UNIVERSITY OF MUMBAI

Syllabus for the M.Sc. Part - II
[Semester III and IV]

Program: M.Sc.
Course: Life Sciences
Specialization:
Biochemistry

Choice Based Credit and Grading System

The Academic Year 2017-18

M.Sc. Semester III and IV - Life Sciences Syllabus
Restructured for Credit Based Semester and Grading System
To be implemented from the Academic year 2017-2018
SEMESTER III
Theory

Course Code	UNIT	TOPIC HEADINGS	Credits	L / Week
PSLSCBMT301 (Biomathematics and Cell Biology Techniques)	**I**	**Biomathematics**	**4**	
	II	**Cell and Molecular Biology Techniques**		
	III	**Animal Tissue Culture**		
	IV	**Plant Tissue Culture**		
PSLSCBMT302 (Bioenergetics and Carbohydrate Metabolism)	**I**	**Bioenergetics and Carbohydrate Metabolism**	**4**	
	II	**Lipid Metabolism**		
	III	**Amino Acid Metabolism**		
	IV	**Metabolic Engineering and Systems Biology**		
PSLSCBMT303 (Biomolecular Structure)	**I**	**Chemical Bonds and Spectroscopic Techniques**	**4**	
	II	**Protein and Nucleic Acid Structure**		
	III	**Supramolecular Assemblies and DNA-protein Interactions**		
	IV	**Biomolecular Structure and Diseases**		

Course Code	UNIT	TOPIC HEADINGS	Credits	L / Week
PSLSCBMT304 (Research Methodology and Quality Control)	**I**	**Research Methodology**	**4**	
	II	**Scientific Writing**		
	III	**ISO**		
	IV	**GLP and GMP**		

Practical

PSLSCBMP301	Biomathematics and Cell Biology Techniques	**2**	
PSLSCBMP302	Bioenergetics and Carbohydrate Metabolism	**2**	
PSLSCBMP303	Biomolecular Structure	**2**	
PSLSCBMP304	Literature Review	**2**	

SEMESTER IV

Theory

PSLSCBMT401 (Molecular Cell Biology)	**I**	**Cell Division and Apoptosis**	**4**	
	II	**Biomembrane and Cell Matrix**		
	III	**Protein Trafficking and Targeting**		
	IV	**Gene Silencing and Epigenetics**		

PSLSCBMT402 (Nitrogen Metabolism and Plant Biochemistry)	**I**	**Nucleotide Metabolism**	**4**	
	II	**Nitrogen Assimilation in Plants**		
	III	**Photosynthesis and Secondary Metabolism**		
	IV	**Free radicals and Antioxidant Biology**		

PSLSCBMT403 (Biomolecular Function)	**I**	**Protein folding and Engineering**	**4**	
	II	**Kinetics and Mechanism in Biological Systems**		
	III	**Metabolomics and Transcriptomics**		
	IV	**Nanobiology**		

PSLSCBMT404 (Drug Development and Environmental Toxicology)	**I**	**Natural products**	**4**	
	II	**Activity Guided Drug Development**		
	III	**Environmental toxicology**		
	IV	**Environmental monitoring**		

Practical

PSLSCBMP401	Molecular Cell Biology	**2**	
PSLSCBMP402	Nitrogen Metabolism and Plant Biochemistry	**2**	
PSLSCBMP403	Biomolecular Function and Environmental Toxicology	**2**	
PSLSCBMP404	Project	**2**	

M.Sc. Part – II Life Sciences Syllabus
Restructured for Credit Based Semester and Grading System
To be implemented from the Academic year 2017-2018
Semester III Detailed Syllabus

Course Code	Title	Credits
PSLSCBMT301	**Biomathematics and Cell Biology Techniques (60L)**	**4**
	Unit I: Biomathematics (15L) **Biomathematics**: 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: Cell and Molecular Biology Techniques (15L) **Cell Biology Techniques:** Principles, Instrument overview, and Applications of flow cytometry, Fluorescence Resonance Energy Transfer (FRET); Surface Plasmon resonance. **Proteomics:** Peptide synthesis and Protein sequencing methods, detection of post-translation modification of proteins; 2-D gel electrophoresis; Mass spectrometry; X-ray diffraction methods; Static and dynamic light scattering (SLS and DLS); Capillary electrophoresis; Protein chips; Differential scanning calorimetry; Isothermal titration calorimetry. **Genomics:** Oligonucleotide synthesis; DNA chips/microarrays; DNA hybridization; DNA sequencing methods; Strategies for genome sequencing; Methods for analysis of gene expression at RNA and protein level; Site directed mutagenesis; Gene knockdown; Differential display; Serial analysis of gene expression (SAGE).	
	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, ethrogenesis - 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: Plant Tissue Culture (15L) **Basics of plant tissue culture**: Totipotency, macro and micro nutrients, media. **Culture:** micropropogation, Callus culture, Somaclonal variation, Suspension cell culture, Protoplast culture, Somatic hybridization, Cybrids, Somatic embryogenesis and synthetic seed production. Cryopreservation. **Recombinant technology:** Plant transformation by *Agrobacterium tumfaciens*[including mechanism of T DNA transfer in wild type Agrobacterium], *A. rhizogenes*its plasmid, Biolistics: chloroplast transformation: advantages and disadvantages of the technique. **Applications of transgenics**: vaccine subunits, edible vaccines, from hairy root cultures. **Transgenic plants**: Stress resistance [salt, water, and temperature], Improved nutrition shelf life and Novel applications for industrial purpose, biodegradable plastics, and novel horticultural traits [flower colour, varigation]. **Examples of secondary metabolite production (**industrial scale**)**: [shikonin, taxol (biosynthesis and bioreactor production) capsasin/ berbrine].	

