Central University of Punjab, Bathinda

M.Sc. Botany

Academic Session
2020-22

Department of Botany

School of Basic and Applied Sciences

Programme learning outcome

The learners of this programme will have necessary skills for Life sciences and Botany-related careers, and for higher education in Plant Sciences and allied subjects. Augmented in this curriculum are attributes including critical thinking, basic psychology, scientific reasoning, and moral ethical reasoning. Emphasis is given on the objectively-measurable teaching-learning outcomes while designing this curriculum to ensure employability of the post graduates.

In addition, the learners will be able to implementing the concepts to address the real-world problems. A major emphasis of these curriculum focuses on issues pertinent to India and west and are holistic. Therefore, the learner will develop reflective thinking, rational skepticism, scientific temper, digital literacy etc. such that they are equipped to take any offer in Plant science.

SEMESTER-I

Course Code	Course Title	Course Type	L	T	P	Cr
BOT.506	Biochemistry	Core Course	3	2	0	4
BOT.507	Biochemistry (P)	Skill based course	0	0	2	1
BOT.508	Genetics	Core Course	3	2	0	4
BOT.509	Genetics (P)	Skill based course	0	0	2	1
BOT.510	Non Vascular Plants and Fungal Systematics	Core Course	3	2	0	4
BOT.511	Non Vascular Plants and Fungal Systematics (P)	Skill based course	0	0	2	1
xxx	From other departments	IDC	2	0	0	2
Opt any one elective/MOOC						
BOT.514	Microbiology	Discipline Elective	3	2	0	4
ZOO.511	Cell Biology	Discipline Elective	3	2	0	4
IDC offered to other Departments						
BOT.515	Basic Concepts in Genetics-1	Interdisciplinary course	2	0	0	2
BOT.516	Economic importance of plants	Interdisciplinary course	2	0	0	2
BOT.517	Fundamentals of Plant Biology	Interdisciplinary course	2	0	0	2
Compulsory Foundation Courses						
BOT.518	Biostatistics	Compulsory Foundation Course	2	0	0	2
BOT.519	Research Methodology	Compulsory Foundation Course	2	0	0	2
	Total Credits		**18**	**8**	**6**	**25**

SEMESTER-II

Course Code	Course Title	Course Type	L	T	P	Cr
BOT.521	Molecular Biology	Core Course	2	0	0	2
BOT.522	Molecular Biology (P)	Skill based course	0	0	2	1
BOT.523	Plant Physiology	Core Course	2	2	0	3
BOT.524	Plant Physiology (P)	Skill based course	0	0	2	1
BOT.525	Plant Tissue and Organ Culture	Core Course	2	2	0	3
BOT.526	Plant Tissue and Organ Culture (P)	Skill based course	0	0	2	1
BOT.527	Ecology, Environment and Biodiversity	Core Course	2	2	0	3
BOT.528	Ecology, Environment and Biodiversity(P)	Skill based course	0	0	2	1
BOT.529	Vascular Plants Systematics	Core Course	2	0	0	2
BOT.530	Vascular Plants Systematics (P)	Skill based course	0	0	2	1
Opt any One						
BOT.531	Mycology & Plant Pathology	Discipline Electives/MOOC	3	2		4
BOT.532	Marine Botany	Discipline Electives/MOOC	3	2		4
IDC offered to other Departments						
BOT.533	Basic Plant physiology and biochemistry (IDC)	IDC	2	0	0	2
BOT.534	Evolution and Humanity (IDC)	IDC	2	0	0	2
BOT.535	Plant Biotechnology (IDC)	IDC	2	0	0	2
xxx		IDC	2	0	0	2
BOT.542	Seminar-1	Skill Based	0	0	0	1
	Total Credits		**15**	**8**	**10**	**25**

SEMESTER-III

Course Code	Course Title	Course Type	L	T	P	Cr
BOT.551	Recombinant DNA Technology	Core Courses	2	2	0	**3**
BOT.552	Recombinant DNA Technology (P)	Skill Based	0	0	2	**1**
BOT.553	Techniques in Life Sciences	Core Courses	2	2	0	**3**
BOT.554	Evolutionary Biology	Core Courses	2	0	0	**2**
Opt any one						
BOT.555	Molecular Stress Physiology	Discipline Elective Courses/ MOOC course	3	2	0	**4**
BOT.556	Principles of Ethnobotany	Discipline Elective Courses/ MOOC course	3	2	0	**4**
BOT.504	E-tools for Plant Identification	Value added course	0	0	2	**1**
BOT.599	Project	Skill based course	0	0	0	**6**
	Total Credits		**9**	**6**	**4**	**20**

SEMESTER-IV

Course Code	Course Title	Course Type	L	T	P	Cr
BOT.571	Plant Metabolic Engineering	Core Course	3	2	0	4
BOT.572	Anatomy and Developmental Biology of Plants	Core Course	2	2	0	3
BOT.573	Anatomy and Developmental Biology of Plants	Skill Based	0	0	2	1
BOT.574	Comprehensive Plant Sciences	Discipline Enrichment course	2	0	0	2
BOT.575	Life Sciences, Communication	Discipline Enrichment course	0	0	4	2
BOT.505	Agro-Ecology	Value based course	1	0	0	1
BOT.544	Research Seminar	Skill based course	0	0	0	1
BOT.599	Project (S/US)	Skill Based course				6
	Total Credits		**8**	**4**	**6**	**20**

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

A: Continuous Assessment: [25 Marks]

i. Surprise Test (Minimum three)-Based on Objective Type Tests (10 Marks),
ii. Term Paper (10 Marks)
iii. Assignment (5 Marks)

B: Mid Semester Test: Based on Subjective Type Test (25 Marks)

C: End Semester Subjective: Based on Subjective Type Test (25 Marks)

D: End Semester Objective: Based on Objective Type Tests (25 Marks)

E: Practical: Evaluation shall be done based on day to day performance (Note book 55% and attendance (5%), and final performance written (15%), practical examination (15%) and oral examination (10%).

Seminar Evaluation

Transaction Mode:

Evaluation Criterion	**Max percentage**
Literature survey/background information	20
Organization of content	5
Physical presentation	15
Question and Answer	10
Report evaluation	50
Total	100

1) Lecture
2) Demonstration
3) Seminar
4) Group discussion
5) Field visit
6) Tutorial
7) Problem solving
8) Self-learning

SEMESTER-I

Course Code: BOT.506
Course Title: Biochemistry

L	T	P	Cr
3	2	0	4

Learning Outcomes

1. Demonstrate an Understanding of basic biophysical chemistry, structure and function of biomolecules, metabolic pathways, and enzymatic machinery involved in metabolic pathways.
2. Demonstrate separation techniques such as electrophoresis, Native, SDS PAGE, chromatography.

