M.Sc. Biotechnology Course Structure (CBCS) and Curriculum
Revised and Approved in the Board of Studies Meeting held on 15/07/2022

ELIGIBILITY CRITERIA:

Bachelor's Degree in Biological, Physical, Agricultural, Veterinary, Chemical, Fishery Sciences, Pharmacy, Engineering/ Technology, Horticulture, Dairy and Food Science from any University Recognized by UGC/ICAR/AICTE/ICMR and other Statutory Recognized Bodies of Government of India with at least 50 % marks (45% in case of SC/ST and Cat-I candidates) in optional subjects put together from all the years of the examinations of the course.

Strategic Approach for Programme Curriculum Revision

Biotechnology as a discipline has made giant strides in the past decade and it now touches lives of all humanity on a daily basis. The recent Covid-19 pandemic has shown the world Biotechnology is truly inter-disciplinary in nature and thus very dynamic. Therefore, essential that the curriculum of the M.Sc., Biotechnology be revised to make it relevant, dyna and also motivational to students to take up research and entrepreneurship for welfare of society. Further, it should also contain the latest cutting edge research advancements for benefit of the students. DBT, Government of India has drafted model curriculum for M. Biotechnology and its allied areas taking into account the latest developments in the respec domains. Therefore, the current revision has taken into account the model syllabus prescribe the DBT as also the local requirements of the students and Life Science Industry. The cu revision strictly follows Tumkur University PG CBCS Regulations on Course Structure, Cr and Assessment Pattern. This revision process follows the philosophy of outcomes b education and all efforts have been made to map the continuous progress of students and s has been given for course correction with regular feedback from all the stake holders invol Pedagogical planning for implementation of this curriculum in the form of lesson plans wi drawn up every year after obtaining a structured feedback. Also, major emphasis on required for IPR and Clinical Research Industry has been included in the form of Skill Value Added Certificate Programme (Non-Credit). The eligibility criteria has also expanded to give opportunity for non-life science graduates and engineers to enter programme to make it inter-disciplinary. Non-life science graduates will have to undert mandatory bridge/foundation course. The curriculum, assessment pattern and the duration f same will be drawn up the Department council based on the need and the number of admiss The pedagogical methods for the programme will include:

- Face to Face Lectures
- Tutorials
- Mentoring
- Group Discussion
- Demonstrations
- Journal Club
- Case study Analysis

- Virtual Labs
- Hands on Experiments
- Analytical Problem Solving Methods
- Group Projects
- Mock Interview Skills
- Field and Industrial Visits
- Special lectures and Seminars
- Extension and Enrichment Activity
- Hypothesis Based Own Experiment Design

Programme Outcome:

Objective of the Programme is to develop;

- Researchers of the highest quality in the field of Life Sciences.
- Entrepreneurs who can develop innovative products and solutions.
- Students who can identify new hypothesis and scientific problem through critical analysis.

Course Structure and Curriculum

I Semester

Sl. No.	Paper	Title of the paper	Instruction Hours per Week	No. of Credits	Duration of the Examination.	Marks		
						Internal Assessment	Semester End Examination.	Total Marks
1	CPT-1.1	**Cell Biology and Microbiology**	4	4	3 Hours	20	[illegible]	100
2	CPT-1.2	**Biochemistry and Biophysics**	4	4	3 Hours	20	[illegible]	100
3	CPT-1.3	**Immunology and Vaccine Technology**	4	4	3 Hours	20	[illegible]	100
4	SPT-1.4 A	**Enzyme Technology**	4	4	3 Hours	20	[illegible]	100
	SPT-1.4.B	**Toxicology and Molecular Forensics**	4	4	3 Hours	20	[illegible]	100
5	CPP-1.5	**Practical's Based on Cell Biology and Microbiology**	4	2	3 Hours	[illegible]	[illegible]	50
6	CPP-1.6	**Practical's Based on Biochemistry and Biophysics**	4	2	3 Hours	[illegible]	[illegible]	50
7	CPP-1.7	**Practical's Based on Immunology and Vaccine Technology**	4	2	3 Hours	[illegible]	[illegible]	50
8	SPP – 1.8 A	**Practical's Based on Enzyme Technology**	4	2	3 Hours	[illegible]	[illegible]	50
	SPP – 1.8 B	**Practical's Based on Toxicology and Molecular Forensics**	4	2	3 Hours	[illegible]	[illegible]	50
		Total	32	24		[illegible]	[illegible]	600

Note: CPT: Core paper theory CPP: Core paper practical
SPT: Special paper theory SPP: Special paper practical

II Semester

Paper	Title of the paper	Instruction Hours per Week	No. of Credits	Duration of the Examination.	Marks		
					Internal Assessment	Semester End Examination.	Total Marks
CPT- 2.1	**Genetics and Molecular Biology**	4	4	3 Hours	20	80	100
CPT- 2.2	**Plant and Agricultural Biotechnology**	4	4	3 Hours	20	80	100
SPT- 2.3 A	**Bioinformatics and Mathematical Biology**	4	4	3 Hours	20	80	100
SPT- 2.3 B	**Pharmaceutical and Medical Biotechnology**	4	4	3 Hours	20	80	100
OEPT – 2.4	**Introduction to Biotechnology**	4	4	3 Hours	20	80	100
CPP-2.5	**Practical's Based on Genetics and Molecular Biology**	4	2	3 Hours	10	40	50
CPP-2.6	**Practical's Based on Plant and Agricultural Biotechnology**	4	2	3 Hours	10	40	50
SPP-2.7 A	**Practical's Based on Bioinformatics and Mathematical Biology**	4	2	3 Hours	10	40	50
SPP-2.7 B	**Practical's Based on Pharmaceutical and Medical Biotechnology**	4	2	3 Hours	10	40	50
OEPP 2.8	**Practical's Based on Introduction to Biotechnology**	4	2	3 Hours	10	40	50
	Total	32	24		120	480	600
Skill Based Value Added Certificate Programme- INTELLECTUAL PROPERTY AND PATENTING (Non-Credit).							

Note: CPT: Core paper theory CPP: Core paper practical

SPT: Special paper theory SPP: Special paper practical

OEPT: Open elective paper theory OEPP: Open elective paper practical

Biotechnology

III Semester

Sl. No.	Paper	Title of the paper	Instruction Hours per Week	No. of Credits	Duration of the Examination.	Marks		
						Internal Assessment	Semester End Examination.	Total Marks
1	CPT- 3.1	Genetic Engineering	4	4	3 Hours	20	80	100
2	CPT- 3.2	Animal and Reproductive Biotechnology	4	4	3 Hours	20	80	100
3	SPT- 3.3 A	System Biology and Biostatistics	4	4	3 Hours	20	80	100
	SPT- 3.3.B	Environmental Biotechnology	4	4	3 Hours	20	80	100
4	OEPT – 3.4	Biotechnology For Human Welfare	4	4	3 Hours	20	80	100
5	CPP-3.5	Practical's Based on Genetic Engineering	4	2	3 Hours	10	40	50
6	CPP-3.6	Practical's Based on Animal and Reproductive Biotechnology	4	2	3 Hours	10	40	50
7	SPP-3.7 A	Practical's Based on System Biology and Biostatistics	4	2	3 Hours	10	40	50
	SPP-3.7 B	Practical's Based on Environmental Biotechnology	4	2	3 Hours	10	40	50
8	OEPP-3.8	Practical's Based on Biotechnology For Human Welfare	4	2	3 Hours	10	40	50
		Total	32	24		120	480	600
	Skill Based Value Added Certificate Programme-CLINICAL RESEARCH (Non-Credit).							

Note: CPT: Core paper theory CPP: Core paper practical

SPT: Special paper theory SPP: Special paper practical

OEPT: Open elective paper theory OEPP: Open elective paper practical

IV Semester

Paper	Title of the paper	Instruction Hours per Week	No. of Credits	Duration of the Examination.	Marks		
					Internal Assessment	Semester End Examination.	Total Marks
CPT- 4.1	**Bioprocess Technology and Food Biotechnology**	4	4	3 Hours	20	80	100
CPT- 4.2	**Research Methodology, Scientific Communication Skills and Bio entrepreneurship**	4	4	3 Hours	20	80	100
SPT- 4.3 A	**Bioresource Biotechnology**	4	4	3 Hours	20	80	100
SPT -4.3 B	**Nano Biotechnology**	4	4	3 Hours	20	80	100
CPPD 4.4	**Project Dissertation**	4	4	3 Hours	20	80	100
CPP-4.5	**Practical's Based on Bioprocess Technology and Food Biotechnology**	4	2	3 Hours	10	40	50
CPP-4.6	**Practical's Based on Research Methodology, Scientific Communication Skills and Bio entrepreneurship**	4	2	3 Hours	10	40	50
SPP- 4. 7A	**Practical's Based on Bioresource Biotechnology**	4	2	3 Hours	10	40	50
SPP- 4.7 B	**Practical's Based on Nano Biotechnology**	4	2	3 Hours	10	40	50
CPPP 4.8	**Practical's Based on Project**	4	2	3 Hours	10	40	50
	Total	32	24		120	480	600

Note: CPT: Core paper theory CPP: Core paper practical
SPT: Special paper theory SPP: Special paper practical
OET: Open Elective Theory OEP: Open Elective practical
CPPD: Core paper project Dissertation CPPP: Core paper project practical

The number of experiments for CPP/SPP papers may vary for each semester. A core set of common experiments will be retained for each CPP SPP paper and up to 50% changes will be done in the number and nature of experiments. These changes will be carried out after evaluating recent research articles and availability of Lab kits Consumables / Protocols and virtual demonstration tools at the begining of each Semester.

CURRICULUM

I SEMESTER

CPT-1.1 CELL BIOLOGY AND MICROBIOLOGY

Course Objectives – The objectives of this course are to sensitize the students to the fact that as we go down the scale of magnitude from cells to organelles, the understanding of various biological processes becomes deeper and inclusive. To introduce the field of microbiology with special emphasis on microbial diversity, morphology, physiology and nutrition; methods for control of microbes.

Student Learning Outcomes- Students should be able to: • Identify major categories of microorganisms and analyze their classification, diversity, and ubiquity; • Identify and demonstrate structural, physiological, genetic similarities and differences of major categories of microorganisms; • Identify and demonstrate how to control microbial growth; • Demonstrate and evaluate interactions between microbes, hosts and environment.

At the end of the course student will be equipped to understand three fundamental aspects in biological phenomenon: a) what to seek; b) how to seek; c) why to seek

UNIT I: Biology of Organelles (16h)

Morphology and Ultra structure of prokaryotic and Eukaryotic cell (intracellular organelles: endoplasmic reticulum and Golgi apparatus, lysosomes and peroxisomes, ribosomes, cellular cytoskeleton, mitochondria, chloroplasts and cell energetics; nuclear compartment: nucleus, nucleolus and chromosomes, periplasmic space and apoplasm). Cell wall chemical composition and characteristics (Gram positive & gram-negative bacteria: lipoproteins, lipopolysaccharides, matrix proteins), cytoplasmic inclusions, endospores (formation and genetics) and Exospores.

UNIT II: Membrane Transport (16h)

Membrane Transport (Prokaryotes and Eukaryotes): The composition and architecture of membranes, Membrane dynamics, Models of membranes. Solute transport across membranes: Passive diffusion, active transport using P and F type ATPases. Ion mediated transport, transport of ions across membranes (ion pumps), co-transport, symport, antiport. Vesicular transport. Biochemical shuttles across mitochondrial membranes. Protein trafficking: Events in cell cycle, Regulation of cell cycle. Analytical methods for cell cycle studies.

UNIT III: Microbial Diversity (16h)

Introduction, history & scope of microbiology, morphology, structure. Contribution of various Scientists. Bacterial genetics: mutation and recombination in bacteria, plasmids, transformation,

transduction and conjugation; antimicrobial resistance. Microbial taxonomy and evolution of diversity, Hierarchical classification of microorganisms, classification of bacteria; Cyanobacteria, endospore forming bacteria, Mycobacteria and Mycoplasma. Archaea: Halophiles, Methanogens, Hyper thermophies and thermoacidophiles; eukarya: Classification and general characteristics of algae, fungi, slime molds and protozoa; Community studies on unculturable microbes. viroid's and Prions.

UNIT IV: Analytical Microbiology (16h)

Microscopy& Microbiological Techniques: Light, Dark field, Phase contrast, Fluorescence, Electron microscopy and its modifications, Confocal microscopy. Hemocytometer and micrometry. Sterilization methods. Growth and nutrition of bacteria, Isolation of microorganisms Bacterial growth curve, Mathematical expression of growth; Measurement of growth and growth yields; Synchronous growth, and continuous culture, growth as affected by environmental factors. Staining Techniques: Simple and differential, fluorescent, negative; Structural staining: capsule, spore, cell wall and reserve food material. Preservation of cultures.

CPT 1.2: BIOCHEMISTRY& BIOPHYSICS

Course Objectives-The objectives of this course are to cover all essentials required to appreciate physico-chemical principles underlying biological processes and to build upon undergraduate level knowledge of biochemical principles with specific emphasis on different metabolic pathways.

Student Learning Outcomes - Students will be able to have a firm foundation in fundamentals and application of current physical scientific theories and to gain fundamental knowledge in biochemistry;

UNIT I: Biomolecules 1 (16 h)

Structure-function relationships: Carbohydrates – structure, functional group properties and classification. Lipids – structure, functional group properties and classification. Nucleic acids – structure, functional group properties and classification. Nature of genetic materials, Structure of purine, pyrimidine and nucleotides. Vitamins and Hormones – structure, functional group properties and classification.

