

**UNIVERSITY OF MUMBAI**



**Syllabus  
for  
Semesters III and IV**

**Program: M.Sc.  
Course: Life Sciences**

**Specialisation: Biotechnology**

(Credit Based Semester and Grading System with  
effect from the academic year 2013-2014)

**M.Sc. Life Sciences Syllabus**  
**Credit Based and Grading System**  
**To be implemented from the Academic year 2013-2014**

**SEMESTER III**

Course Code	UNIT	TOPIC HEADINGS	Credits	L / Week
PSLSCBT301	I	Biomathematics	4	
	II	Research Methodology		
	III	Biostatistics		
	IV	Population Biostatistics		

PSLSCBT302	I	History of Biotechnology	4	
	II	Microbial Biotechnology		
	III	Plant and Animal Biotechnology		
	IV	Protein Engineering and GMO detection methods		

PSLSCBT303	I	Process Biotechnology - Introduction	4	
	II	Upstream processing		
	III	Downstream Processing		
	IV	Measuring, Modelling and control		

PSLSCBT304	I	Microbial biotechnology in Industry	4	
	II	Biomass processing and bioenergy production		
	III	Biotransformations		
	IV	Products of Primary and Secondary Metabolism		

PSLSCBTP301	Biomathematics and Biostatistics	2	
PSLSCBTP302	Biotechnology and Genetic Engineering	2	
PSLSCBTP303	Dissertation on Literature Review	2	
PSLSCBTP304	Biotechnology in Industry	2	

**SEMESTER IV**

<b>Course Code</b>	<b>UNIT</b>	<b>TOPIC HEADINGS</b>	<b>Credits</b>	<b>L / Week</b>
<b>PSLSCBT401</b>	<b>I</b>	<b>Bioinformatics – I</b>	<b>4</b>	
	<b>II</b>	<b>Bioinformatics – II</b>		
	<b>III</b>	<b>Intellectual Property Rights</b>		
	<b>IV</b>	<b>Bioethics</b>		

<b>PSLSCBT402</b>	<b>I</b>	<b>Introduction and therapeutic bioproducts</b>	<b>4</b>	
	<b>II</b>	<b>Vaccines, antibodies, peptibodies</b>		
	<b>III</b>	<b>Gene therapy, Antisense therapy, Diagnostics and genetic testing</b>		
	<b>IV</b>	<b>Applied Medical Biotechnology</b>		

<b>PSLSCEBT403</b>	<b>I</b>	<b>Water Pollution Control</b>	<b>4</b>	
	<b>II</b>	<b>Metal pollution control and soil decontamination</b>		
	<b>III</b>	<b>Soil and gas waste treatment and bioconservation</b>		
	<b>IV</b>	<b>Agricultural Biotechnology</b>		

<b>PSLSCBT404</b>	<b>I</b>	<b>Special Processes and regulations and ethics</b>	<b>4</b>	
	<b>II</b>	<b>Bionanotechnology, biomimetics and drug delivery</b>		
	<b>III</b>	<b>Other applications</b>		
	<b>IV</b>	<b>Biotechnology – Biosafety assessment, legal, economics and ethical issues</b>		

<b>PSLSCBTP401</b>	<b>Bioinformatics</b>	<b>2</b>	
<b>PSLSCBTP402</b>	<b>Medical Biotechnology</b>	<b>2</b>	
<b>PSLSCBTP403</b>	<b>Environmental Biotechnology and Agricultural biotechnology</b>	<b>2</b>	
<b>PSLSCBTP404</b>	<b>Dissertation on Project</b>	<b>2</b>	

**M.Sc. Life Sciences Syllabus**  
**Credit Based and Grading System**  
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**SEMESTER III DETAILED SYLLABUS**

Course Code	Title	Credits
<b>PSLSCBT 301</b>	<b>Biomathematics / Research methodology / Biostatistics (60L)</b>	<b>4</b>
Unit I: <b>Biomathematics</b> <span style="float: right;"><b>(15L)</b></span> Binomial Theorem (without infinite series) Determinants, Matrices, Rank of Matrices by Diagonalisation method Limit and derivatives, Differentiation (including differentiability), Successive Differentiation, Integration – Definite and Indefinite (ordinary, method of substitution, special trigonometric function, partial fraction) Application of integration to find area, Differential equations --homogeneous and Linear ODE's and its simple applications to biological problems		
Unit II: <b>Research Methodology</b> <span style="float: right;"><b>(15L)</b></span> Meaning of Research, Objectives of research, motivation in research; Types of research – Descriptive, Analytical, Applied, Fundamental, Quantitative, Qualitative, Conceptual, Empirical and Other Types of Research; Research Approaches; Research Methods vs. Methodology; Research and Scientific Method; Research Process: Steps of research process; Criteria of Good Research; Sampling, Sample size determination, Plan for data collection, Methods of data collection, Plan for data processing and analysis; Ethical considerations during research		
Unit : III <b>Biostatistics</b> <span style="float: right;"><b>(15L)</b></span> <b>Basics:</b> Introduction, scope, applications and uses of statistics, census and sampling surveys, <b>Data, graphical presentation of data:</b> collection and tabulation and graphical representation of data, frequency distribution <b>Practice of statistical methods</b> in biological research, Measures of central tendency (grouped and ungrouped data), samples and populations; Central tendency measures: Arithmetic mean, median, dispersion and its measures: variance and standard deviation, coefficient of variation. Standard error, Confidence limits Skewness and kurtosis		

<p>Population parameters and sample statistics, sampling techniques: simple random sampling; stratified random sampling, systematic sampling, standard error estimation: point &amp; interval,  Estimators of population mean &amp; proportion (without proof), confidence intervals for population mean &amp; proportion.  Regression and correlation and its application in biology; types of correlation, correlation coefficient</p>	
<p>Unit : IV <b>Population Biostatistics</b> <span style="float: right;"><b>(15L)</b></span>  Concept of probability, Theories of Probability – additive and multiplicative theory  Random variable and its distribution, Probability distributions – Binomial, Poisson and Normal;  Tests of statistical significance,  <b>Testing of hypothesis:</b> Hypothesis and its types (Null hypothesis, Alternative hypothesis),  Errors and its types (Type 1 and Type 2 error),  Levels of significance, one-tailed and two-tailed tests, tests for single mean and single proportion, equality of the two population means and two population proportions , Critical region.  Difference between parametric and non-parametric statistics; confidence interval, critical region,  Levels of significance, t-test; Z-test; <math>\chi^2</math> test;  <b>Analysis of variance (ANOVA)</b>, one-way ANOVA, Tukey’s post hoc test, two-way ANOVA  Basic introduction to Muetrovariate statistics, etc.  Bivariate data, scatter diagram and interpretation, calculation and interpretation of Karl  Pearson’s correlation coefficient, equation of the lines of regression and properties of regression lines</p>	

**Practicals:**

<b>PSLSCBTP301</b>	<p><b><u>Biostatistics and Biomathematics</u></b> (60L)</p> <ol style="list-style-type: none"> <li>1. Mathematical sums to be solved in biomathematics and biostatistics</li> <li>2. Formation of frequency distribution and calculation of descriptive measures – mean, median, mode, variance, standard deviation and standard error</li> <li>3. Large n small sample tests for sample mean and proportion</li> <li>4. Calculation of correlation and regression, coefficients and tests of significance</li> <li>5. ANOVA – one way and two way classification; Estimation of genetic components and heritability from ANOVA data</li> </ol>	<b>2</b>	<b>04</b>
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<b>Course Code</b>	<b>Title</b>	<b>Credits</b>
<b>PSLSCBTT 302</b>	<b>Biotechnology and Genetic Engineering</b> (60L)	<b>4</b>
<p>Unit I: <b>History of Biotechnology</b> (15L)</p> <p><b>Biotechnology- old and modern concepts</b> – historical development, present development – fundamentals in biotechnology, agricultural biotechnology, medical biotechnology, Industrial biotechnology, environmental biotechnology and, social aspects, trends for future developments – medical, GM foods, solid and waste management, bioremediation, marine biotechnology, biotransformations, renewable process industry</p> <p><b>Biotechnology and human development</b> – Introduction, development of rural and urban societies – biotechnology and corporate world, health and survival, DNA technology, religion and ethics, social aspects of biotechnology – health, poverty, starvation, waste management and recycling: clean and green technologies, role of microbiology, future perspectives</p>		
<p>Unit II: <b>Microbial Biotechnology</b> (15L)</p> <p><b>Genetic engineering of Microorganisms:</b> Classification of microorganisms as per rDNA regulations, Principles of genetic engineering for E. coli, Gram Negative Bacteria, Gram positive bacteria, Yeast and filamentous fungi, Strategies of strain improvement – random and directed mutagenesis, directed evolution and in silico methods – engineering of synthetic pathways, gene targeting</p> <p><b>The Expression of Foreign DNA in Bacteria</b> – Introduction, Control of Gene Expression – Prokaryotes and Eukaryotes, The Expression of Eukaryotic Genes in Bacteria – Introns, Promoters, Ribosome Binding Site, Expression</p>		

