Central University of Punjab, Bathinda

M.Sc. Botany

Batch: 2024

Department of Botany

School of Basic Sciences

Graduate Attributes

Students graduating from the program will benefit society by offering the skilled scientific workforce in basic sciences including plant taxonomy, plant biotechnology, and agricultural sector in academia, industry and research institution. The graduates will be abled to develop higher-order thinking skill and capabilities aligned to resolve emerging issues at regional, national, and international level in plant science as well as in surrounding environment.

Course Structure

SEMESTER-I

Course Code	Course Title	Course Type	L	T	P	Cr
BOT.506	General Biochemistry	CC	3	0	0	3
BOT.507	General Biochemistry (P)	SBC	0	0	2	1
BOT.508	Genetics	CC	3	0	0	3
BOT.509	Genetics (P)	SBC	0	0	2	1
BOT.510	Non-Vascular Plant Systematics	CC	3	0	0	3
BOT.511	Non-Vascular Plant Systematics (P)	SBC	0	0	2	1
BOT.527	Ecology and Biodiversity	CC	3	0	0	3
BOT.528	Ecology and Biodiversity (P)	SBC	0	0	2	1
BOT.518	Biostatistics	CFC	3	0	0	3
	Individualized Education Plan	Tutorial/Remedial	0	2	0	0
Discipline Electives*: Opt any one						
BOT.576	Economic and Applied Botany	DEC	3	0	0	3
BOT.582	Applied Phycology	DEC	3	0	0	3
BCH.512*	Animal Cell Culture Technology	DEC	3	0	0	3
MIC.512*	Introduction to Cell and Tissue Culture	DEC	3	0	0	3
MME.515*	Molecular and Cellular Oncology	DEC	3	0	0	3
ZOL.514*	Animal Cell Culture and Applications	DEC	3	0	0	3
ZOL.525*	Nanobiology	DEC	3	0	0	3
ZOL.579*	Cytogenetics	DEC	3	0	0	3
	Total Credits		**18**	**2**	**8**	**22**

SEMESTER-II

Course Code	Course Title	Course Type	L	T	P	Cr
BOT.529	Vascular Plant Systematics	CC	3	0	0	3
BOT.530	Vascular Plants Systematics (P)	SBC	0	0	2	1
BOT.521	Plant Molecular Biology	CC	3	0	0	3
BOT.522	Plant Molecular Biology (P)	SBC	0	0	2	1
BOT.523	Plant Physiology	CC	3	0	0	3
BOT.524	Plant Physiology (P)	SBC	0	0	2	1
BOT.572	Anatomy and Developmental Biology of Plants	CC	3	0	0	3
BOT.573	Anatomy and Developmental Biology of Plants (P)	SBC	0	0	2	1
BOT.517	Fundamentals of Plant Biology	IDC	2	0	0	2
BOT.583	Field Trip*	SBC	0	0	2	1
	Individualized Education Plan	Tutorial/Remedial	0	2	0	0
Discipline Electives: Opt any one						
BOT.553	Techniques in Plant Sciences	DEC	3	0	0	3
BOT.554	Evolutionary Biology and Molecular Systematics	DEC	3	0	0	3
BOT.571	Metabolic Engineering and Synthetic Biology in Plants	DEC	3	0	0	3
BCH.527*	Developmental Biology	DEC	3	0	0	3
ZOL.529*	Genetic Engineering	DEC	3	0	0	3
ZOL.554*	Neurobiology and Degenerative pathophysiology	DEC	3	0	0	3
ZOL.553*	Vascular Biology	DEC	3	0	0	3
ZOL.572*	Endocrinology	DEC	3	0	0	3
HGE.527*	Human Embryology and Developmental Genetics	DEC	3	0	0	3
MME.527*	Stem Cell and Regenerative Medicine	DEC	3	0	0	3
HGE.528*	Population Genetics and Genetic Epidemiology	DEC	3	0	0	3
MIC.524*	Environmental Microbiology	DEC	3	0	0	3
LBI.526*	Biomolecular Structure Modelling and Drug Design	DEC	3	0	0	3
Total			**17**	**2**	**8**	**22**

*Field Trip shall be conducted either in the 2nd or 3rd semester depending upon the seasonal diversity of the selected area for trip.

SEMESTER-III

Course Code	Course Title	Course Type	L	T	P	Cr
BOT.577	Mycology and Plant Pathology	CC	3	0	0	3
BOT.578	Mycology and Plant Pathology (P)	SBC	0	0	2	1
BOT.525	Plant Tissue and Organ Culture	CC	3	0	0	3
BOT.526	Plant Tissue and Organ Culture (P)	SBC	0	0	2	1
BOT.561	Critical Thinking and Soft Skills	VAC	2	0	0	2
BOT.505	Agro-Ecology	VAC	2	0	0	2
BOT.519	Research Methodology	CFC	3	0	0	3
BOT.560	Entrepreneurship	CFC	2	0	0	2
BOT.600	Dissertation I	SBC	0	0	8	4
	Individualized Education Plan	Tutorial/Remedial	0	2	0	0
Discipline Electives: Opt any one						
BOT.551	Recombinant DNA Technology	DEC	3	0	0	3
BOT.555	Molecular Stress Physiology	DEC	3	0	0	3
MME.555*	Evolution and Developmental Biology	DEC	3	0	0	3
EVS.557*	Ecotoxicology and Occupational Health	DEC	3	0	0	3
ZOL.577*	Reproductive Physiology	DEC	3	0	0	3
BCH.556*	Human Physiology	DEC	3	0	0	3
MIC.559*	Microbial Biotechnology	DEC	3	0	0	3
Total			**16**	**2**	**12**	**22**

SEMESTER-IV

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

Semester-wise distribution of credit load

Semester	L	T	P	Cr
I	18	2	8	22
II	17	2	10	22
III	16	2	12	22
IV	0	0	40	20
Total	**51**	**6**	**70**	**86**

Course Type-wise distribution of credits

Course Type	L	T	P	Cr	% of Total
CFC	8	0	0	8	9.3
CC	30	0	0	30	34.9
IDC	2	0	0	2	2.3
VAC	2	0	0	2	2.3
SBC	0	0	70	35	40.7
DEC	9	0	0	9	10.5
Tutorial/Remedial	0	6	0	0	0
Total	**51**	**6**	**70**	**86**	**100**

Examination pattern and evaluation for Masters' students from 2023-24 session onwards

Formative Evaluation: Internal assessment shall be 25 marks using any two or more of the given methods: tests, open book examination, assignments, term paper, etc. The Mid-semester test shall be descriptive type of 25 marks including short answer questions as well essay type questions. The number of questions and distribution of marks shall be decided by teacher aa per instruction receive from examination section.