UNIT II: Biomolecules 2 (16 h)

Structure-function relationships: amino acids – structure and functional group properties, peptides and covalent structure of proteins, elucidation of primary and higher order structures, Ramachandran plot, evolution of protein structure, protein degradation and introduction to molecular pathways controlling protein degradation, structure-function relationships in model proteins like ribonuclease A, myoglobin, hemoglobin, chymotrypsin. Basic principles of Protein purification; tools to characterize expressed proteins; Protein folding: Anfinsen's Dogma, Levinthal paradox, cooperativity in protein folding, free energy landscape of protein folding and

pathways of protein folding, molten globule state, chaperons and diseases associated with protein folding, introduction to molecular dynamic simulation.

UNIT III (Bioenergetics) (16h)

Bioenergetics-basic principles; equilibria and concept of free energy; coupled interconnecting reactions in metabolism;oxidation of carbon fuels; recurring motifs in metabolism; g protein coupled receptors, Inositol/DAG//PKC and Ca++ signaling pathways; glycolysis and gluconeogenesis; reciprocal regulations and non-carbohydrate sources of glucose; Citric acid cycle, entry to citric acid cycle, citric acid cycle as a source of biosynthetic precursors; Oxidative phosphorylation; importance of electron transfer in oxidative phosphorylation; F1-F0 ATP Synthase; shuttles across mitochondria; regulation of oxidative phosphorylation; Photosynthesis – chloroplasts and two photosystems; proton gradient across thylakoid membrane; Calvin cycle and pentose phosphate pathway; glycogen metabolism, reciprocal control of glycogen synthesis and breakdown, roles of epinephrine and glucagon and insulin in glycogen metabolism; Fatty acid metabolism; protein turnover and amino acid catabolism; nucleotide biosynthesis; biosynthesis of membrane lipids and sterols with specific emphasis on cholesterol metabolism and mevalonate pathway; elucidation of metabolic pathways; logic and integration of central metabolism; entry/ exit of various biomolecules from central pathways; principles of metabolic regulation; steps for regulation.

UNIT IV (Biophysics) (16h)

Newton's law of motions (centripetal and centrifugal forces *etc.*); simple harmonic motions, mechanical waves, Doppler effect, wave interference, amplitude, period, frequency & wavelength; diffusion, dissipation, random walks, and directed motions in biological systems; Reynolds number and its biological importance, buoyant forces, Bernoulli's equation, viscosity, turbulence, surface tension, adhesion; laws of thermodynamics: Maxwell Boltzmann distribution, conduction, convection and radiation, internal energy, entropy, temperature and free energy, Maxwell's demon (entropic forces at work in biology, chemical assemblies, self-assembled systems, role of ATP)

CPT-1.3 IMMUNOLOGY AND VACCINE TECHNOLOGY

Course Objectives- The objectives of this course are to learn about structural features of components of immune system as well as their function. The major emphasis of this course will be on development of immune system and mechanisms by which our body elicits immune response. This will be imperative for students as it will help them to predict about nature of immune response that develops against bacterial, viral or parasitic infection. The course is intended to provide an overview and current developments in different aspects of vaccine biotechnology

Student Learning Outcomes - On completion of this course, students will be able to: • Evaluate usefulness of immunology in different pharmaceutical companies; • Identify proper research lab

working in area of their own interests; • Apply their knowledge and design immunological experiments to demonstrate innate, humoral or cytotoxic T lymphocyte responses and figure out kind of immune responses in the setting of infection (viral or bacterial). Immunological Techniques, Conventional and new generation vaccines.

UNIT I: Biology of the Immune System (16h)

Immune system and Immune Response: Innate and acquired immunity, structure andfunctions of immune cells-T cells, B cells and their subtypes, Macrophages, NK cells and dendritic cells,Eosinophils, Neutrophils, Mast cells. Organs of immune system-Primary and secondary lymphoid organs. Primary and secondary immune response, Structure and types ofimmunoglobulins, B and T cell maturation,Mechanism of antigen recognition by T and B - lymphocytes, Immunoglobulin Super family of genes, MHC TLRs, Band T cell receptors, Antigens, Epitopes, Immunogens, Haptens, opsonin's, Clonal selection theory.

UNIT II: Hypersensitivity (16h)

Hypersensitivity Reactions: Allergy, Hypersensitivity reactions -types (I, II, III, and IV), symptoms, immunodiagnosis. Lymphokines and cytokines: Interleukins and Interferons,complementation, Production, biological functions and assay methods, Immunogeneticsand hypersensitivity, Graft rejection, Immune response to tumors, auto immunedisorders, immunodeficiency.

UNIT III: Antigen-Antibody Reactions (16h)

Immunological Techniques: Agglutination, precipitation, immune-fluorescence, immunoelectrophoresis, immunoblotting, ELISA, RIA, Flow cytometry. Production and purification of antibodies, determination of antibody titer by RID and EID. T-cell cloning: Importance of antigen and MHC class II molecules in T-cell cloning. Antigen specific and alloreactive, T-cell cloning -immunologically relevant antigens.

UNIT IV: Immunization and Vaccine Biotechnology (16h)

Immunization: Active and passive immunization; National Immunisation Programme of India and other countries, Antibody engineering: recombinant antibodies, generation of monoclonal antibodies, hetero hybridoma; catalytic antibodies and generation of immunoglobulin gene libraries.History and scope of vaccines, types of vaccines. Development of vaccines, Efficacyand safety of vaccines, live, killed, attenuated, subunit vaccines; vaccine technology: role and properties ofadjuvants, recombinant DNA and protein-based vaccines, plant-based vaccines,reverse vaccinology; peptide vaccines, conjugate vaccines; idiotypic vaccines and marker vaccines, viral-like particles (VLPs), dendritic cell-based vaccines, vaccineagainst cancer, T cell-based vaccine, edible vaccine and therapeutic vaccine, recent trends in vaccine development.

SPT 1.4A ENZYME TECHNOLOGY

Course Objectives- The objectives of this course are to learn about basics of enzyme reactions and allosteric enzymes, immobilization techniques, Enzyme kinetics and its applications.

Student Learning Outcomes - On completion of this course, students will be able to understand and comprehend the following:

- Allosteric interactions and binding isotherms of enzymes.
- The cooperativity, Hill and Scatchard plots.
- kinetics of allosteric enzymes Applications of immobilized enzyme technology and designing and configuration of immobilized enzyme reactors.
- Industrial and diagnostic applications of enzymes .

UNIT I: Enzymatic Reactions (16h)

Classification, characteristics and enzyme substrates reactions. Stereo specificity of enzyme and ES complex formation. Role of metal ions in cofactor and coenzymes. Mechanism of enzyme reaction of single & double substrates: Nucleophilic, electrophilic, substitution and elimination reactions. Factors affecting catalytic efficiency. Isoenzymes, Ribozymes and Abzymes. Allosteric interactions and allosteric enzymes. Enzyme regulation, Biotransformation and Enzyme assay. Catalytic antibodies. Biocatalysts from extreme Thermophilic and Hyper thermophilic microorganisms (extremozymes).

UNIT II: Immobilization (16h)

Immobilized enzymes: Relative practical and economic advantages, effect of partition on kinetics and performance with particular emphasis on charge and hydrophobicity (pH, temperature and Km). Methods of immobilization-ionic bonding, adsorption, covalent bonding (based on R groups of amino acids), microencapsulation and gel entrapment, design and configuration of immobilized enzyme reactors, Immobilized multienzyme systems, Applications of immobilized enzyme technology, The design and construction of novel enzymes, artificial enzymes, Fundamentals of enzyme assay: Enzyme purification: criteria of purity of enzymes and its importance.

UNIT III: Kinetics (16h)

Enzyme kinetics: Rate of reactions, steady state enzyme kinetics, quantitation of enzyme activity and efficiency; enzyme characterization and Michaelis-Menten Equation; Significance of Vmax and Km, K/cat, cooperativity, Hill and Scatchard plots, relevance of enzymes in metabolic regulation, activation,covalent modification, international units, specific activity, molecular activity, turn over number and end point kinetic assay.single substrate enzymes; catalytic strategies with specific examples of proteases, carbonic anhydrases, restriction enzymes and

nucleoside monophosphate kinase; regulatory strategies with specific example of hemoglobin; isozymes; role of covalent modification in enzymatic activity; zymogens.

UNIT IV: Applications (16h)

Industrial Applications: Enzymes used in detergents, use of proteases in food, leather and wool industries; methods involved in production of glucose syrup from starch (using starch hydrolyzing enzymes), production of maltose and sucrose, glucose from cellulose, use of lactase in dairy industry.Medical Applications: Importance of enzymes in diagnostics, Enzyme pattern in diseases like Myocardial infarction (SGOT, SGPT & LDH), Isoenzymes (CK, LD, ALP). Use of isoenzymes as markers in cancer and other diseases. Clinical significance of choline esterases. Enzyme immunoassay techniques. Therapeutic enzymes.

SPT 1.4 B TOXICOLOGY AND MOLECULAR FORENSICS

Course Objectives- The objectives of this course are to learn about basic toxic effects of different Toxicants, Evaluation technique of Toxicants, Metabolism and mechanism of action of toxicants in body. Basics about Forensics Science and its molecular application in Crime Investigation.

Student Learning Outcomes - On completion of this course, students will be able to learn basics and application in different domains of Toxicology and Forensics science.

UNIT I: Biochemical Toxicology (16h)

Introduction to toxicology: History and scope of toxicology, Source of toxicants. Classification of toxic agents. Occupational toxicology: Workplace, hazardous exposure, and occupational diseases. Mechanism of toxicity: Toxicant delivery, Non-target organ toxicity: Cytotoxicity: mechanisms of cell death, mitochondrial dysfunction. Metabolism of toxicants: Phase I Reactions: Microsomal oxidation Non-microsomal oxidations Reduction Reactions, Hydrolysis, Epoxide Hydration. oxidation. Phase II Reactions: Conjugation reactions, Methyltransferases and Acylation. Reactive Metabolites: nature, stability and fate of reactive metabolites, Elimination of Toxicants: renal, hepatic and respiratory elimination.

UNIT II: Toxicity Testing (16h)

Toxicology Testing: Food toxicology: introduction, safety standards for foods and food ingredients and contaminants. *In Vivo*testing: Testing of acute, sub chronic and chronic toxicity. *In Vitro* testing: Cell Culture Methods, Ames forward mutation assay, Assessing genotoxicity: mitotic index, micronucleus assay, cytotoxicity and apoptosis assay. Neurotoxicity testing.

UNIT III: Forensic Science (16h)

Introduction to Forensic science: Definition and Scope, History and Development of Forensic science, basic Principles of Forensic Science. Organization of crime Laboratory services,

services provided by full service crime laboratories, Physical Science unit, Biological Unit, Firearms Unit, Documentation Examination Unit -Function and Duties Performed by each unit and lab. The Crime Scene investigation -Making and recording observations (including sketches with measurements and digital photographs), Chain of Custody, Locard Exchange principle, Evidences and Collection techniques, Marks and impressions, Drug of abuse. Polygraphy. Computer forensics.

UNIT IV: Forensic Biology and Molecular Methods (16h)

Forensic Biology: Forensic Pathology: Rigor mortis, Lovor mortis, Algormortis. Forensic Anthropology, Forensic Entomology, Forensic Psychiatry, Forensic Odontology, Forensics Engineering, forensic serology, DNA Analysis, Dactyloscopy, Finger prints: history, fundamental principle of Fingerprints, Classification and patterns, AFIS, Method of Detecting fingerprint. Trace evidence and contact evidence - targeting potential traces, recovery of trace material assessment of significance-Hair, fiber and Paint.

II SEMESTER

CPT 2.1 GENETICS AND MOLECULAR BIOLOGY

Course Objectives-The objectives of this course are to engage the students in a much deeper understanding of various concepts in genetics and molecular biology of prokaryotes and eukaryotes.

Student Learning Outcomes-At the end of the course the student will be equipped to understand three fundamental aspects in biological phenomenon and students should be able to: • Describe the fundamental molecular principles of genetics; • Understand the relationship between phenotype and genotype in human genetic traits; • Describe the basics of genetic mapping. • Understand how gene expression is regulated.

UNITI: Principles and Mapping (16h)

Classical genetics: Lamarck's principle, Mendel's principles, Chromosomal basis of inheritance, Genetic linkage and gene mapping, Tetrad analysis, Sex chromosomes and sex determination. General features of Genetic code, Cytogenetic: Universal genetic codes, degeneracy of codons, Wobble hypothesis. Population genetics: Introduction to the elements of population genetics: genetic variation, genetic drift, neutral evolution; mutation selection, balancing selection, Fishers theorem, Hardy Weinberg equilibrium, linkage disequilibrium; in-breeding depression & mating systems; population bottlenecks, migrations, Bayesian statistics; adaptive landscape, spatial variation & genetic fitness. Quantitative trait loci: (a) Major genes; (b) Methods of mapping QTLs, Complex traits, mapping QTLs, yeast genomics to understand biology of QTLs. genetics

as a model of eukaryotes: yeast, *Drosophila, Caenorhabditis elegans, Arabidopsis thaliana* and tobacco.

UNITII: Genome (16h)

Genome Structure and Organization: Definition and organization of viral, prokaryotic and eukaryotic genomes. Structure of chromatin, nucleosome, chromatin organization and remodeling, higher order organization- chromosome, centromere, telomere.Histones and their effect on structure and function of chromatin.Chromosome banding, ploidy, chromosome aberrations and position effect.C value paradox and genome size, Cot curves, repetitive and non-repetitive DNA sequences, Cot ½ and Rot ½ values, satellite DNA, DNA melting and buoyant density. Gene families, clusters, Pseudogenes, Organelle genomes.