<p>of Foreign DNA as Fusion Proteins, use of tags and cleavage, Expression of Native Proteins, Detecting Expression of Foreign Genes, Maximizing Expression of Foreign DNA - Optimizing Expression in <i>E. coli</i>, Alternative Host Organisms, Future Prospects</p> <p><b>Yeast Cloning and Biotechnology</b> – Introduction, Gene Manipulation in <i>S. cerevisiae</i> - Introducing DNA into Yeast, Yeast Selectable Markers and Vector Systems, commercially used yeast strains and their expression systems, Heterologous Protein Production - The Source of Heterologous DNA, The Level of Heterologous mRNA Present in the Cell, The Amount of Protein Produced and The Nature of the Required Product, Using Yeast to Analyse Genomes, Genes and Protein-Protein Interactions - YAC Technology, Gene Knockouts, Novel Reporter Systems, Future Prospects</p> <p><b>Filamentous fungi</b> –Host strains, transformation strategies, selection markers, promoters, terminators, translational regulation of protein production, strategies for efficient production, signal sequences, gene fusion approach, overproduction of foldases and chaperones, role of glycosylation, heterologous and homologous gene expression, humanization of yeast and filamentous fungi, applications - pharmaceutically important secondary metabolites, medicinal mushrooms as neoplastic agents, polysaccharides from basidiomycetes for immunostimulating and anticancerous activity</p> <p><b>Special microorganisms of biotechnological interest</b>- cyanobacteria, algae, microalgae and protozoa</p>	
<p>Unit : III <b>Plant and Animal Biotechnology</b> <span style="float: right;"><b>(15L)</b></span></p> <p><b>Genetic engineering of Plants:Plant cells</b></p> <p>Special features and organization of plant cells; Totipotency; Regeneration of plants; Plant products of industrial importance; Biochemistry of major metabolic pathways and products; Autotrophic and heterotrophic growth; Plant growth regulators and elicitors; Cell suspension culture development: methodology, kinetics of growth and production formation, nutrient optimization; Production of secondary metabolites by plant suspension cultures; Hairy root cultures and their cultivation.</p> <p><b>Transgenic Plants:</b></p> <p>Introduction, Applications of Molecular Biology to Speed up the Processes of Crop Improvement – Molecular maps of crop plants, Molecular Markers, Types of Molecular Markers, Marker-assisted Selection, Examples of Marker-assisted Selection, Molecular Diagnostics, DNA Fingerprinting, Variety Identification, DNA Microarrays, Bioinformatics; Transgenic Technologies - Agrobacterium-mediated Transformation, Selectable Marker and Reporter Genes and Particle Bombardment; Applications of Transgenic Technologies, Engineering Crop Resistance to Herbicides, Engineering Resistance to Pests and Diseases - Insect Resistance, Engineered Resistance to Plant Viruses, Resistance to Fungal Pathogens, Natural Resistance Genes, Resistance to Bacterial Pathogens, Resistance to Nematode Pathogens, Manipulating Male Sterility, Tolerance to Abiotic Stresses, Manipulating Quality - Prolonging Shelf Life,</p>	

<p>Nutritional and Technological Properties – Proteins, Oils, Manipulation of Starch and Fructans, Manipulation of Metabolic Partitioning, Production of Plant Polymers and BiodegradablePlastics, Plants as Bioreactors: Biopharming and Nutraceuticals - Edible Vaccines, Production of Antibodies in Plants and Plant Nutraceuticals, Plant Biotechnology in Forestry, Intellectual Property, Public Acceptance, Future Prospects</p> <p><b>Cloning Genes in Mammalian Cell-lines</b> – Introduction, Methods of DNA Transfection - Calcium Phosphate Co-precipitation, DEAE-Dextran, Electroporation, Protoplast Fusion, Lipofection, Polybrene-DMSO Treatment, Microinjection and Scrapefection, Requirements for Gene Expression:</p> <p>The DNA Component - Use of Vectors, Plasmid-based Vectors, Virus-based Vectors, Adenovirus Vectors, Retrovirus Vectors, Poxviral Vectors and Baculovirus Vectors, Some Considerations in Choice of Cell-line, Transient versus Stable Expression - Selection by Host Cell Defect Complementation, Dominant Selective Techniques and Amplifiable Selection Systems, Metabolism, regulation and nutritional requirements for mass cultivation of animal cell cultures; Kinetics of cell growth and product formation and effect of shear force; Product and substrate transport; Micro &amp; macro-carrier culture; Hybridoma technology; Live-stockimprovement; Cloning in animals; Genetic engineering in animal cell culture; Animal cell preservation</p> <p>Applications of gene targeting, Using Yeast to study Eukaryotic gene function, Therapeutic products produced by genetic engineering-blood proteins, human hormones, immune modulators and vaccines, transgenic animals, Production of proteins of Pharmaceutical value.</p> <p><b>Transgenic animals:</b></p> <p><b>Transgenesis</b> – Introduction, The Production of Transgenic Animals by Microinjection - Transgenic Mice, Transgenic Rats, Choice of Animal, Applications of Micro-injection Techniques to Other Animals and Animal Cloning, Embryo Stem Cell Technology, Homologous Recombination and Transgenesis, General Considerations - The Construct and Aberrant Expression, Design of the Transgenic Experiment - Investigating Gene Expression, Reduction of Gene Function, Cell Ablation, Conditional Gene Alteration - Inducible Gene Targeting Using the Cre-lox System and Tetracycline/Tamoxifen, Commercial Applications - Biopharmaceuticals in Transgenic Animals, Xenografts, Toxicological Applications and Immortomouse, Future Prospects, Transgenic drosophila: P-element and microinjection of new genes, Baculovirus system for heterologous gene transfer and expression</p>	
<p>Unit : IV <b>Protein Engineering and GMO detection methods</b> <b>(15L)</b></p> <p><b>Protein Engineering</b> – Introduction, Tools, Protein Structures - Sequence Identification, Sequence Determination and Modelling, Sequence Modification - Site-directed Mutagenesis Methods, Non-PCR Methods and PCR-based Methods, Molecular Evolution – modifying activity, substrate</p>	



<p>specificity, cofactor requirement, increasing stability, pH and temperature optima, <i>de novo</i> Sequence Design, Expression, Analysis and detection, applications, future perspectives</p> <p>Applications - Point Mutations: Betaseron/Betaferon (Interferon /3- 16), Humalog (Lispro Insulin) and Novel Vaccine Adjuvants, Domain Shuffling (Linking, Swapping and Deleting) Linking – Domain Fusions for Cell Targeting, Fused Cytokines and Fusions to Stabilize Dimeric Proteins; Swapping Protein Domains –Chimaeric Mouse-Human Antibodies and Polyketide Synthases (PKCSs); Deleting Domains, Whole Protein Shuffling, Protein-Ligand Interactions -Enzyme Modifications, Hormone Agonists and Substitution of Binding Specificities, <i>de novo</i> Design, future</p> <p><b>Detection and analysis of GMOs and GMO products:</b> modified gene copy number determination, detection of chromosomal changes, toxicological studies, residual DNA analysis, product analysis – microbial, biochemical and molecular, toxicological evaluation</p>	
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**Practicals:**

<b>PSLSCBT302</b>	<b>Biotechnology and Genetic Engineering (60L)</b>	<b>2</b>	<b>04</b>
	<ol style="list-style-type: none"> <li>1. Isolation of plasmid from Bacillus</li> <li>2. Bacillus transformation</li> <li>3. Chloroplast transformation</li> <li>4. Construction of amylase expression cassette and expression in E. coli</li> <li>5. Determination of amylase gene copy number</li> <li>6. Microbial analysis of GMO foods</li> <li>7. PCR mutagenesis of amylase gene to change temp optima</li> <li>8. Slide culture of filamentous fungi</li> <li>9. Preparation and regeneration of <i>T. reesei</i> protoplast</li> <li>10. Detection and estimation of gene copy number by Real Time PCR</li> <li>11. Determination of plasmid copy number</li> </ol>		

Course Code	Title	Credits
<b>PSLSCBT303</b>	<b>Industrial Biotechnology (60L)</b>	<b>4</b>
	<b>Unit I: Process Biotechnology – Introduction (15L)</b> <b>Overview:</b> Bioprocess technology for the production of cell biomass and primary/secondary metabolites, such as baker's yeast, ethanol, citric acid, amino acids, exo-polysaccharides, antibiotics and pigments etc.; Microbial production, purification and bioprocess application(s) of industrial	