Unit I **13 Hours**

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 II **14 Hours**

Composition, structure and function of Biomolecules: Carbohydrates, Lipids, Proteins, Nucleic acids and Vitamins, Human energy requirements, Nutraceuticals.

Unit III **20 Hours**

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

Unit IV **13 Hours**

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 Readings:

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

Course Code: BOT.507
Course Title: Biochemistry – Practical

L	T	P	Cr
0	0	2	1

Learning Outcomes

This course shall provide basic training related to protocols and methods related to biochemistry.

- 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.

Suggested Readings:

1. Campbell, M.K. (2012) Biochemistry, 7th ed., Published by Cengage Learning.
2. K. Wilson & K.H. Goulding (1991) A Biologist guide to Principles and Techniques of practical Biochemistry, ELBS Edition.
3. Nelson, D.L. and Cox, M.M. (2008). Lehninger Principles of Biochemistry, 5th Edition., W.H. Freeman and Company.
4. G.M. Cooper. (2015). The cell: A Molecular Approach. 7th Edition. Sinauer Associates.
5. Sambrook, J., Fritish, E.F., Maniatis, T. (2000). *Molecular cloning: A laboratory manual*. Cold Spring Harbor Laboratory Press, New York.
6. K. Wilson and J. Walker (2010) *Principles and Techniques of Biochemistry and Molecular Biology*, Seventh edition.

Course Code: BOT.508
Course Title: Genetics

L	T	P	Cr
3	2	0	4

Learning outcomes

1. The course will envisage on the basics and advancements in the area of Genetics and its application to understand various phenomena of inheritance in living world.
2. Gain knowledge in the frontier fields of population, evolutionary and quantitative genetics.
3. Understand the history of gene, interaction of genes, genetic recombination producing the characters differently.

Unit I **15 Hours**

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 II **15 Hours**

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, and site-specific recombination**.** Population genetics: Application of Mendel's laws to populations, Hardy-Weinberg principle, inbreeding depression and heterosis, inheritance of quantitative traits.

Unit III **13 Hours**

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, sex limited and sex influenced characters, pleiotropy, genomic imprinting, penetrance and expressivity, phenocopy. 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 IV **17 Hours**

Extra-chromosomal inheritance and mutations: Chloroplast and Mitochondrial inheritance, Yeast, *Chlamydomonas/Neurospora* and higher

plants, tetrad analysis, mapping by using somatic cell hybrids. 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, causes and detection, mutant types – lethal, conditional, biochemical, loss of function, gain of function, germinal verses somatic mutants, insertional mutagenesis.

Suggested 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*. 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.* McGraw Hill, USA.

Course Code: BOT.509
Course Title: Genetics–Practical

L	T	P	Cr
0	0	2	1

Learning outcomes

This course will train the students about practical applicability of basic genetics, population genetics and basic molecular biology techneques.

- Calculation of allele frequencies.
- Calculating recessive gene frequency, Calculate frequency of sex –linked alleles.
- Karyotyping of normal & abnormal chromosome sets.
- Monohybrid and dihybrid ratios, Multiple alleles, Epistasis – Problems.
- Inheritance patterns in Man – Numerical 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 dermatogylphics and calculate indices.
- To test for colour blindness using Ishihara charts.
- Molecular Mapping of Genes.

Suggested Readings:

1. Karp, G. 1999. Cell and Molecular Biology: Concept and Experiments. John Wiley and Sons, Inc., USA.

L	T	P	Cr
3	2	0	4

Course Code: BOT.510
Course Title: Non Vascular Plants and Fungal Systematics

Learning Outcome

1. Acquire necessary skills related to plant taxonomy and systematic also in depth coverage of algal, moss, and Fungi.
2. Training about various taxonomic evidences and how to prepare herbarium sheets.

Unit-I **15 Hours**

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-II **16 Hours**

Mycology: Introduction, scope and general principles of classification of fungi; Myxomycotina: Plasmodiophorales; Mastigomycotina: Chytridiales, Blastocladiales, Saprolegniales and Peronosporales; Zygomycotina: Mucorales and Entomophthorales; Ascomycotina: Endomycetales, Protomycetales, Taphrinales, Erysiphales, Eurotiales and pezizales; Basidiomycotina: Uredinales, Ustilaginales, Lycoperdales, Phallales, Agaricales, Aphyllophorales and Auriculariales; Deuteromycotina: Sphaeropsidales, Moniliales and Mycelia sterilia; Lichens: Thallus structure, reproduction and economic importance

Unit-III **14 Hours**

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, viridaeplantae, Terpentine, and streptophyta; ecological and economic importance of algae, algal life cycles, algal cultivation methods, algal resources of India.

Unit-IV **15 Hours**

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.

Suggested Readings:

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. Lee, R.E., (2008), Phycology, Cambridge University Press, Cambridge
4. Bold, H.C. and Wynne, M.J., (1985), Introduction to the Algae, 2nd Edition, Prentice-Hall Inc.
5. Webster, John, (1980), Introduction to fungi, Cambidge University Press
6. Webster, John and Roland, W.S., (2007). Introduction to Fungi, Cambridge University Press.
7. Alexopoulos, C.J., Minus, C.W. and Blackwell, M. (1996). Introductory Mycology, Wiley
8. Maheshwari, R. (2012) Fungi: Experimental Methods in Biology, CRC Press, Boka Raton, Florida
9. Prescott, G. W. (1969). The Algae: A Review. Thomson Nelson & Sons. London

Course Code: BOT.511
Course Title: Non Vascular Plants and Fungal Systematics – Practical.

L	T	P	Cr
0	0	2	1

Learning Outcome

1. This course will provide basics of taxonomic labwork including herbarium preparation, field trips and chemical taxonomy and algal/fungal/Bryophyte taxonomy.
1. **Algae:** Identification of common algae of Indian Subcontinent, Sectioning and microscopy of algal specimen

2. **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.
3. **Bryophytes:** External morphology and internal anatomy of the vegetative and reproductive organs of genera given in the theory.
4. Sample collection, preparation of herbarium, submission of report based on field trip.
5. Field sampling trip and report using GPS. Herbarium preparation. Identification of plants by morphometry.
6. Chemical taxonomy of plants using Gel Electrophoresis/HPLC.

Suggested Readings:

1. Cronquist, A. 1968. *The Evolution and Classification of Flowering Plants*. Thomas Nel and Sons, Ltd. London.
2. Farnsworth, Elizabeth. 2016 "Plant Systematics: A Phylogenetic Approach." Rhodora118.976: 418-420.
3. Webster J. 1985. *Introduction to Fungi*. Cambridge University Press.

Course Code: BOT.514
Course Title: Microbiology

L	T	P	Cr
3	2	0	4

Learning Outcomes

1. The students will learn the basics of microbial life, growth and nutrition of microbes, their cultivation and applied use.
2. Able to classify viruses and bacteria based on their characteristics and structures and understand diseases and their remediation
3. Increase awareness and appreciation about human friendly viruses, bacteria, algae and their economic significance.