UNIT III: Central Dogma (16h)

Structure and assembly of eukaryotic and prokaryotic DNA polymerases, DNA-replication, Transcriptional control: Structure and assembly of eukaryotic and prokaryotic RNA Polymerases, promoters and enhancers, transcription factors as activators and repressors, transcriptional initiation, elongation and termination; post-transcriptional control: splicing and addition of cap and tail, mRNA flow through nuclear envelope into cytoplasm, breakdown of selective and specific mRNAs through interference by small non-coding RNAs (miRNAs and siRNAs), protein translation machinery, ribosomes-composition and assembly, mechanism of initiation, elongation and termination; co- and post-translational modifications,

UNIT IV: Damage and Repair (16h)

DNA damage and Repair, Types of DNA damage, DNA repair mechanisms- nucleotide excision repair, base excision repair, mismatch repair, recombination repair, double strand break repair, transcriptional coupled repair. Recombination Homologous and site-specific recombination, models for homologous recombination- Holliday junction, NHEJ, Proteins involved in recombination- RecA, RuvA, B, C, Gene conversion. Mobile DNA elements Transposable elements in bacteria, IS elements, composite transposons, replicative and non-replicative transposons, Mu transposition, Controlling elements in TnA and Tn 10 transposition. SINES and LINES, retrotransposons.

CPT-2.2 PLANT & AGRICULTURAL BIOTECHNOLOGY

Course Objectives- The objectives of this course are to introduce students to the principles, practices and application of plant biotechnology, plant tissue culture, plant genomics, genetic transformation and molecular breeding of plants and study of effect of biocontrol agents, ISR and SAR.

Student Learning Outcomes- Students will be able to gain fundamental and applied knowledge in plant biotechnology and its uses.

UNIT I: Plant Tissue Culture (16h)

Plant tissue culture: - History, Laboratory organization, Sterilization methods, Media preparation, Plant Growth Regulators, Micropropagation & Somatic embryogenesis via axillary and adventitious shoot proliferation; production of artificial seeds; Double haploid production by androgenesis and gynogenesis; triploid production by endosperm culture; production of virus free plants by meristem, shoot-tip culture; Cell Suspension cultures; protoplast isolation and regeneration, somatic hybridization and cybridization; protoclonal, somaclonal and gametoclonal variation, Cytoplasmic male sterility for crop improvement; Cryopreservation.

UNIT II: Transformation (16h)

Genetic engineering: Agrobacterium-plant interaction; virulence; Ti and Ri plasmids; opines and their significance; T-DNA transfer; disarmed Ti plasmid; Genetic transformation - Agrobacterium-mediated gene delivery; cointegrate and binary vectors and their utility; direct gene transfer - PEG-mediated, electroporation, particle bombardment and alternative methods; screenable and selectable markers; characterization of transgenics; chloroplast transformation; marker-free methodologies; advanced methodologies - cisgenesis, intragenesis and Genome editing :basic methods, applications and ethics. Molecular pharming - concept of plants as biofactories, production of industrial enzymes and pharmaceutically important compounds.

UNIT III: Transgenics (16h)

Isolation of genes of economic importance. Gene constructs for tissue-specific expression. Molecular analysis of transformants. Potential applications of plant genetic engineering for crop improvement, *i.e.,* insect-pest resistance (insect, viral, fungal and bacterial disease resistance), abiotic stress resistance, herbicide resistance, storage protein quality, increasing shelf-life, oil quality, biosafety norms and controlled field trials and release of transgenics (GMOs) Bt crops & golden crops .

UNIT IV: Biotechnology for Plant Protection (16h)

Importance and scope of biological control, history of biological control: Mechanism of Biocontrol agents-parasites, predators and insect pathogens. Phenomena of multiple parasitisms, hyper parasitism, super parasitism and their applied importance. Microbial insecticides and their formulation. Merits and demerits of microbial control. Role of biocontrol agents and microbial insecticides in Integrated Pest Management. Effect of PGPB, PGPF, PGPA and its mechanisms in crop production and protection. Role of soil microbiome in stress tolerance. QTLs, genetic

basis of disease resistance in plants, Proline rich protein signaling in biotic and abiotic stress tolerance. Phylogeny and mechanism of Desiccation tolerance in plants and its applications. Innate immune response and elicitor mediated ISR and SAR as alternative methods for sustainable plant disease management.

SPT 2.3A BIOINFORMATICS& MATHEMATICAL BIOLOGY

Course Objectives -The objectives of this course are to provide theory and practical experience of the use of common computational tools and databases which facilitate investigation of molecular biology and evolution-related concepts. It is also expected to provide conceptual exposure of essential contents of mathematics to students.

Student Learning Outcomes- At the end of the course the student should be able to : • Develop an understanding of basic theory of computational tools; • Gain working knowledge of computational tools and methods; • Appreciate their relevance for investigating specific contemporary biological questions; • Critically analyse and interpret results • Gain broad understanding in basic mathematics required for Biology; • Recognize importance and value of mathematical thinking, training, and approach to problem solving, on a diverse variety of disciplines.

UNIT I: Basic Bioinformatics (16h)

Bioinformatics basics: Computers in biology and medicine; Introduction to Unix and Linux systems and basic commands; Database concepts; Protein and nucleic acid databases; Structural databases; Biological XML DTD's; pattern matching algorithm basics; databases and search tools: biological background for sequence analysis; Identification of protein sequence from DNA sequence; searching of databases similar sequence; NCBI; publicly available tools; resources at EBI; resources on web; database mining tools.

UNIT II: Sequence Analysis (16h)

DNA sequence analysis: gene bank sequence database; submitting DNA sequences to databases and database searching; sequence alignment; pairwise alignment techniques; motif discovery and gene prediction; local structural variants of DNA, their relevance in molecular level processes, and their identification; assembly of data from genome sequencing.Multiple sequence analysis; multiple sequence alignment; flexible sequence similarity searching with the FASTA3 program package; use of CLUSTALW and CLUSTALX for multiple sequence alignment; submitting DNA& protein sequence to databases: where and how to submit, SEQUIN, genome centres; submitting aligned sets of sequences, updating submitted sequences, methods of phylogenetic analysis.

UNIT III: Modelling (16h)

Protein modelling: introduction; force field methods: energy, buried and exposed residues; side chains and neighbors; fixed regions; hydrogen bonds: mapping properties onto surfaces; fitting

monomers; RMS fit of conformers; assigning secondary structures; sequence alignment-methods, evaluation, scoring; protein completion: backbone construction and side chain addition; small peptide methodology; software accessibility; building peptides; protein displays; sub-structure manipulations, annealing, protein structure and function prediction modeling.

UNIT IV: Basic Mathematics for Biologists (16h)

Algebra: Linear equations, functions: slopes-intercepts, forms of two-variable linear equations; constructing linear models in biological systems; quadratic equations (solving, graphing, features of, interpreting quadratic models etc.), introduction to polynomials, graphs of binomials and polynomials. Mathematical models in biology: Population dynamics; oscillations, circadian rhythms, developmental patterns, symmetry in biological systems, fractal geometries, size-limits & scaling in biology, modeling chemical reaction networks and metabolic networks.

SPT-2.3 B PHARMACEUTICAL & MEDICAL BIOTECHNOLOGY

Course Objectives -The objectives of this course are to provide basic knowledge of pharmaceutical drug action, evaluation and design and conceptual understanding of host–pathogen interactions using well characterized systems as examples. Further, a unique understanding of cancer cells its biology and management is also provided.

Student Learning Outcomes- After successful completion of these course students will be able to:

- Study the principles of chemotherapy, toxicology and immunopharmacology
- Understand the concept of drug discovery, evaluation, delivery and pharmacogenomics
- Understand the concept of biomolecules like protein based therapeutics.
- Learn the difference between development of Biotechnology Products of macromolecules and Chemical Products,
- Understand the concepts of cancer immunotherapy, immunopharmacology
- Compare and contrast different microbial diseases, including properties of different types of pathogens, and mechanisms of pathogenesis and carcinogenesis.

UNIT I: Pharmacology of Drugs (16h)

Fundamental Principles of Pharmacology, Fundamentals of Cardiovascular, Endocrine, and Immunopharmacology, Principles of Chemotherapy, Principles of Toxicology, Contemporary Approaches to Drug Discovery, Development and Delivery, Fundamentals of Drug Evaluation and Pharmacogenomics. Elements of *in silico* drug design.

UNIT II: Pharmacokinetics and Dynamics (16h)

Principles of drug absorption, drug metabolism and distribution - intestinal absorption, metabolic stability, drug-drug interactions, plasma protein binding assays, metabolite profile studies, Principles of toxicology, Experimental design for preclinical and clinical PK/PD/TK studies, Selection of animal model; Regulatory guidelines for preclinical PK/ PD/TK studies; Scope of GLP, SOP for conduct of clinical &non-clinical testing, control on animal house, report preparation and documentation Integration of non-clinical and pre-clinical data to aid design of clinical studies . Objectives of Phase I, II, III and IV clinical studies, Clinical study design, enrollment, sites and documentation, Clinical safety studies: Adverse events and adverse drug reactions, Clinical PK, pharmacology, drug-drug interaction studies, Statistical analysis and documentation.

UNIT III: Host-Pathogen Interaction (16h)

Introduction scope and applications in Medical Biotechnology: Intracellular and extracellular pathogens, Principles of microbial pathogenesis, host damage, inflammatory responses, adaptation strategies of pathogen- impact of host and pathogen metabolism on immunity and pathogen survival; Chronic pathogens and mechanisms of persistence; Evasion mechanisms of pathogens; Methods of culturing and assaying: bacterial, viral and parasites. Bacterial – host interaction-*Mycobacterium tuberculosis, Borreliaburgdorferi*; Viruses – host interaction: HIV, Influenza; Protozoan – host interaction: Plasmodium and Leishmania.Diseases: Other bacterial, viral, fungal and parasitic diseases of medical importance. Investigation of epidemics, emerging, re-emerging and newly emerging pathogens.

UNIT IV: Gene Therapy and Oncology (16h)

General gene therapy strategies, Targeted killing of specific cells, Targeted mutation correction, Targeted inhibition of gene expression. Gene replacement therapy by viral vectors: Oncovirus, Lentivirus, Adenovirus, Adeno associated virus, Herpes Simplex virus. Cancer Biology-Characteristics of tumor cells, cell culture and transformation, characteristics of transformed cells, changes in cell-cell interaction. Etiology of cancer- Agents of transformation –viruses as agents and oncogenes, DNA viruses, RNA viruses-retro viruses, chemical carcinogenesis and radiation carcinogenesis. Immuno, chemo and targeted recombinant therapies for cancer cure.

OEPT 2.4 INTRODUCTION TO BIOTECHNOLOGY

Course Objectives -The objective of this course is to apprise the non-core students who have opted for Biotechnology as an elective about the basics of Biotechnological techniques and its applications.

Student Learning Outcomes- On completion of this course, students should be able to learn-about evolution of life, biodiversity, impact of genetic engineering in modern society, and biotechnological applications.

UNIT I: Biology of Life (16h)

Principles of evolution of life. Evolutionary tree. Origin of microbes and higher organisms. Representative prokaryotic and eukaryotic cells (bacteria, plant and animal cells), higher organisms. Viruses. Nucleic acids (DNA, RNA) and proteins. Genes and genetics. Introduction to biotechnology. Principles of biotechnology and classification.

UNIT II: Diversity of Life (16h)

Microbiological Techniques: Sterilization; Physical methods, chemical methods and Radiation methods. Culture media and types of culture media. Nutritional requirements of microorganisms, Definition of growth; Growth curve, Biodiversity: Microbial, plant and animal diversity; Hotspots of biodiversity; Biodiversity issues and concerns. Energy & Biofuels- Non-conventional or renewable sources of energy, Energy from Biomass, Classes of biofuels. Biogas production as non-conventional energy sources.

UNIT III: Biotechnological Applications for Sustainability (16h)

Biogeochemical Cycles: Carbon, nitrogen, oxygen, phosphorous, sulphur; cycling of toxic metals (Cd, Hg, Pb). Biotechnology for pollution control, treatment of industrial and other wastes, Bioremediation, Principles of microbial bioremediation, *in situ* and *ex situ* bioremediation, microbiological treatment of solid wastes – composting, land farming, bioreactors. Bioleaching. Biological treatment of liquid wastes – aerobic and anaerobic treatments, sewage and effluent treatments.

UNIT IV: Basics of Genetic Engineering (16h)

Introduction to Recombinant DNA Technology, Introduction, outline of genetic engineering procedure, restriction endonucleases, cloning & expression vectors- plasmids, Gene transfer methods. GMOs, Environmental release and monitoring of GMOs, Ethical issues. Bioinformatics- DNA databases, gene bank sequence databases, Phylogenetic, sequence aligning, Protein databases, Information retrieval from databases.

III SEMESTER

CPT 3.1 GENETIC ENGINEERING

Course Objectives- The objective of the course is to facilitate understanding of various approaches in genetic engineering and their applications. Genetic engineering is a technology

that has been developed based on fundamental understanding of the principles of molecular biology which is reflected in the contents of this course.

Student Learning Outcomes- On completion of this course, students should be able to learn- Given the impact of genetic engineering in modern society, the students will be endowed with strong theoretical and practical knowledge in the various nuances that make up the vast scientific world of genetic engineering.

