Central University of Punjab, Bathinda

M.Sc. Botany

Academic Session
2021-23

Department of Botany

School of Basic Sciences

Graduate Attributes

Students graduating from the program will benefit the society by adding to the highly skilled scientific workforce, in basic sciences, plant taxonomy, plant biotechnology, and agricultural sectors, in academia, industry and research institutions. They will have higher order thinking skills and capabilities aligned to resolve emerging regional, national, and international problems in agriculture and environment.

Course Structure
SEMESTER-I

Course Code	Course Title	Course Type	L	T	P	Cr
BOT.506	Biochemistry	Core	3	0	0	3
BOT.507	Biochemistry (P)	Skill Based	0	0	2	1
BOT.508	Genetics	Core	3	0	0	3
BOT.509	Genetics (P)	Skill Based	0	0	2	1
BOT.510	Non-Vascular Plants and Fungal Systematics	Core	3	0	0	3
BOT.511	Non-Vascular Plants and Fungal Systematics (P)	Skill Based	0	0	2	1
BOT.518	Biostatistics	Compulsory Foundation	0	0	3	3
BOT.519	Research Methodology	Compulsory Foundation	0	0	3	3
Discipline Electives: Opt any one						
ZOL.511	Cell Biology	Discipline Elective	3	0	0	3
BOT.554	Evolutionary Biology	Discipline Elective	3	0	0	3
MIC.511	Techniques in Microbiology	Discipline Elective	3	0	0	3
MIC.512	Introduction to Cell and Tissue Culture	Discipline Elective	3	0	0	3
ZOL.525	Nanobiology	Discipline Elective	3	0	0	3
IDC to other department (Our students to choose <u>one</u> IDC offered by any other department)						
BOT.517	Fundamentals of Plant Biology	Inter-Disciplinary	2	0	0	2
BOT.533	Basic Plant physiology and biochemistry	Inter-Disciplinary	2	0	0	2
BOT.535	Fundamentals of Plant Biotechnology	Inter-Disciplinary	2	0	0	2
	Total Credits		**20**	**0**	**6**	**23**

SEMESTER-II

Course Code	Course Title	Course Type	L	T	P	Cr
BOT.521	Molecular Biology	Core	3	0	0	3
BOT.522	Molecular Biology (P)	Skill Based	0	0	2	1
BOT.523	Plant Physiology	Core	3	0	0	3
BOT.524	Plant Physiology (P)	Skill Based	0	0	2	1
BOT.525	Plant Tissue and Organ Culture	Core	3	0	0	3
BOT.526	Plant Tissue and Organ Culture (P)	Skill Based	0	0	2	1
BOT.527	Ecology, Environment and Biodiversity	Core	3	0	0	3
BOT.528	Ecology, Environment and Biodiversity(P)	Skill Based	0	0	2	1
BOT.561	Critical Thinking and Soft Skills (University-Level)	Value-Added	2	0	0	2
Opt any One						
BOT.553	Techniques in Plant Sciences	Discipline Elective	3	0	0	3
BOT.532	Marine Botany	Discipline Elective	3	0	0	3
MIC.524	Environmental Microbiology	Discipline Elective	3	0	0	3
MIC.525	Microbial Pathogenicity	Discipline Elective	3	0	0	3
ZOL.552	Cancer Biology	Discipline Elective	3	0	0	3
ZOL.529	Genetic Engineering	Discipline Elective	3	0	0	3
GEO.524	Biogeography	Discipline Elective	3	0	0	3
GEO.508	Oceanography	Discipline Elective	3	0	0	3
EGS.533	Paleobotany	Discipline Elective	3	0	0	3
EGS.536	Astro and Geobiology	Discipline Elective	3	0	0	3
Total			**17**	**0**	**8**	**21**

SEMESTER-III

Course Code	Course Title	Course Type	L	T	P	Cr
BOT.551	Recombinant DNA Technology	Core	3	0	0	3
BOT.552	Recombinant DNA Technology (P)	Skill Based	0	0	2	1
BOT.571	Plant Metabolic Engineering	Core	3	0	0	3
BOT.579	Plant Metabolic Engineering (P)	Skill Based	0	0	2	1
BOT.529	Vascular Plants Systematics	Core	3	0		3
BOT.530	Vascular Plants Systematics (P)	Skill Based	0	0	2	1
BOT.574	Comprehensive Plant Sciences	Discipline Enrichment	2	0	0	2
BOT.560	Entrepreneurship (Compulsory Foundation)	Compulsory Foundation	1	0	0	1
BOT.600	Research Proposal	Skill Based	0	0	8	4
Opt any one						
BOT.555	Molecular Stress Physiology	Discipline Elective	3	0	0	3
BOT.572	Anatomy and Developmental Biology of Plants	Discipline Elective	3	0	0	3
LMM.555	Evolutionary and Developmental Biology	Discipline Elective	3	0	0	3
LHG.551	Biosafety, Bioethics and IPR	Discipline Elective	3	0	0	3
ZOL.578	Insect Biology	Discipline Elective	3	0	0	3
Total			**15**	**0**	**14**	**22**

SEMESTER-IV

Course Code	Course Title	Course Type	L	T	P	Cr
BOT.600	Dissertation	Skill Based	0	0	40	20
Total					**40**	**20**

Table legends: L: Lectures, **T:** Tutorial, **P:** Practical, **Cr:** Credit (Two Practical credit hours = One credit)

NB: MOOCs may be taken up to 40% of the total credits (excluding dissertation credits). MOOC may be taken in lieu of any course, but content of that course should match a minimum 70%. Mapping will be done by the department and students will be informed accordingly.

Evaluation Criteria for Theory Courses

A. Continuous Assessment (Course-wise): [25 Marks]

Two or more of the given methods (Surprise Tests, in-depth interview, unstructured interview, Jigsaw method, Think-Pair Share, Students Teams Achievement Division (STAD), Rubrics, portfolios, case based evaluation, video based evaluation, Kahoot, Padlet, Directed paraphrasing, Approximate analogies, one sentence summary, Pro and con grid, student generated questions, case analysis, simulated problem solving, media assisted evaluation, Application cards, Minute paper, open book techniques, classroom assignments, homework assignments, term paper).

B. Mid Semester Test: Based on Subjective Type Test [25 Marks]

C. End-Term Exam: Based on Objective Type Tests [50 Marks]: 70% subjective type and 30% objective type.

The objective type will include one word answers, fill-in the blank, sentence completion, true/false, MCQs', and matching, analogies. The subjective type will include a very short answer (1-2 lines), short answer (one paragraph), essay type with restricted response, and essay type with extended response.

Core, Discipline Elective, Compulsory Foundation, Value Added and Interdisciplinary Courses			**Discipline Enrichment Course**		**Entrepreneurship Course**	
	Marks	**Evaluation**	**Marks**	**Evaluation**	**Marks**	**Evaluation**
Internal Assessment	25	Various	-	-	-	-
Mid-semester test (MST)	25	Subjective	50	Objective	25	Objective
End-semester test (EST)	50	Subjective (70%) Objective (30%)	50	Objective	25	Subjective

Semester-I

BOT.506
Biochemistry.
Total Hrs: 45

L	T	P	Credits
3	0	0	3

Learning Outcomes

Upon successful completion of this course, the student will be able to:

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.
Practical aspects of basic biophysical chemistry

Unit II **14 Hours**

Composition, structure and function of Biomolecules: Carbohydrates, Lipids, Proteins, Nucleic acids and Vitamins, Human energy requirements, Nutraceuticals.
Practical aspects of basic biophysical chemistry shall be coved

Unit III **20 Hours**

Metabolism: Bioenergetics and metabolism of Carbohydrates, TCA cycle, ETC, Oxidative phosphorylation, Pentose phosphate pathway, Fatty Acid Metabolism, Amino Acids and Nucleic acid metabolism.
Enzyme assays related to metabolic pathways shall be done in lab

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.
Enzyme catalysis and kinetics shall be studied s

Suggested Reading:

- Berg, J.M., Tymoczko, J.L. and Stryer, L. (2010). *Biochemistry.* W.H. Freeman & Company. USA.
- Haynie, D.T. (2007). *Biological thermodynamics*. Cambridge University. UK.
- Mathews, C.K., Van Holde, K.E. and Ahern, K.G. (2000). *Biochemistry*. Oxford University Press Inc. New York.
- Nelson, D. and Cox, M.M. (2017). *Lehninger Principles of Biochemistry*. W H Freeman & Co; 7 edition.)
- Randall, D. J., Burggren, W. and French, K. (2001). *Eckert animal physiology*. W.H. Freeman & Company. USA.
- Shukla AN (2009). *Elements of enzymology.* Discovery Publishing. New Delhi, India.
- Voet, D. and Voet, J.G. (2017). *Principles of biochemistry*. CBS Publishers & Distributors. New Delhi, India.

