Central University of Punjab, Bathinda

M.Sc. Botany

Batch: 2022

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	P	Cr
BOT.506	General Biochemistry	CC	3	0	3
BOT.508	Genetics	CC	3	0	3
BOT.510	Non-Vascular Plants Systematics	CC	3	0	3
BOT.579	Botany Lab I	SBC	0	4	2
BOT.518	Biostatistics	CFC	3	0	3
BOT.519	Research Methodology	CFC	3	0	3
BOT.517	Fundamentals of Plant Biology	IDC	2	0	2
Discipline Electives*: Opt any one					
BOT.554	Evolutionary Biology	DEC	3	0	3
BOT.576	Economic and Applied Botany	DEC	3	0	3
	Total Credits		**20**	**6**	**22**

SEMESTER-II

Course Code	Course Title	Course Type	L	P	Cr
BOT.521	Plant Molecular Biology	CC	3	0	3
BOT.523	Plant Physiology	CC	3	0	3
BOT.525	Plant Tissue and Organ Culture	CC	3	0	3
BOT.577	Mycology and Plant Pathology	CC	3	0	3
BOT.580	Botany Lab II	SBC	0	4	2
BOT.583	Field Trip	SBC	0	2	1
BOT.584	Credit Seminar	SBC	0	1	1
BOT.561	Critical Thinking and Soft Skills (University-Level)	VAC	2	0	2
Discipline Electives: Opt any one					
BOT.553	Techniques in Plant Sciences	DEC	3	0	3
BOT.559	Science Communication	DEC	3	0	3
BCH.527*	Developmental Biology	DEC	3	0	3
ZOL.529*	Genetic Engineering	DEC	3	0	3
ZOL.554*	Neurobiology and Degenerative pathophysiology	DEC	3	0	3
ZOL.553*	Vascular Biology	DEC	3	0	3
ZOL.572*	Endocrinology	DEC	3	0	3
HGE.527*	Human Embryology and Developmental Genetics	DEC	3	0	3
MME.527*	Stem Cell and Regenerative Medicine	DEC	3	0	3
HGE.528*	Population Genetics and Genetic Epidemiology	DEC	3	0	3
MIC.524*	Environmental Microbiology	DEC	3	0	3
LBI.526*	Biomolecular Structure Modelling and Drug Design	DEC	3	0	3
Total			**17**	**8**	**21**

SEMESTER-III

Course Code	Course Title	Course Type	L	P	Cr
BOT.527	Ecology and Biodiversity	CC	3	0	3
BOT.529	Vascular Plants Systematics	CC	3	0	3
BOT.572	Anatomy and Developmental Biology of Plants	CC	3	0	3
BOT.581	Botany Lab III	SBC	0	4	2
BOT.574	Comprehensive Plant Sciences	DE	2	0	2
BOT.560	Entrepreneurship	CFC	1	0	1
BOT.600	Dissertation I	SBC	0	8	4
Discipline Electives: Opt any one					
BOT.551	Recombinant DNA Technology	DEC	3	0	3
BOT.555	Molecular Stress Physiology	DEC	3	0	3
BOT.571	Plant Metabolic Engineering	DEC	3	0	3
BOT.582	Applied Phycology	DEC	3	0	3
Total			**15**	**12**	**21**

SEMESTER-IV

Course Code	Course Title	Course Type	L	P	Cr
BOT.601	Dissertation II	SBC	0	40	20
Total				**40**	**20**

Table legends: L: Lectures, **T:** Tutorial, **P:** Practical, **Cr:** Credit (Two Practical credit hours = One credit), **CC:** Core Course, **SBC:** Skill Based Course, **DEC:** Discipline Elective Course, **VAC:** Value-added course, **IDC:** Interdisciplinary course; **DE:** Discipline Enrichment Course, **CFC:** Compulsory Foundation

* Please refer to the syllabus of the respective department.

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.

*Discipline Elective Courses offered by other allied departments can also be chosen. The list of all DECs to be offered in upcoming semester will be shared with students who can then make their final choice.

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

D. Dissertation Evaluation:

Dissertation Proposal (Third Semester)			**Dissertation (Fourth Semester)**		
	Marks	**Evaluation Method**		**Marks**	**Evaluation Method**
Supervisor	50	Dissertation proposal and presentation	Supervisor	50	Continuous assessment (regularity in work, mid-term evaluation) dissertation report, presentation, final viva-voce
HoD and senior-most faculty of the department	50	Dissertation proposal and presentation	External expert, HoD and senior-most faculty of the department	50	Dissertation report (30), presentation (10), final viva-voce (10)

Semester-I

Course Title: General Biochemistry
Course Code: BOT.506
Total Hrs: 45

L	P	Credits
3	0	3

Learning Outcomes
Upon successful completion of this course, the student will be able to:
CLO1: Demonstrate an understanding of basic biophysical chemistry.
CLO2: To understand the structure and function of biomolecules.
CLO3: To understand various metabolic pathways, and enzymatic machinery involved in metabolic pathways.
CLO4: To understand basics of enzymology, catalysis, kinetics and regulation.

Unit/ Hours	Content	Mapping with CLO
I 10 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.*	CLO1
II 10 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 covered*	CLO2
III 15 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.*	CLO3
IV 10 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.*	CLO4

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

Course Title: Genetics
Course Code: BOT.508
Contact Hours: 45 Hrs

L	P	Credits
3	0	3

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

CLO 1: Envisage on the basics and advancements in the area of Genetics. The students will learn the chemical nature of the genetic material, helical structure, various models of DNA replication and DNA replication. This will be addressed in Unit I.
CLO 2: Gain knowledge in the frontier fields of population, evolutionary and quantitative genetics, modern concepts of genetic inheritance, concept around loci and allele, genetic linkage and linkage maps. Student would able to solve the various data-based problems in population genetics, concepts around hypothesis testing and null hypothesis. This will be addressed in Unit II.
CLO 3: Understand the history of gene, interaction of genes, genetic recombination producing the characters differently. Students will learn dosage compensation and its effect on sex determination, historical perspective around the structure of gene, modern concepts around the gene structure. This will be addressed in Unit III.
CLO 4: After completion of IVth unit the students will understand organelle-based inheritance and its consequences on deviation from the Mendelian inheritance. Students will learn the chromosome structure and structural changes, various chemical and physical based mutagens and changes in the DNA sequences arising due to mutation.