UNIT I: Tools in Recombinant Technologies (16h)

Impact of genetic engineering in modern society; general requirements for performing a genetic engineering experiment; restriction endonucleases and methylases; DNA ligase, Klenow enzyme, T4 DNA polymerase, polynucleotide kinase, alkaline phosphatase; cohesive and blunt end ligation; linkers; adaptors; homopolymeric tailing; labelling of DNA: nick translation, random priming, radioactive and non-radioactive probes, hybridization techniques: northern, southern, south-western and far-western and colony hybridization, fluorescence *in situ* hybridization.

UNIT II: Vector Systems (16h)

Plasmids; Bacteriophages; M13mp vectors; PUC19 and Bluescript vectors, Phagemids; Lambda vectors; Insertion and Replacement vectors; Cosmids; Artificial chromosome vectors (YACs; BACs); expression expression vectors, pET-based vectors, His-tag; GST-tag; MBP-tag. Inclusion bodies; methodologies to reduce formation of inclusion bodies; mammalian expression and replicating vectors; Baculovirus and Pichia vectors system, plant based vectors, Ti and Ri as vectors, yeast vectors, shuttle vectors.

UNIT III: PCR and Sequencing Technologies (16h)

Principles of PCR: primer design; fidelity of thermostable enzymes; DNA polymerases; types of PCR – multiplex, nested; reverse-transcription PCR, real time PCR, touchdown PCR, hot start PCR, colony PCR, asymmetric PCR, cloning of PCR products; T-vectors; proof reading enzymes; PCR based site specific mutagenesis; PCR in molecular diagnostics; viral and bacterial detection; Introduction to sequencing, Maxam and Gilbert method, Sanger Sequencing techniques and applications; Next Generation sequencing (NGS),Introduction to NGS, Experimental protocol (Isolation of DNA/RNA), quality check, Library Preparations, sequencing reaction); Platform overview and comparison (Illumina, 454 (Roche), SOLiD (Life technology), Specific Biosciences, Ion Torrent, Nanopore, PacBio; Types of NGS, DNA-sequencing - Whole genome sequencing, exome sequencing, Deep sequencing, ChIP sequencing, RNA-sequencing and the types (small RNA sequencing, non-coding RNA sequencing),Whole transcriptome sequencing; Data Processing and Analysis: Data Quality Check, filtering and Genome assembly

and mapping to reference genomes, mapping tools (bowtie, maqetc,), microbial sequencing, Comparison of Microarray technology and High throughput sequencing technology.

UNIT IV: Advanced Technologies (16h)

Insertion of foreign DNA into host cells; transformation, electroporation, transfection; construction of libraries; isolation of mRNA and total RNA; reverse transcriptase and cDNA synthesis; cDNA and genomic libraries; construction of microarrays – genomic arrays, cDNA arrays and oligo arrays; study of protein-DNA interactions: electrophoretic mobility shift assay; DNase foot printing; methyl interference assay, chromatin immunoprecipitation; Gene silencing techniques; introduction to siRNA; siRNA technology; Micro RNA; construction of siRNA vectors; principle and application of gene silencing; gene knockouts and gene therapy.

CPT 3.2: ANIMAL AND REPRODUCTIVE BIOTECHNOLOGY

Course Objectives- The objective of this course is to educate students about the fundamental concepts of animal cell system, their related applications and to acquaint them of recent advances in animal reproductive technologies.

Student Learning Outcomes- Students will be able to gain strong understanding of animal based cell cultures system. This will help them to take up animal based biological research as well as placement in the relevant biotech industry.

UNIT-I: Cell Culture (16h)

Animal Tissue culture and Hybridoma Technology: Cell culture media and preparations. Cell culture techniques: Monolayer and suspension culture, cell lines, organ culture- techniques, three dimensional cultures. Somatic cell fusion and its applications (cybrids, membrane fluid mobility and hybridoma technology). Primary and immortalized cells, Cell transformation and malignancy. Advanced cell culture techniques and application of cultured cells. Cell culture and viability, Cell Synchronization and cell cycle Analysis (mitotic and flow cytometry). Gene transformation methods: Transfection, electroporation and liposome). Immuno-techniques; IFA (membrane, cytoplasmic and nuclear proteins). Detection of contamination in cell culture.

UNIT-2: Applications (16h)

Applications of Animal Biotechnology: Animal improvement: (diary, fishery, sericulture and poultry). Medicine: diagnosis of diseases, detection of genetic disorders. Treatment: vaccines, gene and cell therapy, tissue transplantations. Production of pharmaceutical chemicals, interferons, interleukins, stem cell factors and hormones. Industrial applications: metabolites production, bio control agents, industrially important enzymes. Application of animal cell culture for virus isolation and in vitro testing of drugs, testing of toxicity of environmental pollutants in

cell culture, application of cell culture technology in production of human and animal viral vaccines and pharmaceutical proteins.

UNIT-3: Reproductive Biology (16h)

Animal reproductive biotechnology: structure of sperms and ovum; cryopreservation of sperms and ova of livestock; artificial insemination; super ovulation, embryo recovery and in vitro fertilization; culture of embryos; cryopreservation of embryos; embryo transfer technology; transgenic manipulation of animal embryos; applications of transgenic animal technology; animal cloning - basic concept, cloning for conservation of endangered species.

UNIT-4: Transfection (16h)

Cell cloning and selection; Transfection and transformation of cells; Commercial scale production of animal cells, stem cells and their application; Application of animal cell culture for *in vitro* testing of drugs; Testing of toxicity of environmental pollutants in cell culture; Application of cell culture technology in production of human and animal viral vaccines and pharmaceutical proteins. Cryopreservation and storage of animal cells.

SPT 3.3A: SYSTEM BIOLOGY AND BIOSTATISTICS

Course Objectives- The objective of this course is to give an introduction to Genomics, proteomics, and metabolomics technologies. Further, the course also envisions the students to understand the theory aspects of these technologies and its applications in biology. The student should be able to gain working knowledge of these technologies and appreciate the ability of thes e technologies to impart a global understanding of biological systems. Also, a basic knowledge of biostatistics and its principles will also be imparted.

Student Learning Outcomes- On completion of this course, students will be able to gain knowledge on • Application of various *Omics*-technologies. • Understand how to summaries data; • Apply appropriate statistical tests based on an understanding of the study question, type of study and type of data; • Interpret the results of statistical tests.

UNIT-1: Genomics (16h)

Genome Organisation and model genomes. Computational analysis, Databases, Finding genes and regulatory regions; Tools for genome analysis- PCR, RFLP, DNA fingerprinting, RAPD, SNP detection, SSCP, FISH to identify chromosome landmarks; 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, UCSC

browser.Introduction, Basic principles and design, cDNA and oligonucleotide arrays, DNA microarray, Instrumentation and structure; Designing a microarray experiment - The basic steps, Types of microarray - expression arrays, protein arrays, Comparative Genomic Hybridization (CGH) arrays, Re-sequencing arrays; Different platforms (Affymetrix, Agilent etc.); Data Processing and Normalization .

UNIT-2: Proteomics (16h)

Overview of protein structure-primary, secondary, tertiary and Quaternary structure, Relationship between protein structure and function; 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, quadruple ion trap) and detector; Post translational Modifications: Quantitative proteomics, clinical proteomics and disease biomarkers, mass spectral tissue imaging and profiling; Protein-protein interactions: Surfaceomes and Secretomes, Solid phase ELISA, pull-down assays (using GST-tagged protein) tandem affinity purification, far western analysis, by surface plasma resonance technique; Yeast two hybrid system, Phage display, Protein interaction maps, Protein arrays-definition; applications- diagnostics, expression profiling.

UNIT-3: Metabolomics (16h)

Introduction and overview of metabolites, sample collection and processing, Non tracer and tracer (radio labelled)-based techniques in metabolomics (HPLC, NMR, LC-MS and GC-MS); Metabolome data processingderived by various techniques, analysis of databases (Metabolite , Meta Cyc, MMCD etc), Analysis tools, Metabolic pathways and network analysis;Metabolic flux analysis (TCA, Amino acids, fatty acids, intermediary metabolites), Stoichiometric metabolic flux analysis, 13C metabolic flux analysis (MFA), Metabolic control analysis (MCA); Applications of metabolomics; Integration of metabolomics data sets with other data (e.g. Transcriptomics, enzyme activity, etc.).

UNIT-4: Biostatistics (16h)

Principles of Biostatistics: Scope of Statistical methods in scientific studies: Population, Sample, variable, parameter, primary and secondary data, screening and representation of data. Frequency distribution, tabulation, bar diagram, histograms, per diagram, and cumulative frequency curves. Measures of central tendency-Mean, median, mode, quartiles and percentiles. Measures of Variability-Range, mean deviation, Analysis of variance, standard deviation and coefficient of variation. Testing of hypothesis: basic concepts and definitions, types of Errors. Tests based on Normal T, F-Test, Chi-square. Probability: types of event, sample space, Definition, conditional probability, addition andmultiplication rules of probability and some simple problems.

Probability distributions Binomial, Poisson and Normal distributions and a few simple problems. Statistical package-Features of statistical software, SPSS and R.

SPT 3.3 B Environmental Biotechnology

Course Objectives -The objective of this course is to teach basic principles and characteristics of biochemical technology in environmental studies particularly water and wastewater treatment technologies. Also, knowledge on sustainable role of microbes in Environment, Bioremediation and Metagenomics will also be imparted.

Student Learning Outcomes- On completion of this course, students should be able to learn-basic principles and characteristics of biochemical technology in Water and Wastewater treatment; they will also know about *in situ* and *ex situ Bioremediation* along with recent advances in techniques for studying uncultrable microbial communities.

Unit I: Environmental Interactions and Biodiversity (16h)

Introduction to environment; pollution and its control; pollution indicators; waste management; domestic, industrial, solid and hazardous wastes; strain improvement; Biodiversity and its conservation; Role of microorganisms in geochemical cycles; microbial energy metabolism, microbial growth kinetics and elementary chemostat theory, relevant microbiological processes, microbial ecology, Host-pathogen interaction, ecological impact of microbes; symbiosis (Nitrogen fixation and ruminant symbiosis); microbes and nutrient cycles; microbial communication system; bacterial quorum sensing; microbial fuel cells; prebiotics and probiotics.

Unit II: Environmental Remediation (16h)

Bioremediation; Fundamentals, methods and strategies of application (bio stimulation, bioaugmentation)-examples, bioremediation of metals (Cr, As, Se, Hg), radionuclides (U, Te), organic pollutants (PAHs, PCBs, Pesticides, TNT etc.), technological aspects of bioremediation (in situ, ex situ). Role of microorganisms in bioremediation; Application of bacteria and fungi in bioremediation; White rot fungi vs specialized degrading bacteria; examples, uses and advantages vs disadvantages; phytoremediation; Fundamentals and description of major methods of application (phytoaccumulation, phytovolatilization, rhizofiltration, Phyto stabilization).

Unit III: Biofuels and Biopolymers (16h)

Environmental Biotechnology and biofuels; biogas; bioethanol (2G, 3G and 4G) ; biodiesel; biohydrogen; Description of the industrial processes involved, microorganisms and biotechnological interventions for optimization of production; Microbiologically enhanced oil recovery (MEOR): Bioleaching of metals; Production of bioplastics: Production of biosurfactants; bio emulsifiers; paper production; use of xylanases and white rot fungi.

Unit IV: Waste Management and Meta-Technologies (16h)

Basic aspects of solid waste management; Current practices in India; Aerobic and anaerobic treatments of solid wastes; Composting; Vermiculture; Comparison of aerobic and anaerobic methods. Water Treatment processes and advances in technologies. Prevention and reduction of hazardous waste, Origin, sources and treatment strategies for polychlorinated biphenyls, pesticides, toxic pollutants, polymers, Textile chemical residues etc., Hydrocarbon degradation. Metagenomics: Metagenomics and metatranscriptomics – their potential, methods to study and applications/use (animal and plant health, environmental clean- up, global nutrient cycles & global sustainability, understanding evolution), Global metagenomics initiative - surveys/projects and outcome, metagenomic library construction and functional screening in suitable hosts – tools and techniques for discovery/identification of novel enzymes, drugs (e.g., protease, antibiotic).

OEPT-3.4 BIOTECHNOLOGY FOR HUMAN WELFARE

Course Objectives -The objective of this course is to apprise the non-core students who have opted for Biotechnology as an elective about the applications of Biotechnological techniques for sustainable human welfare.

Student Learning Outcomes- On completion of this course, students will be able to learn-about application of industrially important organisms, Diagnostic techniques , fermentation technology, Nano technology and biocontrol agents.

UNIT I: Disease Diagnosis and Vaccines (16h)

Introduction to vaccines, types, RNA and DNA vaccines, Edible vaccines, Immunology of vaccines and vaccination, production and formulation of vaccines. Immunization- Active and passive immunization, Viral vaccines and its production. Tools for disease diagnosis- ELISA and Western blot, Immunoassay, Biosensors and biochips, Molecular diagnostics for detection of tumor.

UNIT II: Fermentation Technology (16h)

Industrially important microorganisms, Isolation, screening and maintenance of industrially important microbes, strain improvement, Microbial enzymes and their role in various industrial processes and their preservation. Concepts of fermentation processes, Bioreactors- Types of bioreactors: Continuously stirred tank flow reactors, Loop reactors, air lift reactors, fed batch reactors and fluidized bed reactors, rotatory disc reactors. Fermentation- Concept of Batch and Fed batch process, continuous process, liquid and solid-state fermentations.

UNIT III: Industrial Biotechnology (16h)

Downstream processing: Separation of insoluble products – separation of cells and foam: filtration centrifugation sedimentation, flocculation; cell disruption, separation of soluble

products: liquid-liquid extraction, precipitation, chromatographic techniques, reverse osmosis, ultra and micro filtration, electrophoresis; final purification: drying; crystallizationproduction of vitamins, production of industrial ethanol, Secondary metabolites, antibiotics, single cell protein,. Fermented foods and beverages.