<p>enzymes; Production and purification of recombinant proteins on a large scale; Chromatographic and membrane based bioseparation methods; Immobilization of enzymes and cells and their application for bioconversion processes.</p> <p><b>The microbial biochemistry concept</b> Isolation, identification and initial selection of microbial strains – culture preservation, stock culture maintenance, storage of culture and culture collection resources and services, modification of genetic structure to increase product formation, nutrition, optimal nutritional and physical requirements for growth – microbial nutrition, growth measurements, growth curve and optimization of nutritional and physicochemical factors, Process strategy –primary and secondary metabolites and bioconversions, biochemical engineering concept – identification of main products and substrates, stoichiometry of the process, kinetic and process rate, reactor design, product recovery, waste treatment</p> <p><b>Microbial cell cultivation systems</b> – Introduction, Batch cultivation system, continuous growth cultivation system, Fed-batch cultivation system, recycling cultivation system, inoculums cascading system, solid-state and solid-substrate cultivation system- principles, general features, microbial basis of processes, importance of inoculums, bioreactor design and application of SSC, Immobilized cells/enzyme systems – alginate, carrageenan, ion exchange resin, polyurethane foam, cell aggregation/flocculation, covalent coupling, passive immobilization, immobilized bioreactor design and biosensors</p>	
<p><b>Unit II: Upstream Processing</b> <span style="float: right;"><b>(15L)</b></span></p> <p><b>Fermentation Technology</b> – Introduction, Microbial Growth, Applications of Fermentation - Microbial Biomass, Microbial Metabolites, Microbial Enzymes, Transformation Processes, Recombinant Products, types – submerged and solid state, The Fermentation Process - The Mode of Operation of Fermentation Processes, The Genetic Improvement of Product Formation – Mutation, Recombination, Conclusions</p> <p><b>Bioreactors</b>- description and modeling, lab scale fermentation, large scale fermentation, cell culture bioreactors, Media for microbial fermentations, media for cell culture, media and air sterilization, oxygen transfer and mixing – scale up implications, in cell culture reactors, Strategies for fermentation with recombinant microorganisms, Anaerobic fermentations, fermentation monitoring and control, data analysis for design and control, design of aseptic aerated fermentors, biotransformations and enzyme reactors</p> <p><b>Bioprocess Engineering:</b> Kinetics of microbial growth, substrate utilization and product formation; Simple structured models; Sterilization of air and media; Batch, fed-batch and continuous processes; Aeration and agitation; Mass transfer in bioreactors; Rheology of fermentation fluids; Scale-up concepts; Design of fermentation media; Various types of microbial and enzyme reactors; Instrumentation in bioreactors.</p> <p><b>Immobilization of Biocatalysts</b> – Introduction, Biocatalysts: Enzymes –</p>	

<p>Specificity and Catalytic Power, Ribozymes, Abzymes, Multienzyme Complexes – PDC, Proteosome, Cellulosome and Multienzyme Complexes and Immobilization Technology, Cells: Animal Cells, Plant Cells and Microorganisms (Bacteria, Yeast and Filamentous Fungi), Biocatalyst Selection, Immobilization: Choice of Support Material- Next Generation of Support Material, Choice of Immobilization Procedure – Adsorption, Covalent Binding, Entrapment, Encapsulation, Cross-linking, Properties of Immobilized Biocatalysts – Stability and Catalytic Activity, Applications</p>	
<p><b>Unit : III Downstream processing (15L)</b>  <b>Protein Extraction and Purification</b> – Introduction, Cell Disruption: Enzymic Methods of Cell Disruption, Chemical Methods of Cell Lysis – Alkali and Detergents, Physical Methods of Cell Lysis - Osmotic Shock, Grinding with Abrasives, Solid Shear and Liquid Shear, Initial Purification - Debris Removal, Batch Centrifuges, Continuous-flow Centrifugation, Basket Centrifuges and Membrane Filtration, Aqueous Two-phase Separation, in vitro protein refolding, Precipitation - Ammonium Sulfate, Organic Solvents, High Molecular Weight Polymers and Heat Precipitation, Chromatography - Scale-up and Quality Management, Method Selection, Selection of Matrix, Gel Filtration, Ion Exchange Chromatography, Affinity Chromatography, Hydrophobic Interaction chromatography, High Performance Chromatographic Techniques, Perfusion Chromatography, Expanded Bed Adsorption, Membrane Chromatography, Maintenance of Column Packing Materials, Equipment for Large-scale Chromatography and Control and Automation, Ultrafiltration, electrokinetic separation of proteins, lyophilization and spray drying, Design of Proteins for Purification - Inclusion Bodies and Affinity Tags, Future Trends</p>	
<p><b>Unit : IV Measuring, Modeling and control (15L)</b>  <b>Measurements and control:</b> Common instruments in process analysis and control, Methods and Instruments in fermentation gas analysis, Biosensors, Characterization of Bioreactors, Determination of Cell Concentration, optimization of sampling, Cell Models, Stirred Tank Models, Tower Reactor Models, Process Models, Control of Bioreactor Systems, Automation, Control of Downstream Processing  <b>Process Validation and regulatory issues</b>  Analytical protein chemistry, biotechnology facility design and process validation, treatment of biological waste</p>	

**Practicals:**

<p>PSLSCBTP303</p>	<p><u>Dissertation in Literature Review</u> (60L)  1. Dissertation on Literature Review</p>	<p>2</p>	<p>04</p>
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Course Code	Title	Credits
PSLSCBT304	Biotechnology in Industry (60L)	4
<p>Unit I: <b>Microbial biotechnology in Industry</b> (15L)</p> <p><b>Application of enzymes in industrial processing</b>  Textile Processing, Leather Processing, Paper &amp; Pulp Processing, laundry, chiral synthesis of enantiomerically pure compounds, role of cellulases, hemicellulases, Lipases – pancreatic lipases and microbial lipases, proteases – serine proteases, metalloproteases, acid proteinases, laccases</p> <p><b>In Food biotechnology</b> – Role of Cellulases, hemicellulases Pectinases – pectin methyl esterases, pectin depolymerises, glucose oxidase, catalase, lysozyme, sulfhydryl oxidase, glucose isomerase, <math>\beta</math>-1, 4-galacturonidase in Baking, Fruit Processing, Cereal Extraction, Brewing, Grain Processing, Protein Processing &amp; Flavours, Dairy Processing, Extraction and clarification of fruit and vegetable juices, Infusion of pectinases and <math>\beta</math>-glucosidases to alter the sensory properties of fruits and vegetables Production of fruit nectars and purees, Extraction of olive oil, Improving the quality of bakery products, enzymes used in meat industry, dairy industry – enzyme from rennet and rennet substitutes, production of aroma and texture, enzymatic synthesis of aspartame, enzymes in starch processing and baking industry - syrup and sweetener, baking, glucose isomerisation,</p> <p><b>Food Fermentations</b> – Baked Goods, Cheese, Other, Fermented Dairy Products, Indigenous fermented foods, cocoa Fermentation, Vinegar, Olive Fermentations, Vegetable Fermentations, Use of Enzymes in Food Processing, Fermented Feeds, Fermented Feeds and Feed Products, Cellulases, hemicellulases and pectinases in beer and wine biotechnology – Brewing, Wine and Brandy</p> <p><b>Food Biopreservation</b> – Microbial Ecology of Spoilage and Pathogenic Flora Associated to Fruits and Vegetables, chemical preservatives and their safety concerns, biological methods- lactic acid bacteria, LAB bacteriocins, classification, characterization, biosynthesis, regulation of biosynthesis, immunity and mode of action, factors affecting its action, requirements and regulatory status of bacteriocins, applications in dairy, meat, vegetable and fish products, baking industry, fermentations, hurdle technology and application of LAB bacteriocin, endolysins – structure, mode of action and applications, bacteriophages - current bacteriophage based food applications, Tools for Safety Control: HACCP, Risk Assessment, Predictive Microbiology, and Challenge Tests</p>		
<p>Unit II: <b>Biomass processing and bioenergy production</b> (15L)</p> <p><b>Production and processing of microbial biomass for food, feed and nutrition</b> – Introduction, microorganisms – bacteria, yeast, fungi, algae, production of microbial biomass as nutritional protein source – pruteen</p>		

