The University of Burdwan

Syllabus of 3-Year Degree/4-Year Honours in Botany

Under Curriculum and Credit Framework for Undergraduate Programme (CCFUP) as per National Education Policy 2020

With effect from 2023-24

Course Introduction

The new curriculum of B.Sc. Botany offers holistic knowledge and technical skillstostudyplants.Exposure will be given to allareasofplantscience usinga unique combination of core, elective and vocational papers with significant inter-disciplinarycomponents. Students would be exposed to both conceptual ideas and cutting-edge technologies that are presently used in the study of diverse plant life forms, processes, their evolution and interactions with other organisms withinthe ecosystem. Students would also become aware of the social, economic,and environmental significanceofplants and theirrelevance to thenational economy. B.Sc. Botany Programme covers academic activities within the classroom sessions alongwith practical concepts.Candidates will develop strong philia in plantskingdom, ecosystem, life processes, their application in making technology, exploring exotic places which might help them to work as researchers or professionslikeBotanist, Conservationist, Ecologist,Geneticist, Biochemists, Biotechnologist etc.

Programmeoutcomes(POs):

Transformed curriculumshall develop educated outcome-oriented candidature,fostered withdiscovery-learning, equipped with practice & skills to deal practical problems and versed withrecent pedagogical trends in education including e-learning, flipped class and hybrid learning todevelop into responsible citizen for nation-building and transforming the country towards thefuturewith their knowledgegainedinthefield ofplant science.

- Shallproducecompetentplantbiologistswhocanemploy andimplementtheirgainedknowledgein basicandappliedaspectsthatwillprofoundlyinfluencetheprevailingparadigmofagriculture, industry,healthcareandenvironmenttoprovidesustainabledevelopment.

- Willincreasethe abilityofcriticalthinking,developmentofscientificattitude,handlingof problemsandgeneratingsolutions,improvepracticalskills,enhancecommunication skill, social interaction,and increase awarenessin judicioususe ofplantresources byrecognizing theethical valuesystem.

- The training provided to the students will make them competent enough for doingjobs in Govt. and private sectors of academia, research and industry along withgraduatepreparationfornational aswellasinternationalcompetitiveexaminations,especially UGC-CSIR NET.

Programmespecificobjectives(PSOs):B.Sc.1st YearCourseinBotany

- Thiscoursewill provideknowledgeonvariousfieldsofbasicBotany as well as knowhow of basic cell biology and biomolecules.
- Students will be given exposure to evolutionary trend in plant kingdom
- Syllabusispreparedtoenablestudentsforcompetitiveexams infrontierareas of plantsciences.

CourseOutcomes of Paper I (CO)

- Developunderstandingabout theclassification anddiversityofdifferentmicrobesincluding Bacteria, Viruses, Fungi, etc. and other diverse plant groups like,Algae,Fungi& Lichens, Bryophytes, Pteridophytes, Gymnosperms and Angiosperms.
- Gainknowledgeaboutdevelopingcommercialenterpriseofmicrobialproducts.
- Understandthestructureandreproductionofcertainselectedbacteria, algae,fungiandlichens
- Developcriticalunderstandingonmorphology,anatomyandreproductionofMicrobes, Algae, fungi, Bryophytes, Pteridophytes, Gymnosperms and Angiosperms.
- Understandtheinstruments,techniques,labetiquettesandpracticesforworkinginamicrobiologylaboratory.
- Developskillsforidentifyingmicrobesandusingthemfor Industrial,AgricultureandEnvironmental purposes.

CourseOutcome - Paper II (CO)

1. Develop understanding on the basic chemistry of biomolecules, their involvement in cellular life processes.
2. Develop knowledge on plant cell architecture, their functioning in transducing life processes.
3. Develop practical knowledge on biomolecule identification and basic cellular processes.

SEMESTER WISE&COURSEWISE CREDIT DISTRIBUTION STRUCTURE UNDER NEP,2020 at UG LEVEL (HONOURS with RESEARCH)

Semester	CourseType	Paper Code	NameoftheCourse	Credit	Lect.	Tuto.	Pract./Viva	FullMarks	DistributionofMarks		
									Theory	Pract./Tuto./Viva-voce	InternalAssessment
I	Major/DSE Course(Core)	BOTN 1011	Major: Plant Diversity and Evolution	4	3		1	75	40	20	15
	MinorCourse	BOTN1021	Minor: Plant Diversity and Evolution	4	3		1	75	40	20	15
	Multidisciplinary	BOTN1031	Biodiversity and its conservation	3	2	1	0	50	40	0	10
	Ability Enhancement Course(AEC) [L1-1MIL]	..1041	Arabic/ Bengali/ Hindi/ Sanskrit/Santali/Urdu orEquvlnt. Coursefrom SWAYAM	2	2	0	0	50	40	0	10
	Skill Enhancement Course(SEC)	BOTN1051	SEC: Biofertilizer	3	2	1	0	50	40	0	10
	CommonValue Added(CVA) Course	CVA1061	Environmental Science/ Education	4	3	0	1	100	60	20	20
	Total			**20**				**400**			

Semester	CourseType	Course Code	NameoftheCourse	Credit	Lect.	Tuto.	Pract. /Viva	FullMarks	DistributionofMarks		
									Theory	Pract. /Tuto. /Viva -voce	InternalAssessment
II	Major/DSE Course(Core)	BOTN2011	Major: Biomolecules and Cell Biology	4	3	0	1	75	40	20	15
	MinorCourse	BOTN2021	Minor: Biomolecules and Cell Biology	4	3	0	1	75	40	20	15
	Multidisciplinary	BOTN2031	Medicinal Plants and Phytochemistry	3	2	1		50	40	0	10
	Ability Enhancement Course (AEC)[L_2-1]	ENGL 2041	Englishor Equvlnt. Coursefrom SWAYAM	2	2	0	0	50	40	0	10
	Skill Enhancement Course(SEC)	BOTN2051	SEC: Organic cultivation and Protected Agriculture	3	2	1	0	50	40	0	10
	CommonValue Added(CVA) Course	CVA 2061	Understanding India/digital and technological solution/health and wellness, yoga education, sports and fitness.	4	3/3	1/0	0/1	100	80/60	0/20	20
Skillbasedvocationalcourse(addl.4Cr)duringsummertermfor8weeks,whowillexittheprogrammeafterse curing 40cr.											
For UG Certificate 40cr + Additional 4 cr (work based vocational course) = 44 cr. Students areallowedtore-enterwithin 3yearswithinthestipulated max.periodof7years											
	Total			**20**				**400**			

Semester	Course Type	Paper Code	Name of the Course	Credit	Lect.	Tuto.	Pract. /Viva	Full Marks	Distribution of Marks		
									Theory	Pract. /Tuto. /Vivavoce	Internal Assessment
III	Major/DS Course (Core)	BOTN3011	Microbiology	5	4		1	75	40	20	15
		BOTN3012	Archegoniate	5	4		1	75	40	20	15
	Minor Course (Voc. Edn. &Trng.)	MSR3021 Or HRM3021 Or RSA3021	Medical SalesRepresentative Or Human Resource Management Or Retail Sale Associate	4	3	1	0	75	60	0	15
	Multi/inter disciplinary	BOTN3031	Plant Biotechnology	3	2	1		50	40	0	10
	AEC(MIL)	3041	Arabic/Bengali/ Sanskrit/ Santali/ Urdu Or Equivalent Course from SWAYAM	2				50	40		10
	Skill Enhancement Course (SEC)	BOTN3051	Medicinal Botany	3	2	1		50	40	0	10
	Total			**22**				**375**			
IV	Major/DS Course (Core)	BOTN4011	Phycology	5	4		1	75	40	20	15
		BOTN4012	Mycology	5	4		1	75	40	20	15
		BOTN4013	Plant Pathology	5	4		1	75	40	20	15
	Minor Course	BOTN4021	Plant Physiology and Metabolism	4	3		1	75	40	20	15
	Minor Course (other than Botany)	- 4021		4				75			15
	AEC(Eng.)	ENGL4041	Language and Creativity Or Equivalent Course from SWAYAM	2				50	40		10
	Total			**25**				**425**			

Semester	Course Type	Paper Code	Name of the Course	Credit	Lect.	Tuto.	Pract. /Viva	Full Marks	Distribution of Marks		
									Theory	Pract. /Tuto. /Vivavoce	Internal Assessment
V	Major/DS Course (Core)	BOTN 5011	Morphology and Anatomy	5	4	0	1	75	40	20	15
		BOTN 5012	Genetics and Plant Breeding	5	4	0	1	75	40	20	15
		BOTN 5013	Molecular Biology	5	4	0	1	75	40	20	15
	Minor Course (Voc. Edn. &Trng.)	MSR5021 Or HRM5021 Or RSA5021	Medical SalesRepresentative Or Human Resource Management Or Retail Sale Associate	4	3	1	0	75	60	0	15
	Internship	INT 5081		2	0	0	2	50	0	50 (project/Field Diary:30+Viva-voce:20)	
VI	Major/DS Course (Core)	BOTN 6011	Plant Physiology	4	3		1	75	40	20	15
		BOTN 6012	Metabolism	4	3		1	75	40	20	15
		BOTN 6013	Ecology	4	3		1	75	40	20	15
		BOTN 6014	Plant systematics	4	3		1	75	40	20	15
	Minor Course (Voc. Edn. &Trng.)	MSR6021 Or HRM6021 Or RSA6021	Medical Sales Representative Or Human Resource Management Or Retail Sale Associate	4	3	1	0	75	60	0	15

SEMESTER	Course Type	Code	Name of the Course	Credit	L – T - P	Marks	Marks Dist. Th. – Pr. - IA
VII	Major/Core Course	**BOTN 7011**	Research Methodology & Ethics	6	5- 0 - 1 (75+30 lecture hrs)	75	50 – 10 – 15
	Major/Core Course	**BOTN 7012**	Microbiology, Mycology and Plant Pathology	6	4- 0- 2 (60+60 lecture hrs)	75	40 – 20 – 15
	Major/Core Course	**BOTN 7013**	Archegoniates& Angiosperm Systematics	6	4- 0- 2 (60+60 lecture hrs)	75	40 – 20 – 15
	Major/Core Course	**BOTN 7014**	Plant Physiology, Biochemistry & Molecular Biology	6	4- 0- 2 (60+60 lecture hrs)	75	40 – 20 – 15
	Minor Course	**BOTN 7021**	Plant Biodiversity, Informatics & Environmental Sustainability	4	4- 0- 0 (60 lecture hrs)	75	60 – 0 – 15
	Total			**28**		**375**	
VIII Hons. With Research Project/ Dissertation	Major/Core Course	**BOTN 8011**	Cytogenetics & Plant Breeding	6	4- 0- 2 (60+60 lecture hrs)	75	40 –20 – 15
	Minor Course	**BOTN 8021**	Plant Natural Resources & Economic Botany	4	4- 0 -0 (60 lecture hrs)	75	60 – 0 – 15
	Research Project/ Dissertation	**BOTN 8091**	A. Plant Physiology and Biochemistry B. Microbiology C. Applied and Molecular Mycology and Plant Pathology D. Plant Genetics and Biotechnology E. Systematics and Phytogeography of Angiosperms F. Seed Physiology and Technology	12	0-0- 12	225	Seminar Presentation, Preparation & Submission of Research Project/Dissertation-200 + Viva-25
	Total			**22**		**375**	

OR

SEMESTER	Course Type	Code	Name of the Course	Credit	L – T - P	Marks	Marks Dist. Th. – Pr. - IA
VIII Hons. (without research)	Major/Core Course	**BOTN 8011**	Cytogenetics & Plant Breeding	6	4- 0- 2 (60 + 60 lecture hrs)	75	40 – 20 – 15
	Major/Core Course	**BOTN 8012**	Ecology and Evolutionary Biology	4	3- 0- 1 (45 +30 lecture hrs)	75	40 – 20 – 15
	Major/Core Course	**BOTN 8013**	Palaeobotany & Reproductive biology	4	3- 0- 1 (45 +30 lecture hrs)	75	40 – 20 – 15
	Major/Core Course	**BOTN 8014**	Phycology & Indian Knowledge System	4	3- 0- 1 (45 +30 lecture hrs)	75	40 – 20 – 15
	Minor Course	**BOTN 8021**	Plant Natural Resources & Economic Botany	4	4– 0- 0 (60 lecture hrs)	75	60 – 0 – 15
	Total			**22**		**375**	
	Grand total (Sem. I -VIII)			**178**		**3075**	

SEMESTER I

Major: (BOTN1011)-Plant Diversity and Evolution

Credit -3 **Marks – 40**

Course Objectives

1. To introduce the origin and evolution of life and major classification systems.
2. To provide knowledge about structural and reproductive features of bacteria, viruses, algae, and fungi.
3. To explain the diversity, morphology, anatomy, reproduction, and evolutionary trends in Bryophytes, Pteridophytes, Gymnosperms, and Angiosperms.
4. To develop practical skills for microscopic observation, slide preparation, and identification of representative plant groups and microbes.
5. To highlight ecological and economic significance of different plant groups and microorganisms in agriculture, medicine, industry, and environment.

Course Outcomes :-After completing the course, students will be able to:

1. Explain the origin of life, concepts of evolution, and major classification systems including six-kingdom classification.
2. Describe structural features, reproduction, and genetic mechanisms of bacteria, viruses, algae, and fungi.
3. Compare and contrast life cycles, adaptations, and evolutionary trends in Bryophytes, Pteridophytes, Gymnosperms, and Angiosperms.
4. Demonstrate practical skills in microscopic observation, slide preparation, and identification of representative taxa.
5. Assess ecological roles and economic importance of different groups of plants and microorganisms.
6. Appreciate phylogenetic relationships and evolutionary continuity among plant groups**.**

Unit1: Origin of life **Hours: 3**

Chemical basis of origin of life, concepts of evolution, Tree and classification of life, and classification (up to six kingdoms).

Unit2: Bacteria **Hours: 5**

Characteristic features, cell structure and genetic element, asexual reproduction and modes of gene transfer (conjugation, transformation and transduction), brief introduction to Archaea. Role of bacteria in agriculture, medicine and industry.

Unit3: Viruses **Hours: 3**

Characteristic features, replication, RNA virus (structure of TMV), DNA virus (structure of T_2-phage), Lytic and Lysogenic life cycle (Lambda phage).

Unit4: Algae **Hours: 4**

Characteristic features, cell structure, range of thallus, methods of reproduction and evolutionary classification of Lee (2015) up to orders. A brief account of *Nostoc*, *Spirogyra, Sargassum*, *Polysiphonia;* economic significance (brief account)

Unit5: Fungi **Hours: 5**

Characteristics features, affinities with plants and animals, structural features, reproduction and life cycle pattern. Outline classification of Ainsworth (1973) up to orders. Myxomycetes- characteristics and their similarities with fungi. General characteristics and life cycles of *Mucor*, *Saccharomyces*, *Ascobolus*, *Neorospora*, *Agaricus Helminthosporium*(= *Cochiliobolus*). Fungal symbiosis- lichen and mycorrhizae (characteristics and significance), economic importance of fungi.

Unit6: Bryophytes **Hours: 5**

Characteristic features and reproduction, adaptation to land habit, outline classification of Schuster (1958) up to orders, evolutionary trends in Bryophytes. Brief account of *Marchantia, Anthoceros* and *Funaria*. Ecological significance.

Unit7: Pteridophytes **Hours: 5**

Characteristic features and reproduction, Outline classification of Gifford & Foster (1989) up to order, evolutionary trends in Pteridophytes, affinities with Bryophytes. Brief account of *Psilotum, Selaginella, Equisetum, Pteris* and *Marsilea.*

Unit8: Gymnosperms **Hours: 5**

Characteristic features and reproduction, Outline classification of Bhatnagar & Moitra (1996) up to orders, evolutionary trends in Gymnosperm, affinities with Pteridophytes. Brief account of *Cycas, Ginkgo* and *Gnetum.* Economic significance.

Unit 9: Angiosperms **Hours: 5**

Gross morphology and reproduction, Concept of natural, artificial and phylogenetic system of classification.

Practical

Credit 1 Marks 20

1. To study different strains of *Bacillus* and *E. coli* (Gram staining). (01hr)
2. To study structure of TMV and T_2 phage (electronmicrographs/models). (01 hr)
3. To study morphology of *Nostoc*, *Spirogyra, Sargassum*, *Polysiphonia etc.* from permanent slides. (02 hrs)
4. To study *Mucor, Saccharomyces, Ascobolus, Agaricus* and *Fusarium* from permanent slides, dry preserved specimens or museum specimen. Lichens from dry or preserved specimens. (02 hrs)
5. To study *Marchantia*, *Anthoceros* and *Funaria* (vegetative and reproductive morphology from permanent slides). (03 hrs)

6. To study the vegetative and reproductive morphology of *Psilotum, Selaginella, Equisetum* and *Pteris* from permanent slides. (02 hrs)
7. To study the vegetative and reproductive morphology of *Cycas, Ginkgo* and *Gnetum* from permanent slides. (02 hrs)
8. To study morphology of angiosperm leaf, stem, flower, inflorescence and fruits from locally available plant species (Both monocot and dicot). (05 hrs)
9. Temporary anatomical slide preparation of *Pteris* leaflet and *Cycas* leaflet. (02 hrs)
Tutorial: Nil

Minor: (BOTN1021)Plant Diversity and Evolution

Credit: 3 **Marks: 40**

Course Objectives

1. Understand the origin and evolution of life and major classification systems.
2. Learn structural, genetic, and reproductive features of microorganisms (Bacteria, Archaea, Viruses, Algae, Fungi).
3. Study morphology, reproduction, classification, and evolutionary trends of Bryophytes, Pteridophytes, Gymnosperms, and Angiosperms.
4. Recognize ecological and economic importance of plant groups and microbes.
5. Develop practical skills in microscopy, slide preparation, and specimen identification.

Course Outcomes:-After completing this course, students will be able to:

1. Explain origin of life, evolution concepts, and six-kingdom classification.
2. Describe structure, reproduction, and applied roles of bacteria, archaea, and viruses.
3. Analyze diversity, reproduction, and significance of algae and fungi.
4. Compare life cycles and evolutionary trends of Bryophytes, Pteridophytes, Gymnosperms, and Angiosperms.
5. Perform microscopic observation, slide preparation, and identification of representative taxa.
6. Assess ecological and economic importance of microbes and plants.

Unit1: Origin of life **Hours: 3**

Chemical basis of origin of life, concepts of evolution, Tree and classification of life, and classification (up to six kingdoms).

Unit2: Bacteria **Hours: 5**

Characteristic features, cell structure and genetic element, asexual reproduction and modes of gene transfer (conjugation, transformation and transduction), brief introduction to Archaea. Role of bacteria in agriculture, medicine and industry.

Unit3: Viruses **Hours: 3**

Characteristic features, replication, RNA virus (structure of TMV), DNA virus (structure of T_2-phage), Lytic and Lysogenic life cycle (Lambda phage).

Unit4: Algae **Hours: 4**

Characteristic features, cell structure, range of thallus, methods of reproduction and evolutionary classification of Lee (2015) up to orders. A brief account of *Nostoc*, *Spirogyra, Sargassum*, *Polysiphonia;* economic significance (brief account)

Unit5: Fungi **Hours: 5**

Characteristics features, affinities with plants and animals, structural features, reproduction and life cycle pattern. Outline classification of Ainsworth (1973) up to orders. Myxomycetes- characteristics and their similarities with fungi. General characteristics and life cycles of *Mucor*, *Saccharomyces*, *Ascobolus*, *Neorospora*, *Agaricus Helminthosporium*(= *Cochiliobolus*). Fungal symbiosis- lichen and mycorrhizae (characteristics and significance), economic importance of fungi.

