications in food and agriculture; Environmental release of GMOs; Risk Analysis;

Risk Assessment; Risk management and communication; Overview of National Regulations and relevant International Agreements including Cartagena Protocol.

f) Bioethics: Concepts; Philosophical considerations; Epistemology of Science; Ethical Terms; Principles & Theories; Relevance to Biotechnology; Ethics and the Law Issues: Genetic Engineering, Stem Cells, Cloning, Medical techniques, Trans-humanism, Bioweapons; Research concerns - Animal Rights, Ethics of Human Cloning, Reproduction and Stem Cell Research; Emerging issues: Biotechnology's Impact on Society; DNA on the Witness Stand - Use of genetic evidence in civil and criminal court cases; Challenges to Public Policy – To Regulate or Not to Regulate; Improving public understanding of biotechnology products to correct misconceptions.

Part B: Specialized Branches in Biotechnology

Agricultural Biotechnology:

1. Plant Biology, physiology, molecular biology and seed technology

   a) Plant cell structure and function, phloem transport, plant storage proteins and protein biosynthesis, natural pesticides. Concept of plasticity in plant development; Analyzing plant growth; Seed Germination and Seedling Growth; Tropisms.
   b) Hormonal control of seed germination and seedling growth. Floral Induction and Development; Photoperiodism and its significance; Vernalization and hormonal control; Inflorescence and floral determination; Molecular genetics of floral development and floral organ differentiation
   c) Photosynthesis - Light harvesting complexes; mechanisms of electron transport; C3, C4 and CAM pathways. Respiration and photorespiration – Citric acid cycle; plant mitochondrial electron transport and ATP synthesis; alternate oxidase; photorespiratory pathway, Carbon Assimilation
   d) Nitrogen Fixation and regulation, Role of lectins; Nod factors; *nif* genes; Nitrogenases; Leghaemoglobin, Nodulins; Nitrogen metabolism - Nitrate and ammonium assimilation; amino acid biosynthesis.
   e) Biosynthesis of secondary metabolites. Hormonal and environmental control of senescence; PCD in the life cycle of plants. Biosynthesis and structure and molecular mechanisms of plant hormones. Signal Transduction – Basic concepts; Phospholipid and Ca^{2+}-calmodulin cascade; MAP kinase cascade.
   f) Light Control of Plant Development: Molecular mechanisms of light perception, signal transduction and gene regulation; Biological clocks. Structure, function and mechanisms of action of phytochromes, cryptochromes and phototropins; stomatal movement.
   g) Solute transport and photoassimilate translocation – uptake, transport and translocation of water, ions, solutes and macromolecules from soil.

h) Plant microbe interaction: Molecular biology of *Agrobacterium* Infection, Molecular biology of *Rhizobium* infection (molecular mechanisms in symbiosis). *Arabidopsis* in molecular biology, Forward and Reverse Genetic Approaches, RNA interference, Transcriptional gene silencing, Gene traps/ T-DNA and transposable element insertion / activation lines.

i) Seed science and technology: seed processing, seed treatments, Seed storage, Seed sanitation and certification.

2. Tissue Culture, Transgenic Technologies and Biotechnology

a) Totipotency; Tissue culture media; Plant hormones and morphogenesis; embryogenesis; Cell suspension culture; Micropropagation – shoot tip culture, somatic embryos, artificial seeds; Applications of tissue culture; shoot tip culture; Wide hybridization, Anther culture and dihaploids.
b) Production of alkaloids and other secondary metabolites; Protoplast isolation and purification; Protoplast culture; Protoplast fusion; Somatic hybrids; Cybrids.
c) Direct transformation of protoplasts using PEG; electroporation; Transformation by particle bombardment; Chloroplast transformation. Ti plasmid-based transformation; Ti and Ri plasmids, T-DNA genes, borders, Ti plasmid virulence genes and their functions, Monocot transformation, binary vector; Floral dip transformation; Targeted gene delivery and methods of detection
d) Promoters, Plant selectable markers; Reporter genes; Selectable marker elimination; Transgene silencing and strategies to avoid transgene silencing.
e) Genetic engineering of crops; Codon optimization in the expression of genes in plants, Commercial status of transgenic plants; Herbicide resistance, glyphosate, sulfonyl urea, phosphinothricin, atrazine; Pest resistance, Bt toxin; Protease inhibitor; GNA and other lectins; a-amylase inhibitor; nematode resistance; Genetic engineering for male sterility-Barnase-Barstar; Delay of fruit ripening; polygalacturanase, ACC synthase, ACC oxidase; Improved seed storage proteins; Improving and altering the composition of starch and plant oils; Golden rice for ß-carotene accumulation; Production of antibodies and pharmaceuticals in plants.
f) Biofuels, *Bacillus thuringiensis*: molecular basis of insecticidal activity. Agriculturally important microorganisms and their application. Environmental pollution, Bioremediation, Biodiversity and conservation

3. Molecular Breeding and Genomics

a) Principles of plant breeding, breeding for self and cross pollinated crops. Heterosis breeding limitations of conventional breeding.
b) Molecular markers: Restriction based and PCR based; DNA profiling using different assays- RFLP, RAPD, AFLP, ISSR, SNP etc. Development of SCAR and SSR markers.
c) Gene flow in plants: Development of mapping population - Marker Assisted Selection (MAS), screening and validation; Trait related markers and characterization of genes involved; Mapping genes on specific chromosomes; QTL mapping; Gene pyramiding.

d) Development of ESTs. Molecular markers for plant genotyping and germplasm analysis; Fidelity analysis; settling IPR issues.
e) Marker Assisted Breeding for various traits, Foreground and background selection, gene introgression and pyramiding, Non-gel based techniques for plant genotyping.
f) Genome organization, Structural and Functional genomics, Proteomics, Metabolomics, Nutrigenomics, interactomics, Metagenomics.