Unit I **15 Hours**

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

Unit II **15 Hours**

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 III **15 Hours**

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 IV **15 Hours**

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 Readings:

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

Course Code: ZOO.511
Course Title: Cell Biology

L	T	P	Cr
3	2	0	4

Learning Outcomes

1. Demonstrate the concept of structure and basic components of prokaryotic and eukaryotic cells, especially organelles and their related functions.
2. Apply and effectively communicate scientific reasoning and data analysis in both written and oral forums related to cellular structure and function.

3. Describe and correlate the various cellular processes critical for cell growth and development, and function.

Unit I **15 Hours**

Cell: Evolution of the cell, molecules to cell, prokaryotes and eukaryotes. **Membrane Structure and Function:** Models of membrane structure, membrane proteins, membrane carbohydrates, membrane transport of small molecules, membrane transport of macromolecules and particles.

Unit II **15 Hours**

Structural Organization and Function of Intracellular Organelles: Lysosomes, ribosomes, peroxisomes, golgi apparatus, endoplasmic reticulum and its types, mitochondria and chloroplast, Structure of mitochondria and nucleus, oxidation of glucose and fatty acids, electron transport chain (ETC): oxidative phosphorylation, chloroplast and photosynthesis.

Unit III **15 Hours**

The Cytoskeleton: The nature of cytoskeleton, intermediate filaments, microtubules, actin filaments, cilia and centrioles, organization of the cytoskeleton.**Cell Communication:** Cell adhesions, cell junctions and the extra cellular matrix, cell-cell adhesion and communication, cell matrix adhesion, collagen the fibrous protein of the matrix, non-collagen component of the extra cellular matrix.

Unit IV **15 Hours**

Cell Division and Cell Cycle: Mitosis and meiosis, their regulation, steps in cell cycle, regulation and control of cell cycle events.

Suggested Readings:

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.

Interdisciplinary courses

Course Code: BOT.515
Course Title: Basic Concepts in Genetics.

L	T	P	Cr
2	0	0	2

Learning outcomes:

1. This course is designed for the students of sciences who have interest in genetics and want to witness the beauty of inheritance and evolution in day to day life.
2. The overall aim of the course is to prepare the students to apply the understanding of Genetics into their field of interest.
3. The students will be expected to gain knowledge in Mendel Genetics, DNA Biology and Population Genetics.

Unit-I **8 Hours**

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-II **8 Hours**

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

Unit-III **8 Hours**

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-IV **6 Hours**

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

Suggested 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*. 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.

Course Code: BOT. 516
Course Title: Economic importance of plants

L	T	P	Cr
2	0	0	2

Learning Outcome

1. Students will learn about economic important plants and their products commonly utilized for basic human needs as food, clothing, shelter, health etc.
2. Students will also know about how environmental pollution affects life on earth and evolution of plants.

Unit-I **6 Hours**

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

Unit-II **8 Hours**

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-III **8 Hours**

Vegetable oil yielding plants (Groundnut, Soybean, Safflower, mustard), Medicinal and aromatic plants (*Atropha belladonna*, *Rauwolfia 17erpentine*, *Withania somifera* and *Phyllanthus amaraus*),

Unit-IV **8 Hours**

Spices and condiments, 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.

Suggested Readings:

- Kochhar S. L., 5th Edition (2016) Economic Botany: A Comprehensive Study Cambridge University Press.
- Pandey.B.P., 17th edition (2017) Economic Botany. Pandey, S. Chand Publication.
- Singh, Pande, Jain (2015) A Text Book of Botany, Rastogi Publications.
- Verma. V (2009) – Economic Botany, ANE Books.
- Hill.A.W. (1981) – Economic Botany, McGraw Hill Pub.

Course Code: BOT. 517
Course Title: Fundamentals of Plant Biology Credits:

L	T	P	Cr
2	0	0	2

Learning Outcomes

Students will learn fundamentals of plant organization their functions, metabolism organ structure their functions and development. Also about

preparation of culture medium for plant tissue culture and how to grow disease free plant by tissue culture technique.

Unit I **7 Hours**

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

Unit II **8 Hours**

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

Unit III **7 Hours**

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

Unit IV **8 Hours**

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

Suggested 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. Bob B. Buchanan, (2000). Biochemistry and molecular Biology of Plants. Author: Wiley Blackwell,
4. David L. Nelson and Michael Cox. (2017). Lehninger Principles of Biochemistry: International Edition.
5. Ottoline Leyser and Stephen Day (2002) Mechanisms in Plant Development.

Course Code: BOT.518
Course Title: Biostatistics

L	T	P	Cr
2	0	0	2

Learning Outcomes

1. Students' will learn basics of probability and statistics relevant to biological research and able to perform inferential statistics for the data analysis of biological data.
2. Learn about the computer skills for biological data management; learn statistics software and graphical presentation.
3. Students will enlighten about the need for computer applications, programs and techniques for biology.

Unit I **7 Hours**

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

Unit II **9 Hours**

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

Unit III **9 Hours**

Inferential Statistics: t-Distribution and tests of significance based on t-distribution, F-distribution and tests of significance based on F distribution, x2 Distribution and tests of significance based on x2 distribution, Comparing Proportions, Gaussian, Binomial, Lognormal and Poisson Distributions, Pearson's Correlation, Simple Linear Regression, Non-Linear Regression, Nonparametric tests

Unit IV **5 Hours**

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 Readings:

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.

Course Code: BOT.519
Course Title: Research Methodology.

L	T	P	Cr
2	0	0	2

Learning Outcomes

1. Student will learn basic principles of research, formulate hypothesis and scientific writing.

2. Also learn about various search engines related to scientific literature, basic library tools and entrepreneurship.
3. The students will be enabled to know the state of art of research in botany.
4. Plan and carry out short term research projects, thesis, publication, seminar presentation and know the value of research.

Unit I **8 Hours**

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 II **7 Hours**

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

Unit III **8 Hours**

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 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 IV **7 Hours**

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 Readings:

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.

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

Course Code: BOT.521
Course Title: Molecular Biology.

L	T	P	Cr
2	0	0	2

Learning outcomes

1. The course is focused on the Central Dogma of life where students will understand the regulation of genes in response to different conditions.
2. The students will understand the basic concepts of molecular biology and genetic engineering, enhance the understanding of various processes life at molecular level.
3. The students will be expected to gain knowledge in the gene regulation, Genomics and Transcriptomics.

Unit I **9 Hours**

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 II **7 Hours**

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 III **7 Hours**

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 IV **7 Hours**

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 Readings:

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.