Transaction Mode:

1. Lecture
2. Demonstration
3. Seminar
4. Group discussion
5. Tutorial
6. Problem solving
7. Self-directed learning

Tools

1. Power point Presentations
2. YouTube videos
3. Podcasts

BOT.507:
Biochemistry – Practical.

L	T	P	Credits
0	0	2	1

Learning Outcomes

This course shall provide basic hands on 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 Reading:

- Campbell, M.K. (2012) Biochemistry, 7th ed., Published by Cengage Learning.
- K. Wilson & K.H. Goulding (1991) A Biologist guide to Principles and Techniques of practical Biochemistry, ELBS Edition.
- Sambrook, J., Fritish, E.F., Maniatis, T. (2000). *Molecular cloning: A laboratory manual*. Cold Spring Harbor Laboratory Press, New York.
- K. Wilson and J. Walker (2010) *Principles and Techniques of Biochemistry and Molecular Biology*, Seventh edition.

Transaction Mode: Demonstrations, Practical performance, Numerical problem solving,

Evaluation Criteria: Total Marks – 100,

- End semester exam (50 marks), Continuous assessment (30marks), Lab record (10marks), Viva (10marks).

BOT.508
Genetics

Contact Hours: 45 Hrs

L	T	P	Credits
2	1	0	3

Learning outcomes

Upon successful completion of this course, the student will be able to:

1. 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 **12 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.

Group discussion around the chemical nature of the various nucleic acids, structure aspects of DNA and RNA
Various databases for assessment of the genome complexity of a species

Unit II **10 Hours**

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

Calculations of the allele frequencies depending upon the morphological data collected from class students.
Different types of problems solving around the linkage analysis and gene mapping.

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. 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.

Numerical problems for sex linked and sex influenced traits. Group Discussion about the latest research on human dosage compensation

Unit IV **13 Hours**

Extra-chromosomal inheritance and mutations: Chloroplast and Mitochondrial inheritance, Yeast, *Chlamydomonas/Neurospora* and higher plants Chromosomal aberrations: Types of changes– deletions, duplications, inversions, translocations, Change in chromosome number: trisomy and polyploidy. Evolutionary history of bread wheat, Aneuploids–nullisomics,

monosomics, and trisomics, Somatic aneuploids, Changes in chromosome structure, Properties of chromosomes for detection of structural changes. Mutations: Spontaneous and induced mutations, Somatic vs germinal mutation.

Actives: Field visit to find out possible mutations in the nature followed by group discussions. Analysis of various karyotype and its manifestations around the genotype morphology.

Suggested Reading:

- 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.
- Atherly, A.G., Girton, J.R., Mcdonald, J.F. (1999). *The science of Genetics*. Saundern College publication.
- Snusted, D.P., Simmons, M. J. (2010). *Principles of Genetics*. John Wiley & Sons, New York.
- Jocelyn, E.K., Elliott, S.G., Stephen, T.K. (2009). *Lewin's Genes X*. Jones & Bartlett Publishers, USA.
- Tamarin, R.H. (1996). *Principles of Genetics, International edtn.* McGrawhill, USA.
- Web Resources:
  https://www.genome.gov/event-calendar/Current-Topics-in-Genome-Analysis
  http://www.dnai.org/index.htm
  https://www.youtube.com/watch?v=TNKWgcFPHqw

Transaction Mode:

1. Lecture
2. Demonstration
3. Seminar
4. Group discussion
5. Tutorial
6. Problem solving
7. Self-directed learning

Tools

1. Power point Presentations
2. YouTube videos
3. Podcasts

BOT.509
Genetics–Practical.
Contact Hours: 30 Hrs

L	T	P	Credits
0	0	2	1

Learning outcomes

Upon successful completion of this course, the student will be able to:

1. Demonstrate the practical applicability of basic genetics and population genetics.
2. Demonstrate the isolation of DNA from the plant samples
3. Demonstrate the use of various markers for mapping of the genes.

Course Contents

Allele frequency: Calculation of allele frequencies. Calculating recessive gene frequency, Calculate frequency of sex –linked alleles. To test PTC tasting ability in a random sample and calculate gene frequencies for the taster and non–taster alleles. 5 hrs

Karyotyping: Karyotyping of normal & abnormal chromosome sets. Monohybrid and dihybrid ratios, Multiple alleles, Epistasis – Problems. 5 hrs

Inheritance and pedigree analysis: Inheritance patterns in Man – Numerical on Pedigree analysis- Autosomal patterns, X–linked patterns, Y–linked patterns. Mitochondrial inheritance patterns. 5 hrs

Identification of inactivated X chromosome as Barr body and drumstick. 3 hrs

Blood group typing using hemagglutination tests. 2 hrs

Studies of a Model organism: Identification of normal and mutant flies (Drosophila melanogaster). 2hrs

To study finger ball and palmar dermatoglyphics and calculate indices.
To test for color blindness using Ishihara charts. 5 hrs

Molecular Mapping of Genes. 3 hrs

Transaction Mode: Demonstrations, Practical performance, Numerical problem solving, You Tube videos, podcast.

Evaluation Criteria: Total Marks – 100,
End semester exam (50 marks), Continuous assessment (30marks), Lab record (10marks), Viva (10marks).

Suggested Reading:

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

BOT.510 Non-Vascular Plants Systematics

Contact Hours: 45 Hrs

L	T	P	Credits
3	0	0	3

Learning Outcomes

Upon successful completion of this course, the student will be able to:

1. Understand six kingdoms of life with current state of the art for plant taxonomy
2. Acquire necessary skills related to plant taxonomy and systematic also in-depth coverage of algal, moss, and Fungi.
3. Evaluate various taxonomic evidences and how to prepare herbarium sheets.

UNIT-I **12Hours**

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, IAPT Website

UNIT-II **11 Hours**

Tree of life: Root of the Tree of Life: Introduction to the tree of life, alternative hypotheses at the root: Archaea vs. Eocyte tree, LUCA, Unikonts vs Bikonts, Domains of Carl Woese: Eubacteria, Archaea, and Eukarya, Six Kingdoms of Cavalier-Smith Primary endosymbiosis, Unikonta: Amoebozoa, Opisthokonta, Chimaera, Bikonts and Carbazoa, Chromalveolata, Alveolata, Archaeplastida.

iTol: Interactive Tree of Life website: Hands-on training

UNIT-III **11 Hours**

Phycology and Mycology: Cyanobacteria, Algae-A brief Introduction, Seaweeds and Green Algae, Diatoms, Dinoflagellates, Microalgae, red Algae, Brown Algae, Major fungal phyla and classes. Lichens: Thallus structure and reproduction, ecological and and economic importance, with special emphasize on photobionts.

AlgaeBase

UNIT-IV **11 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.

