Centre for Plant Sciences

School of Basic and Applied Sciences

Central University of Punjab, Bathinda

M.Sc. Program in Life Sciences

Specialization: Plant Sciences

Academic Session

2016-17

Centre for Plant Sciences

M.Sc. Life Sciences (Plant Sciences)					
Semester-I					
Paper Code	**Course Title**	**L**	**T**	**P**	**Cr**
Fundamental Courses					
LSS.501	Biostatistics	2			2
LSS.502	Research Methodology	2			2
Core Courses					
LSS.503	Biochemistry	2	1		3
LPS.504	Introductory Plant Sciences	3	1		4
LSS.505	Cell Biology	2	1		3
LSS.506	Genetics	2	1		3
LSS.XXX	Elective Course-1	2			2
LPS.XXX	Inter-disciplinary	2			2
LPS.507	Biochemistry (P)			1	1
LPS.508	Cell Biology (P)			1	1
LPS.509	Genetics (P)			1	1
LPS.XXX	Elective Course (P)			1	1
LSS 599	Synopsis seminar				0
	Total Sem-1	17	4	4	**25**
Elective					
LPS.551	Plant Biosystematics	2			2
LPS.552	Plant Biosystematics (P)			1	1
Interdisciplinary courses offered					
LPS.401	Basic Concepts in Genetics-1	2			2

L: Lectures T: Tutorial P: Practical Cr: Credits

A: Continuous Assessment: Based on Objective Type Tests (10%), Term Paper (10%) and Assignment(s) (5%)

B: Pre-Scheduled Mid Semester Test-1: Based on Objective Type & Subjective Type Test (By Enlarged Subjective Type) (25%)

C: Pre-Scheduled Mid Semester Test-2: Based on Objective Type & Subjective Type Test (By Enlarged Subjective Type) (25%)

D: End-Term Exam (Final): Based on Objective Type Tests (25%)

LSS.501: Biostatistics. Credits Hours: 2. Semester I.

Unit 1 **8 Lectures**

Overview of Biostatistics: Difference between parametric and non-parametric statistics, Univariant and multivariant analysis, Confidence interval, Errors, Levels of significance, Hypothesis testing.

Unit 2 **8 Lectures**

Descriptive statistics: Measures of central tendency and dispersal, Histograms, Probability distributions (Binomial, Poisson and Normal), Sampling distribution, Kurtosis and Skewness.

Unit 3 **8 Lectures**

Experimental design and analysis: Sampling techniques, Sampling theory, Various steps in sampling, collection of data-types and methods.

Unit 4 **12 Lectures**

Inferential Statistics: Student's t-test, Paired t-test, Mann-Whitney U-test, Wilcoxon signed-rank, One-way and two-way analysis of variance (ANOVA), Critical difference (CD), Least Significant Difference (LSD), Kruskal–Wallis one-way ANOVA by ranks, Friedman two-way ANOVA by ranks, χ^2 test. Standard errors of regression coefficients, Comparing two regression lines, Pearson Product-Moment Correlation Coefficient, Spearman Rank Correlation Coefficient, Power and sampling size in correlation and regression.

Suggested Reading:

1. Gookin, D. (2007). *MS Word 2007 for Dummies*. Wiley, USA.
2. Harvey, G. (2007). *MS Excel 2007 for Dummies*. Wiley, USA.
3. Johnson, S. (2009). *Windows 7 on demand*. Perspiration Inc. USA.
4. Norman, G. and Streiner, D. (2008). *Biostatistics: The Bare Essentials.* 3/e (with SPSS). Decker Inc. USA.
5. Sokal, R.R. and Rohlf, F.J. (1994). *Biometry: The Principles and Practices of Statistics in Biological Research*. W.H. Freeman publishers, USA.
6. Thurrott, P. and Rivera, R. (2009). *Windows 7 Secrets*. Wiley, USA.

LSS.502: Research Methodology. Credit Hours: 2. Semester I.

Unit 1 **5 Lectures**

General principles of research: Meaning and importance of research, critical thinking, formulating hypothesis and development of research plan, review of literature, interpretation of results and discussion.

Unit 2 **10 Lectures**

Technical writing: Scientific writing that includes the way of writing Synopsis, research paper, poster preparation and presentation, and dissertation.

Unit 3 **5 Lectures**

Library: Classification systems, e-Library, web-based literature search engines

Unit 4 **16 Lectures**

Entrepreneurship and business development: Importance of entrepreneurship and its relevance in career growth, characteristics of entrepreneurs, developing entrepreneurial competencies, types of enterprises and ownership (large, medium SSI, tiny and cottage industries, limited, public limited, private limited, partnership, sole proprietorship) employment, self-employment and entrepreneurship, financial management-importance and techniques, financial statements- importance and its interpretation, and Intellectual Property Rights (IPRs).

Suggested Reading:

1. Gupta, S. (2005). *Research methodology and statistical techniques.* Deep & Deep Publications (p) Ltd. New Delhi.
2. Kothari, C.R. (2008). *Research methodology (s).* New Age International (p) Limited. New Delhi.
3. Standard /Reputed Journal authors' instructions.

LSS.503: Biochemistry. Credits Hours: 3. Semester I.

Unit 1 **10 Lectures**

Principles of biophysical chemistry, pH, Buffer, Reaction kinetics, Thermodynamics, Colligative properties, Structure of atoms, Molecules and chemical bonds. Stabilizing interactions: Van der Waals, Electrostatic, Hydrogen bonding, Hydrophobic interaction, etc.

Unit 2 **20 Lectures**

Composition, structure and function of Biomolecules: Carbohydrates, Lipids, Proteins, Nucleic acids and Vitamins. Bioenergetics and metabolism of Carbohydrates, Lipids, Amino Acids and Nucleotides.

Unit 3 **11 Lectures**

Enzymology: Classification, Principles of catalysis, Mechanism of enzyme catalysis, Enzyme kinetics, Enzyme regulation, Isozymes Clinically important enzymes.

Unit 4 **13 Lectures**

Protein Chemistry: Ramachandran plot, Secondary, Tertiary and Quaternary structure, Domains, Motif and Folds. Nucleic acids: A-, B-, Z-DNA, tRNA, micro-RNA, Stability of protein and Nucleic acid structures.

Suggested Reading:

1. Berg, J.M., Tymoczko, J.L. and Stryer, L. (2010). *Biochemistry.* W.H. Freeman & Company. USA.
2. Brown, T.A. (2006). *Gene Cloning and DNA analysis: In Introduction*. Blackwell Publishing Professional. USA.
3. Haynie, D.T. (2007). *Biological thermodynamics*. Cambridge University. UK.
4. Mathews, C.K., Van Holde, K.E. and Ahern, K.G. (2000). *Biochemistry*. Oxford University Press Inc. New York.
5. Nelson, D. and Cox, M.M. (2008). *Lehninger Principles of Biochemistry*. BI publications Pvt. Ltd. Chennai, India.
6. Ochiai, E. (2008). *Bioinorganic chemistry: A survey.* Academic Press. Elsevier, India.
7. Randall, D. J., Burggren, W. and French, K. (2001). *Eckert animal physiology*. W.H. Freeman & Company. USA.
8. Raven, P.H., Johnson, G.B. and Mason, K.A. (2007). *Biology*. Mcgraw-Hill. USA.
9. Shukla AN (2009). *Elements of enzymology.* Discovery Publishing. New Delhi, India.