4. Abiotic and Biotic Stress Biology

a) Abiotic stress: Acclimation and crop adaptation to water, salinity, photo oxidative, heavy metal, heat and cold, nutrient stress. Metabolite engineering for abiotic stress tolerance, Functional genomics of stress tolerance. Induced systemic tolerance.
b) Biotic stress: Plant response to pathogens and herbivores, biochemical and molecular basis of host plant resistance , toxins of fungi and bacteria, systemic and induced resistance, pathogen derived resistance, signaling - gene for gene hypothesis, genetic engineering for biotic stress resistance, gene pyramiding. Induced systemic resistance, systemic acquired resistance.

5. Biodiversity

a) Biodiversity Act 2002; Agricultural biodiversity; International Treaty on Plant Genetic Resources for Food and Agriculture (PGRFA); Conservation strategies for seed gene bank; Climate change and conservation of plant genetic resources; Global efforts for management of crop genetic resources; Strategies on PVFR and Biodiversity Acts.
b) Biodiversity Legislation in India; Indian Biodiversity Act and provisions on crop genetic resources.
c) Impact of GE crops on Biodiversity. Functions of International union for the protection of new varieties of plants (UPOV); International treaties relating to Biodiversity.

Animal Biotechnology:

1. Animal Physiology and Biochemistry*:* Hormone cell interactions, endocrine control of development of various organs. Properties of different body fluids, metabolism and homeostasis. Role of enzymes in metabolic regulation, activation, inhibition and covalent modification. Specificity of enzyme actions.

2. Histology and Embryology*:* Systematic histology including microscopic structures of organs of different systems of domestic animals. Reproductive system of males and females. Embryo culture and transfer technology, somatic cell nuclear transfer, embryonic stem cells, transgenic animal production. Induction and synchronization of estrus, superovulation, oocyte collection and grading.

3. Animal Parasitology*:* Host parasite interactions, transmission of parasites, parasite specificity, tissue reaction, protozoa and their development. Parasitic infections of domestic animals.

4. Animal Virology*:* DNA and RNA viruses causing diseases in livestock and poultry. Immunity to viral infections. Development of laboratory animal models of virus infections.

5. Immunology*:* Immunity to bacterial and viral infections of animals. Cells of immune system, clinical and transplantation immunology, tumor immunology and immunodeficiency. Nude and SCID mice biology and immunosuppression.

6. Pathology*:* Cellular pathology, cell necrosis and apoptosis. Pathogenesis and microscopic pathology of bacterial, viral and parasitic diseases of domestic animals and poultry.

7. Animal Genetics*:* Animal breeding, out breeding and inbreeding, open nucleus breeding systems. Conservation of germplasm, breeding of laboratory animals, genetic health monitoring. Concept of production of specific pathogen free (SPF) and germ free laboratory animals. Development of various chimeras.

8. Molecular Medicine and Surgery*:* Anesthesia and anesthetic drugs. Management of shock, hemorrhage, principles of fluid therapy. Surgical techniques in laboratory animals. Imaging, contrast radiography, biological effects of radiation, radiation hazards and their prevention. Isotopes and their uses in diagnosis and therapy.

9. Molecular Diagnostics*:* Concept of molecular diagnosis of pathogens, detection of animal pathogen in environmental systems and in animal feeds. Molecular diagnostics for detection of tumor.

*10.*Research Methodologies*:* Biochemical and immunological techniques. Application of radioactive isotopes in biological research. Cell culture technology, specialized culture techniques such as 3-D cultures, cell senescence, cell differentiation, transdifferentiation, culture of fastidious cells, cancer stem cells, cell cloning and selection, cell culture technology in production of animal viral vaccines and pharmaceutical proteins.

M. Tech. Biotechnology, Biochemical Engineering and Industrial Biotechnology

1. Introductory Mathematics: Calculus review, Ordinary differential equations, Second and higher order differential equations, Linear algebra, Numerical methods

2. Engineering Principles: Material and energy balance, Steady state energy and material balance, Properties of substances, Introduction to transport phenomena, momentum transfer, heat and mass transfer, Introduction to mass transfer equipments

3.Thermodynamics in Biological Systems: First and second law of thermodynamics, Biological systems as open non-equilibrium systems, Failure of classical thermodynamics in describing biological processes, Concepts of thermodynamics flux and force, Concept of entropy production, Constitutive equations, Thermodynamics of coupled biochemical reactions, Thermodynamic analysis of oxidative phosphorylation, Glycolytic oscillations; biological clocks

