UNIVERSITY OF MUMBAI

Syllabus for the
M.Sc. Part – II:Life Sciences
Specialization- Biotechnology
Semester III and IV

Choice Based Credit and Grading System
The academic year 2017-18

M.Sc. Part - II Life Sciences- Biotechnology Syllabus
Choice based Credit and Grading System
The Academic year 2017-2018
SEMESTER III

COURSE CODE	UNIT	TOPIC HEADINGS	CREDITS	L / WEEK
Paper I	**Genetic Engineering**			
PSLSCT301	I	Strain Manipulation Strategies	4	4
	II	Microbial Factories		4
	III	Engineering Lower Eukaryotes I		4
	IV	Engineering Lower Eukaryotes II		4
Paper II	**Fermentation Technology**			
PSLSC302	I	Upstream Processes	4	4
	II	Fermentation Process I		4
	III	Fermentation Process II		4
	IV	Downstream Processes		4
Paper III	**Industrial Enzymes, Tissue Culture and its applications**			
PSLSC303	I	Enzymes in Industry	4	4
	II	Plant Tissue Culture		4
	III	Animal Tissue Culture		4
	IV	Assisted Therapies		4
Paper IV	**Research Methodology and Quality Control**			
PSLSC304	I	Research Methodology	4	4
	II	Scientific Writing		4
	III	ISO		4
	IV	GMP/ GLP		4

Program Objective

- To expose the learner to various aspects of biotechnology
- To give an insight in developing skills and knowledge in biotechnology industry
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Program Outcome
The learner will be able to

- Earn a Master's Degree with specialization in Biotechnology
- Comprehend various techniques and applications ofthe biotechnology industry.
- Increase his/ her employability.
- Setup his/her industry.

SEMESTER IV

COURSE CODE	UNIT	TOPIC HEADINGS	CREDITS	L / WEEK
Paper I	**Medical Biotechnology and Biomathematics**			
PSLSCT401	I	Therapeutics I	4	4
	II	Therapeutics II		4
	III	Biomathematics		4
	IV	Diagnostics and Drug design		4
Paper II	**Applied Biotechnology**			
PSLSC402	I	Aquaculture	4	4
	II	Nanotechnology		4
	III	New Emergent Technologies		4
	IV	Economics of Biotechnology Law and Industrial Considerations		4
Paper III	**Environmental Biotechnology**			
PSLSC403	I	Biological Controls and Biopesticides	4	4
	II	Nitrogen Fixation and Biofertilizers		4
	III	Bioremediation		4
	IV	Phytoremediation and Phytomining		4
Paper IV	**Protein Biology and Drug Development**			
PSLSC404	I	Protein Trafficking and Targeting	4	4
	II	Protein folding and Biomolecular Interactions		4
	III	Natural products		4
	IV	Activity Guided Drug Development		4

SEMESTER III

PAPER - PSLSCT301: Genetic Engineering

Prerequisites: Students should have basic knowledge of molecular biology and genetic engineering.

Course Objectives:

- To make acquainted with various latest genetic engineering techniques.
- To apply the techniques in various prokaryotic and eukaryotic systems.
- To identify various genetic modified organisms.

Course Outcome:

On completion of the course, learner will be able to

- Customize various latest genetic engineering techniques.
- Apply this knowledge in developing genetically engineered organisms
- Distinguish between various genetically modified organisms

Unit I: Strain Manipulation Strategies (15L)

Gene/ regulatory sequence/ protein engineering: Promoter, Gene, Protein and ribosome engineering, epigenetic modification – Mutagenesis, recombination and cell/protoplast fusion.

Mutagenesis: Effect of amino acid changes on protein function, Site-directed Mutagenesis – Non-PCR Methods and PCR-based Methods; Molecular Evolution/Random mutagenesis – Error prone PCR, Cassette mutagenesis, Site Saturation mutagenesis, Overlap PCR, DNA/Domain/Exon shuffling, ICTHY, SCRATCHY, RACHITT; *de novo* Sequence design;

Expression of modified genes – phage, cell, DNA, RNA, ribosome and IVC display, analysis and detection.

Applications - modifying activity, substrate specificity, cofactor requirement, increasing stability, pH and temperature optima, Construction of deregulated mutants resistant to feed back inhibition and repression; Examples of modified proteins - Point Mutations, Domain Shuffling, Domain Fusions for Cell Targeting, Swapping Protein Domains, Whole Protein Shuffling, Protein-Ligand Interactions.

Genome editing: CRISPR/Cas9, TALENS, Modified nucleases – meganuclease, zinc finger nuclease, Recombineering, genome shuffling.

RNAi based strain improvement: use of siRNA, shRNA, miRNA, ribozymes and riboswitches to regulate and optimize gene expression.