Summative Evaluation: The End semester examination (50 marks) with 70% descriptive type and 30% objective type shall be conducted at the end of the semester. The objective type questions shall include one-word/sentence answers, fill-in the blanks, MCQs', and matching type of questons. The descriptive type of questions shall include short answer and essay type questions. The number of questions and distribution of marks shall be decided by the teachers aa per instruction receive from examination section.. **Questions for exams and tests shall be designed to assess course learning outcomes along with ability to focus on knowledge, understanding of content, analysis, interpretation and utilizaiotn of concept for day to day life.**

The evaluation for IDC, VAC and entrepreneurship, innovation and skill development courses shall include MST (50 marks) and ESE (50 marks). The pattern of examination for both MST and ESE shall be same as ESE described above for other courses.

Evaluation of dissertation proposal in the third semester shall include 50% weightage by supervisor and other 50% by HoD and senior-most faculty of the department. The evaluation of dissertation in the fourth semester shall include 50% weightage for continuous evaluation by the supervisor for regularity in work, mid-term evaluation, report of dissertation, presentation, and final viva-voce; The remaining 50% weightage based on average assessment scores by an external expert, HoD and senior-most faculty of the department. Distribution of marks is based on report of dissertation (30%), presentation (10%), and final viva-voce (10%). The external expert may attend final viva-voce through offline or online mode.

Examination pattern from 2022-23 session onwards

Core, Discipline Elective, and Compulsory Foundation Courses			**IDC, VAC, and Entrepreneurship, Innovation and Skill Development Courses**	
	Marks	**Evaluation**	**Marks**	**Evaluation**
Internal Assessment	25	Various methods	-	-
Mid-semester test (MST)	25	Descriptive	50	Descriptive (70%) Objective (30%)
End-semester exam (ESE)	50	Descriptive (70%) Objective (30%)	50	Descriptive (70%) Objective (30%)

Dissertation Proposal (Third Semester)			**Dissertation (Fourth Semester)**		
	Marks	**Evaluation**		**Marks**	**Evaluation**
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)

Marks for internship shall be given by the supervisor, HoD and senior-most faculty of the department.

Some Guidelines for Internal Assessment

1. The components/pattern of internal assessment/evaluation should be made clear to students during the semester.
2. The results of the internal assessment must be shown to the students before final submission to the examination section.
3. The question papers and answers of internal assessment should be discussed in the class.
4. The internal assessment shall be transparent and student-friendly and free from personal bias or influence, and with the best spirit of teaching.

Semester-I

Course Title: Biochemistry
Course Code: BOT.506
Total Hours: 45

L	T	P	Credits
3	0	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 bio chemistry shall be covered at diverse level of organization.*	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 different metabolic pathways shall be done in laboratory*	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* investigated for understanding the regulation of metabolism.	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: Biochemistry (P)
Course Code: BOT.507
Total Hours: 30

L	T	P	Credits
0	0	2	1

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.

Course Content:

- 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. (6 Hrs) CLO1
- Principle and application of electrophoresis, Native, SDS PAGE. (6 Hrs) CLO1
- Estimation of total phenolic compounds. (6 Hrs) CLO1
- Extraction and estimation of Ascorbic Acid (Vit C).p. (4 Hrs) CLO1

Suggested Reading:

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

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

Evaluation Criteria: Total Marks – 100,

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

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

L	T	P	Credits
3	0	0	3

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

CLO 1: Student would able to solve the various data-based problems in population genetics, concepts around hypothesis testing and null hypothesis.
CLO 2: Students will learn dosage compensation and its effect on sex determination, historical perspective around the structure of gene, modern concepts around the gene structure.
CLO 3: 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.
CLO 4: Students will be able to describe the different types of variation, genetic drift and the bottleneck effect in a population. Students will able to demonstrate as why heritable variation can be acted upon by natural selection and how each evolutionary force can influence the allele frequencies of a population.

Unit/ Hours	**Content**	**Mapping with CLO**
I 12 hours	**Introduction and scope of genetics, 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**.** *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.*	CLO1
II 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.*	CLO2
III 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	CLO3

	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 nearby to find out possible mutations in the nature followed by group discussions.* *Analysis of various karyotype and its manifestations around the genotype morphology.*	
IV 11 hours	**Population genetics:** Application of Mendel's laws to populations, Hardy-Weinberg principle, inbreeding depression and heterosis, inheritance of quantitative traits. *Analysis of various available population databases for analysis using different methods and statistical parameters*	CLO4

Suggested Reading:

- Robert, J.B. (2021) Concepts of Genetics 4th Edition. McGraw-Hill Higher Education, UK.
- Hartl, D. and Jones, E., 2019. Analysis of Genes and Genomes. *Genetics*.
- Anthony, J.F., Miller, J.A., Suzuki, D.T., Richard, R.C., Gilbert, W.M. (2004). *An introduction to Genetic Analysis*. W.H. Freeman publication, USA.
- William, S. K., Michael, R. C., Charlotte, A. S., Michael, A. P. (2014). *Concepts of Genetics.* Pearson Education, UK.
- Snusted, D.P., Simmons, M. J. (2015). *Principles of Genetics*. John Wiley & Sons, New York.
- Jocelyn, E.K., Elliott, S.G., Stephen, T.K. (2018). *Lewin's Genes XII*. Jones & Bartlett Publishers, USA.
- Tamarin, R.H. (2017). *Principles of Genetics, International edtn.* McGrawhill, USA.
- Web Resources:
  https://www.genome.gov/event-calendar/Current-Topics-in-Genome-Analysis
  http://www.dnai.org/index.htm
  https://www.youtube.com/watch?v=TNKWgcFPHqw

Transaction Mode:

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

Tools

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

Course Title: Genetics (P)
Course Code: BOT.509
Total Hours: 30

L	T	P	Credits
0	0	2	1

Learning outcomes:
Upon successful completion of this course, the student will be able to:
CLO1: Demonstrate the practical applicability of basic genetics and population genetics.

Course Content
Allele frequency: Calculation of allele frequencies. Calculating recessive gene frequency, Calculate frequency of sex –linked alleles. To test PTC tasting ability in a random sample and calculate gene frequencies for the taster and non–taster alleles. (5 hrs) CLO1

Karyotyping: Karyotyping of normal & abnormal chromosome sets. Monohybrid and dihybrid ratios, Multiple alleles, Epistasis – Problems. (5 hrs) CLO1

Inheritance and pedigree analysis: Inheritance patterns in Man – Numerical on Pedigree analysis- Autosomal patterns, X–linked patterns, Y–linked patterns. Mitochondrial inheritance patterns. (5 hrs) CLO1

Identification of inactivated X chromosome as Barr body and drumstick. 3 hrs CLO1

Blood group typing using hemagglutination tests. (2 hrs) CLO1

Studies of a Model organism: Identification of normal and mutant flies (Drosophila melanogaster). (2 hrs) CLO1

To study finger ball and palmar dermatoglyphics and calculate indices.
To test for color blindness using Ishihara charts. (5 hrs) CLO1

Molecular Mapping of Genes. (3 hrs) CLO1

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

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

Suggested Reading:

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

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

L	T	P	Credits
3	0	0	3

Learning Outcomes
CLO 1: Students will acquire the necessary skills related to plant systematics. Students will be able to evaluate various taxonomic evidences and learn to prepare herbarium sheets.
CLO 2: Students will be able to demonstrate the taxonomy, morphology, anatomy, and life cycle of the major genera of algae.
CLO 3: Students will be able to demonstrate the taxonomy, morphology, anatomy, and life cycle of the major genera of lichens.
CLO 4: Students will be able to demonstrate the taxonomy, morphology, anatomy, and life cycle of the major genera of bryophytes.