UNIT IV: Agriculture and Nano-Biotechnology (16h)

Application of genetic engineering in agriculture, Genetically modified crops-*Bacillus thuringiensis: cotton and brinjal*, Biocontrol agents, Biofertilizer- Bacterial biofertilizers, algal biofertilizers, Aquatic ferns as biofertilizers, Fungi as biofertilizers, biopesticides, Integrated pest management. Nano particles in agriculture, Nanotechnology in Biomedical and Pharmaceutical Industry.

IV SEMESTER

CPT 4.1 BIOPROCESS TECHNOLOGY AND FOOD BIOTECHNOLOGY

Course Objectives- The objective of this course is to educate students about the fundamental concepts of bioprocess technology and its related applications, thus preparing them to meet the challenges of the new and emerging areas of biotechnology industry.

Student Learning Outcomes-At the course the end of students will be able to: • appreciate relevance of microorganisms from industrial context; • carry out stoichiometric calculations and specify models of their growth; • give an account of design and operations of various fermenters; • present unit operations together with the fundamental principles for basic methods in production technique for bio-based products •Give an account of important microbial/enzymatic industrial processes in food and fuel industry and downstream processing .

UNIT I: Microbial Growth and Kinetics (16h)

Isolation, screening and maintenance of industrially important microbes; microbial growth and death kinetics (an example from each group, particularly with reference to industrially useful microorganisms); strain improvement for increased yield and other desirable characteristics Stoichiometry and models of microbial growth.Elemental balance equations; metabolic coupling – ATP and NAD+; yield coefficients; unstructured models of microbial growth; structured models of microbial growth.

UNIT II: Bioreactor Design & Fermentation Processes (16h)

Concepts of basic mode of fermentation processes Bioreactor designs; Types of fermentation and

fermenters; Concepts of basic modes of fermentation - Batch, fed batch and continuous; Conventional fermentation v/s biotransformation; Solid substrate, surface and submerged fermentation; Fermentation economics; Fermentation media; Fermenter design- mechanically agitated; Pneumatic and hydrodynamic fermenters; Large scale animal and plant cell cultivation. Upstream processing: Measurement and control of bioprocess parameters; Scale up and scale down process.

UNIT III: Down Stream Processing (16h)

Screening and design purification strategies: Separation of insoluble products – separation of cells and foam; filtration (plate filters, rotary vacuum filter), centrifugation (continuous, basket and bowl centrifuge, sedimentation, flocculation; cell disruption (mechanical and non-mechanical methods); separation of soluble products: liquid-liquid extraction, precipitation, chromatographic techniques, reverse osmosis, ultra and micro filtration, electrophoresis; final purification: drying (spray, drum, freeze driers); crystallization; Aqueous two phase partitioning systems, A platform for isolation of process related impurities from therapeutic proteins, Simultaneous purification refolding of protein by affinity precipitation and macro (Affinity ligand)-facilitated three-phase partitioning (MLFTPP), Co-expression and co-purification of antigen-antibody complexes in bacterial cytoplasm and periplasm, immunoglobulin purification by caprylic acid; Filtration, chromatography (comparison), rationale of choosing between quality and cost of different products. Introduction, initial recovery of proteins, removal of whole cells and cell debris, concentration and primary purification, protein inactivation and stabilization, protein characterization, storage and packaging.

UNIT IV: Food Biotechnology (16h)

Principles of food processing and preservation:Processing and preservation by heat (blanching, pasteurization, sterilization, ultra high temperature, canning, baking, roasting and frying); low temperature (chilling and freezing); drying, concentration and evaporation; non-thermal methods (irradiation, high pressure); hurdle technology.Application of enzymes (amylases, proteases, cellulases, pectinases, anthocyanases, oxidases) in food processing. Food fermentations, pickling, smoking; food additives: types and functions, permissible limits and safety aspects.Different methods of food packaging-food parks. Role of biotechnology in fermented food products. Starter culture and process development, functional foods. Enzymatic processing of fruit juices, baking, meat and its products. New technologies for food borne pathogen detection . Nutraceuticals and nutrigenomics.

CPT 4.2: RESEARCH METHODOLOGY, SCIENTIFIC COMMUNICATION SKILLS AND BIOENTREPRENEUR SHIP

Course Objectives- The objective of this course is to give an emphasis on methodologies used to do research use framework of these methodologies for understanding effective lab practices and scientific communication and appreciate scientific ethics.

Student Learning Outcomes-At the end of the course students will be able to: • Understand the methodologies of scientific research and applying the same to publish papers; • Understand and practice scientific reading, writing and presentations; • Appreciate scientific ethics through case studies.

Unit I: Research Writing (16h)

Empirical science; scientific method; manipulative experiments and controls; deductiveand inductive reasoning; descriptive science; reductionist vs holistic biology; researchmethods vs methodology; types of research, data collection and analysis; researchethics and IPR; preparation of a research; choosing a mentor; lab and researchquestion; research problem; literature review; hypothesis, gaps in research; researchreports; publication of research. Research metrics: h-index, citation index, i10 index. Research Databases and Researcher identifier tools

Unit II: Scientific Communication (16h)

Technical writing skills - types of reports; layout of a formal report; scientific writing skills-importance of communicating science; problems while writing a scientific document;plagiarism, software for plagiarism; scientific publication writing: elements of a scientificpaper including abstract, introduction, materials & methods, results, discussion,references; drafting titles and framing abstracts; publishing scientific papers – peerreview process and problems, recent developments such as open access and nonblindreview; plagiarism; characteristics of effective technical communication; scientificpresentations; ethical issues; scientific misconduct.

Unit III: Innovation and Entrepreneurship in Bio-Business (16h)

Introduction and scope in Bio-entrepreneurship, Types of bio-industries and competitivedynamics between the sub-industries of the bio-sector (e.g. pharmaceuticals vs.Industrial biotech), Strategy and operations of bio-sector firms: Factors shapingopportunities for innovation and entrepreneurship in bio-sectors, and the businessimplications of those opportunities, Alternatives faced by emerging bio-firms and therelevant tools for strategic decision, Entrepreneurship development programs of publicand private agencies (MSME, DBT, BIRAC, Make In India), strategic dimensions ofpatenting & amplifies, commercialization strategies. Star-ups in Biotechnology and startup ecosystem of the country and the globe. Case studies and Indian Startup policy.

Unit IV: Bio Markets and Technology Management (16h)

Negotiating the road from lab to the market (strategies and processes of negotiationwith financiers, government and regulatory authorities), Pricing strategy, Challenges inmarketing in bio business (market conditions & segments; developing distributionchannels, the nature, analysis and management of customer needs), Basic contractprinciples, different types of agreement and contract terms typically found in jointventure and development agreements, Dispute resolution skills.

SPT 4.3 A: Bioresource Biotechnology

Course Objectives: This course has been designed to acquaint students with plant bioresources, their traditional and non-traditional uses, current status and recent developments in value addition and future prospects. Since the dawn of civilization, humankind realized importance of animals, domesticated them and utilized their services in one way or the other.

Student Learning Outcomes: At the course the end of students will be able to: Identify different microbial, plant & animal bioresources; Understand the importance of the plant & animal bioresources; Apply knowledge gained here for development of innovative product and solutions.

UNIT-I: Plant Bioresources I (16h)

Food supplements: *Solanum tuberosum, Ipomoea batatas, Agaricus bisporus* and *Hippophae rhamnoides* (distribution, classification, parts used and method of use, nutritive value); spices and condiments: *Crocus sativus, Piper nigrum, Zingiber officinale* and *Apium graveolens* (distribution, classification, parts used and method of use). Sources of beverages: non-alcoholic: *Camellia sinensis* (tea) and *Coffea arabica* (coffee); alcoholic: *Vitis vinifera* (grapes) (distribution, classification, parts used and method of use). Fodders, fibres, timbers: Fodders: *Avena byzantina, Grewiaoptiva and Morus alba* (distribution, classification and method of use); Fibers: *Gossypium* spp., *Chorchorus capsularis, Cocos nucifera.* (distribution, classification, part used and durability); Timbers: *Pinus roxburghii, Tectona grandis* and *Dalbergia sissoo* (distribution, classification, wood structure and properties), non-timber forest products (bamboos and canes); Dye yielding plants: Definition; history and sources of natural dyes, commonly used dye plants: *Bixaorellana, Butea monosperma, Lawsonia inermis* and *Indigofera tinctoria*; less used colouring matter: balsam, marigold, and pomegranate (distribution, part used and commercial importance); Biofuels: Waste to wealth.

UNIT-II: Plant Bioresources II (16h)

Medicines: antioxidants (*Ginkgo biloba, Camellia sinensis, Hippophae rhamnoides*); adaptogens (*Eleutherococcus senticosus, Cordyceps sinensis*); anodynes (*Atropa belladona, Zingiber officinale*); laxatives (*Aloe vera* and *Plantago ovata);* nervines (*Melissa officinalis, Aven*

sativa); aromatic oils (*Thymus serpyllum* and *Lavandula angustifolia);* immunostimulants (*Eupatorium perfoliatum, Acanthopanax centicosus*); anti-cancerous (*Taxus wallichiana, Podophyllum hexandrum*) ; anti-malarial (*Artemisia annua*) (distribution, classification, part used and method of use, and medicinal value); Biosweeteners (*Stevia rebaudiana* and *Glycyrrhiza glabra*); bio-flavors (*Vanilla planifolida* and *Fragaria virginiana*); bio-alginates (*Laminaria hyperboria, Ascophyllumnodusum*); bio-gums (*Caesalpina spinosa, Trigonellafoenum-graecum*) (distribution, classification, part used and method of use, and efficacy); Bio-cosmetics (*Aloe vera, Crocus sativus and Santalum album*); bio-preservatives (vinegar, sugar) (distribution, classification, part used and method of use; efficacy); Current scenario and recent advancements in pharmaceutical and cosmoceutical industries.

UNIT-III: Microbial Bioresources (16h)

Principle, methods and applications of extraction methods for obtaining useful metabolites from plants and microbes. Solvent extraction principle and methods; Super critical CO2 extraction principle and applications. Host-pathogen interaction, ecological impacts of microbes; symbiosis (Nitrogen fixation and ruminant symbiosis); microbes and nutrient cycles; microbial communication system; bacterial quorum sensing; microbial fuel cells; prebiotics and probiotics.

UNIT-IV: Animal Bioresource (16h)

Sea food: value addition and export, nutritionally important Marine Product Export; Meat, leather and wool industries and their production with special emphasis on their export potential; poultry farming (chicken, duck and quail); commercial poultry breeds in India, poultry diseases; egg industry - present status in India; Dairy farming in India: breeds of cattle and buffalo, milk production and pasteurization techniques; Animal waste recycling: biogas and its production, types of biogas plants; slaughter house wastes and their utilization; fish byproducts; fish meal methods of processing and uses.

SPT 4.3 B NANOBIOTECHNOLOGY

Course Objectives- The course aims at providing general and broad introduction to multi-disciplinary field of nanotechnology. It will familiarize students with combination of top-down approach of microelectronics and micromechanics along with a bottom-up approach of chemistry/biochemistry; The course will also give an insight into complete systems where nanotechnology can be used to improve everyday life.

Student Learning Outcomes- On successful completion of this course, students will be able to describe basic science behind the properties of materials at the nanometer scale, and the principles behind advanced experimental and analytical techniques for studying nanomaterials.

Unit-I: Introduction to Nanoparticles (16h)

Introduction, history and concepts of Nanotechnology and nano biotechnology. Classification of nano materials, Properties of nano materials – Physical, chemical and Biological Properties, Synthesis of Nano materials: Physical, Chemical and Biological methods,

Unit-II: Characterisation of Nanoparticles (16h)

Characterization of nano materials and its significance: X-ray diffraction (XRD), UV-Visible spectroscopy (UV-Vis), Fourier Transform Spectroscopy (FT-IR), Dynamic Light Scattering (DLS), Photoluminescence (PL), Energy Dispersive X-Ray Analysis (EDX), Gas Sorption for Surface Area Analysis (BET), Nano Scan SMPS, Scanning Electron Microscopy (SEM) and Transmission Electron Microscopy (TEM).

Unit- III: Applications I: Clinical and Medical (16h)

Concept of nano medicines, Rational for designing of nano medicines, Materials for preparation of nano medicines, Different structures of nanomedicines. Preclinical and clinical considerations of nano medicines, Overview of current clinical nano medicines, Regulations of nano medicines for human health. Applications in Medicine. Nano carriers for gene delivery: Challenges in gene delivery, basic concept, design of nanotechnology-based systems for gene delivery, non-viral vectors, formulation strategies, and applications in delivery of genes for different diseases.

Unit-IV: Applications II: Diagnostics (16h)

Nano particles in agricultural and food diagnostics: Enzyme Biosensors and Diagnostics - DNA-Based Biosensors and Diagnostics Radiofrequency Identification and Integrated Nano sensor Networks: Detection and Response- Lateral Flow (Immuno)assay - Nucleic Acid Lateral Flow (Immuno)assay - Flow-Through (Immuno)assays - Antibody Microarrays Surface Plasmon Resonance Spectroscopy.

CPPD 4.4 Core Paper Project Dissertation

Course Objectives- Objective of the course is to provide students with a platform to conduct a short hypothesis based research project.

Student Learning Outcomes- On successful completion of this course, students will be able to understand nuances of; research writing, sampling and data collection, writing an hypothesis and gaps in research, drawing up appropriate protocols, analytical instrumentation, statistical analysis, writing meaning full inferences, plagiarism free manuscripts and submission research articles.