BBS Website

Suggested Reading:

- 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.
- Graham, L., Wilcox. L.W. (2000) Algae. Prentice Hall. P 1416
- Schuh, R.T. and Brower, A.V.Z. (2009). *Biological Systematics: Principles and Applications*. Comstock Pub Assoc.
- Lee, R.E., (2008), Phycology, Cambridge University Press, Cambridge
- Bold, H.C. and Wynne, M.J., (1985), Introduction to the Algae, 2nd Edition, Prentice-Hall Inc.
- Webster, John and Roland, W.S., (2007). Introduction to Fungi, Cambridge University Press.
- Alexopoulos, C.J., Minus, C.W. and Blackwell, M. (1996). Introductory Mycology, Wiley
- Maheshwari, R. (2012) Fungi: Experimental Methods in Biology, CRC Press, Boka Raton, Florida
- Web resources:
  - https://itol.embl.de/
  - https://www.britishbryologicalsociety.org.uk/resources/bryophyte-identification/
  - https://www.algaebase.org/
  - https://www.iaptglobal.org/

Transaction Mode:

1. Lecture
2. Demonstration
3. Seminar
4. Group discussion
5. Tutorial
6. Problem solving
7. Self-directed learning

Tools

1. LMS
2. YouTube videos
3. Related Swayam Courses
4. Podcasts
5. IAPT Glossary

BOT.511 Non-Vascular Plants and Fungal Systematics – Practical.

Total Hours: 30 Hrs

L	T	P	Credits
0	0	2	1

Learning Outcomes

Upon successful completion of this course, the student will be able to:

1. Demonstrate various Non Vascular plant specimen and under microscope.
2. Learn basics of plant taxonomic labwork
3. Perform herbarium preparation, field trips and algal/fungal/Bryophyte taxonomy.

Course Contents

- **Algae:** Identification of common algae of Indian Subcontinent, Sectioning and microscopy of algal specimen (7 Hrs)
- **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. (7 Hrs)
- **Bryophytes:** External morphology and internal anatomy of the vegetative and reproductive organs of genera given in the theory. (7 Hrs)
- **Basic Taxonomy:** Sample collection, preparation of herbarium, submission of report based on field trip. Field sampling trip and report using GPS. Herbarium preparation. Identification of plants by morphometry. (8 Hrs)

Transactional Modes: Demonstration, practical with real specimens, Problem solving, Group discussion, Tools used: PPT, Video, Animation.

Evaluation Criteria: Total Marks – 100,
End semester exam (50 marks), Continuous assessment (30marks), Lab record (10marks), Viva (10marks).

Suggested Reading:

- Gabrielson, P. W., Widdowson, T. B., & Lindstrom, S. C. (2004). Keys to the seaweeds and seagrasses of Oregon and California: North of Point Conception.
- Other Protocols and Monographs pertinent to taxonomy practicals
- Web tools pertinent to taxonomy including iTOL

Compulsory Foundation Course

BOT.518 Biostatistics

Contact hours: 45

L	T	P	Credits
3	0	0	3

Learning Outcomes

Upon successful completion of this course, the student will be able to:

1. 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. Enlighten about the need for computer applications, programs and techniques for biology.

Unit I **11 Hours**

Overview of Biostatistics: Essentials of Critical Thinking, Scientific Methodology, Types of Studies, Levels of Measurements, Summarizing Data, Charting with Excel, Descriptive statistics: Measures of central tendency and dispersal, Kurtosis and Skewness, Error Bars, Moments, Normality Tests and Outliers

Basic Excel training

Unit II **11 Hours**

Statistical Hypothesis Testing: Concepts of population, Sample, Confidence Intervals, Statistical Hypothesis testing, Significance and P values, CI and Statistical Significance, Statistical Power and choosing the right sample size.

Basic GraphPad Prism training

Unit III **12 Hours**

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

Statistics with Excel

Unit IV **11 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

Statistics with GraphpadPrism, Virtual Monty Hall problem website

Suggested Reading:

- Harvey Motulsky (2013) Intuitive Biostatistics: A Nonmathematical Guide to Statistical Thinking. OUP USA; 3 edition
- Biostatistics A Methodology For the Health Sciences – Gerald van Belle, Patrick J. Heagerty, Lloyd D. Fisher, Thomas S. Lumley
- Introductory Biostatistics – Chap T. Le
- Norman, G. and Streiner, D. (2008). *Biostatistics: The Bare Essentials.* 3/e (with SPSS). Decker Inc. USA.
- Sokal, R.R. and Rohlf, F.J. (1994). *Biometry: The Principles and Practices of Statistics in Biological Research*. W.H. Freeman publishers, USA.

  Web resources:

  https://stats.stackexchange.com/

  Royal Society's Visual Guide to Cognitive Biases accessible at: https://www.scribd.com/document/253916350/Cognitive-Biases-a-Visual-Study-Guide-by-the-Royal-Society-of-Account-Planning-VERSION-1

Transaction Mode:

1. Lecture
2. Demonstration
3. Seminar
4. Group discussion
5. Tutorial
6. Problem solving
7. Self-directed learning

Tools

1. LMS
2. YouTube videos
3. Related Swayam Courses
4. Podcasts

BOT.519 Research Methodology

Contact Hours: 45 Hrs.

L	T	P	Credits
3	0	0	3

Learning Outcomes
Upon successful completion of this course, the student will be able to:

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 formulation of research hypothesis.
4. Knowledge dissemination about drafting research projects, thesis, publication, seminar presentation and know the value of research.

Unit I 12 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. Ethics, Plagiarism, Data Manipulation, Bad Science, Patent, IPR

Formulation of hypothesis and research design

Unit II 11 Hours

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

Paper writing and poster preparation

Unit III 11 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)

Curation of research article and assessing the quality of papers

Unit IV 11 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, patent, trademarks, domain names and geographical indications

Story of a few examples of world-famous entrepreneurship

Suggested Reading:

1. Arumugam N (2015). Research Methodology for Life Sciences. Saras publications (p) Ltd. ISBN: 9384826790
2. Laake P, Benestad H, Oslen B (2007) Research Methodology in the Medical and Biological Sciences. Academic Press. Elsevier.
3. Gupta, S. (2005). *Research methodology and statistical techniques.* Deep & Deep Publications (p) Ltd. New Delhi.
4. Kothari, C.R. (2008). *Research methodology (s).* New Age International (p) Limited. New Delhi.
5. Standard /Reputed Journal authors' instructions.

Transaction Mode:

1. Lecture
2. Demonstration
3. Group Discussion
4. Tutorial
5. Flip flop teaching
6. Assignments

Tools

1. LMS
2. Podcasts

Discipline Elective Courses: Opt any one

ZOL.511
Cell Biology.

L	T	P	Credits
3	0	0	3

Learning Outcomes

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

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

BOT.554 Evolutionary Biology

Contact hours: 45

L	T	P	Credits
3	0	0	3

Learning Outcome

Upon successful completion of this course, the student will be able to:

1. Learn basics of Darwin's theory of evolution, evolutionary mechanisms and macroevolution, including punctuated equilibrium also about molecular evolution.
2. Familiarize with the various applications of evolutionary theory including phylogenetics.