Course Code: BOT.522
Course Title: Molecular Biology –Practical

L	T	P	Cr
0	0	2	1

Learning outcomes

Get Hands on training on practical applications of molecular biology

- 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 CaCl2 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.

Suggested Readings:

1. J. Sambrook and D. Russell (2001) Molecular Cloning: A Laboratory Manual, Fourth edition.
2. Sambrook, J., Fritish, E.F., Maniatis, T. (2000). *Molecular cloning: A laboratory manual*. Cold Spring Harbor Laboratory Press, New York.

Course Code: BOT.523
Course Title: Plant Physiology

L	T	P	Cr
2	2	0	3

Learning outcomes

1. To learn about basic plant processes and their functioning aspects, transport systems, nutrition and primary and secondary metabolism.

2. The students will understand and appreciate the plant world we depend on.
3. Know about the basic principles of plant function, metabolism, secondary products, cell physiology & principles of growth & development.

Unit I **14 Hours**

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 II **10 Hours**

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 III **11 Hours**

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 IV **10 Hours**

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 Readings:

1. Buchanan, B.B. and Gruissem, 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.
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.

Course Code: BOT.524:
Course Title: Plant Physiology – Practical

L	T	P	Cr
0	0	2	1

Learning Outcomes

To learn about various aspects of physiological process and their measurements

- 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 analysis (Electrolyte leakage, Lipid peroxidation etc.)
- 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.
- 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.

Suggested Readings:

1. Srivastava, L.M. Plant Growth and Development. New York: Associated Press, 2002. Print.
2. Taiz, L., and Zeiger, E. Plant Physiology. California: The Benjamin/Cumming Publishing Company, 1998. Print

Course Code: BOT.525
Course Title: Plant Tissue and Organ Culture

L	T	P	Cr
2	2	0	3

Learning Outcomes

1. Students will learn tissue culture technique and its usage in conservation technology.
2. Students also can prepare culture medium for plant tissue culture.
3. The students will learn about the basic concept, technical skills, practical experience, and plant tissue culture and molecular biology training.

4. Understand the micropropagation methods and basic concept of somatic embryogenesis.

Unit I **11 Hours**

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 **12 Hours**

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 **12 Hours**

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 **10 Hours**

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;

Suggested Readings:

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.

Course Code: BOT.526
Course Title: Plant Cell, Tissue and organ culture –Practical

L	T	P	Cr
0	0	2	1

Learning Outcomes

To impart basic training in plant cell and tissue culture

- Practical demonstration of media preparation
- Practical demonstration of plant regeneration form various explant
- 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 to show the best utilization of microscopic and photography techniques for plant tissue culture

Suggested Readings:

1. Rainert, J.and Yeoman, M.M. Plant Cell and Tissue Culture ; A Laboratory Manual. Berlin: Springer-Verlag, 1982. Print.
2. Bhojwani, S. S., and Razdan, M. K. Plant Tissue Culture: Theory and Practice. Amsterdam: Elsevier;, 1983. Print

Course Code: BOT.527
Course Title: Ecology, Environment and Biodiversity

L	T	P	Cr
2	2	0	3

Learning Outcome

1. Students will learn basics of ecosystem and population ecology, an overview of biodiversity and various threats on biodiversity.
2. Students will understand the vegetative organization in community and how changes take place during ecological succession, role of biogeochemical cycle in environment and sources of greenhouse gases and their role.

Unit I **12 Hours**

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 II **12 Hours**

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 III **11 Hours**

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 IV **10 Hours**

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 Readings:

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

Course Code: BOT.528

Course Title: Ecology, Environment and Biodiversity – Practical

L	T	P	Cr
0	0	2	1

Learning Outcomes

Practical demonstration of ecological methods and analytical strategy

Syllabus

- 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.

- 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

Suggested Readings:

1. Eugene Odum (2004). Fundamentals of Ecology. Brooks. Cole

Course Code: BOT.529
Course Title: Vascular Plants Systematic

L	T	P	Cr
2	0	0	2

Learning Outcome

1. Students will learn in-depth taxonomy of Pteridophytes, gymnosperms, angiosperms with APG-IV system, economical importance of angiosperms and about DNA Taxonomy.
2. Understand external structure of plants.
3. Students are able to understand about modern approaches in taxonomic studies and the role of taxonomy in conservation of biodiversity.
4. To know about the economic importance and medicinal importance of plants.

Unit I **8 Hours**

Pteridophytes: Defining features of tracheophytes, Classification of pteridophytes; Euphyllophytes, 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.

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 II **8 Hours**

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 III **8 Hours**

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 (*Atropha belladonna*, *Rauwolfia serpentine*, *Withania somifera* and *Phyllanthus amaraus*), vegetable oil yielding plants (Groundnut, Soybean, Safflower, mustard), Spices and condiments, 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 IV **6 Hours**

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 Readings:

1. Bhojwani, S.S. and Bhatnagar, S.P. (1979) Embryology of Angiosperms, Vikash Publishing House, New Delhi
2. Gangulee, H.C. and Kar, A.K., College Botany Vol. II- 2011 (Algae+Fungi+Brophyta+Pteridophyta), New Central Book Agency, Kolkata
3. Hall, B.G. (2011). *Phylogenetic Trees Made Easy: A How-To Manual*. Sinauer Associates, Inc. USA.
4. Hennig, W., Dwight, D. and Zangerl, R. (1999). *Phylogenetic Systematics*. University of Illinois Press, USA.
5. Hill.A.W. (1981) – Economic Botany, McGraw Hill Pub.
6. 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.
7. Judd,W.S.,Christopher,S.,Campbell.,Kellogg,A.E.,Stevens,P.F.(1999). Plant Systematics: A Phylogenetic Approach. Sinauer Associates Inc. Publishers.
8. Lawrence.G.H.M. (1985). An Introduction to Plant Taxonomy, Central Book Depot, Allahabad.
9. Pandey, B.P., Angiosperms-Taxonomy, Emrbyology and Anatomy, S. Chand and Co., New Delhi.
10. Pandey.B.P. (1987) – Economic Botany.

11. Parihar. N.S., (1967). An introduction of Embryophyta, Vol.III – Pteriodophyta, Central book depot, Allahabad.
12. Porter.C.L. (1982) Taxonomy of Flowering Plants, Eurasia Publications House, New Delhi
13. Rashid, A., An Introduction to Pteridopyta by, 2nd edition, (2011), Vikas Publishing House Pvt. Ltd., Noida.
14. Schuh, R.T. and Brower, A.V.Z. (2009). *Biological Systematics: Principles and Applications*. Comstock Pub Assoc.
15. Simpson, M. G., (2006). Plant Systematics. Elsevier Academic Press.
16. Singh, Gurucharan (2019). Plant Systematics- Theory and Practices, Oxford and I.B.H. Publishing Co. New Delhi
17. Singh, Pande, Jain, A Text Book of Botany, (2014) (Algae+Fungi+Brophyta+Pteridophyta) ,Rastogi Publication, Meerut
18. Sporne, K.R. (2015) Morphology of Gymnosperms, B.I. Publication, New Delhi
19. Vashista, 1976, Gymnosperms, S. Chand & Co.