Metabolic Engineering: Metabolic pathway analysis and modelling – approaches, Methods for metabolic engineering, Model organisms – *E. coli, B. Subtilis*, Yeast, plants and animals, Applications.

Systems Biology and Synthetic Biology for strain improvement: Omics analysis, *in silico*modeling, development of improved strains.

Unit II: Microbial Factories (15L)

Prokaryotic: *E. coli*: Expression systems – pET, pBAD, λ_{PL}, $prha_{BAD}$ systems, Expression of Foreign Genes in Bacteria – Problems, optimization of expression: host, transcriptional, translational, post translational compatibility, solubility and purification, transport and localization (use of Promoters, Ribosome Binding Site, Fusion Proteins, signal sequences,

Tags and cleavage sites), Modification of gene – codon optimization, host strain modification Expression of Native Proteins, Detecting Expression of Foreign Genes.

Gram Positive Bacteria: *Bacillus subtilis*, *Lactobacilli*, *Streptomyces* – Expression systems, optimization of expression and applications.

Unit III: Engineering Lower Eukaryotes I (15L)

Yeasts: Yeast Selectable Markers and Vector Systems, commercially used yeast strains (***S.*** *cerevisiae*and *Pichia*) and their expression systems

Heterologous Protein Production - Design parameters: Source of DNA, Heterologous mRNA and protein levels and downstream applications, humanization of yeast for post translational compatibility.

Uses: Analysis of Genes, Genomes and Protein-Protein Interactions - YAC Technology, Constructing Gene Knockouts and Novel Reporter Systems, synthesis of commercially compounds.

Filamentous fungi – 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, gene targeting, use of RNAi technology, heterologous and homologous gene expression, humanization of filamentous fungi, applications - industrial applications, enzymes, pharmaceutically important secondary metabolites, therapeutic compounds and products.

Unit IV: Engineering Lower Eukaryotes II (15L)

Algae: Types, Culture systems, Genetic modification - transformation strategies, selection markers, promoters, terminators, translational regulation of protein production, strategies for efficient protein production, applications – increasing photosynthetic efficiency, yield of commercial and therapeutic products, Risks of GM algae.

Protozoa: Advantages of protozoan expression systems from *Dictyosteliumdiscoideum*, *Leishmaniatarentolae*, *Perkinsusmarinus and Tetrahymenathermophila*, cultivation and applications of protozoan biotechnology.

GMO and GMO product detection and analysis: Detection of GMOs and GMO products: Methods – phenotypic, Molecular methods - DNA (PCR, qPCR and alternate methods) and protein (immunoassays, lateral flow devices and dip sticks) based methods, chromatography and infra-red spectroscopy; residual DNA analysis, microbial, biochemical, molecular and toxicological evaluation.

PRACTICALS – PSLSCT301:

1. Construction of amylase expression cassette and expression in *E. coli*.
2. Isolation of plasmid from bacteria.
3. Isolation of Protease degraders from soil and estimation of the protease activity.
4. Preparation and regeneration of fungal protoplast.
5. Detection and estimation of gene copy number by real time PCR (demonstration).
6. Transformation of Yeast
7. Slide culture of filamentous fungi
8. Microbial analysis of GMO foods

References:

1. Molecular Biology and Biotechnology, 4th edition by J. M. Walker and R. Rapley
2. Molecular Biology and Biotechnology, 5th edition by J. M. Walker and R. Rapley

3. Biotechnology, Concepts and Applications by R. R. Vittal and R. Bhat
4. Biotechnology, Principles and Applications by S. C. Rastogi
5. More Gene Manipulations in Fungi by J. W. Bennette and Linda L. Lasure
6. Microbial Metabolism and biotechnology, e-book by Horst Doelle
7. The Metabolic Pathway Engineering Handbook- Fundamenals Christina D Somlke
8. Systems Biotechnology for strain improvement. Trends in Biotechnology. Volume 3 (7), 2006.
9. Molecular Biology: A laboratory Manual, 2nd edition, 1989: Maniatis, Fritsch and Sambrook
10. Molecular Biology: A laboratory Manual, 4th edition, 2012: M. Green and J. Sambrook
11. Introduction to Molecular Biology and Genetic Engineering, 2011: Oliver Brandenberg, Zephaniah Dhlamini, Alessandra Sensi, KakoliGhosh and Andrea Sonnino
12. Genetically Engineered Food: Methods and Detection, 2nd Ed, 2006 :Knut Heller
13. Algal transgenics and Biotechnology. Transgenic plant Journal, 2007: Armin Hallmann.
14. Biotechnology with protozoa in Special Processes - II Special Microorganisms of Biotechnological Interest, Biotechnology Set, 2nd Ed., Vol 10, 2008: Rehm and Reed
15. Recombinant Gene Expression. Reviews and Protocols 3rd ed. 2012: ArgeliaLorence
16. Recombinant Gene Expression. Reviews and Protocols 2nd ed. 2004: Paulina Balbas and ArgeliaLorence
17. Principles of Gene Manipulation, 6thed, 2002: Primrose, Twymann and Old

PAPER – PSLSCT302: Fermentation Technology

Prerequisites: Students should have basic knowledge of microorganisms

Course Objectives:

- To comprehend with various aspects of fermentation technology.
- To understand various industrial fermentation processes.
- To evaluate the economics of the fermentation products.