<p>process, baker's yeast production, fodder yeast production, Pekilo process, mushroom production, algal biomass production,</p> <p><b>Production of microbial biomass as enrichment for animal feed</b> – protein enriched starch, protein enriched whey, conversion of lignocelluloses into feed using cellulases and hemicellulases of white-rot fungi, role of phytases, Silage – ensiling process, silage - microflora, additives, quality, in tropical areas, from crop residues and by products, Composting – physical and chemical factors, microbiology, health risk from pathogens, odour sources</p> <p><b>Human Nutrition</b> - Nutraceuticals, dietary supplements, Introduction to nutraceuticals: definitions, basis of claims for a compound as a nutraceutical, regulatory issues for nutraceuticals, production of nutraceuticals like lycopene, isoflavonoids, prebiotics and probiotics, glucosamine, phytosterols. Formulation of functional foods containing nutraceuticals – stability and analytical issues, labelling issues</p> <p><b>Processing of simple polymer biomass (starch, sugar, oil, protein) from various agricultural crops</b> – Introduction , enzyme production, starch crops – grain, cassava, potato and sagopalm, sugar crop –sugarcane, fatty acid and oil containing crops –oil palm, fish processing industries</p> <p><b>Biorefinery – Processing of lignocellulosic biomass, human and animal waste with control of pathogens,</b> Community involvement and joint venture capital, Bio-refinery concept, Products from lignocellulosic biomass: Energy (energy and/or heat) – direct combustion, cofiring, cogeneration, gasification, Mushrooms, fertilizer through composting, animal feed through silage, Products from human, animal and residual agricultural biomass – energy (biogas) and fertilizer and food (fish and algae through aquaculture)</p> <p><b>Bioenergy production</b> – Introduction, biofuels from soils as electricity and heat – pretreatment of biomass, direct combustion, co-firing, gasification and small modular systems, biofuel in the form of gas – hydrogen and methane (biogas), biofuel in form of liquid – ethanol and diesel, biofuel from phytoplankton, bioelectrochemical fuel cells</p>	
<p>Unit : III <b>Biotransformations</b> <span style="float: right;"><b>(15L)</b></span></p> <p>Perspectives in Biotransformation, Biotransformations - Practical Aspects, <b>Hydrolases</b> -Biotransformations with Lipases, Esterases, Cleavage and Formation of Amide Bonds, Nitriles, Redox Enzymes, alkaloids, Yeast, Dehydrogenases - Characteristics, Design of Reaction Conditions, and Applications, Hydroxylation and Dihydroxylation, Flavin Monooxygenases - Uses as Catalysts for Baeyer-Villiger Ring Expansion and Heteroatom Oxidation</p> <p><b>Solid Waste Treatment, Carbon-Carbon Bond Formation, Addition, Elimination and Substitution Reactions</b> – Lyases, Halocompounds, Phosphorylation</p> <p><b>Enzymes in Carbohydrate Chemistry:</b> Formation of Glycosidic Linkages, Applications -Industrial Biotransformations, Regioselective Oxidation of Aminosorbitol with Gluconobacteroxydans, A Key Reaction in the</p>	

<p>Industrial Synthesis of 1-Deoxyojirimycin, Engineering Microbial Pathways for Amino Acid Production, Biotechnological Production of Natural Aroma Chemicals by Fermentation Processes, Synthetic Applications of Enzyme-Catalyzed Reactions, The Future of Biotransformations –catalytic antibodies, Synthetic Enzymes: Artificial Peptides in Stereoselective Synthesis</p>	
<p><b>Unit : IV Products of Primary and Secondary Metabolism (15L)</b></p> <p><b>Raw Materials and Raw Material Strategies</b> - Sugar-Based Raw Materials for Fermentation Applications, Starch-Based Raw Materials for Fermentation Applications, Raw Material Strategies - Economical Problems</p> <p><b>Products of Primary Metabolism</b> – Ethanol: Classical Methods, Ethanol - Potential Source of Energy and Chemical Products, Microbial Production of Glycerol and Other Polyols, Microbial Production of Acetone/Butanol/Isopropanol, Microbial Production of 2,3-Butanediol, Lactic Acid, Citric Acid, Gluconic Acid, Further Organic Acids, Acetic Acid, PHB and Other polyhydroxyalkanoic Acids, Technical Production and Use of Amino Acids, Enzymology of Amino Acid Production, Nucleotides and Related Compounds, Extracellular Polysaccharides – dextran, xanthan gum, alginate, approaches to improvement of microbial polysaccharides production, Biosurfactants</p> <p><b>Products of Secondary Metabolism</b></p> <p>General Aspects of Secondary Metabolism, Regulation of Bacterial Antibiotic Production, Screening of Novel Receptor-Active Compounds of Microbial Origin, Microbial Lipids, Microbial Siderophores, Advances in the Molecular Genetics of <math>\beta</math>-Lactam Antibiotic Biosynthesis, Peptide antibiotics, Lantibiotics, Glycopeptide Antibiotics, (Dalbaheptides), Aminoglycosides, Products from Basidiomycetes, Cyclosporins: recent developments in biosynthesis, pharmacology and biology and clinical applications, Secondary Products from Plant Cell Cultures, Biotechnical Drugs as Antitumor Agents, secondary products from filamentous fungi – antibacterials, Antivirals, Insecticidal, antihelmintic antibiotics, cholesterol inhibitors, anti-diabetic agents, anticancer, antitumor agents, other bioactive compounds,</p> <p><b>Production of Biochemicals</b>-production of vitamins, polyketidesynthesis, terpenoidflavor and fragrance compounds, degradable resins. Microencapsulation based cell therapy, Medicinal Mushrooms – production of mycelium (liquid culture), antitumor polysaccharides</p>	

**Practicals:**

<p><b>PSLSCBTP304</b></p>	<p><b>Biotechnology in Industry (60L)</b></p> <ol style="list-style-type: none"> <li>1. Fermentation of wheat bran/ cellulose/ birchwood xylan by Trichoderma</li> <li>2. Analysis of spent broth</li> <li>3. Purification and precipitation secreted proteins</li> </ol>	<p><b>2</b></p>	<p><b>04</b></p>
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	<p>from spent broth</p> <ol style="list-style-type: none"> <li>4. 2-D gel electrophoresis of precipitated protein</li> <li>5. Estimation of cellulase activity of cellulose degraders</li> <li>6. Estimation of cellulose/xylanase activity in broth and precipitated protein fraction</li> <li>7. Production of algal biomass</li> <li>8. Fermentation of lignocellulolytic biomass</li> <li>9. Detection of GMO food</li> <li>10. Microbial load of canned foods</li> <li>11. Analysis of preserved food stuff for presence of pathogens</li> <li>12. Detection of viable, non-viable and viable but non culturable cells by fluorescence microscopy in GMO products</li> </ol>		
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**SEMESTER IV DETAILED SYLLABUS**

Course Code	Title	Credits
<b>PSLSCBT401</b>	<b>Bioinformatics and IPR and Bioethics (60L)</b>	<b>4</b>
<p>Unit I: <b>Bioinformatics – I</b> <span style="float: right;"><b>(15L)</b></span></p> <p><b>Introduction to Bioinformatics:</b> Definition and History of Bioinformatics, Internet sources for Bioinformatics, Introduction to Data Mining, Bioinformatics Problems and data mining solutions</p> <p><b>Biological databases:</b> Introduction to variety of data sources. Population, sample, Classification and modeling of Data. Quality of data, Private and public data sources.</p> <p>Example Databases:</p> <p>(a) Nucleic acid databases (NCBI, DDBJ, and EMBL).</p> <p>(b) Protein databases (Primary, Composite, and Secondary)</p> <p>(c) Specialized Genome databases: (SGD, TIGR, and ACeDB)</p> <p>(d) Structure databases (CATH, SCOP, and PDBsum)</p> <p><b>Alignment problem and solutions</b></p> <p>Alignment: Basics and techniques, Local alignment and Global alignment</p> <p>Pairwise sequence alignment: NEEDLEMAN and Wunsch algorithm, Smith and Waterman algorithm, The Dot Plot, Dynamic Programming Algorithm.</p> <p>Multiple Sequence Alignment (MSA): Definition, Objective, Consensus, Methods for MSA: Heuristic approach, Dynamic programming approach and their combinations. Complexity analysis.</p> <p>Phylogenetic Analysis: Molecular-Phylogenetics, Phylogenetic-trees, Terminology of tree-reconstruction, rooted and un-rooted trees, gene vs species trees and their properties.</p> <p>Algorithms /methods of phylogenetic analysis: UPGMA, Neighbor-Joining Method.</p>		
<p>Unit II: <b>Bioinformatics – II</b> <span style="float: right;"><b>(15L)</b></span></p> <p><b>Protein structure analysis and prediction:</b> Identification/assignment of secondary structural elements from the knowledge of 3-D structure of macromolecule using DSSP and STRIDE methods , Prediction of secondary structure: PHD and PSI-PRED method</p> <p>Tertiary (3-D) Structure prediction: Fundamentals of the methods for 3D structure prediction (sequence similarity/identity of target proteins of known structure, fundamental principles of protein folding etc.)</p> <p>Homology Modeling, fold recognition, threading approaches, and ab-initio structure prediction methods</p> <p><b>Genomics:</b> Basic concepts on identification of disease genes, role of bioinformatics-OMIM database, reference genome sequence, integrated genomic maps, gene expression profiling; identification of SNPs, SNP database (DbSNP). Role of SNP in Pharmacogenomics, SNP arrays</p> <p><b>Drug discovery and Development</b> : - Introduction to Drug Design and</p>		