Course Code: BOT.530.
Course Title: Vascular Plants Systematics - Practical

L	T	P	Cr
0	0	2	1

Learning Outcomes
Practical demonstration of methods in angiosperm taxonomy and Practical training on molecular systematics

- **Pteridophytes:** External morphology and internal anatomy of the vegetative and reproductive organs of genera given in the theory.
- **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.

Suggested Readings:

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. Farnsworth, Elizabeth (2016). Plant Systematics: A Phylogenetic Approach. Rhodora118.976: 418-420.

Course Code: BOT.531
Course Title: Mycology & Plant Pathology

L	T	P	Cr
3	2	-	4

Learning Outcomes: The students will

1. Understand basic fungal biology, taxonomy of the fungi and major fungal lineages.
2. Develop functional knowledge on differentiating disease caused by virus, fungi, and bacteria
3. Learn about the biology of major, and emerging pathogens and pests of crop plants
4. Examine advantages and disadvantages of current control practices based on chemical ecology, genetics of plant resistance and breeding including transgenic approaches
5. Combine theoretical and practical knowledge of plant disease and pest management.

Unit I **15 hours**

Overview of Fungi and fungus-like organisms (Myxomycetes, Acrasiomyctes, and Oomyctes), A higher-level phylogenetic classification of the Fungi. True fungi: Characteristics and important Genera of Phyla – Chytridiomycota, Zygomycota, Glomeromycota, Ascomycota, and Basidiomycota. Physiology of fungal growth, reproduction and Importance and ecological role of fungi.

Unit II **15 hours**

Plant Pathology: General concepts, General characteristics of plant pathogenic organisms and pests,. Molecular approaches for the investigation of plant diseases. Control mechanisms based on chemical treatments, biological control and genetic engineering.

Unit III **15 hours**

Plant interactions with pathogens and pests: Methods of disease diagnosis: Field observation, isolation and identification of Pathogens. History, symptomology, pathogen, etiology and management: Jowar (Head and Grain smut), Bajara (Green ear), Wheat (Rust and Bunt), Rice (Blast), Groundnut (Leaf spot and Rust), Sunflower (Downy mildew), Soybean (Mosaic), Cotton (Angular leaf spot),Sugarcane (Whip smut and Grassy shoot), Citrus (Canker), Grapes (Powdery mildew, Anthracnose, Downy mildew), Pigeon pea (Wilt), Bhendi (Yellow vein mosaic virus), Potato (Early and late blight), Tomato (Early blight).

Unit IV **15 hours**

Integrated management of plant diseases: Definition of IDM, international approach, Quarantine laws, Culture methods, avoidance of pathogen, breeding and use of disease resistant varieties. Seed certification

Suggested Readings:

1. Alexopoulos, C.J., Mims, C.W. and Blackwell, M. (2007). Introductory Mycology. Fourth Edition Wiley India Pvt. Limited
2. Webster, J. and Weber, R. (2007). Introduction to Fungi. Third Edition. Cambridge University Press. Cambridge and New York
3. Sethi, I.K. and Walia, S.K. (2018). Text book of Fungi & Their Allies, Second Edition. MacMillan Publishers Pvt. Ltd., Delhi, India
4. Dickinson, M. (2003). Molecular Plant Pathology, Bios Scientific Publishers, London.
5. Sharma, P.D. (2017). Mycology and Phytopathology. Rastogi Publishers, Meerut, India
6. Burchett, S. and Burchett, S. (2018). Plant Pathology, Garland Science, US Department of Botany, University of Delhi 37
7. Koul, O., Dhaliwal, G.S. and Cuperus, G.W. (2004). Integrated Pest Management: Potential, constraints and challenges , CABI Press, UK
8. Dhaliwal, G.S. and Arora, R. (1996). Principles of insect pest management, National Agricultural Technological Information Center, Ludhiana, India

SEMESTER II

Course Code: BOT. 532
Course Title: Marine Botany

L	T	P	Cr
3	2	-	4

Learning Outcomes: The students will understand basic aquatic plant biology, taxonomy of the marine Plants, lichens, Mangroves salt marshes, bacteria and viruses etc.

Unit I **15 hours**

Marine environment and organisms: Benthic & Pelagic environment, Classification of marine organisms-Plankton, Nekton, Benthos, Marine Plant Groups, Marine phytoplankton: Classification & diversity, Buoyancy, Red tides Microbial diversity in marine habitat: Brief idea of Marine Fungi, Actinomycetes, Marine Bacteria , Viruses & Marine Lichens, Coral reefs: Types, Biology, Zooxanthellae, Reef algae & herbivores, Importance.

Unit II **15 hours**

Microalgae: Classification & Salient features of Cyanophyta, Pyrrhophyta, Chrysophyta, Cryptophyta, Examples from each division. Macroalgae: Classification of Seaweeds, General characteristics, life cycle & type studies of Chlorophyta (Ulva, Enteromorpha), Phaeophyta (Sargassum, Padina) & Rhodophyta (Gracilaria, Porphyra), Evolution of thallus in different classes.

Unit III **15 hours**

Biodiversity of mangroves: Definition of the term 'mangrove', biodiversity, brief idea of Creek, Estuary, Lagoon and Delta. Distribution & biogeography of Indian mangroves, East and west coast mangroves, Mangrove forest types. Salient Features of Important Mangrove Families: Rhizophoraceae, Sonneratiaceae, Avicenniaceae, Myrsinaceae, Acanthaceae. Mangrove associates.

Unit IV **15 hours**

Salt marshes: Salt marsh flowering plants-Occurrence, Taxonomy, Distribution, Morphological and anatomical adaptations, Ecological roles, Salt marsh ferns, bryophytes, algae. Sea grasses: Taxonomy, Distribution, Morphological & anatomical adaptations, Ecological roles, Sea grasses & Human affairs. Sand dunes: Occurrence, Formation of coastal sand dunes. Classification, Embryo dune, Yellow dune, Grey dune, Succession in dune vegetation, Dune vegetation.