4. Bioprocess Engineering and Technology: Principles of microbial growth and factors affecting growth, Growth kinetics and substrate utilization in batch, fed-batch and continuous systems, Introduction to bioreactors: batch and fed-batch, plug flow, continuous, enzyme reactors, Sterilization, Mass transfer of oxygen, aeration and agitation, fluid rheology, Fermentation technology (Description of industrial processes: antibiotics, organic acids, alcohol, bioplastics, vitamins, enzymes; biotransformation of steroids, Basics of neutrigenomics – food-gene interactions, Process flow sheet and process economics

5. Downstream Processing in Biotechnology: Biomass removal and disruption, Precipitation by salts, solvents, Membrane based purification, Adsorption and chromatography, Extraction (solvent, aqueous two-phase, super critical), Drying

6. Bioprocess Plant Design: General design information, Material and energy balance, Process flow sheet, Scale up and scale down issues, Scale up and downstream processes. Selection and specifications of bioprocess equipments, Facility design aspects. Utilities, Process economics,

Bioinformatics & Computational Biology

1. Major Bioinformatics Resources: Sequence databases, Gene Expression database: GEO, SAGE, 3D Structure Database: PDB, NDB, Knowledge driven Databases & utility, Pattern Sequence: InterPro, Prosite, Pfam, ProDom, Gene Ontology
2. Database Searches: Keyword-based searches using tools like ENTREZ and SRS Sequence-based searches: BLAST and FASTA
3. Sequence Analysis, Basic concepts: Sequence similarity, identity and similarity, definitions of homologues, orthologues, paralogues, Tandem and Interspersed repeats, repeat finding.
4. Scoring Matrix, Pairwise sequence alignments, Multiple sequence alignments (MSA), Application in Taxonomy and phylogeny, Comparative genomics.
5. Structural Biology: 3-D structure visualization and simulation, Basic concepts in molecular modeling: different types of computer representations of molecules. External coordinates and Internal Coordinates, Molecular Mechanics, Force fields etc.
6. Proteins: Secondary structure elucidation using Peptide bond, phi, psi and chi torsion angles, Ramachandran map, anatomy of proteins – Hierarchical

organization of protein structure –like CATH,SCOP, FSSP .

7. DNA & RNA secondary and tertiary structures, t-RNA tertiary structure
8. Classification and comparison of protein 3D structures: Secondary structure prediction: Algorithms viz. Chou Fasman, GOR methods, Tertiary Structure prediction: Fundamentals of the methods for 3D structure prediction (sequence similarity/identity of target proteins of known structure, fundamental principles of protein folding etc.) Homology/comparative Modeling, fold recognition, threading approaches, and *ab initio* structure prediction methods. CASP. Computational design of Promoters, Proteins & Enzymes.
9. Application in drug design: Chemical databases like NCI /PUBCHEM. Fundamentals of Receptor-ligand interactions. Structure-based drug design: Identification and Analysis of Binding sites and virtual screening. Ligand based drug design: Structure Activity Relationship – QSARs & Pharmacophore etc. *In silico* predictions of drug activity and ADMET.

Environmental Biotechnology

1. Basic Ecological Concepts and Principles: Ecosystem: types, development and evolution; Homeostasis, energy transfer in ecosystem, Energy budget, trophic structure, food chain, food web, ecological efficiency, biogeochemical cycles

2. Chemistry of organic and inorganic chemicals polluting Environment (air, water and soil)

3. Environmental Pollution; Types, Detection and Measurement of Pollutants; Environmental monitoring techniques

4. Water Pollution: sources, measurement and management;

5. Waste Water Treatment systems: primary, secondary and tertiary treatments; Biological Treatment Processes, Biochemistry and Microbiology of Aerobic and Anaerobic Treatment, Bioreactors for waste water treatment,,Disinfection and Disposal

6. Treatment of Typical Industrial Effluents: Dairy, Distillery, Sugar, and Antibiotic Industries.

7. Management of municipal, biomedical and agricultural solid waste.

8. Environmental Pollution control: concepts of bioaugmentation, biostimulation, biodegradation, biosorption, biofilms in the bioremediation of xenobiotics, petroleum hydrocarbons, pesticides and heavy metals, evolution of biodegradative pathways.

9. Environment friendly technologies: Biosurfactants, biofertilizers,biopesticides, microbially enhanced oil recovery, resource management, integrated waste management; production of biomass, biogas and biofuel from waste.

10. Pollution monitoring: chemical, biological and molecular methods; Environmental impact assessment, Biodiversity and its conservation, GMOs and Biosafety.

11. Global environmental problems: Ozone depletion, UV-B and green house gases

Marine Biotechnology

1. Important marine organisms and their behavior: Introduction to marine environment; Marine flora - phytoplankton, seaweeds, sea grasses and mangroves - their characteristics and identification; Marine fauna–zooplankton; Major marine invertebrates (crustaceans & molluscs); Vertebrates (Pisces) and marine mammals (dolphin and whales) - characteristics and identification; Biology - food & feeding - age & growth - reproduction - life history of crustaceans, molluscs and fishes.

2. Marine resources assessment: Methods of surveying the living resources (Acoustic, Aerial and Remote sensing); Principal methods of exploitation (Indigenous and modern crafts & gears).