Unit/ Hours	**Content**	**Mapping with CLO**
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*	CLO1
II 11 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.	CLO2

	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.*	
III 11 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.*	CLO3
IV 11 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. *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.*	CLO4

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 **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

L	P	Credits
3	0	3

Course Title: Non-Vascular Plants Systematics
Course Code: BOT.510
Contact Hours: 45 Hrs

Learning Outcomes
CLO 1: Understand six kingdoms of life with the current state of the art in plant taxonomy. Students will acquire the necessary skills related to plant taxonomy and systematics. Students will be able to evaluate various taxonomic evidences and learn to prepare herbarium sheets. These will be addressed in Unit I.
CLO 2: Understand the current state of the art of molecular phylogeny with a special focus on the tree of life. This will be addressed in Unit II.
CLO 3: Learn the taxonomy and systematics of the major genera of non-vascular plant groups, *viz*. algae, and lichens. In-depth coverage of the morphology, anatomy, and life cycle of different genera of algae, and lichens. These will be addressed in Unit III.
CLO 4: Learn the taxonomy and systematics of the major genera of bryophytes. In-depth coverage of the morphology, anatomy, and life cycle of different genera of bryophytes. Students will learn about the classification and life-cycle of common mosses of India. These will be addressed in Unit IV. Upon successful completion of this course, the student will be able to:

Unit/ Hours	Content	Mapping with CLO
I 12 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 (ICBN): principles of priority, typification, effective and valid publications; voucher specimens in plant systematics, herbarium vouchers and herbariums. *Understanding the tree of life with special focus on kingdom plantae, IAPT Website.*	CLO1
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.*	CLO2

III 11 hours	**Phycology:** Cyanobacteria, Algae-A brief Introduction, Seaweeds and Green Algae, Diatoms, Dinoflagellates, Microalgae, red Algae, Brown Algae, **Lichens:** Thallus structure and reproduction, ecological and economic importance with special emphasize on photobionts. *Collection of algal samples from local areas and their taxonomic identification through practical demonstration and discussion.* *Website: AlgaeBase*	CLO3
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. *Collection of bryophyte samples from local areas and their taxonomic identification through practical demonstration and discussion.* *Website: BBS Website*	CLO4

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.
- Goffinet, B. and Shaw, J. A. 2008 Bryophyte biology, 2nd Edition, Cambridge, UK: Cambridge University Press
- Rashid, A. (1998). An Introduction to Bryophyta, 1st Edition, Vikas Publishing House Pvt. Ltd., New Delhi.
- 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

Tools

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

6. Problem solving
7. Self-directed learning

5. IAPT Glossary

Course Title: Botany Lab I

L	P	Credits
0	4	2

Course Code: BOT.511
Total Hours: 60 Hrs

Learning outcomes:
Upon successful completion of this course, the student will be able to:
CLO1: Hands-on training related to protocols and methods related to biochemistry.
CLO2: Demonstrate the practical applicability of basic genetics and population genetics.
CLO3: Demonstrate the isolation of DNA from the plant samples.
CLO4: Demonstrate the use of various markers for mapping of the genes.
CLO5: Demonstrate various vascular plant specimen under microscope and learn basics of plant taxonomic labwork.
CLO6: Demonstrate the morphology and anatomy of various non-vascular plants.
CLO7: Learn the skills of plant collection and herbarium preparation of algae/lichens/bryophytes. Taxonomic description of collected specimens of algae/lichens/bryophytes.

Course Content:
General Biochemistry:

- Preparation of Solutions, buffers, pH setting etc. (2 Hrs) CLO1
- Amino acid and carbohydrate separations by paper & thin layer chromatography. (3 Hrs) CLO1
- Quantitative Estimation of Proteins, Sugars, total lipids and amino acids. (3 Hrs) CLO1
- Assay and estimation of different enzymes e.g., invertase, amylases, acid and alkaline phosphatases in plant seeds. (4 Hrs) CLO1
- Principle and application of electrophoresis, Native, SDS PAGE. (3 Hrs) CLO1
- Estimation of total phenolic compounds. (3 Hrs) CLO1
- Extraction and estimation of vitamins. (2 Hrs) CLO1

Genetics:

- **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. (3 Hrs) CLO2
- **Karyotyping:** Karyotyping of normal & abnormal chromosome sets. Monohybrid and dihybrid ratios, Multiple alleles, Epistasis – Problems. (3 Hrs) CLO2
- **Inheritance and pedigree analysis:** Inheritance patterns in Man – Numerical on Pedigree analysis- Autosomal patterns, X–linked patterns, Y–linked patterns. Mitochondrial inheritance patterns. (2 Hrs) CLO2
- Identification of inactivated X chromosome as Barr body and drumstick.(2 Hrs) CLO2
- Blood group typing using hemagglutination tests. (2 Hrs) CLO2
- Studies of a Model organism: Identification of normal and mutant flies (Drosophila melanogaster). (2 Hrs) CLO2

- To study finger ball and palmar dermatoglyphics and calculate indices. 2 Hrs (CLO4)
- To test for color blindness using Ishihara charts and Molecular Mapping of Genes. (4 Hrs) CLO2, CLO3 & CLO4

Non-Vascular Plants Systematics:

- **Algae:** Identification of common algae of Indian subcontinent, sectioning, and microscopy of algal specimen. (5 Hrs) CLO5 & CLO6
- **Bryophytes:** External morphology and internal anatomy of the vegetative and reproductive organs of genera studied in the theory. (5 Hrs) CLO5 & CLO6
- **Basic Taxonomy:** Field sampling trip and report using GPS, sample collection, preparation of herbarium (algae/lichens/bryophytes), submission of report based on field trips. Herbarium preparation. Identification of plants by morphometry. (10 Hrs) CLO7

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

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

Transactional Modes: Demonstration, Practical performance, Numerical problem solving, practical with real specimens, Problem solving, Group discussion, In-campus, and off-campus field trips.

Tools used: PPT, Video, Animation, Podcast.

Compulsory Foundation Course

Course Title: Biostatistics
Course Code: BOT.518
Contact hours: 45

L	P	Credits
3	0	3

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

CLO 1: Learn basics of critical thinking and scientific methodology essential for the understanding of biostatistics
CLO 2: Learn about statistical hypothesis testing, significance and power
CLO 3: Learn various statistical significance tests including t-Tests, F-test, $\chi 2$ test, correlation, regression etc.
CLO 4: Learn about probability relevant to biological research

Unit/ Hours	Content	Mapping with CLO
I 12 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 *Webcomic XKCD on Math related cartoons*	CLO1
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. *Web-based sample size and power calculators*	CLO2
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 *Web-based statistical hypothesis testing tools*	CLO3
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 *Web-based Monty-Hall Problem simulator*	CLO4

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

Course Title: Research Methodology
Course Code: BOT.519
Contact Hours: 45 Hrs.

L	P	Credits
3	0	3

Learning Outcomes
Upon successful completion of this course, the student will be able to:
CLO 1: Learner will be aware of the basis of research, the formulation of hypothesis, points need to be taken care before acceptance or rejection of hypothesis and basic rules of research including ethics, plagiarism and how to avoid bad science and data manipulations and know the skill to avoid plagiarism in scientific writing.
CLO 2: The students will be enabled to know the formulation of research hypothesis and will be able to write any scientific document including poster presentation and dissertation.
CLO 3: Learners learn how to use scientific databases Also learn about various search engines related to scientific literature, basic library tools.
CLO 4: Learners are able to understand the industries importance of plant science and IPR for any future use.