Unit I **11 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

PBS Evolution resource

Unit II **11 Hours**

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

PBS Evolution resource

Unit III **11 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*

A new history of life

Unit IV **12 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

Alignment and tree construction using MEGA

Suggested Reading:

- 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.
- Dawkins, R. (1996). The Blind Watchmaker, W.W. Norton & Company Jones and Bartlett Publishers.
- Futuyma, D.J. (2009). Evolution. Sinauer Associates Inc. USA.
- Hake, S. and Wilt, F. (2003). Principles of Developmental Biology. W.W. Norton & Company, New York, USA.
- Hall, B.K. and Hallgrimsson, B. (2007). Strickberger's Evolution. Jones and Bartlett Publishers, India.
- Lewin, R. (2004). Human Evolution - An Illustrated Introduction. Wiley-Blackwell, USA.
- Web resource:
  https://www.pbs.org/wgbh/evolution/students/index.html
  https://www.thegreatcourses.com/courses/a-new-history-of-life.html

Transaction Mode:

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

Tools

1. LMS
2. YouTube videos
3. Related Swayam Courses
4. Podcasts

IDC to another department (Our Student to choose one IDC from other department)

BOT. 517. Fundamentals of Plant Biology Credits
Contact Hours: 30

L	T	P	Credits
2	0	0	2

Learning Outcomes
Upon successful completion of this course, the student will be able to:
1. Learn fundamentals of plant organization their functions, metabolism organ structures their functions and development.
2. 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
identifications of different pics for different growth conditions

Unit II: 8 Hours

Plant metabolism: Glycolysis, photosynthesis, photorespiration, C4 and CAM photosynthesis, Secondary plant chemistry and Plant defenses
identification of different plants with different type of photosynthesis and different type of secondary metabolites

Unit 1II: 7 Hours

Organ structure and function: leaves, shoots and roots
identification of different organ structure manually

Unit IV: 8 Hours

Plant development and morphogenesis: life history strategies, organogenesis and hormones, plant reproduction, seed formation, seed germination
Demonstration of complete life cycle of plants.

Suggested readings:

- 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,
- Charles B. Back (2010). An Introduction to Plant Structure and Development: Plant Anatomy for the Twenty-First Century. CAMBRIDGE
- Bob B. Buchanan, (2000). Biochemistry and molecular Biology of Plants. Author: Wiley Blackwell,
- David L. Nelson and Michael Cox. (2017). Lehninger Principles of Biochemistry: International Edition.
- Ottoline Leyser and Stephen Day (2002) Mechanisms in Plant Development.

Transaction Mode:
1. Lecture
2. Seminar
3. Term paper
4. Assignments

Tools:
1. LMS
2. Podcasts

Interdisciplinary Course:
BOT.533
Basic Plant physiology and biochemistry.
Total Hrs: 30

L	T	P	Credits
2	0	0	2

Learning Outcome
Upon successful completion of this course, the student will be able to:

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, Photosynthesis
Unit-II **7 Hour**
Respiration: 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

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

Transaction Mode:
1. Lecture
2. Seminar
3. Term paper
4. Assignments

Tools:
1. LMS

Semester II

BOT.521
Molecular Biology.

Contact Hours: 45 Hrs

L	T	P	Credits
2	1	0	3

Learning outcomes
Upon successful completion of this course, the student will be able to:

1. demonstrate the Central Dogma of life and will understand the regulation of genes in response to different conditions.
2. understand the basic concepts of molecular biology and enhance the understanding of various processes life at molecular level.
3. gain knowledge in the Chromatin regulation, gene regulation, Genomics and Transcriptomics.

Unit: I **12 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. Chromosome Structure, Chromatin and the Nucleosome: The nucleosome, Histone proteins, Chromatin structure: euchromatin, heterochromatin, Constitutive and facultative heterochromatin, Regulation of chromatin structure and nucleosome assembly, Nucleolus.

Group discussion on structural stability of DNA and RNA, latest research articles for chromatin remodeling and epigenetic inheritance, discussion various experiments pertain to chromatin.

Unit: II **11 Hours**

Gene & Genome organization: Split genes, Overlapping genes, Transposons & retrotransposons, Gene clusters, 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.

Group discussions around the transposons. Students will be divided in to two groups and will ask to debate on intron gain and intron loss theory.

Unit: III **10 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.

Nucleic acid databases i.e., NCBI, EBI and database search of nucleic acids, Finding of Open reading frames (ORF), group discussion.

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.

Swissprot database for gene translation tools, protein viewing servers, group discussion.

Suggested Reading:

- Fasman, G.D. (1989). *Practical Handbook of Biochemistry and Molecular Biology*. CRC Press, Taylor and Francis Group, UK.
- Gupta, P.K. (2005). *Cell and Molecular Biology*. Rastogi publications, Meerut, India.
- James, D.W., Baker, T.A., Bell, S.P., Gann, A. (2009). *Molecular Biology of the Gene*. Benjamin Cummings, USA.
- Jocelyn, E.K., Elliott, S.G., Stephen, T.K. (2009). *Lewin's Genes X*. Jones & Bartlett Publishers, USA.
- Johnson, A., Lewis, J., Raff, M. (2007). *Molecular Biology of the Cell*. Garland Science, USA.
- Lodish, H., Berk, A., Chris, A.K. and Krieger, M. (2008). *Molecular Cell Biology*. W.H. Freeman, USA.
- Sambrook, J., Fritish, E.F., Maniatis, T. (2000). *Molecular cloning: A laboratory manual*. Cold Spring Harbor Laboratory Press, New York.
- Web resources:
  https://www.ncbi.nlm.nih.gov/
  https://blast.ncbi.nlm.nih.gov/Blast.cgi?PAGE_TYPE=BlastSearch
  https://www.uniprot.org/
  https://web.expasy.org/docs/swiss-prot_guideline.html
  https://www.ebi.ac.uk/uniprot/

Transaction Mode:

1. Lecture
2. Demonstration
3. Seminar
4. Group discussion
5. Tutorial
6. Problem solving
7. Self-directed learning

Tools

1. Power point Presentations
2. YouTube videos
3. Podcasts

BOT.522:
Molecular Biology –Practical

Contact Hrs: 30

L	T	P	Credits
0	0	2	1

Learning outcomes
Upon successful completion of this course, the student will be able to:

1. Demonstrate the nucleic acid isolation from various plant and bacterial sources.
2. Perform independently PCR and analyse the results
3. Demonstrate the restriction digestion of DNA and analyse the results.

Course Content
Nucleic Acid Isolation: Isolation of genomic DNA from Plant, Quantification of DNA using spectrophotometric method. RNA isolation, cDNA synthesis, RT-PCR. 8 hrs

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

Blotting: Construction of restriction map by single and double digestion, Designing DNA probe, Southern blot hybridization (demonstration only). 7 hrs

PCR amplification: Amplification of known DNA sequences by Polymerase Chain Reaction. 8 hrs

Transaction Mode: Demonstrations, Practical performance, Numerical problem solving, You Tube videos, podcast.

Evaluation Criteria: Total Marks – 100,
End semester exam (50 marks), Continuous assessment (30marks), Lab record (10marks), Viva (10marks).

Suggested Reading:

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

BOT.523:
Plant Physiology

L	T	P	Credits
3	0	0	3

Contact Hrs: 45

Learning outcomes

Upon successful completion of this course, the student will be able to:

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.

Practical aspects of photosynthesis, respiration amino acid quantification shall be done

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.

Practical aspects of plant water relations shall be done

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.

Mechanism of action of Phytohormones shall be done

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.

Secondary metabolite quantification shall be done

Suggested Reading:

- Buchanan, B.B. and Gruissem, W. (2015). *Biochemistry and molecular biology of plants.* Willy Blackwell ASPB USA.
- Ross and Salisbury. (2009). *Plant Physiology.* Cengage Learning (Thompson), New Delhi, India.
- Segel, I.H. and Segel, E. (1993). *Enzyme kinetics: Behavior and analysis of rapid equilibrium and steady-state enzyme systems.* Wiley-Interscience, USA.
- Taiz, L., Zeiger, E. Mollar, I. M. and Murphy, A. (2015). Plant physiology and Development 6th edition. . Sinauer Associates Inc., USA.

Transaction Mode:

1. Lecture
2. Demonstration
3. Seminar
4. Group discussion
5. Tutorial
6. Problem solving
7. Self-directed learning

Tools

1. Power point Presentations
2. YouTube videos

BOT.524:

Plant Physiology – Practical.