<p>Development, Drug targets, Lead Identification and Modification, Computer-Aided Drug Design, Drug Delivery, Pre-clinical and Clinical Testing</p> <p><b>Applications of Bioinformatics:</b> Pharmaceutical industries, immunology, agriculture, forestry; Legal, ethical and commercial ramifications of bioinformatics; Bio-sensing</p>	
<p><b>Unit : III Intellectual Property Rights (15L)</b></p> <p>Introduction to IPR; Types of Intellectual property – Patents, Trademarks, Copyrights and related rights; Traditional vs. Novelty;</p> <p>Importance of intellectual property rights in the modern global economic environment,</p> <p>Importance of intellectual property rights in India; IPR and its relevance in biology and environmental sciences;</p> <p>Case studies and agreements - Evolution of GATT and WTO and IPR provisions under TRIPS;</p> <p>Madrid agreement; Hague agreement; WIPO treaties; Budapest treaty; Indian Patent Act (1970)</p> <p><b>Patents:</b> Definition, patentable and non-patentable inventions; types of patent application – Ordinary, Conventional, PCT, Divisional, and Patent of addition;</p> <p>Concept of Prior Art; Precautions while patenting - disclosure / non-disclosure; Time frame and cost;</p> <p>Patent databases, Searching International databases; Patent licensing and agreement; Patent infringement – meaning, scope, litigation, case studies. Patenting rules – European Scenario, US Scenario, Australia Scenario, Indian Scenario, Non Patentable IP and Patentable IP in Indian Patent Act</p>	
<p><b>Unit : IV Bioethics (15L)</b></p> <p>Bioethics: Definition – moral, values, ethics and ethics in biology; Role and importance of ethics in biology;</p> <p>Basic Approaches to Ethics;</p> <p>Posthumanism and Anti-Posthumanism;</p> <p>Bioethics: legal and regulatory issues;</p> <p>Bioethics in healthcare, agriculture, modern biology, biotechnology, animal welfare &amp; right / animals in research, wildlife conservation and management, commercialism in scientific research</p> <p>Bioethics and cross-cultural bioethics – Autonomy, Rights, Beneficence, Do No Harm, Justice, Confidentiality, Animal Rights, Environmental ethics, Decision-Making Perceptions of Ethical Biotechnology ‘Moral’ is not the same as Ethical, Mixed Perception of Benefit &amp; Risk, Reasoning behind Acceptance or Rejection of Genetic Manipulation, Concerns about Consuming products of GMOs.</p> <p>Past and Present ‘Bioethical Conflicts’ in Biotechnology- Interference with Nature , Fear of Unknown, Regulatory Concerns, Human Misuse</p>	

Future 'Bioethical Conflicts' in Biotechnology - Changing perception of Nature, Human Genetic Engineering	
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**Practicals:**

<b>PSLSCBT401</b>	<b>Bioinformatics (60L)</b>	<b>2</b>	<b>04</b>
	<ol style="list-style-type: none"> <li>1. Introduction to (Open office / Libre office version) Use of worksheet to enter data, edit data, copy data, move data. Use of in-built statistical functions to compute means, S.D., correlation (you may require to add correlation and regression in the theory part of statistics), regression coefficients etc. Use of bar diagram, histogram, scatter plots, etc. graphical tools for presentation of data.</li> <li>2. Searching PubMed , Introduction to NCBI, NCBI data bases, BLAST BLASTn, BLASTp, PSI-BLAST, Sequence manipulation Suite, Multiple sequence alignment, Primer designing, Phylogenetic Analysis, SRS, Entrez, Pubmed.</li> <li>3. Secondary Structure Prediction</li> <li>4. Homology Modeling, Fold recognition, Abinito methods – SWISS-MODEL, MODELLER, GenTHREADER, ROSETTA.</li> <li>5. Identification of Disease Genes</li> <li>6. Ligand-Protein Docking</li> <li>7. Case study of various Applications of Bioinformatics</li> </ol>		

Course Code	Title	Credits
<b>PSLSCBT402</b>	<b>Medical Biotechnology (60L)</b>	<b>4</b>
	Unit I: <b>Introduction and therapeutic bioproducts (15L)</b> <b>Molecular, Structural and Chemical Biology in Pharmaceutical Research-</b> Introduction, Molecular Biology of Disease and <i>in vivo</i> , Transgenic Models, Genomic Protein Targets and Recombinant Therapeutics, Structural Biology and Rational Drug Design, Chemical Biology and Molecular Diversity, Gene Therapy and DNA/RNA-Targeted, Therapeutics, Future Prospects in Pharmaceutical Research, Conclusions <b>Therapeutic Proteins:</b> In vitro folding of inclusion bodies on an industrial scale, Medical applications in humans and animals, Monoclonal Antibodies, vitamin, , blood proteins, human hormones – Growth hormones, insulin, somatostatin, steroid hormones, immune modulators – factors VIII IX,	

interferons and interleukins, erythropoietin, relaxin, epinephrine, TNF, tissue plasminogen activator protein and vaccines, Viral antigens by bacteria	
<p>Unit II: <b>Vaccines, antibodies, peptibodies</b> <span style="float: right;"><b>(15L)</b></span></p> <p><b>Vaccination and Gene Manipulation</b> - Infectious Disease - The Scale of the Problem, Current Vaccination Strategies - Inactivated Vaccines, Live Attenuated Vaccines and The Relative Merits of Live <i>versus</i> Killed Vaccines, The Role of Genetic Engineering in Vaccine - Identification, Analysis and Production: Identification and Cloning of Antigens with Vaccine Potential - DNA/Oligonucleotide Hybridization, Hybrid Selection and Cell-free Translation, Expression cloning and Genomic Sequencing, Analysis of Vaccine Antigens - B-cell Epitopes and T-cell Epitopes, Generation of Subunit Vaccines - Expression of Potential Vaccine antigens, Improvement and Generation of New Live Attenuated Vaccines: Improving Current Live Attenuated Vaccines - New Vaccines for Pseudorabies Virus, Improving Attenuation in <i>Vibrio</i> and Improving Stability – Poliovirus, Recombinant Live Vectors - Vaccinia Virus Recombinants, Recombinant BCG Vaccines, Attenuated Salmonella Strains as Live Bacterial Vaccines, Poliovirus Chimaeras, Cross-species Vaccination, ‘Live-dead’ Vaccines, Other Virus Vectors and Recombinant <i>E. coli</i> Strains, Other Approaches to Vaccines: DNA Vaccines (Genetic Immunisation) – <i>cholera</i> Optimizing Responses and RNA Immunisation, Peptide Vaccines, Anti-idiotypes, Enhancing Immunogenicity and modifying Immune Responses - Adjuvants, Carriers and Vehicles, Carriers, Mucosal Immunity, Modulation of Cytokine Profile, Modulation by Antigen Targeting and, Modulation of Signalling</p> <p><b>Monoclonal Antibodies</b> – Introduction, Antibody Structure, Preparation of Hybridomas by Somatic Cell Fusion: Principle of the Technology, Choice of Myeloma Cell-line, Choice of Host for production of Immune B-cells, Immunogen and Route of Immunization, Preparation of Myeloma Cell-line and Host Immune Lymphocytes for Fusion, Hybridoma Formation by Somatic Cell Fusion, Screening Hybridoma Culture Supernatants, Cloning Hybridomas, Bulk Production, Isolation and Purification of Monoclonal Antibodies - Bulk Production and Isolation and Purification, Examples of the Preparation of Rat Monoclonal Antibodies Which Have Been Used to Investigate the Structural and Functional Properties of Macromolecules - Rituximab: Clinical Development of the First Therapeutic Antibody for Cancer, HIV I gp120, mAbs to Growth Factor Receptors and Monoclonal Antibodies for Clinical Application,</p> <p><b>Generation of Monoclonal Antibodies Using Recombinant Gene Technology:</b> Isolation of Immunoglobulin Variable Region, Genes and Expression on the Surface of Bacteriophage - Isolation of mRNA for VHand VL and Generation of cDNA, PCR Amplification of cDNAs for Antibody VH and VL, Linking of VH and VL to Give scFv, Insertion of scFv into Phagemid Vector, Expression of scFv on the Surface of Bacteriophage, Screening Phage Display Libraries of Immunoglobulin Genes, Preparation of Soluble scFv and Screening Supernatants Containing soluble scFv, Monoclonal Antibodies in Biomedical Research, Monoclonal Antibodies in the</p>	

Diagnosis and Treatment of Disease, Biotechnology medicine, Use of Antibodies for Immunopurification, Preclinical Testing of Antibodies: Pharmacology, Kinetics, and Immunogenicity, Preclinical Testing of Antibodies: Safety Aspects, Therapeutic Applications of Monoclonal Antibodies: A Clinical Overview: **Case Studies** – Antibodies for Sepsis: Some Lessons Learnt, An Engineered Human Antibody for Chronic Therapy: CDP571, Antibody Targeted Chemotherapy, ReoPro Clinical Development: A Case Study

**Peptibodies** – definition, peptide-Fc fusion, advantages over monoclonal antibodies, production in *E. coli* using recombinant DNA technology, production, and mechanism of action, applications – pain, ovarian cancer and immune thrombocytopenic purpura, limitations

Unit : III **Gene therapy, Antisense therapy, Diagnostics and genetic testing (15L)**

**Molecular technologies** – an overview of Genetic screening for any predisposition symptoms, Cancer screening, Cloning, Gene therapy, DNA fingerprinting,(Paternity and Forensics) in vitro fertilization, surrogate motherhood, PGD, transgenic organisms, xenotransplantation, GMOs

**Gene therapy**– Overview, viral and non viral Vectors for somatic cell gene therapy, Large scale plasmid DNA manufacturing, Enhancement genetic engineering, Gene therapy for inherited immunodeficiency syndromes, Cystic fibrosis gene therapy, HIV-1 gene therapy. Retroviral mediated gene transfer.