Unit/ Hours	**Content**	**Mapping with CLO**
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, *Formulation of hypothesis and research design*	CLO1
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*	CLO2
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*	CLO3
IV 11 hours	**Intellectual Property Rights and Bioentrepreneurship:** General introduction to intellectual property rights, patent, trademarks, domain names and geographical indications. 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. *Stories of a few examples of world-famous entrepreneurship and IPR issues*	CLO4

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

Course Title: Evolutionary Biology
Course Code: BOT.554
Contact hours: 45

L	P	Credits
3	0	3

Learning outcomes:
Upon successful completion of this course, the student will be able to:
CLO 1: Learn basics of Darwin's theory of evolution
CLO 2: Learn about evolutionary mechanisms and population genetics
CLO 3: Learn about macroevolution, including punctuated equilibrium and history of life on planet earth
CLO 4: Familiarize with the various concepts of molecular evolution, with applications of evolutionary theory including phylogenetics.

Unit/ Hours	Content	Mapping with CLO
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.*	CLO1
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.*	CLO2
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.*	CLO3
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	CLO4

	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

Course Title: Economic and Applied Botany
Course Code: BOT.576
Contact hours: 45

L	P	Credits
3	0	3

Learning Outcomes:
Upon successful completion of this course, the student will be able to:
CLO1: Understand the origin of agriculture and modern agricultural practices.
CLO2: Demonstrate understanding of the common economic plants and their commercial applications.
CLO3: Demonstrate understanding of emerging technologies and value-added products from plants and their role in sustainable development.
CLO4: Demonstrate an understanding of ethnobotany and its importance.

Unit/ Hours	**Content**	**Mapping with CLO**
I 11 hours	Basic introduction to economic botany- Algae, Bryophytes, Pteridophytes, Gymnosperms, and Angiosperms. Plants and their products. World centres of primary diversity of domesticated plants, Concept of centres of origin, and their importance. Ancient and modern agriculture. Brief account: Organic farming, Urban farming, Hydroponics, Aquaculture and Mariculture, Horticulture *Group discussion on the commercial value of plant groups, understanding the origin of agriculture, ancient and modern agricultural practices.*	CLO1
II 12 hours	Origin, morphology, cultivation and uses of cereals. Cultivation and uses of fruits, vegetables, spices, beverages, and legumes. Cultivation and uses of forage and fodder crops, wood and timber-yielding plants, non-wood forest products-raw materials for paper making, gums, tannins, dyes, perfumes, and resins**.** Plants used for shade, pollution control, and aesthetics. Edible oils, its importance and commercial value. General account of major medicinal and aromatic plants. Plant genetic resources and their conservation. *Visit to a botanical garden, and group discussion on the botanical name, family, morphology and uses of the economically important plants.*	CLO2
III 11 hours	Introduction to Sustainable Development Goals, Role of plants in sustainable development. Biofuels from plants. Carbon sequestration and phytoremediation. Agroforestry and Ecotourism. Bioinoculants and biocontrol. Plant-based feed, nutraceuticals and edible vaccines. Plants in vegan food	CLO3

	industry. Metabolic and genetic engineering of plants for commercial products. *Demonstrate understanding on the plant-based value-added products for sustainable development and environmental applications through peer group learning and assignments.*	
IV 11 hours	Ethnobotany: Brief account of Folk/Tribal communities of India, Role of Ethnobotany in sustainable development and conservation. Methods and techniques used in Ethnobotany. Peoples' biodiversity Register. Biodiversity and conservation of some useful medicinal plants, Common plants used in ethnomedicine: Preparation and their uses. *Understanding the importance of ethnobotany and its implementation for the betterment of human society through peer group learning. Discussion on Peoples' biodiversity Register.*	CLO4

Suggested readings

- Bhat, R. A., Tonelli, F. M. P., Dar, G. H. and Hakeem, K. R. (Eds.). (2021). *Phytoremediation: Biotechnological Strategies for Promoting Invigorating Environs.* Elsevier.
- Bhat, R.A., Singh, D.A., Tonelli, F.M.P. and Hakeem, K.R. (2022). *Plant and Algae Biomass (Feasible Sources for Biofuel Production)*. Springer International Publishing.
- Gupta, V. K. (2016). *Traditional and folk herbal medicine: Recent researches* (Vol. 3) (New Delhi, India: Daya Publishing House).
- Kochhar, S.L. (2016). *Economic Botany: A Comprehensive Study 5th Edition* Cambridge University Press.
- Martin, G. J. (2004). *Ethnobotany: A Methods Manual 1st Edition*. Routledge.
- Pullaiah, T., Krishnamurthy, K. V. and Bahadur, B. (2017). *Ethnobotany of India, 5-Volume Set*. Routledge.
- Simpson, B.B. and Conner-Ogorzaly, E.M. (2014). *Economic Botany: Plants in Our World 4th edition*. McGraw-Hill Book Company, New York.
- Somerville, C., Cohen, M., Pantanella, E., Stankus, A. and Lovatelli, A. (2014). *Small-scale aquaponic food production: integrated fish and plant farming*. FAO Fisheries and Aquaculture Technical Paper, (589), I. Food and Agriculture Organization of the United Nations.
- Srivastava, H.C. (2014). *Medicinal and Aromatic Plants*. Indian Council of Agricultural Research, New Delhi.
- Verma, V. (2009). *Economic Botany.* ANE Books Pvt. Ltd, India.
- Web resources:

  https://www.pmfias.com/organic-farming-bio-fertilizers-and-their-use-in-agriculture/

https://link.springer.com/article/10.1007/s43615-021-00129-7
https://www.nature.com/articles/s41467-020-16982-3
https://nph.onlinelibrary.wiley.com/doi/full/10.1002/ppp3.39
https://www.nature.com/scitable/knowledge/library/phytoremediation-17359669/
https://www.greenmatters.com/p/plant-based-meat-ingredients
https://www.sciencedirect.com/science/article/pii/B9780323910019000347
http://www.nbrienvis.nic.in/Database/1_2162.aspx#:~:text=In%20addition%20to%20carbon%20storage,and%20stored%20(i.e.%20sequestered).
https://www.nature.com/scitable/topicpage/genetically-modified-organisms-gmos-transgenic-crops-and-732/
https://www.sciencedirect.com/science/article/pii/S2214662819301379
https://link.springer.com/chapter/10.1007/978-3-030-75358-0_22
http://nbaindia.org/uploaded/pdf/PBR%20Format%202013.pdf
https://ethnobiomed.biomedcentral.com/articles/10.1186/1746-4269-10-48

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)

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

L	P	Credits
2	0	2

Learning Outcomes
Upon successful completion of this course, the student will be able to:
CLO 1: Learners will be able to understand the different types of cells and tissues in plants, their growth pattern and how wood is formed in plants.
CLO 2: Learner will be able to know the different metabolic activity which are essential for growth and development of plants.
CLO 3: Learner fundamentals of plant organization their functions, structures of different organs, functions and development.
CLO 4: The basis stages of plant life cycles including plant reproduction, seed formation and seed germination will help to understand the whole cycle of plant life for learners.