Course Outcome:

On completion of the course, learner will be able to

- Explain various fermentation processes.
- Develop and fabricate fermentors and products.
- Capture the convenience of Bio-transformations in this industry.
- Evaluate the effectiveness of the new product formulation.

Unit I: Upstream Processes (15L)

Isolation and Screening of microorganisms: Isolation of microorganisms from various sources, Preservation, Primary and Secondary Screening of microorganisms.

Microbial growth: General parameters, growth kinetics for various fermentation and types of stock culture, scaling up of culture for fermentation.

Strain improvement: Need for improvement, Criteria for improved strains, Physical, Chemical, Biological methods.

Fermentation Media: Definition, Criteria, Various components, Types: crude and synthetic, sterilization, rheology of various components of media.

Fermenter design: Components of the fermenter, sterilization, aeration and agitation.

Types of Fermenters: batch, continuous, air lift, fluidized bed, stirred tank.

Unit II: Fermentation Process I (15L)

Single Cell Protein, Biomass and Immobilization: Need of single cell production, production of bacteria, yeast, algae and fungi. Immobilization: cells and enzymes, methods of immobilization, applications.

Commercial Fermentations: Cheese: Culture, Fermentation process, Applications.

Alcohol: Wine, Commercial Ethanol (by product fusel oils): Culture, Process and Applications.

Acids: Lactic acid industrial production and applications.

Carbohydrate: Commercial starch production.

Flavour/fragrance production.

Unit III: Fermentation Process II (15L)

Biotransformations: Classification and characteristics of enzymes – OTHLIL, applications of enzymes: (chiral synthesis of enantiomerically pure compounds, resolution of isomers). Examples of biotransformations: Oxidoreductases- Oxidation of 1- amino - D - sorbitol in the production of miglitol using *Gluconobacteroxydans*; Hydrolases: any one example, catalytic antibodies.

Secondary metabolites production from plants: Secondary metabolite types (alkaloids, terpenes [include IPP synthesis: Classic pathway and Alternate pathway for IPP synthesis in plastids], tannins, lignans pigments, lipids); Selection of callus cultures, Bioreactor types:

Stirred-tank (hollow paddle), roller drum, immobilized, membrane, surface – immobilized; elicitation, permeation.
Examples of secondary metabolite production (industrial scale**)**: [shikonin, taxol (biosynthesis and bioreactor production) capsasin/ berbrine].

From microbes: Polymers [dextrans, xanthan gums, alginate], antibiotics [peptide, lantibiotics, aminoglycosides, beta lactam], cyclosporins, medicinal mushrooms, biosurfactants.

Unit IV: Downstream Processes (15L)

Product recovery: Product: internal, external, cell disruption methods: physical, chemical and biological, precipitation, filtration, centrifugation, extraction and purification, drying.
Product Economics: Microbial culture, Fermentation: Upstream and Downstream processes, recovery process, product processing.
Effluent Treatment: Need, Traditional methods disposal and disadvantage, physical, chemical and biological methods.

PRACTICALS: PSLSCP302

1. Immobilization of cells
2. Demonstration of fermenter/ chemostat
3. Estimation of alcohol production: Sucrose/ fruit (s)/ sugarcane juice.
4. Isolation of cellulase producing microorganisms from natural source(s).
5. Determination of cellulose activity using Filter paper assay/ carboxy-methyl cellulose assay.
6. MIC determination
7. Secondary metabolite production using plant tissue culture (dye/ drug Alkaloids etc.)
8. Effect of elicitor(s) on the production of the plant secondary metabolite.

Reference:

1. Principles of Fermentation Technology byStanbury and Whitaker
2. Industrial Microbiology by Casida
3. Industrial Microbiology by Prescott and Dunn
4. Industrial Biotrasformations by A. Liese, K. Seelbach and C. Wandrey; Wiley – VCH
5. Role of Biotechnology in Medicinal and Aromatics Plants by Khan and Khanum Vol. 1 to
6. Plant Tissue Culture by M. K. Razdan

PAPER – PSLSCT303: Industrial Enzymes, Tissue Culture and its applications

Prerequisites: Students should have basic knowledge of enzymes, plant and animal cell.

Course Objectives:

- To distinguish between various enzymes used in different food and textile industry.
- To demonstrate various aspects of plant tissue culture.
- To examine different culturing techniques of animal cells.
- Applications of plant and animal tissue culture.