SKILL BASED VALUE ADDED CERTIFICATE PROGRAMME (Non-Credit)
(Conducted in Association with Industry Partners)

INTELLECTUAL PROPERTY AND PATENTING: II SEMESTER

Preamble

Intellectual Property Rights (IPR) is essential for better identification, planning, commercialization, rendering, and thus the preservation of inventions or creativity. IPR is a strong tool, to protect the investment, time, money, and effort invested by the inventor/creator of the IP, as it gives the inventor/creator an exclusive right for a certain period of time for the use of its invention/creation. Thus, IPR affects the economic development of a country by promoting healthy competition and encouraging industrial growth and economic growth.

This value-added course is aimed for introducing fundamentals of Intellectual Property Rights (IPRs) to appreciate IPRs and its impact on innovation, trade, commerce and societal dynamics. This course also helps in sensitizing and igniting minds of students towards the fundamentals of IPRs and appreciate its presence in daily lives.

Objective of the Course

After completion of the course:

1. It is expected that these students will be able to appreciate the uniqueness of the regional products and ways and means to protect and promote them using IPR tools.
2. They will be able to connect with the inventiveness in the commercialized products and processes having IPR protection.
3. Understand the processes of patenting and IP in the national and international platforms.

Duration: Duration: 80 hrs (4 Weeks@ 10 hours/week)

1. **Overview of Intellectual Property**
    a. Introduction and the need for intellectual property right (IPR)
    b. Kinds of Intellectual Property Rights:
        i. Patent
        ii. Copyright
        iii. Trade Mark
        iv. Design
        v. Geographical Indication
        vi. Plant Varieties
        vii. Layout Design
        viii. Genetic Resources and Traditional Knowledge
        ix. Trade Secret
    c. Major International Instruments concerning Intellectual Property Rights:

i. Paris Convention, 1883,
ii. The Berne Convention, 1886,
iii. The Universal Copyright Convention, 1952,
iv. The WIPO Convention, 1967,
v. The Patent Co-operation Treaty, 1970,
vi. The TRIPS Agreement, 1994.

2. Patenting

a. Elements of Patentability: Novelty , Non-Obviousness (Inventive Steps), Industrial Application;
b. Non - Patentable Subject Matter;
c. Registration Procedure;
d. Rights and Duties of Patentee;
e. Assignment and licence;
f. Restoration of lapsed Patents;
g. Surrender and Revocation of Patents,
h. Infringement, Remedies & Penalties

3. Patent Drafting ,laws and Case Studies

a. Patent application preparation
b. Fundamentals of claim drafting
c. Patent claim design
d. Drafting description, drawings, abstract
e. Filing patent applications: Prosecution and strategies
f. National/Regional Patent Laws of WIPO
g. WIPO Patent laws
h. Patent laws in India
i. United States patent law
j. Case studies

4: Biosafety, Policies, Laws and Bioethics

- 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 labeling – Food Safety and Standards Authority of India (FSSAI).
- 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, Agricultural biotechnology - Genetically engineered food, environmental risk, labeling and public opinion. Sharing benefits and protecting future generations - Protection of environment and biodiversity – biopiracy.

EVALUATION PATTERN

Grades

Grades to be awarded (O, A+, A, B+,B, C, P, F) based on following aspects;

1. **Attendance**- minimum 75% attendance to be required for awarding certificates
2. **Continuous assessment**
   a. Assessment at the end of the week -02(Patent application preparation)
   b. Assessment at the end of the week-04 (Identification of non-patentable subject matter)
   c. Assessment at the end of the week-06 (Patent claims design)
   d. Assessment at the end of the week-08(Case studies on patents of India, USA, Europe and WIPO)
   *All assessment to be based on submission of assignments.
3. **Assignments review: Marks for assignments: Max marks: 50**

1. Novelty + Innovation – 10
2. Plagiarism – 10
3. Clarity of thought process & organization of the assignment-10
4. Quality of the references used -10
5. Writing style, language & bibliography-10

Grades to be awarded

O - Outstanding: (Above 95%)
A+ - Excellent: (85-95% % of the allotted Marks)
A - Very Good: (80 -85 % of the allotted Marks)
B+ - Good: (70-80 % of the allotted Marks)
B- Above average (60- 70% of the allotted Marks)
C- Average (50-60% of the allotted Marks)
P- Pass(40-50% of the allotted Marks)
F- Fail (Below 40%)
*Average of 4 assignments for award of grades.

SKILL BASED VALUE ADDED CERTIFICATE PROGRAMME (Non-Credit)
(Conducted in Association with Industry Partners)

CLINICAL RESEARCH: III SEMESTER

Duration: 80 hrs

Preamble

Clinical Research involves scientific approach to establish the safety and effectiveness of specific health and medical products and practices. Clinical research is the study of health and illness in people and describes many different elements of scientific investigation. Clinical Research experiment designed to answer specific questions about possible new treatments or new ways of using existing (known) treatments. Clinical trials are part of a long and careful process to determine whether a new drugs or treatments are safe and effective for improved health outcomes. India is emerging as a global hub for clinical research. In view of above, a certificate program in Clinical Research will provide an essential platform to all students of DOSR in Biotechnology to have hands on experience in clinical research avenue to further opt for a career in clinical research. The present proposal will be an optional value added course and certification.

Objectives of the Course:

1. To promote a comprehensive understanding of the broad area of clinical research
2. To develop a theoretical understanding of the concept and correlating into relevant practice area.
3. To develop and perceive a rationale for the conduct of clinical research activities.
4. To acquire sufficient preparatory knowledge for more detailed studies in clinical research.

CLINICAL RESEARCH (III SEMESTER)

1. **Introduction to Clinical Research (20h)**

Clinical Trial–Indian and Global Perspective, Career in Clinical Research, Drug discovery and development process, Clinical trials: Types and Phases of Clinical Trial, Investigational New Drug Application, New Drug Application and Approval, post marketing surveillance. Ethics and Guidelines in Clinical Research: Regulation in clinical research, ICHGCP. Schedule Y, ICMR, Indian GCP .Stake holders Role and Responsibilities in Clinical Research: Sponsor, Investigator, Ethics committee, Sponsor–Vendor, Regulatory body. Contract Research Organization (CRO), Site management organizations (SMO).

2. **ClinicalTrialDesignandManagement (20h)**

Protocol and ClinicalTrialDesign, InformedConsent document and informed consent Form. Case Report Form, Investigator's Brochure (IB), Clinical Study report. EssentialdocumentsinClinicalResearchandRegulatory Requirements: Essentialdocuments before the study conduct, Essentialdocuments during the study conduct, Essentialdocuments after the study conduct.

3. StudySetupProcess and management (20h)

Site Selection– Selection of an Investigator and Site, Site Initiation, Subject Recruitment and study conduct, Site Contract and Budgeting, Monitoring, Site closure.

4. Quality Assurance, Compliance & Auditing in Clinical Research (20h)

Site Auditing, Sponsor Compliance and Auditing, SOP for Clinical Research. Clinical Monitoring: CRF Review & Source Data Verification, Drug Safety Reporting, Drug Accountability Work, Routine Site Monitoring, Site Close Out Visit, Data management and its components. Safety reporting: Adverse Event and Adverse drug reactions, serious adverse event, Case Narrative Writing. Personality development and communication skills

Grades

Grades to be awarded (O, A+, A, B+,B, C, P, F) based on following aspects;

1. **Attendance**- minimum 75% attendance to be required for awarding certificates
2. **Continuous assessment**
   a. Assessment at the end of the week -02 (Protocol writing)
   b. Assessment at the end of the week-04 (Informative content preparation)
   c. Assessment at the end of the week-06 (Drawing a clinical trial design)
   d. Assessment at the end of the week-08(Case narration on successful clinical trial)
   *All assessment to be based on submission of assignments.
3. **Assignments review: Marks for assignments: Max marks: 50**
   a. Novelty + Innovation – 10
   b. Plagiarism – 10
   c. Clarity of thought process & organization of the assignment-10
   d. Quality of the references used -10
   e. Writing style, language & bibliography-10

Grades to be awarded

O - Outstanding: (Above 95%)
A+ - Excellent: (85-95% % of the allotted Marks)
A - Very Good: (80 -85 % of the allotted Marks)
B+ - Good: (70-80 % of the allotted Marks)
B- Above average (60- 70% of the allotted Marks)
C- Average (50-60% of the allotted Marks)
P- Pass(40-50% of the allotted Marks)
F- Fail (Below 40%)
*Average of 4 assignments for award of grades

READING MATERIALS FOR CURICULLUM

CPT-1.1 CELL BIOLOGY AND MICROBIOLOGY

1. Alberts, B., Johnson, A., Lewis, J., Raff, M., Roberts, K., & Walter, P. (2008).
2. Molecular Biology of the Cell (5th Ed.). New York: Garland Science.
3. Lodish, H. F. (2016). Molecular Cell Biology (8th Ed.). New York: W.H. Freeman.
4. Krebs, J. E., Lewin, B., Kilpatrick, S. T., & Goldstein, E. S. (2014). Lewin's Genes XI. Burlington, MA: Jones & Bartlett Learning.
5. Cooper, G. M., &Hausman, R. E. (2013). The Cell: a Molecular Approach (6th Ed.). Washington: ASM; Sunderland.
6. Hardin, J., Bertoni, G., Kleinsmith, L. J., & Becker, W. M. (2012). Becker's World of the Cell. Boston (8th Ed.). Benjamin Cummings.
7. Watson, J. D. (2008). Molecular Biology of the Gene (5th ed.). Menlo Park, CA: Benjamin/Cummings.
8. Pelczar, M. J., Reid, R. D., & Chan, E. C. (2001). Microbiology (5th ed.). New York: McGraw-Hill.
9. Willey, J. M., Sherwood, L., Woolverton, C. J., Prescott, L. M., & Willey, J. M. (2011).
10. Prescott's Microbiology. New York: McGraw-Hill.
11. Matthai, W., Berg, C. Y., & Black, J. G. (2005). Microbiology, Principles and Explorations. Boston, MA: John Wiley & Sons

CPT 1.2: BIOCHEMISTRY & BIOPHYSICS

1. Stryer, L. (2015). Biochemistry. (8th ed.) New York: Freeman.
2. Lehninger, A. L. (2012). Principles of Biochemistry (6th ed.). New York, NY: Worth.
3. Voet, D., &Voet, J. G. (2016). Biochemistry (5th ed.). Hoboken, NJ: J. Wiley & Sons.
4. Dobson, C. M. (2003). Protein Folding and Misfolding. Nature, 426(6968), 884-890. doi:10.1038/nature02261.
5. Richards, F. M. (1991). The Protein Folding Problem. Scientific American, 264(1), 54-63. doi:10.1038/scientificamerican0191-54.
6. Baaquie, B. E. (2000). Laws of Physics: A Primer. Singapore: National University of Singapore.
7. Matthews, C. P., & Shearer, J. S. (1897). Problems and Questions in Physics. New York: Macmillan Company.
8. Halliday, D., Resnick, R., & Walker, J. (1993). Fundamentals of Physics. New York: Wiley

CPT-1.3: IMMUNOLOGY AND VACCINE TECHNOLOGY

1. Kindt, T. J., Goldsby, R. A., Osborne, B. A., &Kuby, J. (2006). Kuby Immunology. New York: W.H. Freeman.
2. Brostoff, J., Seaddin, J. K., Male, D., &Roitt, I. M. (2002). Clinical Immunology. London: Gower Medical Pub.

3. Murphy, K., Travers, P., Walport, M., &Janeway, C. (2012). Janeway's Immunobiology. New York: Garland Science.
4. Paul, W. E. (2012). Fundamental Immunology. New York: Raven Press.
5. Goding, J. W. (1996). Monoclonal Antibodies: Principles and Practice: Production and Application of Monoclonal Antibodies in Cell Biology, Biochemistry, and Immunology. London: Academic Press.
6. Parham, P. (2005). The Immune System. New York: Garland Science

SPT 1.4 A ENZYME TECHNOLOGY

1. Stanbury, P. F., & Whitaker, A. (2010). Principles of Fermentation Technology. Oxford: Pergamon Press
2. Fundamentals of Enzymology- Price and Stevens
3. El-Mansi, M., & Bryce, C. F. (2007). Fermentation Microbiology and Biotechnology. Boca Raton: CRC/Taylor & Francis.
4. Enzymes -Dixon and Webb
5. Isoenzymes By D. W. Moss
6. Immobilized Biocatalysts- W. Hartneir
7. Selected papers Allosteric Regulation -M. Tokushige
8. Enzymes: Biochemistry, Biotechnology and Clinical Chemistry, TrevorPalmer, (2004)
9. Principles and Applications in Engineering Series: Biotechnology for Biomedical
10. Engineers - Martin L.Yarmush, CRC Press, Boca Raton London NewYork Washington, D.C.

SPT 1.4 B TOXICOLOGY AND MOLECULAR FORENSICS

1. Barile FA (2008) principles of toxicology testing CRC Press is an imprint of the Taylor & Francis Group New York
2. Hodgson E (2004) A Textbook of Modern Toxicology Third edition John Wiley & Sons, Inc., publication
3. Curtis D. Klaassen (2001) Casarett and DPoisons Sixth Edition McGraw-Hill publishers New Delhi.
4. Osweiler GD (1996) Toxicology, Wiley-Blackwell Publisher
5. Marquardt H (1999) Toxicology, Academic Press.
6. DerelankoMJ (2002) Handbook of toxicology, CRC Press.

