

**Department of Plant Sciences**  
**School of Basic and Applied Sciences**  
**Central University of Punjab, Bathinda**



**M.Sc. Program in Life Sciences**  
**Specialization: Plant Sciences**

**Academic Session**  
**2018-19**

# Department of Plant Sciences

M.Sc. Life Sciences (Plant Sciences)					
Semester-I					
Paper Code	Course Title	L	T	P	Cr
Fundamental Courses					
LPS.501	Biostatistics	2			2
LPS.502	Research Methodology	2			2
Core Courses					
LPS.506	Microbiology	2	1		3
LPS.507	Cell Biology	2	1		3
LPS.508	Biochemistry	3	1		4
LPS.509	Biochemistry (P)			1	1
LPS.510	Genetics	2	1		3
LPS.511	Genetics (P)			1	1

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LPS.XXX	Elective Course-1	2	1		3
LPS.XXX	Inter-disciplinary (IDC)	2			2
LPS.XXX	Elective Course (P)			1	1
	<b>Total Sem-1</b>	17	5	3	<b>25</b>
<b>Elective</b>					
LPS.512	Plant Systematics: Cryptogams	2	1		3
LPS.513	Plant Systematics: Cryptogams (P)			1	1
<b>Interdisciplinary courses offered</b>					
LPS.514	Basic Concepts in Genetics-1(IDC)	2			2
LPS.515	Economic importance of plants (IDC)	2			2
LPS.516	Fundamentals of Plant Biology (IDC)	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%)

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## LPS.501: Biostatistics. Credits Hours: 2. Semester I.

### Unit1 8 Lectures

**Overview of Biostatistics:** Types of Studies, Levels of Measurements, Presentation of Data: Frequency tables and diagrams, Descriptive statistics: Measures of central tendency and dispersal, Kurtosis and Skewness, Error Bars, Moments, Normality Tests and Outliers

### Unit2 10 Lectures

**Statistical Hypothesis Testing:** Sampling techniques, Sampling theory, Various steps in sampling, collection of data-types and methods, Concepts of Population, Sample and Confidence Interval, Statistical Hypothesis Testing, Statistical Significance and P-Values, Relationship between Confidence Intervals and Statistical Significance, Statistical Power and Choosing the right Sample Size

### Unit3 10 Lectures

**Inferential Statistics:** t-Distribution and tests of significance based on t-distribution, F-distribution and tests of significance based on F distribution,  $\chi^2$  Distribution and tests of significance based on  $\chi^2$  distribution, Comparing Proportions, Gaussian, Binomial, Lognormal and Poisson Distributions, Pearson's Correlation, Simple Linear Regression, Non-Linear Regression, Nonparametric tests

### Unit 4 8 Lectures

**Mathematical Biology:** Permutations and Combinations, Probability, Bayes Theorem and Likelihood, Statistics with MS Excel and GraphPad Prism, Key concepts of statistics, Statistical Pitfalls to Avoid

### Suggested Reading:

1. Harvey Motulsky (2013) *Intuitive Biostatistics: A Nonmathematical Guide to Statistical Thinking*. OUP USA; 3 edition
2. *Biostatistics A Methodology For the Health Sciences* - Gerald van Belle, Patrick J. Heagerty, Lloyd D. Fisher, Thomas S. Lumley
3. *Introductory Biostatistics* - Chap T. Le
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.

## LPS.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 5 Lectures

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

### Unit 3 5 Lectures

**Web-based literature search engines:** Introduction to Web Sciences, Google Scholar and PubMed, Impact factor metrics, Reviewing process of Journals, list of good publications houses and their

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contributions in plant sciences. A few examples of good journal with their scope and significant in Plant sciences.

**Library:** Classification system (Colon, Dewey & others)

## Unit 4

16 Lectures

Bio Entrepreneurship and overview of Plant based Industries: Importance of entrepreneurship and its relevance in career growth, characteristics of entrepreneurs, developing entrepreneurial competencies. A few examples of plant based company and their future prospective. General introduction to Intellectual Property Rights (IPRs), Patent, Trademarks, Domain names and Geographical indications

### 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.

## LPS.506: Microbiology. Credit Hours: 3. Semester I.

### Unit: 1

Lectures: 12

Introduction to Microbiology: Scope and history of Microbiology, Cell structure, function and classification of Bacteria, Fungi, Protozoa, Algae, and viruses.

### Unit: 2

Lectures: 14

Growth, Nutrition & Control: Phases in bacterial growth, Growth Curve, Calculation of G-time, Physical and environmental requirements of growth, Microbial nutrient requirements – macro-nutrients, micro-elements – growth factors - sources of nutrients – nutritional classification of bacteria - Phototroph, Chemotroph, Autotroph (lithotroph), Heterotroph (organotroph), Photoautotroph, Photoheterotroph, Chemoautotroph, Chemoheterotroph - Nutritional patterns of pathogens – Saprophytes – Auxotroph.