Course Outcome:

On completion of the course, learner will be able to

- Understand the applications of enzymes in food and textile industry.
- Apply the knowledge in developing various transgenic plants.
- Evaluate the various applications of the tissue cultures and embryology.

Unit I: Enzymes in Industry (15L)

Industries: Textile Processing, Leather Processing, Paper & Pulp Processing, Detergents and laundry.

Food biotechnology: Fruit and vegetable processing: juices, nectars, purees; syrup and glucose isomerases, enzymatic synthesis of aspartame.

Other industrial uses: Vinegar, Baking, Cocoa fermentation, Olive oil production, fish processing industries.

Nutraceuticals: Probiotics::lycopene, isoflavonoids, glucosamine, phytosterol.

Feed Biotechology: lignocelluloses into feed using cellulases, silage.

Biopreservation: chemical preservatives and their safety concerns, LAB Bacteriocins - Types of bacteriocins, mode of action, applications and regulation.

Unit II: Plant Tissue Culture (15L)

Basics of plant tissue culture: totipotency, macro and micro nutrients, media.

Culture: micropropagation, Callus culture, Somaclonal variation, Suspension cell culture, Protoplast culture, Somatic hybridization, Cybrids, Somatic embryogenesis and synthetic seed production.

Conservation: Improvement, exploitation and conservation of genetic resources, Cryopreservation of genetic resources.

Recombinant technology: Plant transformation by *Agrobacterium tumfaciens*[including mechanism of T DNA transfer in wild type Agrobacterium], *A. rhizogenes*- its plasmid. Biolistic: factors that influence transformation success, chloroplast transformation: vectors, advantages and disadvantages of the technique.

Applications of transgenic: Overview, Recombinant proteins of pharmaceutical importance in plants including vaccine subunits, edible vaccines, from hairy root cultures.

Transgenic plants: Strategies for virus resistance, Herbicide resistance, Insect resistance, nematode infections and resistance, stress resistance [salt, water, temperature], Improved nutrition [carbohydrate, protein], improved shelf life; Novel applications: change in lipid profile for industrial purpose, biodegradable plastics, novel horticultural traits [flower colour, varigation].

Unit III: Animal Tissue culture (15L)

Basic of animal tissue culture: Methods of cell dissociation/separation and preparation of primary cell culture, characteristics of cells *in vitro*, cell culture growth parameters, detection, prevention and determination of contamination in tissue culture.

Culture: Short term culture, Specialized cells: bone marrow myogenesis*in vitro* skin cell culture, erythrogenesis, leukemia cells, chondriogenesis- *in vitro*, cryopreservation of tissues and cell lines.

Analysis and Production: cell synchronization, cell transformation *in vitro*, Mass cultivation- cytodex and biofermentors. Cell cloning and Transgenic animals.

Applications: Stem cells & therapeutic cloning, Tissue engineering and 3D printing.

Unit IV: Assisted Therapies (15L)

In Vitro Fertilization: Formation of sex gametes and embryonic development: Cell cycle: molecular details: Checkpoints (Damaged DNA, unreplicated DNA, spindle attachment, segregation of chromosomes) Meiosis (special division; Ime2, Rec8 and monopolin) Cell-cell fusion in normal and abnormal cells.

Basics of events during fertilization, molecules on sperm and egg and their interactions, post Fertilization, early embryonic development, causes of infertility, *In vitro* fertilization: sperm and egg culture, fertilization, embryonic culture at various stages of development, transfer of embryos.

Antisense therapy: Introduction, strategies. oligodeoxyribonucleotide, catalytic antisense RNA, triple - helix forming oligonucleotides (TFOs), production, and limitations, first generation antisense drugs, second generation antisense drugs.

Applications: cancer therapy, viral diseases, gene function analysis and in agriculture.

Gene therapy: Overview, viral and non viral Vectors for somatic cell gene therapy, Gene therapy for inherited immunodeficiency syndromes, Cystic fibrosis gene therapy, HIV-1 gene therapy.

PRACTICALS: PSLSCP 303:

1. Isolation and partial purification of Acid/ Alkaline phosphatase from potato
2. Analysis of purification fold of the extracted enzyme
3. Determination of molecular weight of enzyme by SDS-PAGE
4. Isolation and estimation of Nutraceuticals (lycopene/ isoflavanoids) by a suitable method.
5. Micropropagation of selected ex-plants.
6. Transformation using *Agrobacterium* spp**.**
7. RAPD analysis for plants
8. Establishment of Primary Culture (ATC) using a suitable source.