Contact Hrs: 30

L	T	P	Credits
0	0	2	1

Learning Outcomes

Upon successful completion of this course, the student will be able to:

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.
- 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 on plant growth.
- TTC reduction and mitochondrial respiratory ability.
- Estimation of enzymatic and non enzymatic antioxidants

Suggested Reading:

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

Transaction Mode: Demonstrations, Practical performance, Numerical problem solving, You Tube videos, podcast.

Evaluation Criteria: Total Marks – 100,

- End semester exam (50 marks), Continuous assessment (30marks), Lab record (10marks), Viva (10marks).

BOT.525 Plant Tissue and Organ Culture

Contact Hours: 45 hours

L	T	P	Credits
3	0	0	3

Learning Outcomes

Upon successful completion of this course, the student will be able to:

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.

Enlisting all tissue culture requirements

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.

Demonstration of culture of toot, organ and callus culture

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.

Demonstration of in-vitro fertilization and micropropagation, Cryopreservation

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

Drawing of plant transformation method and t DNA insertion

Suggested Reading:

- Bhojwani S.S. and Razdan MK (1996) Plant Tissue Culture: Theory and Practice, Elsevier.
- Slater A, Scott A, Flower M (2008). Plant Biotechnology: The Genetic Manipulation of Plants, Oxford University Press Inc.
- Chrispeels MJ and Sadava DE (2002) Jones, Plants, Genes and Crop Biotechnology, Barlett Publishers.
- Primrose SB, Twyman RM (2006) Principles of Gene Manipulation and Genomics, Blackwell Publishing.
- Gamborg OL and Phillips GC (1995) Plant Cell, Tissue and Organ Culture: Fundamental Methods, Springer-Verlag.
- Singh BD (2011) Plant Biotechnology, Kalyani Publishers.
- Bhojwani SS, Razdan MK (2009) Plant tissue culture. Theory and Practice, a revised edition. Elsevier
- Bhojwani SS (2015) Plant Tissue Culture: Applications and Limitations. Elsevier.

Transaction Mode:

1. Lecture
2. Demonstration
3. Seminar
4. Group Discussion
5. Term paper
6. Assignment

Tools:

1. LMS
2. Podcasts

BOT.526. Plant Cell, Tissue and organ culture –Practical.
Total Hours: 30 Hrs

L	T	P	Credits
0	0	2	1

Learning Outcomes

Upon successful completion of this course, the student will be able to:

1. **Demonstration of media preparation and perform tissue culture activity**
2. **Learn basics of Plant Tissue culture**
3. **Perform of callus formation form a few selected plant explants.**

Course Content

- **Media formation**: Basic media preparation and also for different purposes
- **Sterilization techniques**: Sterilization techniques and prevention strategies to avoid contamination in plant tissue culture room/media.
- **Inoculation:** different explants in tissue culture
- **Regeneration**: From various explants, adventitious shoot and callus culture, cell culture
- Best utilization of microscopic and photography techniques for plant tissue culture, application

Transactional Modes: Demonstration, diverse practical with samples, problem solving, group discussion etc.

Evaluation Criteria: Total Marks: 100
Ens semester exam (50 marks), Continuous assessment (30 marks), Lab record (10 marks) and Viva (10 marks)

Suggested Reading:

- Rainert J and Yeoman MM (1982) Plant Cell and Tissue Culture; A Laboratory Manual. Berlin: Springer-Verlag.
- Bhojwani SS and Razdan MK (1983) Plant Tissue Culture: Theory and Practice. Amsterdam: Elsevier.

BOT.527
Ecology, Environment and Biodiversity.

Contact Hours: 45

L	T	P	Credits
2	1	0	3

Learning Outcome
Upon successful completion of this course, the student will be able to:

1. understand the basics of ecosystem and population ecology, biodiversity and various threats on biodiversity.
2. understand the vegetative organization in community and how changes take place during ecological succession, flow of energy in an ecosystem, role of biogeochemical cycles 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.

Group discussion on various biogeochemical cycles, interaction of biotic and abiotic factors. iDiv Biodiversity Portal (evolutive version): https://doi.org/10.25829/idiv.286-21-2695.

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. GIS and Biogeography.

Group discussion, BioTIME: A database of biodiversity time series

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.

Group discussion" Global Biodiversity Information Facility (GBIF) database (https://www.gbif.org/).

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, CBD and other International Environmental Agreements.

Group Discussion, IUCN Red Data List https://www.iucnredlist.org/ www.cbd.int (Convention on Biological Diversity)

Suggested Reading:

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

  https://doi.org/10.25829/idiv.286-21-2695.
  https://www.gbif.org/
  https://www.iucnredlist.org/
  www.cbd.int

Transaction Mode:

1. Lecture
2. Demonstration
3. Seminar
4. Group discussion
5. Tutorial
6. Problem solving
7. Self-directed learning

Tools

1. Power point Presentations
2. YouTube videos
3. Podcasts

BOT.528 Ecology, Environment and Biodiversity – Practical.

L	T	P	Credits
0	0	2	1

Learning Outcomes

Upon successful completion of this course, the student will be able to:

1. demonstrate the ecological methods and analytical strategy
2. Demonstrate the quality of water and air
3. Demonstrate the various sampling methods and analysis

Curse Content

Ecosystem analysis: Quadrat method- Data collection Methods and species diversity estimations. Field and Laboratory Investigations, Biomes study. Eco-modeling. 8 hrs.

Monitoring: Biological Monitoring. Air, water and soil analysis. 5 hrs

Vegetation sampling methods: Quadrats, Line, Random Number generation etc. Usage of handheld GPS device and maps overlay 7 hrs.

Measurement of Biodiversity: Species Richness and Evenness, Various Indices 5 hrs.

Transaction Mode: Demonstrations, Practical performance, Numerical problem solving, You Tube videos, podcast.

Evaluation Criteria: Total Marks – 100,
End semester exam (50 marks), Continuous assessment (30marks), Lab record (10marks), Viva (10marks).

Suggested Reading:

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

Discipline Elective Courses: Opt Any One

BOT.553: Techniques in Life Sciences
Contact hours: 45 Hrs

L	T	P	Credits
3	0	0	3

Upon successful completion of this course, the student will be able to:

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

Unit I **13 Hours**

Centrifugation: Principle and applications, Ultracentrifugation and their application in mass determination. Chromatography: Principle, procedure and applications of paper & thin layer chromatography (TLC), gel filtration and ion exchange, affinity chromatography, GC (GLC & GSC), HPLC and FPLC.

Demonstration of a paper chromatography and sedimentation process

Unit II **10 Hours**

Spectrometry: UV, IR, XRD, CD, NMR, atomic absorption and MS spectrophotometry. Microscopy: Light microscopy, phase contrast microscopy, fluorescent microscopy, scanning electron microscopy (SEM/FESEM), transmission electron microscopy (TEM), Scanning-probe microscopy, atomic force microscopy, CLSM.

Understanding of functions of different microscope

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.

Demonstration of electrophoresis

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.