3. Population study and marine environment protection: Population dynamics - Principles of population dynamics; Unit stocks; Age & size composition of the population; Abundance and density; Recruitment; Growth; Mortality (fishing & natural); Conservation and management-*in situ* and *ex situ*; Marine biosphere reserves; Marine parks - heritage sites.

4. Oceanography: Physical; Temperature, salinity and density – horizontal, vertical and temporal variations; waves, tides and currents, upwelling. Chemical; nutrient cycle, metals, minerals and trace elements Biological-primary and secondary productivity, finfish and shellfish resources.

5. Types of marine microbes and their biology: Structure of Bacteria, fungi, algae, protozoa and viruses; Classification of microbes (Genetic level) –conventional and modern methods. Biology of microorganisms used in genetic engineering *(Escherichia coil, Agrobacterium tumefaciens, Saccharomyces cerevisiae, phage lambda).*

6. Microbial Assessment: Methods of studying the marine microorganisms - Methods of collection, enumeration (total and viable counts), Isolation, culture & identification based on morphological, physiological and biochemical characteristics; Preservation of marine microbes; Culture Collection Centres (ATCC, IMTECH, NCCS-MCC etc.). Microbial nutrition - influence of environment factors on microbial growth, activity and distribution.

7. Role of microbes in marine environment: Microbial nitrogen fixation; Carbon, nitrogen and phosphorus cycle; Decomposition of organic matter; Bioleaching and biodeteroriation of natural and synthetic materials.

8. Microbial metabolites: Microbes of biotechnological importance; Primary and secondary metabolites (enzymes, antibiotics, organic acid, toxins etc.).

9. Microbial interaction: Seafood microbiology - normal genera associated with fish, food spoilage, fish & human pathogens; Indicator of pollution - faecal coliforms; prevention & control.

10. Culture systems and hatchery techniques: Importance of coastal aquaculture; Aquafarms: design and construction; Criteria for selecting cultivable species; Culture systems and management practices – extensive, semi-intensive and intensive culture practices. Seed production in controlled condition; Types; Design and management of hatchery –induced spawning; Mass production of seeds; Live feed culture technique and feed formulation; Artificial insemination - *in vitro* fertilization.

11. Introduction to marine pharmacology: Terms and definitions; Medicinal compounds from marine flora and fauna - marine toxins, antiviral and antimicrobial agents.

12. Manipulation and microbial techniques: Chromosome manipulation in aquaculture – hybridization; Ploidy induction; Gynogenesis, Androgenesis and sex reversal in commercially important fishes. Application of microbial biotechnology in culture ponds; Bioaugmentation; Bioremediation for soil and water quality improvement - nutrient cycling; bio-fertilization; Probiotics – Immunostimulants; Regulation of bacterial growth.

13. Disease diagnosis: Tools for disease diagnosis in cultivable organisms; Enzyme immunoassays; Dot immunobinding assay; Western blotting; Latex agglutination test; Monoclonal antibodies; DNA based diagnosis; Cryopreservation.

14. Marine organisms and environment interaction: Types of marine environment - Physical, Chemical and Biological aspects and their interaction with marine life; Air – Sea interaction; Green house gases (CO_2 and Methane).

15. Pollution & Biomaterial interaction: Marine pollution-major pollutants (heavy metal, pesticide, oil, thermal, radioactive, plastics, litter and microbial); Biological indicators (Marine microbes, algae and crustaceans) and accumulators: Application of protein biomarkers; Biosensors and biochips. Biodegradation and Bioremediation; Biodegradation of natural and synthetic waste materials; Bioremediation; Separation, purification and bio removal of pollutants.

16. Fouling and corrosion: Biofouling; Biofilm formation; Marine fouling and boring organisms - their biology, adaptation; Factors influencing the settlement of macrofoulers; Antifouling and Anti boring treatments; Corrosion process and control of marine structures.

17. Wastewater bio-treatment: BOD, COD; Biosensors; Biomolecules; membrane and transducer; Bioaugmentation-estimation of microbial load; Methods of inorganic and organic waste removal.

Medical Biotechnology

1. Vaccinology: Active and passive immunization; Live, killed, attenuated, sub unit vaccines; Vaccine technology- Role and properties of adjuvants, recombinant DNA and protein based vaccines, plant-based vaccines, reverse vaccinology; Peptide vaccines, conjugate vaccines; Antibody genes and antibody engineering- chimeric and hybrid monoclonal antibodies; Catalytic antibodies and generation of immunoglobulin gene libraries. Rational vaccine design based on clinical requirements: Hypersensitivity, Immunity to Infection, Autoimmunity, Transplantation, Tumor immunology, immunodeficiency; Transfusion of immuno-competent cells, Stem cell therapy; Cell based vaccines.

2. Immunotechnology: Kinetics of immune response, memory; Principles of Immunization; Techniques for analysis of Immune response; Immunochemistry of Antigens - Immunogenicity, Antigenicity, haptens, Toxins-Toxiods, Hapten carrier system; Genetic bases of immune response – Heterogenecity; Immune modulators; B cell epitopes; Hybridoma Rabbit, human; Antigen – Antibody interaction, Immunoassays, RIA, ELISA, Western blotting, ELISPOT assay, immunofluorescence, Surface plasmon resonance, Biosensor assays for assessing ligand –receptor interaction. Antibody engineering; Phage display Libraries; Antibodies as in vitro and in vivo probes.