Unit6: Bryophytes **Hours: 5**

Characteristic features and reproduction, adaptation to land habit, outline classification of Schuster (1958) up to orders, evolutionary trends in Bryophytes. Brief account of *Marchantia, Anthoceros* and *Funaria*. Ecological significance.

Unit7: Pteridophytes **Hours: 5**

Characteristic features and reproduction, Outline classification of Gifford & Foster (1989) up to order, evolutionary trends in Pteridophytes, affinities with Bryophytes. Brief account of *Psilotum, Selaginella, Equisetum, Pteris* and *Marsilea.*

Unit8: Gymnosperms **Hours: 5**

Characteristic features and reproduction, Outline classification of Bhatnagar & Moitra (1996) up to orders, evolutionary trends in Gymnosperm, affinities with Pteridophytes. Brief account of *Cycas, Ginkgo* and *Gnetum.* Economic significance.

Unit 9: Angiosperms **Hours: 5**

Gross morphology and reproduction, Concept of natural, artificial and phylogenetic system of classification.

Practical

Credit: 01 Marks 20

1. To study different strains of *Bacillus* and *E. coli* (Gram staining). (01 hr)
2. To study structure of TMV and T_2 phage (electronmicrographs/models). (01 hr)
3. To study morphology of *Nostoc*, *Spirogyra, Sargassum*, *Polysiphonia etc.* from permanent slides. (02 hrs)
4. To study *Mucor, Saccharomyces, Ascobolus, Agaricus* and *Fusarium* from permanent slides, dry preserved specimens or museum specimen. Lichens from dry or preserved specimens. (02 hrs)
5. To study *Marchantia*, *Anthoceros* and *Funaria* (vegetative and reproductive morphology from permanent slides). (03 hrs)
6. To study the vegetative and reproductive morphology of *Psilotum, Selaginella, Equisetum* and *Pteris* from permanent slides. (02 hrs)

7. To study the vegetative and reproductive morphology of *Cycas, Ginkgo* and *Gnetum* from permanent slides. (02 hrs)
8. To study morphology of angiosperm leaf, stem, flower, inflorescence and fruits from locally available plant species (Both monocot and dicot). (06 hrs)
9. Temporary anatomical slide preparation of *Pteris* leaflet and *Cycas* leaflet. (02 hrs)

Tutorial: Nil

Multidisciplinary: (BOTN1031)-Biodiversity and its conservation

Credit: 3 **Marks: 50**

Course Objectives

1. Understand the concept, types, and components of biodiversity.
2. Learn the role of SDGs in biodiversity conservation.
3. Recognize the significance, value, and threats to biodiversity.
4. Gain knowledge of biodiversity hotspots, endemism, and IUCN Red List categories.
5. Study biodiversity acts, policies, and conservation approaches in India.
6. Learn and apply in-situ and ex-situ conservation strategies**.**

Course Outcomes:-After completing this course, students will be able to:

1. Define biodiversity and explain its types and importance.
2. Identify threats to biodiversity and their impact on ecosystems.
3. Recognize Indian biodiversity hotspots and endemic species.
4. Interpret IUCN Red List categories for Indian plants.
5. Explain biodiversity acts and policies.
6. Differentiate and apply in-situ and ex-situ conservation methods.

Unit I. Biodiversity: Definition and types; Habitat diversity, species diversity and genetic diversity, SDG's in biodiversity conservation. **Hours: 12**

Unit II. Significance and threats to Biodiversity: Economic and aesthetic value, Medicinal and timber yielding plants. NTFP,threats to biodiversity. **Hours: 22**

Biodiversity Hotspots, Biodiversity hot spots of India.

Endemism and endemic species.

ICUN Red listed categories with special reference to plants of Indian hotspots.

Unit III. Biodiversity Conservation- Indian forest conservation act, Biodiversity bill (2002)**Hours: 16**

Conservation methods – *In-situ* and *ex-situ* methods.

Biosphere reserves, National parks, Sanctuaries, Sacred grooves, Botanical gardens, Seed banks, Gene banks, Pollen banks, Culture – collections, Cryopreservation.

SEC: (BOTN1051)- Biofertilizer

Credit-3 **Marks: 50**

Course Objectives

1. Understand the concept, role, and advantages of biofertilizers.
2. Learn steps in biofertilizer production, quality control, and standards.
3. Study major microbial inoculants and their effect on crop growth.
4. Explain the role of cyanobacteria and Azolla–Anabaena in nitrogen fixation.
5. Understand mycorrhizal associations, isolation, and identification methods.
6. Learn organic farming techniques: composting, green manuring, and waste recycling.

Course Outcomes:-After completing this course, students will be able to:

1.Explain biofertilizers and compare them with chemical fertilizers.

2. Describe production, quality control, and standards of biofertilizers.

3. Identify microbial inoculants and evaluate their role in crop productivity.

4. Analyze the role of cyanobacteria in agriculture and nitrogen fixation.

5. Explain mycorrhizal associations and their role in nutrient uptake.

6. Apply composting and organic farming methods for sustainable agriculture.

Hours: 12

Unit 1: Introduction to microbial inoculants or biofertilizers, Plant nutrition, advantages of using biofertilizers over chemicalfertilizers;Methodsandstepsinmass productionofbiofertilizers: stock culture, broth culture, growth medium, fermentation, blending with thecarrier, packaging, quality check, longevity, ISI standard specification for biofertilizers; scope ofbiofertilizersinIndia.

Hours:08

Unit 1: Microinnoculants:Study of important microbial inoculants: *Rhizobium*, *Azospirillum*,*Azotobacter* and PGPR.Actinorhizae;Characteristics,and crop response.

Hours:08

Unit 3: Role of Cyanobacteria: Cyanobacteria (blue-green algae) in Agriculture: Cyanobacteria in rice cultivation;*Azolla*and *Anabaena* association, nitrogen fixation, and factors affecting growth.

Hours:12

Unit 4: Mycorrhizalassociation : Types of mycorrhizal association, occurrence and distribution; Role of Arbuscularmycorrhizal fungi in phosphorus nutrition, growth and yield of crop plants; VAM and AMF – methods inisolation (wet sieving and decanting), identification (morphological

and molecular methods)

Unit 5: Biofertilizer and Organicfarming: Hours:10

Introductiontoorganicfarming,recyclingofbiodegradablemunicipal(domestic),agriculturalandindustrialwaste;greenmanuring,bio-composting,vermicomposting andtheinfield application.

SEMESTER II

Major:(BOTN2011)- Biomolecules & Cell Biology

Credit: 3 **Marks: 40**

Course Objectives

1. Understand the chemical basis of life, including biomolecules, bonds, and enzyme chemistry.
2. Learn the structure, origin, and organization of prokaryotic and eukaryotic cells.
3. Study plant cell wall, plasma membrane, and transport mechanisms.
4. Understand structure and function of cell organelles, endomembrane system, cytoskeleton, and post-translational modifications.
5. Learn the process and regulation of cell division (mitosis and meiosis).
6. Develop practical skills in biochemical tests, microscopy, and demonstration of cellular processes.

Course Outcomes:-After completing this course, students will be able to:

1. Explain the structure and roles of biomolecules and their relevance to life processes.
2. Differentiate between prokaryotic and eukaryotic cells and describe their origin.
3. Describe the structure and function of cell wall, membrane, and transport systems.
4. Explain the structure, function, and coordination of cell organelles and cytoskeleton.
5. Illustrate the stages of cell cycle, mitosis, and meiosis.
6. Perform basic biochemical tests, pigment separation, and microscopic observations of cells and organelles.

Unit 1: Biomolecules **Hours: 07**

Chemical Bond types and characteristics, Non-covalent bonds and their biological significance. Basic chemical structure and roles of bio molecules- carbohydrates, lipids, proteins and nucleic acids. ATP as energy rich molecule. Basic Enzyme chemistry, Organic chemical principles in life processes, Basic concept of signalling molecules.

Unit 2: Cell architecture **Hours: 04**

Prokaryotic and eukaryotic cells; Origin of eukaryotic cell (endosymbiotic theory).

Unit 3: Cell Wall and Plasma Membrane **Hours: 06**

Chemistry, structure and function of Plant Cell Wall. Singer and Nicolson's fluid mosaic model of cell membrane. Membrane transporters.

Unit 4: Cell Organelles: Structure and function of the following Organelles

Nucleus: Nuclear envelope, nuclear pore complex, nuclear lamina; types of chromatins; nucleolus. **Hours: 05**

Chloroplast and Mitochondria: Structural organization; Function; chloroplast and mitochondrial genomes. **Hours: 04**

Endomembrane system: RER and SER, folding of protein in ER, export of proteins and lipids; Golgi Apparatus organization, protein sorting and export from Golgi Apparatus. PTM (Post Translational Modifications). **Hours: 05**

Cytoskeleton: Role and structure of microtubules, microfilaments, intermediary filament and motor proteins. **Hours: 04**

Unit 5: Cell division **Hours: 05**

Cell cycle; mitosis and meiosis.

Practical

Credit:01 **Marks: 20**

1. Microchemical tests for proteins, reducing and non reducing carbohydrates, starch and lipid. (09 hrs)

2. Separation of chloroplast pigments by paper chromatography. (02 hrs)

3. Study the effect of organic solvent and temperature on membrane permeability. (02 hrs)

4. Study of cell and its organelles with the help of electron micrographs and other digital resources. (02 hrs)

5. Study of plant cell structure with the help of epidermal peel mount of *Allium/Rhoeo*

(02 hrs)

6. Demonstration of the phenomenon of protoplasmic streaming in *Hydrilla* leaf. (01 hr)

7. Demonstration of the phenomenon of plasmolysis and deplasmolysis. (01 hr)

8. Demonstration of separation of biomolecules by dialysis. (01 hr)

Tutorial: Nil

Minor (BOTN2021): Biomolecules & Cell Biology

Credit:4 **Marks:40**

Course Objectives

1. Understand the chemical basis of life, including biomolecules, bonds, and enzyme chemistry.
2. Learn the structure, origin, and organization of prokaryotic and eukaryotic cells.
3. Study plant cell wall, plasma membrane, and transport mechanisms.
4. Understand structure and function of cell organelles, endomembrane system, cytoskeleton, and post-translational modifications.
5. Learn the process and regulation of cell division (mitosis and meiosis).
6. Develop practical skills in biochemical tests, microscopy, and demonstration of cellular processes.

Course Outcomes:-After completing this course, students will be able to:

1. Explain the structure and roles of biomolecules and their relevance to life processes.
2. Differentiate between prokaryotic and eukaryotic cells and describe their origin.
3. Describe the structure and function of cell wall, membrane, and transport systems.
4. Explain the structure, function, and coordination of cell organelles and cytoskeleton.
5. Illustrate the stages of cell cycle, mitosis, and meiosis.
6. Perform basic biochemical tests, pigment separation, and microscopic observations of cells and organelles.

Unit 1: Biomolecules **Hours: 07**

Chemical Bond types and characteristics, Non-covalent bonds and their biological significance. Basic chemical structure and roles of bio molecules- carbohydrates, lipids, proteins and nucleic acids. ATP as energy rich molecule. Basic Enzyme chemistry, Organic chemical principles in life processes, Basic concept of signalling molecules.

Unit 2: Cell architecture **Hours: 04**

Prokaryotic and eukaryotic cells; Origin of eukaryotic cell (endosymbiotic theory).

Unit 3: Cell Wall and Plasma Membrane **Hours: 06**

Chemistry, structure and function of Plant Cell Wall. Singer and Nicolson's fluid mosaic model of cell membrane. Membrane transporters.

Unit 4: Cell Organelles: Structure and function of the following Organelles

Nucleus: Nuclear envelope, nuclear pore complex, nuclear lamina; types of chromatins; nucleolus. **Hours: 05**

Chloroplast and Mitochondria: Structural organization; Function; chloroplast and mitochondrial genomes. **Hours: 04**

Endomembrane system: RER and SER, folding of protein in ER, export of proteins and lipids; Golgi Apparatus organization, protein sorting and export from Golgi Apparatus. PTM (Post Translational Modifications). **Hours: 05**

Cytoskeleton: Role and structure of microtubules, microfilaments, intermediary filament and motor proteins. **Hours: 04**

Unit 5: Cell division **Hours: 05**

Cell cycle; mitosis and meiosis.

Practical

Credit:01 **Marks: 20**

1. Microchemical tests for proteins, reducing and non reducing carbohydrates, starch and lipid. (09 hrs)

2. Separation of chloroplast pigments by paper chromatography. (02 hrs)

3. Study the effect of organic solvent and temperature on membrane permeability. (02 hrs)

4. Study of cell and its organelles with the help of electron micrographs and other digital resources. (02 hrs)

5. Study of plant cell structure with the help of epidermal peel mount of *Allium/Rhoeo*

(02 hrs)

6. Demonstration of the phenomenon of protoplasmic streaming in *Hydrilla* leaf. (01 hr)

7. Demonstration of the phenomenon of plasmolysis and deplasmolysis. (01 hr)

8. Demonstration of separation of biomolecules by dialysis. (01 hr)

Tutorial: Nil

Multidisciplinary (BOTN2031:Medicinal Plants and Phytochemistry

Credit:3 **Marks:40**

Course Objectives

1. **Un**derstand the history, scope, and importance of medicinal plants and indigenous systems (Ayurveda, Siddha, Unani).
2. Learn about conservation of endangered and endemic medicinal plants through in-situ and ex-situ methods.
3. Study nursery techniques and propagation methods for medicinal plants.
4. Understand ethnobotany, folk medicines, and their applications in Indian traditional healthcare.
5. Learn basics of phytochemistry, active principles, and testing of selected medicinally important plants.

Course Outcomes--After completing this course, students will be able to:

1. Explain the concepts of Ayurveda, Siddha, and Unani systems and their use of medicinal plants.
2. Describe conservation strategies for endangered and endemic medicinal plants.
3. Demonstrate knowledge of nursery management and propagation techniques.
4. Apply ethnobotanical methods to study and document traditional medicinal knowledge.
5. Identify phytochemicals and explain their medicinal uses using examples like *Catharanthus roseus*, *Withaniasomnifera*, *Clerodendrum phlomides*, and *Centella asiatica*.

Unit 1: History, Scope and Importance of Medicinal Plants,indigenous Medicinal Sciences; Definitionand Scope-Ayurveda: History, origin, panchamahabhutas, saptadhatu and tridosha concepts, Rasayana, plants used in ayurvedic treatments, Siddha: Origin of Siddha medicinal systems, Basis of Siddha system, plants used in Siddha medicine. Unani: History, concept: Umoor-e- tabiya, tumors treatments/ therapy, polyherbal formulations.

Hours:12

Unit 2: Conservation of endangered and endemic medicinal plants, endemic and endangered medicinal plants, Red list criteria; *Insitu* conservation: Biosphere reserves, sacred groves, National Parks; *Exsitu* conservation: Botanic Gardens, Ethnomedicinal plant Gardens. Propagation of Medicinal Plants: Objectives of the nursery, its classification, important components of a nursery, sowing, pricking, use of green house for nursery production, propagation through cuttings, layering, grafting and budding.

Hours:12

Unit 3: Ethnobotany and Folk medicines: Definition; Ethnobotany in India: Methods to studyethnobotany; Applications of Ethnobotany: National interacts,medicines of ethno-botany.

Hours:06

Unit 4: Phytochemistry: active principles and methods of their testing - identification andutilization of the medicinal herbs; *Catharanthusroseus* (cardiotonic), *Withaniasomnifera* (drugs acting on nervous system), *Clerodendrumphlomides* (anti-rheumatic) and

Centellaasiatica (memory booster).

Hours:10

SEC: (BOTN2051)-Organic Cultivation And Protected Agriculture

Credit-3 Marks: 40

Course Objectives

1. Understand the principles and significance of organic farming and its management practices.
2. Learn the role of biofertilizers, biopesticides, bioherbicides, and biocontrol agents in sustainable agriculture.
3. Study marketing strategies, government policies, and institutional support for organic and protected farming.
4. Understand types, importance, and challenges of protected agriculture (hydroponics, aquaponics).
5. Learn plant growth requirements, nutrient media formulations, and the use of growth regulators for optimal production.

Course Outcomes_:-After completing this course, students will be able to:

1. Explain the concept, practices, and benefits of organic farming.
2. Apply biofertilizers, biopesticides, and biocontrol agents for integrated pest and nutrient management.
3. Describe marketing approaches, policies, and institutional support for organic/ protected farming.
4. Differentiate types of protected agriculture and evaluate their advantages and limitations.
5. Prepare and optimize nutrient media and manage physical and chemical parameters for plant growth.

Unit 1:Organic farming and its management: Organic farming and its significance, management practices (nutritional requirements, pest, diseases, weeds); Use of biofertilizers, biopesticides, bioherbicides, biocontrol agents (plant growth promoting rhizobacteria (PGPR), pheromone trapping, *Trichoderma*, *Pseudomonas*, neem oil, garlic etc.)in management. **Hours:12**

Unit 2:MarketingandPolicies: Marketing of the produce and government institutes and policies related to protected farming (hydroponics and organic farming).

Hours:06

Unit 3:ProtectedAgriculture: Protected Agriculture types (hydroponics, aquaponics and organic farming),definition history, terminology, importance and advantages over traditional agriculture, limitations andchallenges. **Hours:08**

Unit 4:Plant Growth Requirements and Media formulations: Physical parameters- Light(qualityandquantity), lightbalancers;pH,conductivity, salinity (Dissolved Oxygen-DO, Total Dissolved Solid - TDS) and temperature; Chemical parameters-mineral nutrient

requirements, deficiencies, heavy metal toxicities, growth regulators (auxins, gibberellins, cytokinins and abscisicacids); Growth media-types, properties, uses, nutrient formulae, preparation of solutions, solid Media and nutrient film. **Hours:14**

Suggested readings:

1. Alexopoulos, C.J., Mims, C.W., Blackwell, M. (1996). Introductory Mycology, John Wiley &Sons (Asia) Singapore. 4th edition.
2. Ayurveda and Aromatherapy. Miller, Light and Miller, Bryan, 1998. Banarsidass, Delhi.
3. Ayurvedic drugs and their plant source. V.V. Sivarajan and Balachandran Indra 1994. Oxford IBHpublishing Co.
4. Becker, W.M., Kleinsmith, L.J., Hardin. J. and Bertoni, G. P. (2009) The World of the Cell.7th edition. Pearson Benjamin Cummings Publishing, San Francisco
5. Berg JM, Tymoczko JL and Stryer L (2011) Biochemistry, W.H.Freeman and Company
6. Bhatnagar, S.P. & Moitra, A. (1996). Gymnosperms. New Age International (P) Ltd Publishers, NewDelhi, India.
7. Campbell, MK (2012) Biochemistry, 7th ed., Published by Cengage Learning
8. Campbell, N.A., Reece J.B., Urry L.A., Cain M.L., Wasserman S.A. Minorsky P.V., Jackson R.B.(2008). Biology, Pearson Benjamin Cummings, USA. 8th edition.
9. Campbell, PN and Smith AD (2011) Biochemistry Illustrated, 4th ed., Published by ChurchillLivingstone
10. Capon, B. (2010). Botany for Gardeners. 3rd Edition. Timber Press, Portland, Oregon.
11. Chrispeels, M.J. and Sadava, D.E. 1994 Plants, Genes and Agriculture. Jones & BartlettPublishers.
12. Chrispeels, M.J. and Sadava, D.E. 1994 Plants, Genes and Agriculture. Jones & BartlettPublishers
13. Colton C.M. 1997. Ethnobotany - Principles and applications. John Wiley and sons - Chichester
14. Cooper, G.M. and Hausman, R.E. (2009) The Cell: A Molecular Approach. 5th edition. ASMPress & Sunderland, Washington, D.C.; Sinauer Associates, MA.
15. Dubey, R.C., 2005 A Text book of Biotechnology S.Chand& Co, New Delhi.
16. Faulks, P.J.1958.An introduction to Ethnobotany, Moredale pub. Ltd.
17. Glossary of Indian medicinal plants, R.N.Chopra, S.L.Nayar and I.C.Chopra, 1956. C.S.I.R, NewDelhi.
18. Hardin, J., Becker, G., Skliensmith, L.J. (2012). Becker's World of the Cell, PearsonEducation Inc. U.S.A. 8th edition.
19. Herbal plants and Drugs Agnes Arber, 1999. Mangal Deep Publications.