### Unit: 3

Lectures: 12

Cultivation and Control of Microbes: Types of growth media (natural, synthetic, complex, enriched, selective- definition with example), pure culture methods (streak plate, spread plate, pour plate, stab culture, slant culture). Control of microbes- Sterilization, disinfection, antiseptic, tyndallization, pasteurization: Physical- dry heat, moist heat, UV light, ionizing radiation, filtration, HEPA filter, Chemical methods- antimicrobial drugs, Antibiotic assays, and Drug resistance in bacteria.

### Unit: 4

Lectures: 14

**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.

### Suggested Reading:

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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. (2001). 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. (2005). Microbiology. McGraw-Hill Science, USA. 6. Experiments In Microbiology, Plant Pathology and Biotechnology. 4th Edition (2010). New Age Intl. Publishers Ltd. - New Delhi Additional Reading:
6. Strelkauskas, A., Strelkauskas, J. and Moszyk-Strelkauskas, D. (2009). Microbiology: A Clinical Approach. Garland Science, New York, USA. 8. Tortora, G.J., Fun

## LPS.507: 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 secretory 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.

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## Suggested reading:

1. Alberts, B., Bray, D., Lewis, 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.508: Biochemistry. Credits Hours: 4. Semester I.

### Unit 1 16 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, Human energy requirements, Nutraceuticals.

### Unit 3 20 Lectures

**Metabolism:** Bioenergetics and metabolism of Carbohydrates, TCA cycle, ETC, Oxidative phosphorylation, Pentose phosphate pathway, Lipids Breakdown and biosynthesis, Amino Acids and Nucleic acid metabolism.

### Unit 4 16 Lectures

**Enzymology:** Classification, Principles of catalysis, Mechanism of enzyme catalysis, Enzyme kinetics; Michaelis Menten, Lineweaver burk and Bisubstrate kinetics, Enzyme inhibition, Enzyme regulation, Isozymes, Clinically important enzymes.

## Suggested Reading:

1. Berg, J.M., Tymoczko, J.L. and Stryer, L. (2010). *Biochemistry*. W.H. Freeman & Company. USA.
2. Brown, T.A. (2016). *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. (2017). *Lehninger Principles of Biochemistry*. W H Freeman & Co; 7 edition.)
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.

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9. Shukla AN (2009). *Elements of enzymology*. Discovery Publishing. New Delhi, India.
10. Voet, D. and Voet, J.G. (2017). *Principles of biochemistry*. CBS Publishers & Distributors. New Delhi, India.

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

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

## **LPS.510: 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



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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., Girtton, 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.509: Genetics - Practical. Credit Hours: 1. Semester I.

- Calculation of allele frequencies.
- Calculating recessive gene frequency, Calculating frequency of sex –linked alleles.
- Karyotyping of normal & abnormal chromosome sets.
- Monohybrid and dihybrid ratios, Multiple alleles, Epistasis – Problems.
- Inheritance patterns in Man – Numericals on Pedigree analysis- Autosomal patterns, X–linked patterns, Y–linked patterns.
- Mitochondrial inheritance patterns.
- To test PTC tasting ability in a random sample and calculate gene frequencies for the taster and non–taster alleles.
- Identification of inactivated X chromosome as Barr body and drumstick.
- Blood group typing using haemagglutination tests.
- Studies of a Model organism: Identification of normal and mutant flies (*Drosophila melanogaster*) & Preparation of *Drosophila* polytene chromosomes.
- To study fingerball and palmar dermatoglyphics and calculate indices.
- To test for colour blindness using Ishihara charts.
- Molecular Mapping of Genes.

## LPS.512: Plant Systematics: Cryptogams Credits Hours: 3. Semester I.

### UNIT-1

14 Lectures

**General Introduction to Plant Systematics:** Taxonomy, Classification and Biological nomenclature; use of dichotomous taxonomic keys, Tree of life, Basic Latin used in systematics, Concepts of species and hierarchical taxa, Speciation: Allopatry, Sympatry, Parapatry and Peripatry; Reproductive isolation mechanisms, The species problem, International Code of Botanic Nomenclature (ICN): principles of priority, typification, effective and valid publications; voucher specimens in plant systematics, herbarium vouchers and herbariums, the tree of life with special focus on kingdom plantae

### UNIT-2

14 Lectures

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**Phycology:** Cyanobacteria and picoplankton; primary, secondary and tertiary endosymbiosis; systematics of superkingdom Chromalveolata, dinoflagellates and HABs, diatoms, brown algae; systematics of superkingdom archeplastida, biliphyta, rhodophyta, glaucophyta, viridiaeplantae, chlorophyta and streptophyta; ecological and economic importance of algae, algal life cycles, algal cultivation methods, algal resources of India.