Practical:

PSLSCBMP301	**Biomathematics and Cell Biology Techniques (60L)** 1. Mathematical sums to be solved in biomathematics 2. Site directed mutagenesis 3. 2-D Gel electrophoresis (Demonstration) 4. Expression of foreign protein in *E. coli* 5. Establishment of Primary Culture (ATC) using a suitable source. 6. In vitro Culture - Washing & Sterilization, Preparatory steps for tissue culture, surface sterilization of plant material, basic procedures for Aseptic tissue transfer, incubation of culture. 7. Preparation of Culture media & Reagents - Media composition, Nutrition, Hormones. 8. Tissue Culture – Callus culture, Cell suspension 9. Preparation of plant protoplast and test for viability 10. Plant micro-propagation – micro-culture of plants. 11. Nucleic acid isolation and blotting A. Isolation of RNA from *E. Coli* B. Spectrophotometric characterization of RNA C. Capillary blotting (Southern/Northern) of nucleic acids from agarose gels	**2**	**04**

	D. Preparation of cDNA and RT-PCR 12. Demonstration of proteomic and genomic techniques.		

References:

1. Primrose, S.B. and Twyman, R.M. (2006) Principles of Genetic Manipulation and Genomics. Seventh Edition. Blackwell Publishing, USA.
2. Winnacker, E-L.(1987) From Genes to Clones. VCH Publishers, USA.
3. SambrookJ.and Russell D.2001.Molecular Cloning: A Laboratory Manual, 3rd edition. Cold Spring Harbor Laboratory Press, Cold Spring Harbor, New York.
4. A K Vasil. Cell culture and somatic cell genetics of plants (Vols.1to3) - A,Press.
5. Ed. John R.W Masters Animal cell culture-Practical approach 3rd edition, Oxford university press-2000
6. In vitro cultivation of Animal cells. Elsevier India PVT LTD-17-A/1 Main Ring Road, New Delhi-110024
7. R. Sasidhara, Animal Biotechnology MJP publishers-Chennai.
8. Industrial Biotrasformations by A. Liese, K. Seelbach and C. Wandrey; Wiley – VCH.
9. Role of Biotechnology in Medicinal and Aromatics Plants by Khan and Khanum Vol. 1 to 3. Plant Tissue Culture by M. K. Razdan.
10. Animal Cell Culture by Ian Freshney
11. Basic Cell Culture. Ed.J.M.Davis 2nd.Ed 2007. Oxford press
12. Animal Cell Culture SudhaGangal

Course Code	Title	Credits
PSLSCBMT302	**Bioenergetics and Metabolism (60L)**	**4**

Unit I: **Bioenergetics and Carbohydrate Metabolism (15L)**

Bioenergetics: Concept of free energy, standard free energy, determination of ΔG for a reaction; Relationship between equilibrium constant and standard free energy change, biological standard state & standard free energy change in coupled reactions; Biological oxidation-reduction reactions; Redox potentials; Relation between standard reduction potentials & free energy change; High energy phosphate compounds – introduction, phosphate group transfer, free energy of hydrolysis of ATP and sugar phosphates alongwith reasons for high ΔG.

Carbohydrate Metabolism: Glycolysis in higher organisms and microorganisms; Pentose phosphate pathway and its regulation; Gluconeogenesis, glycogenesis and glycogenolysis, glyoxylate and Gamma aminobutyrate shunt pathways; Cori cycle; Anaplerotic reactions; Entner-Doudoroff pathway; Glucuronate pathway; Metabolism of disaccharides; Hormonal regulation of carbohydrate metabolism; Inborn errors of carbohydrate metabolism.

Unit II: **Lipid Metabolism (15L)**

Fatty acid catabolism: Hydrolysis of tri-acylglycerols; α-, β-, ω- oxidation of fatty acids; Oxidation of odd numbered fatty acids – fate of propionate; Role of carnitine; Degradation of complex lipids; Formation of ketone bodies; Energetics of beta oxidation.