CPT 2.1 GENETICS AND MOLECULAR BIOLOGY

1. Alberts, B., Johnson, A., Lewis, J., Raff, M., Roberts, K., & Walter, P. (2008).
2. Molecular Biology of the Cell (5th Ed.). New York: Garland Science.
3. Lodish, H. F. (2016). Molecular Cell Biology (8th Ed.). New York: W.H. Freeman.
4. Krebs, J. E., Lewin, B., Kilpatrick, S. T., & Goldstein, E. S. (2014). Lewin's Genes XI. Burlington, MA: Jones & Bartlett Learning.
5. Cooper, G. M., &Hausman, R. E. (2013). The Cell: a Molecular Approach (6th Ed.).

Washington: ASM; Sunderland.
6. Hardin, J., Bertoni, G., Kleinsmith, L. J., & Becker, W. M. (2012). Becker's World of the Cell. Boston (8th Ed.). Benjamin Cummings.
7. Watson, J. D. (2008). Molecular Biology of the Gene (5th ed.). Menlo Park, CA: Benjamin/Cummings.
8. Hartl, D. L., & Jones, E. W. (1998). Genetics: Principles and Analysis. Sudbury, MA: Jones and Bartlett.
9. Pierce, B. A. (2005). Genetics: A Conceptual Approach. New York: W.H. Freeman.
10. Tamarin, R. H., & Leavitt, R. W. (1991). Principles of Genetics. Dubuque, IA: Wm. C. Brown.
11. Smith, J. M. (1998). Evolutionary Genetics. Oxford: Oxford University Press.

CPT-2.2 PLANT & AGRICULTURAL BIOTECHNOLOGY

1. Chawla, H. S. (2000). Introduction to Plant Biotechnology. Enfield, NH: Science.
2. Razdan, M. K. (2003). Introduction to Plant Tissue Culture. Enfield, NH: Science.
3. Slater, A., Scott, N. W., & Fowler, M. R. (2008). Plant Biotechnology: An Introduction to Genetic Engineering. Oxford: Oxford University Press.
4. Buchanan, B. B., Gruissem, W., & Jones, R. L. (2015). Biochemistry & Molecular Biology of Plants.Chichester, West Sussex: John Wiley & Sons.
5. Umesha, S. (2013). Plant Biotechnology. The Energy and Resources.
6. Glick, B. R., & Pasternak, J. J. (2010). Molecular Biotechnology: Principles and Applications of Recombinant DNA. Washington, D.C.: ASM Press.
7. Brown, T. A. (2006). Gene Cloning and DNA Analysis: An Introduction. Oxford: Blackwell Pub.
8. Primrose, S. B., &Twyman, R. M. (2006). Principles of Gene Manipulation and Genomics. Malden, MA: Blackwell Pub.
9. Slater, A., Scott, N. W., & Fowler, M. R. (2003). Plant Biotechnology: The Genetic Manipulation of Plants. Oxford: Oxford University Press.
10. Handbook of Agriculture (1987), ICAR Publication New Delhi.
11. Disease of crop plants in India –G.Rangaswamy and D.H. Bagyaraj 3rd Edition (1994), Prentice Hall of India Private Limited, New Delhi.
12. Plant Pathology –R.S. Mehrotra (1993) Tata McGraw Hill Publications Limited, New Delhi.
13. Microbial Biotechnology –Fundamentals of applied Microbiology. Glazer and Nikaido (1995) W.H. Freeman Publication company.
14. Biotechnology theory and techniques –Chirikjian. Veena, D.P.S. and Hons T (1984) Plant gene research, Springer Verlag, Heidelberg and New York.
15. Trevan, M.D. Boffey, S. Goulding, K.H. and Starberry P (1990) Biotechnology –the basic principles Tata McGraw Hill Edition.
16. Plant Pathology by Agrios. Powel C.L. and Bagyaraj, D.J. (1984) V.Mycorrhiza, CRD Press Florida.

17. Vincent J.M. (1982) Nitrogen fixation in legumes Cambridge University Press, London.
18. Stacey R.H. Evans H.J (1992) Biological Nitrogen fixation, Chapman and Hall Limited, London.

SPT 2.3A BIOINFORMATICS& MATHEMATICAL BIOLOGY

1. Lesk, A. M. (2002). Introduction to Bioinformatics. Oxford: Oxford University Press.
2. Mount, D. W. (2001). Bioinformatics: Sequence and Genome Analysis. Cold Spring Harbor, NY: Cold Spring Harbor Laboratory Press.
3. Baxevanis, A. D., & Ouellette, B. F. (2001). Bioinformatics: A Practical Guide to the Analysis of Genes and Proteins. New York: Wiley-Interscience.
4. Pevsner, J. (2015). Bioinformatics and Functional Genomics. Hoboken, NJ.: Wiley-Blackwell.
5. Bourne, P. E., &Gu, J. (2009). Structural Bioinformatics. Hoboken, NJ: Wiley-Liss. Lesk, A. M. (2004). Introduction to Protein Science: Architecture, Function, and GeStroud, K. A., & Booth, D. J. (2009).Foundation Mathematics. New York, NY: Palgrave Macmillan.
6. Aitken, M., Broadhursts, B., &Haldky, S. (2009) Mathematics for Biological Scientists. Garland Sciencenomics. Oxford: Oxford University Press

SPT-2.3 B PHARMACEUTICAL & MEDICAL BIOTECHNOLOGY

1. Krogsgaard-Larsen et al. Textbook of Drug Design and Discovery. 4th Edition. CRC Press.
2. Kuhse, H. (2010). Bioethics: An Anthology. Malden, MA: Blackwell.
3. Nally, J. D. (2006) GMP for Pharmaceuticals. 6th edition. CRC Press
4. Brody, T. (2016) Clinical Trials: Study Design, Endpoints and Biomarkers, Drug Safety, and FDA and ICH Guidelines.Academic Press.
5. KC Carroll, SA Morse, T Mietzner, S Miller. (2016) Jawetz, Melnick and Adelbergs's Medical Microbiology 27th edition, McGraw Hill.
6. J Owen, J Punt and Sharon Stranford, (2012), Kuby Immunology; 7th edition, W.H. Freeman and Co.
7. IT Kudva, NA. Cornick, PJ Plummer, Q Zhang, TL Nicholson, JP Bannantine and BH Bellaire. Virulence Mechanisms of Bacterial Pathogens, (2016) 5th edition, ASM Press.
8. V Kumar, AK. Abbas and JC Aster, (2015), Robbins &Cotran Pathologic Basis of Disease. 9th Edition, Elsevier.
9. K Murphy and K Weaver, (2016), Janeway'sImmunobiology, 9th Edition, Garland Science.
10. AK Abbas, (2015), Cellular and Molecular Immunology. 8th Edition, Elsevier.
11. Ananthanarayan and Paniker, Textbook of Microbiology, 8th Edition.
12. Baveja CP, (2001) Textbook of Microbiology. 5th Ed., Mcgraw Hill Education.

OEPT 2.4 INTRODUCTION TO BIOTECHNOLOGY

1. Das H.K. (2004), Textbook of Biotechnology, Willey Dreamtech. Pvt. Ltd, New Delhi.
2. Natesh S., Chopra V.L. and Ramachandran S. (1987), Biotechnology in Agriculture Oxford &IBH, New Delhi.*M.Sc., Biotechnology Syllabus (CBCS)* 22
3. Kumar H.D. (2004), A Text Book of Biotechnology, E astern Willey Press, New Delhi.
4. Tizard I.R. (2013) Immunology- An introduction, 5th Edition, Philadelphia Saunders College press.
5. Bhushan, Bharat (Ed.) 2012 Encyclopedia of Nanotechnology. Springer.
6. Bhushan, Bharat (Ed.) 2010 Handbook of Nanotechnology. Springer.
7. Gupta P.K. (2010), Biotechnology & Genomics, 5th Reprint, Rastogi Publications Meerut.
8. Singh B.D. (2010), Biotechnology, 4th edition, Kalyani Publication.
9. Black J.G (2008) Microbiology- Principles and Explorations, 7th edition, John Wiley & Sons.

CPT 3.1 GENETIC ENGINEERING

1. Old, R. W., Primrose, S. B., &Twyman, R. M. (2001). Principles of Gene Manipulation and Genomics, 7th Edition: Oxford: Blackwell Scientific Publications.
2. Green, M. R., &Sambrook, J. (2012). Molecular Cloning: A Laboratory Manual. Cold Spring Harbor, NY: Cold Spring Harbor Laboratory Press.
3. Brown, T. A. (2006). Genomes (3rd ed.). New York: Garland Science Pub.
4. Selected papers from scientific journals, particularly Nature & Science.
5. Technical Literature from Stratagene, Promega, Novagen, New England Biolabs
6. Maeder, M. L., &Gersbach, C. A. (2016). Genome-editing Technologies for Gene and Cell Therapy. Molecular Therapy. 24(3), 430-446. doi:10.1038/mt.2016.10.
7. Genome Editing Resource Library (Thermo Fisher)https://www.thermofisher.com/in/en/home/life-science/genome-editing/genome-editing-learning-center/genome-editing-resource-library.html
8. Cox, D. B., Platt, R. J., & Zhang, F. (2015). Therapeutic Genome Editing: Prospects and Challenges. Nature Medicine, 21(2), 121-131. doi:10.1038/nm.3793
9. Sander JD Joung JK. (2014) CRISPR-Cas Systems for Editing, Regulating and
10. Targeting Genomes. Nature Biotechnology 32, 347–355 doi:10.1038/nbt.2842
11. Doudna, J. A., &Charpentier, E. (2014). The New Frontier of Genome Engineering with CRISPR-Cas9. Science, 346(6213), 1258096-1258096.doi:10.1126/science.1258096.

CPT 3.2: ANIMAL AND REPRODUCTIVE BIOTECHNOLOGY

1. Gordon, I. (2005). Reproductive Techniques in Farm Animals. Oxford: CAB International.
2. Levine, M. M. (2004). New Generation Vaccines. New York: M. Dekker.

3. Pörtner, R. (2007). Animal Cell Biotechnology: Methods and Protocols. Totowa, NJ: Humana Press.
4. Glick, B. R., & Pasternak, J. J. (2010). Molecular Biotechnology: Principles and Applications of Recombinant DNA. Washington, D.C.: ASM Press.
5. Brown, T. A. (2006). Gene Cloning and DNA Analysis: an Introduction. Oxford: Blackwell Pub.
6. Primrose, S. B., &Twyman, R. M. (2006). Principles of Gene Manipulation and Genomics. Malden, MA: Blackwell Pub
7. Ball PJH & Peter AR. (2004). Reproduction in Cattle. Blackwell.
8. Gordon I. (2003). Laboratory Production of Cattle Embryos.CABI.
9. Gordon I. (2005). Reproductive Techniques in Farm Animals.CABI.

SPT 3.3A SYSTEM BIOLOGY AND BIOSTATISTICS

1. Brown TA (2006) Genomes, 3rd Edition, Garland Science
2. Campbell AM and Heyer LJ (2007) Discovering Genomics, Proteomics and Bioinformatics. Benjamin Cummings
3. Primrose S and Twyman R (2006) Principles of Gene Manipulation and Genomics, 7th Edition, Blackwell
4. Rehm H (2006) Protein Biochemistry and Proteomics, 4th Edition, Academic Press
5. Twyman RM. (2013) Principles of Proteomics Second Edition by Garland Science Taylor & Francis Group New York and London
6. Liebler DC (2002) Introduction to Proteomics: Tools for the New Biology, Humana Press, Totowa NJ. USA.
7. Griffiths WJ, Metabolomics, Metabonomics and Metabolite Profiling (The Royal Society of Chemistry UK) (2008) ISBN 978-0-85404-299-9
8. Teresa Whei-Mei Fan (Editor), Andrew M. Lane (Editor), Richard M. Higashi (Editor) (2012) The Handbook of Metabolomics. Springer ISBN 978-1-61779-618-0
9. Jaype Brothers, (2011), Methods in Biostatistics for Medical Students and Research Workers (English), 7th Edition
10. Norman T.J. Bailey, (1995), Statistical Methods in Biology, 3rd Edition, Cambridge University Press.
11. P. N. Arora and P. K. Malhan, (2006), Biostatistics, 2nd Edition, Himalaya Publishing House.
12. Jerold Zar, Biostatistical Analysis, 4th Edition. Pearson Education.
13. Biostatistics: A Foundation for Analysis in the Health Sciences, 7th Edition, Wiley.
14. ML Samuels, JA Witmer (2003) Statistics for the Life Sciences, 3rd edition. Prentice Hall

SPT 3.3 B Environmental Biotechnology

1. Bruce Rittman, Perry L. McCarty, (2000), Environmental Biotechnology: Principles and Applications, 2nd edition, McGraw-Hill.
2. Milton Wainwright, (1999), An Introduction to Environmental Biotechnology,

Kluwer Academic Publishers, Boston.Hardbound.
3. Martin Alexander, Biodegradation and Bioremediation, (1999), 2nd edition, Academic Press.
4. M.N.V. Prasad, KazimierzStrzalka, (2002), Physiology and Biochemistryof Metal Toxicity and Tolerance in Plants, Kluwer Academic Publishers, Dordrecht Hardbound.
5. Wastewater Engineering –Treatment, Disposal and Reuse. Metcalf and Eddy. Comprehensive Biotechnology Vol.4, M.Moo-Young.
6. Environmental Chemistry, A.K.De,
7. Introduction to Biodeterioration, D.Allsopp and K.J.Seal
8. Biotechnology and Patent protection, Beier, F.K., Crespi, R.S. and Straus, T., 1985. Oxford and IBH Publishing Co, New Delhi.
9. Intellectual Property rights on Biotechnology, Singh K, BCIL, New Delhi
10. Allsopp D. and K.J. Seal (1999) Introduction to Biodeterioration – ELBS/Edward Arnold.
11. Christson, J.Harst (1997) Manual of Environmental Microbiology, ASM Press, Washington. DC.
12. De, A.K. (1987) Environmental Chemistry –Wiley Eastern Limited, New Delhi
13. Foster C.F. John Ware D.A. Environmental Biotechnology, Ellis Horwood Limited.
14. Ericksson Ed. (1998) Biotechnology in the pulp and paper industry, Springer.
15. Geetha Bali et al eds (2001) Environmental Biotechnology, ApS Pub.
16. Jitendraprakash and LM Pierik, (1993) Plant Biotechnology: Commercial aspect and problems Oxford and IBH.
17. Hurst C.J. et al eds (1997) Environmental microbiology, ASM Press, Washington, D.C.
18. Larry Anderson and David A. Tilman (1977) Fuels from waste, Academic press.
19. Moo –Young M (Ed-in-Chief), Comprehensive Biotechnology, Vol. 4- Pergamon Press, Oxford.