10. Voet, D. and Voet, J.G. (2008). *Principles of biochemistry*. CBS Publishers & Distributors. New Delhi, India.

LPS.504: Introductory Plant Sciences. Credit Hours 4. Semester I

Unit 1: 18 Lectures

Origin, Evolution and Diversification of Plants Life on Earth: Origin of green cells from abiotic components, Origin of multicellularity, Diversity of plant life- classification, Evolution from algae to higher plants, Conquer of land by angiosperms, Plant reproduction, seed and fruit formation

Unit 2: 18 Lectures

Plant Structure and Propagation: Basic types of plant cells and tissues , Plant organs and their anatomy, Plant genome structure and division, Meristematic tissues and basis of indeterminate growth, Principles and practices of macro and micro propagation

Unit 3: 18 Lectures

Plant Growth and Development: Energy processes: Overview of Transport processes in plants, Plant hormones in growth and development, Signal molecules in plant growth, development and stress

Unit 4: 18 Lectures

Plants and Society: Interaction of plants and environment, Plants and society: Dependence of human societies on plants for food, fiber, health and environment.

Suggested Readings:

1. Mauseth, James D. (2014). Botany- an introduction to Plant Biology 5th edition. Jones and Bartlett Learning, USA
2. Taiz, L., Zeiger, E. Mollar, I. M. and Murphy, A. (2015). Plant physiology and Development 6th edition. . Sinauer Associates Inc., USA.
3. Clark, David P. and Pazdernik, Nanette, J, (2016) Biotechnology, 2nd edition. Elsevier Academic Cell
4. Taylor, D.J., Green, N.P.O and Stout, G.W. (1997). Biological Science. Cambridge University Press.
5. Rost, Thomas, L., Barbour, Michael, G, Stocking, C. R.and Murphy, Terence M. (2006). Plant Biology. Thomson Brooks, USA

LSS.505: Cell Biology. Credit Hours: 3. Semester I.

Unit 1 15 Lectures

Introduction to the cell: Evolution of the cell, From molecules to first cell, From prokaryotes to eukaryotes, Prokaryotic and eukaryotic genomes, Single cell to multicellular organisms.**Membrane structure and function:** Models of membrane structure, Membrane proteins, Membrane carbohydrates, Membrane transport of small molecules, Membrane transport of macromolecules and particles. Structural organization and function of intracellular organelles: The lysosomes, Ribosomes, The peroxisomes, The golgi apparatus, The endoplasmic reticulum,

Mitochondria and chloroplast, Structure of mitochondria and chloroplast, Oxidation of glucose and fatty acids, Electron transport oxidative phosphorylation, Chloroplast and photosynthesis.

Unit 2 **10 Lectures**

Protein secretion and sorting: Organelle biogenesis and protein secretion, synthesis and targeting, of mitochondria, chloroplast, peroxisomal proteins, translational modification in the ER. Intracellular traffic, vesicular traffic in the secretary pathway, protein sorting in the Golgi bodies, traffic in the endocytic pathway, exocytosis.

Unit 3 **14 Lectures**

The cytoskeleton: The nature of cytoskeleton, Intermediate filaments, Microtubules, Actin filaments, Cilia and centrioles, Organization of the cytoskeleton. **Cell communication and cell signaling:** Cell adhesions, Cell junctions and the extra cellular matrix, Cell-cell adhesion and communication, Cell matrix adhesion, Collagen the fibrous protein of the matrix, Noncollagen component of the extra cellular matrix.

Unit 4 **15 Lectures**

Cell growth and division: Overview of the cell cycle and its control, The molecular mechanisms for regulating mitotic and meiotic events, Amitosis, Cell cycle control, Checkpoints in cell cycle regulation. Cell to cell signaling, Overview of the extra cellular signaling, Identification of cell surface receptors, G-protein coupled receptors and their effectors, Second messengers, Enzyme-linked cell surface receptors, Interaction and regulation of signaling pathways.

Suggested reading:

1.Alberts, B., Bray, D., Lews, J., Raff, M., Roberts, K. and Watson, J.D. (2010). *Molecular Biology of the cell*. Garland publishers, Oxford.
2.Celis, J.E. (2006). *Cell biology: A laboratory handbook*, Vol 1, 2, 3. Academic Press, UK.
3.Gupta, P.K. (2008). *Cytology, Genetics and Evolution*. Rastogi publications, Meerut, India.
4.Karp, G. (2010). *Cell and Molecular Biology: Concepts and Experiments*. John Wiley & Sons. Inc. New Delhi, India.

LPS.506: Genetics. Credits Hours: 3. Semester I.

Unit 1 **15 Lectures**

Introduction and scope of genetics, DNA as genetic material: The vehicles of inheritance, Chemical structure and base composition of nucleic acids, Double helical structure, Structure of DNA and RNA, Different types of DNA molecules, forces stabilizing nucleic acid structure, super coiled DNA, properties of DNA, denaturation and renaturation of DNA and Cot curves. **DNA replication:** Messelson and Stahl Experiment, Carins Experiment, Okazaki Experiment, Basic mechanism of DNA replication.

Unit 2 **12 Lectures**

Cell division and Cell cycle: Mitosis, Meiosis, Chromosomal basis of inheritance. Basic principles of Mendelian inheritance: Segregation and independent assortment, Alleles and

multiple alleles, Human pedigrees and inheritance. Linkage analysis and gene mapping: Coupling and repulsion phase linkage, Crossing over and recombination**.** Population genetics: Application of Mendel's laws to populations, Hardy-Weinberg principle, inbreeding depression and heterosis, inheritance of quantitative traits.

Unit 3 **15 Lectures**

Gene Interaction: Sex determination and Sex linked inheritance, Sex determination in humans, *Drosophila* and other animals, Sex determination in plants, Sex linked genes and dosage compensation. Human genetics: pedigree analysis. Gene concept: Fine structure of gene and gene concept, Fine structure analysis – Benzer's experiments, Complementation analysis and fine structure of gene, Complementation and recombination, Concept of gene.

Unit 4 **12 Lectures**

Extra-chromosomal inheritance and mutations: Chloroplast and Mitochondrial inheritance, Yeast, *Chlamydomonas/Neurospora* and higher plants Chromosomal aberrations: Types of changes– deletions, duplications, inversions, translocations,Change in chromosome number: trisomy and polyploidy. Evolutionary history of bread wheat, Aneuploids–nullisomics, monosomics, and trisomics, Somatic aneuploids, Changes in chromosome structure, Properties of chromosomes for detection of structural changes. Mutations: Spontaneous and induced mutations, Somatic vs germinal mutation.

Suggested Reading:

1.Anthony, J.F., Miller, J.A. ,Suzuki, D.T., Richard, R.C., Gilbert, W.M. (1998). *An introduction to Genetic Analysis*. W.H. Freeman publication, USA.

2.Atherly, A.G., Girton, J.R., Mcdonald, J.F. (1999). *The science of Genetics*. Saundern College publication.

3.Snusted, D.P., Simmons, M. J. (2010). *Principles of Genetics*. John Wiley & Sons, New York.

4.Jocelyn, E.K., Elliott, S.G., Stephen, T.K. (2009). *Lewin's Genes X*. Jones & Bartlett Publishers, USA.

5.Tamarin, R.H. (1996). *Principles of Genetics, International edtn.* McGrawhill, USA.

LPS.551: Plant Biosystematics. Credits Hours: 2. Semester I.