3. CMI and Imaging techniques: CD nomenclature, Identification of immune Cells; Principle of Immunofluoresence Microscopy, Flurochromes; Staining techniques for live cell imaging and fixed cells; Flow cytometry, Instrumentation, Applications; Cell Functional Assays – lymphoproliferation, Cell Cytotoxicity, mixed lymphocyte reaction, Apoptosis, Cytokine expression; Cell cloning, Reporter Assays, In–situ gene expression techniques; Cell imaging Techniques- *In vitro* and *In vivo*; Immuno-electron microscopy; *In vivo* cell tracking techniques; Microarrays; Transgenic mice, gene knock outs.

4. Genetics in Medical Practice: Genetic Principles and their application in medical practice; Case studies (Interacting with patients, learning family history and drawing pedigree chart); Syndromes and disorders: Definition and their genetic basis; Molecular pathology of monogenic diseases: Cystic fibrosis, Tay Sach's Syndrome & Marfan Syndrome; Genetics of diseases due to Inborn an errors of metabolism: Phenylketonuria, Galactosemia & Mucopolysaccharidosis.

5. Genetics of Neurogenetic disorders: Charcot-Marie tooth syndrome, Spino-muscular atrophy, Alzheimer's disease & Syndromes due to triplet nucleotide expansion, Genetic basis of muscle disorders: Dystrophies (Duchenne Muscular dystrophy and Becker Muscular Dystrophy), Myotonians & Myopathies; Genetic disorders of Haemopoitic systems: Overview of hematopoisis, Blood cell types and haemoglobin, Sickle cell anemia, Thalassemias & Hemophilias.

6. Genetic basis of eye disorders: Colour Blindness, Retinitis pigmentose, Glaucoma & Cataracts; Genetics of skeleton & skin disorders; Genetics of Syndromes & Genomic Imprinting; Neurofibromatosis I, Prader-Willi & Angleman syndromes, Beckwith-Wiedeman syndrome; Genetics of Cancers and cancer-prone syndromes. Haematological malignancies, Retinoblastoma, Wilm's tumour, Colorectal camcer, DNA-repair deficiency syndromes, Breast Cancer.

7. Complex polygenic syndromes: Hyperlipidemia, Atherosclerosis, Diabetes mellitus; Mitochondrial syndromes; Management of genetic disorder; Genetic counseling; Historical overview (philosophy & ethos) and components of genetic counseling: Indications for and purpose; Information gathering and construction of pedigrees; Medical Genetic evaluation (Basic components of Medical History, Past medical history, social & family history).

8. Components of genetic counseling: Physical examination (General and dysmorphology examination, Documentation), Legal and ethical considerations; Patterns of inheritance, risk assessment and counseling in common Mendelian and multifactor syndromes; Genetics testing : biochemical & molecular tests: in children, Presymptomatic testing for late onset diseases (predictive medicine); Prenatal and Preimplantation screening and diagnosis: Indications for prenatal diagnosis, Indications for chromosomal testing, Noninvasive methods (Ultrasound, Embryoscopy, MRI, etc.) Invasive methods; Prenatal screening for Down's syndrome (maternal serum) & Neural tube defect; Pre-implantation genetic diagnosis; Ethical issues in prenatal screening and diagnosis.

9. Infections of the Gastrointestinal Tract: Amoebiasis; Giardiasis and cryptosporidiosis; Intestinal infection by nematodes; Intestinal infection by cestodes (taeniasis and H.nana infection); Trematodes; Bacterial food poisoning(toxic and infective); *E.coli* Diarrhoea; Cholera; Bacillary dysentery; Hepatitis.

10. Infections of the Respiratory system: Streptococcal infections; Viral infections; Diphtheria; Whooping cough; Bacterial pneumonias (Haemophilus and GNB, Pneumococcus/Legionella/ etc); Tuberculosis.

11. Pyrexial Illness: Malaria; Kala-azar; Leishmaniasis; Filaria; Enteric fever; Brucellosis; Rickettsial diseases; Leptospirosis and relapsing fever; Viral Hemorragic fever.

12. Infections of the Nervous System: Viral encephalitis and Aseptic meningitis; Rabies; Cysticercosis and other CNS parasitic infections; Tetanus.

13. Sexually Transmitted Diseases and Congenital Infections: Herpes Simplex virus infections; HIV infection and AIDS; Chlamydial infection; Syphilis; Mycoplasma and Ureaplasma infection; Gonorrhea and other bacterial STD; Congenital viral infections; Toxoplasmosis.

14. Host pathogen interactions in disease process: Protective immune response in Bacterial, Viral and Parasitic diseases; Cancer; Inappropriate Immune response; Disease pathology and clinical spectrum; Clinical diagnosis of diseases; Molecular Genetics of the host and the pathogen.

15. DNA based diagnosis: Biochemical disorders; Immune, Genetic and Neurological disorders; Molecular techniques for analysis of these disorders; Assays for the Diagnosis of inherited diseases; DNA sequencing and diagnosis; PCR and Array based techniques in diagnosis; Single nucleotide polymorphism and disease association; Two dimensional gene scanning.