## UNIT-3

14 Lectures

**Bryophytes:** Defining features of embryophytes, Classification of bryophytes; Major phylogenetic groups: Liverworts, non-peristomate, peristomate, and hornworts, Origin and evolution of heterotrichy in plants; Comparative account of gametophyte structure; Sporophytic structure and evolution; Peristome structure and its significance in the classification of Mosses, Moss life cycle, Common mosses of India, ecological and economic importance of mosses.

## UNIT-4

12 Lectures

**Pteridophytes:** Defining features of tracheophytes, Classification of pteridophytes; Euphylllophytes, Evolution of vascular systems in plants; Early vascular plants: Rhyniophyta, Trimerophylophyta and Zosterophylophyta; Major phylogenetic groups: Lycophytes and Monilophytes; Brief account of structure and reproduction in Ferns; Telome concept, apogamy and apospory, heterospory and seed habit, Common ferns of India, ecological and economic importance of ferns.

### Suggested Reading:

1. 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.
2. Schuh, R.T. and Brower, A.V.Z. (2009). *Biological Systematics: Principles and Applications*. Comstock Pub Assoc.
3. Gangulee, H.C. and Kar, A.K., College Botany Vol. II- 2011 (Algae+Fungi+Brophyta+Pteridophyta), New Central Book Agency, Kolkata
4. Singh, Pande, Jain, A Text Book of Botany, 2014 (Algae+Fungi+Brophyta+Pteridophyta) ,Rastogi Publication, Meerut
5. Rashid, A., An Introduction to Pteridopyta by, 2nd edition, 2011 (Reprint), Vikas Publishing House Pvt. Ltd., Noida.
6. Lee, R.E., 2008, Phycology, Cambridge University Press, Cambridge
7. Bold, H.C. and Wynne, M.J., 1985, Introduction to the Algae, 2nd Edition, Prentice-Hall Inc.
8. Webster, John, 1980, Introduction to fungi, Cambidge University Press
9. Webster, John and Roland, W.S., 2007, Introduction to Fungi, Cambridge University Press.
10. Alexopoulos, C.J., Minus, C.W. and Blackwell, M. 1996, Introductory Mycology, Wiley
11. Maheshwari, R., 2012, Fungi: Experimental Methods in Biology, CRC Press, Boca Raton, Florida
12. Prescott, G. W. 1969.The Algae: A Review. Thomson Nelson & Sons. London
13. Parihar. N.S., 1967 – An introduction of Embriophyta, Vol.III – Pteridophyta, Central book depot, Allahabad.

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### LPS.512: Plant Systematics:Crptogams– Practical. Credit Hours: 1. Semester I.

- **Algae:** Identification of common algae of Indian Subcontinent, Sectioning and microscopy of algal specimen

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- **Fungi:** Study of morphological and reproductive structures of the genera mentioned in theory. Isolation and identification of fungi from soil and air. Preparation of culture media.
- **Bryophytes:** External morphology and internal anatomy of the vegetative and reproductive organs of genera given in the theory.
- **Pteridophytes:** External morphology and internal anatomy of the vegetative and reproductive organs of genera given in the theory.
- Sample collection, preparation of herbarium, submission of report based on field trip.
- Field sampling trip and report using GPS. Herbarium preparation. Identification of plants by morphometry.
- Chemical taxonomy of plants using Gel Electrophoresis/HPLC.
- Molecular systematics using Internal Transcribed Spacer sequence analysis.
- Preparation and use of stains. Construction of phylogenetic trees.

## Interdisciplinary courses

### LSS.514. 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.

## Suggestive Readings:

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*. Saunders 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.

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## LPS. 515. Economic importance of plants, Credit Hours: 2. Semester-I

### Unit-1 8 Lectures

Basic introduction to plant systematics, economic importance of Algae, Bryophytes, Pteridophytes and Gymnosperms

### Unit-2 8 Lectures

Origin, evolution, botany, cultivation and uses of food (Wheat, rice, Potato and Sugarcane) crops, forage and fodder crops (Sorgham, bajra, Gram), Fibre crops (Cotton, Jute Sunhemp)

### Unit-3 8 Lectures

Vegetable oil yielding plants (Groundnut, Soybean, Safflower, mustard), Medicinal and aromatic plants (*Atropa belladonna*, *Rauwolfia serpentina*, *Withania somifera* and *Phyllanthus amarus*),

### Unit-4 8 Lectures

Important fiber – wood and timber yielding plants, non-wood forest products- raw materials for paper making, gums, tannins, dyes, resins and fruits, Plants used for shade, pollution control and aesthetics.