Suggested Readings

1. Alexopoulos, C.J. & Bold, H.C. (1967). Algae & Fungi: Current Concepts in Biology Series. The Macmillan Company, London.
2. Chapman, V. J. (1976). Coastal Vegetation. 2nd ed. Pergamon Press. New York
3. Chaudhuri. A. B. (2007). Biodiversity of Mangroves.
4. Kamat, N. D. (1982). Topics in Algae. Sai Kripa Prakashan, Aurangabad Kumar H. D. 1990. Introduction to Phycology. Affiliated East West Press pvt. Ltd. publ. New Delhi.
5. McConnaughey, B. H (1974). Introduction to Marine Biology. 2nd ed. Mosby publisher.
6. Santhanam, R.; Ramnathan,N.; Venkataramanjan K. & Jegathanam,G. (1987) . Phytoplankton of Indian Seas. & Aspects of Marine Botany.Daya Publication Home. Delhi.
7. Sen Neera and Kumudranjan Naskar, (2003). Algal Flora of Sundarbans. Mangal Daya
8. Stein, J. R. (1973) Handbook of Phycological Methods. Cambridge University Press.

Interdisciplinary Course:

Course Code: BOT.533
Course Title: Basic Plant physiology and biochemistry

L	T	P	Cr
2	0	0	2

Learning Outcome

1. The students will understand basic plant processes and functions aspects of these processes.
2. Student will be able to understand plant water relations, mechanism of photosynthesis and Respiration.
3. Students will get about nitrogen fixation, plant growth regulators and photoperiodism.

4. Students will understand stress types and their mechanism.
5. Students have a detailed knowledge of plant maturation mechanisms and biological clocks.

Unit-I **8 Hours**

Basic plant physiology, processes and functions, Photosyntheisis

Unit-II **7 Hours**

Primary and Secondary Metabolism

Unit-III **7 Hours**

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

Unit-IV **8 Hours**

Plant Growth regulators, Auxins, Gibberellins, Cytokinins, Ethyklene, 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.
2. Taiz, L. and Zeiger, E. (2010). *Plant physiology*. Sinauer Associates Inc., USA.
3. Taiz, L., Zeiger, E. Mollar, I. M. and Murphy, A. (2015). Plant physiology and Development 6th edition. Sinauer Associates Inc., USA.

L	T	P	Cr
2	0	0	2

Course Code: BOT.534
Course Title: Evolution and Humanity

Learning Outcome

1. Students will learn the basics of theory of evolution and its implications, historical linguistics and how this field is influenced by Darwin's theory and about historical socio-politics and its connection with Darwinism.
2. The students will be able to learn about the basics of cell and its inclusions
3. Familiarize with the various concepts of evolution.
4. Students will be able to utilize embryological studies in various aspects like analysis of evolutionary trends and delimitation of taxa.

Unit I **8 Hours**

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

Unit II **7 Hours**

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 III **8 Hours**

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 IV **7 Hours**

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 Readings:

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.

Course Code: BOT.535
Course Title: Fundamentals of Plant Biotechnology

L	P	T	Cr
2	0	0	2

Learning Outcome:

1. Introduction to fundamentals of plant biotechnology course is an overview of plant tissue culture, application of tissue culture to plant breeding, gene cloning, gene transfer in plants, transgenic in crop improvement, and impact of recombinant DNA technology.
2. Understand the basic principles of plant tissue culture and acquire knowledge on how to develop transgenic plant.
3. Students will be able do the genetic transformation methods and metabolic engineering in plants.

Unit I **6 Hours**

Introduction to plant biotechnology, Tissue culture media and preparation, Sterilisation techniques, In vitro Micropropagation, Application of tissue culture to plant breeding

Unit II **6 Hours**

Introduction to molecular biology, Basic molecular techniques, PCR based techniques, Genetic markers, Applications of molecular markers

Unit III **9 Hours**

Cloning vectors, cDNA and DNA libraries; Approaches for gene isolation, Analysis of cloned genes; Transient and stable gene transfer, Gene transfer methods, Agrobacterium mediated gene transfer

Unit IV **9 Hours**

Transgenic Development: Insect resistance, Virus and disease resistance, Resistance to abiotic stresses, Herbicide resistance, Transgenic for quality, Impact of recombinant DNA technology: Commercial transgenic crops: Ethical issues and impact on environment

Suggested Readings:

1. Bhojwani SS, Razdan Mk (2009) Plant Tissue Culture: Theory and Practice, Volume 5, Elsevier Science
2. M.K. Razdan (2003) Introduction to Plant Tissue Culture, Science Publisher, Science
3. T A Brown (2016) Gene cloning and DNA analysis: An introduction, Seventh Edition, Wiley Blackwell
4. H Lorz and G. wenzel (2005) Molecular marker systems in Plant Breeding and crop improvement, Springer
5. Chittaranjan Kole, Charles H. Michler, Albert G. Abbott, Timothy C. (2010) HalTransgenic crop plant, volume 1: Principle and development, l, Springer
6. Ammann K, Jacot Y, Kjellsson Simonsen V, (1999) Methods for Risk Assessment of transgenic plants. Springer

Course Code: BOT.542
Course Title: Seminar-1

L	T	P	Cr
0	0	2	1

Learning outcomes

1. Ability to critically analyze the topic on emerging areas
2. Enhancement of presentation skills of the students.

Course Code: BOT.551
Course Title: Recombinant DNA Technology

L	T	P	Cr
2	2	0	3

Learning Outcomes

1. Students will learn the basics of Genetic Engineering and understanding of various molecular tools needed for DNA manipulations.
2. The overall aim of the course is enhancing the understanding of various DNA manipulating tools and practical applications in Agriculture and different Industries.
3. Students will get knowledge about importance of recombinant DNA technology for the production of vaccines, crop developed by genetic engineering.

Unit I **12 Hours**

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 II **10 Hours**

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 III **12 Hours**

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 IV **11 Hours**

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 Readings:

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.

Course Code: BOT.552
Course Title: Recombinant DNA Technology-Practical

L	T	P	Cr
0	0	2	1

Learning Outcomes
Practical demonstration and hands on training on various aspects of genetics as mentioned below

- 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.

Suggested Readings:

1. J. Sambrook and D. Russell (2001) Molecular Cloning: A Laboratory Manual, Fourth edition.
2. J.D. Watson et al., (1992), Recombinant DNA: A Short Course

Course Code: BOT.553
Course Title: Techniques in Life Sciences

L	T	P	Cr
2	2	0	3

Learning Outcome

1. Students will learn basics of analytical methods used frequently in biological sciences, including microscopy, spectroscopy, nucleic acid techniques and flow cytometry.
2. Students get enhances skills in handling scientific instruments, planning and executing biological research.

Unit I **13 Hours**

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 II **10 Hours**

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

Unit III **12 Hours**

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 IV **10 Hours**

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 Readings:

1. Brown, T.A. (2015). 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.

Course Code: BOT.554
Course Title: Evolutionary Biology

L	T	P	Cr
2	0	0	2

Learning Outcome

1. Students will learn basics of Darwin's theory of evolution, evolutionary mechanisms and macroevolution, including punctuated equilibrium also about molecular evolution.
2. Students will familiarize with the various concepts of evolution.
3. Interpret the Mendel's principles, acquire knowledge on cytoplasmic inheritance and sex linked inheritance.
4. Interpret the concepts of the Mendel, acquire knowledge about cytoplasmic ancestry and inheritance related to sex.