Utilization of ELISA

Suggested Reading:

- Brown, T.A. (2015). Gene cloning and DNA analysis: An Introduction. 6th Edition, Wiley-Blackwell Publisher, New York.
- Goldsby, R.A., Kindt, T.J. and Osborne, B.A. (2008). Kuby Immunology. 6th Edition, W. H. Freeman & Company, San Francisco.
- Gupta, P.K. (2005). Elements of biotechnology. Rastogi Publications, Meerut.
- Gupta, S. (2005). Research methodology and statistical techniques, Deep & Deep Publications (P) Ltd. New Delhi.
- Kothari, C.R. (2008.) Research methodology(s). New Age International (P) Ltd., New Delhi
- Lewin, B. (2010). Genes X, CBS Publishers & Distributors. New Delhi.
- Mangal, S.K. (2007). DNA Markers *In* Plant Improvement. Daya Publishing House,New Delhi.
- Nelson, D. and Cox, M.M. (2009). Lehninger Principles of Biochemistry. W.H. Freeman and Company, New York.
- Primrose. S.B. and Twyman, R. (2006). Principles of Gene Manipulation and Genomics. Blackwell Publishing Professional, U.K.
- Sambrook, J. (2006). The Condensed Protocols from Molecular Cloning: A Laboratory Manual. Cshl Press. New York.
- Sambrook, J. and Russell, D.W. (2000). Molecular Cloning: A Laboratory Manual (3 Vol-set). 3rd Edition, CSHL Press, New York.
- Sawhney, S.K. and Singh, R. (2005). Introductory Practical Biochemistry. Narosa Publishing House, New Delhi .
- Slater, A., Scott, N.W. and Fowler, M.R. (2008). Plant Biotechnology: The Genetic Manipulation of Plants. Oxford University Press, USA.
- Wilson, K. and Walker, J. (2006). Principles and Techniques of Biochemistry and Molecular biology. 6th Edition, Cambridge University Press India Pvt. Ltd., New Delhi.

Transaction Mode:

1. Lecture
2. Demonstration
3. Seminar
4. Group discussion
5. Tutorial
6. Term papers
7. Assignments

Tools

1. LMS
2. PodCasts

BOT. 532: Marine Botany

Contact hours: 45

L	T	P	Credits
3	0	0	3

Learning Outcomes:

Upon successful completion of this course, the student will be able to:

1. Understand basic marine environment
2. Understand taxonomy of the marine Plants, including cyanobacteria, microalgae, macroalgae, Mangroves and Seagrasses

Unit I : Marine Environment 11 hours

Marine environment and organisms: Marine Biodiversity: Spatial patterns, Benthic & Pelagic environment, Classification of marine organisms-Plankton, Nekton, Benthos. Ocean acidification, microplastic pollution and effects of climate change

Deep sea-interactive website

Unit II: Cyanobacteria and Microalgae 11 hours

Cyanobacteria: Important families, physiology, ecological and economic importance. Green Microalgae, Diatoms, Dinoflagellates, Photosynthetic protists, Algal epiphytes. Ecological and economic importance of microalgae.

AlgaeBase database

Unit III: Macroalgae 11 hours

Green seaweeds, Red seaweeds Brown seaweeds, Major families, Phylogenetic systematics, Life cycle, Commercial cultivation methods, ecological and economic importance. Common seaweeds of Indian coasts

AlgaeBase database

Unit IV: Mangroves and Seagrasses 12 hours

Biodiversity of mangroves: Definition of the term ‘mangrove’, biodiversity, 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. Major types of seagrasses. Ecological and economic importance of mangroves and seagrasses.

GLOMIS

Suggested readings

- Alexopoulos, C.J. & Bold, H.C. (1967). Algae & Fungi: Current Concepts in Biology Series. The Macmillan Company, London.
- Chapman, V. J. (1976). Coastal Vegetation. 2nd ed. Pergamon Press. New York
- Chaudhuri. A. B. (2007). Biodiversity of Mangroves.
- 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.
- McConnaughey, B. H (1974). Introduction to Marine Biology. 2nd ed. Mosby publisher.
- Santhanam, R.; Ramnathan,N.; Venkataramanjan K. & Jegathanam,G. (1987) . Phytoplankton of Indian Seas. & Aspects of Marine Botany.Daya Publication Home. Delhi.
- Sen Neera and Kumudranjan Naskar, (2003). Algal Flora of Sundarbans. Mangal Daya
- Stein, J. R. (1973) Handbook of Phycological Methods. Cambridge University Press.
- Web resources:
  https://neal.fun/deep-sea
  https://www.algaebase.org/
  http://www.glomis.com/

Transaction Mode:

1. Lecture
2. Demonstration
3. Seminar
4. Group discussion
5. Tutorial
6. Problem solving
7. Self-directed learning

Tools

1. LMS
2. YouTube videos
3. Related Swayam Courses
4. Podcasts
5. IAPT Glossary

BOT. 561 Critical Thinking and Soft Skills (Value Added Course)
Contact Hours: 30

L	T	P	Credits
2	0	0	2

Note: This course is offered at the university level.

Learning Outcome

Upon successful completion of this course, the student will be able to:

- A thorough introduction to critical thinking including cognitive biases, logical fallacies and psychological effects
- A thorough introduction to philosophy of science and to learn about hallmarks of scientific method and scientific thinking
- A thorough introduction to soft skills

Unit: 1 **8 Lectures**

Overview of Critical Thinking: Cognitive Biases, Logical fallacies, Mental Heuristics, Psychological Effects, Mental Models and brief introduction to philosophy Spot gimmicks and flawed logic in popular advertisements

Case study: Advertisement Gimmicks

Unit: 2 **7 Lectures**

Philosophy of Science: An overview of philosophy, dialectics, important philosophical concepts pertinent to academics and research, philosophy of science, Karl Popper and Falsification, Thomas Kuhn and Paradigm Shift, Russel's Teapot, Philosophical burden-of-proof, Cultural Biases

Case study: Pseudoscience

Unit: 3 **7 Lectures**

The Scientific method and scientific thinking: Hallmarks of scientific method, Rationalism, Objectivism, Skepticism, Disconfirmation vs Confirmation, Vs, Belief systems, Scientific Measurement, Scientific Communication

Case study: Neutrality vs Objectivity in Journalism

Unit: 4 **8 Lectures**

Soft skills: Emotional and Social Intelligence, Empathy, Active Listening, Stoic Philosophy, Inter-cultural communication, High and Low context cultures, Cultural relativism, Types of communication, Non-verbal cues, Time Management and personal productivity, Personality types and personality tests, Leadership, Problem Solving and Decision Making, Digital Literacy. Work ethics, Public speaking, Technical writing.

Attempt free online personality test to identify individual personality type

Suggested Reading:

1. Popper, K. (2005). *The logic of scientific discovery*. Routledge.
2. Kuhn, T. S. (2012). *The structure of scientific revolutions*. University of Chicago press.
3. Pinker, S. (2018). *Enlightenment now: The case for reason, science, humanism, and progress*. Penguin.
4. Sardar, Z. (2015). *Introducing philosophy of science: A graphic guide*. Icon Books Ltd
5. Tulgan, B. (2015). *Bridging the soft skills gap: How to teach the missing basics to todays young talent*. John Wiley & Sons.
6. Web references

   Royal Society's Visual Guide to Cognitive Biases accessible at: https://www.scribd.com/document/253916350/Cognitive-Biases-a-Visual-Study-Guide-by-the-Royal-Society-of-Account-Planning-VERSION-1

Transaction Mode:

1. Lecture
2. Demonstration
3. Seminar
4. Group discussion
5. Tutorial
6. Problem solving
7. Self-directed learning

Tools

1. LMS
2. YouTube videos
3. Related Swayam Courses
4. Podcasts

Semester III

BOT.551.
Recombinant DNA Technology

L	T	P	Credits
2	1	0	3

Learning Outcomes

Upon successful completion of this course, the student will be able to:

1. learn the basics of Genetic Engineering and understanding of various molecular tools needed for DNA manipulations.
2. enhance the understanding of various DNA manipulating tools and practical applications in Agriculture and different Industries.
3. 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.

Construction of own plasmid sequence on addgene.org database server, quick search of plasmid database on Harvard medical school plasmid database. Searching for various plasmids in the different companies catalogue available in the lab.

Unit II **9 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.

Searching BRENDA database for various enzymes, companies catalogues for various enzymes used in the day to day experiments.