References:

1. Principles of Biochemistry by Lehninger, Nelson and Cox
2. Biochemistry by Stryer
3. Biochemistry by Harper
4. Industrial Biotransformations by A. Liese, K. Seelbach and C. Wandrey; Wiley – VCH
5. Introduction to plant tissue culture by M. K. Razdan
6. Animal Cell Culture by Ian Freshney
7. Basic Cell Culture by J. M. Davis
8. Animal Cell Culture by SudhaGangal

PAPER – PSLSCT304: Research Methodology and Quality Control

Prerequisites:

Course Objectives:

- To understand the different types of research work.
- To present the research work scientifically.
- To acquaint with latest good laboratory practices used in various industries.
- To explain the importance of Quality Management System.

Course Outcome:

On completion of the course, learner will be able to

- Design a research framework.
- Develop soft skills in compilation and presentationof their research work.
- Apply and practice good laboratory practices.
- Generate management quality assurance based on ISO tenets..

Unit I: Research Methodology (15L)

Meaning of Research;Objectives of research, motivation in research;Types of research – Descriptive, Analytical, Applied, Fundamental,Quantitative, Qualitative, Conceptual, Empirical and Other Types ofResearch;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 II Scientific writing (15L)

Meaning of Scientific and non scientific writings; Structures of Research proposals, Synopsis, Dissertations, Thesis, Research paper writings (Abstract, Introduction, Review literature, methodology, Results, Discussions, Summary, Conclusion, Bibliography etc); Presentations: Graphical, Tabular, Animation, Power point etc

Unit III: ISO (15L)

Introduction: Over View of standards in ISO9000 Family

Key principles: Key principles of ISO 9000- Quality Management System

ISO 9001: Detailed study on ISO 9001:2015 standard, based on a seven principles of quality management, including a strong customer focus, the motivation and implication of top management, the process approach and continual improvement

Application: Sector specific Application of ISO 9001- Quality Management System adapted by various industries

Unit IV: GMP/ GLP (15L)

Introduction to GMP (Good Manufacturing Practices) and GLP (good Laboratory Practices) in Pharmaceutical Industries

Overview: GMPs as enforcement by the U.S. Food Drug Administration (US FDA) under Title 21 CFR.

Documentation: Requirement related to GMP and GLP.

Case studies for Documentation related to SOP preparation and CAPA (Corrective action Preventive Action).

PRACTICALS: PSLSCP 304:

Literature review

References:

1. The Oxford Book of Modern Science Writing (Oxford Landmark Science) 2009 by Richard Dawkins
2. Writing Science: How to Write Papers That Get Cited and Proposals That Get Funded (2012) by Joshua Schimel
3. The Best of the Best of American Science Writing (The Best American Science Writing) 2010 by Jesse Cohen
4. From Research to Manuscript A Guide to Scientific Writing (Second Edition) By Katz**,** Michael J. (Springer Publication)
5. Science Research Writing for Non-Native Speakers of English byHilary Glasman-Deal, Imperial College Press, London, UK
6. Scientific Writing and Communication by Angellka Hofmann, Oxford University Press (2014)
7. ISO 9000 quality systems handbook fourth edition by David Hoyle
8. International standard ISO9001: quality management systems — requirements fifth edition 2015-09-15.

SEMESTER - IV

PAPER - PSLSCT401: Medical Biotechnology and Biomathematics

Prerequisites: Students should have basic understanding of limits and derivations; medical terms and genetic engineering

Course Objectives:

- To understand the application of mathematics in biology.
- To diagnose various diseases and disorders.
- To distinguish between various aspects of biopharming and pharmaceuticals.

Course Outcome:

On completion of the course, learner will be able to

- Apply mathematics in evaluation of biological experiments.
- Differentiate various diseases.
- Outline and capture the essence of pharmaceutical products.

Unit I: Therapeutics I (15L)

Pharmaceutical Research: Introduction, Traditional medicine versus emerging areas of focus, Role of Molecular biology - disease Models, Genomic Protein Targets and Recombinant Therapeutics; Structural Biology - Rational Drug Design, Chemical Biology and Molecular Diversity and interplay.

Therapeutic Proteins: Group I, II, III and IV and their applications in humans and animals, mode of action, stability, processing and formulation. Examples of each class - Monoclonal Antibodies, vitamins, 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, glucagon, secretin and antigens.

Unit II: Therapeutics II (15L)

Genetic Engineering of Vaccines: 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, Improvement and Generation of New Live Attenuated Vaccines - *Pseudorabies* Virus, *Vibrio* and *Poliovirus*, Recombinant Live Vectors - *Vaccinia* Virus, Recombinant BCG Vaccines, Attenuated *Salmonella* Strains, Poliovirus Chimaeras, Cross-species Vaccination, 'Live-dead' Vaccines, Other Virus Vectors and Recombinant *E. coli* Strains, DNA, RNA and 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 Signaling.

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.
Peptidomimetics: Definition, design, features, analysis and application.
Biosimilars: Definition, design, features, analysis and application.