Unit/ Hours	Content	Mapping with CLO
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.*	CLO 1
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.*	CLO 2
III 7 hours	Organ structure and function: leaves, shoots and roots *Identification of different organ structure manually.*	CLO 3
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.*	CLO 4

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

Semester-II

L	P	Credits
3	0	3

Course Title: Plant Molecular Biology.
Course Code: BOT.521
Contact Hours: 45 Hrs

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

CLO 1: Demonstrate the Central Dogma of life and will understand the regulation of genes in response to different conditions. Students will gain knowledge in the gene regulation, learn the various aspects of chromatin modelling and its regulation. This will be addressed in Unit I.
CLO 2: Understand the basic concepts about the gene, gene families and their function. Students will learn the DNA damage and DNA repair mechanisms. This will be addressed in Unit II.
CLO 3: Demonstrate the basic transcription mechanism. Students will understand the pre and post mRNA processing. This will be addressed in Unit III.
CLO 4: Understand the genetic code, translation machinery, and processes involve in post translational modification and protein targeting. This will be addressed in Unit IV.

Unit/ Hours	**Content**	**Mapping with CLO**
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.*	CLO 1
II 12 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.*	CLO 2

III 11 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.*	CLO 3
IV 10 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.*	CLO 4

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

Couse Title: Plant Physiology
Course Code: BOT.523
Contact Hrs: 45

L	P	Credits
3	0	3

Learning outcomes

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

CLO1: To learn about basic plant processes and their functioning aspects, nutrition and primary and secondary metabolism.

CLO2: The students will understand the plant water relationship and its transport system and appreciate the plant world we depend on.

CLO3: Deeply understand the plant growth regulators their biosynthesis and mechanism of action,

CLO4: Know about the basic principles of plant function, metabolism, secondary products, cell physiology & principles of growth & development.

Unit/ Hours	**Content**	**Mapping with CLO**
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.*	CLO1
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.*	CLO2
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.*	CLO3
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.*	CLO4

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 6^{th} 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

Course Title: Plant Tissue and Organ Culture
Course Code: BOT.525
Contact Hours: 45 hours

L	P	Credits
3	0	3

Learning Outcomes
Upon successful completion of this course, the student will be able to:
CLO 1: The history and story of Plant Tissue Culture will spark the interest of students to know much about Plant tissue Culture. The regeneration potential of plants will help to understand the importance of this phenomena in plant biotechnology.
CLO 2: The different techniques of plant tissue culture will help learner to use them for different purposes in different plants for propagation and conservation strategy.
CLO 3: The formation and utilization of artificial seeds and development of virus free plants will help learner to use them for conservation strategies.
CLO 4: The development of transgenic, different methods and application of transgenic in crop improvement will help the learner to pay attention for its utilization in plant biotechnology for crop improvement programs.

Unit/ Hours	**Content**	**Mapping with CLO**
I 14 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.*	**CLO 1**
II 10 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.*	**CLO 2**
III 11 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.*	**CLO 3**
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;	**CLO 4**

	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

L	P	Credits
3	0	3

Course Title: Mycology and Plant Pathology
Course Code: BOT. 532
Contact Hours: 45

Learning Outcomes:

CLO 1: Student will learn the overview of fungi, physiology, growth, reproduction, importance and their ecological role and also will learn the historical background and current scenario of plant pathology, and in-depth knowledge of plant pathogen interaction and defence mechanism.

CLO 2: Get knowledge on management to reduce pathogenesis in plants.

CLO 3: Study the possible molecular mechanism involved in plant pathogen interaction.

CLO 4: Students will study the different plant diseases and will be able to find themselves immersed in research-based information that can be applied to control these diseases in the environment around them.

Unit/ Hours	Content	Mapping with CLO
I 11 hours	**Plant-Pathogen Interactions:** Overview of fungi and major fungal phyla, historical and developmental aspects of plant pathology, Mode of infection, role of enzymes and toxins in plant disease, Defense mechanisms of plants against infection: Preexisting, induced, structural and chemical defense; role of phytoalexins and other phenolic compounds. *Group discussion on plant pathogen interaction.*	**CLO 1**
II 11 hours	**Plant diseases management:** Cultural, biological, chemical, biopesticides, breeding for resistant varieties, plant quarantine, integrated pest management, post-harvest pathology: Fungal deterioration of food commodities, mycotoxins and health hazards, control measures *Assignment on different processes related to plant diseases management.*	**CLO 2**
III 11 hours	**Plant pathology: Molecular Perspective** Host-pathogen interactions, PR proteins, degradation of phytoalexins, systemic resistance mechanism; application of molecular biology to plant disease control - transgenic approach for crop protection	**CLO 3**

	Discussion on genetics of plant pathogen interaction.	
IV 12 hours	**Common plant diseases** Wart disease of potato, downy mildew of cucurbits, stem gall of coriander, peach leaf curl, ergot of bajra, smut of sugarcane, grassy shoot of sugarcane, Karnal bunt of wheat, Tikka disease of groundnut, red rot of sugarcane, Panama disease (*Fusarium* wilt) of banana, bacterial blight of rice, leaf curl of tomato, yellow vein mosaic of bhindi, mosaic of sugarcane, potato spindle tuber mosaic, blight of colocasia, ear cockles of wheat, Citrus greening, linseed rust. *Demonstration of sign and symptoms of plant diseases.*	**CLO 4**

Suggested Readings

- Agrios, G.N. (2005), *Plant Pathology.* Academic Press. San Diego, USA.
- Gullino, M.L., Albajes, R. and Nicot, P.C. eds., (2020). *Integrated pest and disease management in greenhouse crops*. Swizerland: Springer.
- Mehrotra, R. S. and Aggarwal, A. (2008), *Plant Pathology.* Tata McGraw.,846.
- Kimatu, J.N. (2018), *Advances in plant pathology*. BoD–Books on Demand.
- Singh, R.S. (2002), *Introduction to Principles of Plant Pathology*. Oxford & IBH, NewDelhi.
- Singh, D.P. and Singh, A. (2007), *Disease and Insect Resistance in Plants.* Oxford & IBH, New Delhi.
- Willey, J.M., Sherwood, L., Woolverton, C.J., 2010. Prescott's Microbiology. 8th edition, McGraw-Hill
- Webster, John and Roland, W.S., 2007, Introduction to Fungi, Cambridge University Press.
- Singh, R. S., 2008. Principles of Plant Pathology, Oxford and IBH Publishing Co. Pvt Ltd.