20. Jeffrey, C. (1982). An Introduction to *Plant Taxonomy.* Cambridge University Press,Cambridge.
21. John Jothi Prakash, E. 2004. Outlines of Plant Biotechnology. Emkay Publication, New Delhi.
22. Judd, W.S., Campbell, C.S., Kellogg, E.A., Stevens, P.F. (2002). Plant Systematics-APhylogenetic Approach. Sinauer Associates Inc., U.S.A. 2nd edition.
23. Kader, A.A. (2002). Post-Harvest Technology of Horticultural Crops. UCANR Publications,USA.
24. Karp, G. (2010). Cell Biology, John Wiley & Sons, U.S.A. 6*edition.
25. Kochhar, S.L. (2012). Economic Botany in Tropics, MacMillan & Co. New Delhi, India.
26. Kochhar, S.L. (2012). Economic Botany in Tropics, MacMillan & Co. New Delhi, India.
27. Krishnamurthy, K.V. (2004). An Advanced Text Book of Biodiversity - Principles and Practices.
28. Kumar, H.D. (1999). Introductory Phycology. Affiliated East-West Press, Delhi.
29. Kumaresan, V. 2005, Biotechnology, Saras Publications, New Delhi.
30. Lee, R.E. (2008). Phycology, Cambridge University Press, Cambridge. 4th edition.
31. Lone et al,.Palaeoethnobotany
32. Maheshwari, J.K. (1963). *Flora* of Delhi. CSIR, New Delhi.
33. Nelson DL and Cox MM (2008) Lehninger Principles of Biochemistry, 5th Edition., W.H.Freeman and Company.
34. NIIR Board (2005). Cultivation of Fruits, Vegetables and Floriculture. National Institute ofIndustrial Research Board, Delhi.
35. Oxford and IBH Publications Co. Pvt. Ltd. New Delhi
36. Parihar, N.S. (1991). An introduction to Embryophyta: Vol. I. Bryophyta. Central Book Depot.Allahabad.
37. Pelczar, M.J. (2001). Microbiology, 5th edition, Tata McGraw-Hill Co, New Delhi.
38. Pharmacognosy, Dr.C.K.Kokate et al. 1999. Nirali Prakashan.
39. Principles of Ayurveda, Anne Green, 2000. Thomsons, London.
40. Radford, A.E. (1986). Fundamentals of *Plant Systematics.* Harper and Row, New York.
41. Rama Ro, N and A.N. Henry (1996). The Ethnobotany of Eastern Ghats in AndhraPradesh, India.Botanical Survey of India. Howrah. 8) Rajiv K. Sinha - Ethnobotany The
42. Raven, P.H., Johnson, G.B., Losos, J.B., Singer, S.R. (2005). Biology. Tata McGraw Hill, Delhi.
43. Renaissance of Traditional Herbal Medicine -INA -SHREE Publishers, Jaipur-1996
44. S.K. Jain (ed.) 1989. Methods and approaches in ethnobotany. Society of ethnobotanists,Lucknow, India.
45. S.K. Jain (ed.) Glimpses of Indian. Ethnobotny, Oxford and I B H, New Delhi-1981

46. S.K. Jain, 1990. Contributions of Indian ethnobotny.Scientific publishers, Jodhpur.
47. S.K. Jain, Manual of Ethnobotany, Scientific Publishers, Jodhpur, 1995.
48. Sahoo, D. (2000). Farming the ocean: seaweeds cultivation and utilization. Aravali International, NewDelhi.
49. Sathe, T.V. 2004 Vermiculture and Organic Farming. Daya publishers.
50. Sethi, I.K. and Walia, S.K. (2011). Text book of Fungi and Their Allies, Macmillan PublishersIndia Ltd.
51. Singh, (2012). *Plant Systematics:* Theory and Practice Oxford & IBH Pvt. Ltd., New Delhi.3rdedition.
52. Singh, D. & Manivannan, S. (2009). Genetic Resources of Horticultural Crops. RidhiInternational, Delhi, India.
53. Subha Rao, N.S. 2000, Soil Microbiology, Oxford & IBH Publishers, New Delhi.
54. Swaminathan, M.S. and Kochhar, S.L. (2007). Groves of Beauty and Plenty: An Atlas ofMajor Flowering Trees in India. Macmillan Publishers, India.
55. The indigenous drugs of India, Kanny, Lall, Dey and Raj Bahadur, 1984. International BookDistributors.
56. Tymoczko JL, Berg JM and Stryer L (2012) Biochemistry: A short course, 2nd ed.,W.H.Freeman
57. Vanderpoorten, A. & Goffinet, B. (2009) Introduction to Bryophytes. Cambridge University
58. Vashistha, P.C., Sinha, A.K., Kumar, A. (2010). Pteridophyta. S. Chand. Delhi, India.
59. Vayas,S.C, Vayas, S. and Modi, H.A. 1998 Bio-fertilizers and organic Farming Akta Prakashan,Nadiad
60. Webster, J. and Weber, R. (2007). Introduction to Fungi, Cambridge University Press,Cambridge. 3rd edition.
61. Wickens, G.E. (2001). Economic Botany: Principles & Practices. Kluwer Academic Publishers,The Netherlands.
62. Wickens, G.E. (2001). Economic Botany: Principles & Practices. Kluwer Academic Publishers,The Netherlands.
63. Wiley JM, Sherwood LM and Woolverton CJ. (2013). Prescott's Microbiology. 9th Edition. McGrawHill International.

SEMESTER-III

Major: (BOTN 3011) Microbiology

Credit:5 **Marks-40**

Course Objective:

To gain knowledge of diversity, life forms, life cycles, morphology and importance of microorganisms (Virus & Bacteria) and basic concept of Immunology.

Course Outcomes: Students will learn the structure, function of microbial cell and acquire knowledge about the microbial growth, nutrition, classification and their economic importance. They will also know the structural organization of virus, viroid, prion. Students will know the basic concept of Immunology.

Theory

Unit 1: Viruses

Discovery, physiochemical and biological characteristics; organization and structure of capsid, viral genome- type and structure; classification of virus (Baltimore, 1975); viroids and prions.

(9 lectures)

Unit 2: Ultrastructure of prokaryotic cell:- Cell wall and cell membrane of bacteria and archaea; glycocalyx, pili, and flagella. Bacterial chromosome, plasmid types and episome. Reserve material and other cytoplasmic inclusions; Endospore – structure, formation and germination. **(9 lectures)**

Unit 3: Bacterial taxonomy: Classical Taxonomy and Molecular Taxonomy, Modern concept of bacterial taxonomy specifically 16 S rDNA-based sequence homology and its importance in bacterial taxonomy. Bergey's Manual of Systemic Bacteriology; 2nd Ed. Characteristic features of Archaea and Bacteria

(9 lectures)

Unit 4: Bacterial growth and nutrition: - Growth curve, growth factor, growth Kinetics; batch and continuous culture; Microbial growth control by disinfectant, antiseptic and chemotherapeutic agents – a brief account of their types and mode of action. Brief idea about Autotrophy and heterotrophy. **(9 lectures)**

Unit 5: Microbes in N_2Cycle:-Nitrification, Denitrification, Mechanism of biological N_2 fixation. **(8 lectures)**

Unit 6: Applied Microbiology: Application of microbes in agriculture (biofertilizer, biocontroling agents), Industry (fermentation and Food), environment bioremediation) and medicine (sources of antibiotics) **(8 lectures)**

Unit 7: Basic immunology: Innate and acquired immunity; T-cell, B-cell; Antigen (Ag), hapten, and Antibody (Ab); Cell mediated and Humoral Immunity, vaccine. **(8 lectures)**

Practical (20 marks)

1. Aseptic method

a) Sterilization technique by Autoclaving, Hot air oven and surface sterilization.

b) Preparation of standard bacteriological medium (Nutrient agar, Nutrient broth and Glucose - peptone medium).

c) Preparation of slant and plates.

d) Subculturing of pure bacteriological culture.

e) Pure culture technique: dilution streak method.

2. Simple staining; differential staining: Gram staining.

3. Microscopic examination of bacteria from natural habitats: curd and root nodules of leguminous plants.

Suggested Readings

1.Pelczar, M. J., Reid, R. D. & Chan, E. C. (1993). *Microbiology,* 5th ed. Macmillan. London.

2. Pinehuk, G. (2003). *Schaum's outline Series: Theory and Problems of Immunology*. McGrawHill.

3.Presscott, L. M., Harley, J. P. & Klein, D. A. (1999). *Microbiology*, McGrawHill, New York.

4.Schlegel, H. G. (1993). *General Microbiology* .7th ed. Cambridge University Press.

5.Slonczeweski, J.L. & Foster, J.W. *Microbiology- An Evolving Science.*Norton.

6.Stanier, R. Y., Adelberg, E. A. & Ingraham, J. L. (1986).*General Microbiology.*5th ed. Macmillan.

7.Talaro, K. &Talaro, A. (1999). *Foundations in Microbiology*. Dubuque, McGraw Hill.

8.Tortora, G. J., Funke, B. R., & Case. C. L. *Microbiology.An Introduction*. 6th ed. Benjamin/Cummings Publishing. Menlo Park Calif.

9.Atlas, R. M. (1984). *Microbiology, Fundamentals and Applications*. Macmillan.

10.Black, J. G. (2001). *Microbiology: Principles and Explorations, 5th ed*. John Wiley & Sons, New York.

11.Khan F. H. (2009) *The Elements of Immunology.* Pearson.

12.Kindt, T., Goldsby, R. Osborne, B. (2007).*Kuby Immunology*.6th ed. W.H. Freeman & Co.

13. A.K.Banerjee and N Banerjee (2006) Fundamentals of Microbiology and Immunology

Major: (BOTN 3012) Archegoniate

Credit:5 **Marks-40**

Course Objective:

This course aims at making a familiarity with special groups of plants joined together by a common feature of sexual reproduction involving Archegonia. Creating an understanding by observation and table study of representative members of phylogenetically important groups should be able to make students learn the process of evolution in a broad sense. Study of morphology, anatomy, reproduction and developmental changes therein through typological study should create a knowledge base in understanding plant diversity, economic values, taxonomy of lower group of plants.

Course Outcomes:

The students will be made aware of the group of plants that have given rise to land habit and the flowering plants. Through field study they will be able to see these plants grow in nature and become familiar with the biodiversity. to my knowledge students should create their small digital reports where they can capture the zoomed in and zoomed out pictures as well as videos in case, they are able to find some rare structure or phenomenon related to these plant

Theory

Unit 1: Introduction

Unifying features of Archegoniate; Transition and adaptation to land habit; Alternation of generations. **(4 lectures)**

Unit 2: Bryophytes

General characteristics & Classification [up toclass] of Stotler and Stotler (2000); Adaptations to land habit, Diversification of gametophytes and sporophytes. **(6 lectures)**

Unit 3: Type Studies- Bryophytes

Origin and evolution of Bryophytes, Morphology, anatomy, reproduction and evolutionary trends in *Riccia*, *Pellia*, *Porella*, *Sphagnum*, *Pogonatum* (developmental stages not included). Economic importance of bryophytes (a brief account). **(12 lectures)**

Unit 4: Pteridophytes

General characteristics & Classification [up toclass] of Smith (2006) Origin and evolution of Pteridophytes; Telome theory; General characteristics; early land plants (*Cooksonia*, *Rhynia*, *Lepidodendron*, *Lepidocarpon*). **(6 lectures)**

Unit 5: Type Studies- Pteridophytes

Morphology, anatomy and reproduction of *Lycopodium, Adiantum, Azolla*(Developmental details not to be included). Apogamy, and apospory, heterospory and seed habit; stelar evolution; Ecological and economic importance. **(14 lectures)**

Unit 6: Gymnosperms

General characteristics, Origin and evolution of Gymnosperms; classification Stewart and Rothwell, 1985(up to class),Brief idea about Progymnospermopsida. **(08 lectures)**

Unit 7: Type Studies-Gymnosperms

Morphology, anatomy and reproduction of *Lyginopteris*, *Pinus*, and *Ephedra* (Developmental details not to be included); Ecological importance.**(10 lectures)**

Practical: (20 marks)

1. *Riccia, Marchantia, Anthoceros*-Anatomical study of sporophyte.

2. Morpho-anatomical study of *Lycopodium, Adiantum*.

3. Morpho-anatomical study of *Pinus*, *Ephedra.*

4. Study of fossil slides of *Lepidodendron, Lyginopterisoldhamia.*

Suggested readings

1. Vashistha, P.C., Sinha, A.K., Kumar, A. (2010). Pteridophyta. S. Chand. Delhi, India.

2. Bhatnagar, S.P. & Moitra, A. (1996). Gymnosperms. New Age International (P) Ltd Publishers, New Delhi, India.

3. Parihar, N.S. (1991). An introduction to Embryophyta: Vol. I. Bryophyta. Central Book Depot. Allahabad.

4. Raven, P.H., Johnson, G.B., Losos, J.B., Singer, S.R. (2005). Biology. Tata McGraw Hill, Delhi.

5. Vanderpoorten, A. & Goffinet, B. (2009) Introduction to Bryophytes. Cambridge University

Multi/Interdisciplinary course: (BOTN 3031) Plant Biotechnology

Credit:3 Marks-40

Course Objective: The objective of the course is to give students new knowledge on plant biotechnology processes, including tissue culture. To make students understand about basic biotechnological processes such as recombinant DNA technology and their applications.

Learning Outcomes: The successful students will be able to: Learn the basic concepts, principles and processes in plant biotechnology. Have the ability of explanation of concepts, principles and usage of the acquired knowledge in biotechnological applications.

Theory

Unit 1: Plant Tissue Culture: Historical perspective, Composition of MS medium; Plasticity and Totipotency; Organogenesis, Embryogenesis.**(12 lectures)**

Unit 2: Protoplast culture; application of plant tissue culture (micropropagation, virus elimination, secondary metabolite production, cybrids; Cryopreservation; Germplasm Conservation).

(14 lectures)

Unit 3: Recombinant DNA technology: Basic concepts of tools of recombinant DNA technology, Restriction Endonucleases, Cloning Vectors. Ti plasmid, BAC, Eukaryotic Vectors (YAC).

(12 lectures)

Unit 4: Gene cloning: Basic concept of gene Cloning; Gene Construct; Methods of gene transfer-(*Agrobacterium*-mediated). **(12 lectures)**

Unit 5: Transgenics: Basic concept and Examples.**(7 lectures)**

Unit 6: Applications of Biotechnology: Short account. **(03 lectures)**

Suggested Readings.

1. Introduction to Plant Biotechnology- (2002) H.S. Chawla. Oxford and IBH Publication.
2. Plant Biotechnology – A Text Book. (2022) S.N. Paul Khurana and Narendra Kumar. Scientific Publisher.
3. Plant Biotechnology (2010)– P.K.Gupta. Rastogi Publication.

Skill Enhancement Course: (BOTN 3051) Medicinal Botany

Credit:3 **Marks-40**

Course Objective

To impart knowledge on plant chemical resources that may be explored in complementary herbal and alternative medicine. Also to provide an opportunity to explore uses of plants as medicine based on traditional indigenous knowledge and their application in modern pharmaceutical industries.

Course Outcomes:

The course will help in skill development related to the contribution of medicinal plants to traditional and modern medicine. The importance of holistic mode of treatment of the Indian traditional systems of medicine will be easier. It will also help in developing entrepreneurship skills to establish value addition products, botanical.

Theory:

Unit 1: Medicinal plants in the traditional systems of medicine and modern medicine. Concept on the Indian traditional systems of medicine. (**8lectures)**

Unit 2:Ayurveda& its fundamental doctrine, Important plants used in the Ayurveda system of medicine. Brief idea of Rasayanadrugs.**(7lectures)**

Unit 3:Siddha& its concepts, therapeutic and pharmaceutical uses of important plants used in Siddha system of medicine; **(7 lectures)**

Unit 4:Unani: Concept of Umoor-e-Tabiya(Fundamentals of Physique), therapeutic and pharmaceutical uses of plants used in Unani system of medicine. (**8 lectures)**

Unit 5: Nutraceuticals and polyherbal formulations. Plants used for the treatment of hepatic disorders, cardiac diseases,infertility, diabetes, blood pressure, cancer and skin diseases.**(8 lectures)**

Unit 6:Role of AYUSH, NMPB in the promotion of medicinal plants. **(4 lectures)**

Unit 7:Fundamentals of Pharmacognosy. Organoleptic, microscopic and phytochemical evaluation of plant drugs. **(8 lectures)**

Unit 8:Conservation of Endangered and Endemic Medicinal plants. Brief idea oncategories of Red Listed plants. *In situ* and *ex situ* Conservation. **(6 lectures)**

Suggested Readings.

1. Trivedi P C, 2006. Medicinal Plants: Ethnobotanical Approach, Agrobios, India.

2. Purohit and Vyas, 2008. Medicinal Plant Cultivation: A Scientific Approach, 2nd edn. Agrobios, India.

SEMESTER-IV

Major: (BOTN 4011) Phycology

Credit:5 **Marks-40**

Course Objective:

To gain knowledge of diversity, life forms, life cycles, morphology and importance of algae

Course Outcomes: Students would have understood the classification, characteristic features, cell structure and growth and reproduction in various groups of marine and fresh water algae and their ecological and economic importance

Theory

Unit 1: Algae

Definition and position of algae in plant kingdom, Basic criteria of classification of algae, Range of thallus organization; Cell structure and components; cell wall, pigment system, reserve food (of only groups represented in the syllabus), flagella; Life cycle patterns, methods of reproduction; general concept of endosymbiosis, classification of Lee (2018); contributions of F.E. Fritsch & M.O.P. Iyengar; Role of algae in the environment, agriculture, biotechnology, food and industry. **(6 lectures)**

Unit 2: Cyanophyta and Xanthophyta

Ecology and occurrence; Cell structure; Heterocyst structure & function; Reproduction, Genetic recombination (in Cyanophyta); Morphology and life-cycle of *Oscillatoria, Anabaena, Scytonema, Vaucheria*. **(6 lectures)**

Unit 3: Chlorophyta and Charophyta

General characteristics; Occurrence; Cell structure. Life-cycles of *Volvox*, *Oedogonium*, *Coleochaete*and *Chara*.

Bacillariophyceae- Cell structure, Reproduction with special emphasis on auxospore formation, ecology and economic significance.**(8 lectures)**

Unit 4: Phaeophyta

General characteristics and occurrence; thallus structure and tissue organization, Cell structure; Reproduction, life-cycles of *Ectocarpus* and *Fucus*; economic and ecological significance. **(5 lectures)**

Unit 5: Rhodophyta:

Characteristic; Cell structure, reproduction including post-fertilization changes, ecology and economic significance: Lifecycle pattern of *Batrachospermum*.