**Genes and Human behavior** - Aggressive, impulsive, and violent behavior, Schizophrenia susceptibility loci

**Stem cells & therapeutic cloning** - Embryonic stem cells and therapeutic cloning, multi-potent adult stem cells, pluripotent adult stem cells, transgenic stem cells, Regeneration therapy.

**Antisense therapy** – Introduction, strategies – oligodeoxyribonucleotide, catalytic antisense RNA, triple – helix forming oligonucleotides (TFOs), production, drug delivery, problems and limitations, first generation antisense drugs, second generation antisense drugs, applications –cancer therapy, viral diseases, gene function analysis and in agriculture, future

**Molecular Diagnosis of Inherited Disease** – Introduction; Direct Detection of Gene Mutations- Detection of Deletions, Duplications and Insertions, Expansion Mutations, Point Mutations - Allele-specific Oligonucleotides and Restriction Enzyme Site Analysis, ‘ARMS’, Oligonucleotide Ligation, and Fluorescently Labelled DNA Sequencing; Indirect Diagnosis with Linked Genetic Markers, Future Prospects

**DNA in Forensic Science** – Introduction; MLP and SLP Technology, PCR Technology- The First PCR-based Forensic System, Short Tandem Repeats, Databases, Interpretation of the Results, Mitochondria1 DNA, Y Chromosome Analysis, Future - Capillary Electrophoresis, DNA Chip Technology, DNA probes for diagnosis in epidemiology and forensic science

Unit : IV **Applied Medical Biotechnology**

**(15L)**

**Reproductive biology** – Superovulation, embryo culture and embryo transfer technology, gene transfer or transfection using eggs of cultured stem cells, development of transgenic animals such as mice, sheep, pig, rabbit, goat, cow and fish, embryogenic polarity and its molecular genetics – drosophila melanogaster, C. elegans, sexually transmitted diseases and vaccines, infertility and reproductive vaccines, study of reproductive cancers – testicular, ovarian and breast cancer, frontiers of contraceptive research, cryopreservation of sex gametes and embryos, ethical issues related to embryo research

**Immunotechnology** – Immunoassays: SRID, ELISA, RIA, application of avidin-biotin interactions, epitope mapping and design of synthetic vaccines, DNA vaccines, idiotyping vaccines and T-cell vaccines, immunophenotyping, and flow cytometry: principles and applications, transplantation immunology: HLA typing method using serological and molecular techniques, SCID, transgenic and knock out animal models – study of mechanism of disease development and therapy, tumor immunology: basic concepts and immunological approaches to tumor therapy, autoimmune diseases and their treatment, apoptosis: biochemical, immunological and molecular methods of detection, relevance to immune system

**Patho-biotechnology** – concept, L. monocytogenes as a vaccine delivery vehicle, non-pathogenic strains as vaccine and drug delivery vehicles, Probiotics – essential prerequisites, types: bioengineered, therapeutic, designer, biological containment, role of metagenomics.

**Pharmacogenomics** – types of pharmacogenetic knowledge and obstacles, variations of drug metabolizers, transporters, drug targets and biological milieu of drug action, pharmacogenomics of cancer syndromes, neuro-psychotic disorders, alzheimer's disease, mental retardation, cardiovascular diseases and smoking and alcoholism, genetic influences on drug targets involved in pharmacodynamics, long QT syndromes, future prospects.

**Regulatory and Economic Aspects**

Regulation of Antibodies and Recombinant Proteins, Regulation of Human Gene Therapy,

Economic Considerations Social issues - public opinions against the molecular technologies.

Legal issues – legal actions taken by countries for use of the molecular technologies, regulations of antibodies and recombinant proteins, regulation of gene therapy, economic considerations

Ethical issues – ethical issues against the molecular technologies.

Bioethics – Necessity of Bioethics, different paradigms of Bioethics – National & International

**Practicals:**

<b>PSLSCBTP402</b>	<p align="center"><b>Medical Biotechnology (60L)</b></p> <ol style="list-style-type: none"> <li>1. Residual DNA analysis of recombinant insulin preparation</li> <li>2. Identification of amplified DNA by sequencing</li> <li>3. Analysis of recombinant therapeutic proteins for presence of antibiotic resistance markers</li> <li>4. Antibiotic sensitivity assay</li> <li>5. DNA fingerprinting</li> <li>6. Detection of Thalassemia and breast cancer mutations by PCR</li> <li>7. Detection of Shiga toxin toxins by PCR/Real Time PCR</li> <li>8. Microbial analysis of therapeutic products</li> <li>9. Multiplex PCR</li> </ol>	<b>2</b>	<b>04</b>
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<b>Course Code</b>	<b>Title</b>	<b>Credits</b>
<b>PSLSCBTT 403</b>	<b>Environmental Biotechnology and Agricultural biotechnology (60L)</b>	<b>4</b>
<p>Unit I: <b>Water Pollution Control (15L)</b>  <b>Environmental Pollutants</b> – sources generating pollutants, natural and man-made pollution, categories of pollutants  <b>General Aspects</b> –Historical Development of Wastewater Treatment Processes, Bacterial Metabolism in Wastewater Treatment Systems, Nitrification and Denitrification - Microbial Fundamentals and Consequences for Application, Autoaggregation of Microorganisms: Flocs and Biofilms Nucleic Acid-Based Techniques for Analyzing the Diversity, Structure, and Dynamics of Microbial Communities in Wastewater Treatment, Analytical Parameters for Monitoring of Wastewater Treatment Processes, Monitoring of Environmental Processes with Biosensors, Laws, Statutory Orders and Directives on Waste and Wastewater Treatment  <b>Processes of Wastewater Treatment</b>  <b>Waste Water Sources and Composition</b> - Municipal Wastewater and Sewage Sludge, Industrial Wastewater Sources and Treatment Strategies, Agricultural Waste and Wastewater Sources and Management  <b>Aerobic Carbon, Nitrogen, and Phosphate Removal</b> - Biological Processes in Wetland Systems for Wastewater Treatment, Activated Sludge Processes, Biological and Chemical Phosphate Removal, Continuous Flow and Sequential Processes in Municipal Wastewater Treatment, Trickling Filter Systems, Submerged Fixed-Bed Reactors, Experience with Biofilters in Wastewater Treatment, Special Aerobic Wastewater and Sludge Treatment Processes and Process Combinations, Modeling of Aerobic</p>		

<p>Wastewater Treatment Processes</p> <p><b>Drinking Water Preparation</b> – Potable Water Treatment, Hygienic Aspects of Drinking Water, Artificial Groundwater Recharge and Bank Filtration, Biofilms in Biofiltration, Biofiltration Processes for Organic Matter Removal, Perspectives of Waste, Wastewater, Off-Gas, and Drinking Water Management</p>	
<p>Unit II: <b>Metal pollution control and soil decontamination</b> (15L)</p> <p><b>Metal Ion Removal</b>–Removal by Biomass: Physico-Chemical Elimination Methods, Anaerobic Processes: Anaerobic Metabolism and its Regulation, CSTR-Reactors and Contact Processes in Industrial Wastewater Treatment, Fixed Film Stationary Bed Reactors and Fluidized Bed reactors, Possibilities and Potential of Anaerobic Wastewater Treatment Using Anaerobic Sludge Bed (ASB)-Reactors, Modeling of Biogas Reactors, Future Aspects - Cleaner Production</p> <p><b>Soil Decontamination – General aspects</b> - Contaminated Soil Areas, Different Countries and Contaminants, Monitoring of Contaminants, Characterization of the Geological and Hydrogeological Situation, Effects on Natural Geochemical Barriers and Remediation, Bioavailability of Contaminants, Humification, Ecotoxicological Assessment</p> <p><b>Microbiological Aspects</b> – Aerobic Degradation by Microorganisms, Anaerobic Degradation, Degradation of Aliphatics, degradation of Aromatic and Polyaromatic Compounds, Degradation of Chlorinated Compounds, Compounds with Nitro Functions</p> <p><b>Processes for Soil Clean-Up</b> – Thermal Processes, Scrubbing/Extraction, Bioremediation, Disposal, Bioremediation with Heap Technique, Utilization of Treated Soil, Bioreactors, <i>In situ</i> Remediation, Phytoremediation of Organics, Phytoremediation of Metals, Advanced in situ Bioremediation - A Hierarchy of Technology Choices, Immobilization, Bacterial Activity Enhancement and Soil Decontamination, Genetically Engineered Microorganisms and Bioremediation, Possibilities, Limits, and Future Developments of Soil Bioremediation, Sampling and Analysis of Soil</p> <p><b>Biodeterioration</b>– Microbial deterioration of timber, petroleum products, leather, plastics and food products, effect of metals and salt on the growth of microbes and higher organisms, different adaptation mechanisms to tolerate higher concentrations of metals by organisms</p>	
<p>Unit : III <b>Soil and gas waste treatment and bioconservation</b> (15L)</p> <p><b>Solid Waste Treatment</b></p> <p>Bio- and Pyrotechnology of Solid Waste Treatment, Microbiology of Composting, Composting of Plant Residues and Waste Plant Materials, Technology and Strategies of Composting, anaerobic Fermentation of Wet or Semi-Dry Garbage Waste Fractions, Landfill Systems, Sanitary Landfilling of Solid Wastes - Long-Term Problems with Leachates, Sanitary Landfills - Long-Term Stability and Environmental Implications, Combined Mechanical and Biological Treatment of Municipal Solid Waste, Future</p>	