Fatty acid biosynthesis: Acetyl CoA carboxylase; Fatty acid synthase; ACP structure and function; Lipid biosynthesis; Biosynthetic pathway for tri-acylglycerols, phosphoglycerides, sphingomyelin and prostaglandins; Metabolism of cholesterol and its regulation; Biosynthesis of bile acids and steroid hormones; Alternative pathway for isoprenoid biosynthesis in chloroplast; Inborn errors of fatty acid metabolism.

Unit III **Amino Acid Metabolism (15L)**

Amino acid catabolism: Proteolysis; General reactions of amino acid metabolism - Transamination, decarboxylation, oxidative & non-oxidative deamination of amino acids; Acetyl CoA, alpha ketogutarate, acetoacetyl CoA, succinate, fumarate and oxaloaccetate pathway; Urea cycle and its regulation; Ammonia excretion.

Biosynthesis of Amino Acids: Biosynthesis of aromatic amino acids and Histidine; One carbon atom transfer by folic acid (Biosynthesis of glycine, serine, cysteine, methionine, threonine); Conversion of amino acids to specialized products; Inborn errors of protein metabolism.

TCA cycle: Central role of TCA cycle in energy generation and biosynthesis of energy rich bond; Integration/regulation of carbohydrate, lipid and

	protein metabolism.	
	Unit : IV **Metabolic Engineering and Systems Biology (15L)** **Metabolic Engineering:** Historical perspective and introduction; Importance of metabolic engineering; Paradigm shift; Information resources; Scope and future of metabolic engineering; Plant and microbial metabolic engineering; Metabolically engineered organisms; Metabolic flux analysis. **Systems Biology:** Concepts and working principles of System Biology - Practical applications of System Biology in Life Sciences - Introduction to System Biology platforms; Proprietary system Biology platform; Different Markup languages used in systems biology. Introduction to NGS technology.	

Practical:

PSLSCBMP302	**Bioenergetics and Metabolism (60L)** 1. Estimation of inorganic phosphorus by Fiske and SubbaRao method 2. Determination of pyruvate by 2,4-dinitrophenyl hydrazine method 3, Isolation of cholesterol and lecithin from egg yolk 4. Assay of alanine and aspartate aminotransferases 5. Fractionation of cell organelles from animal/plant tissues and identification by marker enzymes 6. Effect of metal ions on the activity of enzymes/proteins 7. Determination of Molar absorption coefficient of tyrosine	**2**	**04**

References

1. L. Stryer, Biochemistry, W.H. Freeman and Co. 5th 2002
2. Voet, Donald, Voe Judith, Pratt, Charlotte W. Fundamentals of Biochemistry: Life at the molecular Level 2nd Edition. Publisher: Asia, John Wiley & Sons. 2006.
3. Nelson David L., Cox Michale. Lehninger Principles of Biochemistry 5th Edition.Publisher: New York. W. H. Freeman. 2008.
4. Text Book of Biochemistry with clinical correlation by Thomas M. Devlin, John Wiley - Liss, Hobokhen NJ publishers (2006)
5. Zubey, Biochemistry GL WCB Publishers.
6. Stephanopoulos Gregory N., Aristidou Aristos A., Nielsen Jens. Metabolic Engineering: Principles and Methodologies. Publisher: New Delhi, Reed Elsevier India Pvt. Ltd. 2006.
7. Purich Daniel L., Allison R. Donald. The Enzyme Reference: A Comprehensive Guidebook to Enzyme Nomenclature, Reactions, and Methods. Publisher: California, Academic Press.
8. Andres Kriete (Editor), Roland Eils (Editor). System Biology: Computational Systems Biology (Hardcover)
9. Uri Alon, An Introduction to Systems Biology: Design Principles of Biological Circuits, Chapman & Hall/CRC Press, Mathematical and Computational Biology, 2nd edition, 2006.

Course Code	Title	Credits
PSLSCBMT303	**Biomolecular Structure (60L)**	**4**

Unit I: **Chemical Bonds and Spectroscopic Techniques (15L)**

Inter atomic interactions, ionic, covalent and metallic bonds; Importance of weak, non-covalent bonded interactions in biomolecules, such as Van der Waals forces and hydrogen bonding; Energies and geometrics of these interactions and their roles in structure and conformation of biomolecules.
Spectroscopic techniques: Principle, methodology and applications of Infrared, Raman, ESR, Atomic absorption spectroscopy.
Optical Activity: Importance of chirality in biomolecules; Principles and applications of CD and ORD.