Unit III **13 Hours**

Cloning vectors and sequencing technologies: 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. DNA* Sequencing by chemical, enzymatic and big-bye terminator methods. Sequencing by Synthesis (NGS) (Chemistry and different platforms)

Construction of own plasmid sequence on addgene.org database server, quick search of plasmid database on Harvard medical school plasmid database. companies catalogues for various cloning vectors used in the day to day experiments.

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, Oligonucleotide derived mutagenesis, Site directed mutagenesis – Its applications; Applications of rDNA technology in diagnostics; Pathogenesis; Genetic diversity; Therapeutic Proteins-Vaccines, Molecular probes (Production, labelling and uses).

Group discussion. Molecular prob designing on Primer 3 server. Various search engines for DNA and Proteins

Suggested Reading:

- Brown, T.A. (2010), *Gene Cloning and DNA analysis*. John Wiley & Sons.
- Jocelyn, E.K., Elliott, S.G. and Stephen, T.K. (2009), *Lewin's Genes X*. Jones and Bartlett Publishers, LLC.
- Primrose, S.B., Twyman, R.M and Old, R.W., (2001). *Principles of Gene manipulations*. Blackwell Science.
- Web resources:
  https://www.addgene.org/vector-database/
  https://plasmid.med.harvard.edu/PLASMID/
  https://www.brenda-enzymes.org/

Transaction Mode:

1. Lecture **Tools**

2. Demonstration
3. Seminar
4. Group discussion
5. Tutorial
6. Problem solving
7. Self-directed learning

1. Power point Presentations
2. YouTube videos
3. Podcasts

BOT.552

Recombinant DNA Technology-Practical.

L	T	P	Credits
0	0	2	1

Learning Outcomes

Upon successful completion of this course, the student will be able to:

1. Demonstrate the DNA isolation from different plant samples
2. Design the primers for different PCR reactions.
3. Demonstrate the DNA sequencing

Nucleic Acid Isolation: Genomic DNA isolation from Plant Cell, RNA isolation, Plasmid Isolation from Bacteria. 7 hrs

Restriction Digestion: Genomic DNA restriction, Plasmid DNA restriction Digestion, Visualization of DNA restricted fragments. 7 hrs

PCR amplification: RAPD PCR, Gene specific PCR, Sequencing PCR, Colony PCR. 6 hrs
Cloning: Cloning of specific fragments, TA cloning. 6 hrs
Sequencing: Sequencing of the inserted Fragments, Bioinformatic analysis of the sequence. 4hrs.

Transaction Mode: Demonstrations, Practical performance, Numerical problem solving, You Tube videos, podcast.

Evaluation Criteria: Total Marks – 100,
End semester exam (50 marks), Continuous assessment (30marks), Lab record (10marks), Viva (10marks).

Suggested Reading:

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

BOT.571 Plant Metabolic Engineering
Contact Hours: 45 Hrs

L	T	P	Credits
2	2	0	3

Learning Outcomes

Upon successful completion of this course, the student will be able to

1. Get to know the production of secondary metabolites and metabolic engineering.
2. Student will learn how to engineer plants for specific metabolite production, and various metabolomics techniques.
3. Students will know the molecular knowledge in network biology, Local and global features of network and simple modeling to understand biologically important mechanism.

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

Compilation of different plants with different secondary metabolites.

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

Construction of any network of common practical use.

Unit III **15 Hours**

Metabolomics, Techniques used in metabolomics, Metabolome informatics.

Extraction of different metabolites from different plant source

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

Enlisting some current research on plant metabolic engineering.

Suggested readings:

- Bhojwani SS and Razdan MK (1996) Plant Tissue Culture: Theory and Practice, Elsevier.
- Slater A, Scott N and Fowler M (2008) Plant Biotechnology: The Genetic Manipulation of Plants Oxford University Press Inc.
- Chrispeels MJ and Sadava DE (2002) Plants, Genes and Crop Biotechnology Barlett Publishers.
- Primrose SB and Twyman RM (2006) Principles of Gene Manipulation and Genomics, Blackwell Publishing.
- Gamborg OL and Phillips GC (2004) Plant Cell, Tissue and Organ Culture: Fundamental Methods Springer-Verlag.
- Singh BD (2014) Plant Biotechnology Kalyani Publishers, New Delhi.
- Smolke CD (2009) The Metabolic Pathway Engineering Handbook, CRC Press.
- Palsson BO (2011) Systems Biology, Cambridge University Press.

Transaction Mode:

1. Lecture
2. Demonstration
3. Seminar
4. Group Discussion
5. Tutorial
6. Term papers
7. Assignments

Tools

1. LMS
2. Podcasts

BOT.579 Plant Metabolic Engineering Practical
Contact Hours: 30 Hrs

L	T	P	Credits
0	0	2	1

Learning Outcomes
Upon successful completation of this course, the students will be able to practical demonstration and hands on training on various aspects of Metabolic Engineering below

- Secondary metabolites isolation.
- Network Biology: Creation of simple network with using different tools. Different computation approaches used in metabolic Engineering
- Metabolomics: Interpretation of data from HPLC, and GC-MS. Usages of different availed databases.
- Cell Culture: plant cell and tissue cultures

Suggested Reading:

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

BOT.529. Vascular Plant Systematics
Contact hours: 45

L	T	P	Credits
2	2		3

Learning Outcome
Upon successful completion of this course, the student will be able to:

1. Learn in-depth taxonomy of Pteridophytes, gymnosperms, angiosperms with APG-IV system, and Ecological and economical importance of vascular plants
2. Understand modern approaches in taxonomic studies and the role of taxonomy in conservation of biodiversity.
3. Understand how DNA Taxonomy and DNA barcoding works

UNIT I **11 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.

BPS Fern Guide

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UNIT II **11 Hours**

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

Conifers Database

UNIT III **12 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. Ecological and economic importance of Angiosperms

Overview of various species identification apps for android/iPhone including PlantNet, and PlantSnap

UNIT IV **11 Hours**

Molecular Systematics: Biodiversity characterization and inventorying- a taxonomic approach, 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.

Phylogenetic inference with MEGA

Suggested Reading:

- Bhojwani, S.S. and Bhatnagar, S.P. (1979) Embryology of Angiosperms, Vikash Publishing House, New Delhi
- Gangulee, H.C. and Kar, A.K., College Botany Vol. II- 2011 (Algae+Fungi+Brophyta+Pteridophyta), New Central Book Agency, Kolkata
- Hall, B.G. (2011). *Phylogenetic Trees Made Easy: A How-To Manual*. Sinauer Associates, Inc. USA.
- Hennig, W., Dwight, D. and Zangerl, R. (1999). *Phylogenetic Systematics.* University of Illinois Press, USA.
- 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.
- Rashid, A., An Introduction to Pteridopyta by, 2nd edition, (2011), Vikas Publishing House Pvt. Ltd., Noida.
- Schuh, R.T. and Brower, A.V.Z. (2009). *Biological Systematics: Principles and Applications*. Comstock Pub Assoc.
- Simpson, M. G., (2006). Plant Systematics. Elsevier Academic Press.
- Sporne, K.R. (2015) Morphology of Gymnosperms, B.I. Publication, New Delhi
- Web resources
  http://www.ebps.org.uk/wp-content/uploads/2014/05/Fern-Guide01.pdf
  https://www.conifers.org/zz/gymnosperms.php

Transaction Mode:

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

Tools

1. LMS
2. YouTube videos
3. Related Swayam Courses
4. Podcasts
5. IAPT Glossary

BOT.530. Vascular Plants Systematics - Practical.

Contact hours: 30

L	T	P	Credits
0	0	2	1

Learning Outcomes

Upon successful completion of this course, the student will be able to:

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

Transactional Modes: Demonstration, practical with real specimens, Problem solving, Group discussion, Tools used: PPT, Video, Animation.