Unit/ Hours	Content	Mapping with CLO
I 10 hours	**General Introduction to Plant Systematics:** Taxonomy, Classification and Biological nomenclature; use of dichotomous taxonomic keys, 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. *Group discussion on ICBN and herbarium preparation*	CLO1
II 12 hours	**Phycology:** Algal classification; Thallus organisation and reproduction in Cyanophyta, Glaucophyta, Rhodophyta, Chlorophyta, Euglenophyta, Dinophyta, Cryptophyta, Heterokontophyta; Ecological and economic importance of algae *Collection of algal samples from local nearby areas and their taxonomic identification through practical demonstration and discussion* *Website: AlgaeBase*	CLO2
III 10 hours	**Lichens:** Classification, thallus structure and reproduction of lichens, ecological and economic importance with special emphasis on photobionts. *Collection of lichen samples from local areas and their taxonomic identification through practical demonstration and discussion*	CLO3
IV 12 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	CLO4

	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 selected areas and their taxonomic identification through practical demonstration and discussion* *Website: BBS Website*	

Suggested Reading:

- Judd, W.S., Campbell, C.S., Kellogg, E.A., Stevens, P.F. and Donoghue, M.J. (2015). *Plant Systematics, A Phylogenetic Approach*. 4th edition, 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., (2018). Phycology, 5th edition, Cambridge University Press, Cambridge.
- Bold, H.C. and Wynne, M.J., (1985). Introduction to the Algae, 2nd Edition, Prentice-Hall Inc.
- Ahmadjian, V., Hall, M.E. (Eds.), The Lichens. Academic Press, London
- Goffinet, B. and Shaw, J. A. (2009). 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
6. Problem solving
7. Self-directed learning

Tools

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

Course Title: Non-Vascular Plant Systematics (P)
Course Code: BOT.511
Total Hours: 30

L	T	P	Credits
0	0	2	1

Learning outcomes:
Upon successful completion of this course, the student will be able to:
CLO1: Demonstrate the morphology and anatomy of various non-vascular plants and skill to learn plant collection, taxonomy and herbarium preparation of algae/lichens/bryophytes.

Course Contents

- **Algae:** Identification of common algae of the Indian subcontinent, sectioning, and microscopy of the algal specimens. (4 Hrs) CLO1
- **Bryophytes:** External morphology and internal anatomy of the vegetative and reproductive organs of genera studied in the theory. (4 Hrs) CLO1
- **Lichens:** External morphology and internal anatomy of lichen specimens (4 Hrs) CLO1
- **Basic Taxonomy:** Field sampling trip and report using GPS, sample collection, preparation of herbarium (algae/lichens/bryophytes), and submission of the report based on field trips. Herbarium preparation. Identification of plants by morphometry. (8 Hrs) CLO1

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

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

Suggested Reading:

- Bendre, A. M., & Kumar, A., (2019). A Text Book of Practical Botany- 1, Algae, Fungi, Lichens, Microbiology, Plant Pathology, Bryophyta, Pteridophyta, Gymnosperms and Palaeobotany. Tenth edition, Rastogi Publications ISBN 978-1937757-1-4.
- 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.
- Ahmadjian, V., Hall, M.E. (Eds.), The Lichens. Academic Press, London
- Other Protocols and Monographs pertinent to taxonomy practicals

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

L	T	P	Credits
3	0	0	3

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

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. *Group discussion" Global Biodiversity Information Facility (GBIF) database (https://www.gbif.org/).*	CLO2
IV 10 hours	**Conservation biology:** Overview of HIPPO: Habitat Loss, Invasive Species, Pollution, Human Population, and Overharvesting, Climate Change, Climate Change mitigation,	CLO2

	ozone depletion, Carbon credit, Kyoto Protocol, CBD and other International Environmental Agreements. *Group Discussion, IUCN Red Data List https://www.iucnredlist.org/ www.cbd.int (Convention on Biological Diversity)*	

Suggested Reading:

- Odum, E. and Barrett, G.W. (2005). *Fundamentals of Ecology*. Brooks Cole, USA.
- Prasanthrajan, M and Mahendran, P.P. (2008). *A Text Book on Ecology and Environmental Science*. Agrotech, India.
- Begon, M. and Townsend, C.R. (2021). Ecology: from individuals to ecosystems. John Wiley & Sons.
- Sharma, P.D. (2005). *Ecology and Environment.* Rastogi Publications, Meerut, India.
- Verma, P.S. Agarwal, V. K. (2000). *Environmental Biology: Principles of Ecology*. S. Chand, New Delhi, India.
- Gupta, S. and Singh J. (2014) Environmental Science and Conservation. S, Chand Publishing, New Delhi
- Web Resources:
  https://doi.org/10.25829/idiv.286-21-2695.
  https://www.gbif.org/
  https://www.iucnredlist.org/
  www.cbd.int

Transaction Mode:

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

Tools

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

Course Title: Ecology and Biodiversity (P)
Course Code: BOT.528
Total Hours: 30

L	T	P	Credits
0	0	2	1

Learning Outcomes
Upon successful completion of this course, the student will be able to:
CLO1: Demonstrate the ecological methods and analytical strategy

Course Content

- Ecosystem analysis: Quadrat method- Data collection Methods and species diversity estimations. Field and Laboratory Investigations, Biomes study. Eco-modeling. (8 Hrs) CLO1
- Monitoring: Biological Monitoring. Air, water and soil analysis. (8 Hrs) CLO1
- Vegetation sampling methods: Quadrats, Line, Random Number generation etc. Usage of handheld GPS device and maps overlay. (8 Hrs) CLO1
- Measurement of Biodiversity: Species Richness and Evenness, Various Indices (6 Hrs) CLO1

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

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

Suggested Reading:
Eugene Odum (2004). Fundamentals of Ecology. Brooks. Cole

Compulsory Foundation Course

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

L	T	P	Credits
3	0	0	3

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

CLO 1: Learn basics of critical thinking and scientific methodology essential for the understanding of biostatistics
CLO 2: Learn about Data Visualization tools and descriptive statistics.
CLO 3: Learn about statistical hypothesis testing, significance, and power.
CLO 4: Learn various statistical significance tests including t-Tests ANOVA, Post Hoc tests, $\chi 2$ tests, correlation, and regression