(5 lectures)

Practical (20 marks)

1. Workout and identification of vegetative and reproductive structures of *Oscillatoria*, *Scytonema, Rivularia, Gloeotrichia, Zygnema, Oedogonium*, *Cladophora*, *Chara*, *Vaucheria,Ectocarpus*and *Batrachospermum.*

2. Identification of all the genera included in the theoretical syllabus from Permanent slides (vegetative and reproductive structures).

Suggested Readings.

1. Phycology by Robert Edward Lee, 5th Edition
2. Algae by James E. Graham, Linda E. Graham, Lee W. Wilcox, M.E. Cook, 3rd Edition
3. Freshwater Algae: Identification, Enumeration and Use as Bioindicators by Edward G. Bellinger, David C. Sigee, 2nd Edition
4. Algae: Anatomy, Biochemistry, and Biotechnology, By Laura Barsanti, Paolo Gualtieri, 2nd Edition.
5. The Algae World, by Dinabandhu Sahoo and Joseph Seckbach.

6. A beginner's guide to freshwater algae, by Hilary Belcher, Erica Swale.
7. Freshwater Algae of North America, by John Wehr Robert Sheath, J. Patrick Kociolek, 2nd Edition.
8. Kumar, H.D. (1999). Introductory Phycology. Affiliated East-West Press, Delhi.
9. Sahoo, D. (2000). Farming the ocean: seaweeds cultivation and utilization. Aravali International, New Delhi.
10. Campbell, N.A., Reece J.B., Urry L.A., Cain M.L., Wasserman S.A. Minorsky P.V., Jackson R.B. (2008). Biology, Pearson Benjamin Cummings, USA. 8th edition.

Major: (BOTN 4012) Mycology

Credit:5 **Marks-40**

Course Objective: To introduce students with various fungal groups, their ecology, classification, characteristics, reproduction and economic Importance 2. To introduce students with the phytopathology, its concepts and principles 3. To acquaint with various plant diseases, causal organisms and their control

Course Outcomes: Upon completion of this course, the students will be able to: 1. Understand the world of fungi, lichens and pathogens of plants 2. Understand the characteristics of the fungi and lichens 3. Understand the ecological and economic significance of lichen 4. Understand the significance and applications of mycology in various fields of live hood. 6. Identification of common plant diseases and their control measures

Theory

Unit 1: Introduction

General characteristics; Affinities with plants and animals; Thallus organization; Cell wall composition; Nutrition; Classification of Alexopoulos & Mims, 1979 (up to order), symbiotic association, Lichen, Mycorrhizae-basic concept and their significance. **(6 lectures)**

Unit 2: Chytridiomycota and Zygomycota

Characteristic features; Thallus organization; Life cycle of *Synchytrium*. **(5 lecture)**

Unit 3: Ascomycota

General characteristics, sexual reproduction and development of ascus and ascospores, types of ascocarps; Phenomenon of heterokaryosis and parasexuality in asexual members; Life cycle of *Talaromyces, Ascobolus, Aspergillus*. **(8 lecture)**

Unit 4: Basidiomycota

General characteristics; Phenomenon of dikaryotization, development of basidia and basidiospores and basidiocarps, Life cycles of *Polyporus* sp., *Puccinia* sp., and*Ustilago*sp.; Bioluminescent fungi, Fairy Rings and Mushroom Cultivation (brief idea). **(6 lecture)**

Unit 5: Deuteromycota

General characteristics, asexual reproduction, fruiting structures, studies on the genera *Fusarium* and *Alternaria*. **(4 lecture)**

Unit 6: Allied Fungi

General characteristics; Status of Slime molds, Occurrence; Types of plasmodia. **(2 lecture)**

Unit 6: Oomycota

General characteristics; Life cycle of *Phytophthora* and *Albugo.***(3 lecture)**

Unit 8: Applied Mycology

Role of fungi in biotechnology; Application of fungi in food, flavor, and leather industry, Fermentation, Organic acids, Enzymes, Mycoproteins; Secondary metabolites, pharmaceutical preparations with reference to penicillin; Agriculture (Biofertilizers); Biological control and overview of biocontrol agents. **(10 lecture)**

Practical (20 marks)

1. Study of the following genera and their identification: *Rhizopus, Penicillium, Alterneria, Ascobolus, Agaricus* and *Polyporus.*

2. Identification of all the macroscopic and microscopic genera included in the theoretical syllabus.

Suggested Readings:

1. Introduction to Fungi- John Webster and Roland W.S. Weber
2.Introductory Mycology -Alexopoulos C.J., C.W. Mims and M. Blackwell
3.The Mycota- Esser, K. and Bennet J. W. (Eds.)
4.An Introduction to Mycology - Mehrotra, R.S. and Aneja, K.R.
5.Fundamentals of Mycology -Burnett, J. H.
6.Chemical fungal taxonomy -Frisvad, J.C. Bridge, P.D. and Arora, D.K.
7.The Filamentous Fungi - Smith, J.E.
8.Fungal Nutrition and Physiology - Garraway, M. O. and Evans, R. C.
9.Mushroom Biology - Miles, P.G. and Chang, S.T.
10.Mycorrhizae Verma - A. and Hock, B.
11.Industrial Mycology -Berry, R.

Major: (BOTN 4013) Plant Pathology

Credit:5 **Marks-40**

Course Objective:

To introduce students with the phytopathology, its concepts and principles and also to acquaint with various plant diseases, causal organisms and their control measures.

Course Outcomes:

Upon completion of this course, the students will be able to understand the basic principles for identification of common plant diseases and their control measures. Also to understand the economic and pathological importance of pathogenic microorganisms.

Theory

Unit 1: Plant pathology: A brief history of plant pathology in India and losses caused by pathogens and pests; Types of pathogens, signs and symptoms, symptoms of different plant diseases. Inoculum potential, survival and longevity of inoculum, inoculum production, plant quarantine, Koch's postulates. **(12 lecture)**

Unit 2: Plant microbe interaction: molecular basis of host recognition, entry, pre-penetration, penetration and post penetration events, pathogenesis; Dissemination of pathogens: Means of dissemination (active and passive dissemination).**(12 lecture):**

Unit 3: Host parasite interaction: Concept of compatibility and specificity, gene for gene hypothesis, genetics of resistance- vertical and horizontal resistance, source of resistance. Enzymes and toxins- a brief idea on their role in pathogenesis. **(12 lecture):**

Unit 4: Disease resistance: (i) Plant defense (structural and biochemical defense), with special reference to polyphenols and phytoalexins. Genetic resistance: biotechnological approaches for transfer of R- genes into susceptible plants. General idea on seed borne pathogens, market disease of fruits and vegetables. Disease control: Cultural practices, physical control, chemical control and biological control.**(12 lecture)**

Unit 5: Brief account, structure, importance, disease cycle and control of the following: black rust of wheat, loose smut of wheat, white rust of *Amaranthus*, early blight and late blight of potato, brown spot of rice, powdery mildew of cucurbits. **(12 lecture):**

Practical (20 marks)

1. Identification of diseases prescribed in the theoretical syllabus.
2. Workout of the following diseases: Late blight of potato, White rust of *Amaranthus*, Rust of wheat/*Justicia,* loose smut of wheat, powdery mildew of cucurbits, shot hole of *Basella*.
3. Study of herbarium and museum specimens of bacterial, fungal, and viral diseases-(Citrus Canker,bacterial blight of rice, Fusarial wilt of tomato, tikka disease of ground nut, loose and cover smut of wheat, TMV, Vein clearing of legumes.
4. Mycorrhizae-Ecto and Endo mycorrhizae (photographs only)

Suggested Readings:

1.Plant Pathology - Agrios, G.N.
2.Plant Pathology -Mehrotra, R.S.
3.Annual Review of Phytopathology - APS Press
4.Biotechnology in Plant Disease Control-Cheet,I.
5.Postinfectional defense mechanisms - Mahadevan, A.
6.Pathogenesis and host specificity in plant diseases. Vol. III.-Rudra P. Singh, Uma S. Singh
7.Keiisuke Kohmoto (eds.) 1995.
8.The nature of disease in plants - Scheffer, R.P.
9.Principles of Plant Pathology -Tarr, S.A.J .

Minor: (BOTN 4021) Plant Physiology & Metabolism

Credit:4 **Marks-40**

Course Objective: The course aims impart knowledge on how plants function and interact with environment, namely the importance of water, minerals, hormones, and light in plant growth and development; understand transport mechanisms and translocation in the phloem, and appreciate the commercial applications of plant physiology.

Course Outcomes The students will be able to correlate structure-function relationship that govern plant life processes. The chemical basis of life processes that regulate system biology of plants will also be understandable. The link between theory and practical syllabus is established, and the employability of youth would be enhanced. The youth can also begin small-scale enterprises.

Theory

Unit 1: **Photophysiology:** Basic photoprocesses; Photosynthesis & chemistry of light trapping mechanisms, Photophoshorylation; chemistry of CO_2 fixation(brief accounts of C3& C4 pathways and their significance); C_2 pathway and its significance; Basic concept of photomorphohenesis, plant photorecepts, red & blue light responsive photoprocesses- General concept.**(16 lecture):**

Unit 2:Plant-water relations: Concept of water potential, Mechanism of ascent of sap, transpiration; Phloem translocation, Composition of phloem sap, Pressure Flow Model, phloem loading and unloading. **(06 lectures)**

Unit 3: Mineral nutrition: Criteria of essentiality of elements, Role of essential elements, transport of ions across membrane, active and passive transport, carriers, channels and pumps. **(08 lecture):**

Unit 4:Respiration: Chemistry of glycolysis, anaerobic respiration, TCA cycle, ETS, oxidative phosphorylation, RQ.**(04 lecture):**

Unit 5:Enzymes: Basic structure, properties, chemical order of enzyme catalyzed reactions; Classification(IUBMB),Km (no derivation), Basic mechanism of enzyme catalysis and enzyme inhibition. **(04 lecture):**

Unit 6: Hormones & Plant growth regulators: Basic concept of PGR & hormone; Discovery, physiological roles of auxins, gibberellins, CK, ABA and ethylene.**(06 lecture):**

Unit 7: Photoperiodism & Flowering – Concept of photoperiodism, SDP, LDP, day neutral plants; Basic concept of flowering biology & chemistry of floral signal. **(10 lecture):**

Practical(20marks)

1. To demonstrate of Photolysis of water during photosynthesis.
2. To demonstrate of plasmolysis of plant cell
3. To demonstrate the activity of a plant enzyme (catalase/amylase)
4. To study the effect of CO2 concentration on photosynthetic rate.
5. To determine the rate of respiration of any one plant part (vegetative/reproductive)
6. To compare the stomatal frequency of a mesophyte and a xerophyte.
7. To prepare a standard solution of sucrose and grades of lower solution from it by dilution method.
8. To prepare Phosphate buffer (0.5M,pH6.5)

References

1. Hopkins, W. G., Huner, N. P. A. (2009). Introduction to Plant Physiology, 4th edition. New Delhi, Delhi: Wiley India Pvt. Ltd.

2. Kochhar, S.L., Gujral, S.K. (2017). Plant Physiology: Theory and Applications. New Delhi, Delhi: Foundation Books, imprint of Cambridge University Press India Pvt, Ltd.

3. Taiz, L., 3. Zeiger, E., Moller, I. M., Murphy, A. (2018). Plant Physiology and Development International, 6th edition. New York, NY: Oxford University Press,Sinauer Associates.

4. S. Bajracharya, D. (1999). Experiments in Plant Physiology: A Laboratory Manual. New Delhi, Delhi: Narosa Publishing House

SEM-V Botany

MAJOR/ DS COURSE (CORE)
Course code: BOTN 5011
Name of the course: MORPHOLOGY AND ANATOMY
Full Credit: 5 (Lecture: 4, Practical: 1)
Full Marks: 75 (Theory: 40; Practical: 20; Internal Assessment: 15)

Course objectives:

To understand the basics of plant parts like leaf, stem, flowers, fruits etc., along with plant tissue structures, plant growth, organization of the plant body and adaptive significance of the morpho-anatomy of plant parts.

Course outcomes:

On completion of the course, the students will be able to: understand different morpho-parts of plant and their functions; understand vegetative and reproductive morphology of angiosperms; describethe reproductive processes involved in the life cycle of angiosperms; use the concept of reproductive biology in the field of agriculture; understand the structure and functions of various plant tissues; organization of root, stem, leaf etc. and their growth pattern; realize the developmental pathways resulting in the differentiation of plant body; finally, students will realize how different forms of angiosperms are there in nature and how they are thriving in different environmental conditions.

MORPHOLOGY

Unit 1: Introduction to root and stem, and their modifications. (5 lectures)

Unit 2: Leaves (7lectures)

Types; phyllotaxy; venation; leaf shape, apex, margin and tip; modifications of leaves.

Unit 3: Inflorescence (5lectures)

Concept of inflorescence and synflorescence; types; evolution.

Unit 4:Flower (9 lectures)

The flower as a modified shoot; merosity and symmetry of flowers; modification of different floral parts; calyx, corolla, androecium and gynoecium types (adhesion and cohesion and their evolutionary significance); aestivation; placentation and its evolution; floral formulae and floral diagram in different major clades of angiosperms.

Unit 5:Fruit and Seeds (4lectures)

Fruit and seed diversity and their dispersal mechanisms.

ANATOMY

Unit 1: Introduction to diversity of plant forms (6lectures)

Historical perspective, methods/tools and techniques (fixation, sectioning, macerations); terms for describing plant cells; basic plant growth-meristems and cell differentiation; Primary and Secondary plant body (introduce terms); Classification of tissues; Simple and complex tissues, Vascular system.

Unit 2: Tissue organisation in stem, root and leaf (7lectures)

Organization of shoot apex -Apical cell theory, Tunica Corpus theory, Cyto-Histological Zonation Theory; Types of vascular bundles; Structure of dicot and monocot stem; Shoot Chimeras (concept only). Organisation of root apex -Apical cell theory, Korper- Kappe theory; Structure of dicot and monocot root. Dermal tissue system, cuticles and special epidermal cells - cuticle; epi-cuticular waxes, appendages; stomata types, structure of dicot and monocot leaf.

Unit 3: Vascular Cambium (7lectures)

Structure (axially and radially oriented elements); function and seasonal activity of cambium; Secondary growth in stem, cambial variants in anomalous secondarythickening stem.

Unit 4: Wood and Periderm (5lectures)

Basic structure of secondary wood; types of rays and axial parenchyma; sapwood and heartwood; ring and diffuse porous wood; early and late wood, tyloses; wall ingrowths and transfer cells; ergastic substances; development and composition of periderm; rhytidome and lenticels.

Unit 5: Adaptive and Defensive Systems (5lectures)

Anatomical adaptation of halophytes, xerophytes and hydrophytes

Practical

(30 hours)

1. Study epidermal system: cell types, stomata types; trichomes: non-glandular and glandular through temporary whole mounts/peels.
2. Study of morphological peculiarities from the families: Arecaceae, Apiaceae, Orchidaceae, Poaceae, Magnoliaceae, Apocynaceae, Brassicaceae, Malvaceae, Cucurbitaceae, Euphorbiaceae, Asteraceae, Lamiaceae (from live specimens as well as digital images).
3. Study the types and features of wood: ring porous; diffuse porous; heartwood and sapwood through specimens and permanent slides.

4. Prepare permanent slides with double staining to study organisation of dicot-primary and secondary growth and anomalous secondary growth (*Bignonia*, *Dracaena, Boerhavia, Nyctanthes,Tecoma*).
5. Study the adaptive anatomy in halophytes (from permanent slide) xerophytes and hydrophytes through permanent slide preparation.
6. Study the secretory tissues: cavities, lithocysts and laticifers through permanent slides / digital resources.
7. Submission of permanent slides and lab copy.

Suggested Reading:

1. Harris, J. and Harris, M. (2001) Plant Identification terminology: An illustrated glossary. Spring Lake Publication, Payson.
2. Radford, A. E. (1974). Vascular plant systematics. Harper & Row Publishers, New York, London.
3. Takhtajan, A. (1991). Evolutionary Trends in Flowering Plants-Columbia University Press
4. Beck, C.B. (2010). Plant Structure and Development. Second edition. Cambridge University Press, Cambridge, UK, New York, USA.
5. Dickison, W.C. (2000). Integrative Plant Anatomy. Harcourt Academic Press, USA.
6. Esau, K. (1977). Anatomy of Seed Plants. John Wiley & Sons, Inc., Delhi.
7. Fahn, A. (1974). Plant Anatomy. Pergmon Press, USA.
8. Mauseth, J.D. (1988). Plant Anatomy. The Benjammin/Cummings Publisher, USA.
9. Bahadur, B. Rajam, M.V., Sahijram, L., Krishnamurthy, K.V. (2015). Plant Biology and Biotechnology. Volume 1: Plant Diversity, Organization, Function and Improvement.
10. Crang, R., Lyons-Sobaski, S., Wise, R. (2018) Plant Anatomy: A Concept-Based Approach to the Structure of Seed Plants 1st ed. Springer
11. Cutler, D.F., Botha, T., Stevenson, D.W. (2007). Plant Anatomy - An Applied Aspect. Blackwell Publishing, USA
12. Evert, R.F. (2017) Esau's Plant Anatomy; Meristems, Cells and Tissues OfThe Plant Body-Their Structure, Function And Development. 3rd Edn Wiley India.
13. Moza M. K., Bhatnagar A.K. (2007). Plant reproductive biology studies crucial for conservation. Current Science 92:1907.
14. Shivanna, K.R., Tandon, R. (2014). Reproductive Ecology of Flowering Plants: A Manual. Springer (India) Pvt. Ltd. New Delhi, Heidelberg, New York, Dordrecht, London.

MAJOR/ DS COURSE (CORE)

Course Code: BOTN 5012

Name of theCourse: GENETICS AND PLANT BREEDING

Full Credit: 5 (Lecture: 4, Practical: 1)

Full Marks: 75 (Theory: 40; Practical: 20; Internal Assessment: 15)

Course objectives:

To develop comprehensive knowledge on principles of inheritance, chromosome structure, gene function and fundamental concepts on various aspects of plant breeding

Course Outcomes:

After the successful completion of the course, the student will be able to acquire fundamental knowledge on principles of inheritance, chromosome structure, gene function and fundamentals of plant breeding.

Unit 1:Mendelian genetics: (14lectures)

Principles of inheritance**,**History and concept of inheritance, chromosomal theory of inheritance, autosomes and sex chromosomes, and probability pedigree analysis (autosomal and sex linked traits); autonomous and sex-linked traits; non-Mendelian genetics –Allelic (incomplete and co – dominance) and non- allelic gene interactions (complementary, supplementary, dominant and recessive epistasis), lethal gene interaction, multiple alleles, pleiotropy, polygenic inheritance.

Unit 2: Linkage, crossing over and chromosome mapping: (7lectures)

Concept of linkage and crossing over, cytological basis of crossing over including molecular mechanism (Holliday Model), recombination frequency, three factor crosses, interference and coincidence, linkage map, linkage map, sex - linked inheritance.

Unit 3:Variation in chromosome number and structure: (6lectures)

Structural changes of chromosomes - deletion, duplication, translocation and inversion with their meiotic behaviour and genetic consequences. Numerical changes of chromosomes – euploidy, aneuploidy and polyploidy and crop evolution.