Web resources:

1. https://agritech.tnau.ac.in/crop_protection/crop_prot.html
2. www.india.gov.in/topics/agriculture/plant-protection
3. https://www.apsnet.org/Pages/default.aspx

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

L	P	Credits
0	4	2

Course Title: Botany Lab II
Course Code: BOT.580
Contact Hrs: 60

Course learning outcomes (CLO):

Upon successful completion of this course, the student will be able to:
CLO1: Demonstrate the nucleic acid isolation, PCR and restriction digestion of DNA.
CLO2: Upon successful completion of this course, the student will be able to learn about various aspects of physiological process and their measurements.
CLO3: Demonstration of media preparation and perform basic tissue culture activity
CLO4: Learn basics of sterilization techniques and their usages in Plant tissue culture.
CLO5: The formation of callus formation forms a few selected plant explants help to use them for different purposes including transgenic formation and plant cell culture.
CLO6: Learn media preparation and isolation of fungi
CLO7: Learn identification of plant disease through symptoms in field
CLO8: Learn proper plant disease management as well as identification of causal agents by microscopic study

Course Content:

Molecular Biology:

- Isolation of genomic DNA from Plant, Quantification of DNA using spectrophotometric method. RNA isolation, cDNA synthesis, RT-PCR. (5 Hrs) CLO1
- Digestion of DNA using restriction endonucleases, Resolution and molecular weight estimation of fragmented DNA using agarose gel electrophoresis. (3 Hrs) CLO1
- Construction of restriction map by single and double digestion, Designing DNA probe, Southern blot hybridization (demonstration only). 3 (Hrs) CLO1
- Amplification of known DNA sequences by Polymerase Chain Reaction. (4 Hrs)

Plant Physiology:

- Osmosis, Plasmolysis, Relative leaf water content, Imbibition. (2 Hrs) CLO2
- Growth Parameters: CGR, RGR. LAR, PAR etc. (2 Hrs) CLO2
- Quantitative estimation of chlorophyll a, b, carotenoids, anthocyanins, and Measurement of Photosynthesis (Pn). (2 Hrs) CLO2
- Membrane Damage analysis (Electrolyte leakage, Lipid peroxidation etc.) (2 Hrs) CLO2
- Quantitative estimation of proteins, sugars and amino acids, and Thin Layer Chromatography for separation of amino acids and principle and application of electrophoresis. (2 Hrs) CLO2
- Assay and estimation of acid, alkaline phosphatases (in plant seeds) and assay and estimation of amylases from different plant tissues. (2 Hrs) CLO2
- Effect of phytohormones (auxin, cytokinin, gibberellic acid) on plant growth and estimation of enzymatic and non-enzymatic antioxidants. (3 Hrs) CLO2
- TTC reduction and mitochondrial respiratory ability. (2 Hrs) CLO2

Plant Cell, Tissue and organ culture

- **Media formation**: Basic media preparation and also for different purposes (4 Hrs) CLO3
- **Sterilization techniques**: Sterilization techniques and prevention strategies to avoid contamination in plant tissue culture room/media. (3 Hrs) CLO4

- **Inoculation:** different explants in tissue culture (2 Hrs) CLO4
- **Regeneration**: From various explants, adventitious shoot and callus culture, cell culture (3 Hrs) CLO5
- Best utilization of microscopic and photography techniques for plant tissue culture, application (3 Hrs) CLO5

Mycology and Plant Pathology

- Study of morphological and reproductive structures of the genera studied in theory (2 Hrs) CLO6
- Preparation of culture media (2 Hrs) CLO6
- Isolation and identification of fungi from soil and air (2 Hrs) CLO6
- Isolation of plant pathogens following standard techniques (3Hrs) CLO6
- Study of symptoms and causal organism etc. for different plant diseases as outlined in theory courses (3Hrs) CLO7
- In-campus and off-campus field trips to identify the diseases through symptoms in field as well as identification of causal agents by microscopic study (3Hrs) CLO8

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.
- 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
- 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.
- Agrios, G.N. (2005), *Plant Pathology.* Academic Press. San Diego, USA.
- Mehrotra, R. S. and Aggarwal, A. (2008), *Plant Pathology.* Tata McGraw.,846.
- Singh, R.S. (2002), *Introduction to Principles of Plant Pathology*. Oxford & IBH, NewDelhi.

Transaction Mode: Demonstrations, Practical performance, Numerical problem solving, Practical with real specimens, Problem solving, and Group discussion, You Tube videos, podcast.

Evaluation Criteria: Total Marks – 100,

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

Course Title: Field Trip
Course Code: BOT.583
Contact Hrs: 30

L	P	Credits
0	2	1

Learning Outcome
The student would be able to
CLO1: Learn the basics of exploration-based research
CLO2: Enrich and execution of diversity and taxonomic identification of indigenous flora.

A field trip shall be conducted for a minimum of five days to explore the indigenous flora of a diversity rich area. The student shall carry out a field survey of the diversity and taxonomy of plants and submit a report upon the completion of the tour. The report shall be evaluated by the departmental committee and given satisfactory/non-satisfactory.

L	P	Credits
0	1	1

Course Title: Credit Seminar
Course Code: BOT.584
Contact Hrs: 15

Learning Outcome
The student would be able to
CLO1: Learn the basic skills of presentation and analyze a scientific topic

The students shall be given topics for seminar. Each student shall present the assigned topic in front of the departmental committee and be given marks.

Course Title: Critical Thinking and Soft Skills (Value Added Course)
Course Code: BOT.561
Contact Hours: 30
Note: This course is offered at the university level.

L	P	Credits
2	0	2

Learning Outcome

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

CLO 1: A thorough introduction to critical thinking including cognitive biases, logical fallacies and psychological effects

CLO 2: A thorough introduction to philosophy of science

CLO 3: To learn about hallmarks of scientific method and scientific thinking

CLO 4: A thorough introduction to soft skills

Unit/ Hours	Content	Mapping with CLO
I 8 hours	**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*	**CLO 1**
II 7 hours	**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*	**CLO 2**
III 7 hours	**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*	**CLO 3**
IV 8 hours	**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*	**CLO 4**

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

Discipline Elective Courses: Opt Any One

Course Title: Techniques in Plant Sciences
Course Code: BOT.553
Contact hours: 45 Hrs

L	P	Credits
3	0	3

Upon successful completion of this course, the student will be able to:
CLO 1: Learner got the knowledge for separation of biomolecules using centrifugation and chromatography. The utilization of centrifugation to know molecular mass of biomolecules and interpretation of chromatograms run by different chromatography techniques will help to identify the analyte in the sample.
CLO 2: The characterization of light and its interaction with metal and analyzing its impact to understand the elemental composition and for different uses is the outcome of unit II. The utilization of microscopy for different purposes and basics of microscopy will help to understand the precise selection of microscopy according to different use among learners.
CLO 3: The basis of nucleic acid, different separation techniques and its further utilization help the learners to understand the genomic composition of different samples.
CLO 4: The utilization of antibody for different analytical methods gives the idea for further designing the antibody for different purposes.