Unit 1 **10 Lectures**

General Introduction to systematics: Taxonomy, Classification and Biological nomenclature; Tree of life, Basic Latin used in systematics, Classical and quantititative methods of taxonomy. Concepts of species and hierarchical taxa, Speciation: Allopatry, Sympatry, Parapatry and Peripatry; Reproductive isolation mechanisms, The species problem.

Unit 2 **10 Lectures**

Plant systematics: ICBN rules, Major classes and orders, Major families of commercially important plants, Overview of Fungal, algal and microbial systems. Major domestic plant pathogens.

Unit 3 **8 Lectures**

Natural history of Indian subcontinent: Major habitat types of the subcontinent, Geographic origins and migrations of species, Biogeography, Major terrestrial biomes, Theory of island biogeography and biogeographical zones of India.

Unit 4 **8 Lectures**

Overview of Biodiversity: Evolutionary Significant Units, Importance of biodiversity, Patterns of biodiversity, Endemism and hotspots, Continental drift and dispersal routes, Geologic time scale, Role of extinctions and additions, measuring biodiversity: Realism vs. Nominalism, Species richness, species evenness, Simpson's diversity index, Biodiversity acts, Conservation of biodiversity. Concept of biosphere reserves and current status.

Suggested Reading:

1.Hall, B.G. (2011). *Phylogenetic Trees Made Easy: A How-To Manual*. Sinauer Associates, Inc. USA.

2.Hennig, W., Dwight, D. and Zangerl, R. (1999). *Phylogenetic Systematics.* University of Illinois Press, USA.

3.Judd, W.S., Campbell, C.S., Kellogg, E.A., Stevens, P.F. and Donoghue, M.J. (2007). *Plant Systematics, A Phylogenetic Approach*. Sinauer Associates, Inc. USA.

4.Mayr, E. and Ashlock, P.D. (1991). *Principles of Systematic Zoology*. Mcgraw-Hill, USA.

5.Schuh, R.T. and Brower, A.V.Z. (2009). *Biological Systematics: Principles and Applications*. Comstock Pub Assoc.

Interdisciplinary courses

LSS.401. Basic Concepts in Genetics. Credit Hours: 2. Semester -I

Unit-1 **10 Lectures**

Mendelian Genetics, Non-Mendelian Genetics: Linkage, Incomplete Dominance, Maternal Inheritance, Extra-nuclear inheritance, Sex-linked inheritance, Sex determination, Dosage Compensation, Epigenetics. The Chromosomal basis of inheritance.

Unit-2 **8 Lectures**

The Genetics of Bacteria and Bacteriophages. Vertical and Horizontal gene transfer. Transformation, Transfection & Transduction. Genetic Complementation.

Unit-3 **10 Lectures**

Genetic Mapping. Genetic screens as a basis for functional genomics. Deficiencies, Gene isolation Manipulation and the techniques that revolutionized modern genetics. Working with Nucleic Acids and Proteins. Polymerase Chain Reaction. DNA Sequencing, Southern, Western & Northern Blots. In-situ Hybridization.

Unit-4 **8 Lectures**

Population genetics, Gene Pool, Genetic drift, Mendel's law to whole population, inbreeding depression and heterosis.

LSS.503: Biostatistics - practical. Credit Hours: 1. Semester I.

1.Experimental design and analysis.

2.Training on basic usage of Microsoft Word, Microsoft Excel, Microsoft PowerPoint and Internet Explorer.
3.Optimizing web search: Google advanced search, Boolean operators, Literature search using Google Scholar, HighWire.
4. Bibliography management and research paper formatting using reference software EndNote.
5.Performing statistics analyses using MS Excel Analysis toolpack.
6.Creating a functional website using HTML.
7.Basic programming using DOS batch files and Auto Hot Key.

LSS.507: Biochemistry – Practical. Credit Hours: 1. Semester I.

1. Preparation of Solutions, buffers, pH setting etc.
2. Amino acid and carbohydrate separations by paper & thin layer chromatography.
3. Quantitative Estimation of Proteins, Sugars, total lipids and amino acids.
4.Assay and estimation of different enzymes e.g. invertase, amylases, acid and alkaline phosphatases in plant seeds.
5. Principle and application of electrophoresis, Native, SDS PAGE.
6. Estimation of total phenolic compounds.
7. Extraction and estimation of vitamins.

LSS.508: Cell Biology – Practical Credit Hours: 1. Semester I.

1. Preparation of mitotic & meiotic chromosomes.
2. Study of structure of cell organelles through electron micrographs.
3. Instrumental methods for cell biology-centrifugation, chromatography.
4. Bacterial staining and identification.
5. Sectioning of tissues (Plant and animal).
6. Histochemical techniques (Fixing, Processing, Staining).

LPS.509: Genetics - Practical. Credit Hours: 1. Semester I.

1.Calculation of allele frequencies.
2. Calculating recessive gene frequency, Calculating frequency of sex –linked alleles.
3. Karyotyping of normal & abnormal chromosome sets.
4. Monohybrid and dihybrid ratios, Multiple alleles, Epistasis – Problems.
5. Inheritance patterns in Man – Numericals on Pedigree analysis- Autosomal patterns, X–linked patterns, Y–linked patterns.
6. Mitochondrial inheritance patterns.
7. To test PTC tasting ability in a random sample and calculate gene frequencies for the taster and non–taster alleles.
8. Identification of inactivated X chromosome as Barr body and drumstick.
9. Blood group typing using haemagglutination tests.

10.Studies of a Model organism: Identification of normal and mutant flies (Drosophila melanogaster) & Preparation of Drosophila polytene chromosomes.
11. To study fingerball and palmar dermatogylphics and calculate indices.
12. To test for colour blindness using Ishihara charts.
13. Molecular Mapping of Genes.

Elective - 1 Course Practicals

LPS.552: Plant Biosystematics – Practical. Credit Hours: 1. Semester I.

1. Field sampling trip and report using GPS.
2. Herbarium preparation.
3. Identification of plants by morphometry.
4. Chemical taxonomy of plants using Gel Electrophoresis/HPLC.
5. Molecular systematics using Internal Transcribed Spacer sequence analysis.
6. Preparation and use of stains.
7. Construction of phylogenetic trees.

***More practicals may be added/modified from time to time depending on available faculties/facilities.**

Centre for Plant Sciences

Semester-II					
Paper Code	**Course Title**	**L**	**T**	**P**	**Cr**
Core Courses					
LSS.508	Molecular Biology	2	1		3
LSS.510	Plant Physiology	3	1	-	4
LPS.511	Plant Ecology and Environment	2	1		3
LPS.512	Plant Cell, Tissue and organ culture	2	1		3
LPS.514	Techniques in Life Sciences	2	1	-	3
LPS.XXX	Elective Course-2	2			2
LPS.XXX	Interdisciplinary course-1	2			2
LPS.513	Molecular Biology (P)	-		1	1
LPS.515	Plant Physiology (P)			1	1
LPS.516	Plant Cell, Tissue and organ culture (P)			1	1
LPS.517	Plant Ecology (P)			1	1
LPS.XXX	Elective Course -2 (P)			1	1
LPS.599	Credit Seminar	0		1	1
		15	4	6	**26**
Electives					
LPS.561	Plant Biochemistry	2			2
LPS.562	Plant Biochemistry (P)	0		1	1
Interdisciplinary courses offered					
LPS.402	Basic Plant stress physiology and biochemistry.	2			2

L: Lectures T: Tutorial P: Practical Cr: Credits

A: Continuous Assessment: Based on Objective Type Tests (10%), Term Paper (10%) and Assignment(s) (5%)

B: Pre-Scheduled Mid Semester Test-1: Based on Objective Type & Subjective Type Test (By Enlarged Subjective Type) (25%)

C: Pre-Scheduled Mid Semester Test-2: Based on Objective Type & Subjective Type Test (By Enlarged Subjective Type) (25%)

D: End-Term Exam (Final): Based on Objective Type Tests (25%)

LSS.508: Molecular Biology. Credit Hours: 3. Semester II.