Unit 4:Gene mutation: (7lectures)

Types, molecular basis of mutations; mutagens, - Physical and chemicals, (base analogs, deaminating, alkylating and intercalating agents); detection of mutations: ClBmethod, DNA repair systems.

Unit 5:Fine structure of gene: (5lectures)

Classical and molecular concept of genes, *Cis-tans* complementation test.

Unit 6:Extra chromosomal inheritance: (8lectures)
Concept of extra chromosomal inheritance, maternal effects, variegation in four o'clock plant.

Unit 7:Population and evolutionary genetics: (5lectures)
Allele frequencies, genotype frequencies, Hardy - Weinberg Law, role of natural selection, mutation and genetic drift.

Unit 8:Aims and methods of plant breeding: (8lectures)
Introduction, domestication, selection (pure line, mass selection, inbreed line selection), hybridization, heterosis and inbreeding depression, achievements of plant breeding.

Practical

(30 hours)

1. Testing of goodness of fit with Mendelian mono- and dihybrid ratios.
2. Numerical problems on gene interaction. (12:3:1, 9:3:4, 13:3, 9:7)
3. Numerical problems on Linkage Map construction.
4. Studies on determination of crossover frequencies (Meiotic cell division in *Allium cepa* flower bud by aceto carmine staining method).
5. Studies on effects of mutagens (methyl methane sulphonate/ ethyl methane sulphonate/ gamma ray)- Cytological study using *Allium cepa* root tip by acetoorcein staining method.
6. Pollen viability test from fresh material.
7. Studies on emasculation and plant hybridization methods.

Practical should be supported by practical record, slides/field report.

Suggested readings

1. D.P. Snustad and J. Simmons - 2009, Principles of Genetics, John Wiley and Sons Inc.
2. W. Johns and Kasp G - Introducing Genetics, John Murrey Pub.
3. W. S. Klug and M.R. Cummings - Concepts of Genetics. Prentice Hall Publishers.
4. Elrod S and Stansfield W. - Genetics, Tata McGraw Hilt.
5. P.K. Gupta - Cytogenetics. Rastogi Publication.
6. Tamarin R.H. – Principles of Genetics – Tata McGraw Hill.
7. Singh B. D, (2022) Plant Breeding Principles and methods.-12th Edition Med Tech Science Press.
8. Choudhury R.C. (2017): Introduction to Principles of Plant Breeding.-2nd Edition, Oxford and IBH publishing.

MAJOR/ DS COURSE (CORE)

Course code: BOTN5013
Name of the course: MOLECULAR BIOLOGY
Full Credit: 5 (Lecture: 4, Practical: 1)

Full Marks: 75 (Theory: 40; Practical: 20; Internal Assessment: 15)

Course objectives:

To gain comprehensive knowledge about of genetic material, central dogma, genetic code, DNA replication, transcription, modification of transcript, translation and regulation of gene expression.

Learning Outcomes:

At the end of this course the student will understand about DNA and RNA structure and function, nucleic acid as the carrier of genetic information, genetic code, DNA replication, regulation of transcription and translation, mechanism of regulation of gene expression in prokaryotes and eukaryotes.

Unit 1. (16lectures)

Structure and organisation of the genetic material: DNA double helix structure (Chargaff's rule; Watson and Crick model); salient features of DNA double helix. Types of DNA: A, B & Z conformations, denaturation and renaturation (only melting profile- Tm), Organization of DNA- prokaryotes and eukaryotes, mitochondria and chloroplast DNA, the nucleosome structure, euchromatin, heterochromatin- constitutive and facultative heterochromatin, types of RNA (mRNA, rRNA, tRNA, small RNAs). Split genes (Phillip Sharp)

Unit2. (13lectures)

Nucleic acids as carriers of genetic information: Discovery of nucleic acids, Experiments that established nucleic acids (DNA & RNA) as the carrier of genetic information: Griffith's, Hershey & Chase, Avery, McLeod & McCarty, and Fraenkel-Conrat's experiment.

Unit 3. (13lectures)

Central Dogma and Genetic Code: Beadle and Tatum's one gene one enzyme hypothesis; The Central Dogma, Genetic code and its salient features, Experiments for deciphering Genetic code (Experiments by Nirenberg &Matthaei, and Har Gobind Khorana). Adaptor hypothesis by Crick; Baltimore and Temin's discovery of reverse transcription.

Unit 4. (18lectures)

Structure and function of nucleic acids at molecular level; molecular details of DNA replication and its types; cellular processes of transcription, modification of transcripts - concept of introns and exons, removal of introns, spliceosome machinery, splicing pathways, alternative splicing, eukaryotic mRNA processing (5' cap, 3' polyA tail); Ribozymes,

translation - steps in protein synthesis - initiation, elongation and termination of polypeptides, inhibitors of protein synthesis; post-translational modifications of proteins. Mechanism of regulation of gene expression - Principles of transcriptional regulation; Prokaryotes: regulation of lactose metabolism and tryptophan synthesis *in E.coli,* gene silencing in eukaryotes.

Practical

(60 hours)

1. Isolation of plasmid and genomic DNA from E. coli and quantification using agarose gel electrophoresis

2. Isolation of genomic DNA from plant samples (atleast two different genera / species) using CTAB method and quantification using agarose gel electrophoresis

3. Quantification of unknown DNA by diphenylamine reagent (Spectrophotometry).

4. Quantification of unknown RNA by orcinol reagent (spectrophotometry)

5. Photographs establishing nucleic acid as genetic material (Messelson and Stahl's, Avery et al, Griffith's, Hershey & Chase's and Fraenkel and Conrat's experiments).

6. Study of DNA replication mechanisms through photographs (Rolling circle, Theta replication and semi-discontinuous replication).

7. Study of structures of prokaryotic RNA polymerase and eukaryotic RNA polymerase II through photographs.

Suggestive readings:

1. William S. Klug, Michael R. Cummings, Charlotte A. Spencer, Michael A. Palladino, & Darrell Killian (2019). Concepts of Genetics. Pearson; 12th edition.
2. 2. Watson J.D., Baker, T.A., Bell, S.P., Gann, A., Levine, M., Losick, R. (2007). Molecular Biology of the Gene, Pearson Benjamin Cummings, CSHL Press, New York, U.S.A. 6th edition.
3. Snustad, D.P. and Simmons, M.J. (2019). Principles of Genetics. John Wiley, 7th edition.
4. Russell, P. J. (2010). iGenetics- A Molecular Approach. Benjamin Cummings, U.S.A. 3rd edition.
5. Additional Resources: 1. Griffiths, A.J.F., John Doebley J., Peichel, C., Wassarman D.A. (2020). Introduction to Genetic Analysis. W H Freeman & Co; 12th edition
6. Micklos D A., Freyer G.A. (2003) DNA Science: A First Course (2nd Edition), Cold Spring Harbor Laboratory; Greg A., CSHL Press, USA

SEM-VI Botany

MAJOR/ DS COURSE (CORE)

Course code: BOTN 6011

Name of the course: PLANT PHYSIOLOGY

Full Credit: 4 (Lecture: 3, Practical: 1)

Full Marks: 75 (Theory: 40; Practical: 20; Internal Assessment: 15)

Course objectives:

To introduce the basic principles of plant life processes and their application.

Course outcomes:

On completion of the course the students will be able to:

Understandplant life processes in quantitative term; comprehend and compare various functional systems in plants; realise the importance of plant-environmental interaction that influence plant performance; realise plant sensory mechanisms for adaptation; realise plant manufacturing of carbohydrate and transport.

Unit 1: (5 lectures)

Plant-water relations:Concept of water potential, Mechanism of water absorption by roots, symplastic and apoplastic movement and aquaporins, root pressure, ascent of sap, mechanism of transpiration, role of blue light in transpiration.

Unit 2: (5 lectures)

Mineral nutrition: Beneficial elements and their physiological role, macro- and micro-elements, criteria for essentiality, chelating agents, phytosiderophores, mineral nutrition in hydroponics and aeroponics.

Unit 3: (7 lectures)

Physiology of nutrient uptake transport: Transport of ions across cell membrane, passive absorption, simple and facilitated diffusion (carrier and channel proteins), Fick's law, active absorption, proton ATPase pump, electrochemical gradient, ion flux, uniport, co-transport (symport, antiport).

Unit 4: (4 lectures)

Physiology of translocation: Phloem translocation, Composition of phloem sap, phloem loading and unloading, Pressure-Flow Model.

Unit 5: (4 lectures)

Crop physiology: Physiological basis of crop yield, Source-sink relationship, Ideal plant type (basic concept).

Unit 6: (9 lectures)

Hormone physiology: Hormones & Plant growth regulators, Chemical nature (basic structure, precursor) and physiological roles of Auxins, Gibberellins, Cytokinins, Abscisic Acid, Ethylene, Jasmonic Acid and Polyamines.

Unit 7: (8 lectures)

Photo-physiology & Physiology of photo-sensory molecules - Photosynthesis *vis-a-vis* photomorphogenesis (overview), Discovery, chemical nature, mode of action and role of phytochrome, cryptochrome and phototropin; Physiological roles of phytochrome and phototropins.

Unit 8: (6 lectures)

Physiology of flowering: Understanding flowering as signaling processes; photoperiodism, CO-FT Model of flowering, vernalization.

Unit 9: (6 lectures)

Seed physiology: Seed dormancy -causes and methods to induce and/or overcome dormancy, seed viability and aging, artificial seed.

Unit 10: (6 lectures)

Plant system biology: general concept and application.

Practical

(30 Hours)

1. Determination of osmotic potential of plant cell sap by plasmolytic method.
2. Determination of water potential of potato tuber cells by falling drop method.
3. Comparisons of stomatal index and stomatal frequency from the lower surface of leaves of a mesophyte and a xerophyte.
4. To calculate the area of an open stoma and percentage of leaf area open through stomata in a mesophyte and a xerophyte (lower surface).
5. To study the effect of different concentrations of ABA on stomatal closure.

6. To study the effect of light and darkness on seed germination.
7. To study the effect of ethylene on fruit ripening.
8. To study the effect of auxin and salicylic acid on rooting.
9. To compare the status of seed aging by a standard biochemical process. (TTC method).

Suggested Readings:

1. Taiz, L., Zeiger, E., Moller, I. M., Murphy, A. (2018). Plant Physiology and Development, International 6th edition, Oxford University Press, Sinauer Associates, New York, USA.
2. BIOCHEMISTRY AND MOLECULAR BIOLOGY OF PLANTS, 2ND EDN, Bob B. Buchanan et al (ed).
3. Hopkins, W.G., and Hunter, NPA, 2011, Introduction to Plant Physiology, Wiley International Edition, John Wiley & Sons, USA.
4. Srivastava, H.S., 2008, Plant Physiology & Biochemistry, Rastogi publications, Meerut, India.
5. Bajracharya, D. (1999). Experiments in Plant Physiology: A Laboratory Manual, Narosa Publishing House, New Delhi.

MAJOR/ DS COURSE (CORE)

Paper code: BOTN 6012

Name of the course: METABOLISM

Full Credit: 4 (Lecture: 3, Practical: 1)

Full Marks: 75 (Theory: 40; Practical: 20; Internal Assessment: 15)

Course objectives:

To make students realize chemical basis of plants functioning, chemistry of plant signalling,defence, and role of environmental cue in plant growth and development.

Course Outcomes:

At the end of this course, students will be able to: understand chemistry of plants learning behaviour, and life processes;correlate life processes with metabolism and functioning of the plants; establish the link between theoretical knowledge and experimental evidence; interpret and evaluate the significance of defense chemicals.

Unit 1:Enzymology: (12 lectures)

Enzymes Classification (IUBMB); Structure and properties of enzymes; mechanism of enzyme catalysis kineticsand enzyme inhibition, allosteric enzyme, isozymes.

Unit 2:Photosynthetic metabolism: (16 lectures)

Chemistry of photosynthetic pigments (chlorophyll a and chlorophyll b, xanthophyll, carotene), Z-scheme of photosynthesis and light trapping mechanisms and consequences, Metabolism of C3 pathway, Synthesis and degradation of sucrose and starch, Metabolism of C4 and CAM pathways and their significance (no chemical structures), Metabolism of C2 pathway and its role. Metabolite pool and exchange of metabolites.

Unit 3:Respiratory metabolism: (6 lectures)

Glycolysis, TCA cycle, ETC, Basic differences in animal and plant respiration, Cyanide resistant respiration (Basic concept).

Unit 4:Nitrogen metabolism: (8 lectures)

Chemistry of Biological nitrogen fixation in legumes (nodulation and role of dinitrogenase), Nitrate assimilation (NR and NiR), Ammonia assimilation: GS-GOGAT pathway, Reductive amination and transamination.

Unit 5:Stress responses: (5 lectures)

Abiotic and biotic stresses (types); Plant responses to drought; ROS, RNS and their physiological role.

Unit 6: Plant cell signalling: (5 lectures)

Basic concept, Receptors and their basictypes, basic modules of plant signal transduction and response.

Unit 7: Secondary metabolism & Plant defence chemicals: (5 lectures)

Major types, chemistry and formation of majordefence chemicals (secondary metabolites); physiological roles of defence chemicals.

Unit 8: Plant metabolomics: (3 lectures)

General concept and its applications.

Practical

(30 hours)

1. To Study Hill's reaction.
2. To study the effect of light intensity on O_2 evolution during photosynthesis.
3. To study the activity of catalase.
4. To study induction ofalpha-amylase activity in germinating barley grains.
5. To study the effect of temperature and pH on the activity of enzyme (catalase).
6. To separate amino acids by paper chromatography.
7. To study the delay of senescence by cytokinins.
8. To study germination of photobalstic and non-photoblastic seeds.
9. To compare Respiratory Quotient (RQ) of germinating starchy, fatty and proteinaceousseeds.

Suggested Readings:

1. Lehninger Principles of Biochemistry, David L. Nelson , Michael Cox (2017) (Int. Edition).

2. Devlin TM (2011) Textbook of Biochemistry, 7th edition, John Wiley & Sons, Inc, New York

3. Hopkins, W. G., Huner, N. P. A. (2009). Introduction to Plant Physiology, 4th edition, Wiley India Pvt. Ltd, New Delhi.

4. Jones, R.,Ougham, H., Thomas,H.,Waaland, S. (2013). The molecular life of plants. Chichester, England: Wiley-Blackwell.

5. Taiz, L., Zeiger, E., Moller, I. M., Murphy, A. (2018). Plant Physiology and Development, International 6th edition, Oxford University Press, Sinauer Associates, New York, USA.

6. Kochhar, S.L. & Gujral, S.K. 2020. Plant Physiology: Theory and Applications, 2nd Edition. Cambridge University Press, UK;

7. Thimmiah, S.K. (2016) Standard methods of Biochemical analysis.

MAJOR/ DS COURSE (CORE)

Paper code: BOTN 6013

Name of the course: ECOLOGY

Full Credit: 4 (Lecture: 3, Practical: 1)

Full Marks: 75 (Theory: 40; Practical: 20; Internal Assessment: 15)

Course objectives:

To make students understand basic components of ecosystem and how environmental factors affecting the biotic components particularly the plants, the basic principles of ecology, conservation of biodiversity and environmental pollution; To make them understand the organization of plant community and its complex patterns and processes, and ecosystem functioning.

Course outcomes:

On completion of the course, the students will be able to: understand complex interrelationship between organisms and environment; understand methods to studying vegetation, community patterns and processes, ecosystem functions; evolving strategies for sustainable natural resource management and biodiversity conservation.

Unit 1: Introduction (4 lectures)

Basic concepts and definitions: ecology, landscape, habitat, ecozones, biosphere, ecosystems, ecosystem stability, resistance and resilience; autecology; synecology; major terrestrial biomes.

Unit2: Ecology of individuals (6 lectures)

Ecological amplitude; Liebig's Law of the Minimum; Shelford's Law of Tolerance; phenotypic plasticity; ecotypes; ecoclines; acclimation; ecological niche; types of niches: fundamental niche, realized niche; niche breadth; niche partitioning; niche differentiation.

Unit 3: Ecology of populations (6 lectures)

Concept of population; characteristics of population: density, dispersion, natality, mortality, phenology, density-dependence; population dynamics (concept only).

Unit 4: Ecology of communities (10 lectures)

Community structure and organization: physiognomy, species associations, biomass, stability, keystone species, ecotone and edge effect. **Species interactions**: mutualism, commensalism, amensalism, predation, competition, parasitism, mimicry, herbivory. Ecological succession: Concept of pioneer species, seral stages and climax community: primary and secondary successions with examples, models and types of successions.

Unit 5: Ecosystem ecology (5 lectures)

Ecosystem types, structure and function; ecosystem productivity and models of energy flow; food chain, food web; grazing and detritus pathway of energy flow; ecological pyramids: pyramids of number, biomass, and energy.

Unit 6:Biogeochemical cycles and nutrient cycling (6 lectures)

Carbon cycle; nitrogen cycle; hydrological cycle; nutrient cycle models, retranslocation; biotic accumulation; ecosystem losses; nutrient supply and uptake; decomposition and nutrient release; nutrient budget, Carbon budge and nutrient conservation strategies.

Unit 7:Biological invasions (6 lectures)

Concept of exotic and invasive plants; characteristics of invaders; stages of invasion; mechanisms of invasions; invasive pathways; impacts of invasion on ecosystem and communities; economic costs of biological invasions.

Unit 8:Biodiversity conservation: (8 lectures)

Biodiversity- concept, types, threats; Conservation- Types; Biodiversity treaties (CBD, CITES, Ramsar Convention), Rio summit, Kyoto Protocol; Mega-diversity countries, Global organization for Biodiversity Conservation: IUCN, TRAFFIC, WWF– activities.

Unit 9: Environmental Pollution: (9 lectures)

Concept, types (Air pollution, Water Pollution, Noise pollution), pollutants and their effects on plants and agriculture. Green house effects, Global warming, Ozone layer depletion, Sea level rise.

Practical

(30 hours)

1. Determination of minimum area of a quadrate in a herbaceous plant community by species area curve.
2. Determination of relative frequency and relative density of a herbaceous plant community.
3. Measurement of temperature, turbidity/penetration of light, determination of pH, salinity and Dissolved Oxygen content (Winkler's method).
4. Determination of different plant life forms following Raunkiaer's concept.

Suggested Readings:

1. Gurevitch, J., Scheiner, S. M., & Fox, G. A. 2020. The Ecology of Plants. 3 rd Ed. Sinauer associatesincorporated.
2. Henderson, P.A., 2009. Practical Methods in Ecology. John Wiley & Sons.
3. Jorgensen, S.E. ed., 2009. Ecosystem Ecology. Academic press.
4. Morin, P.J., 2009. Community Ecology. John Wiley & Sons.
5. Odum, E.P. 1971. Fundamentals of Ecology. W.B. Sounders.
6. Rockwood, L.L., 2015. Introduction to Population Ecology. John Wiley & Sons.
7. Sutherland, W.J. ed., 2006. Ecological Census Techniques: A Handbook. Cambridge university press.
8. Groom. B. & Jenkins. M. 2000. Global Biodiversity: Earth's Living Resources in the 21st Century. World Conservation Press, Cambridge, UK.
9. Loreau, M. & Inchausti, P. 2002. Biodiversity and Ecosystem Functioning: Synthesis and Perspectives. Oxford University Press, Oxford, UK.
10. Pastor, J., 2008. Mathematical Ecology of Populations and Ecosystems. John Wiley & Sons.
11. Pimentel, D. (Ed.). 2011. Biological invasions: Economic and Environmental Costs of Alien Plant, Animal, and Microbe Species. CRC Press.
12. Ranta, E., Lundberg, P. and Kaitala, V., 2005. Ecology of Populations. Cambridge University Press.
13. Wilson, E. O. 1985. The biological diversity crisis. BioScience 35: 700-706.
14. Thomas M. Smith, Robert Leo Smith (2014). Elements of Ecology, Global Edition

MAJOR/ DS COURSE (CORE)

Paper code: BOTN 6014

Name of the course: PLANT SYSTEMATICS

Full Credit: 4 (Lecture: 3, Practical: 1)

Full Marks: 75 (Theory: 40; Practical: 20; Internal Assessment: 15)

Course objectives:

To make students understand: basic components of angiosperm taxonomy, evolution of angiosperms and uses of different data sources to identify and classify angiosperms along with understanding about the concept of species.