Unit III: Biomathematics (15L)
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 IV: Diagnostics and Drug design (15L)
Diagnostics and Forensics: Inherited and non inherited diseases, Direct Detection of Gene Mutations - Allele-specific Oligonucleotides and Restriction Enzyme Site Analysis, ARMS, Oligonucleotide Ligation, and Fluorescently Labelled DNA Sequencing; Indirect Diagnosis with Linked Genetic Markers, Cancer screening; F**orensics:** Markers MLP, SLP, mitochondrial DNA, Y chromosome analysis, Applications.
Drug designing and Pharmacogenomics: types of pharmacogenetic knowledge and obstacles, variations of drug metabolizers, transporters, drug targets and biological milieu of drug action, pharmacogenomics of cancer syndromes, neuropsychotic disorders, alzheimer's disease, mental retardation, cardiovascular diseases and smoking and alcoholism, Eugenetics and epigentics of above disorders, genetic influences on drug targets involved in pharmacodynamics, long QT syndromes, emerging technologies.

PRACTICALS: PSLSCP401
1. Residual DNA analysis of recombinant therapeutic protein
2. Restriction Fragment Length Polymorphism
3. *In silico* drug designing with suitable example
4. Detection of Thalassemia / breast cancer mutations by PCR
5. Study of embryogenesis with suitable animal system
6. Multiplex PCR
7. Inhibition of cell division by its inhibitors
8. Pedigree analysis (disease/disorder/trait)

References:

1. Molecular Biology and Biotechnology, 4th edition (2002) by J. M. Walker and R. Rapley
2. Biotechnology for Beginners (2006) by ReinhardRenneberg
3. Biotechnology Vol5 by Rehm& Reed
4. Biotechnology, An Introduction (2008) by S. Ignacimuthu, S. J.
5. Biotechnology, Concepts and Applications (2009) by R. R. Vittal and R. Bhat
6. Biotechnology, Principles and Applications (2007) by S. C. Rastogi
7. Microbial Metabolism and biotechnology, e-book by Horst Doelle
8. Medical Biotechnology, Himalaya Publishing House, Mumbai, (2008) by Jogdand S. N.

9. Medical Biotechnology, Churchill Livingstone, Elsevier (2009) by JuditPongracz, Mary Keen

10. Medical Biotechnology, Oxford University Press, India (2010)by PratibhaNallari& V. VenugopalRao,
11. Therapeutic peptides and proteins by A. K. Banga

PAPER – PSLSCT402: Applied Biotechnology

Prerequisites:

Course Objectives:

- To outline various new technologies in the field of biotechnology.
- To explain the feasibility in setting up a biotechnology industry.
- To elucidate the fate and legalities in biotechnology industry.

Course Outcome:

On completion of the course, learner will be able to

- Analyze the feasibility of biotechnology industry.
- Explore the new biotechnology techniques.
- Adapt the legal and economical aspects of biotechonology.

Unit 1: Aquaculture (15L)

Aqua culture technology: definition, history and scope, constraints and recent development, criteria for selection of species, aquafarm engineering.

Pisiculture: cultivable fish species, seed production technology of carps, carps culture, mono and poly culture.

Prawn culture: cultivable prawn species, spawning techniques, culture methods in India.

Pearl oyster culture: pearl producing species, pearl culture technology, composition of pearl quality and prospects.

Seaweed culture: economically important species culture and post harvest technology.

Unit II: Nanotechnology (15L)

Bionanotechnology: Concept. Types of bionanostructures (Carbon nanostructures, nanoshells, dendrimers, quantum dots, nanowires, liposomes).

Synthesis of bionanoparticles: Physical, chemical and biological methods.

Applications of nanotechnology: medicine and diagnostics (antimicrobial properties, therapies, drug delivery including rate programmed drug delivery, Microencapsulation of cells. imaging) agriculture, environment.

Potential risks of Bionanotechnology.

Unit III: New emergent Technology (15L)

Biosensors: Concepts. Types of biosensors: ampereometric, potentiometric, conductometric, calorometric, peizoelectric, evanascent wave sensors, Surface Plasmon Resonance, whole cell biosensors.

Biomimetics: Concept and possible applications: Adhesion (lizard's foot) Water repulsion (lotus leaf), nanostructures in colour display (butterfly wings/ peacock feather).

Microfluidics: Fundamental characteristics of fluidics at microscale, applications of microfluidics (cell separation, dip sticks).

Biomechanics: Introduction and Biotechnology in biomechanics.