Unit: 1 14 Lectures

Structure, Conformation, Denaturation, Renaturation of Nucleic acids: Carrier of genetic information, Chemical structure of DNA and base composition, Watson-Crick model, Supercoiled DNA, Different forms of RNA: mRNA, tRNA, rRNA and other Types of RNA. Organelle DNA: mitochondria and chloroplast DNA. Chromosome Structure, Chromatin and the

Nucleosome: Genome Sequence and Chromosome Diversity, Chromosome Duplication and segregation, The nucleosome, Chromatin structure: euchromatin, heterochromatin, Constitutive and facultative heterochromatin, Regulation of chromatin structure and nucleosome assembly, Nucleolus.

Unit: 2 **14 Lectures**

Gene & Genome organization: Split genes, Overlapping genes, Transposons & retrotransposons, Gene clusters, Histones, Non-histones, Nucleosome, Chromatin, Chromosome structure in prokaryotes & eukaryotes. Basic Processes, Replication of DNA: Prokaryotic and eukaryotic DNA replication, Mechanism of DNA replication, Enzymes and accessory proteins involved in DNA replication, Replication errors, DNA damage and their repair.

Unit: 3 **14 Lectures**

Transcription and mRNA processing: Prokaryotic &, eukaryotic transcription, general and specific transcription factors, Regulatory elements and mechanisms of transcription regulation, Transcriptional and posttranscriptional gene silencing: Initiation, Elongation & Termination of transcription, Capping, Polyadenylation, Splicing, editing, mRNA stability, RNA interference, Microarray.

Unit: 4 **14 Lectures**

Translation: Genetic code, Prokaryotic & eukaryotic translation, the translation machinery, mechanisms of chain initiation, elongation and termination, regulation of translation, co-and post- translational modifications of proteins, Epigenetics.

Suggested Reading:

1. Fasman, G.D. (1989). *Practical Handbook of Biochemistry and Molecular Biology*. CRC Press, Taylor and Francis Group, UK.
2. Gupta, P.K. (2005). *Cell and Molecular Biology*. Rastogi publications, Meerut, India.
3. James, D.W., Baker, T.A., Bell, S.P., Gann, A. (2009). *Molecular Biology of the Gene*. Benjamin Cummings, USA.
4. Jocelyn, E.K., Elliott, S.G., Stephen, T.K. (2009). *Lewin's Genes X.* Jones & Bartlett Publishers, USA.
5. Johnson, A., Lewis, J., Raff, M. (2007). *Molecular Biology of the Cell*. Garland Science, USA.
6. Lodish, H., Berk, A., Chris, A.K. and Krieger, M. (2008). *Molecular Cell Biology*. W.H. Freeman, USA.
7. Sambrook, J., Fritish, E.F., Maniatis, T. (2000). *Molecular cloning: A laboratory manual*. Cold Spring Harbor Laboratory Press, New York.

LSS.510: Plant Physiology. Credit Hours: 4. Semester II.

Unit:1 **18 Lectures**

Photosynthesis, Respiration and Photorespiration: Light harvesting complexes, Mechanisms of electron transport, Photoprotective mechanisms, CO_2 fixation, C3 , C4 and CAM pathways.

Citric acid cycle. Plant mitochondrial electron transport and ATP synthesis, Alternate oxidase, Photo-respiratory pathway. **Nitrogen metabolism:** Nitrate and ammonium assimilation, Amino acid biosynthesis.

Unit: 2 **18 Lectures**

Water relations, Solute transport and photoassimilate translocation: Properties of water, Properties of solutions, Cell water potential, Soil -plant -atmosphere continuum. Uptake, transport and translocation of water, ions, Solutes and macromolecules from soil, Through cells, Across membranes, Through xylem and phloem, Transpiration, Mechanisms of loading and unloading of photoassimilates.

Unit: 3 **18 Lectures**

Phytohormones: Biosynthesis, storage, breakdown and transport, physiological effects and mechanisms of action. **Sensory photobiology:** Structure, function and mechanisms of action of phytochromes, cryptochromes and phototropins, Photoperiodism and Biological clocks.

Unit: 4 **18 Lectures**

Stress physiology and Secondary metabolism: Responses of plants to biotic (pathogens and insects) and abiotic (water, temperature and salt) stresses, Mechanisms of resistance to biotic stress and tolerance to abiotic stress. Biosynthesis of terpenes, Phenols and nitrogenous compounds and their roles. Programmed cell death: Apoptosis, Caspases, Importance and role of PCD in plant development.

Suggested Reading:

1.Buchanan, B.B. and Gruissem, W. (2010). *Biochemistry and molecular biology of plants.* IK International Pvt. Ltd. New Delhi, India.

2.Campbell, M.K. and Farrell, S.O. (2007). *Biochemistry.* Thomson Brooks/cole, USA.

3.Dey, P.M. and Harborne, J.B. (2000). *Plant biochemistry*. Academic Press, UK.

4.Goodwin, T.W. and Mercer, E.I. (2003). *Introduction to plant biochemistry*. CBS Publishers & Distributors, New Delhi, India.

5.Ross and Salisbury. (2009). *Plant Physiology.* Cengage Learning (Thompson), New Delhi, India.

6.Segel, I.H. and Segel, E. (1993). *Enzyme kinetics: Behavior and analysis of rapid equilibrium and steady-state enzyme systems.* Wiley-Interscience, USA.

7. Taiz, L. and Zeiger, E. (2010). *Plant physiology*. Sinauer Associates Inc., USA.

8.Taiz, L., Zeiger, E. Mollar, I. M. and Murphy, A. (2015). Plant physiology and Development 6th edition. . Sinauer Associates Inc., USA.

LPS.511: Plant Ecology and Environment. Credit Hours: 3. Semester II.

Unit: 1 **14 Lectures**

The Environment: Physical environment, biotic environment, biotic and abiotic interactions. Concept of habitat and niche, niche width and overlap, fundamental and realized niche, resource partitioning and character displacement.

Unit: 2 **14 Lectures**

Ecosystem: Structure and function, energy flow and mineral cycling (CNP), primary production and decomposition, structure and function of some Indian ecosystems: terrestrial (forest, grassland) and aquatic (fresh water, marine, eustarine). Types, mechanisms, changes involved in succession, concept of climax. Nature of communities, community structure and attributes, levels of species diversity and its measurement, edges and ecotones.

Unit: 3 **18 Lectures**

Population ecology: Characteristics of a population, population growth curves, population regulation, life history strategies (*r* and *K* selection), concept of metapopulation – demes and dispersal, interdemic extinctions, age structured populations. Types of interactions, interspecific competition, herbivory, carnivory, pollination and symbiosis.

Unit: 4 **8 Lectures**

Environmental and sustainability: Global environmental change, ozone depletion, biodiversity-status, monitoring and documentation, major drivers of biodiversity change, biodiversity management approaches, Carbon credit.