Course outcomes:

On completion of the course, the students will be able to identify and classify the angiosperms, and will be able to understand variation among the angiosperms which ultimately lead the conservation of biodiversity.

Unit 1: Introduction (5 lectures)

Concept of Taxonomy, Systematics and Biosystematics; Contribution in Taxonomy by Parasara, Charaka, Theophrastus, Linnaeus, Adanson, de Candolle, Bessey and M.W. Chase. Contribution of W. Roxburgh, N. Wallich Indian and J.D. Hooker in Plant Taxonomy.

Unit 2: Plant Identification (6 lectures)

Field inventory, Herbarium Techniques, Roles of Herbarium and Virtual Herbarium in Plant Taxonomy, Important herbaria and botanic gardens of the world and India; E-flora; traditional taxonomic literature (Floras, Manuals, Icones, Monographs, Revisions, Journals); Cybertaxonomy of the world related to plant identification; Authentication of unknown specimens.

Unit 3: Plant Systematics-An Interdisciplinary Science (10 lectures)

Evidence from Cytology (Cytotaxonomy), Phytochemistry (Chemotaxonomy) [Alkaloids, Phenolics, Glycosides, (in brief)] and molecular data (Molecular Taxonomy) (cp. DNA, mt-DNA, nuclear DNA, PCR amplification, sequence data analysis); Palynology, with examples from each on application in resolving taxonomic problems.

Unit 4: Botanical Nomenclature (7lectures)

Principles and rules of ICN/ICBN; Major Articles; Ranks and names of the Taxa; Principle of priority and its limitations; Concept of Nomenclatural Type and typification, Author citation, Valid publication, Rejection of names; Nomenclature of cultivated plants (ICNCP); Nomenclature of hybrids (Nothotaxa).

Unit 5: Taxonomic Hierarchy (4 lectures)

Concept of taxa (family, genus, species); Categories and taxonomic hierarchy; Species concept (taxonomic, biological & evolutionary).

Unit 6: Systems of Classification (12 lectures)

Classifications - Bentham and Hooker's (up to series with characters), Cronquist' system of classification (upto sub-class) and Angiosperm Phylogeny Group (APG IV) classification (major clades).

Unit 7: Concepts of Phylogeny (4 lectures)

Terms and concepts (apomorphy and plaseomorphy, homology and analogy, parallelism and convergence, monophyly, paraphyly, polyphyly; Major clades and ANA grades).

Unit 8: Phenetics (4 lectures)

Principles, Methodology, Unit characters (Characters and character states); OTUs, Character weighing and Coding; Cluster analysis; Phenogram analysis.

Unit 9: Cladistics (4 lectures)

Principles, Methodology, Morphocline; EUs, Character weighing and Coding; Monophyly determination, Cladogram.

Unit 10: Evolution of Angiosperms (4 lectures)

Theories of Angiosperm evolution (Euanthial theory and Pseudanthial theory)

Practical

(30 hours)

1. Field trips in different Phytogeographical regions and/ or Visit to any herbaria and/ or Botanical Garden.
2. Description of taxa using Botanical terms as much as possible and identification of the families/natural orders according to Bentham and Hooker's classification and compare the placement of family with APG IV System (Only placement of family according to APG IV system to be mentioned)

Suggested Families:

Acanthaceae, Amaranthaceae, Apiaceae, Apocynaceae, Asteraceae, Brassicaceae, Cucurbitaceae, Cyperaceae, Euphorbiaceae, Leguminosae (three subfamilies to be covered), Lamiaceae, Liliaceae, Malvaceae, Moraceae, Myrtaceae, Orchidaceae, Poaceae, Polygonaceae, Ranunculaceae, Solanaceae (at least 15 families to be covered).

3. To prepare at least twenty five (25) herbarium specimens and identify them using available taxonomic Literature and resources (Floras, herbaria, e-resources, taxonomic keys), and placed them up to the family level (according to Bentham and Hooker's classification and to be compared it with APG IV System in the field note book**).**
4. Finding out the updated nomenclature of the identified species/taxa by consulting different taxonomic literature and resources (e-resources).

Suggested Readings:

1. Simpson, M. G. (2019). Plant systematics. 3 rd Edition, Academic press.
2. Singh, G. (2019). Plant Systematics- An Integrated Approach. 4th edition. CRC Press, Taylor and Francis Group.
3. Stuessy, T.F. (2009). Plant Taxonomy: The Systematic Evaluation of Comparative Data, 2nd edition, Columbia University Press.
4. Pandey, A. K., Kasana, S. (2021). Plant Systematics. 2nd Edition. CRC Press Taylor and Francis Group
5. Harris, J. G., Harris, M. W. (2001). Plant Identification Terminology: An Illustrated Glossary. Spring Lake, Utah: Spring Lake Pub. Spring Lake, Utah.
6. Radford, A. E. (1974). Vascular plant systematics. Harper & Row Publishers, New York, London.
7. Judd, W.S., Campbell, L.S., Kellogg, E.A., Stevens, P.F. & Donoghue, M.J. (2016) Plant Systematics: A Phylogenetic Approach. 4th edition. Sunderland, MA: Sinauer Associates.
8. D. E. Soltis, P. S. Soltis, P. K. Endress, M. W. Chase. (2005). Phylogeny and Evolution of Angiosperms. Sinauer Associates.
9. Cronquist, A. (1988). The Evolution and Classification of Flowering Plants. New York Botanical Garden.
10. Besse, P. (2015). Molecular Plant Taxonomy Methods and Protocols. Springer Nature

Additional Resources:

1. https://www.mobot.org/MOBOT/research/APweb/treeapweb2s.gif
2. https://www.digitalatlasofancientlife.org
3. http://apps.kew.org/herbcat/navigator.do
4. https://efloraofindia.com/
5. https://powo.science.kew.org/
6. http://www.mobot.org/MOBOT/research/APweb/
7. https://www.iapt-taxon.org/nomen/main.php
8. https://www.iaptglobal.org/icn

SEMESTER VII

Course title & Code	Credit	Distribution of course credits			Eligibility criteria
		Lecture	Tutorial	Practical	
Major/Core Course: Research Methodology & Ethics **BOTN 7011**	06	05	00	01	B.Sc. 3 yr Botany Hons.

Course title: **RESEARCH METHODOLOGY & ETHICS**

Course Code: **BOTN 7011**

Course outcome:

- This course offers overview of Research Methodology including quantitative and qualitativeresearch in basic as well as applied aspects of Biological Sciences. It is designed to providehandson experience with collection, analysis and interpretation of data and also writing a report/thesis. It enables the students to understand the entire process of research from problem identification, literature review, designing the project to documenting the outcome.
- To make aware students about ethical values and virtues of moral practice in science and research.
- To introduce bioinformatics concepts with special reference to plant sciences.
- To develop understanding of biological databases relevant to Botany.
- To impart skills in sequence alignment and genome analysis.
- To develop computational skills useful for higher studies and plant research.

Course Specific Outcome: By the end of this course, students will be able to

- Identify the problem alter conduct of a literature survey.
- Define goals, approach, and scope of the research.
- Explore, download and interpret datasets.
- Perform literature review using library online resources
- Write scientific report/ review/ thesis and prepare seminar/ conference presentations
- Understand the methods of citation and referencing styles, check plagiarismandget insight of intellectual property rights.
- Orienting students to learn specific values about academic honesty and its pros and cons in scientific culture and publications
- Explain core principles and applications of bioinformatics in Botany.
- Retrieve and analyze plant biological data from public databases.
- Perform sequence alignment and comparative genomic analysis.
- Analyze genomes and phylogenetic analysis.

THEORY

Sl. No.	Content	Lecture hours
1	**Research Fundamentals**: Meaning and significance of research, requirements and characteristics of research; Types of research - basic, applied, analytical, conceptual, empirical, experimental, non-experimental, prospective, retrospective;	08

Sl. No.	Content	Lecture hours
	Understanding the language of research – Concept, Construct, Definition, Variable. Research Process.	
2	**Problem Identification & Formulation** – Research Question – Investigation Question – Measurement Issues – Hypothesis – Qualities of a good Hypothesis.	05
3	**Research Design**: Concept and Importance in Research – Features of a good research design – Exploratory Research Design – concept, types and uses, Descriptive Research Designs – concept, types and uses. Experimental Design: Concept of Independent & Dependent variables.	05
4	**Qualitative and Quantitative Research**: Qualitative research – Quantitative research – Concept of measurement, causality, generalization, replication. Merging the two approaches.	05
5	**Sampling: Concepts of Statistical Population**, Sample, Sampling Frame, Sampling Error, Sample Size, Non-Response. Characteristics of a good sample. Probability Sample – Simple Random Sample, Systematic Sample, Stratified Random Sample & Multi-stage sampling. Determining size of the sample	05
6	**Data Analysis**: Data Preparation – Univariate analysis (frequency tables, bar charts, pie charts, percentages), Bivariate analysis – Cross tabulations and Chi-square test including testing hypothesis of association.	06
7	**Bioinformatics & Plant Databases:** Introduction to Bioinformatics, Aim, Scope and Research areas of Bioinformatics. Types of biological data. Nucleotide databases (GenBank, EMBL, DDBJ). Protein databases (UniProt, PDB). 3D structure database. Plant-specific databases: TAIR, Gramene. Data formats and accession numbers.	06
8	**Sequence Alignment & Comparative Genomics**: Sequence similarity and homology. Global and local alignment. Scoring Matrices, Percent Accepted Mutation (PAM), Blocks of Amino Acid Substitution Matrix (BLOSUM). Multiple sequence alignment and its evolutionary significance.	06
9	**Molecular Phylogeny:** Methods of Phylogeny, Software for Phylogenetic Analyses, Consistency of Molecular Phylogenetic Prediction.	06
10	**Interpretation of Data and Paper Writing** – Layout of a Research Paper, Journals in Computer Science, Impact factor of Journals, When and where to publish? Ethical issues related to publishing, Plagiarism and Self-Plagiarism.	08
11	**Use of tools / techniques for Research**: methods to search required information effectively, Reference Management Software like Zotero/Mendeley, Software for paper formatting like LaTeX/MS Office, Software for detection of Plagiarism	05
12	**Philosophy of ethics**: Introduction of philosophy: Definition, Nature and scope, concept, branches. Ethics- Definition, Concept of ethics in science and research; Intellectual honesty and moral integrity.	05
13	**Publication misconduct**: Subject specific ethical issues, falsification, fabrication; Plagiarism- concept of plagiarism, awareness & its redressal, authorship. Conflicts of interest; Complaints and appeals; Examples and fraud from India and abroad; Use of plagiarism software like Turnitin, Urkund and other open-source software tools.	05
		75

PRACTICAL

Sl. No.	Content	Lecture hours
1	Drafting research proposal on a topic	03
2	Processing and analysis of a research data using software	06
3	Writing a research report	06
4	Preparation of a Literature review report (Reviewing on a topic)	03
5	Development of a Questionnaire for field survey	03
6	Preparation of a poster and PPT based on research data.	03
7	Sequence retrieval from databases – Demonstration. Sequence alignment – Protocol. 3-D structure visualization and simulation. Sequence homology and Gene annotation-Technique study. Construction of phylogenetic tree – Protocol.	06
		30

Suggested reading:

1. Research Methodology. Paneersevam, PHI
2. Research Methodology. Chawla and Sondhi.
3. Research Methodology. C.R.Kothari
4. Business Research Methods – Alan Bryman & Emma Bell, Oxford University Press
5. PB, K. K., Bandopadhyay, R., & Suravajhala, P. (Eds.). (2014). Agricultural bioinformatics (No. 14766). Springer India.
6. Chavali, L. N., & Kavi Kishor, P. B. (2013). Principles of Biological Databases.Himalaya Publishing House
7. Ghosh, Z., & Mallick, B. M. (2018). Bioinformatics principles and Applications. Oxford University Press.

Course title & Code	Credit	Distribution of course credits			Eligibility criteria
		Lecture	Tutorial	Practical	
Major/Core Course: Microbiology & Mycology and Plant Pathology **BOTN 7012**	Unit I (Microbiology): 03 + Unit II (Mycology and Plant Pathology): 03 = 06	Unit I: 02 + Unit II: 02 = 04	00	Unit I: 01 + Unit II: 01 = 02	B.Sc. 3 yr Botany Hons.

Course title: **MICROBIOLOGY & MYCOLOGY AND PLANT PATHOLOGY**

Course Code: **BOTN 7012**

Unit: I

Unit Title: **MICROBIOLOGY**

Course outcome:

- To provide students with a foundational understanding of microbiology and immunology.
- To study the structure, function, and growth of microorganisms including bacteria, archaea, and viruses.
- To understand microbial genetics, physiology, and their role in nitrogen cycle and ecosystems.
- To introduce applied microbiology in agriculture, industry, environment, and medicine.

Course Specific Outcome: By the end of this course, students will be able to

- Explain the principles and historical milestones in microbiology.
- Comprehensive idea of microbial structure, growth, genetics, physiology etc.
- Analysis of viral structure, replication cycles, and emerging pathogens (e.g., COVID-19).
- Demonstration of knowledge of immunity, antigen-antibody interactions, and immunological techniques.
- Application of microbiological concepts in agriculture, industry, environment, and medicine.

THEORY

Sl. No.	Content	Lecture hours
1	**History of Microbiology and Prokaryotic structure:** Early history and landmark discoveries in microbiology. Cell structure of Archaea and bacteria, endospore and chemotaxis	03
2	**Modern approaches of Bacterial Taxonomy**: Phenotypic characterization, 16S	03

Sl. No.	Content	Lecture hours
	rDNA sequencing, DNA-DNA hybridization, Whole Genome Sequencing. Fatty Acid Methyl Ester (FAME) profiling, Metagenomics approaches.	
3	**Bacterial Growth and Nutrition:** Growth curve, growth factors, growth, kinetics. Batch, continuous, synchronous, and enrichment culture. Diauxic growth. Control of microbial growth: disinfectants, antiseptics, chemotherapeutic agents (types and modes of action). Autotrophy, heterotrophy, and mixotrophy.	03
4	**Bacterial Genetics:**Molecular mechanisms of transformation, conjugation, transduction. Gene mapping. Complementation test. Operon models: lac, trp, and arabinose operons. Catabolite repression, attenuation, riboswitch. Allosteric control. Feedback inhibition and isozymes.	05
5	**Microbes in the Nitrogen Cycle:** Nitrification, denitrification, ammonification. Biological nitrogen fixation: nitrogenase and alternative systems. Structure and regulation of *nif*genes.	03
6	**Viruses:** Capsid organization and viral genome types. Replication and Transcription strategies of virus, Baltimore system of Viral classification, Bacteriophages: lytic and lysogenic cycles. Regulation of lysogeny, induction, significance. Viroids and prions. HIV & COVID-19: genome, epidemiology, and significance.	03
7	**Fundamentals of Immunology:** Innate and acquired immunity. T-cells, B-cells, MHC, cytokines, APC. Antigens: types and characteristics. Structure and functions of immunoglobulins. Cell-mediated and humoral immunity. Antigen-antibody reactions. Immunological techniques: RIA, ELISA.	05
8	**Applied Microbiology:** Agriculture: biofertilizers, biocontrol agents. Industry: fermentation and food microbiology. Environment: bioremediation. Medicine: antibiotics and other microbial products.	05
		30

PRACTICAL

Sl. No.	Content	Lecture hours
1	Aseptic techniques: Autoclave, hot air oven, incubator, bacterial filter, laminar airflow.	03
2	Preparation and sterilization of culture media: preparation of media, slants, stabs, plates.	03
3	Isolation of pure culture: streak plate and pour plate methods.	03
4	Morphology and staining: simple, Gram, and endospore staining.	03
5	Observation of root nodule bacteria and isolation of *Rhizobium*.	03
6	Measurement of bacterial growth: turbidimetry, direct cell count (haemocytometer).	03
7	Isolation and enumeration of microorganisms from soil and water samples.	03
8	Physiological and biochemical tests: catalase, protease, amylase, indole production.	03
9	Blood grouping by antigen-antibody reaction (kit-based method).	06
		30

Suggested reading:

1. Pelczar, M.J., Chan, E.C.S., & Krieg, N.R. – *Microbiology: Concepts and Applications*. McGraw-Hill.
2. Prescott, L.M., Harley, J.P., & Klein, D.A. – *Microbiology*. McGraw-Hill Education.

3. Willey, J.M., Sherwood, L.M., & Woolverton, C.J. – *Prescott's Microbiology*. McGraw-Hill.
4. Madigan, M.T., Bender, K.S., Buckley, D.H., Sattley, W.M., & Stahl, D.A. – *Brock Biology of Microorganisms*. Pearson Education.
5. Stanier, R.Y., Ingraham, J.L., Wheelis, M.L., & Painter, P.R. – *The Microbial World*. Prentice Hall.
6. Atlas, R.M. – *Principles of Microbiology*. McGraw-Hill.
7. Cappuccino, J.G. & Sherman, N. – *Microbiology: A Laboratory Manual*. Pearson.
8. Tortora, G.J., Funke, B.R., & Case, C.L. – *Microbiology: An Introduction*. Pearson.
9. Snyder, L., Peters, J.E., Henkin, T.M., & Champness, W. – *Molecular Genetics of Bacteria*. ASM Press.
10. Maloy, S.R., Cronan, J.E., &Freifelder, D. – *Microbial Genetics*. Jones & Bartlett Learning.
11. Primrose, S.B., Twyman, R.M., & Old, R.W. – *Principles of Gene Manipulation and Genomics*. Wiley-Blackwell.
12. Brown, T.A. – *Genomes*. Garland Science.
13. Lewin, B. – *Genes XI*. Jones & Bartlett Learning.
14. Kuby, J., Punt, J., & Stranford, S.A. – *Kuby Immunology*. W.H. Freeman.
15. Roitt, I.M., Brostoff, J., & Male, D.K. – *Immunology*. Elsevier.
16. Atlas, R.M. & Bartha, R. – *Microbial Ecology: Fundamentals and Applications*. Benjamin Cummings.
17. Pelczar, M.J. – *Industrial Microbiology*. McGraw-Hill.
18. Crueger, W. &Crueger, A. – *Biotechnology: A Textbook of Industrial Microbiology*. Sinauer Associates.
19. Stanbury, P.F., Whitaker, A., & Hall, S.J. – *Principles of Fermentation Technology*. Elsevier.
20. Waites, M.J., Morgan, N.L., Rockey, J.S., & Higton, G. – *Industrial Microbiology: An Introduction*. Wiley-Blackwell.
21. Cappuccino, J.G. & Sherman, N. – *Microbiology: A Laboratory Manual*. Pearson.
22. Harley, J.P. – *Laboratory Exercises in Microbiology*. McGraw-Hill.
23. Dubey, R.C. & Maheshwari, D.K. – *A Textbook of Practical Microbiology*. S. Chand & Company.
24. Aneja, K.R. – *Experiments in Microbiology, Plant Pathology and Biotechnology*. New Age International.
25. Salle, A.J. – *Fundamental Principles of Bacteriology*. McGraw-Hill (for classical techniques).
26. Kannan, S. – *Laboratory Manual in General Microbiology*. Panima Publishing.
27. Benson, H.J. – *Microbiological Applications: Laboratory Manual in General Microbiology*. McGraw-Hill.