<p>Settlement Structures with Minimized Waste and Wastewater Generation</p> <p><b>Waste Gas Treatment</b> – Process Engineering of Biological Waste Gas Purification, Microbiological Aspects of Biological Waste Gas Purification, Bioscrubbers, Biofilters, Treatment of Waste Gas Pollutants in Trickle Filters, Membrane Processes and Alternative Techniques, Commercial Applications of Biological Waste Gas Purification</p> <p><b>Biodiversity conservation</b>- current level of biodiversity, alpha and beta diversity, extinction and endangered species –natural and human causes, conservation mechanisms, in situ and ex situ conservation – gene banks and management of germ plasm collection, conservation efforts by G-15 countries, Europe, India and private sector, Benefits – economic, essential services provided by natural ecosystems, ethical and aesthetic rewards</p> <p><b>Biorecycling</b>– definition, recycling of medical waste, biodegradable waste, septic tank waste, animal manure, mechanical, biological and thermal processes used, applications – generation of heat, electricity, alternative fuels, fertilizer, humus and other products</p>	
<p>Unit : IV <b>Agricultural Biotechnology</b> <span style="float: right;"><b>(15L)</b></span></p> <p><b>Nitrogen fixing bacteria</b> – nitrogen cycle, fixation of nitrogen, leghaemoglobin, nitrogen fixation, a reductive process, nitrogenase system, nitrogenase gene cluster, hydrogenase system, blue green algae as nitrogen fixers</p> <p><b>Biofertilizers</b> – Symbiotic associations and its biotechnological relevance, evolution of symbiosis, Nitrogen fixation – mechanism, molecular genetics and biochemistry, microorganisms involved, biofertilizers–types, methods of manufacture, application to soil and seed</p> <p><b>Biopesticides</b></p> <p>Chemical pesticides – uses, advantages and disadvantages, biological pesticides –types, advantages over chemical pesticides, mechanism of production, mode of action, stability and formulation in natural organisms and genetically modified microorganisms, selective targeting, molecular mechanisms of resistance development and strategy for integrated pest management, biological control of vector communicable diseases such as malaria and Filiria – Mechanism of parasite action and difficulties associated with the successful use of biopesticides against these diseases. Biopesticides of plant origin – Neem, biocontrol of plant and grain fungal diseases – <i>Trichoderma</i>, <i>P. fluorescence</i>, <i>Ampelomycescomothyrum</i> and others</p> <p><b>Bio-insecticides</b>– principles, stages in the investigation, presently used candidates as biological control agents, production of biological insecticides – submerged fermentation, surface culture, in vivo culture, Bioassays, formulation and use bio-insecticides, safety testing of bio-insecticides, future</p> <p><b>Bioherbicides</b> – deleterious effects of weeds on crops and crop yield, use of synthetic herbicides and its disadvantages, bioherbicides – microbes and insects as agents, mechanism of action, benefits, genetic engineering to increase weed specificity</p>	



**Practicals:**

<b>PSLSCBTP 403</b>	<b>Environmental Biotechnology and Agricultural biotechnology (60L)</b> <ol style="list-style-type: none"> <li>1. Soil analysis- nitrogen, phosphorus, chloride, organic matter, &amp; calcium carbonate content</li> <li>2. Microbial analysis of sludge</li> <li>3. Microbiological analysis of fish</li> <li>4. Determination of histamine in frozen fish</li> <li>5. Determine of moisture content and sodium chloride in dried fish</li> <li>6. Analysis of canned fish – polyphosphates and sulphur dioxide</li> <li>7. Waste water analysis - pH, COD, BOD, Hardness, halides, Total solids, alkalinity and chloride</li> <li>8. Isolation of marine microorganisms</li> <li>9. Isolation of cellulase and xylanase producers from soil</li> <li>10. Isolation of protease producers from soil</li> </ol>	<b>2</b>	<b>04</b>
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<b>Course Code</b>	<b>Title</b>	<b>Credits</b>
<b>PSLSCBTT 404</b>	<b>Special Processes and regulations and ethics (60L)</b>	<b>4</b>
<p>Unit I: <b>Marine biotechnology (15L)</b>            Definition, Concerns – Extreme environmental conditions, Marine life forms, 40 percent of coastal waters are unfit for swimming because of bacteria and pollutants. Understanding the dynamics of fish populations and the impact of disease is essential to manage resources. Seafood-borne illness adversely affects public health and coastal economies,  <b>Goals and applications</b> – to develop rapid diagnostic assays , study of growth and natural habitats, genetic engineering of marine microorganisms and significance –discover new compounds with therapeutic and industrial applications, new tools to monitor ecosystem health and find solutions for difficult environmental problems, restore and protect aquatic ecosystems, increase the food supply through aquaculture, enhance seafood safety and quality, types and resources of industrial materials and processes, expand knowledge of biological and geochemical processes in the world ocean, Biology of methanogenesis; regulation of gene transcription in Archaea; desiccation tolerance in the context of exobiology, applied technologies for bioremediation of PCBs. Marine bioprospecting – Isolation of Marine Natural Products  <b>Study of marine microbiology</b> – Nitrogen metabolism in marine and terrestrial bacteria, regulation of microbial gene expression, adaptation of bacteria in extreme environments, microbial genetics of marine</p>		

<p>microorganisms, physiology and molecular biology of extremophiles, molecular interactions of symbiotic bacteria and microbial diversity and its impact on human health, Fish reproductive endocrinology, applied technologies for manipulation of spawning</p> <p><b>Aqua culture technology-</b> definition, history and scope, constraints and recent development, criteria for selection of species, aquafarm engineering – selection of sites, infrastructure, designing, layout and construction of farm, types of culture – culture in lentic and lotic waters, lagoons and backwaters, cage culture, pen culture, on and off bottom culture and raceways culture, Pisciculture – cultivable fish species, seed production technology of carps, carps culture, mono and poly culture, extensive, semi-intensive and intensive, prawn culture – cultivable prawn species, spawning techniques, culture methods in india, Pearl oyster culture – pearl producing species, oyster farming, pearl culture technology, composition of pearl quality and prospectus, seaweed culture – economically important species culture and post harvest technology, seaweed products and commercial exploitation, seed and seed formulation – conventional and non-conventional seed stuffs, seed formulation technology, growth promoting agents, problems and prospectus, future focus - controlled delivery of hormones and other compounds into finfish, recirculating marine aquaculture, blue crab aquaculture, applied technologies for microbial mediated water treatment in recirculating aquaculture systems, applied technologies for nitrogen metabolism in aquaculture systems, biology of methanogenesis in aquaculture systems, molecular biology of economically important fish viruses and focuses on viral pathogenesis and development of novel vaccines.</p>	
<p><b>Unit II: Bionanotechnology, biomimetics and drug delivery (15L)</b></p> <p><b>Bionanotechnology</b>–Oppurtunities and challenges, nano devices - nanoparticles, nanowires, paramagnetic ironoxidecrystals dendrimers, carbon nanotubes, nanosomes and polymersomes, nanoshells and buckballs,thin films and multilayers; nanostructures and nanoscale systems, properties of nanomaterials, Synthesis of nanostuctures - physical, chemical and biological,microbiological methods - Biomolecules as nanostructures, nanofabrication, nanomechanics, nanotribology, materials science, and reliability engineering;Applications: biosensors, drug and gene delivery systems, chip technologies, nanoscale analytical techniques, nanoimaging, nanomedicine and cancer diagnostics and nanoparticular carrier systems, micro and nanofluidics, advanced materials, energy, electronics, agriculture, environmental sensing and space habitation, medical diagnostics and tissue regeneration, potential risks and furure.</p> <p><b>Drug and gene delivery systems</b> – routes of delivery, targeted delivery, virus based drug systems, role of vesicles and lipids, new drug delivery systems –microspheres, nanoshells and buckballs, synthesis of vehicles for</p>	