Suggested Reading:

1.Odum, E. and Barrett, G.W. (2005). *Fundamentals of Ecology*. Brooks Cole, USA.
2.Prasanthrajan, M and Mahendran, P.P. (2008). *A Text Book on Ecology and Environmental Science*. Agrotech, India.
3.Sharma, P.D. (2005). *Ecology and Environment.* Rastogi Publications, Meerut, India.
4.Verma, P.S. Agarwal, V. K. (2000). *Environmental Biology: Principles of Ecology*. S. Chand, New Delhi, India.
5. Gupta, S. and Singh J. (2014) Environmental Science and Conservation. S, Chand Publishing, New Delhi

LPS.512: Plant Cell, Tissue and Organ Culture. Credit Hours: 3. Semester II

Unit I **13 Lectures**

Overview: Historical developments**;** Disinfection and sterilization, Nutrient media; Tissue culture conditions; Role of phytohormones in plant development *in vitro*; Plant regeneration pathways - Organogenesis and Somatic embryogenesis.

Unit II **13 Lectures**

Plant cell, tissue and organ Culturing: Organ culture, Root culture, Embryo culture - Embryo rescue, Breakdown of seed dormancy; Endosperm culture and triploid production; Anther and pollen culture, and production of haploid and doubled haploid plants; Callus culture; Protoplast culture and fusion, Somatic hybrids; Organelle transfer and cybrids.

Unit III **10 Lectures**

Conservation techniques: *In-vitro* fertilization for production of novel hybrids; Micropropagation, Artificial seed and bioreactor technology, Virus-free plants by meristem culture; Use of somaclonal and gametoclonal variation for crop improvement; *In-vitro*

mutagenesis and mutant selection; Preservation of plant germplasm *in-vitro*, Genetic fidelity of culture systems and common problems.

Unit IV **15 Lectures**

Transgenic Development: Plant transformation vectors - T-DNA and viral vectors, direct gene transfer vectors; Selectable marker and reporter genes, Plant transformation by *Agrobacterium* sp., non-*Agrobacterium* sp., and *in planta* transformation, Molecular mechanism of T-DNA transfer; Direct gene transfer methods in plants - gene gun and other methods; Chloroplast transformation. Transgene analysis, Mutant formation, Silencing and targeting; Marker-free and novel selection strategies; Multigene engineering; Gene knock-down by ribozymes, Antisense RNA and RNA interference technologies; Genome editing.

Suggested Reading:

1. **Plant Tissue Culture: Theory and Practice (1996)**, *Bhojwani S. S. & Razdan M. K.*, Elsevier.
2. **Plant Biotechnology: The Genetic Manipulation of Plants (2008)**, *Slater A. Scott N. & Fowler M*., Oxford University Press Inc.
3. **Plants, Genes and Crop Biotechnology (2002)**, *Chrispeels M. J. & Sadava D. E. Jones*, Barlett Publishers.
4. **Principles of Gene Manipulation and Genomics (2006),** *Primrose S. B. & Twyman R. M*., Blackwell Publishing.
5. **Plant Cell, Tissue and Organ Culture: Fundamental Methods (1995)**, *Gamborg O. L & Phillips G. C*., Springer-Verlag.
6. **Plant Biotechnology (2011)**, *Singh B. D*., Kalyani Publishers.

LPS.514: Techniques on Life Sciences. Credit Hours: 2. Semester II

Unit 1 **10 Lectures**

Good laboratory practices: Sterilization techniques, Spectrometry: Colorimetry, mass, UV, IR, NMR and atomic absorption spectrophotometery, Centrifugation: Principle and applications, Ultracentrifugation. Chromatography: Principle, procedure and applications of thin layer chromatography (TLC), gel filtration and ion exchange, affinity chromatography, GC, GLC, HPLC and FPLC.

Unit: 2 **6 Lectures**

Microscopy: Light microscopy, phase contrast microscopy, fluorescent microscopy, scanning electron microscopy (SEM/FESEM), transmission electron microscopy (TEM), micrometry and photomicrography, Histochemistry, Scanning-probe microscopy, Atomic force microscopy, CLSM.

Unit: 3 **10 Lectures**

Nucleic acids: Isolation, purification and analysis of nucleic acids. Electrophoresis: Principle of gel electrophoresis, polyacrylamide gel electrophoresis (PAGE and SDS-PAGE), agarose gel electrophoresis, pulse field gel electrophoresis (PFGE) and 2-Dimensional gel electrophoresis. Polymerase chain reaction (PCR): Principle, types and applications, PCR based markers: RAPDs, SSRs, SNPs, ISSRs, and SCARs etc. Blotting techniques: Southern, Northern, Western, Dot blotting and hybridization, DNA fingerprinting.

Unit: 4 **10 Lectures**

Flow cytometry: Cell sorting, Hybridoma technology/Production of antibodies, Histochemical and Immunotechniques, Immunochemical Techniques, Developing Monoclonal and Polyclonal antibodies, Immunocytochemistry, Radioimmunoassay (RIA), Enzyme Linked Immunosorbent Assay (ELISA) and Autoradiography. **Mutation Analyses Techniques:** Restriction mapping, SSCP analyses, DNA sequencing-manual and automated methods. **Cell and tissue culture techniques:** Plants and animals.

Suggested Reading:

1.Brown, T.A. (2010). *Gene cloning and DNA analysis: An Introduction*. 6th Edition, Wiley-Blackwell Publisher, New York.

2.Goldsby, R.A., Kindt, T.J. and Osborne, B.A. (2008). *Kuby Immunology*. 6th Edition, W. H. Freeman & Company, San Francisco.

3.Gupta, P.K. (2005). *Elements of biotechnology*. Rastogi Publications, Meerut.

4.Gupta, S. (2005). *Research methodology and statistical techniques*, Deep & Deep Publications (P) Ltd. New Delhi.

5.Kothari, C.R. (2008.) *Research methodology(s)*. New Age International (P) Ltd., New Delhi

6.Lewin, B. (2010). *Genes X*, CBS Publishers & Distributors. New Delhi.

7.Mangal, S.K. (2007). *DNA Markers In Plant Improvement*. Daya Publishing House,New Delhi.

8.Nelson, D. and Cox, M.M. (2009). *Lehninger Principles of Biochemistry*. W.H. Freeman and Company, New York.

9.Primrose. S.B. and Twyman, R. (2006). *Principles of Gene Manipulation and Genomics.* Blackwell Publishing Professional, U.K.

10.Sambrook, J. (2006). *The Condensed Protocols from Molecular Cloning: A Laboratory Manual.* Cshl Press. New York.

11.Sambrook, J. and Russell, D.W. (2000). *Molecular Cloning: A Laboratory Manual* (3 Vol-set). 3rd Edition, CSHL Press, New York.

12.Sawhney, S.K. and Singh, R. (2005). *Introductory Practical Biochemistry*. Narosa Publishing House, New Delhi .

13.Slater, A., Scott, N.W. and Fowler, M.R. (2008). *Plant Biotechnology: The Genetic Manipulation of Plants*. Oxford University Press, USA.

14.Wilson, K. and Walker, J. (2006). *Principles and Techniques of Biochemistry and Molecular biology*. 6th Edition, Cambridge University Press India Pvt. Ltd., New Delhi.

Centre for Plant Sciences

LPS. 561 : Plant Biochemistry. Credits: 2. Semester: II

Unit 1 **10 Lectures**

Photosynthesis –Photosynthetic apparatus, pigments system, role of carotenoids, photosystems I and II, photosynthetic electron transport and generation of NADPH & ATP, cyclic and non-cyclic photophosphorylations, complexes associated with thylakoid membranes; light harvesting complexes, path of carbon in photosynthesis – C_3 and C_4 pathway of carbon reduction and its regulation, Photorespiration.