### Suggestive Readings:

1. Ray F Evert and Susan E Eichhorn, Esau,s. (2006). Plant Anatomy: Meristems, Cells, and Tissues of the plant body: Their structure, function and development. Wiley Publishers,
2. Charles B. Back (2010). An Introduction to Plant Structure and Development: Plant Anatomy for the Twenty-First Century. CAMBRIDGE
3. Ottoline Leyser and Stephen Day (2002) Mechanisms in Plant Development.

## LPS.516. Fundamentals of Plant Biology Credits: 2, Semester: 1

### Unit I: 6 Lectures

Organization and function of the plant body: cells and tissues differentiation, meristem, primary and secondary growth and wood formation

### Unit II: 12 Lectures

Plant metabolism: Glycolysis, photosynthesis, photorespiration, C4 and CAM photosynthesis, Secondary plant chemistry and Plant defenses

### Unit III: 9 Lectures

Organ structure and function: leaves, shoots and roots, I

### Unit IV: 9 Lectures

Plant development and morphogenesis: life history strategies, organogenesis and hormones, plant reproduction, seed formation, seed germination

### Suggested readings:

4. Ray F Evert and Susan E Eichhorn, Esau,s. (2006). Plant Anatomy: Meristems, Cells, and Tissues of the plant body: Their structure, function and development. Wiley Publishers,
5. Charles B. Back (2010). An Introduction to Plant Structure and Development: Plant Anatomy for the Twenty-First Century. CAMBRIDGE
6. Bob B. Buchanan, (2000). Biochemistry and molecular Biology of Plants. Author: Wiley Blackwell,
7. David L. Nelson and Michael Cox. (2017). Lehninger Principles of Biochemistry: International Edition.
8. Ottoline Leyser and Stephen Day (2002) Mechanisms in Plant Development.

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

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Semester-II					
Paper Code	Course Title	L	T	P	Cr
<b>Core Courses</b>					
LPS.521	Molecular Biology	2	1		3
LPS.522	Molecular Biology (P)	-		1	1
LPS.523	Plant Physiology	3	1	-	4
LPS.524	Plant Physiology (P)			1	1
LPS.525	Plant Tissue and Organ Culture	2	1		3
LPS.526	Plant Tissue and Organ Culture (P)			1	1
LPS.527	Techniques in Life Sciences	2	1	-	3
LPS.XXX	Elective Course-2	2	1		3
LPS.XXX	Elective Course -2 (P)			1	1
LPS.XXX	Interdisciplinary course-1	2			2
LPS.597	Credit Seminar	0		1	1
		13	5	5	23
<b>Electives</b>					
LPS.531	Plant Systematics:Phanerogams	2	1		3
LPS.532	Plant Systematics:Phanerogams (P)			1	1
<b>Interdisciplinary courses offered</b>					
LPS.533	Basic Plant physiology and biochemistry (IDC)	2			2
LPS.534	Evolution and Humanity (IDC)	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%)

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**LPS.521: 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.

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## LSS.522: Molecular Biology Practical - Credit Hours: 1. Semester II.

- Isolation of genomic DNA from bacteria (*E.coli*) and human blood, Quantification of DNA using spectrophotometric method.
- RNA isolation, cDNA synthesis, RT-PCR.
- Isolation of plasmid DNA from bacteria.
- Transformation of bacteria using CaCl<sub>2</sub> heat shock method-Competent cell preparation.
- Digestion of DNA using restriction endonucleases, Resolution and molecular weight estimation of fragmented DNA using agarose gel electrophoresis.
- Construction of restriction map by single and double digestion, Designing DNA probe, Southern blot hybridization (demonstration only).
- Amplification of known DNA sequences by Polymerase Chain Reaction.

## LPS.523: Plant Physiology. Credit Hours: 4. Semester II.

### Unit:1 20 Lectures

**Photosynthesis, Respiration and Photorespiration:** Light harvesting complexes, Mechanisms of electron transport, Photoprotective mechanisms, CO<sub>2</sub> fixation, C<sub>3</sub>, C<sub>4</sub> 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 20 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, WUE.

### 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 14 Lectures

**Secondary metabolism:** Biosynthesis of terpenes, Phenols and nitrogenous compounds and their roles. Growth, development and Programmed cell death: Apoptosis, Caspases, Importance and role of PCD in plant development.

### Suggested Reading:

1. Buchanan, B.B. and Grissem, W. (2015). *Biochemistry and molecular biology of plants*. Willy Blackwell ASPB USA.
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.