16. Antibody based diagnosis: Monoclonal antibodies as diagnostic reagents; Production of monoclonal antibodies with potential for diagnosis; Diagnosis of bacterial, viral and parasitic diseases by using; ELISA and Western blot.

17. Proteomics based diagnosis: Protein profiling for disease diagnosis ; 2D analysis of isolated proteins associated with disease by sequencing individual spots by Mass Spectrometry; Protein Micro array; Present methods for diagnosis of Specific diseases like Tuberculosis, Malaria and AIDS.

18. Gene therapy: Intracellular barriers to gene delivery; Overview of inherited and acquired diseases for gene therapy; Retro- and adeno- virus mediated gene transfer; Liposome and nanoparticles mediated gene delivery.

19. Cellular therapy: Stem cells: definition, properties and potency of stem cells; Sources: embryonic and adult stem cells; Concept of tissue engineering; Role of scaffolds; Role of growth factors; Role of adult and embryonic stem cells; Clinical applications; Ethical issues.

20. Recombinant therapy: Clinical applications of recombinant technology; Erythropoietin; Insulin analogs and its role in diabetes; Recombinant human growth hormone; Streptokinase and urokinase in thrombosis; Recombinant coagulation factors.

21. Immunotherapy: Monoclonal antibodies and their role in cancer; Role of recombinant interferons; Immunostimulants; Immunosupressors in organ transplants; Role of cytokine therapy in cancers; Vaccines: types, recombinant vaccines and clinical applications.

22. Gene silencing technology: Antisense therapy; siRNA; Tissue and organ transplantation; Transgenics and their uses; Cloning; Ethical issues.

23. Human disease genes: DNA polymorphism including those involved in disease; Hemoglobin and anemia; Phenylketonuria (monogenic) and diabetes (multigenic) genetic disorders; 'disease' gene vs. 'susceptibility' gene; SNP detection: hybridization based assays (allele specific probes); Polymerization based assays (allele specific nucleotide incorporation, allele-specific PCR); Ligation based assays (allele specific oligonucleotide ligation); Polymorphism detection without sequence information: SSCP; Proteomics and drug discovery; High throughput screening for drug discovery; Identification of drug targets; Pharmacogenomics and pharamacogenetics and drug development; Toxicogenomics; Metagenomics.

Molecular and Human Genetics

1. Cell Biology and Cytogenetics: Tissue culture techniques: Composition of media, cultures for prenatal, and postnatal cytogenetic diagnosis.Chromosomal analysis: Chromosome preparation and chromosome banding techniques, International system for human chromosome nomenclature. Mechanisms of numerical and structural chromosomal aberrations, chromosomal and non-chromosomal basis of sex determination.

2. Principles of Genetics: Mendelism and its extensions: Law of segregation, Law of independent assortment, Chromosomal basis of segregation and independent assortment, Linkage, Crossing over and recombination, Multiple allelism, Pleiotropy, Cytoplasmic inheritance.
Pedigree analysis, patterns of transmission of characters
Genetic mapping of Mendelian traits: Identifying recombinants and nonrecombinants in pedigrees, Genetic and physical map distances, Genetic markers, Two-point mapping-LOD score analysis, Multipoint mapping, Homozygosity mapping.
Genetic mapping of complex traits: Difficulties in mapping complex traits, Allele sharing methods- Affected sib pair analysis, Allelic association, Linkage disequilibrium mapping.
Physical mapping methods: Low resolution mapping- Cell hybrids, mini- and microcells, synteny of genes, Radiation hybrid mapping, Assembly of clone contigs, Identifying genes in cloned DNA, Integration of cytogenetic, genetic and physical maps.
Chromosomal and molecular basis of carcinogenesis:
Common chromosome abnormalities in cancer
Cell transformation and tumourigenesis: Cell cycle check point and cancer, Oncogenes, Tumour suppressor genes, DNA repair genes and genetic instability, Epigenetic modifications, telomerase activity, centrosome malfunction, Genetic heterogeneity and clonal evolution.
Familial cancers: Retinoblastoma, Wilms' tumour, Li-Fraumeni syndrome, colorectal cancer, breast cancer.
Genetic predisposition to sporadic cancer
Tumour progression: angiogenesis and metastasis

Tumour specific markers
Cancer and environment: physical, chemical and biological carcinogens
Concept and theories of evolution: Microevolution in Mendelian population, Mendelian Population, Allele frequencies and genotype frequencies, Hardy-Weinberg equilibrium and conditions for its maintenance.
Elemental forces of evolution: Mutation, Selection (Types of selection, selection coefficient, selection in natural populations), Genetic drift, Migration.
Molecular population genetics: Molecular evolution (neutral theory, punctuated equilibrium), DNA-based phylogenetic trees, Human phylogeny (Hominid evolution: (Anatomical, Geographical, Cultural), Molecular phylogenetics of Homo sapiens, Peopling of continents (Europe, Africa, Asia)

3. Common genetic disorders:
Chromosomal and molecular basis, minimal critical chromosomal regions and genes, and clinical features of the following syndromes: Down syndrome, Edward syndrome, Klinefelter syndrome, Turner syndrome, Patau syndrome, Phenylketonuria, Alzheimer's disease, Duchanne muscular disorder, Sickle cell anemia, Diabetes mellitus.