Unit II: Protein and Nucleic Acid Structures (15L)

Structure and Stability of Proteins: Myoglobin, Hemoglobin, Lysozyme, Ribonuclease A, Carboxypeptidase and Chymotrypsin; Conformation of proteins by Ramachandran plot; N and C terminal analysis of proteins.
Covalent modification of proteins: Acetylation, phosphorylation, adenylation, methylation, ribosylation, lipidation.

Synthetic protein modifications: Protein-based hybrid structures and protein polymer systems; applications of protein polymer systems; Amino acid targeting for synthetic protein modification; Synthetic approaches for polymer-protein hybrid structure; Non-covalent approaches for polymer-protein conjugates; Protein-nanopartcle hybrids via surface conjugation; Biocatalytic approaches for biohybrid structures.

DNA structure: A/B/Z/D forms of double helical structure of DNA; Triple helix; DNA supercoiling and topoisomerases.

Unit III: Supramolecular Assemblies and Complex proteins (15L)

Viruses: Viral assembly; Capsid; Capsomere, eg., TMV, HIV, Adenovirus, Influenza.
Nucleic Acid Binding Motifs in Proteins: Leucine zipper; Zinc fingers; Helix-turn-helix; Beta barrel; OB fold and their role in regulation of gene expression.
Metalloproteins: General principles of metal coordination; Storage and transport metalloproteins (Rubredoxin, Plastocyanin, Ferritin, Ceruloplasmin); Signal-transduction metalloproteins (Calmodulin, Troponin); Metalloenzymes (Carbonic anhydrase, SOD, Hydrogenase).
Transport proteins: Oxygen transport proteins from vertebrate and invertebrate (haemoglobin, hemoeryhtrin, cytochrome C), Albumin.

Unit IV: Biomolecular Structure and Diseases (15L)

Structural and functional aspects of proteins and DNA: Relationships between structure and function and their role in human disease; DNA-protein 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. **Diseases:** Huntington's disease, Sickel-cell anemia**;** Cataract; Alzheimer's disease; p53 in cancer**;** Von Hippel-Lindau syndrome; Metabolic syndrome (Diabetes).	

Practical:

PSLSCBMP303	**Biomolecular Structure (60L)** 1. Protein purification methods: A. Isolation of casein from milk B. Purification of an enzyme by ion exchange chromatography/affinity chromatography C. Use of ammonium sulphate precipitation and dialysis D. Use of gel filtration E. SDS-PAGE 2. Polyacrylamide gel electrophoresis under non denaturing conditions A. Silver staining B. Activity staining of enzymes C. Determination of effect of acrylamide concentration on the mobility of proteins 3. Determination of melting temperature (Tm) of DNA. 4. Analysis of DNA A. Estimation of DNA and RNA by UV absorption method B. Determination of purity of nucleic acids C. Conformational analysis of plasmid DNA by agarose gel electrophoresis (Oxidative/carbonyl stress induced damage). 5. Spectrofluorimetric analysis of proteins 6. Determination of N- and C-terminal amino acids (demonstration). 7. Protein aggregation studies by Congo Red and Thioflavin T. 8. Generation and measurement of non-enzymatic glycosylated products (Protein/DNA). 9. Assay of transport protein (BSA) – esterase activity. 10. Analysis of protein-sugar-DNA interactions	**2**	**04**

References:

1. K. Wilson and I. Walker, Practical Biochemistry, 5th edition, University press (2000)
2. Shawney, Practical Biochemistry

3. P. Asokan, Analytical Biochemistry. China publications, (2003)
4. David Frifelder, Physical Biochemistry, W. H. Freeman; 2nd edition (1982)
5. Sheehan, D. (2009) Physical Biochemistry: Principles and Applications. John Wiley & Sons Ltd., UK.
6. Branden, C. I. and Tooze, T.(1999) Introduction to Protein Structure. Garland Publishing, USA.
7. Lesk, A. M. (2004) Introduction to Protein Science: Architecture, Function and Genomics. Oxford University Press, UK.
8. Creighton, T.E. (1983) Proteins: Structures and Molecular Properties. W.H. Freeman and Co., USA.
9. Pain, R.H. (2000) Mechanism of Protein Folding. Oxford University Press, UK.
10. Arai, M. and Kuwajima, K. (2000) Advances in Protein Chemistry. Academic Press, USA
11. The Chemical Reactions of Living Cells: David E Metzler
12. William J. Marshall, Stephan K. Bangert, Elizabeth S.M. Ed. S.M (ed) Marshall, Clinical Biochemistry: Metabolic And Clinical Aspects by (2008) Publisher: Elsevier Science Health Science Div

Course Code	Title	Credits
PSLSCBMT304	**Research Methodology and Quality Control (60L)**	**4**
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 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 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:** Good Manufacturing Practices (GMO) and Good Laboratory Practices (GLP) in Pharmaceutical Industries. Overview of GMPs is enforcement by the U.S. Food Drug Administration (US FDA) under Title 21 CFR **Documentation requirement** for GMP and GLP **Case studies for Documentation** related to SOP preparation and CAPA (Corrective action Preventive Action).		