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

## LPS.524: Plant Physiology – Practical. Credit Hours: 1.

- Osmosis, Plasmolysis, Relative leaf water content, Imbibition.
- Growth Parameters: CGR, RGR. LAR, PAR etc.
- Quantitative estimation of chlorophyll a ,b, carotenoids and anthocyanins.
- Measurement of Photosynthesis (Pn).
- Membrane damage.
- Quantitative estimation of proteins, sugars and amino acids.
- Thin Layer Chromatography for separation of amino acids.
- Application of centrifugation in isolation of plant cell organelles.
- Assay and estimation of acid and alkaline phosphatases in plant seeds.
- Assay and estimation of amylases from different plant tissues.
- Principle and application of electrophoresis.
- Effect of auxin, cytokinin, gibberellic acid acid on plant growth.
- Stress measurement.

## LPS.525: Plant 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

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**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.526. Plant Cell, Tissue and organ culture -Practical. Credit Hour: 1.

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

## LPS.527: Techniques in Life Sciences. Credit Hours: 3. Semester II

### Unit 1

16 Lectures

Centrifugation: Principle and applications, Ultracentrifugation and their application in mass determination. Spectrometry: UV, IR, XRD, CD, NMR, atomic absorption and MS spectrophotometry. Chromatography: Principle, procedure and applications of paper & thin layer chromatography (TLC), gel filtration and ion exchange, affinity chromatography, GC (GLC & GSC), HPLC and FPLC.

### Unit: 2

12 Lectures

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**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

12 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

12 Lectures

**Flow cytometry:** Cell sorting, Hybridoma technology/Production of antibodies, Developing Monoclonal and Polyclonal antibodies. Histochemical and Immuno-techniques, Immunochemical Techniques: Radioimmunoassay (RIA), Enzyme Linked Immunosorbent Assay (ELISA) and Autoradiography. Mutation Analyses Techniques: Restriction mapping, SSCP analyses.

## Suggested Reading:

1. Brown, T.A. (2015). *Gene cloning and DNA analysis: An Introduction*. 6<sup>th</sup> Edition, Wiley-Blackwell Publisher, New York.
2. Goldsby, R.A., Kindt, T.J. and Osborne, B.A. (2008). *Kuby Immunology*. 6<sup>th</sup> 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)*. 3<sup>rd</sup> 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.

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

## LPS.531. Plant Systematics: Phanerogams Credits: 3 Semester: II

### UNIT-1

14 Lectures

**Gymnosperms:** Spermatophytes, Classification of gymnosperms, Phanerogamic way of reproduction in plants, General account of Glossopteridaceae, Comparative study of Coniferales (Pinaceae, Cupressaceae, Araucariaceae, Podocarpaceae, Cephalotaxaceae, Taxodiaceae), Taxales and Gnetales (Gnetaceae, Ephedraceae and Welwitschiaceae), Ginkgos, Cycads, Phylogeny of gymnosperms, Ecological and economic importance of gymnosperms.

### UNIT-2

15 Lectures

**Angiosperms:** Angiosperms Apomorphies, Evolutionary trends in characters, Fossil angiosperms, Principles and outline of classification of Angiosperms: Takhtajan, Cronquist, merits and demerits, Angiosperm Phylogeny Group (APG)-III system, Basal Angiosperms: ANITA Grade and Magnolids, "Monocots", Eudicots, Basal Tricholpates, Caryophyllales, Santalales, Saxifragales, Rosids: Vitales, geraniales, Fabids, Malvids, Myrtales, Asterids: Cornales, Erycales, Lamids, Campanulids. Aquatic angiosperms including mangroves.

### UNIT-3

15 Lectures

**Economic importance of angiosperms:** Origin, evolution, botany, cultivation and uses - food (Wheat, rice, Potato and Sugarcane), forage and fodder crops (Sorgham, bajra, Gram), Fibre crops (Cotton, Jute Sunhemp), Medicinal and aromatic plants ( *Atropa belladonna*, *Rauwolfia serpentina*, *Withania somifera* and *Phyllanthus amarus*), vegetable oil yielding plants (Groundnut, Soybean, Safflower, mustard), Important fiber – wood and timber yielding plants, non-wood forest products- raw materials for paper making, gums, tannins, dyes, resins and fruits, Plants used for shade, pollution control and aesthetics.

### UNIT-4

10 Lectures

**Molecular Systematics:** DNA Barcoding, Major Loci used in molecular systematics of plants, Selection of loci, Tortoise and Hare approach in molecular systematics, phylogenetic tree and tree thinking, Monophyly, Paraphyly, Polyphyly, Apomorphy Vs Plesiomorphy, Homoplasy, Introduction to phylogeny reconstruction, characters and character coding, Delimitation and identification of taxa, Barcode Gap analysis, Identification of species with DNA sequences.