Unit/ Hours	Content	Mapping with CLO
I 12 hours	**Overview of Biostatistics:** Essentials of Critical Thinking, Cognitive biases pertinent to statistical understanding, Scientific Methodology, Types of Studies, Observational studies, Experimental studies, Levels of Measurements *Webcomic XKCD on Math related cartoons*	CLO1
II 11 hours	**Data Visualization and Descriptive statistics**: Summarizing Data, Charting with Excel, Descriptive statistics: Measures of central tendency and dispersal, Kurtosis and Skewness, Error Bars, Moments, Normality Tests and Outliers *Web based data visualization tools*	CLO2
III 12 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*	CLO3
IV 11 hours	**Inferential Statistics:** t-Distribution paired t test, independent t test, ANOVA, Post Hoc tests, , $\chi 2$ Distribution and tests of significance based on $\chi 2$ distribution, Pearson's Correlation, Simple Linear Regression, Non-Linear Regression *Web-based statistical hypothesis testing tools*	CLO4

Suggested Reading:

- Bast, F (2023) Biostatistics and Mathematical Biology. Pearson India. ISBN 9789356066267
- Motulsky H (2013) Intuitive Biostatistics: A Nonmathematical Guide to Statistical Thinking. OUP USA; 3rd edition
- Van Belle, G., Heagerty, PJ., Fisher, LD, Lumley TS. (2003) Biostatistics A Methodology for the Health Sciences
- 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. YouTube videos
2. Related Swayam Courses
3. Podcasts

(Tutorial/Remedial)

L	T	P	Credits
0	2	0	0

Course Title: Individualized Education Plan
Contact Hours: 30

Learning Outcomes:
The student would be able to
CLO1: To understand the concepts better, absorb and assimilate the content related to courses in the respective semester.

Remedial classes will be taken to cater the learning needs of all the learners. The objective of this class is to facilitate the students to understand the concepts better and absorb and assimilate the content more effectively during extra hours. (CLO1)

Discipline Elective Courses: Opt any one

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

L	T	P	Credits
3	0	0	3

Learning Outcomes:
Upon successful completion of this course, the student will be able to:
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. *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. 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. *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	Plant-based feed, nutraceuticals and edible vaccines. Plants in vegan food industry. Metabolic and genetic engineering of plants for commercial products. *Demonstrate understanding on the plant-based value-added products through peer group learning and assignments.*	CLO3
IV 11 hours	Ethnobotany: Brief account of Folk/Tribal communities of India, Methods and techniques used in Ethnobotany. Biodiversity and	CLO4

	conservation of some useful medicinal plants, General account of major medicinal and aromatic plants and their use in ethnomedicine. *Understanding the importance of ethnobotany and its implementation for the betterment of human society through peer group learning. Discussion on Peoples' biodiversity Register.*	

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.
- SWeb 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

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

L	T	P	Credits
3	0	0	3

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

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 and industrial applications.
CLO4: 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: Methods for mass scale algae cultivation, Phototrophic, Heterotrophic and Mixotrophic algae cultivation; Biomass harvesting and drying techniques. *Demonstrate the methods for laboratory and commercial-scale algae-biomass production and group discussion*	**CLO1**
II 11 hours	**Environmental applications of algae:** Algae and UN's Sustainable Development Goals (SDGs), Algae-based systems for wastewater treatment and carbon sequestration, Carbon credits, Algae-based technologies for the remediation of contaminated sites (aquatic and terrestrial environment), Reclamation of degraded habitats; Algae-microbe interaction and its importance, Algal allelopathy, Algae as environmental indicators, Algal blooms. *Demonstrate understanding of the environmental applications of algae 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 and Functional food, Algalization and soil health, Algal biofertilizers	**CLO3**

	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 and group discussion*	
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. *Group discussion on algae industry, and field advancements in the commercial use of algae through research-based articles and web sources*	**CLO4**

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-II

Course Title: Vascular Plant Systematics
Course Code: BOT.529
Contact Hours: 45

L	T	P	Credits
3	0	0	3

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

CLO 1: Learn the taxonomy, morphology, anatomy, and reproduction of the major genera of pteridophytes.
CLO 2: Learn the taxonomy, morphology, anatomy, and reproduction of the major genera of gymnosperms.
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.
CLO 4: Understand modern approaches in taxonomic studies and the role of taxonomy in the conservation of biodiversity. Learn the skills of molecular systematics. Understand how DNA Taxonomy and DNA barcoding works.

Unit/ Hours	Content	Mapping with CLO
I 11 hours	**Pteridophytes:** Defining features and 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, Important aquatic and terrestrial ferns, Common ferns of India, ecological and economic importance of ferns. *Group discussion on BPS Fern Guide.*	**CLO1**
II 11 hours	**Gymnosperms:** Defining features and 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.*	**CLO2**
III 12 hours	**Angiosperms I:** 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 and IV system, Basal Angiosperms: ANITA Grade and Magnolids *Group discussion on angiosperms of different areas and their evolutionary trends.*	**CLO3**

IV 11 hours	**Angiosperms II:** Monocots, Eudicots, Basal Tricholpates, Caryophyllales, Santalales, Saxifragales, Rosids: Vitales, geraniales, Fabids, Malvids, Myrtales, Asterids: Cornales, Erycales, Lamids, Campanulids. Ecological and economic importance of Angiosperms *Group discussion on the overview of various species identification apps for android/iPhone including PlantNet, and PlantSnap.*	**CLO4**

Suggested Reading:

- Judd, W.S., Campbell, C.S., Kellogg, E.A., Stevens, P.F. and Donoghue, M.J. (2015). *Plant Systematics, A Phylogenetic Approach*. 4th edition, Sinauer Associates, Inc. USA.
- Rashid, A., An Introduction to Pteridopyta by, 2nd edition, (2011)., Vikas Publishing House Pvt. Ltd., Noida.
- Sporne, K.R. (2015). Morphology of Gymnosperms, B.I. Publication, New Delhi.
- 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., Dantu, P.K. and Bhatnagar, S.P. (2014). Embryology of Angiosperms, Vikash Publishing House, New Delhi, p 392.
- Gangulee, H.C. and Kar, A.K. (2011). College Botany Vol. II- (Algae+Fungi+Brophyta+Pteridophyta), New Central Book Agency, Kolkata
- Brower, A.V.Z. and Schuh, R.T. (2021). *Biological Systematics: Principles and Applications*. Cornell University Press
- Simpson, M. G., (2019). Plant Systematics. Elsevier Academic Press.
- 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

Course Title: Vascular Plant Systematics (P)
Course Code: BOT.530
Total Hours: 30