4. Human Genome:
The Genome project: History, organization and goals of human genome project, Mapping strategies, current status of various maps, DNA segment nomenclature, Human genome diversity, human genome databases.
Organization of human genome: Mitochondrial genome, Gross base composition of nuclear genome, Gene density. CpG islands, RNA-encoding genes, Functionally identical/similar genes, Diversity in size and organization of genes, Annotation
Gene families: Multigene families – Classical gene families, families with large conserved domains, families with small conserved domains, Gene superfamilies, Gene families in clusters, Pseudogenes, Repetitive DNA and transposable elements, Origin of gene families
Functional genomics: Transcriptome and its analysis, Proteome and Proteomics, Gene silencing
Implications of human genome on research and society.

Neuroscience

1. Neurons: Ultrastructure, myelination and synapses.

2. Glial cells: Structure and function of glial cells: astrocytes – type I & II astrocytes, fibrous and protoplasmic astrocytes, Importance of astrocytes in glutamate metabolism and blood brain barrier, Functions of other glial cells: oligodendrocyte and microglial cells, Microglial phenotypes, Overview of glial and neuronal relationship in the CNS, Glial –neuronal interplay in the CNS.

3. Neurophysiology and Behavior: Tools in electrophysiological studies of the brain in animals; animal activity monitoring; Different types of mazes and their application in studies on behavior, learning and memory and cognitive aspects of animals;

Rotarod; grip strength meter; Pain sensitivity testing with the help of tail-flick instrument and paw test.

4. Major events in early embryonic development: Embryonic origin of nervous system, early neural morphogenesis in vertebrates and invertebrates, Neural Induction: Molecular nature of the Neural inducer, Conservation of neural induction; Dorsal neural tube and neural crest; Neural crest cells and its derivatives.

5. Patterning, polarity and regionalization of the nervous system; Fate mapping of cell determination, differentiation of nerve cells and cell lineage, acquisition of neurotransmitter property and electrical excitability.

6. Birth and migration of neurons, Control of neuronal and glial cell population; Histogenesis of cerebral cortex and cerebellar cortex. Adult neurogenesis.

7. Neuronal death during development: Target dependent and innervation dependent neuronal death.

8. Neurotrophic factors: Nerve growth factor (NGF). Axon growth, path finding and nerve patterns: Growth Cone, Axonal navigation and axon elongation, Synapse formation and elimination: Selective synaptic connections: Skeletal muscle, autonomic ganglia, spinal cord and CNS. Denervation and regeneration of synaptic connections.

9. Electrical properties of excitable membranes: Basic electricity and electric circuits, neurons as conductors of electricity, equivalent circuit representation; Electrical properties of excitable membranes: Membrane conductance, linear and nonlinear membrane, ionic conductance, current-voltage relations. Ion movement in excitable cells: Physical laws, Nernst-Planck Equation, active transport of ions, movement of ions across biological membranes; Membrane potential and role of sodium and potassium pumps, Action potential, non-gated ion channels and generation of action potential.

10. Electrical properties of neurons, quantitative models of simulations, Hodgkin & Huxley's analysis of squid giant axon: Voltage-clamp experiments; Voltage gated channels;Biophysical, biochemical and molecular properties of voltage gated channels. Synaptic transmission at nerve-muscle synapses. Synaptic transmission at central synapses; Ligand gated channels; Second messengers and synaptic transmission.

11. Synaptic transmission and cellular signaling: Synthesis, action and distribution of acetylcholine, catecholamine, dopamine, serotonin, and neuropeptide neurotransmitters.

12. Sensation and perception: Receptors, Structure, function & connections of sensory cortex; Sensory Transduction: Phototransduction, olfactory transduction, taste, mechanoreception; Somatic sensation: Peripheral and central mechanisms
Touch: somatic sensory system, mechanoreceptors and other receptors, representation of body surfaces in the brain. Pain: Nociceptors, control of pain, opioid peptides and pain. Taste: Taste receptors and taste buds, Innervation by cranial nerves, Modulation of taste activity in the Medulla. Olfaction: Odor stimuli, Information processing in the dendrodendritic synapses in Accessory Olfactory Bulb.

13. Fundamentals of Motor Systems: Spinal cord as central pattern generator; Posture and voluntary movement, Basal nuclei and cerebellum; Focusing and coordinating movement. Muscle, Motor neurons and Motor neuron pools: Motor neuron pools, Muscle afferents. Spinal Motor control, Reflexes and locomotion: Basic Principles, Reflexes, Interneurons associated with movements, Locomotion
Supraspinal Descending Control: Postural reflexes of the head and the body, vestibular damage & disorders of the postural control. Voluntary Descending Control: Control of voluntary movements by the motor cortex. Eye Movements: Gaze-stabilization mechanisms, Gaze-shifting Mechanisms.

14. Chemical Control of Brain and Behavior: Role of hypothalamus, pituitary hormones and ANS

15. Neural Control of the Breathing: Breathing & gas exchange, CNS & Breathing, Respiratory Rhythm Generation, Sensory Inputs and Altered Breathing, Modulation of Respiratory Motor Out-put, Suprapontine Structures and Breathing, Respiratory neurons and their discharge pattern.

16. Neural Control of Heart, Cardiovascular Homeostasis: The Nervous System and the Long-term control of the Cardiovascular System.