Evaluation Criteria:

- Total Marks – 100,
- End semester exam (50 marks), Continuous assessment (30marks), Lab record (10marks), Viva (10marks).

Suggested Reading:

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

BOT.574.
Comprehensive Plant Sciences
(Discipline Enrichment Course)

L	T	P	Credits
0	4	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 **12 Hours**

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

Unit II **16 Hours**

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

Unit III **16 Hours**

Subject related problems shall be addressed viz. revision of specific topics and CSIR NET exams.

Unit IV **16 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.

Discipline Elective Courses: Opt any one

BOT.555
Molecular Stress Physiology
Contact Hrs: 45

L	T	P	Credits
3	0	0	3

Learning outcome
Upon successful completion of this course, the students will be able:

1. To learn about various environmental factors involved in normal growth and development of plants and how plants cope up under adverse conditions.
2. To 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.
Practical aspects

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 **10 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.Post translational modification and other hormones

Unit IV **8 Hours**

Genetic engineering and production of plants for improved stress tolerance: Physiological approach, Mutant approach, Wild resource approach, Contrasting genotypes approach, Getting clue from sub - relative approach, Getting clue from sub lethal stress application, Success of plant breeding vs modern genetic modifications, Raising of stress tolerant genotypes through genetic engineering. High throughput analysis techniques in stress biology

Suggested Reading:

- Taiz, L., Zeiger, E. Mollar, I. M. and Murphy, A. (2015). *Plant physiology and Development*, 6th edition. Sinauer Associates Inc., USA.
- Buchanan B. (2014). *Biochemistry and Molecular Biology of Plants*. American Society of Plant Physiologists, USA.
- Hopkins, W.G. and Hüner, N.P.A. (2004). *Introduction to plant physiology*. J. Wiley, USA.
- Orcutt, D.M. and Nilsen, E.T. (2000). *Physiology of Plants Under stress*. J. Wiley, USA.
- Galun, E. and Breiman. (1997). *Transgenic Plants*. World scientific Publishing, Chennai, India.
- Hopkins, W.G. (2007). *Plant Biotechnology*. Infobase Publications Inc.. USA.
- Chrispeels, M.J. and Sadava, D.E. (2002). *Plant, Genes and Crop Biotechnology*. American Society of Plant Biologists, USA.

BOT.572

Anatomy and Developmental Biology of Plants.

Contact Hours: 45	**L**	**T**	**P**	**Credits**
Learning Outcome	**3**	**0**	**0**	**3**

Upon successful completion of this course, the students will be able

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. Ultra-structure study using light microscopy, fluorescence, SEM, TEM

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.
Ultra-structure study using light microscopy, fluorescence, SEM, TEM

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, Anatomy of **S**tems and roots with special reference to plants showing anomalies- *Nyctanthes, Bignonia, Strychnos, Salvadora, Boerhaavia, Dracaena* and *Tinospora*.
Ultra-structure study using light microscopy, fluorescence, SEM, TEM

Suggested Reading:

- Dawkins, R. (1996). *The Blind Watchmaker*, W.W. Norton & Company Jones and Bartlett Publishers.
- Hake, S. and Wilt, F. (2003). *Principles of Developmental Biology*. W.W. Norton & Company, New York, USA.
- Scott, F. and Gilbert, S.F. (2010). *Developmental Biology*. Sinauer Associates, Inc. USA.
- Slack, J.M.W. (2005). *Essential Developmental Biology*, Wiley-Blackwell, USA.
- Bhojwani, S.S. and Bhatnagar, S.P. (2016) Embryology of Angiosperms, Vikash Publishing House.
- Maheshwari, P. (2015) An introduction to the embryology of angiosperms, Nabu Press or Tata McGraw Hill
- Hake, S. and Wilt, F. (2003). Principles of Developmental Biology. W.W. Norton & Company, New York, USA.
- Slack, J.M.W. (2005). Essential Developmental Biology, Wiley-Blackwell, USA.
- B P Pandey (2014) Plant Anatomy, S. Chand Publications
- Singh, Pande, Jain (2015) A Text Book of Botany, Rastogi Publications.

BOT.560
Entrepreneurship (Compulsory Foundation)

L	T	P	Cr
1	0	0	1

Learning Outcomes: This 1 credit course will introduce the students to the current state of the art of entrepreneurship with a focus on opportunities in plant sciences and plant biotechnology. The expected outcome is to get familiarize with various management strategies and ways to foster innovation in start-up ecosystem.

UNIT I: 3 Hours

Introduction to entrepreneur and entrepreneurship; Characteristics of an entrepreneur; Characteristics of entrepreneurship; entrepreneurial traits and skills; innovation and entrepreneurship; Types of entrepreneurial ventures; enterprise and society in Indian context; Importance of women entrepreneurship

UNIT II 4 Hours

Promotion of a venture – Why to start a small business; How to start a small business; opportunity analysis, external environmental analysis, legal requirements for establishing a new unit, raising of funds, and establishing the venture - Project report preparation – format for a preliminary project report, format for a detailed/final project report.

UNIT III 5 Hours

Scopes in botany, Industries in plant sciences and plant biotechnology, mentoring and internship, professional networking, blue economy and scopes in marine botany, Non Governmental Organizations and Private Sectors, Eco-tourism, Social entrepreneurship

UNIT IV 3 Hours

Start-up ideas and surveys of existing start-ups, Preparing Project Proposal for a new start-up– Feasibility report; Planning, resource mobilization and implementation, Business Incubators, Cloud funding, Venture capital financing and angel investing

- Group discussion on start-up ideas

Suggested Readings:

- Kahan, D. (2013). Entrepreneurship in farming. *Farm management extension guide*, (5).
- Pauli, G. A. (2010). *The blue economy: 10 years, 100 innovations, 100 million jobs*. Paradigm publications.
- Smith-Godfrey, S. (2016). Defining the blue economy. *Maritime affairs: Journal of the national maritime foundation of India*, *12*(1), 58-64.
- Romanelli, E. (1989). Environments and strategies of organization start-up: Effects on early survival. *Administrative Science Quarterly*, 369-387.
- Hitt, M. A., Ireland, R. D., Camp, S. M., & Sexton, D. L. (2001). Strategic entrepreneurship: Entrepreneurial strategies for wealth creation. *Strategic management journal*, *22*(6□7), 479-491.

BOT.600. Research Proposal (Skill-based).

L	T	P	Credits
0	0	8	4

Learning outcomes

- Students' shall be exposed to formulate a small research problem in consultation with supervisors.
- A comprehensive literature review will be conducted. Literature review as well as the proposal should be submitted to supervisor for evaluation.

Evaluation Criteria:

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

Semester IV

BOT. 600:
Master's Research Project/Dissertation (Skill Based)

L	T	P	Credits
		40	20

- MSc. Dissertation should be an original research.
- It can be wet-lab, in-silico work, or drafting a comprehensive review.
- A field study tour may also be conducted to enrich execution of exploration-based research.

Dissertation evaluation guidelines:

The evaluation of dissertation proposal in the third semester will carry 50% weightage by supervisor and 50% by HoD and senior-most faculty of the department. The evaluation of dissertation in the fourth semester will be as follows: 50% weightage for continuous evaluation by the supervisor which includes regularity in work, mid-term evaluation, report of dissertation, presentation, and final viva-voce; 50% weightage based on average assessment scores by an external expert, HoD and senior-most faculty of the department. Distribution of marks will be based on report of dissertation (30%), presentation (10%), and final viva-voce (10%). The final viva-voce will be through offline or online mode. Similar evaluation pattern will be used for internship where supervisor will award 50% marks and external co-supervisor, HoD and senior-most faculty will award 50% marks. The work load of one contact hour per student will be calculated for dissertation in fourth semester.

Note: Field visits can be part of dissertation as and when required.