L	T	P	Credits
0	0	2	1

Learning Outcomes
Upon successful completion of this course, the student will be able to:
CLO1: Learn the skills of plant taxonomy, morphology and internal anatomy of vascular plant groups

Course Content:

1. **Pteridophytes:** External morphology and internal anatomy of the vegetative and reproductive organs of genera given in the theory. (10 Hrs) CLO1
2. **Gymnosperms and Angiosperms:** External morphology and internal anatomy of the vegetative and reproductive organs of genera given in the theory. (10 Hrs) CLO1
3. **Taxonomy:** Description of a species based on live specimens of the families mentioned in the theory as well as their herbarium preparation. (4 Hrs) CLO1
4. Field trips to familiarize with the diversity of vascular plants. Sample collection, preparation of herbarium, submission of report based on field trips. (6 Hrs) CLO1

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

Evaluation Criteria:

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

Suggested Reading:

- Judd, W.S., Campbell, C.S., Kellogg, E.A., Stevens, P.F. and Donoghue, M.J. (2007). *Plant Systematics, A Phylogenetic Approach*. Sinauer Associates, Inc. USA.
- Farnsworth, Elizabeth (2016). Plant Systematics: A Phylogenetic Approach. Rhodora118.976: 418-420.
- Bendre, A. M., and Kumar, A., (2017). A Text Book of Practical Botany -2, Taxonomy, Economic Botany, Embrylogy, Anatomy, Ecology, Physiology, Biostatistics, Cytology and Genetics. *Rastogi Publications* ISBN 97817133877-1.

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

L	T	P	Credit
3	0	0	3

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

CLO 1: Students will gain knowledge in the gene regulation, learn the various aspects of chromatin modelling and its regulation.
CLO 2: Students will learn the DNA damage and DNA repair mechanisms.
CLO 3: Students will understand the pre and post mRNA processing, transcription and its regulation at different points.
CLO 4: Understand the genetic code, translation machinery, and processes involve in post translational modification and protein targeting.

Unit/ Hours	Content	Mapping with CLO
I 12 hours	**Genome structure and function:** 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 espicallly in plants, discussion of various experiments pertain to chromatin in plants*	CLO1
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 in plants. Students will be divided in to two groups and will ask to debate on intron gain and intron loss theory.*	CLO2
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.	CLO3

	Nucleic acid databases i.e., NCBI, EBI and database search of nucleic acids in diverse type of plant, Finding of Open reading frames (ORF) in plant.	
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.*	CLO4

Suggested Reading:

- Fasman, G.D. (2019). *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. (2008). *Molecular Biology of the Gene*. Benjamin Cummings, USA.
- Jocelyn, E.K., Elliott, S.G., Stephen, T.K. (2018). *Lewin's Genes XII.* 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. (2012). *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

Course Title: Molecular Biology (P)
Course Code: BOT.522
Contact Hrs: 30

L	T	P	Credits
0	0	2	1

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.

Course content:

1. Isolation of genomic DNA from plant, Quantification of DNA using spectrophotometric method. RNA isolation, cDNA synthesis, RT-PCR. (10 Hrs) CLO1
2. Digestion of DNA using restriction endonucleases, Resolution and molecular weight estimation of fragmented DNA using agarose gel electrophoresis. (6 Hrs) CLO1
3. Construction of restriction map by single and double digestion, Designing DNA probe, Southern blot hybridization (demonstration only). 6 (Hrs) CLO1
4. Amplification of known DNA sequences by Polymerase Chain Reaction. (8 Hrs) CLO1

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

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

Suggested Reading:

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

Course Title: Anatomy and Developmental Biology of Plants
Course Code: BOT.572
Contact Hours: 45

L	T	P	Credits
3	0	0	3

Learning Outcome

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

CLO 1: To understand morphology and anatomy of plants

CLO 2: To understand the detail study of male and female gametophyte formation in angiosperms and 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	Introduction of morphology and anatomy including brief historical account; External and internal organization of higher plants; Morphology of root and stem and their modifications; Xylem and phloem; Floral morphology and anatomy, fruits and seeds; Periderm, Wood structure, Sapwood and Heartwood and Growth rings *Discussion on morphology and anatomy of plant*	**CLO 1**
II 10 hours	**Male and female gametophyte, Pollen-pistil interaction and Double fertilization:** Microsporangium and Microsporogenesis, Megasporangium and Megasporogenesis, Gametophyte formation, Pollen development, Ovule development. Pollen tube guidance; recognition and rejection, Embryo-sac development and double fertilization in plants, preferential fertilization; pistil activation and ovule penetration. *Discussion on reproductive parts and 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. *Understanding the process of seed development and dormancy*	**CLO 3**

IV 12 hours	**Shoot and Root development:** Organization of the shoot and root, apical meristem (SAM and RAM), and **floral development;** Vascular cambium and its derivatives, Anomalous secondary growth in roots and stems with special reference plants *Nyctanthes, Bignonia, Strychnos, Salvadora, Boerhaavia, Dracaena* and *Tinospora*. *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.

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: Anatomy and Developmental Biology of Plants (P)
Course Code: BOT.573
Contact Hours: 30

L	T	P	Credits
0	0	2	1

Course learning outcomes (CLO):
Upon successful completion of this course, the student will be able to:
CLO1: Anatomical demonstration of reproductive and anomalous structure of plants.

Course Content:

1. **Male and female gametophyte:** Demonstration of microsporangium and Microsporogenesis, Megasporangium and Megasporogenesis, types of pollen and ovule in the angiospermic plants. (15 Hrs) CLO1
2. **Embryogenesis**: Demonstration of typical dicot and monocot embryo. 8 Hrs CLO1
   Anatomy: Sectioning of root and stem of dicot and monocot plants including plants showing anomalies- *Nyctanthes*, *Bignonia*, *Strychnos*, *Salvadora*, *Boerhaavia*, *Dracaena* and *Tinospora*. 15 Hrs CLO1

Suggested Reading:

- 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.

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

L	T	P	Credits
3	0	0	3

Learning outcomes

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

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 signaling quality and development, 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.	CLO4

	Secondary metabolite quantification shall be done	

Suggested Reading:

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

Transaction Mode:

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

Tools

1. Power point Presentations
2. YouTube videos

Course Title: Plant Physiology (P)
Course Code: BOT.524
Contact Hours: 30

L	T	P	Credits
0	0	2	1

Course learning outcomes (CLO):
Upon successful completion of this course, the student will be able to:
CLO1: Upon successful completion of this course, the student will be able to learn about various aspects of physiological process and their measurements.