Unit I **8 Hours**

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 II **7 Hours**

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

Unit III **8 Hours**

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 IV **7 Hours**

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 Readings:

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.

Course Code: BOT.555
Course Title: Molecular Stress Physiology

L	T	P	Cr
3	2	0	4

Learning outcome

1. To learn about various environmental factors involved in normal growth and development of plants and how plants cope up under adverse conditions.
2. Student will understand the significance of stresses in plants and develop knowledge about signaling pathways and tolerance during stress condition.

Unit I **15 Hours**

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

Unit II **15 Hours**

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 III **15 Hours**

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 IV **15 Hours**

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 Readings:

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.

Course Code: BOT.556
Course Title: Principles of Ethnobotany

L	T	P	Cr
3	2	0	4

Learning outcome

To learn about basic approaches to the study of Traditional Botanical Knowledge and Protection of Traditional Botanical Knowledge

Unit I **15 Hours**

Ethnobotany: Definitions. Scope and functions. History and development of Ethnobotany: Development of Ethnobotany in Asia with special reference to that in India, Ethnobotany outside Asia. Traditional Scientific knowledge: Indigenous technical knowledge (ITK): Indigenous Agricultural knowledge (IAK), Traditional ecological knowledge (TEK), Rural people's knowledge (RPK), Traditional botanical knowledge (TBK), Integrated knowledge system (IKS).

Unit II **15 Hours**

Documentation and interpretation of Traditional Botanical Knowledge: Basic approaches to the study of Traditional Botanical Knowledge - Utilitarian, Cognitive, and Ecological. Scientific validation of traditional plant use: Nutritional quality, Pharmacological properties. Insect repellent activity.

Unit III **15 Hours**

Ecology of Culture and Cultural Ecology: Functional interpretations of culturally determined behaviour - Human sacrifice. Male supremacy. Pollution taboos, In-law avoidance. Evil spirit homes. Sacred groves. Drug preparation. Collecting Ethnobotanical Evidence: The dynamics and distribution of traditional botanical knowledge. Sources of knowledge: The dissemination of traditional botanical knowledge, differential distribution of traditional botanical knowledge: Socio-cultural influence on knowledge distribution - Intercultural influences (Mode of production. Biological environment. Level of external contact (acculturation), Ethnicity, Religion), Intracultural influences - Gender, Age, Class, Place of birth, Literacy, Occupation, Migration for work or marriage. Language ability.

Unit IV **15 Hours**

Dynamics of Knowledge: Observation, Experimentation and Adaptation. Traditional Botanical Knowledge in Rural Development: The origins of participatory research. Partnership in practice. Ethnobotany and sustainable utilization of plant resources. Protection of Traditional Botanical Knowledge. Major subdisciplines of Ethnobotany. Major tribes of India and their dependence on plants.

Suggested Readings:

1. Faulks, P.J. 1958. An Introduction to Ethnobotany. Moredale Publications Ltd., London
2. Jain, S. K. (Ed.). 1981. Glimpses of Indian Ethnobotany. Oxford & IBH Jain, S. K. 1995. A Manual of Ethnobotany. Scientific Publishers.
3. Jain, S. K., Mudgal, V., Banerjee, D. K., Guha, A., Pal, D. C. & Das, D.1984. Bibliography of Ethnobotany. Botanical Survey of India. Ranfrew, Jane. 1973. Paleoethnobotany. Columbia University Press.

Course Code: BOT.504
Course Title: E-tools for Plant Identification

L	T	P	Cr
0	0	2	1

Learning Outcomes: This 1 credit course will introduce the students to the current state of the art online tools that aid in the taxonomic identification of plant species. Existing online ID keys, databases, app-based tools etc. will be introduced. In addition, guidance on developing android apps for plant identification will also be covered.

At the completion of this course students will be able to:

Introduce students to various online tools for plant identification

Introduce concepts of SDK tools and APK documentation (for android app development)

Unit I **4 Hours**

Interactive identification: e-Resources for the plant Taxonomy, Overview of various websites and databases including that for cyanobacteria, algae, mosses, ferns, angiosperms, monocots and dicots

Unit II **4 Hours**

Automated identification: Review of various existing apps that aid in taxonomic identification of plant species, with a thorough training on its use as well as using these apps for fostering citizen science. Apps will include PlantNet, PlantSnap, LeafSnap, PictureThis, Flora Incognita, PlantIdentifier and What's that flower

Unit III **4 Hours**

Basics of SDK and APK: Basic architecture of android apps, android app development, developing plant taxonomy app based on Google's reverse image search API, Simple tools for building android app

Unit IV **3 Hours**

Digital taxonomic resources, the big picture: Pros and Cons of trusting e-tools, Artificial Intelligence- assisted deep learning to assist plant species identification and curation of herbaria, Convolutional neural networks. use of mnemonics, interactive dichotomous keys, pitfalls to avoid**.**

Suggested Readings:

1. Wilson, J. B., & Partridge, T. R. (1986). Interactive plant identification. Taxon, 35(1), 1-12.
2. Yanikoglu, B., Aptoula, E., & Tirkaz, C. (2014). Automatic plant identification from photographs. Machine vision and applications, 25(6), 1369-1383.
3. Joly, A., Goëau, H., Bonnet, P., Bakić, V., Barbe, J., Selmi, S., & Boujemaa, N. (2014). Interactive plant identification based on social image data. Ecological Informatics, 23, 22-34.
4. Kumar, N., Belhumeur, P. N., Biswas, A., Jacobs, D. W., Kress, W. J., Lopez, I. C., & Soares, J. V. (2012, October). Leafsnap: A computer vision system for automatic plant species identification. In European conference on computer vision (pp. 502-516). Springer, Berlin, Heidelberg.
5. Lee, S. H., Chan, C. S., Wilkin, P., & Remagnino, P. (2015, September). Deep-plant: Plant identification with convolutional neural networks. In 2015 IEEE international conference on image processing (ICIP) (pp. 452-456). IEEE.
6. Yigit, E., Sabanci, K., Toktas, A., & Kayabasi, A. (2019). A study on visual features of leaves in plant identification using artificial intelligence techniques. Computers and electronics in agriculture, 156, 369-377.

Course Code: BOT.599
Course Title: Project. Credits

L	T	P	Cr
0	0	12	6

Learning outcomes
Students' shall be exposed to formulate a small research problem and execute in real lab conditions. Students'/concern supervisor may opt for review writing also.