Unit: II

Unit Title: **MYCOLOGY AND PLANT PATHOLOGY**

Course outcome:

- The course outcomes are categorized into specific academic and skill-based proficiencies.
- It will train the students in fungal taxonomy, biology, physiology, genetics and economic benevolence of fungi for the benefit of human beings.
- It will enlighten the students about the basis of plant- pathogen interactions.
- The students will be groomed on the common diseases of economically important plants/crops – their symptoms and control measures.
- It will equip the students to identify, diagnose and treat agricultural diseases using sustainable methods.

Course Specific Outcome:

- By the successful completion of the course, the students will be able to identify the diverse group of fungi.
- They will be able to understand the etiology, epidemiology and management of selected plant diseases caused by the microbial phyto-pathogens.
- They will be able to develop their basic scientific skills in the laboratory and in the field of plant pathology.

THEORY

Sl. No.	Content	Lecture hours
1	**Introduction to Fungi, Fungal systematic:** Modern approaches towards classification of fungi (G. C. Ainsworth, 1973 system of classification of fungi); classification of Deuteromycetes with special reference to conidial ontogeny.	03
2	**Ultra structure of fungal cells, Fungal cytology and Genetics:** Fungal cell wall and its biochemical composition, Fungal nucleus and its division, other cell organelles. life-cycles of major fungal groups- Phycomycetes, Ascomycetes, Basidiomycetes and Deuteromycetes, Para-sexual cycle and its significance.	04
3.	**Fungal symbiosis:** Mycorrhiza-basic concept, types, Host-fungal interactions and cross-talk in mycorrhiza; application of mycorrhizal biofertilizer in agriculture and forestry. Mass inoculum production of mycorrhizal biofertilizers. Lichen- Phycobiont and mycobiont, histology, biology and physiology of lichen thallus, Economic importance of fungi.	03
4.	**Economic benevolence of fungi:** Industrial application of fungi producing medicines, alcohol, organic acids, and myco-diesel, Fermentation and industrial production of ethyl alcohol, penicillin, citric acid; Cultivation technology of oyster mushrooms and Button mushrooms. Mushrooms: Nutritional and pharmaceutical properties and mushrooms as nutraceuticals.	05

Sl. No.	Content	Lecture hours
	Adverse effects of fungi on Human being and the society– Mycoses of vertebrates- types, symptoms, clinical measures; insect fungal association. Fungal deterioration of seeds and grains, Mycotoxin contamination and their effects on humans and other animals.	
5.	**Introduction to Plant Pathology:** History of Plant pathology, Basic concepts, terminology and classification of plant diseases. Pathogenesis-contact, entry, penetration and establishment of the plant pathogens inside the host plant. Plant pathogens in offence- enzymes and toxins.	03
6.	**Plant Disease Epidemic:** Plant disease epidemics, definition, history, factors responsible for plant disease epidemics. Disease forecasting, remote sensing and computer simulation techniques.	03
7.	**Host plant defence:** Plant defence responses- structural and biochemical defence and host plant resistance, horizontal and vertical resistance – basic concepts. ISR, SAR.	04
8.	**Study of some Common plant diseases andstrategies of plant disease management:** Symptoms, etiology, disease -cycle and control measures of some common important plant diseases of the following crops- Rice, Wheat, Potato, Sugarcane, Tea. Different strategies for plant disease management like-Cultural, Chemical, Biological and Integrated management of plant diseases, Mycoherbicides, Biopesticides and their applications in the management of plant diseases.	05
		30

PRACTICAL

Sl. No.	Content	Lecture hours
1.	Methods of sterilization**:** Autoclave, hot air oven, incubator, laminar air flow; principles and methods of sterilization.	06
2.	Preparation of fungal culture media; Basic idea about different types of fungal culture media, media preparation and preparation of slants, stabs and petri-plates.	03
3.	Demonstration on sub culturing-- fungal and bacterial sub culture techniques.	03
4.	Methods of isolation of fungi and bacteria and establishment of pure culture by dilution plate and streak plate technique.	03
5.	Study of fungal tissue organisationfrom fruit bodies and study of different spore forms.	03
6.	a) Phycomycetes b) Ascomycetes c) Basidiomycetes and d) Deuteromycetes.	03
7.	Study of the vegetative and reproductive structures of members of the following groups – Phycomycetes, Ascomycetes, Basidiomycetes and Deuteromycetes.	06
8.	Demonstration and conceptual knowledge on the principles and applications of the following instruments: Colorimeter, spectrometer, UV-vis spectrophotometer, Light microscopy and Phase contrast microscopy,	03

	Ultracentrifuge, TLC and HPLC.	
		30

Students are required to submit field and laboratory records, preserved and dried specimens and permanent slides

Suggested reading:

1. Introduction to Fungi- John Webster and Roland W.S. Weber
2. Introductory Mycology -Alexopoulos C.J., C.W. Mims and M. Blackwell
3. The Mycota- Esser, K. andBennet J. W. (Eds.)
4. An Introduction to Mycology - Mehrotra, R.S. and Aneja, K.R.
5. Fundamentals of Mycology -Burnett, J. H.
6. Chemical fungal taxonomy -Frisvad, J.C. Bridge, P.D. and Arora, D.K.
7. The Filamentous Fungi - Smith, J.E.
8. Fungal Nutrition and Physiology - Garraway, M. O. and Evans, R. C.
9. Mushroom Biology - Miles, P.G. and Chang, S.T.
10. MycorrhizaeVerma - A. and Hock, B.
11. Ectomycorrhizal Fungi - Cairney, J.W.G. and Chambers, S.M.
12. Industrial mycology -Berry, R.
13. Plant Pathology - Agrios, G.N.

Course title & Code	Credit	Distribution of course credits			Eligibility criteria
		Lecture	Tutorial	Practical	
Major/Core Course: Archegoniates & Angiosperm Systematics **BOTN 7013**	Unit I (Archegoniates): 03 + Unit II (Angiosperm Systematics): 03 = 06	Unit I: 02 + Unit II: 02 = 04	00	Unit I: 01 + Unit II: 01 = 02	B.Sc. 3 yr Botany Hons.

Course title: **ARCHEGONIATES& ANGIOSPERM SYSTEMATICS**

Course Code: **BOTN 7013**

Unit: I

Unit Title: **ARCHEGONIATES**

Course outcome:

- The course develops an understanding of the origin, diversity and evolutionary significance of archegoniate plants, including their structural organization, reproductive biology and life-cycle patterns.

Course Specific Outcome: By the end of this course, students will be able to

- Explain the origin, diversity and major evolutionary innovations of archegoniate plants across bryophytes, pteridophytes and gymnosperms.
- Describe structural organization, reproductive biology and life-cycle patterns of major archegoniate groups.
- Interpret evolutionary trends, phylogenetic relationships using classical and molecular approaches.

THEORY

Sl. No.	Content	Lecture hours
1	**Origin and Evolution of Archegoniates:** Charophyte ancestry; transition from aquatic to terrestrial habitats; evolution of archegonium; alternation of generations and theories of sporophyte origin; major evolutionary innovations including cuticle, vascular tissues and seed habit.	04
2	**Bryophytes – Diversity, Structure, Reproduction and Phylogeny:** Diversity, habitats; origin and evolution; morphology and anatomy of Marchantiophyta (Liverworts),Anthocerotophyta (Hornworts)and Bryophyta (Mosses); gametophyte–sporophyte organization; vegetative propagation; embryogeny; sporophyte diversity; cytogenetics; evolution of conducting structures and peristome; traditional and molecular classification of bryophytes based on modern phylogenetic systems—Marchantiophyta (Liverworts) following Stotler & Crandall-Stotler (2000 onward), Bryophyta (Mosses) following Goffinet & Buck (2004 onward), and Anthocerotophyta (Hornworts) following Stotler & Crandall-Stotler (2005 onward).	04

Sl. No.	Content	Lecture hours
3	**Pteridophytes – Morphology, Reproduction and Life Cycles:** Characteristics and evolutionary position of Pteridophytes; comparative morphology, evolutionary trends and affinities of Lycopsida, Sphenopsida and Pteropsida; reproductive strategies including vegetative reproduction; evolution of vascular organization and stelar patterns; evolution of sporophyll and sori; heterospory and origin of seed habit; embryology and life cycles.	04
4	**Classification, Fossil History and Significance of Pteridophytes:** Traditional classification based on Reimers (1954) and Sporne (1966); modern classification following Smith et al. (2006) and Pteridophyte Phylogeny Group (PPG I, 2016); overview of early vascular plants and fossil history including arborescent Lycophytes and Sphenophytes; evolutionary significance, ecological and economic importance of pteridophytes; Progymnospermopsida concept and Evolutionary and Geological Significance.	05
5	**Gymnosperms–Diversity, Distribution and Reproductive Biology:** Comparative account of major groups-Coniferales, Ephedrales, Taxales, Welwitschiales and Gnetales; gametophyte reduction; pollination biology; embryogeny; anatomical specialization; spore bearing structures and organization; secondary growth; biogeography and adaptive radiation.	07
6	**Gymnosperm Classification and Evolutionary Framework:** Classification based on Bhatnagar & Moitra (1996); linear sequence of extant gymnosperms following Christenhusz et al. (2011); phylogenetic implications, genome evolution, interrelationships among gymnosperm lineages, and their significance in understanding angiosperm ancestry.	06
		30

PRACTICAL

Sl. No.	Content	Lecture hours
1	**Bryophytes:** Detailed study of representative forms including preparation and microscopic observation; morphology and internal organization of available taxa of Marchantiophyta, Bryophyta and Anthocerotophyta; comparative study of pore structure; study of endohydric and ectohydric mosses; and comparative analysis of peristome structure.	12
2	**Pteridophytes:** Study of vegetative morphology and anatomy of available taxa; observation of stelar organization; comparative study of sori types; observation of heterospory; study of reproductive structures and interpretation of life cycles.	06
3	**Gymnosperms:**Comparative study of vegetative and reproductive structures; stem and leaf anatomy of common Indian gymnosperms; comparative study of cones; stages of embryogeny and adaptive features.	09
4	**Field Study and Identification:** Collection and preservation of wild archegoniate taxa; preparation of voucher, herbarium and museum specimens; habitat recording; identification using taxonomic keys; documentation with digital archiving.	03
		30

Suggested reading:

1. Chopra, R. S. 1975. *Taxonomy of Indian Mosses*. CSIR, New Delhi.
2. Dyer, A. F. & Duckett, J. G. 1984. *The Experimental Biology of Bryophytes*. Academic Press, London.
3. Goffinet, B. & Shaw, A. J. 2008. *Bryophyte Biology*, 2nd ed. Cambridge University Press.
4. Kashyap, S. R. 1932. *Liverworts of Western Himalayas and Punjab Plains*. Researchco Publications.
5. Kumar, S. S. 1984. An approach towards phylogenetic classification of mosses. *Journal Hattori Botanical Laboratory*.
6. Porley, R. & Hodgetts, N. 2005. *Mosses and Liverworts*.
7. Price, D. & Bealey, C. 2022. *A Field Guide to Bryophytes*.
8. Richardson, D. H. S. 1981. *Biology of Mosses*. Blackwell Scientific Publications.
9. Schofield, W. B. 1985. *Introduction to Bryology*. Macmillan.
10. Schuster, R. M. 1966–1973. *The Hepaticae and Anthocerotae of North America*, Vol. I–IV. Columbia University Press.
11. Schuster, R. M. 1983, 1984. *New Manual of Bryology*, Vol. I & II. Hattori Botanical Laboratory.
12. Vanderpoorten, A. & Goffinet, B. 2009. *Introduction to Bryophytes*. Cambridge University Press.
13. Smith, A. J. E. 1982. *Bryophyte Ecology*. Chapman & Hall.
14. Alam, A. 2015. *Textbook of Bryophyta*. I K International Publishing House.
15. Shaw, A. J. & Goffinet, B. 2009. *Bryophyte Biology*, 2nd ed. Cambridge University Press.
16. Vashishta, P. C., Sinha, A. K. & Kumar, A. 2011. *Bryophyta*. S. Chand.
17. Sporne, K. R. 1974. *The Morphology of Pteridophytes*. Hutchinson University Library.
18. Gifford, E. M. & Foster, A. S. 1989. *Morphology and Evolution of Vascular Plants*, 3rd ed. W. H. Freeman.
19. Kenrick, P. & Crane, P. R. 1997. *The Origin and Early Diversification of Land Plants*. Smithsonian Institution Press.
20. Taylor, T. N., Taylor, E. L. & Krings, M. 2009. *Paleobotany: The Biology and Evolution of Fossil Plants*, 2nd ed. Academic Press.
21. Vashishta, P. C., Sinha, A. K. & Kumar, A. 2012. *Pteridophyta*. S. Chand.
22. Sporne, K. R. 1965. *The Morphology of Gymnosperms*. Hutchinson University Library.
23. Bhatnagar, S. P. & Moitra, A. 1996. *Gymnosperms*. New Age International.
24. Vashishta, P. C., Sinha, A. K. & Kumar, A. 2013. *Gymnosperms*. S. Chand.
25. Raven, P. H., Evert, R. F. & Eichhorn, S. E. 2020. *Biology of Plants*, 9th ed. W. H. Freeman.
26. Beck, C. B. 2010. *An Introduction to Plant Structure and Development*. Cambridge University Press.

Unit: II

Unit Title: **ANGIOSPERM SYSTEMATICS**

Course outcome:

- To introduce students to the principles, scope, and modern approaches of angiosperm systematics, emphasizing biosystematics as a dynamic and integrative discipline.
- To develop a conceptual understanding of species, variation, phenotypic plasticity, and epigenetic regulation, and their roles in adaptation, speciation, and conservation.
- To familiarize students with speciation process and types, classical and modern species concepts and enable critical evaluation of their applicability in plant taxonomy.
- To provide comprehensive knowledge of modern multicharacter-basedsystematics, and phylogenomics, highlighting their significance in contemporary taxonomy and accelerated species discovery.
- To introduce the principles, structure, and evolutionary framework of the Angiosperms.
- To acquaint students with phytogeography and phylogeography, including plant migration, endemism, disjunction, and vicariance, in a global and Indian context.
- To develop practical skills in plant identification, analysis of variation, taxonomic delimitation.
- To cultivate analytical, interpretative, and research-oriented skills relevant to taxonomy, biodiversity assessment, conservation biology, and evolutionary studies.

Course Specific Outcome: By the end of this course, students will be able to

- Explain the principles, aims, and methodologies of Systematics and Biosystematics and evaluate their role in understanding different dynamic units such as ecotypes, clines, and speciation in angiosperms.
- Distinguish between natural variation, phenotypic plasticity, and epigenetically mediated variation, and assess their evolutionary significance androle in conservation.
- Critically compare and apply different species concepts to resolve taxonomic problems in angiosperms.
- Explain the concepts and methodologies of phylogeography and phylogenomics, and relate genetic patterns to plant distribution and evolutionary history.
- Interpret endemism, phytogeographical patterns,phytochoria, and plant migration processes, with special reference to India and Southern Hemisphere.
- Identify angiosperm taxa using different characters, and apply standard taxonomic literature and digital resources effectively.
- Perform practical taxonomic and systematic analyses, including variation studiesand phytogeographical assessment.

THEORY

Sl. No.	Content	Lecture hours
1	**Systematics and Biosystematics:** Plant systematics-aims and objectives, methods; concept of Cladistics; comparative data in plant systematics. Biosystematics:Principles, aims, steps in study, dynamic units of Biosystematics	06

Sl. No.	Content	Lecture hours
	study; concept of ecotype (ecological races), cline and good species, role of ecotype in speciation, methods in Biosystematics studies, ecotypic variations and taxonomy; scope and limitations of Biosystematics studies.	
2	**Phenotypic plasticity and Epigenetics:** Concept and role in adaptation, speciation and conservation. Concept of natural variation.	03
3	**Speciationand Species concept:**Speciation-types and methods; different species concepts- Biological Species Concept (BSC), Evolutionary Species Concept (ESC), Morphological Species Concept (MSC), Phylogenetic Species Concept (PSC), Recognition Species Concept (RSC), Successional Species Concept (SSC), Taxonomic Species Concept (TSC) *etc*.	06
4	**Phylogenomics and Phylogeography:** Principles, methods and outcome.	03
5	**Endemism and Plant migration/dispersal:**Endemism-concept, causes, types, levels; endemism in relation to chromosome number; brief account on endemic and threatened Angiosperms taxa of India; distribution of endemic plant families/taxa in the globe,specifically in Southern Hemisphere.Plant migration-Plant migrations a process; concept of 'front' and 'jump', long distance migration, basic components of plant migration- fecundity, dispersal, establishment and growth to reproductive maturity; Disjunction and Vicariance.	06
6	**Phytogeography and Phytochoria:** Concepts of Phytogeography; Major phytochoria of the world and India: basic principles, four 'realms' classification, A.Takhtajan's (1986) six kingdom classification, levels of Takhtajan'sphytochoria, levels of endemicity in Takhtajan's kingdoms, Indian phytochoria.	06
		30

PRACTICAL

Sl. No.	Content	Lecture hours
1	Identification of angiosperm specimens (both from locally available plants and/or plant samples collected from different phytogeographical areas during excursion/study tour) from the following taxonomic groups on the basis of gross vegetative and reproductive characters by using different taxonomic literature: ANA/ANITA (Nymphiaceae); MONOCOTS (Poaceae, Cyperaceae); EUDICOTS (Menispermaceae, Ranunculaceae, Nelumbonaceae);CORE EUDICOTS **(**Nyctaginaceae, Polygonaceae, Loranthaceae/ Santalaceae);ROSIDS (Vitaceae, Oxalidaceae, Euphorbiaceae, Rhizophoraceae, Polygalaceae); ASTERIDS (Lamiaceae, Rubiaceae, Apiaceae, Asteraceae) and other locally available plants.	21
2	Study of morphological variation– both intra-specific and inter-specific variation; variation study to find out difference between true natural variation and phenotypic plasticity (both from locally available plants and/or plant samples collected from different phytogeographical areas during excursion/study tour).	06
3	Comparative study of morphologically similar taxa to identify diagnostic characters. Study of taxon specific diagnostic characters (at the infra-specific level and supra-specific level).	03
		30

Suggested reading:

1. Angiosperm Phylogeny Group (2016) An update of the Angiosperm Phylogeny Group Classification for the orders and families of flowering plants: APG IV. Botanical Journal of the Linnaean Society 181: 1-20.
2. Armen Takhtajan (1991) Evolutionary Trends in Flowering Plants-Columbia University Press.
3. Briggs David 2009. Plant microevolution and Conservation in Human-influenced Ecosystems.Cambridge University Press.
4. Crawford, D.J. 2003. Plant Molecular Systematics. Cambridge University Press, Cambridge, UK.
5. Cronquist, A. 1981.An Integrated System of Classification of Flowering Plants Columbia University Press, New York.
6. Cronquist, A. 1988. The Evolution and Classification of Flowering Plants (2nded.) Allen Press, U.S.A.
7. Davis, P. H. and V. H. Heywood 1991. Principles of Angiosperm Taxonomy. Today and Tomorrow Publications, New Delhi.
8. Grant W. F. 1984. Plant Biosystematics.Academic press, London.
9. Heywood, V. H. and Moore, D. M. 1984. Current concepts in Plant Taxonomy. Academic Press, London.
10. Jones, S. B., Jr.and Luchsinger, A. E. 1986. Plant Systematics (gd edition). McGraw -Hill Book Co., New York.
11. Judd W. S., Campbell, C. S., Kellogg, E. A., Stevens P. F. and M. J. Donoghue 2008. Plant Systematics: A phylogenetic Approach.Sunderland, Massachusetts, USA.
12. Judd, W.S., Campbell, C.S, Kellogg, E.A., Stevens, P.A. and Donoghue, M.J. 2016. Plant Systematics: A Phylogenetic Approach. Sinauer Associaes, Inc., Massachusetts.
13. Lawrence George H. M. 1951. Taxonomy of Vascular Plants.Oxford and IBH Publ. Co. Pvt. Ltd. New Delhi.
14. Leadlay E. and S. Jury (ed.) 2006. Taxonomy and Plant conservation.Cambridge University Press.
15. Manilal, K. S. and M. S. Muktesh Kumar [ed.] 1998. A Handbook of Taxonomic Training. DST, New Delhi.
16. Naik, V. N. 1984. Taxonomy of Angiosperms. Tata McGraw-Hill Publication Com. Ltd. New Delhi
17. Nordentam, B., El Gazaly, G. and kassas, M. 2000.Plant systematic for 21st century.Portlandpress.Ltd, London.
18. Pamela S. Soltis et al. (2005) Phylogeny & Evolution of Angiosperms, Sinauer Associates.
19. Quicke, Donald, L. J. 1993. Principles and Techniques of Contemporary Taxonomy.Blakie Academic & Professional, London
20. Radford, A. E. 1986. Fundamentals of plant systematic.Harper and Raw publication, USA.
21. Simpson M. G. 2006. Plant systematics (Second Edition) Elsevier.
22. Simpson, M.G. 2010. Plant Systematics. Elsevier, Amsterdam.
23. Stuessy TF 2009. Plant Taxonomy: The systematic Evaluation of Comparative Data. Columbia University Press, New York.
24. Stuessy, T.F., Crawford, D.J., Soltis, D.E. and Soltis, P.S. 2014. Plant Systematics: The origin, interpretation, and ordering, of plant biodiversity. Koeltz Scientific Books, Konigstein, Germany.
25. Takhtajan, A. 1986. Floristic Regions of the World. Berkeley: University of California Press.
26. Takhtajan, A. L. 1997. Diversity and classification of Flowering Plants. Columbia University Press, New York.
27. Hennig, W. 1966. Phylogenetic Systematics. Urbana: Univ. Illinois Press (an English translation of a book published earlier in German).
28. Different on-line Journals available on UGC website.