Course Content:

- Assesment of water status using relative leaf water content method. (3 Hrs) CLO1
- Growth Parameters: CGR, RGR. LAR, PAR etc. (4 Hrs) CLO1
- Quantitative estimation of chlorophyll a, b, carotenoids, anthocyanins, and Measurement of Photosynthesis (Pn). (3 Hrs) CLO1
- Membrane Damage analysis (Electrolyte leakage, Lipid peroxidation etc.) (3 Hrs) CLO1
- Quantitative estimation of proteins, sugars and amino acids, and Thin Layer Chromatography for separation of amino acids and principle and application of electrophoresis. (3 Hrs) CLO1
- Assay and estimation of acid, alkaline phosphatases (in plant seeds) and assay and estimation of amylases from different plant tissues. (3 Hrs) CLO1
- Effect of phytohormones (auxin, cytokinin, gibberellic acid) on plant growth and estimation of enzymatic and non-enzymatic antioxidants. (4 Hrs) CLO1
- TTC reduction and mitochondrial respiratory ability. (4 Hrs) CLO1
- RuBisCO quantification using SDS-PAGE (3 Hrs) CLO1

Suggested Reading:

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

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

Evaluation Criteria: Total Marks – 100,

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

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

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

L	T	P	Credits
2	0	0	2

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

- Evert R.F. (2017). Plant Anatomy: Meristems, Cells, and Tissues of the plant body: Their structure, function and development. 3Rd Edn Wiley Publishers,
- Fitzgerald L (2020) Plant Anatomy and Morphology: Structure, Function and Development, Callisto Reference, ISBN: 1641162589
- Garg R, Lyons-Sobaski S, Wise R (2018) Plant Anatomy: A concept-based approach to the structure of seed plants. Springer, ISBN: 3319772082
- David L. Nelson and Michael Cox. (2017). Lehninger Principles of Biochemistry: International Edition.
- Rudall PJ (2020) Anatomy of flowering plants: An introduction to plant structure and development. Cambridge University Press, ISBN: 1108749127

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: Field Trip
Course Code: BOT.583
Contact Hours: 30

L	T	P	Credits
0	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 approxately 4-5 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 in group and submit a report upon the completion of the tour. The report shall be evaluated by the departmental committee and given satisfactory/non-satisfactory depending upon overall performance.

(Tutorial/Remedial)

Course Title: Individualized Education Plan
Contact hours: 30

L	T	P	Credits
0	2	0	0

Learning Outcomes:
The student would be able to
CLO1: To understand the concepts better, absorb and assimilate the content related to courses in the respective semester.

Remedial classes will be taken to cater the learning needs of all the learners. The objective of this class is to facilitate the students to understand the concepts better, absorb, and assimilate the content more effectively during extra hours.

Discipline Elective Courses: Opt Any One

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

L	T	P	Credits
3	0	0	3

Upon successful completion of this course, the student will be able to:
CLO 1: The learner will be able to demonstrate the principle, working, data interpretation and applications of centrifugation and chromatographic techniques.
CLO 2: The students will be able to demonstrate the principle, working, data interpretation and applications of different spectroscopic techniques.
CLO 3: The students will understand the basis of techniques used in nucleic acid isolation, purification and quantification, and utilization to understand the genomic composition of different samples and their further utilization in various applications
CLO 4: To demonstrate the principle and applications of flow cytometry, histochemical and Immuno-techniques, antibody designing and their utilization for different analytical methods.

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 and thin layer chromatography (TLC), gel filtration and ion exchange, affinity chromatography, GC (GLC & GSC), HPLC and FPLC. *Demonstration of a paper chromatography and sedimentation process. Peer group-discussion and assignments.*	**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 the functioning of different types of microscopes. Peer group-discussion and assignments.*	**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. *Demonstration of electrophoresis. Peer group-discussion and assignments.*	**CLO 3**
IV 10 hours	Flow cytometry: Cell sorting, Hybridoma technology/Production of antibodies, Developing Monoclonal	**CLO 4**

	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.*	

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. (2010). Elements of biotechnology. 2nd edition, Rastogi Publications, Meerut, p 468.
- 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. (2021). Lehninger Principles of Biochemistry. 8th edition, 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. (2018). Principles and Techniques of Biochemistry and Molecular biology. 8th 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: Metabolic Engineering and Synthetic Biology in Plants
Course Code: BOT.571
Contact Hours: 45

L	T	P	Credits
3	0	0	3

Learning Outcomes

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

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 synthetic biology tools and techniques used to develop products and technologies.

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, Metabolomic techniques and informatics. *Construction of any network of common practical use.*	**CLO 2**
III 12 hours	*E. coli*: appropriate hosts for metabolic engineering, modelling foundation, chemical kinetics, deterministic models, stochastic models, spatiotemporal models, noise in gene expression, bacterial circuits, bacterial communication circuits, functional synthetic systems: from modules to systems synthetic circuit design and engineering: Biobrick.BioFAB and designing software	**CLO 3**

	Standardization, replicability, modelling and modularisation to biological systems	
IV 10 hours	Production of secondary metabolites by plant cell and tissue cultures. Metabolic engineering to improve the content of bioactive secondary metabolism with applicable value in medicinal plants. Engineering of crop plants with altered nutrient content, improved photosynthesis efficiency, biofuel production and enhanced lignin content *Enlisting some current research on plant metabolic engineering.*	**CLO 4**

Suggested readings:

- Smolke CD (2009) The Metabolic Pathway Engineering Handbook, CRC Press.
- Palsson BO (2011) Systems Biology, Cambridge University Press.
- Christina S, Lee SY, Nielsen J, Stephanopoulos G (2018) Synthetic Biology: Parts, Divees and Applications. Wiley-VCH Verlag GmbH & Co. KGaA.
- Vijai Singh (2022) New Frontiers and applications of synthetic biology, Elsevier, New Delhi.
- Aftab T, Hakeem KR (2022) Metabolic Engineering in plants. Springer Singapore,
- Sarah O'Connor (2016) Synthetic Biology and Metabolic Engineering in plants and microbes part B: Metabolism in plants.
- Verpoorte R, Alfermann AW (2000) Metabolic engineering of plant secondary metabolism , Springer

1.