Unit 2 **10 Lectures**

Electron transport machinery in plants,Oxidative phosphorylation, mitochondrial respiratory complexes, organization of electron carriers, electrochemical gradient, chemiosmotic theory, mechanism of ATP synthesis. (10)

Unit 3 **10 Lectures**

Secondary plant metabolism,Classification, biosynthesis of Terpenes alkaloids, and phenolic compounds. Toxins of plant origin – mycotoxins, phytohemagglutinins, lathyrogens, nitriles, protease inhibitors, protein toxins. (10)

Unit 4 **10 Lectures**

Stress management in plants; Protective solutes synthesis and metabolism, Jasmonic acid as a messenger of stress response. Antioxidative defence system in plants – reactive oxygen species and their generation, antioxidative defence mechanism. (10)

LSS.513: Molecular Biology Practical - Credit Hours: 1. Semester II.

1.Isolation of genomic DNA from bacteria (E.coli) and human blood, Quantification of DNA using spectrophotometric method.

2.RNA isolation.

3.cDNA synthesis.

4.RT-PCR.

5.Isolation of plasmid DNA from bacteria.

6.Transformation of bacteria using CaCl2 heat shock method-Competent cell preparation.

7.Digestion of DNA using restriction endonucleases, Resolution and molecular weight estimation of fragmented DNA using agarose gel electrophoresis.

8.Construction of restriction map by single and double digestion, Designing DNA probe, Southern blot hybridization (demonstration only).

9.Amplification of known DNA sequences by Polymerase Chain Reaction.

LPS.515: Plant Physiology – Practical. Credit Hours: 1.

1. Osmosis, Plasmolysis, Relative leaf water content, Imbibition.
2. Growth Parameters: CGR, RGR. LAR, PAR etc.
3. Quantitative estimation of chlorophyll a ,b, carotenoids and anthocyanins.
4. Measurement of Photosynthesis (Pn).
5. Membrane damage.
6. Quantitative estimation of proteins, sugars and amino acids.

7. Thin Layer Chromatography for separation of amino acids.
8. Application of centrifugation in isolation of plant cell organelles.
9. Assay and estimation of acid and alkaline phosphatases in plant seeds.
10. Assay and estimation of amylases from different plant tissues.
11. Principle and application of electrophoresis.
12. Effect of auxin, cytokinin, gibberellic acid acid on plant growth.
13. Stress measurement.

LPS.516. Plant Cell, Tissue and organ culture -Practical. Credit Hour: 1.

1. Preparation of plant tissue culture media for different purposes
2. Demonstration of sterilization techniques and prevention strategies to avoid contamination in plant tissue culture room/media.
3. Demonstration of plant regeneration from adventitious shoot
4. Demonstration of plant regeneration from callus culture
5. Demonstration of protoplast isolation and culture method
6. Demonstration to show the best utilization of microscopic and photography techniques for plant tissue culture

LPS.517: Plant Ecology and Environment – Practical. Credit Hours: 1.

1. Ecosystem analysis: Quadrat method- Data collection Methods and species diversity estimations.
2. Field and Laboratory Investigations: Biomes study.
3. Biological Monitoring.
4. Air, water and soil analysis.
5. Determination of dissolved oxygen concentration of water sample.
6. Determination of biological oxygen demand (BOD) of sewage sample.
7. Determination of Chemical oxygen demand (COD) of sewage sample.
8. Isolation of xenobiotic degrading bacteria by selective enrichment technique.
9. Test for the degradation of aromatic hydrocarbons by bacteria.
10. Study on biogenic methane production in different habitats.
11. Eco-modeling.

LPS.562. Plant Biochemistry- Practical. Credits: 1

i. Quantitative estimation of Photosynthetic pigments.
ii. Quantitative estimation of proteins, sugars and amino acids.
iii. Thin Layer Chromatography for separation of Pigments and amino acids.
iv. Assay and estimation of amylases from different plant tissues.
v. Activity of antioxidative enzymes
vi. Principle and application of electrophoresis.
vii. Measurement of Photosynthesis (Pn).
viii. Membrane damage as Stress measurement

ix. SDS PAGE quantification of RUBISCO.

x. Native PAGE of antioxidative enzymes.

***More practicals may be added/modified from time to time depending on available faculties/facilities**.

Interdisciplinary Course:

LPS.402 . Basic Plant stress physiology and biochemistry. Credit Hours: 2. Semester-II

Unit-1 **9 Lectures**

Basic Processes in plants : Photosynthesis, Respiration and Photorespiration:

Unit-2 **9 Lectures**

Responses of plants to biotic (pathogen and insects) and abiotic (water, temperature and salt) stresses,

Unit-3 **9 Lectures**

Water Relations: Properties of water, Properties of solutions, Cell water potential, Soil -plant -atmosphere

Unit-4 **9 Lectures**

Secondary metabolism and stress physiology

LPS.559: Credit Seminar (on emerging topics)– Credit Hours: 1. Semester II.

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Semester-III					
Paper Code	**Course Title**	**L**		**P**	**Cr**
Core Courses					
LSS.504	Microbiology	2	1	-	3
LPS.518	Evolutionary and Developmental Biology	2	1	-	3
LPS.519	Recombinant DNA Technology	2	1		3
LPS.XXX	Elective Course - 3	2			2
LPS.520	Recombinant DNA Technology (P)			1	1
LPS.XXX	Elective Course -3 (P)			1	1
LPS.600	Research Project (S/US)			6	6
		8	**3**	**8**	**19**
Electives					
LPS.571	Physiology and Molecular Biology of stress	2		-	2
LPS.572	Physiology and Molecular Biology of stress (P)	-		1	1

L: Lectures T: Tutorial P: Practical Cr: Credits

A: Continuous Assessment: Based on Objective Type Tests (10%), Term Paper (10%) and Assignment(s) (5%)

B: Pre-Scheduled Mid Semester Test-1: Based on Objective Type & Subjective Type Test (By Enlarged Subjective Type) (25%)

C: Pre-Scheduled Mid Semester Test-2: Based on Objective Type & Subjective Type Test (By Enlarged Subjective Type) (25%)

D: End-Term Exam (Final): Based on Objective Type Tests (25%)

LSS.504: Microbiology. Credit Hours: 3. Semester III.

Unit: 1 **16 Lectures**

Prokaryotic, Eukaryotic structure and function: Cell structure and function, Classifications. Bacteria, Fungi, Protozoa, Algae, and viruses, Structure of major viruses, and Viral replication.

Unit: 2 **16 Lectures**

Growth, nutrition & control: Phases in bacterial growth, Growth Curve, Calculation of G-time, Physical and environmental requirements of growth, Microbial nutritional requirements, Types of culture media. Physical and Chemical methods, Antimicrobial drugs, Antibiotic assays, Drug resistance in bacteria.

Unit: 3 **6 Lectures**

Microbial Genetics: DNA replication, Transcription and translation, Operon, Horizontal Gene Transfer.

Unit: 4 **16 Lectures**

Applied Microbiology: Environmental microbiology, Microbial ecology, Aquatic Microbiology, Food, Dairy and Agricultural Microbiology, Industrial Microbiology. Major bacterial diseases of animals and plants, Airborne, Food-borne, Soil-borne, Nosocomial and Sexually Transmitted/Contagious Diseases, Principles of disease and epidemiology, Host-Microbe relationship, Viral pathogenesis, Major viral diseases of plants and animals.Avian Influenza A/H5N1, A/H1N1 Swine Influenza, SARS, AIDS, Japanese encephalitis, Malaria and Tuberculosis, West Nile, Mechanisms of emergence and reemergence.