OEPT 3.4 BIOTECHNOLOGY FOR HUMAN WELFARE

1. Gautam, N. C., Food Biotechnology in Comprehensive Biotechnology, Vol. 6., Shree Publishers, New Delhi, 2007
2. Gutierrez –Lopez, G. F. et. al., Food Science and Food Biotechnology.CRC Publishers. Washington, 2003
3. Maheshwari, D. K. et. al., Biotechnological applications ofmicroorganisms, IK. International, New Delhi, 2006
4. Stanbury, P. F. et. al., Principles of Fermentation Technology, 2nd Edition,Elsevier, UK. 1995.
5. Waites, M. J. et. al., Industrial Biotechnology: An Introduction, Blackwellpublishing UK, 2007.
6. Bisen P.S (1994) Frontiers in Microbial Technology, 1st Edition, CBS Publishers.
7. Glaser A.N and Nilaido.H (1995) Microbial Biotechnology, W.H Freeman and Co.

8. Prescott and Dunn (1987) Industrial Microbiology 4th Edition, CBS Publishers& Distributors.
9. Prescott and Dunn (2002) Industrial Microbiology, Agrobios (India) Publishers.

CPT 4.1 BIOPROCESS TECHNOLOGY AND FOOD BIOTECHNOLOGY

1. Shuler, M. L., &Kargi, F. (2002). Bioprocess Engineering: Basic Concepts.Upper Saddle River, NJ: Prentice Hall.
2. Stanbury, P. F., & Whitaker, A. (2010). Principles of Fermentation Technology. Oxford: Pergamon Press.
3. Blanch, H. W., & Clark, D. S. (1997). Biochemical Engineering. New York: M. Dekker.
4. Bailey, J. E., &Ollis, D. F. (1986). Biochemical Engineering Fundamentals. New York: McGraw-Hill
5. El-Mansi, M., & Bryce, C. F. (2007). Fermentation Microbiology and Biotechnology. Boca Raton: CRC/Taylor & Francis
6. M.T. Madigan and J.M. Martinko, (2006), Brock Biology of Microorganisms, 11th Ed, Pearson Prentice-Hall.
7. J. M. Willey, L. Sherwood, C.J. Woolverton, L.M. Prescott, (2011). Prescott'sMicrobiology, McGraw Hill, New York.
8. A.L. Demain and J. Davies, (2004), Manual of Industrial Microbiology and Biotechnology, 2nd Ed.ASM Press

CPT 4.2: RESEARCH METHODOLOGY, SCIENTIFIC COMMUNICATION SKILLS AND BIOENTREPRENEUR SHIP

1. Adams, D. J., & Sparrow, J. C. (2008). Enterprise for Life Scientists: Developing Innovation and Entrepreneurship in the Biosciences.Bloxham: Scion.
2. Shimasaki, C. D. (2014). Biotechnology Entrepreneurship: Starting, Managing, and Leading Biotech Companies. Amsterdam: Elsevier. Academic Press is an imprint of Elsevier.
3. Onetti, A., &Zucchella, A. Business Modeling for Life Science and Biotech Companies: Creating Value and Competitive Advantage with the Milestone Bridge. Routledge.
4. Jordan, J. F. (2014). Innovation, Commercialization, and Start-Ups in Life Sciences. London: CRC Press.
5. Desai, V. (2009). The Dynamics of Entrepreneurial Development and Management. New Delhi: Himalaya Pub. House.
6. Valiela, I. (2001). Doing Science: Design, Analysis, and Communication of Scientific Research. Oxford: Oxford University Press.
7. On Being a Scientist: A Guide to Responsible Conduct in Research. (2009). Washington, D.C.: National Academies Press.
8. Gopen, G. D., & Smith, J. A. The Science of Scientific Writing. American Scientist, 78 (Nov-Dec 1990), 550-558.

9. Mohan, K., & Singh, N. P. (2010). Speaking English Effectively. Delhi: Macmillan India.
10. Movie: Naturally Obsessed, The Making of a Scientist

SPT 4.3A: BIORESOURCE BIOTECHNOLOGY

1. Pelczar, M. J., Reid, R. D., & Chan, E. C. (1977). Microbiology (5th ed.). New York: McGraw-Hill.
2. Willey, J. M., Sherwood, L., Woolverton, C. J., Prescott, L. M., & Willey, J. M. (2011). Prescott's Microbiology. New York: McGraw-Hill.
3. Matthai, W., Berg, C. Y., & Black, J. G. (1999). Microbiology, Principles and Explorations. Boston, MA: John Wiley & Sons.
4. Bennett, B. C. Plant Domestication and the Origins of Agriculture. Encyclopedia of Life Support System (EOLSS) Online.
5. Ameenah Gurib-Fakim. (2014). Novel Plant Bioresources: Applications in Food, Medicine and Cosmetics. Wiley-Blackwell.
6. Timothy R. Tomlinson, Olayiwola Akerele (1998). Medicinal Plants: Their Role in Health and Biodiversity. University of Pennsylvania Press.
7. Khare, C. P. (2008). Indian Medicinal Plants: An Illustrated Dictionary. Springer Science & Business Media.
8. Trivedi, P. C. (2006). Medicinal Plants: Traditional Knowledge. IK International Pvt Ltd.
9. Das, S. K. (1959). Medicinal, Economic and Useful Plants of India- (Alphabetically arranged).
10. Blackwelder. E. Richard. (1996). Taxonomy: A Text and Reference Book, 3rd Edition, John Wiley and Sons INC.
11. Jabde V. Pradip. (2005). Text Book of Applied Zoology, 1st Edition, Discovery Publishing House, New Delhi.
12. Malhotra P. (2008). Economic Zoology, 5th Edition, Adhyayan Publishers, New Delhi.
13. Shukla G.S. and Upadhyay (2001). Economic Zoology, 4th Edition, Rastogi Publications. Meerut. Hickman, C. P., & Roberts, L. S. (2011). Animal Diversity (6th ed.). McGraw-Hill Education.
14. Helfman, G., Collett, U. B., & Facey, U. E. (2011). The Diversity of Fishes: Biology, Evolution and Ecology (2nd ed.). Wiley-Blackwell.

SPT 4.3 B: NANO BIOTECHNOLOGY

1. GeroDecher, Joseph B. Schlenoff, (2003); Multilayer Thin Films: Sequential Assembly of Nanocomposite Materials, Wiley-VCH Verlag GmbH & Co. KGaA
2. David S. Goodsell, (2004); Bionanotechnology: Lessons from Nature, Wiley-Liss
3. Neelina H. Malsch, Biomedical Nanotechnology, CRC Press
4. Greg T. Hermanson, (2013); Bioconjugate Techniques, (3rd Edition); Elsevier
5. Recent review papers in the area of Nanomedicine

EVALUATION RUBRICS		
THEORY INTERNAL ASSESSMENT -- 20Marks		
1. Continuous Theory Internal Assessment C1+ C2 (Descriptive -7)+ MCQ (3)		
EVALUATION PATTERN: O - Outstanding: (Above 95%) A^+ - Excellent: (85-95% % of the allotted Marks) A - Very Good: (80 -85 % of the allotted Marks) B^+ - Good: (70-80 % of the allotted Marks) B- Above average (60- 70% of the allotted Marks) C- Average (50-60% of the allotted Marks) P- Pass(40-50% of the allotted Marks) F- Fail (Below 40%)		**10 Marks**
2. Assignments (Biotechnology Perspective)		
• Latest developments in that field	1	**3 Marks**
• Sentence structure and flow	1	
• Comparison between the recent technology developments	1	
3. Seminars (Journal Club)		
• Concept communication	1	**3 Marks**
• PPT/Video visibility, clarity & organization	0.5	
• References	0.5	
• Time limit	0.5	
• Confidence in answering queries	0.5	
4. Write Up on Innovative Product Production		
• Concept understanding	1	**4 Marks**
• Technical/scientific supporting material		
• Objectives		
• Methodology: Experimental skills and/or mathematical skills/Analytical skills	1	
• Innovation Quotient	1	
• Reference	1	
• Importance/Significance		
• Grammar and Style		
PRACTICAL INTERNAL ASSESSMENT -- 10M		
1. Continuous Practical Internal Assessment C1		
EVALUATION PATTERN: Excellent: A (85-100 % of the allotted Marks)		

Very Good: B (70 -85 % of the allotted Marks) Good: C (55-70 % of the allotted Marks) Inadequate: D (< 55 % of the allotted Marks)		**05 Marks**
Do Your Own Experiment		
• Selection of the problem	**02**	**05 Marks**
• Hypothesis		
• Relevant Content		
• Demonstration	**02**	
• Reporting		
• References	**01**	
• Grammar/Spelling		
THEORY (INTERNALS AND SEMESTER END EXAMS) 80M		
EVALUATION PATTERN: **Answer in Brief- 2M×10q=20** **Short Answers – 6M×4q=24** **Essay Type- 12M×3q=36**		
Answer in Brief 2M		**2M×10q=20 Marks**
• Clear definition/description	**01**	
• Importance	**0.5**	
• Significance	**0.5**	
Short Answers- 6M		**6M×4q=24 Marks**
• Introduction	**01**	
• Description/classification/pathway/functions etc…	**02**	
• Diagrams/ Flow charts/tables/charts/representation/general account	**02**	
• Importance/Significance	**01**	
Essay Type—12M		**12M×3q=36 Marks**
• Introduction	**02**	
• Description/classification/pathway/functions etc…	**04**	
• Diagrams/ Flow charts/tables/charts/representation/general account	**04**	

• Importance/Significance	02		
PRACTICALS (SEMESTER END EXAMS) 40M			
PRACTICALS Major (12) and Minor (08) Experiments-20M			
	Major (12)	**Minor (08)**	
• Understanding of the Objective	01	02	12+8 Marks
• Principle of the experiment	04		
• Methods to be followed		03	
• Formula	04		
• Steps of Calculation		02	
• Result	02		
• Conclusion/Inference	01	01	
SPOTTERS --- 10 Marks			
• Correct Identification	01	02	
• Description			
• Significance/Importance	01		
RECORD SUBMISSION – 03 Marks		03	
• CONTENT PAGE			
• CERTIFICATE			
• DATES OF EXPERIMENTS			
• CONTENT & LEGIBILITY	01		
• DIAGRAMS /GRAPHS	01		
• PROPER REPRESENTATION OF RESULTS	01		
Case Study—02 Marks			
• Introduction of the of given case and significance	0.5	2.0	
• Body of the content and comparison with known and unknown scenario	0.5		
• Relevance to the content	0.5		
• Conclusion, Reference and recent updated & Supportive materials	0.5		
• Market Perspective			
PRACTICAL VIVA:			
• Knowledge about the topic			
• Depth in understanding	02	5.0 Marks	
• Comprehension	01		

• Clarity in answers • Relating case studies with practical's conducted	02	
GROUP PROJECT		
• Project value • Project innovation and implementation of their ideas • Group coordination and involvement in the activities	20 Marks	
• Plagiarism • Review of Literature • Introduction • Hypothesis • Gaps in Research	20 Marks	80 Marks
• Materials and Methods • Results and Discussion • Summary and Conclusion	30 Marks	
• Scientific Knowledge produced • Societal Impact • References • Grammar/ Spelling	10 Marks	
PROJECT VIVA- 40M		
• Introduction - Significance of topic, • objectives	10 Marks	40 Marks
• Review - succinct explanation, current reviews • Methodology -selection of experiments	10 Marks	
• Results & Discussion- clear and lucid presentation, organisation of data/ charts/ spectral data, highlight of key findings with suitable justification	15 Marks	
• Reference- Appropriate references	05 Marks	

THEORY QUESTION PAPER PATTERN

Max. Marks = 80 **Time: 03 hours**

1. **Answer in Brief (Answer any ten)** **2 X 10 = 20**

a.
b.
c.
d.
e.
f.
g.
h.
i.
j.
k.
l.

2. **Write short notes on the following (Answer any four)** **4x6=24**

a.
b.
c.
d.
e.
f.

3. **Essay type questions (Answer any three)** **3 x 12 = 36**

a.
b.
c.
d.
e.

Note: Equal Weightage should be given to all the units while setting the question paper

PRACTICAL QUESTION PAPER PATTERN

Max. Marks = 40 **Time: 03 hours**

1. Major Experiment: **12Marks**
2. Minor Experiment: **08 Marks**
3. Spotters (04): **10 Marks**
4. Records: **03 marks**
5. Case study: **02 marks**
6. Viva –Voce: **05 marks**