Transaction Mode:

8. Lecture
9. Demonstration
10. Seminar
11. Group discussion
12. Tutorial
13. Problem solving
14. Self-directed learning

Tools

5. LMS
6. YouTube videos
7. Related Swayam Courses
8. Podcasts

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

L	T	P	Credits
3	0	0	3

Learning outcomes:
Upon successful completion of this course, the student will be able to:
CLO 1: Learn basics of Darwin's theory of evolution
CLO 2: Learn about Punctuated Equilibrium model of evolution
CLO 3: Learn about macroevolution, including history of life on planet earth
CLO 4: Familiarize with the various concepts of molecular systematics, 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	**Punctuated Equilibrium:** Stephen Jay Gould and the concept of Spandrels, Exaptation, Extended Phenotype, Inclusive Fitness, Stasis, Saltation, and Punctuated Equilibrium, Moto Kimura and Theory of Neutral Evolution, Connection with the concept of Genetic Drift *PBS Evolution resource.*	CLO2
III 11 hours	**Macroevolution:** Concepts: Kin Selection, Group Selection, Adaptations, Radiations and Extinctions, Evolutionary Time Scale and Dating, Fossils and Paleontology, Evolution of major plant lineages: Root of Tree of Life, Unikonts vs. Bikonts, Chimaera, Carbazoa, Chromalveolate, Alveolate, Archeplastida *iToL (Interactive Tree of Life) website.*	CLO3
IV 12 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.*	CLO4

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 resources:
  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. YouTube videos
2. Related Swayam Courses
3. Podcasts
4. Web/software tools including iToL, NCBI Taxonomy, and MEGA

Semester-III

Course Title: Mycology and Plant Pathology
Course Code: BOT. 577
Contact Hours: 45

L	T	P	Credits
3	0	0	3

Learning Outcomes:
CLO 1: Student will learn the overview of fungi and their morphology.
CLO2: Student will learn the historical background and current scenario of plant pathology, and in-depth knowledge of plant pathogen interaction and defence mechanism.
CLO 3: Get knowledge on management to reduce pathogenesis in plants.
CLO 4: Study the possible molecular mechanism involved in plant pathogen interaction.

Unit/ Hours	Content	Mapping with CLO
I 11 hours	Classification of Fungi (Ainsworth 1973 & Alexopoulos et al., 1996); Vegetative structure of thallus and their range, types of septa in different groups of fungi; Fungal associations: parasitic, saprophytic, symbiotic and endophytic; Development of conidia; Reproduction in fungi including formation of Asco and Basidiocarps; Economic importance of fungi; Different factor (Physical and nutrioonal) affecting germination of fungal spore. *Group discussion on morphology and physiology of fungi*	**CLO 1**
II 11 hours	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 2**
III 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 3**
IV 12 hours	**Plant pathology: Molecular Perspective** Host-pathogen interactions, PR proteins, degradation of phytoalexins, systemic resistance mechanism; application of	**CLO 4**

	molecular biology to plant disease control – transgenic approach for crop protection *Assignment and presentation on plant pathogen interaction*	

Suggested Readings

- Singh, K.P., Jahagirdar, S. and Sarma, B.K. eds., 2021. Emerging Trends in Plant Pathology (pp. 577-590). Springer.
- 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, 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:

15. Lecture
16. Demonstration
17. Seminar
18. Group discussion
19. Tutorial
20. Problem solving
21. Self-directed learning

Tools

9. LMS
10. YouTube videos
11. Related Swayam Courses
12. Podcasts

Course Title: Mycology and Plant Pathology (P)
Course Code: BOT.578
Contact Hours: 30

L	T	P	Credits
0	0	2	1

Course Leaning Outcomes (CLO):

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

CLO1: Learn media preparation, isolation and identification of plant pathogenic fungi and their management.

Course Content:

Mycology and Plant Pathology

- Study of morphological and reproductive structures of the genera studied in theory (4 Hrs) CLO1
- Preparation of culture media (4 Hrs) CLO1
- Isolation and identification of fungi from soil and air (4 Hrs) CLO1
- Isolation of plant pathogens following standard techniques (6Hrs) CLO1
- Study of symptomsand causal organism for different plant diseases (6Hrs) CLO1
- 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 (6Hrs) CLO1

Suggested Reading:

- Agrios, G.N. (2005), *Plant Pathology.* Academic Press. San Diego, USA.
- Mehrotra, R. S. and Aggarwal, A. (2008), *Plant Pathology.* Tata McGraw.,846.
- Dhingra, O.D. and Sinclair, J.B., 2017. Basic plant pathology methods. CRC press.
- Singh, R.S. (2002), *Introduction to Principles of Plant Pathology*. Oxford & IBH, New Delhi.

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

L	T	P	Credits
3	0	0	3

Learning Outcomes
Upon successful completion of this course, the student will be able to:
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:** History-Cell theory/totipotency, tissue culture methodology: sterile technique, media components, genetic control of TC, plant growth regulators, factors affecting plant tissue culture, Plant regeneration pathways – organogenesis and somatic embryogenesis. *Enlisting all tissue culture requirements.*	**CLO 1**
II 10 hours	**Plant cell, tissue and organ Culturing:** Cell growth, mutation and differentiation processes in plant cultures. organogenesis/somatic embryogenesis, 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 root, 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, Somaclonal variation, In Vitro selection, Disease elimination,—*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	**Plant cell cultures for plant transformation:** *Agrobacterium* cocultivation, Direct DNA uptake, Chloroplast transformation. Transgene analysis, Silencing and targeting; CRISPR-Cas9 and	**CLO 4**

	other genome editing tools. Marker-free and novel selection strategies, Societal issues in plant biotech. *Drawing of plant transformation method and t DNA insertion.*	

Suggested Reading:

- Razdan MK (2019) Introduction to Plant Tissue Culture, 3Ed, Oxford & IBH Publishing, ISBN: 9788120417939
- Pullaiah E, Rao T, Subba MV, Sreedevi S (2017) Plant Tissue Culture: Theory and Practical's 2nd, Scientific Publishers, ISBN: 9386347350
- Yadav M, Tripathi MK (2022) Plant Tissue Culture: Concepts and Techniques, Narendra Publishing House, B09RJM1H33
- Philip R (2022) A Handbook of Plant Tissue Culture. Legare Stree Press, ISBN: 1015750397.
- Pistelli L & Danova K (2023) Plant Tissue Culture and Secondary Metabolites Production. MDPI AG Publisher, 3036567860

Transaction Mode:

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

Tools:

1. LMS
2. Podcasts

Course Title: Plant Cell, Tissue and Organ Culture (P)
Course Code: BOT.526
Contact Hours: 30

L	T	P	Credits
0	0	2	1

Course Learning Outcomes (CLO):
Upon successful completion of this course, the student will be able to:
CLO1: Demonstration of media preparation, sterilization techniques and plant tissue culture activity including transgenic formation.

Course content:

- **Media formation**: Basic media preparation and also for different purposes (8 Hrs) CLO1
- **Sterilization techniques**: Sterilization techniques and prevention strategies to avoid contamination in plant tissue culture room/media. (6 Hrs) CLO1
- **Inoculation:** different explants in tissue culture (4 Hrs) CLO1
- **Regeneration**: From various explants, adventitious shoot and callus culture, cell culture (6 Hrs) CLO1
- Best utilization of microscopic and photography techniques for plant tissue culture, application (6 Hrs) CLO1

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

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

Suggested Reading:

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

Value Added Courses

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

L	T	P	Credits
2	0	0	2

Note: This course is offered at the university level.