Suggested Reading:

1. Bauman, R.W. (2011). *Microbiology with Diseases by Body System*. Benjamin Cummings, USA.
2.Capuccino, J.G. and Sherman, N. (2004). *Microbiology-A Laboratory Manual*. Benjamin Cummings, USA.
3.Pelczar, M. J., Chan, E.C.S. and Krieg, N.R. (1993). *Microbiology: Concepts and Applications*. McGraw-Hill Inc. USA.
4.Pommerville, J.C. (2010). *Alcamo's Fundamentals of Microbiology*. Jones & Bartlett Publishers, USA.
5.Prescott, L.M., Harley, J.P. and Klein, D.A. (2004). *Microbiology*. McGraw-Hill Science, USA.
6.Strelkauskas, A., Strelkauskas, J. and Moszyk-Strelkauskas, D. (2009). *Microbiology: A Clinical Approach.* Garland Science, New York, USA.
7.Tortora, G.J., Funke, B.R. and Case, C.L. (2009). *Microbiology: An Introduction.* Benjamin Cummings, USA

LPS.518: Evolutionary and Developmental Biology of Plants. Credit Hours: 3. Semester III.

Unit: 1 **14 Lectures**

Emergence of evolutionary thoughts & Origin of life: Lamarckism, Darwinism, Concepts of variation, adaptation, struggle, Mendelism, Spontaneity of mutations, Theories of phyletic gradualism vs. punctuated equilibria, Modern evolutionary synthesis. Origin of basic biological molecules, Abiotic synthesis of organic monomers and polymers, Concept of Oparin and Haldane, Experiment of Miller (1953), The first cell, Evolution of prokaryotes, Origin of eukaryotic cells, Evolution of unicellular eukaryotes, Anaerobic metabolism, Photosynthesis and aerobic metabolism.

Unit: 2 **14 Lectures**

Paleontology and molecular evolution: The evolutionary time scale, Eras, periods and epoch, Major events in the evolutionary time scale, Origins of unicellular and multicellular organisms, Stages in primate evolution including *Homo sapiens*. Concepts of neutral evolution, Molecular divergence and molecular clocks, Molecular tools in phylogeny, Classification and identification; Origin of new genes and proteins; Gene duplication and divergence.

Unit: 3 **14 Lectures**

Basic concepts of development: Totipotency, Commitment, Specification, Induction, Competence, Determination and Differentiation, Morphogenetic gradients, Cell fate and cell lineages, Stem cells, Genomic equivalence and the cytoplasmic determinants, Imprinting, Mutants and transgenics in analysis of development.

Unit: 4 **12 Lectures**

Gametogenesis, fertilization and cell death: Gametophyte formation, Pollen tube growth and guidance, self incompatibility, fertilization mechanisms Embryo-sac development and double fertilization in plants, Embryogenesis and establishment of symmetry in embryo, Seed and fruit formation. Hypersensitive response, functions, relevance with diseases, apoptosis, Caspases, Importance of PCD in plant development, role of PCD, model of PCD.

Suggested Reading:

1.Darwin, C.R. (1911). *On the origin of species by means of natural Selection, or preservation of favoured races in the struggle for life*. Hurst Publishers, UK.
2.Dawkins, R. (1996). *The Blind Watchmaker*, W.W. Norton & Company Jones and Bartlett Publishers.
3.Futuyma, D.J. (2009). *Evolution*. Sinauer Associates Inc. USA.
4.Hake, S. and Wilt, F. (2003). *Principles of Developmental Biology*. W.W. Norton & Company, New York, USA.
5.Hall, B.K. and Hallgrimsson, B. (2007). *Strickberger's Evolution.* Jones and Bartlett Publishers, India.
6.Lewin, R. (2004). *Human Evolution - An Illustrated Introduction*. Wiley-Blackwell, USA.
7.Scott, F. and Gilbert, S.F. (2010). *Developmental Biology*. Sinauer Associates, Inc. USA.
8.Slack, J.M.W. (2005). *Essential Developmental Biology*, Wiley-Blackwell, USA.

LPS.519. Recombinant DNA Technology, Credit Hours: 3. Semester II

Unit: 1 **10 Lectures**

Plasmid biology: Structural and functional organization of plasmids, Plasmid replication, stringent and relaxed plasmids, Incompatibility of plasmid maintenance. Biology of bacteriophage: lambda phage as a natural in vivo vector, *in vitro* construction of lambda vector, classes of vectors and their use.

Unit: 2 **14 Lectures**

Enzymes in genetic engineering: DNA polymerase, Polynucleotide kinase, T4 DNA ligase, Nick translation system, Terminal deoxynucleotidy1 transferase, Reverse transcriptase, Restriction endonucleases Type I & II.

Unit: 3 **14 Lectures**

Cloning vectors: Types of cloning vectors viz. plasmids, cosmids, ssDNA Phages, Yeast cloning vectors, animal viruses, Ti plasmids and Cauliflower Mosaic Virus. Cloning and subcloning strategies: Preparation of competent cell-Transformation, transfection – recombinant

selection and screening; Isolation of genomic and nuclear DNA: DNA restriction and restriction fragment analysis, Genomic DNA and cDNA library[cDNA synthesis strategies – Linkers – Adapters – Homopolymer tailing], Making genomic and cDNA libraries in plasmids and phages, PCR product cloning (TA cloning), Cloning strategies in yeast, *Escherichia coli* and *Bacillus subtilis.* Sequencing by chemical, enzymatic and big-bye terminator methods.

Unit: 4 **14 Lectures**

Selection of rDNA clones and their expression products: Direct and indirect methods, Drug resistance, Gene inactivation, DNA hybridization, colony hybridization and in-situ hybridization (Southern, Northern and Dot blots and immunological techniques Western blotting). Gene modification & application of recombinant DNA technology: Mutagenesis – Deletion mutagenesis, Oligonucletoide derived mutagenesis, Site directed mutagenesis – Its applications; Applications of rDNA technology in diagnostics; Pathogenesis; Genetic diversity; Therapeutic proteins-Vaccines, Molecular probes (Production, labelling and uses).

Suggested Reading:

1.Brown, T.A. (2010), *Gene Cloning and DNA analysis*.John Wiley & Sons.
2.Jocelyn, E.K., Elliott, S.G. and Stephen, T.K. (2009), *Lewin's Genes X.* Jones and Bartlett Publishers, LLC.
3.Primrose, S.B., Twyman, R.M and Old, R.W., (2001). *Principles of Gene manipulations*. Blackwell Science.

LPS.571: Physiology and Molecular Biology of stress. Credit Hours: 2. Semester III.

Unit: 1 **10 Lectures**

Environmental Stresses and stress factors: Definition, Significance, Types, Stress- as perceived by plants and animals. **Responses of plants towards biotic factors:** Choice between fight or flight, acquired vs induced tolerance, Plant defense system, Genetic basis, understanding R genes, Systemic plant defense responses.

Unit: 2 **10 Lectures**

Responses towards abiotic factors: Stresses involving water deficit, High and low temperature stress, Salinity stress, Drought stress, Anoxia and Heavy metal stress, Role of osmotic adjustments towards tolerance, Altitude Stress, understanding of genetic basis.