Unit IV: Economics of Biotechnology law and industrial considerations (15L)

Emerging trends in biotechnology industry, organizational structure, funding and investment, Demand, markets, viability, licensing, collaboration and technology transfer,

bioenterpreneuship in Rural and Urban India, Business ethics and government policy, Indian bioenterpreneurs

PRACTICALS: PSLSCP 402

1. Identification of cultivable fish species
2. Identification of cultivable prawn species
3. Identification of cultivable pearl bivalves and oyster species
4. Identification of cultivable seaweed species
5. Isolation and determination of colony characteristics of marine organisms
6. Synthesis of silver nanoparticles- biological method
7. Antimicrobial/Antioxidant activity of SNP
8. Demonstration of Laminar Flow in Microfluidic system

References:

1. Aquaculture by UjwalaJadhav
2. Bio - Nanotechology by Madhuri Sharon.
3. Molecular Biology and Biotechnology, 4th edition (2002) by J. M. Walker and R. Rapley
4. Microfluidics for Biotechnology 2nd Edition by Jean Berthier and Pascal Silberzan
5. Introduction to microfluidics by Patrick Tabeling
6. Economics of Biotechnology by T.V.S Rama Mohan Rao
7. Entrepreneurship and Business of Biotechnology by S. N. Jogdand
8. Economic dynamics of Modern Biotechnology by Maureen D. McKelvey, Annika Rickne, Jens Laage-Hellman

PAPER – PSLSC403: Environmental Biotechnology

Prerequisites: Basic knowledge about environment

Course Objectives:

- To outline various environmentalissues.
- To capture the importance of waste management.
- To explain application of biotechnology in environment mitigation.

Course Outcome:

On completion of the course, learner will be able to

- Enumerate the environmental friendly practices.
- Classify and manage different waste generated.
- Adapt methods for improvement of the environment.
- Integrate remediation principles with revenue generation.

Unit I: Biological Controls and Biopesticides (15L)

Chemical Pesticides: Spectrum of chemical pesticides for control of biotic stress: uses, advantages and disadvantages.

Spectrum of biological pesticides: types, advantage on chemical pesticides, mode of action, stability and formulation in natural and genetically modified organism, Selective targeting, Molecular mechanism of resistance development and strategies including integrated pest management.

Biopesticides from Plants: Neem and pyrethrins, mode of action on insect pests, Bio-control against fungal diseases of plants.

Biological Controls: Viral/ fungal/ bacterial parasites for control of insects pests, ife cycle, symptoms and mode of action.

Unit II: Nitrogen Fixation and Biofertilizers (15L)

Nitrogen fixation: Molecular genetics: nif genes and regulation of nif gene expression.

Biofertilizer: definition, methods of manufacture, application to soil and seed.

Aquaponics: fish culture and plant culture using this water.

Composting: physical and chemical factors, microbiology, health risk from pathogens, odour sources.

Mycorrhiza: Types, importance to plant health (nutrient uptake, resistance to stress, microbial symbiosis), importance of network analysis, role in ecosystem (Plant to plant interaction).

Biofuels: Liquid and gaseous. Bioenergy: Biofuels - Introduction, in the form of gas– hydrogen and methane (biogas), biofuel in form of liquid– ethanol and diesel, biofuel from phytoplankton.

Unit III: Bioremediation (15L)

Solid management: Types, need, unit processes, laws and regulations.

Adaptation: Effect of metals and salts on the growth of microbes and higher organisms, Different adaptation mechanism to tolerate higher concentration of metals by organisms.

Bioremediation: using natural, genetically engineered bacterial systems and plants with examples.
Biotechnology of coal
Bio-mineralization: Concept, Heaps and Dumps.

Unit IV: Phytoremediation and Phytomining (15L)
Phytoremediation: Types of phytoremediation**,** Restoration of soil, water and air quality citing suitable examples**.**
Phytomining: Indicator plants, extraction of valuable minerals/ metals from low grade ore/ soils.
Biotechnology in gold mining/ extraction.

PRACTICALS: PSLSCP403

1. Soil analysis- nitrogen, phosphorus, chloride, organic matter, & calcium carbonate content
2. Waste water analysis - pH, COD, BOD, Hardness, Halides, Total solids,
3. Effect of Neem pesticides on plant pathogens
4. Waste water analysis - alkalinity and chloride
5. Staining of mycorrhiza from root tips
6. Analysis of heavy metals uptake by plants
7. Identification of indicator plants for environmental conditions
8. Biofuels production

References:

1. Environmental Biotechnology by M. H. Fulekar
2. Environmental Sciences: Odum
3. Environmental Biotechnology: Alan Scragg
4. Environmental Biotechnology: BimalBhattachraya and Ritu Banerjee
5. Environmental pollution control engineering. C. S. Rao. New Age International Publishers.

PAPER – PSLSC404: Protein Biology and Drug Development

Prerequisites: Basic knowledge about biochemistry

Course Objectives:

- To understand protein processing and trafficking.
- To explain the interactions between biomolecules and disorders
- To develop drugs from natural resources.

Course Outcome:

On completion of the course, learner will be able to

- Explain the formation and localization of functional proteins.
- Evaluate the correlation between protein interactions and diseases.
- Explore natural resources for new drug formulations.