PSLSCBMP304	**Dissertation in Literature Review** **(60L)** 1. Project dissertation of literature review	**2**	**04**

References:

1. Kothari, C.R., 1985, Research Methodology - Methods and Techniques, New Delhi, Wiley Eastern Limited.
2. Das, S.K., 1986, An Introduction to Research, Kolkata, Mukherjee and Company Pvt. Ltd.
3. Misra R.P., 1989, Research Methodology: A Handbook, New Delhi, Concept Publishing Company
4. Kumar, R., 2005, Research Methodology - A Step-by-Step Guide for Beginners,(2nd.ed.), Singapore, Pearson Education.
5. Bhattachraya, D.K., 2006, Research Methodology,(2nd.ed.),New Delhi, Excel Books.
6. Panneerselvam R., 2012, Research Methodology, New Delhi, PHI Learning Pvt. Ltd.
7. ISO 9000 quality systems handbook fourth edition by David Hoyle
8. International standard iso9001 : quality management systems — requirements fifth edition 2015-09-15.
9. Pharmaceutical quality assurance for students of pharmacy, @nd edition Dec.2007.by Mr. manohar a. Potdar. NiraliPrakashan.
10. How to Practice GMPs 7th ed. by P.P. Sharma ,Seventh edition 2015.
11. Hand Book, Good Laboratory Practices: Quality practices for regulated non-clinical research and development, 2nd Edition, 2009.
12. The Oxford Book of Modern Science Writing (Oxford Landmark Science) 2009 by Richard Dawkins (Author, Editor)
13. Writing Science: How to Write Papers That Get Cited and Proposals That Get Funded (2012) by Joshua Schimel (Author)
14. The Best of the Best of American Science Writing (The Best American Science Writing) 2010 by Jesse Cohen (Author)
15. From Research to Manuscript A Guide to Scientific Writing (Second Edition) By Katz**,** Michael J. (Springer Publication)

M.Sc. Part – II Life Sciences Syllabus
Restructured for Credit Based Semester and Grading System
To be implemented from the Academic year 2017-2018
Semester IV Detailed Syllabus

Course Code	Title	Credits
PSLSCBMT401	**Molecular Cell Biology (60L)**	**4**
Unit I: **Cell Division and Apoptosis (15L)** **Cell division and cell cycle:** Meiosis: its regulation, steps in cell cycle, and control of cell cycle. Cell-cell fusion in normal and abnormal cells. **Programmed Cell Death**: Regulation of Apoptosis; Induction and Inhibition by Genes and proteins involved in apoptosis; Receptors with death domains and their signalling pathways; Role of apoptosis in development and disease; Caspase-independent pathways eg., Necrosis, necrotopsis, autophagy, mitotic catastrophy. **Carcinogenesis**: Characteristics of cancerous cells; Agents promoting carcinogenesis; molecular basis of cancer therapy, Tumor markers - AFP, CEA, hCG; Telomere replication; Telomerase and its role in cancer and aging.		
Unit III: **Biomembrane and Cell Matrix (15L)** **Biomembranes:** Structure and assembly; Orientation of membrane proteins, their solubilisation with detergents and enzymes; Membrane reconstitution; Liposomes and their application in biology and medicine **Nuclear pore complex:** Structure; Assembly and disassembly; RNA transport; Role in macromolecular exchange and regulation; nuclear import–export cycle **Molecules of the matrix:** Proteins of the microfilament, microtubules and intermediary filaments; Structure, properties and assembly of actin and tubulin, examples and roles of these filaments in cell structure and function, eg., dynamics and roles of kinesin and dynein; Organization of proteins on microvillus; Cell-cell/cell-matrix interactions.		
Unit III: **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 IV: **Gene silencing and Epigenetics (15L)** **Gene silencing:** Historical background; RNA interference as regulatory		

	mechanism in eukaryotes; Slicer and dicer; Synthesis and function of RNAi molecules in plants; Gene silencing mechanisms; RNAi-based gene therapy; Chromatin remodelling in human disease and diagnosis **Epigenetics:** Background, chromosomal inheritance taking fission yeast as an example; DNA methyltransferases, DNA methylation maintenance; Histone modification and regulation of chromatin structure; Bivalent histones; Histone demethylation; Epigenetic therapy; Epigenetic regulation of gene expression	

Practical:

PSLSCP401	**<u>Molecular Cell Biology</u> (60L)** 1. Preparation of lipid bilayer vesicles (liposomes) using the purified lipids 2. Effect of detergents on membranes 3. Protease protection assay to study protein transport and secretion 4. Isolation of DNA and demonstration of apoptosis of DNA laddering 5. MTT assay for cell viability and growth 6. UV damage and repair mechanism in *Escherichia coli* or *Serratia marcescens* 7. Synthesis of siRNA 8. Histone modification assays	**2**	**04**

References

1. Kleinsmith and Harden, The World of the cell, Becker, Academic Internet Publishers; 5th edition (2006)
2. Geoffrey M. Cooper and Robert E. Hausman. The Cell: A Molecular Approach, Fourth Edition
3. Harvey Lodish. Molecular cell Biology. W. H. Freeman; Sol edition (2007)
4. Alberts B., Johnson, A., Lewis, J., Raff, M., Roberts, K. and Walter, P. (2002) Molecular Biology of the Cell. Garland Publishing, Taylor & Francis Group, USA.
5. Karp, J.G. (2007) Cell and Molecular Biology. John Wiley & Sons, USA.
6. Kleinsmith, L.J.and Kish, V.M. (1996) Principles of Cell & Molecular Biology. Second Edition. Harper Collins College Publishers, USA.
7. Pollard, T.D. and Earnshow, W.C.(2002) Principles of Cell and Molecular Biology, Saunders, USA.
8. Ross Dalbey (Editor), Protein Targeting, Transport, and Translocation:, Publisher: Academic Press; 1 edition (May 13, 2002)
9. T Gesteland et al. The RNA World Eds CSHL Press
10. Eds. Fire et. al. RNA Interference Technology: From Basic Science to Drug Development. Cambridge University Press,
11. Ed. Gregory J. Hannon. RNAi: A Guide to Gene Silencing. CSHL Press
12. Ed. Gordon G. Carmichael. RNA Silencing: Methods and Protocols CSHL Press
13. Ed. Ute Schepers, RNA Interference in Practice, Wiley-VCH GmbH & Co. KGaA.
14. B. M. Turner, Chromatin and Gene Regulation: Molecular Mechanisms in Epigenetics

Course Code	Title	Credits
PSLSCBMT402	**Nitrogen Metabolism and Plant Biochemistry (60L)**	**4**
	Unit II: **Nucleotide Metabolism** **(15L)** Nucleotide Metabolism: Role of nucleases and phosphodiesterases in the degradation of nucleic acids; Biosynthesis and degradation of purines and pyrimidine nucleotides and their regulation; Thymine biosynthesis; Role of foluc acid in nucleotide biosynthesis; Purine salvage pathway; Role of ribonucleotide reductase; Biosynthesis of deoxyribonucleotides and polynucleotides; Inhibitors of nucleic acid biosynthesis; Inherited disorders of nucleotide metabolism; Anticancer drugs; Nucleotide metabolism as target for cancer, antiviral therapy and malaria.	
	Unit II: **Nitrogen Assimilation in Plants** **(15L)** Nitrogen Fixation: Nitrogenase complex; Electron transport chain and mechanism of action of nitrogenase; Structure of 'NIF' genes and its regulation; Hydrogen uptake and bacterial hydrogenases. Nitrate assimilation in plants: Structural features of nitrate reductase and nitrite reductase, incorporation of ammonia into organic compounds, regulation of nitrate assimilation; Ammonium assimilating enzymes – glutamine synthetase, glutamate synthase and GDH.	
	Unit III: **Photosynthesis and Secondary Metabolism** **(15L)** **Photosynthesis:** Light harvesting complexes; plant mitochondrial electron transport and ATP synthesis; alternate oxidase; Carbon fixation by C_3, C_4 and CAM pathways; Photoprotective mechanisms; Photorespiration; Bioluminescence. Special features of secondary plant metabolism, terpenes (classification and biosynthesis), lignin, tannins, pigments, phytochrome, waxes, alkaloids; Biosynthesis of nicotine; Functions of alkaloids.	
	Unit IV: **Free radicals and Antioxidant Biology** **(15L)** **Free radicals:** Introduction & Chemistry of Reactive Oxygen/Nitrogen Species (ROS/RNS); Sources of ROS/RNS; Transition metals as catalyst; ROS and Signal Transduction; Glycation mediated free radicals; Carbonyl and oxidative stress; Beneficial Aspects of Oxidative Metabolism. Oxidative damage markers Methods of Detecting ROS/RNS; Detection of free radicals in biological systems; EPR spectroscopy principles and determination. **Antioxidants:** Diet-Derived Antioxidants; Enzymatic and non-enzymatic components of antioxidative defense mechanism (catalase, peroxidase, superoxide dismutases, vitamins E and C, uric acid, glutathione, metal chelators); Chemical scavengers; Antioxidant therapy. **Role of free radicals in development of diseases:** Mechanisms of Protein oxdidation, Lipid peroxidation, DNA oxidation. Types of oxidized lesions and their biological importance	