### 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. Schuh, R.T. and Brower, A.V.Z. (2009). *Biological Systematics: Principles and Applications*. Comstock Pub Assoc.
5. Pandey, B.P., Angiosperms-Taxonomy, Emrbyology and Anatomy, S. Chand and Co., New Delhi
6. Bhojwani, S.S. and Bhatnagar, S.P., Embryology of Angiosperms, Vikash Publishing House, New Delhi
7. Sporne, K.R., Morphology of Gymnosperms, B.I. Publication, New Delhi

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8. Singh, Gurucharan, Plant Systematics- Theory and Practices, Oxford and I.B.H. Publishing Co. New Delhi
9. Judd,W.S.,Christopher,S.,Campbell.,Kellogg,A.E.,Stevens,P.F.,1999.Plant Systematics: A Phylogenetic Approach. Sinauer Associates Inc. Publishers.
10. Simpson, M. G., 2006 Plant Systematics. Elsevier Academic Press.
11. Vashista, 1976, Gymnosperms, S. Chand & Co.
12. Lawrence.G.H.M, 1985 – An Introduction to Plant Taxonomy, Central Book Depot, Allahabad.
13. Porter.C.L., 1982 – Taxonomy of Flowering Plants, Eurasia Publications House, New Delhi
14. Pandey.B.P. (1987) – Economic Botany.
15. Verma. V (1984) – Economic Botany.
16. Hill.A.W. (1981) – Economic Botany, McGraw Hill Pub.

## LPS.532. Plant Systematics: Phanerogams- Practical. Credits: 1

- **Gymnosperms:** External morphology and internal anatomy of the vegetative and reproductive organs of genera given in the theory.
- **Taxonomy:** Description of a species based on live specimens of the families mentioned in the theory as well as their herbarium preparation.
- **Molecular Systematics:** BLAST, Introduction to MEGA, Multiple Sequence Alignment, CLUSTALW, MUSCLE, Model Selection, Construction of Phylogenetic Trees
- Sample collection, preparation of herbarium, submission of report based on field trip.

## Interdisciplinary Course:

### LPS.533 . Basic Plant physiology and biochemistry. Credit Hours: 2. Semester-II

#### Unit-1 9 Lectures

Basic plant physiology and metabolism

#### Unit-2 9 Lectures

Secondary Metabolism

#### Unit-3 9 Lectures

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

#### Unit-4 9 Lectures

Plant Growth regulators, Auxins . Gibberellins Cytokinins Ethylene, Abscisic Acid, Growth and development

## Suggested Readings

1. Buchanan, B.B. and Gruissem, W. (2015). *Biochemistry and molecular biology of plants*. Willy Blackwell ASPB USA.
1. Taiz, L. and Zeiger, E. (2010). *Plant physiology*. Sinauer Associates Inc., USA.
2. Taiz, L., Zeiger, E. Mollar, I. M. and Murphy, A. (2015). *Plant physiology and Development* 6th edition. Sinauer Associates Inc., USA.

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**LPS.534: Evolution and Humanity, Credits Hours: 2. Semester II.**

**Unit 1** **8 Lectures**

**Overview of theory of evolution:** Pre-Darwinian concepts, Darwinism in detail, Artificial and Natural Selection, Adaptation, Molecular Evolution and Phylogeny

**Unit 2** **8 Lectures**

**Cultural and Philosophical implications of Darwinism:** Species concepts in biology, Philosophical realism Vs. Nominalism, nature of objective reality, ethics, aesthetics, post modernism, epistemology, metaphysics, cultural evolution, Memes and memetics, Spandrels, Inclusive Fitness, Extended Phenotype, Altruism and Sexual Cannibalism, Promiscuity

**Unit 3** **8 Lectures**

**Evolutionary linguistics:** Evolution of languages, Parallelism between organic evolution and linguistic evolution, cognates, comparative linguistics, major language families of the world and its evolution, evolutionary legacy of languages of Indian subcontinent, brief overview to the field of phylolinguistics

**Unit 4** **12 Lectures**

**Evolutionary socio-politics:** Left-right political spectra and its evolution, Political philosophies contributing to Speciation Vs. Hybridization, Assortative mating and social stratification, Evolution and Indian caste system, socio-economical implications of evolution

**Suggested Reading:**

1. Dawkins, R. (1996). *The Blind Watchmaker*, W.W. Norton & Company Jones and Bartlett Publishers.
2. Futuyma, D.J. (2009). *Evolution*. Sinauer Associates Inc. USA.
3. Hake, S. and Wilt, F. (2003). *Principles of Developmental Biology*. W.W. Norton & Company, New York, USA.
4. Hall, B.K. and Hallgrimsson, B. (2007). *Strickberger's Evolution*. Jones and Bartlett Publishers, India.
5. Lewin, R. (2004). *Human Evolution - An Illustrated Introduction*. Wiley-Blackwell, USA.