Unit I: Protein Trafficking and Targeting (15L)

N-glycosylation in the ER and Golgi (quality control, UPR, ERAD and proteosomal degradation

Intracellular and membrane protein trafficking and targeting; Secretory pathways in prokaryotes and eukaryotes; Endocytic pathways; Signal sequences; Co-translational transport (protease protection assay); Targeting of mitochondrial, chloroplast, peroxisomal and nuclear proteins; Vesicle biogenesis and ER to Golgi transport; ER translocation of polypeptides (soluble and transmembrane); ER chaperons; SNAPs and SNAREs; Methods of studying Protein Transport; Disorders of protein transport.

Unit II: Protein folding and Biomolecular Interactions (15L)

Protein Folding: Folding pathways; Intermediates of protein folding; Compact Intermediates; Hierarchical and non-heirarchical folding mechanisms; Molten globule structure; Role of chaperons (trigger factor, prefoldin), heat shock proteins (Hsp70, Hsp90), chaperonins (Group I & II) and enzymes in protein folding (PDI, PPI), Protein folding disorders.

Biomolecular Interactions and Diseases:

Structural and functional aspects of proteins and DNA: Relationships between structure and function and their role in human diseases; Protein-DNA interactions; Protein-RNA interactions; Protein-protein interactions; Protein aggregation; Non-enzymatic glycosylation (Protein-sugar interaction); Methods to study these interactions.

Molecular basis of disease: methods for prevention, diagnosis, and treatment; Advanced techniques used in the diagnostics of diseases due to structural alteration.

Unit III: Natural products

History of natural drugs, Sources of natural drugs - Plants, Animals, Microorganisms**;** Primary metabolites: carbohydrates, proteins, nucleic acids and lipids and their importance to plants**;** Secondary metabolites: Types, mechanism of synthesis, Importance in plants and for mankind as fragrance, pigments, flavours and medicines

Unit IV: Activity Guided Drug Development

Plant collection and Extract preparations: Methods of Plant collection, solvent extraction (cold, hot, critical fluid extraction etc), screening of medicinal properties; Natural products: methods of identification (Qualitative and Quantitative), isolation and purification (Chromatography), Characterization (LC-MS**,** GC-MS, NMR, XRD, Elemental analysis etc); Bio efficacy studies: *In vitro* testing - Antimicrobial, Anti-diabetic, Antioxidant, Anti-inflammatory, anti-larvicidal etc.; Pre-clinical and clinical trials.

PRACTICALS: PSLSCP404:

Research Project

References:

1. Chemistry of Natural Products by Sujata V. Bhat, B.A. Nagasampagi, MeenakshiSivakumar (Springer Publication)
2. Indian Uses of Native Plants by Edith Van Allen Murphey
3. Plant Taxonomy (2nd Edition) by Sharma
4. Plant Drug analysis by H. Wagner
5. Biochemistry and Molecular Biology of *Plants* by Bob B. *Buchanan*
6. Plant Secondary Metabolites
   Volume 1: Biological and Therapeutic Significance
   Volume 2: Stimulation, Extraction, and Utilization by Kamlesh Prasad,
7. VasudhaBansalHerbal Cosmetics &Ayurvedic Medicines by P. K. Chattopadhyay
8. *Textbook of Clinical Trials* by David Machin, Simon Day, Sylvan Green
9. Plant Bioactives and Drug Discovery: Principles, Practice, and Perspectives, 1st Edition ValdirCechinel-Filho, Wiley Publication.
10. Drug Discovery from Plants By Angela A. Salim, Young-Won Chin, A. Douglas Kinghorn (Springer publication)
11. Bioassay Methods in Natural Product Research and Drug Development By Lars Bohlin, Jan G. Bruhn (Springer Publication)
12. Principles of Biochemistry by Lehninger, Nelson and Cox
13. Biochemistry by Stryer
14. Biochemistry by Harper

SEMESTER III

	COURSE CODE											
Theory	**PSLSCT301**			**PSLSCT302**			**PSLSCT303**			**PSLSCT304**		
	Internal	External	Total	Internal	External	Total	Internal	External	Total	Internal	External	Total
	40	60	100	40	60	100	40	60	100	40	60	100
Practicals	**PSLSCP301**			**PSLSCP302**			**PSLSCP303**			**PSLSCT304**		
	-	50	50	-	50	50	-	50	50	-	50	50

SEMESTER IV

	COURSE CODE											
Theory	**PSLSCT401**			**PSLSCT402**			**PSLSCT403**			**PSLSCT404**		
	Internal	External	Total	Internal	External	Total	Internal	External	Total	Internal	External	Total
	40	60	100	40	60	100	40	60	100	40	60	100
Practicals	**PSLSCP401**			**PSLSCP402**			**PSLSCP403**			**PSLSCT404**		
	-	50	50	-	50	50	-	50	50	-	50	50