Unit: 3 **8 Lectures**

Signaling under stress conditions: Perception, Transduction and response trigger, Induction of specific gene expression, Stress proteins, Convergence and divergence of signaling pathways, ABA as stress hormone, ABA the phenomenon of cross adaptation.

Unit: 4 **8 Lectures**

Genetic engineering and production of plants for improved stress tolerance: Physiological approach, Mutant approach, Wild relatives approach, Contrasting genotypes approach, Getting clue from sub - relative approach, contrasting genotypes approach, Getting clue from sub-lethal stress application, Success of plant breeding vs modern genetic modifications,

Raising of stress tolerant genotypes through genetic engineering. **High throughput analysis techniques in stress biology:** Transriptome analysis, Proteome analysis, Microarray, SAGE, Genome Editing etc.

Suggested Reading:

1.Taiz, L., Zeiger, E. Mollar, I. M. and Murphy, A. (2015). *Plant physiology and Development*, 6th edition. Sinauer Associates Inc., USA.

2.Gruissem, W. and Jones, R.L. (2000). *Biochemistry and Molecular Biology of Plants*. American Society of Plant Physiologists, USA.

3.Hopkins, W.G. and Hüner, N.P.A. (2004). *Introduction to plant physiology*. J. Wiley, USA.

4.Orcutt, D.M. and Nilsen, E.T. (2000). *Physiology of Plants Under stress*. J. Wiley, USA.

5.Galun, E. and Breiman. (1997). *Transgenic Plants*. World scientific Publishing, Chennai, India.

6.Hopkins, W.G. (2007). *Plant Biotechnology*. Infobase Publications Inc.. USA.

7.Chrispeels, M.J. and Sadava, D.E. (2002). *Plant, Genes and Crop Biotechnology*. American Society of Plant Biologists, USA.

8.Pessarakli et al. (2002). *Handbook of Plant and Crop Physiology*. Marcel Dekker, USA.

9.Primrose, S. B. and Twyman, R. (2006). *Principles of gene manipulation and genomics*. Blackwell Publishing Professional, Society of Plant Biologists, USA

LPS.520: Recombinant DNA Technology-Practical. Credit Hour: 1.

1.Nucleic Acid Isolation: Genomic DNA isolation from Plant Cell, RNA isolation, Plasmid Isolation from Bacteria.

2.Restriction Digestion:Genomic DNA restriction, Plasmid DNA restriction Digestion, Visualization of DNA restricted fragments.

3. PCR amplification: RAPD PCR, Gene specific PCR, Sequencing PCR, Colony PCR.

4. Cloning: Cloning of specific fragments, TA cloning.

5. Sequencing: Sequencing of the inserted Fragments, Bioinformatic analysis of the sequence.

LPS.572: Physiology and Molecular Biology of stress (P) Credit Hours: 1, Semester III.

1.Membrane Damage and TTC reduction test.

2.Expression of different isozymes.

3.Molecular expression of SOD, APX, CAT, POX, GR, Etc.

4.DNA Damage due to stress.

5.Reactive species localization.

***More practicals may be added/modified from time to time depending on available faculties/facilities.**

LPS.600. Research Project (S/US), Credits: 6 Semester-III

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Semester-IV					
Paper Code	**Course Title**	**L**	**T**	**P**	**Cr**
Core Course					
LPS.521	Metabolic Engineering	2			2
LPS.522	Metabolic Engineering(P)			1	1
LPS.600	Research Project (S/US)			18	18
					21
Year-1	**Sem-I**	**25**			
Year-1	**Sem-II**	**26**			
Year-2	**Sem-III**	**19**			
Year-2	**Sem-IV**	**21**			
	Total credits	**91**			

L: Lectures T: Tutorial P: Practical Cr: Credits

A: Continuous Assessment: Based on Objective Type Tests (10%), Term Paper (10%) and Assignment(s) (5%)

B: Pre-Scheduled Mid Semester Test-1: Based on Objective Type & Subjective Type Test (By Enlarged Subjective Type) (25%)

C: Pre-Scheduled Mid Semester Test-2: Based on Objective Type & Subjective Type Test (By Enlarged Subjective Type) (25%)

D: End-Term Exam (Final): Based on Objective Type Tests (25%)

LPS.521: Metabolic Engineering. Credit Hours: 3. Semester IV.

Unit: 1 **12 Lectures**

Cellular metabolism, Ecological significance of plant secondary metabolites; their effects on bacteria, insects and human health; Introduction to cellular and metabolic engineering. Major classes of secondary metabolites of plants, Regulation of specific pathways and secondary metabolism. Building networks as assemblies of simpler control schemes.

Unit: II **12 Lectures**

Metabolic flux analysis, Metabolic control analysis, Structure and flux analysis of metabolic networks, Genome-scale models of cellular metabolism, Validation of metabolic models.

Unit: III **12 Lectures**

Metabolomics, Techniques used in metabolomics, Metabolome informatics.

Unit: IV **12 Lectures**

E. coli: appropriate hosts for Metabolic Engineering. Production of secondary metabolites by plant cell and tissue cultures. Metabolic engineering to improve the content of bioactive secondary metabolism with applicable value in medicinal plants. Engineering of crop plants with

altered nutrient content, improved photosynthesis efficiency, biofuel production and enhanced lignin content.

Suggested readings:

1. Bhojwani S. S. & Razdan M. K., (1996) Plant Tissue Culture: Theory and Practice, Elsevier.
2. Slater A. Scott N. & Fowler M., (2008) Plant Biotechnology: The Genetic Manipulation of Plants Oxford University Press Inc.
3. Chrispeels M. J. & Sadava D. E. Jones, (2002) Plants, Genes and Crop Biotechnology Barlett Publishers.
4. Primrose S. B. & Twyman R. M. (2006) Principles of Gene Manipulation and Genomics, Blackwell Publishing.
5. Gamborg O. L & Phillips G. C., (2004), Plant Cell, Tissue and Organ Culture: Fundamental Methods Springer-Verlag.
6. Singh B. D., (2014) Plant Biotechnology Kalyani Publishers, New Delhi.
7. C.D. Smolke, (2009) The Metabolic Pathway Engineering Handbook, CRC Press.
8. B.O. Palsson, (2011) Systems Biology Cambridge University Press.
9. G.N. Stephanopoulos et al., (1998) Metabolic Engineering: Principles and Methodologies Academic Press.
10. Verpoorte R et al., (2008), Applications of Plant Metabolic Engineeirng, Springer.
11. Verpoorte R et al., (2010), Metabolic Engineeirng of Plant Secondary Metabolism Springer.
12. Ashihara H et al., (2010) Plant Metabolic and Biotechnology Wiley.

LPS.522: Metabolic Engineering-Practical. Credit Hours: 1. Semester IV.

1. Metabolic Databases and knowledge base for explaining plant primary metabolites
2. Isolation and quantification of plant secondary metabolites
3. Metabolic control analysis: framework development and case studies
4. Constructions of gene/protein networks and exploration of pathways using Bioinformatics tools.
5. Demonstration of cell suspension culture and secondary metabolites production in tobacco

***More practicals may be added/modified from time to time depending on available faculties/facilities.**

LPS 600: Master's Research Project/Dissertation – Credit Hours: 18, Semester IV.

The S**ynopsis** and **Master's Research Project/ Dissertation Research** shall be evaluated by a three member committee consisting of

a. COC of the centre
b. Supervisor or Co-supervisor
c. One faculty of allied department nominated by the vice chancellor