**LPS.597: Credit Seminar (on emerging topics) – Credit Hours: 1. Semester II.**

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

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Semester-III					
Paper Code	Course Title	L	T	P	Cr
<b>Core Courses</b>					
LPS.551	Ecology, Environment and Biodiversity	3	1		4
LPS.552	Ecology, Environment and Biodiversity(P)			1	1
LPS.553	Recombinant DNA Technology	2	1		3
LPS.554	Recombinant DNA Technology (P)			1	1
LPS.555	Evolutionary Biology	2			2
LPS.556	Anatomy and Developmental Biology of Plants	2			2
LPS.557	Anatomy and Developmental Biology of Plants			1	1
LPS.XXX	Elective	2	1		3
LPS.XXX	Elective (P)			1	1
LPS.599	Project Research & Synopsis Seminar (S/US)			6	6
	<b>Total</b>	11	3	10	24
<b>Elective Courses</b>					
LPS.561	Physiology and Molecular Biology of stress	2	1	-	3
LPS.562	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

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Enlarged Subjective Type) (25%)

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



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**LPS.551: Ecology, Environment and Biodiversity. Credit Hours: 4. Semester III.**

**Unit: 1** **14 Lectures**

**Ecosystem:** 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, Structure and function, energy flow and mineral cycling (CNP), primary production and decomposition, Ecological succession, concept of climax. Nature of communities, community structure and attributes, edges and ecotones.

**Unit: 2** **15 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, interdemec extinctions, age structured populations. Types of interactions, interspecific competition, herbivory, carnivory, pollination and symbiosis.

**Unit: 3** **14 Lectures**

**Overview of Biodiversity:** Importance of biodiversity: Bioprospecting, Biopiracy, Patterns of biodiversity, Endemism and hotspots, Continental drift and dispersal routes, 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.

**Unit: 4** **12 Lectures**

**Threats to Biodiversity:** Overview of HIPPO: Habitat Loss, Invasive Species, Pollution, Human Population, and Overharvesting, Climate Change, Climate Change mitigation, ozone depletion, Carbon credit, Kyoto Protocol and other International Environmental Agreements

## **Suggested Reading:**

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

**LPS.552: Ecology, Environment and Biodiversity – Practical. Credit Hours: 1.**

- Ecosystem analysis: Quadrat method- Data collection Methods and species diversity estimations.
- Field and Laboratory Investigations: Biomes study.
- Biological Monitoring.
- Air, water and soil analysis.
- Isolation of xenobiotic degrading bacteria by selective enrichment technique.

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- Test for the degradation of aromatic hydrocarbons by bacteria.
- Study on biogenic methane production in different habitats.
- Eco-modeling.
- TDS and Salinity measurement for water
- Vegetation sampling methods: Quadrats, Line, Random Number generation etc
- Usage of handheld GPS device and maps overlay
- Measurement of Biodiversity: Species Richness and Evenness, Various Indices

## LPS.553. Recombinant DNA Technology, Credit Hours: 3. Semester III

**Unit: 1** **12 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 deoxynucleotidyl 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, Oligonucleotide 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.

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## LPS.554: Recombinant DNA Technology-Practical. Credit Hour: 1.

- Nucleic Acid Isolation: Genomic DNA isolation from Plant Cell, RNA isolation, Plasmid Isolation from Bacteria.
- Restriction Digestion: Genomic DNA restriction, Plasmid DNA restriction Digestion, Visualization of DNA restricted fragments.
- PCR amplification: RAPD PCR, Gene specific PCR, Sequencing PCR, Colony PCR.
- Cloning: Cloning of specific fragments, TA cloning.
- Sequencing: Sequencing of the inserted Fragments, Bioinformatic analysis of the sequence.

## LPS.555: Evolutionary Biology, Credit: 2. Semester III

### Unit: 1 10 Lectures

**Darwinism and Microevolution:** Pre-Darwinian developments, Darwin's theory of evolution, Artificial Selection: Intentional Vs. Unintentional, Natural Selection, Darwinian Fitness, Adaptation, Overproduction, Types of Selection: Purifying vs. Positive, Co-evolution, Nature of Natural Selection

### Unit: 2 8 Lectures

**Evolutionary Mechanisms and Population Genetics:** Modern Evolutionary Synthesis, Variations, Hardy-Weinberg equilibrium, Selection Vs. Drift, Mutation, Gene Flow and Assortative Mating

### Unit: 3 8 Lectures

**Macroevolution:** Concepts: Spandrel, Exaptation, Extended Phenotype, Inclusive Fitness, Kin Selection, Group Selection, Evolutionary Game Theory, Adaptations, Punctuated Equilibrium, Radiations and Extinctions, Evolutionary Time Scale and Dating, Fossils and Paleontology, Origin of life and pre-cambrian, Origin of multicellularity, plants and animals, Evolution of Homo sapiens

### Unit: 4 10 Lectures

**Molecular Evolution:** Concepts of neutral evolution, Molecular divergence and molecular clocks, Molecular tools in phylogeny, Sequence Alignments, Models of molecular evolution and model selection, distance based methods of phylogeny reconstruction: UPGMA, Minimum Evolution and Neighbour Joining, discrete-character based methods of phylogeny reconstruction: Maximum Likelihood, Maximum Parsimony and Bayesian Inference

### 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 Hallgrímsson, B. (2007). *Strickberger's Evolution*. Jones and Bartlett Publishers, India.