Unit/ Hours	**Content**	**Mapping with CLO**
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. *Peer group-discussion and demonstration of a paper chromatography and sedimentation process.*	**CLO 1**
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.*	**CLO 2**
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.	**CLO 3**

	Demonstration of electrophoresis. Peer group-discussion and assignments.	
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. Peer group-discussion and assignments.*	**CLO 4**

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

Course Title: Science Communication
Course Code: BOT. 559

L	P	Credits
3	0	3

Learning outcome
CLO1: To learn the basics of enhancing written communication skills
To learn the art of public speaking
CLO2: To learn how to leverage other media forms for effective science communication
CLO3: To learn about various challenges of science communication and how to overcome those.

Unit/ Hours	Content	Mapping with CLO
I 6 hours	Written science communication. Cohesiveness, Precision, Perspicuity, Style. Importance of right analogies and visualization. Regional Language science communication *Learning Activities: Reading selected popular science articles and drafting*	CLO1
II 8 hours	Science communication through public speaking. The art of public speaking-verbal and non-verbal communication. *Learning Activities: Listening to selected Ted Talks*	CLO2
III 8 hours	Science communication through other media, including video and podcasts, art-including performance art, and social media *Learning Activities: Listening to selected Podcasts*	CLO2
IV 8 hours	Major challenges of science communication, NOMA, Dunning-Kruger, Curse of Knowledge, Illusion of Explanatory Depth, AI, Sagan Effect, and Constructed Audience *Learning Activities: Group Discussion brainstorming possible solutions to the challenges in Science Communication*	CLO3

Suggested reading

1. Strunk Jr, W., & White, E. B. (2007). *The Elements of Style Illustrated*. Penguin.
2. Burns, T. W., O'Connor, D. J., & Stocklmayer, S. M. (2003). Science communication: a contemporary definition. *Public understanding of science*, *12*(2), 183-202.
3. Bubela, T., Nisbet, M. C., Borchelt, R., Brunger, F., Critchley, C., Einsiedel, E., ... & Caulfield, T. (2009). Science communication reconsidered. *Nature biotechnology*, *27*(6), 514-518.
4. Fischhoff, B., & Scheufele, D. A. (2013). The science of science communication. *Proceedings of the National Academy of Sciences*, *110* (Supplement 3), 14031-14032.
5. Lesen, A. E., Rogan, A., & Blum, M. J. (2016). Science communication through art: objectives, challenges, and outcomes. *Trends in Ecology & Evolution*, *31*(9), 657-660.

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

Course Title: Ecology and Biodiversity.
Course Code: BOT.527
Contact Hours: 45

L	P	Credits
3	0	3

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

CLO 1: Understand the basics of ecosystem and population ecology, biodiversity and various threats on biodiversity.
CLO 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/ Hours	Content	Mapping with CLO
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.*	CLO1
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*	CLO1
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.	CLO2

	Group discussion" Global Biodiversity Information Facility (GBIF) database (https://www.gbif.org/).	
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)*	CLO2

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:

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

Tools

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

Course Title: Vascular Plants Systematics
Course Code: BOT.529
Contact hours: 45

L	P	Credits
3	0	3

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

CLO 1: Learn the taxonomy of the major genera of pteridophytes. In-depth coverage of the morphology, anatomy, and reproduction in different genera of pteridophytes. These will be addressed in Unit I.
CLO 2: Learn the taxonomy of the major genera of gymnosperms. In-depth coverage of the morphology, anatomy, and reproduction in different genera of gymnosperms. These will be addressed in Unit II.
CLO 3: Learn in-depth taxonomy of angiosperms with APG-IV system. In-depth coverage of the morphology, anatomy, and reproduction in different genera of angiosperms. These will be addressed in Unit III.
CLO 4: Understand modern approaches in taxonomic studies and the role of taxonomy in conservation of biodiversity. Learn the skills of molecular systematics. Understand how DNA Taxonomy and DNA barcoding works. This will be addressed in Unit IV.

Unit/ Hours	**Content**	**Mapping with CLO**
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. *Group discussion on BPS Fern Guide.*	**CLO 1**
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 *Group discussion on Conifers Database.*	**CLO 2**
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	**CLO 3**

	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 *Peer discussion on the overview of various species identification apps for android/iPhone including PlantNet, and PlantSnap.*	
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. *Peer discussion on the phylogenetic inference with MEGA.*	**CLO 4**

Suggested Reading:

- Siddiqui, M.O., Pathak A. and Dikshit, A. (2016). Taxonomy of Angiosperms: Basic Concepts, Molecular Aspects and Future Prospects, Studera Press, India.
- 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

L	P	Credits
3	2	4

Course Title: Anatomy and Developmental Biology of Plants.
Course Code: BOT.572
Contact Hours: 60

Learning Outcome

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

CLO 1: To understand the detail study of male and female gametophyte formation in angiosperms.

CLO 2: Interaction of pollen tube with pistil followed by double fertilization and embryo formation.

CLO 3: Get knowledge on structure, development, classification and types of plant embryo followed by seed development and dormancy.

CLO 4: Students will learn in-depth differences related to development and anatomy of stem and roots with special reference.

Unit/ Hours	Content	Mapping with CLO
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 *Discussion on reproductive parts of plant.*	**CLO 1**
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 *Discussion on process of fertilization in plants.*	**CLO 2**
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.	**CLO 3**

	Understanding the process of seed development and dormancy.	
IV 12 hours	**Shoot development:** Organization of the shoot, apical meristem (SAM), **Root development:** Organization of root apical meristem (RAM), Anomalous secondary growth in roots and stems with special reference plants *Nyctanthes, Bignonia, Strychnos, Salvadora, Boerhaavia, Dracaena* and *Tinospora*. Ultra-structure study using light microscopy, fluorescence, SEM, TEM *Case study of anomalous secondary growth through practical.*	**CLO 4**

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.
- Cutter, Elizabeth (1969), Plant Anatomy part –I Cells and Tissues IInd edition,EdwardArnold,London
- Cutter, Elizabeth (1971), Plant Anatomy Part- II Organs ,Edward Arnold London
- Fahn ,A. (1982), Plant Anatomy Vol I and Vol II Pergamon Press. Oxford New York
- Mauseth, James D. (1988) Plant Anatomy. Benjamin/Cummings.

0	4	2

Course Title: Botany Lab III

Course Code: BOT.581

Contact Hrs: 60

Course learning outcomes (CLO):

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

CLO1: Demonstrate the ecological methods and analytical strategy

CLO2: Demonstrate the quality of water and air

CLO3: Demonstrate the various sampling methods and analysis

CLO4: Demonstrate the morphology and anatomy of various vascular plants viz. pteridophytes, gymnosperms, angiosperms.

CLO5: Learn the skills of plant taxonomic labwork of vascular plant groups, plant collection and herbarium preparation of pteridophytes, gymnosperms, angiosperms.

CLO6: In-campus and off-campus field trips, herbarium preparation, and taxonomic description of collected specimens of pteridophytes, gymnosperms, angiosperms.

CLO7: Learn the skills of molecular systematics of plants.