<p>delivery - nanolevel manipulation of colloidal systems, proteins, peptides, liquid crystalline phases, organogels and dendrimers, chemistry, Delivery profiles – RatePreprogrammed Drug Delivery Systems, FeedbackRegulated Drug Delivery Systems, Transdermal, Blood brain barrier nanodrug delivery chip</p> <p><b>Biomimetics</b> – History, Sculpturing the Architecture of Mineralized Tissues: Tissue Engineering of Bone from Soluble Signals to Smart Biomimetic Matrices, Nanobiomimicry – biomorphic mineralization, biologically inspired engineering, Nanowires, nanotubes, and quantum dots, Display technology</p>	
<p>Unit : III <b>Other applications</b> <span style="float: right;"><b>(15L)</b></span></p> <p><b>Biosensors</b> –Introduction, The Biological Reaction, theory, Electrochemical Methods - Amperometric Biosensors, Potentiometric Biosensors and Conductimetric Biosensors, Calorimetric Biosensors, Piezoelectric Biosensors, Optical Biosensors - Evanescent Wave Biosensors and Surface Plasmon Resonance, Whole Cell Biosensors, Immunosensors</p> <p><b>Inorganic biotechnology</b>–Introduction, advantages of heaps and dumps, bioreactors in bioleaching, biomining operation, microbial leaching of metals (biomineralization), gold, biotechnology of coal, accumulation and transformations of metals by microbes, microbial corrosion and its inhibition</p>	
<p>Unit : IV <b>Biotechnology – Biosafety assessment, legal, economics and ethical issues</b> <span style="float: right;"><b>(15L)</b></span></p> <p><b>Modern Biotechnology - What Is New About It?</b></p> <p>The Evaluation of Technology as an Interactive Commitment-Building Process - The Failure of Technology Assessment, Concepts of Risk Assessment: "Process versus Product", Controversy Put to the Rest, Biosafety in rDNA Research and Production, Biotechnology and Bioethics: What is Ethical Biotechnology?</p> <p><b>Product Development and Legal Requirements</b> - Structured Risk Assessment of rDNA Products and Consumer Acceptance of these Products, Strategic Regulations for Safe Development of Transgenic Plants, Biomedical Product Development, Regulations for Recombinant DNA Research, Product Development and Production in the US, Japan and Europe</p> <p><b>Biosafety assessment</b> – Safety evaluation of Biotherapeutics, agribiotechnology products, crops derived through biotechnology, food and food ingredients produced by GMOs, Animal feeds, Preclinical safety assessment of vaccines, Immunotoxicological assessment of therapeutic products, Allergenicity of recombinant products used in food and feed, Environmental impact and risk monitoring of recombinant products, microbes, plants, Regulatory requirements</p> <p><b>Intellectual Property and Bioinformatics</b> - Biotechnology and Intellectual Property</p>	

<p>Patent Applications for Biomedical Products, Databases in Biotechnology</p> <p><b>Biotechnology in a Developing World</b> - Commercial Biotechnology: Developing World Prospects, Biotechnology in the Asian-Pacific Region, Biotechnology and Biological Diversity</p> <p><b>Public Attitudes and Political Responses</b></p> <p>"Oui" or "Non" to Biotechnology: The Other French Referendum, Government, Researchers and Activists: The Critical Public Policy Interface, Press Coverage of Genetic Engineering in Germany: Facts, Faults and Causes, The Regulation of Modern Biotechnology: A Historical and European Perspective</p> <p><b>Genetic Modification in Agriculture, Food Industry and Medicine</b> – terminology, controversies over genetic modification, policy around the world (USA, European Union, EU regulation, Japan, China &amp; other developing countries), ecological impact of transgenic plants, Genetically modified foods – organic foods, types of organic foods, identifying organic foods, organic food &amp; preservatives, Legal Requirements in the Production of Novel Foods and Processes, Foodcrops, Food Animals, Current Trends in Manufactured Foods, Consumer Acceptance and Market Forces, Food industry – background, history, controversies over risks, application, future applications, Medicine - gene therapy, molecular engineering, human genetic engineering, problems &amp; ethics</p>	
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**Practicals:**

<b>PSLSCBTP 404</b>	<b><u>Dissertation of Research Project</u></b> (60L)	<b>2</b>	<b>04</b>
	1. Project studies: presentation and preparation of report of observations and results		

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2. Biotechnology for Beginners (2006): ReinhardRenneberg
3. Biotechnology Vol 1: Rehm& Reed
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5. Biotechnology, An Introduction (2008): S. Ignacimuthu, S. J.
6. Biotechnology, Concepts and Applications (2009): R. R. Vittal and R. Bhat
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8. More Gene Manipulations in Fungi (1991): J. W. Bennette and Linda L. Lasure
9. Microbial Metabolism and biotechnology, e-book: Horst Doelle
10. Introduction to plant tissue culture: M. K. Razdan
11. Animal Cell Culture by Ian Freshney
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14. Molecular Biology: A laboratory Manual, 2<sup>nd</sup>edition, 1989: Maniatis, Fritsch and Sambrook
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5. Biotechnology, An Introduction (2008): S. Ignacimuthu, S. J.
6. Biotechnology, Concepts and Applications (2009): R. R. Vittal and R. Bhat
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1. Molecular Biology and Biotechnology, 4<sup>th</sup> edition (2002): J. M. Walker and R. Rapley
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3. Biotechnology Vol6: Rehm& Reed
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#### **PSLSCEBTT401**

1. Fundamentals of Bioinformatics: Harisha S.
2. Bioinformatics and Molecular Evolution: Higgs & Attwood
3. Bioinformatics: Harshwardhan Pal

#### **PSLSCEBTT 402**

1. Molecular Biology and Biotechnology, 4<sup>th</sup> edition (2002): J. M. Walker and R. Rapley
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3. Biotechnology Vol 5a: Rehm & Reed
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**OVERALL EXAMINATION AND MARKS DISTRIBUTION PATTERN****Semester III**

Course	PSLSCBTT301			PSLSCBTT302			PSLSCBTT303			PSLSCBTT304			Grand Total
	Internal	External	Total	Internal	External	Total	Internal	External	Total	Internal	External	Total	
<b>Theory</b>	40	60	100	40	60	100	40	60	100	40	60	100	<b>400</b>
	<b>PSLSCBTP301</b>			<b>PSLSCBTP302</b>			<b>PSLSCBTP303</b>			<b>PSLSCBTP304</b>			
<b>Practicals</b>	-	50	50	-	50	50	-	50	50	-	50	50	<b>200</b>

**Semester IV**

Course	PSLSCBTT401			PSLSCBTT402			PSLSCBTT403			PSLSCBTT404			Grand Total
	Internal	External	Total	Internal	External	Total	Internal	External	Total	Internal	External	Total	
<b>Theory</b>	40	60	100	40	60	100	40	60	100	40	60	100	<b>400</b>
	<b>PSLSCBTP401</b>			<b>PSLSCBTP402</b>			<b>PSLSCBTP403</b>			<b>PSLSCBTP404</b>			
<b>Practicals</b>	-	50	50	-	50	50	-	50	50	-	50	50	<b>200</b>

## MODALITY OF ASSESSMENT:

### THEORY EXAMINATION PATTERN:

#### A) Internal Examination for Theory: 40 marks

No.	Particulars	Marks
1.	Active participation in routine Class instructional deliveries	05
2.	Overall conduct as a responsible learner, Communication & leadership qualities in organizing related academic activities.	05
3.	One seminar based on curriculum to be assessed by the teacher of the institution teaching P.G. learners/ publication of a research paper/ presentation of a research paper in seminar or conference	30
(a)	Selection of the topic, Introduction, write up, references (15)	
(b)	Presentation with the use of ICT (15)	

#### B) External Examination - 60 % [Semester End Theory Assessment]: 60 marks

- Duration - These examinations shall be of two and half hours duration.
- Theory question paper pattern :-
  - There shall be **five** questions each of **12** marks. On each unit there will be one question & fifth one will be based on all the four units .
  - All questions shall be compulsory with internal choice within the questions. Each question will be of **24** marks with options.
  - Questions may be sub divided into sub questions **a, b, c & d only, each carrying six marks OR a, b, c, d, e & f only** each carrying **four** marks and the allocation of marks depends on the weightage of the topic.

### PRACTICAL EXAMINATION PATTERN

#### A) Internal Examination:

There will not be any internal examination/ evaluation for Practicals.

#### B) External (Semester end practical examination) Per course:

No.	Particulars	Marks
1.	Laboratory work	40
2.	Journal	05
3.	Viva	05

### SEMESTER III:

Practical examination will be held at the college / institution at the end of the Semester.

The students are required to present a duly certified journal for appearing at the practical examination, failing which they will not be allowed to appear for the examination.



In case of loss of Journal and/ or Report, a Lost Certificate should be obtained from Head of the Department/ Co-ordinator of the department, failing which the student will not be allowed to appear for the practical examination.

**Research proposal (Dissertation based on Literature Review):** Candidates are required to present duly certified research proposal (as per the BCUD format) with relevant references (minimum 25) and make the power point presentation of the same for the evaluation by the examiner (the research proposal must be included with literature survey of the selected research topic).

#### **SEMESTER IV:**

Practical examination will be held at the college / institution at the end of the semester. The students are required to present a duly certified journal for appearing at the practical examination, failing which they will not be allowed to appear for the examination.

In case of loss of Journal and/ or Report, a Lost Certificate should be obtained from Head of the Department/ Co-ordinator of the Department, failing which the student will not be allowed to appear for the practical examination.

**Research Project work (Dissertation based on Research):** Candidates are required to present duly certified dissertation report based on the topic of research along with the laboratory notebook containing raw data and make the poster presentation of the research work for evaluation by the examiner.