Evaluation Criteria:
Supervisor has to evaluate and give Satisfactory/Unsatisfactory
Final evaluation shall be of open seminar and shall be conducted in 4th Semester

Course Code: BOT.571
Course Title: Plant Metabolic Engineering

L	T	P	Cr
3	2	0	4

Learning Outcome

1. Student will learn how to engineer plants for specific metabolite production, and various metabolomics techniques.
2. Get to know the production of secondary metabolites and metabolic engineering.
3. Students will know the molecular knowledge in metabolic engineering of transgenic plant to produce biologically important products.

Unit I **15 Hours**
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.

Unit II **15 Hours**
Building networks as assemblies of simpler control schemes, Metabolic flux analysis, Metabolic control analysis, Structure and flux analysis of metabolic networks,

Unit III **15 Hours**
Metabolomics, Techniques used in metabolomics, Metabolome informatics.

Unit IV **15 Hours**
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.

Course Code: BOT.572
Course Title: Anatomy and Developmental Biology of Plants

L	T	P	Cr
2	2	0	3

Learning Outcome

1. Students will learn in-depth anomalies related to anatomy of stem and roots and in-depth Developmental biology of plants.
2. Understand external and internal structure of plants and economic importance.
3. Get knowledge on structure and development plant embryo.
4. Acquire knowledge on the physiological functions of plants.
5. Get knowledge on anatomy and developmental biology of the plants.

Unit I **12 Hours**

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

Unit II **10 Hours**

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 III **11 Hours**

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

Unit IV **12 Hours**

Anatomy: Shoot development: organization of shoot apical meristem Root development: organization of root apical meristem. Leaf development and phyllotaxy; transition to flowering, floral meristems and floral development in *Arabidopsis and Antirrhinum.* Anatomy of Stems and roots with special reference to plants showing anomalies- *Nyctanthes, Bignonia, Strychnos, Salvadora, Boerhaavia, Dracaena* and *Tinospora*.

Suggested Readings:

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.
5. Bhojwani, S.S. and Bhatnagar, S.P. (2016) Embryology of Angiosperms, Vikash Publishing House.
6. Maheshwari, P. (2015) An introduction to the embryology of angiosperms, Nabu Press or Tata McGraw Hill
7. Hake, S. and Wilt, F. (2003). Principles of Developmental Biology. W.W. Norton & Company, New York, USA.
8. Slack, J.M.W. (2005). Essential Developmental Biology, Wiley-Blackwell, USA.
9. B P Pandey (2014) Plant Anatomy, S. Chand Publications
10. Singh, Pande, Jain (2015) A Text Book of Botany, Rastogi Publications.

Course Code: BOT.573
Course Title: Anatomy and Developmental Biology of Plants

L	T	P	Cr
0	0	2	1

Learning Outcomes

Students will learn about the structural aspects of developmental events

- Practical demonstration of various reproductive plant parts
- Practical demonstration of Stem and root anatomy of dicots and monocots
- 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

Course Code: BOT.574
Course Title: Comprehensive Plant Sciences

L	T	P	Cr
2	0	0	2

Learning outcome

1. This course is designed to sensitize the students' regarding competitive world and various options, and revision of important course contents.
2. Apply the knowledge of biology to make scientific queries and enhance the comprehension potential.

Unit I **6 Hours**

Revision of key topics (to be chosen by the students' Semester –I &II)

Unit II **8 Hours**

Revision of key topics (to be chosen by the students' Semester –III &IV)

Unit III **8 Hours**

Subject related problems shall be addressed viz. revision of specific topics, mock tests of last year's CSIR NET exams.

Unit IV **8 Hours**

This course shall focus on utility of life sciences in this competitive world, various career options as well as Sensitization about higher education in India and abroad.

Course Code: BOT.575
Course Title: Life Sciences, Communication

L	T	P	Cr
0	0	4	2

Learning outcome

1. This course is designed to enhance presentation and interpersonal skills.
2. Successful transfer of scientific knowledge both orally and in writing.

Unit I **6 Hours**

The focus shall be give on communication and presentation skills. Basic presentation skills, Oration etc.

Unit II **8 Hours**

Flip Class on specific topics (Topics be chosen by the students'). The evaluation shall be done based on the presentation.

Unit III **8 Hours**

Subject related problems shall be addressed viz. revision of specific topics, mock tests of last year's CSIR NET exams.

Unit IV **8 Hours**

Develop writing skills, language improvement, online language improvement tools etc

Course Code: BOT.505
Course Title: Agro-Ecology

L	T	P	Cr
0	0	2	1

Learning Outcomes:

Students will learn the current practices of sustainable agriculture. The components of farm management will be studied within the context of a complex ecosystem. Class time will be spent in lecture, field studies and field trips that will attempt to integrate concepts in agroecology with actual practices in sustainable agriculture.

At the completion of this course students will be able to:

Integrate knowledge of biological and sociological systems into the development of sustainable food production strategies, which are innovative and ecologically sound.

Communicate in written and oral formats a clear understanding of sustainable agriculture concepts and their basis in natural ecosystem functioning.

Analyse current popular models of agroecology with a critical understanding of potential biological and sociological flaws.

Unit I **4 Hours**

Introduction, Concept, Plant and their environment, other environmental factors (temp, water and wind)

Unit II **4 Hours**

Soil (chemical, physical, biological characteristics,), soil organic matter and its management. Soil testing activity, soil water, cover cropping and soil fertility management. Role of BIOchar in soil fertility. Vermicomposting, root growth and interaction with soils, allelopathy, germ plasm conservation

Unit III **3 Hours**

Build hoop house at community Garden, Genetic resources. The benefits and risks of GMO's. Pollution processes in agriculture, Species interaction in crop communities.

Unit IV **4 Hours**

Agroecosystem diversity, stability, disturbance & succession, animals in the agroecosystem. Bees and pollination. Integrated pest management & Biological control.

Suggested Readings:

1. Gliessman, S. R. 2007. Agroecology: Ecological Processes in Sustainable Agriculture. 2nd. Ed., An Arbor Press, Chelsea, MI
2. Powers, L.E., and R. McSorley. 2000. Ecological principles of agriculture. Delmar Thomson Learning, Albany, NY.

Course Code: BOT.544
Course Title: Research Seminar

L	T	P	Cr
0	0	0	1

Course Code: BOT. 599
Course Title: Master's Research Project

L	T	P	Cr
0	0	0	6

The Synopsis and Master's Project Research shall be evaluated by a three member committee consisting of

a. Head of the Department
b. Supervisor or Co-supervisor
c. Vice Chancellor's Nominee (One Senior faculty of the department)

Evaluation Criterion	**Max percentage**
Literature survey/background information	20
Organization of content	5
Physical presentation	15
Question and Answer	10
Report evaluation	50
Total	100

Year-1	**Sem-I**		**25**
Year-1	**Sem-II**		**25**
Year-2	**Sem-III**		**20**
Year-2	**Sem-IV**		**20**
	Total credits		**90**