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6. Lewin, R. (2004). *Human Evolution - An Illustrated Introduction*. Wiley-Blackwell, USA.

## LPS.556 Anatomy and Developmental Biology of Plants. Credit Hours:2. Semester III.

**Unit: 1** **8 Lectures**

**Male and female gametophyte:** Microsporangium and Microsporogenesis, Megasporangium and Megasporogenesis, Gametophyte formation, Pollen development, Ovule development.

**Unit: 2** **8 Lectures**

**Pollen-pistil interaction and double fertilization:** Pollen tube guidance; recognition and rejection, Embryo-sac development and double fertilization in plants, preferential fertilization; pistil activation and ovule penetration.

**Unit: 3** **8 Lectures**

**Seed development and dormancy:** Embryogenesis, Embryo and endosperm development, Classification of typical dicot and monocot embryo, Seed maturation and dormancy, polyembryony, apomixes, apospory.

**Unit: 4** **8 Lectures**

**Anatomy:** Anatomy of Stems and roots with special reference to plants showing anomalies- *Nyctanthes*, *Bignonia*, *Strychnos*, *Salvadora*, *Boerhaavia*, *Dracaena* and *Tinospora*.

### Suggested Reading:

1. Dawkins, R. (1996). *The Blind Watchmaker*, W.W. Norton & Company Jones and Bartlett Publishers.
2. Hake, S. and Wilt, F. (2003). *Principles of Developmental Biology*. W.W. Norton & Company, New York, USA.
3. Scott, F. and Gilbert, S.F. (2010). *Developmental Biology*. Sinauer Associates, Inc. USA.
4. Slack, J.M.W. (2005). *Essential Developmental Biology*, Wiley-Blackwell, USA.

## LPS.557. Anatomy and Developmental Biology of Plants, Practicals : Credit 1

- Types of Ovules, mature embryo, endosperms
- Types of placentation – Axile, basal, free central, marginal, parietal, superficial
- Floral morphology
- Types of pollens, Anther, microsporogenesis
- Dicot and monocot stems
- Dicot and monocot roots

## LPS.561: Physiology and Molecular Biology of stress. Credit Hours: 3. Semester III.

**Unit: 1** **14 Lectures**

**Environmental Stresses and stress factors:** Definition, Significance, Types, Stress- as perceived by plants. **Responses of plants towards biotic factors:** Choice between fight or flight, acquired vs

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induced tolerance, Plant defense system, Genetic basis, understanding R genes, Systemic plant defense responses.

**Unit: 2** **14 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, understanding of genetic basis.

**Unit: 3** **14 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** **12 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

## 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. Buchanan B. (2014). *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.562: Physiology and Molecular Biology of stress (P) Credit Hours: 1, Semester III.

- Membrane Damage
- TTC reduction and mitochondrial respiratory ability.
- Estimation of enzymatic and non enzymatic antioxidants.
- Native expression of enzymatic antioxidants i.e. SOD, APX, CAT, POX, GR, Etc.
- DNA Damage due to stress.
- Reactive species localization.

# Department of Plant Sciences

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

**LPS.599. Research Project (S/US), Credits: 6 Semester-III**

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Semester-IV					
Paper Code	Course Title	L	T	P	Cr
<b>Core Course</b>					
LPS.571	Metabolic Engineering	2	1		3
LPS.599	Research Project (S/US)			18	18
					21
<b>Year-1</b>	<b>Sem-I</b>	<b>25</b>			
<b>Year-1</b>	<b>Sem-II</b>	<b>23</b>			
<b>Year-2</b>	<b>Sem-III</b>	<b>24</b>			
<b>Year-2</b>	<b>Sem-IV</b>	<b>21</b>			
	<b>Total credits</b>	<b>93</b>			

**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.571. Metabolic Engineering. Credit Hours: 3. Semester III**

**Unit: 1** **14 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** **14 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** **14 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:**

# Department of Plant Sciences

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.

## **LPS 599: Master's Research Project/Dissertation – Credit Hours: 16, Semester IV.**

- The Synopsis 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 Senior faculty of the department