17. Sleep and Dreaming: The two states of sleep- slow wave and rapid eye movement. Circadian Timing: Pineal and Circadian Rhythms, The Suprachiasmatic Nucleus, Light as the Dominant Stimulus. Sex and behavior: Neuronal basis of sexual behaviour, Sex Hormones and Brain.

18. Cognitive development and aging; Neuronal basis of object recognition; Spatial cognition; Neural system of spatial cognition: Parietal cortex, Frontal cortex, Hippocampus and adjacent cortex. Learning and Memory: Basic Systems; Long-term potentiation, Classical conditioning in vertebrates, Mechanism of memory storage. Major memory systems in mammalian brain; Executive brain functions; Consciousness.

19. Clinical neurochemistry and neuropathology: Molecular, genetic aspects and diagnostic characteristics; Neurochemical and molecular mechanisms of peripheral Neuropathy; Multiple sclerosis and other demyelinated disorders; Duchenne Muscular dystrophy, Wernicke-Korsakoft syndrome; Pellagra; Metabolic Encephalopathies and Coma, Ischemia and hypoxia; Epileptic seizures; Genetics and diagnosis of Huntington disease and other triplet repeat disorders; Alzheimer's disease, Parkinson's disease, Motor Neuron Diseases; Prion's Disease; Biochemical aspects of the psychotic disorders; Biochemical basis of mental illness: Anxiety disorders; Mood disorders; Attention disorders; Schizophrenia

Pharmaceutical Biotechnology

1. Drug metabolism: Biotransformation of drugs; microsomal and nonmicrosomal mechanisms; Enzymes in transformation; factors inhibiting and inducing enzymes; factors affecting drug metabolism; drug metabolism in fetus and new born; models of drug metabolism; dose-effect relationship. Adverse drug reaction and drug interactions, toxic reactions, allergic reactions, idiosyncracy; acute poisoning and its treatment; extraction of drug from plasma, tissues including biliary and fecal excretion.

2. Pharmacological screening and assays: Principles of screening-correlation between various animal models and human situation, animal ethics; Screening models for therapeutic areas like hypertension, cerebral ischemia, pain, epilepsy, depression, Parkinson's disease, Alzheimer's disease, diabetes etc.; Correlation between in vitro and in vivo screens, cell-based, biochemical, radiological based assays, high through put screening, pharmacokinetic analysis, reference drugs and interpretation of results. Animal handling-mice-guinea pig etc., route of administration of drugs-intravenous-intramuscular-intraperitoneal-intradermal etc., Dose-response relationship of drugs, determination of analgesic activity of a compound-estimation of protein and hematological parameters.

3. Enzymes and microbial technology: Enzymes in organic solvents and ionic liquids, biocatalysts, enzyme engineering, random and rational approach to protein engineering, Biocatalysis with different enzymes: lipase, amidase, aminopeptidase, acylase, hydantoinase, lyases, oxidoreductase, nitrilase, epoxide hydrolase, hydoxylase, aldolases, decarboxylases; techniques of immobilization of enzymes and whole cells-design, operation and kinetics of immobilized enzyme reactors-Diffusional resistance and Thiele's modules- multi step immobilized enzyme systems. Microorganisms in degradation of xenobiotics and removal of heavy metals; stereo selective production of drug intermediates, biocatalyst for synthesis of some chiral pharmaceutical intermediates such as synthesis of ACE inhibitors, synthesis of anti-cholesterol drugs by biocatalytic routes, calcium channel blocking

drugs, potassium-channel openers, anti-arrythmic compounds, anti-psychotic compounds, anti-infective drugs, anti-inflammatory drugs, antiviral drugs, prostagladin synthesis.

4. Biochemical engineering: Microbial growth kinetics-substrate utilization-product formation-aerobic fermentation-methods-types-fluid properties-Sterilization-methods, kinetics, batch and continuous-batch, continuous and field bioreactors; Mass and energy balance in microbial process-effects of dissolved oxygen; Dimensional analysis-heat transfer-counter current and co-current system of heat transfer, scale-up and scale down methods, problems and trouble shooting. Plant cell, animal cell and reactors for production of secondary metabolites and enzymes.

5. Downstream processing: Separation of cell mass, centrifugation, clarification, filtration, unit operations; methods cell disruption-solid shear and liquid shear methods; Concentration methods-evaporation, distillation, crystallization, SCFE, solvent extraction, phase separation, drying etc., whole broth extraction, protein precipitation, extraction, adsorption; Cross flow filtration, Microfiltration, preparative isoelectric focusing; Effluent treatment-aerobic and anaerobic process for waste water treatment, BOD, COD, stabilization etc..

6. Industrial applications: Metabolites-ethanol, acetone, citric acid, lactic acid, amino acid, polysaccharides, nucleosides and bioplastics, penicillin, cephalosporin, streptomycin, vitamins etc.; Bioprocess-applications of enzymes in pharmaceutical industry-therapeutic and clinical analysis-production and use of glucose isomerase, amidase/amidopetidase, amylase, cellulase, penicillin acylase, lipase, oxido-reductase, hydantoinase, epoxide hydrolase, nitrlase, hydoxylase, alolases, decaboxylases etc. for production of different types of drugs and drug intermediates.