Learning Outcome
Upon successful completion of this course, the student will be able to:
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, Cultural Biases *Cognitive Biases Visual Guide*	**CLO 1**
II 7 hours	**Philosophy of Science:** An overview of philosophy, philosophy of science, Karl Popper and Falsification, Thomas Kuhn and Paradigm Shift, Russel's Teapot, Philosophical burden-of-proof, Philosophical Razor, Philosophical thought experiments including Trolley Problem and Ship of Theseus *Case study: Pseudoscience*	**CLO 2**
III 7 hours	**The Scientific Method and Scientific Thinking:** Hallmarks of scientific method, Rationalism, Objectivism, Skepticism, Neutrality, Postmodernism, Misinformation, Disinformation, Non Overlapping Magisteria (NOMA) *Case study: Neutrality vs Objectivity in Journalism*	**CLO 3**
IV 8 hours	**Soft skills:** Emotional and Social Intelligence, Empathy, Active Listening, 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, Work ethics, Public speaking, Technical writing. *Attempt free online personality test to identify individual personality type*	**CLO 4**

Suggested Reading:

1. Bast, F (2022). Life Skills: Manual of Critical Thinking and Soft Skills. White Falcon
2. Popper, K. (2005). *The logic of scientific discovery*. Routledge.
3. Kuhn, T. S. (2012). *The structure of scientific revolutions*. University of Chicago press.
4. Pinker, S. (2018). *Enlightenment now: The case for reason, science, humanism, and progress*. Penguin.
5. Sardar, Z. (2015). *Introducing philosophy of science: A graphic guide*. Icon Books Ltd
6. Tulgan, B. (2015). *Bridging the soft skills gap: How to teach the missing basics to todays young talent*. John Wiley & Sons.
7. 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

Course Title: Agro-Ecology (Value Added Course)
Course Code: BOT.505
Contact Hours: 30

L	T	P	Credits
2	0	0	2

Note: This course is offered at the university level.

Learning Outcome

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

CLO 1: Students will be able to analyze current popular models of agroecology with a critical understanding of potential biological and sociological flaws.

CLO 2: Students will be able to communicate a clear understanding of agroecosystem, sustainable agriculture concepts and their basis in natural ecosystem functioning.

CLO 3: Students will be able to analyze biological and sociological systems in the development of sustainable food production strategies, which are innovative and ecologically sound.

Unit/ Hours	Content	Mapping with CLO
I 8 hours	**Agro-Ecology:** Introduction, concept, plant and their environment, other environmental factors (temp, water and wind), pollution processes in agriculture, sustainable agriculture practices. *Group discussion on the concepts and principles of Agro-Ecology*	**CLO 1&2**
II 7 hours	**Agroecosystem:** Agroecosystem diversity, stability, disturbance & succession, animals in the agroecosystem, bees and pollination, integrated pest management and biological control. *Group discussion on agroecosystem and sustainable practices*	**CLO 1&2**
III 7 hours	**Soil ecosystem:** Soil (chemical, physical, biological characteristics,), Soil organic matter and its management, soil testing activity, soil water, cover cropping and soil fertility management, Role of biochar in soil fertility, vermicomposting, root growth and interaction with soils, germplasm conservation. *Group discussion on soil agroecosystem and its management*	**CLO 2&3**
IV 8 hours	**Genetic resources and GMOs:** Genetic resources, GMOs and their benefits and risks, allelopathy, species interaction in crop communities. *Group discussion on genetically modified crops and species interaction in agro-ecosystem*	**CLO 1&3**

Suggested Reading:

- Gliessman, S. R. 2007. Agroecology: Ecological Processes in Sustainable Agriculture. 2nd. Ed., An Arbor Press, Chelsea, MI

- Powers, L.E., and R. McSorley. 2000. Ecological principles of agriculture. Delmar Thomson Learning, Albany, NY.

Transaction Mode:

8. Lecture
9. Demonstration
10. Seminar
11. Group discussion
12. Tutorial
13. Problem solving
14. Self-directed learning

Tools

5. LMS
6. YouTube videos
7. Related Swayam Courses
8. Podcasts

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

L	T	P	Credits
3	0	0	3

Learning Outcomes

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

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 write any scientific document including poster presentation and dissertation.

CLO 3: Learners learn how to use scientific databases and also learn about various search engines related to scientific literature, basic library tools.

CLO 4: Learners can understand the 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, Research design, Sampling errors and appropriate methods, Ethics, Plagiarism, Data manipulation, Bad Science, *Formulation of hypothesis and research design*	CLO1
II 11 hours	**Technical writing:** Key elements of review of literature, interpretation of results and discussion sections. 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** General introduction to intellectual property rights, patent, trademarks, domain names and geographical indications. *Stories of a few examples of IPR related issues*	CLO4

Suggested Reading:

1. Banerjee S (2021), Research Methodology for Natural Sciences, IISC Press, ISBN: 8194835178
2. Arumugam N (2015). Research Methodology for Life Sciences. Saras publications (p) Ltd. ISBN: 9384826790
3. Jain R.K. (2021). Research Methodology: Methods and Techniques, 5th Edition. Vayu Education of India. ISBN: 9391054978.
4. Kothari, C.R. & Garg G (2021). Research methodology. 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

Course Title: Entrepreneurship (Compulsory Foundation)
Course Code: BOT.560
Contact Hours: 15

L	T	P	Credits
1	0	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, 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.

(Tutorial/Remedial)

L	T	P	Credits
0	2	0	0

Course Title: Individualized Education Plan
Contact Hours: 30

Learning Outcomes:
The student would be able to
CLO1: To understand the concepts better, absorb and assimilate the content related to courses in the respective semester.

Remedial classes will be taken to cater learning needs of all the learners. The objective of this class is to facilitate the students to understand the concepts better and absorb and assimilate the content more effectively during extra hours.

Discipline Elective Courses: Opt any one

Course Title: Recombinant DNA Technology
Course Code: BOT.551
Contact Hours: 45

L	T	P	Credits
3	0	0	3

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

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	**CLO 3**

	in plasmids and phages, PCR product cloning (TA cloning), Cloning strategies in yeast, *Escherichia coli* and *Bacillus subtilis. DNA* Sequencing by chemical, enzymatic and big-bye terminator methods. Sequencing by Synthesis (NGS) (Chemistry and different platforms) *Construction of own plasmid sequence on addgene.org database server, quick search of plasmid database on Harvard medical school plasmid database. companies catalogues for various cloning vectors used in the day to day experiments.*	
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. (2020), *Gene Cloning and DNA analysis*. John Wiley & Sons.
- Jocelyn, E.K., Elliott, S.G. and Stephen, T.K. (2018), *Lewin's Genes XII.* Jones and Bartlett Publishers, LLC.
- Primrose, S.B., Twyman, R.M and Old, R.W., (2006). *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 Hours: 45

L	T	P	Credits
3	0	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:** Different 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.

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

Semester-IV

Course Title: Dissertation II
Course Code: BOT.601

L	T	P	Credits
0	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.