Practical:

PSLSCBMP402	**Nitrogen Metabolism and Plant Biochemistry (60L)** 1. Measurement of activity of plant nitrate assimilation enzymes A. Isolation of nitrate reductase from plants B. Effect of environmental factors and hormones (CO_2, light, pH, growth hormones) 2. Measurement of free radicals by spectrophotometric method (Total phenolics, DPPH assay, ABTS assay, FRAP assay) 3. Analysis of free radical scavengers and antioxidant enzymes (Assay of any one - peroxidase, catalase, phenol oxidase, ascorbic acid oxidase, SOD) 4. Generation and measurement of oxidative and carbonyl stress in proteins and DNA (Protein oxidation method/DNA cleavage assay) 5. Plant pigments A. Extraction of plant pigments from spinach B. Separation by column chromatography C. Determination of absorption spectra of plant pigments	**2**	**04**

References

1. Campbell and Farrell: Biochemistry 4th ed. Brooks/Cole Pub Co.
2. Buchanan: Biochemistry and molecular Biology of Plant
3. Heldt - Plant Biochemistry
4. Lubert Stryer, Biochemistry, W. H. Freeman; 6 editions (2006).
5. Voet and Voet, Fundamentals of Biochemistry:
6. Kuchel and Ralston, Biochemistry 1998. 2nd ed. Schaum's Outlines McGraw Hill.
7. Harper's Biochemistry: Murray, et al. 2003. 28th ed. McGraw Hill.
8. Nelson & Cox, Lehninger's Principle of Biochemistry
9. K.G Ramawat, Biotechnology: Secondary Metabolites (2000) Publisher: Science Publishers, U.S.
10. P.M Dey and J.B. Harborne, Plant Biochemistry (1997) Publisher: Academic Press
11. Prof David T. Dennis, Prof David H. Turpin, Dr Daniel D. Lefebvre and Dr David B. Layzell(Editors), Plant Metabolism by (1997) publisher: Longman
12. Packer L and Helumt S. Oxidative Stress and Inflammatory Mechanisms in Obesity, Diabetes, and the Metabolic Syndrome. CRC Press.
13. Milan Lazár, Free Radicals in Chemistry and Biology,
14. Barry Halliwell, Free Radicals in Biology and Medicine (Paperback), John Gutteridge
15. Barry Halliwell, DNA & Free Radicals (Textbook Binding), Okezie I. Aruoma (Editor)

Course Code	Title	Credits
PSLSCBMT403	**Biomolecular Function (60L)**	**4**

Unit I: Protein folding and Engineering (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. **Protein Engineering** Design and construction of novel proteins and enzymes using site-directed mutagenesis and Random/directed evolution strategies; Conformation of proteins in general and enzymes in particular; Effect of amino acids on structure of proteins; Energy status of a protein molecule, Structure- function relations of enzymes. Basic concepts for design of a new protein/enzyme molecule; Specific examples of enzyme engineering – Dihydrofolate reductase and Subtilisin.

Unit II: Kinetics and Mechanism in Biological Systems (15L)

Enzyme Kinetics: Enzyme catalysis and factors contributing to high catalytic rates; Molecular aspects of catalysis for specific enzyme substrate complexes (Lysozyme, carbonic anhydrase, carboxypeptidase and chymotrypsin); Multisite binding of ligands to proteins; Bohr's effect; Models of Allostery - MWC and KNF models Hill's equation coefficient; Kinetics of multi-substrate enzyme-catalysed reactions; Ping-pong bi-bi, random order and compulsory order mechanism. **Immobilised enzymes:** Methods and applications.

Unit III: Metabolomics and Transcriptomics (15L)

Metabolomics: Modern Concept of metabolomics; Detection and characterization of metabolites; metabolite library; Metabolite isolation and analysis by Mass Spectrometry, NMR, LIF, LC-UV; Metabolomics databases and resource (e.g. MetaboLights).

Plant metabolomics: Plant stress responses, nutrigenomics, and metabolite dynamics; Metabolite profiling in phenotyping and breeding (*Arabidopsis* ecotypes, rice).

Transcriptomics: basic concepts and technology, data normalization, clustering (Hierarchical, k-means, SOM), detection of over expression and under expression (PCA). Modeling using Boolean Networks. EST, Unigene.

Unit IV: Nanobiology (15L)

Introduction: Nanoscience; Nanobiotechnology; Nanodevices; Applications in various fields viz. Physical and Chemical, Materials and Life Sciences.

Application: Gold bonding proteins; Nanopharmaceuticals such as liposomal formulations; Membrane nanodiscs; Biosensors; Nanowires. **Synthesis of nanostructure:** Physical, chemical and biological methods. **Properties and Characterization of nanomaterials:** Optical (UV-Vis / Fluorescence), X-ray diffraction; Imaging and size (Electron microscopy,

Light scattering, Zeta potential), Surface and composition (ECSA, EDAX, AFM/STM).	