CLO8: Demonstrate various reproductive plant parts including gymnosperm, pteridophytes and angiosperms.

CLO9: Demonstrate the floral morphology including reproductive parts (Androecium and Gynoecium).

CLO10: Demonstrate ovules and their types, different kinds of placentation, structure of mature embryo and endosperms.

CLO11: Demonstrate the structure and types of pollen grains, microscopic view of anther, and microsporogenesis.

CLO12: Demonstrate the section of dicots and monocots plants including anomalous secondary growth showing plants.

Course Content:

Ecology and Biodiversity

- **Ecosystem analysis:** Quadrat method- Data collection Methods and species diversity estimations. Field and Laboratory Investigations, Biomes study. Eco-modeling. (6 Hrs) CLO1
- **Monitoring:** Biological Monitoring. Air, water and soil analysis. (5 Hrs) CLO2
- **Vegetation sampling methods:** Quadrats, Line, Random Number generation etc. Usage of handheld GPS device and maps overlay. (4 Hrs) CLO3
- **Measurement of Biodiversity:** Species Richness and Evenness, Various Indices (5 Hrs) CLO1

Vascular Plants Systematics

- **Pteridophytes:** External morphology and internal anatomy of the vegetative and reproductive organs of genera given in the theory. (4 Hrs) CLO4
- **Gymnosperms and Angiosperms:** External morphology and internal anatomy of the vegetative and reproductive organs of genera given in the theory. (3 Hrs) CLO4
- **Taxonomy:** Description of a species based on live specimens of the families mentioned in the theory as well as their herbarium preparation. (3 Hrs) CLO5

- **Molecular Systematics:** BLAST, Introduction to MEGA, Multiple Sequence Alignment, CLUSTALW, MUSCLE, Model Selection, Construction of Phylogenetic Trees (4 Hrs) CLO7
- Field trips to familiarize with the diversity of vascular plants. Sample collection, preparation of herbarium, submission of report based on field trips. (6 Hrs) CLO5 & CLO6

Anatomy and Developmental Biology of Plants

- **Male and female gametophyte:** Demonstration of microsporangium and Microsporogenesis, Megasporangium and Megasporogenesis, types of pollen and ovule in the angiospermic plants. (4 Hrs) CLO8, CLO9, CLO10 & CLO11
- **Embryogenesis**: Demonstration of typical dicot and monocot embryo. 8 Hrs (CLO10)
- **Anatomy:** Sectioning of root and stem of dicot and monocot plants including plants showing anomalies- *Nyctanthes, Bignonia, Strychnos, Salvadora, Boerhaavia, Dracaena* and *Tinospora*. 8 Hrs (CLO12)

Suggested Reading:

- Eugene Odum (2004). Fundamentals of Ecology. Brooks. Cole
- 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.
- Maheshwari, P. (2015) An introduction to the embryology of angiosperms, Nabu Press or Tata McGraw Hill
- Kumar, A. and Bendre, A., 1986. A textbook of practical botany, vol. I, II.

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

Transactional Modes: Demonstration, Practical performance, Numerical problem solving, practical with real specimens, Problem solving, Group discussion, In-campus, and off-campus field trips.

Tools used: PPT, Video, Animation, Podcast.

(Discipline Enrichment Course)

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

L	T	P	Credits
0	4	0	2

Learning outcome

CLO 1: This course is designed to sensitize the students' regarding competitive world and various options, and revision of important course contents.

CLO 2: Apply the knowledge of biology to make scientific queries and enhance the comprehension potential.

Unit/ Hours	Content	Mapping with CLO
I 12 hours	Revision of key topics (to be chosen by the students' Semester –I &II)	CLO1& CLO2
II 16 hours	Revision of key topics (to be chosen by the students' Semester –III)	CLO1& CLO2
III 16 hours	Subject related problems shall be addressed viz. revision of specific topics and CSIR NET exams.	CLO1& CLO2
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.	CLO1& CLO2

Course Title: Entrepreneurship (Compulsory Foundation)
Course Code: BOT.560

L	P	Cr
1	0	1

Learning Outcomes:
CLO1: 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.
CLO2: To familiarize with various management strategies and ways to foster innovation in start-up ecosystem.

Unit/ Hours	Content	Mapping with CLO
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	CLO1 & CLO2
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	CLO1 & CLO2
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	CLO1 & CLO2
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	CLO1 & CLO2

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.

Course Title: Dissertation I (Skill-based).
Course Code: BOT.600

L	T	P	Credits
0	0	8	4

Learning outcomes

- Investigate various aspects related to thrust areas of research in botany.
- Generate interest in emerging areas of research in botany.
- Analyse the literature and bring forward the research gaps and propose hypotheses and tentative solutions.

Dissertation supervisor would be allocated at the start of the semester and entire dissertation would be undertaken in discussion with the supervisor. At the end of the semester the student has to prepare a research proposal/synopsis as per the university guidelines. Upon submission of the synopsis, the research proposal shall be evaluated based on a presentation of review of literature, research gap, objective, methodology and PERT Chart for the next semester for sections of experimental work and compilation of dissertation.

Discipline Elective Courses: Opt any one

L	P	Credits
3	0	3

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

Learning Outcomes
Upon successful completion of this course, the student will be able to:
CLO 1: Learn the basics of Genetic Engineering and understanding of various molecular tools needed for DNA manipulations. This will be addressed in Unit I.
CLO 2: Enhance the understanding of various DNA manipulating tools and practical applications of different DNA modifying enzymes. This will be addressed in Unit II.
CLO 3: Get knowledge about different processes involved in preparing DNA libraries and their application in gene and protein isolation. This will be addressed in Unit III.
CLO 4: Demonstrate the role various cloning technologies and their application in agriculture and medicines. This will be addressed in Unit IV.

Unit/ Hours	Content	Mapping with CLO
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 catalogues available in the lab.*	**CLO 1**
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 catalogue for various enzymes used in the day-to-day experiments.*	**CLO 2**
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),	**CLO 3**

	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.*	
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.*	**CLO 4**

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
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

Course Title: Molecular Stress Physiology
Course Code: BOT.555
Contact Hrs: 45

L	P	Credits
3	0	3

Learning outcome

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

CLO1: To learn about various environmental factors involved in normal growth and development of plants and how plants cope up under adverse conditions.

CLO2: To understand the significance of stresses in plants

CLO3: To develop knowledge about signaling pathways and tolerance during stress conditions.

CLO4: To perform the strategies to improve plant stress tolerance is assessment of tolerance capacity.

Unit/ Hours	Content	Mapping with CLO
I 12 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. *Group discussion/ assignment and flip class*	CLO1
II 13 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. *Group discussion/ assignment and flip class*	CLO2
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 *Group discussion/ assignment and flip class*	CLO3
IV 10 hours	**Genetic engineering and production of plants for improved stress tolerance:** Physiological approach, Mutant approach, Wild resource approach, Contrasting 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 *Group discussion/ assignment and flip class*	CLO4

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.