Practical:

PSLSCBMP403	**Biomolecular Function and Environmental Toxicology (60L)** 1. Protein denaturation by Guanidine hydrochloride/urea 2. Enzyme inhibition A. Inhibition of enzyme activity B. Determination of Ki values 3. Immobilization studies: A. Preparation of urease entrapped in alginate beads and determination of percent entrapment B. Study of the kinetics of the rate of urea hydrolysis by urease entrapped alginate beads C. Study of reusability and storage stability of urease entrapped alginate beads D. Immobilization of urease by covalent attachment to solid support 4. Study of nanoparticles A. Synthesis of Silver nanoparticles B. Spectroscopic characterisation 5. Toxicity testing: Effect of chemicals on seeds 6. Cytotoxicity assay (onion root tip/pollen germination) to estimate water contamination	**2**	**04**

References:

1. Lutz, S. and Bornschesser, U. T. (2008) Protein Engineering Handbook. Wiley-VCH,
2. Gary C. Howard, Modern Protein Chemistry: Practical Aspects Published: September 12, 2001 by CRC Press
3. Thomas E. Creighton, Proteins: Structures and Molecular Properties Publisher: W. H. Freeman 1992 Edition: Second Edition
4. Christian Müller (Editor), Protein Engineering Protocols (Methods in Molecular Biology) K, Publisher: Humana Press; Softcover reprint of hardcover 1st ed. 2007
5. Anders Liljas, Structural Aspects of Protein Synthesis Publisher: World Scientific Pub Co Inc; 1 edition (November 2004)
6. David S. Goodsell, Bionanotechnology: Lessons from Nature, 1st Edition, Wiley-Liss, 2004.
7. Nicholas C. Price, Lewis Stevens, and Lewis stevens, Fundamentals of Enzymology: The cell and molecular Biology of Catalytic Proteins by (2000) Publisher: Oxford University Press, USA
8. Alejandro G. Marangoni, Enzyme Kinetics: A modern Approach Book: Enzyme Kinetics: A Modern Approach, (2003) Publisher: Wiley-Interscience Enzyme Kinetics and Mechanisms by Taylor Publisher: Springer
9. W. Weckwerth, Metabolomics: Methods and Protocols, Humana Press, USA (2006).
10. M. Tomita and T. Nishioka, Metabolomics: The Frontier of Systems Biology, Springer Verlag, Japan (2005).

Course Code	Title	Credits
PSLSCBMT404	**Drug Development and Environmental Toxicology (60L)**	**4**
	Unit I: Natural products (15L) History of natural drugs, Sources of natural drug ie Plants, Animals, Micro organisms**;** 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 II: Activity Guided Drug Development (15L) 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, Antidiabetic, Antioxidant, Antiinflammatory, antilarvicidal etc. Pre clinical and clinical trials.	
	Unit III: Environmental toxicology (15L) **Toxic chemicals in the environment** (air and water): their effects and biochemical interactions **Biochemical aspects:** of arsenic, cadmium, lead, mercury, carbon monoxide, ozone and PAN pesticide; Mode of entry of toxic substance, its breakdown and detoxification; biotransformation of xenobiotics; Insecticides / Pesticides in environment, MIC effects. **Carcinogens**: in environment, chemical carcinogenicity, mechanism of carcinogenicity, environmental carcinogenicity testing. **Epidemiological issues** of toxic compounds and metal poisoning.	
	Unit IV: Environmental monitoring (15L) **Basics:** Definition and environmental monitoring process; Sampling – land (site) sampling, water sampling, air sampling. **Analysis**: physical, chemical and biological analysis methods and process. **Monitoring pollution**: Bioindicators, Biomarkers. **Toxicity:** testing using biological material. **Biosensors**: mechanism, principle and working. **Environment Impact Assessment**: EIA complete process, Importance of EIA. **Principles of environmental mitigation and monitoring**. **Remote sensing**: Principles and its applications in Environmental Monitoring. **Geographical Information System (GIS):** Concept of GIS; Types of Geographical Data.Importance of Geographical Information System in environmental studies.	

PSLSCBMP404	**Dissertation of Research Project (60L)** 1. Project studies: presentation and preparation of report of observations and results	**2**	**04**

References:

1. Chemistry of Natural Products by Sujata V. Bhat , B.A. Nagasampagi , Meenakshi Sivakumar (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. Vasudha Bansal Herbal 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 Valdir Cechinel-Filho (Author), 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. An Introduction to environmental toxicology: Michael H.Dong.
13. Environmental biotechnology: Alan Scragg.
14. Remote Sensing and GIS: Basudev Bhatta