L	P	Credits
3	0	3

Course Title: Plant Metabolic Engineering
Course Code: BOT.571
Contact Hours: 45

Learning Outcomes
Upon successful completion of this course, the student will be able to
CLO1: The basic understanding of metabolism and its link with formation of secondary metabolites help the learner to understand the direct link in-between cellular metabolism and formation of secondary metabolites. The importance of secondary metabolites gives idea of their importance in insects and human health.
CLO2: The drawing of any network will help to canvas the same for biologically important mechanism is the leaning outcomes of network biology.
CLO3: The different techniques used for metabolites analysis will help learner to use them accordingly and the available databases will further help to strengthen the skill of metabolites identification.
CLO4: The metabolic flux analysis will help to identify the targets for manipulations and further for improving values in plants.

Unit/ Hours	**Content**	**Mapping with CLO**
I 12 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.*	**CLO 1**
II 11 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.*	**CLO 2**
III 12 hours	Metabolomics, Techniques used in metabolomics, Metabolome informatics. *Extraction of different metabolites from different plant source.*	**CLO 3**
IV 10 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	**CLO 4**

	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

Course Title: Applied Phycology
Course Code: BOT.482
Contact hours: 45

L	P	Credits
3	0	3

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

CLO1: Learn the basics of algal physiology and commercial-scale cultivation.
CLO2: Demonstrate understanding of the potential role of algal systems in achieving Sustainable Development Goals.
CLO3: Demonstrate understanding of the algae-based technologies for environmental applications.
CLO4: Demonstrate understanding of algae-based products and technologies of industrial importance.
CLO5: Demonstrate understanding of the value-added products from algae, technology advancements, and commercialization.

Unit/ Hours	Content	Mapping with CLO
I 11 hours	**Overview of algae cultivation methods:** General importance of algae, and their ecophysiology, Methodologies for sampling, Isolation, purification, identification (morphometric and molecular) and conservation, Algal physiology and nutrition, Basic to advanced algae culturing techniques, Algae cultivation: Phototrophic, Heterotrophic and Mixotrophic; Biomass harvesting and drying techniques, Mass scale algae cultivation: Methods, National and International status. *Demonstrate the methods for laboratory and commercial scale algae-biomass production through research-based articles and group discussion*	**CLO1**
II 11 hours	**Environmental applications of algae:** Introduction to the UN's Sustainable Development Goals (SDGs), Algae and SDGs, Algae-based systems for wastewater treatment and carbon sequestration, Carbon credits, Algae-based technologies for the remediation of contaminates sites (aquatic and terrestrial environment), Reclamation of degraded Algae-microbe interaction and its importance, Algal allelopathy, Algae as environmental indicators, Algal blooms. *Demonstrate understanding of the environmental applications of algae through research-based articles and group discussion*	**CLO2 and CLO3**

III 12 hours	**Algae-based commercial products:** Algal metabolites and their importance, Bioactive compounds in algae, Extraction of compounds of industrial importance, Algal toxins and biocides, Toxicity tests and bioassays, Algae derived Nutraceuticals, Pharmaceuticals and Edible-vaccines, Cosmetics, Bioplastics, Algae-based aquaculture feed, animal feed, Algae as food, Functional food from algae, Algalization and soil health, Algal biofertilizers and biocontrol, Biofuels from algae, Biodiesel, Bioethanol, Thermochemical conversion of algae biomass and potential products, Anaerobic digestion and biogas production using algae biomass, Biohydrogen production. *Demonstrate understanding of the industrial applications of algae through research-based articles and group discussion*	**CLO4**
IV 11 hours	**Commercialization:** Biochemical and metabolic engineering of algae for industrial applications, Techniques for genetic modification and editing, Life-cycle assessment and commercialization challenges, Current status of algae industries. *Demonstrate the national and international status of the algae industry, and field advancements in the commercial use of algae through research-based articles, web sources, and group discussion*	**CLO5**

Suggested readings:

- Richmond, A. and Hu, Q., 2013. Handbook of microalgal culture: Applied Phycology and Biotechnology. John Wiley & Sons, eISBN: 9781118567166
- Yousuf, A. ed., 2020. Microalgae Cultivation for Biofuels Production. Academic Press, ISBN: 9780128175361.
- Alam, M.A., Xu, J.L. and Wang, Z. eds., 2020. Microalgae biotechnology for food, health, and high value products. Singapore: Springer. eISBN: 9780128241813.
- Slocombe, S.P. and Benemann, J.R. eds., 2017. Microalgal production for biomass and high-value products. CRC Press, ISBN 9781032097923.
- Jacob-Lopes, E., Maroneze, M.M., Queiroz, M.I. and Zepka, L.Q. eds., 2020. Handbook of microalgae-based processes and products: fundamentals and advances in energy, food, feed, fertilizer, and bioactive compounds. Academic Press. ISBN: 978-0-12-818536-0.
- Singh, B., Bauddh, K. and Bux, F. eds., 2015. Algae and environmental sustainability (Vol. 7). India: Springer. eBook ISBN978-81-322-2641-3.
- Bux, F. and Chisti, Y. eds., 2016. Algae biotechnology: products and processes. Springer, eISBN: 978-3-319-12334-9.

- Nambisan, P., 2017. An introduction to ethical, safety and intellectual property rights issues in biotechnology. Academic Press.
- El-Sheekh Mo, Abomohra Ae., eds., 2021. Handbook of Algal Biofuels, Aspects of Cultivation, Conversion, and Biorefinery. ISBN: 978-0-12-823764-9.
- Venkataraman G.S., 1972. Algal Biofertilizers and Rice Cultivation. Today & Tomorrow's Printers & Publishers, p. 75.
- Web resources:

https://sdgs.un.org/goals
https://doi.org/10.1016/j.copbio.2014.11.001
https://doi.org/10.1016/j.crsust.2021.100050
https://doi.org/10.1016/j.jenvman.2021.113257
https://doi.org/10.1016/j.biotechadv.2018.04.004
https://doi.org/10.1016/j.algal.2017.08.024
https://doi.org/10.1186/s12934-021-01656-6

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-IV

Course Title: Dissertation II
Course Code: BOT.601

L	P	Credits
0	40	20

Learning Outcome
The student would be able to

- Understand the lacunas in the methodology to experimentation.
- Independently plan and execute experiments in the laboratory set-up
- A field study tour may also be conducted to enrich execution of exploration-based research.
- Analyze and interpret the results obtained through different experiments.
- Apply their expertise and specific skills in the frontier area of research.

As per the defined objectives in the research proposal/synopsis, the student would carry out his experimentation to achieve these goals. The student would get experiments evaluated by the supervisor regularly, wherein the progress of the student would be evaluated. Upon achieving the objectives of the synopsis, the dissertation would be prepared as per the university guidelines for M.Sc. Dissertation in consultation with the supervisor. Dissertation would be verified for plagiarism and submitted for evaluation by committee.