Course title & Code	Credit	Distribution of course credits			Eligibility criteria
		Lecture	Tutorial	Practical	
Major/Core Course: Plant Physiology, Plant Biochemistry & Molecular Biology **BOTN 7014**	Unit I (Plant Physiology): 03 + Unit II (Plant Biochemistry & Molecular Biology): 03 = 06	Unit I: 02 + Unit II: 02 = 04	00	Unit I: 01 + Unit II: 01 = 02	B.Sc. 3 yr Botany Hons.

Course title: **PLANT PHYSIOLOGY, BIOCHEMISTRY & MOLECULAR BIOLOGY**

Course Code: **BOTN 7014**

Unit: I

Unit Title: **PLANT PHYSIOLOGY**

Course outcome:

- This course aims to educate student on concepts of plant life processes, like photoprocesses, plant hormones and signalling, flowering biology, senescence biology, seed biology, and stress physiology of plants.

Course Specific Outcome:

- This course will introduce students to physiological advances in plant photosynthetic chemistry and their regulation
- This course will introduce students to physiological advances in sensory photobiology.
- Students will learn Respiration and photorespiration mechanisms along with their regulation.
- Students will gain the knowledge on physiology of flowering, molecular basis of multiple signalling of flowering mechanism.
- Students will learn plant senescence biology and seed biology.
- Students will gain the knowledge on physiology of plant growth regulators and their signalling.
- Students will learn plant stress physiology and stress signalling.

THEORY

Sl. No.	Content	Lecture hours
1	Photosynthesis: Z scheme, Photosynthetic electron transport (PET) and Light harvesting complexes; photoprotective mechanisms; Chemistry of CO_2 fixation mechanisms C3, C4 and CAM pathways& their regulation.	04
2	Plant Sensory photobiology: Structure, function and mechanisms of action of phytochromes, cryptochromes and phototropins; stomatal movement; photoperiodism and biological clocks.	04
3	Respiration and photorespiration: Glycolysis, Citric acid cycle& their regulation; plant mitochondrial electron transport and ATP synthesis; alternate oxidase;	04

Sl. No.	Content	Lecture hours
	photorespiratory pathway, GS-GOGAT & Oxalate-Malate shuttle pathway.	
4	Plant hormones: Biosynthesis, storage, breakdown of IAA, GA, CK, ABA and ethylene; physiological effects, mutants, mechanisms of action and their signalling episodes.	05
5	Physiology of Flowering: Photoperiodic control, hormonal regulation; nature of floral stimulus; experimental evidence to prove the mobile nature and chemistry of floral signal, Signalling pathway during flowing; gene- induced regulation floral development, ABC model, second messengers and flowering.	03
6	Senescence Biology: Types of senescence, biochemical indices of senescence, biochemical changes occurring during leaf senescence, senescence regulatory genes, Regulation of Senescence, ROS & Senescence.	02
7	Stress Physiology: Basic concepts of plant responses to abiotic and biotic stress. Tolerance mechanisms, Concept of Oxidative stress, Transcription factors and genes in stress tolerance	03
8	Seed Biology: Seed dormancy; Mechanism of Seed aging, viability loss and repair mechanisms.	02
9	Plant Secondary metabolites: Biosynthesis of terpenes, phenols and nitrogenous compounds and their roles in chemical warfare.	03
		30

PRACTICAL

Sl. No.	Content	Lecture hours
1	Effect of chilling stress on photosynthetic and antioxidant pigments from normal and drought stressed seedling	06
2	Effect of high temperature stress on membrane deterioration of germinating seedling	06
3	Effect of drought stress on root metabolic activity and osmolyte content (proline/glycine betaine) of germinating seedling	03
4	Effect of salinity stress on ion homeostasis of experimental seedlings	03
5	Effect of heavy metal stress on redox homeostasis of experimental plant	04
6	Isolation of chloroplast and study of photolysis of water by Hill reaction.	04
	Comparison of viability status of differently aged seed lots by standard physiological test.	04
		30

Suggested reading:

1. Buchanan, B., Gruissem, G. and Jones, R. (2015). Biochemistry and Molecular Biology of Plants. 2nd Edition, American Society of Plant Physiologists, USA.

2. Davies P J. (2010). Plant Hormones Biosynthesis, Signal Transduction, Action. 3rd Edition, Kluwer Academic Publisher, Dordrecht, The Netherlands.

3. Jordan, B.R. (2006). The Molecular Biology and Biotechnology of Flowering, 2nd Edition, CAB

International, U.K.

5. Taiz, L. and Zeiger, E., Møller, I.M., Murphy, A. (2023) Plant Physiology and Development. 7th Edition. Sinauer Associates, USA.

6. Bhatla, S.C., Lal, M.A. (2024). Plant Physiology, Development and Metabolism. 2nd Edition. Springer Nature, Singapore

7. Hossain A. et al 2018. Drought stress response of Plants, Vol I and vol II. Springer Nature

8. Bhattacharjee S. ROS in Plant Biology. Springer Nature. 2019.

Unit: II

Unit Title: **PLANT BIOCHEMISTRY & MOLECULAR BIOLOGY**

Course outcome:

- This course aims to educate student on concepts of biomolecules, their metabolisms, enzyme kinetics, basic plant signaling mechanisms, sensory photobiology, photochemistry, plant defense compounds and important biochemical methods and associated instrumentation.
- To provide fundamental knowledge of techniques used in Genetic Engineering and Recombinant DNA Technology, biotechnology and their application.

Course Specific Outcome:

- This course will introduce students to physiological advances in photo-processes, sensory and photosynthesis.
- Students will gain the knowledge on structure-function relationship of biomolecules
- Students will gain the knowledge on basic metabolisms and their regulation
- Students will be learning about protein chemistry, their folding, post translational modifications. The course will also teach enzyme kinetics, its inhibitors and regulation.
- Students will be learning about Secondary metabolites and their role in chemical warfare
- Students will gain the knowledge on cellular communication & signaling
- This course will introduce students on important biochemical methods and high throughput technologies for biochemical studies.
- Understand basic concepts, principles and methods in Genetic Engineering and Recombinant DNA Technology, biotechnology.
- Explain the use of acquired knowledge in biotechnological, pharmaceutical, medical, ecological and agricultural applications.

THEORY

Sl. No.	Content	Lecture hours
1	**Carbohydrate metabolism**: Glycolysis & TCA cycle and their regulatory mechanisms; Oxidative Phosphorylation; Pentose phosphate pathway and its control and significance;Gluconeogenesis and Glyoxylate cycle and their control and significance.	04
2	**Lipid metabolism**: biosynthesis and oxidation of fatty acids.	02
3	**Protein chemistry**: Amino acids and peptide bonds, determination of amino acid sequence in a polypeptide; Conformation of proteins (Ramachandran plot, secondary structure, domains, motif and folds) Post translational modification of protein, chaperone and protein folding, protein targeting.	04

Sl. No.	Content	Lecture hours
4	**Enzyme kinetics**: Deduction of Michaelis-Menten equation, Lineweaver-Burk plot; enzyme inhibition, isozymes, allosteric enzymes, ribozymes and abzymes.	03
5	**Secondary metabolites and chemical defence**: Plant natural products (secondary metabolites), their range and eco-physiological functions.	02
6	**Cellular communication & signalling**: Chemistry of host-parasite interaction; Overview, second messengers, receptors and G-proteins, phospholipid signaling, role of cyclic nucleotides, calcium-calmodulin cascade, diversity in protein kinases and phosphatases, specific signaling mechanisms and their regulation; Cellular communication.	03
7	**Biochemical methods**: Analysis of RNA, DNA and proteins by one- and two-dimensional gel electrophoresis, Chromatography,Protein sequencing methods, detection of post translation modification of proteins, MS technology and protein mass fingerprinting, DNA sequencing methods, strategies for genome sequencing, Radiotracer techniques, Bioassay techniques.	04
8	**Recombinant DNA technology:** Molecular Tools for Genetic Engineering; Restriction Endonucleases: Types I, II, and III; Type II restriction enzymes (isoschizomers, neoschizomers); Restriction mapping. DNA Modifying Enzymes: DNA Ligases, Alkaline Phosphatase, Polynucleotide Kinase, Taq Polymerase, DNA polymerase I, Terminal Transferase, Reverse Transcriptase. Linkers, adaptors, and homopolymer tailing; introduction to prokaryotic and eukaryotic cloning vectors: pBR322, pUC18, pUC19, BACs, Lambda phage, YACs. Expression Vectors: Promoters (lac, T7), fusion protein tags, shuttle vectors; gene cloning: restriction digestion of DNA, elution of DNA from agarose gels, ligation, bacterial transformation and selection of recombinant clones - Blue-white screening	05
9	**Polymerase Chain Reaction and DNA Sequencing methods:** PCR: Mechanism, Primer design, Optimization, Types (RT-PCR, qPCR, Nested PCR, Inverse PCR).DNA Sequencing: Sanger's dideoxy method, Next Generation Sequencing (NGS) (basics).Genomics and Proteomics Tools: DNA Footprinting, Yeast Two-Hybrid System.	03
		30

PRACTICAL

Sl. No.	Content	Lecture hours
1	Assay and compare activity of an antioxidant enzyme (ascorbate peroxidase) and hydrolytic enzyme (protease)from drought stressed and untreated control supplied experimental seedling	06
2	Separate amino acids from a mixture sample by paper chromatographic technique	03
3	Extraction of soluble proteins from drought stressed rice seedlings and comparative quantitative estimation of proteins by Bradford's method.	03
4	Determine molecular weight of polypeptides from plant tissue by CBB stained SDS PAGE gel	03

5	Soxlet extraction, concentration (vacuum evaporation) and quantification of phenolic compounds from plant sample.	03
6	To study the lipid peroxidation under salinity stress in two contrasting germplasms of rice by estimating the thiobarbituric acid reactive substances	03
7	Demonstration of Biochemistry tools: 2 DE, qRT-PCR, GC-MS .	03
8	Isolation of Genomic DNA: From plant or bacterial cells.	03
9	Restriction digestion and gel electrophoresis of plasmid DNA.	03
		30

Suggested reading:

1. Buchanan, B., Gruissem, G. and Jones, R. (2015). Biochemistry and Molecular Biology of Plants. 2nd Edition, American Society of Plant Physiologists, USA.
2. Jordan, B.R. (2006). The Molecular Biology and Biotechnology of Flowering, 2nd Edition, CAB International, U.K.
3. Nelson, D.L., and Cox, M.M. (2021). Lehninger Principles of Biochemistry (8th edition). W.H. Freeman & Co., New York.
4. Heldt, H-W. and Piechulla, B. (2024). Plant Biochemistry, 6th Edition. Academic Press, NY.
5. Cell and Molecular Biology - Gerald Karp, Janet Iwasa, and Wallace F. Marshall
6. Brown, T. A. (2020) Gene Cloning & DNA Analysis: An Introduction. 8thedn. UK: Wiley Blackwell.
7. Primrose, S. B. &Twyman, R.M. (2006). Principles of Gene Manipulation and Genomics. 7thedn. Victoria, Australia: Blackwell Publishing.
8. Principles of Gene Manipulation and Genomics by Sandy B. Primrose and Richard Twyman.
9. From Genes to Genomes: Concepts and Applications of DNA Technology by Jeremy W. Dale.
10. Recombinant DNA Technology and Genetic Engineering Paperback - Rajagopal K
11. Molecular Cloning: A Laboratory Manual by Sambrook and Russell.
12. Brown, T. A. (2020) Gene Cloning & DNA Analysis: An Introduction. 8thedn. UK: Wiley Blackwell.
13. Recombinant DNA Techniques (Paperback) - Jain M

Course title & Code	Credit	Distribution of course credits			Eligibility criteria
		Lecture	Tutorial	Practical	
Minor Course: Plant Biodiversity, Informatics & Environmental Sustainability **BOTN 7021**	04	04	00	00	B.Sc. 3 yr Botany Hons.

Course title: **PLANT BIODIVERSITY, INFORMATICS & ENVIRONMENTAL SUSTAINABILITY**

Course Code: **BOTN 7021**

Course Outcome:

- Provide a comprehensive understanding of the concepts, levels, patterns, and values of biodiversity, along with the major threats and conservation strategies.
- Familiarize students with methods of biodiversity inventorying, assessment, and long-term monitoring, including the application of modern tools.
- Develop an understanding of the bioeconomy and biodiversity-based livelihoods.
- Introduce the principles and applications of biodiversity informatics, including digitization of biological collections, and biodiversity databases.
- Enhance knowledge of agrobiodiversity, crop domestication, and genetic diversity, highlighting their role in food security and sustainable agriculture.
- Promote understanding of environmental sustainability and sustainable development, with reference to global initiatives such as the SDGs and the Paris Climate Accord.
- Impart theoretical and practical knowledge of bioremediation such as phytoremediation, and phycoremediation as eco-friendly approaches for environmental restoration.
- Develop practical skills in biodiversity assessment, informatics tools, environmental monitoring, and biological remediation techniques.

Course specific Outcome: By the end of this course, students will be able to

- Explain the concepts, levels, distribution patterns, values, and threats of biodiversity**,** and critically evaluate *in-situ* and *ex-situ* conservation strategies**.**
- Apply standard field-based and quantitative methods for biodiversity inventorying and monitoring, including the use of diversity indices, and geospatial tools.
- Assess the role of biodiversity in the bioeconomy, ecosystem services, and sustainable livelihoods, with an understanding of bioprospecting, and biodiversity-based entrepreneurship.
- Demonstrate proficiency in biodiversity informatics, including data types, standards, digitization of biological collections, and the use of major national and global biodiversity databases.
- Analyze the significance of agrobiodiversity, plant domestication, and genetic diversity in ensuring food security and sustainable agricultural systems.
- Explain the principles of environmental sustainability and sustainable development, assess climate change impacts, and relate global initiatives such as the SDGs and Paris Agreement to

environmental governance.

- Describe the principles, mechanisms, advantages, and limitations of bioremediation, including microbial degradation of pollutants and risk assessment.
- Compare and evaluate phytoremediation and phycoremediation techniques, including their mechanisms, applications, and environmental benefits.
- Perform hands-on practical exercises involving biodiversity assessment, informatics tools, agrodiversity documentation, environmental quality analysis, and biological remediation techniques, and interpret the generated data scientifically.

THEORY

Sl. No.	Content	Lecture hours
1	**Biodiversity and Conservation** Concept and levels of biodiversity (genetic, species, ecosystem, and landscape). Patterns of biodiversity distribution and global biodiversity hotspots. Values of biodiversity: ecological, economic, social, cultural, and ethical. Threats to biodiversity, including habitat loss, climate change, invasive species, overexploitation, and pollution. Principles and approaches of biodiversity conservation: *in situ* and *ex situ* conservation strategies. Role of protected areas, community participation, and traditional knowledge in biodiversity conservation.	10
2	**Inventorying and monitoring of biodiversity** Concept and importance of biodiversity inventory and monitoring. Methods of biodiversity assessment: field surveys, quadrat and transect methods, population estimation, and biodiversity assessment. Use of indices for biodiversity monitoring. Role of remote sensing, GIS, and georeferencing in biodiversity assessment and monitoring.	08
3	**Biodiversity based economy (Bioeconomy)** Concept of bioeconomy and its relevance to sustainable development. Biodiversity as a resource for food, medicine, agriculture, forestry, and industry. Bioprospecting, bioentrepreneurship, and biodiversity-based livelihoods, biodiesel, major and minor forest products. Role of biodiversity board, PBR.	05
4	**Biodiversity Informatics and Resources** Concept and scope of biodiversity informatics; data types in biodiversity studies: taxonomic, ecological, genetic, spatial, and temporal data, biodiversity data collection and management, digitization of biological collections, and biodiversity databases; role of biodiversity informatics in conservation planning, species distribution, and climate change studies. GBIF databases, IUCN criteria and category.	08
5	**Agrodiversity** Concept and significance of agrobiodiversity in food security and sustainable agriculture. Conservation of crop diversity, landraces, and wild relatives. Traditional farming systems and indigenous knowledge. Plant domestication: Vavilov concept, centre of plant domestication of major crops; dispersal and distribution of major crops; causes and consequences, primary & secondary genetic diversity and regulation of domestication syndrome.	08

Sl. No.	Content	Lecture hours
6	**Environmental Sustainability & Sustainable Development** Concept, scope, and dimensions of environmental sustainability; Sustainable development: principles and major challenges; Sustainable Development Goals (SDGs) and environmental governance; Environmental ethics and sustainability indicators; Green technologies, circular economy, and sustainable resource use; Climate change: causes and impacts, carbon footprint, mitigation and adaptation; Paris Agreement (Paris Climate Accord): objectives, commitments, and significance.	07
7	**Bioremediation for Environmental Sustainability** Principles, mechanisms, and types of bioremediation; Microbial metabolism and degradation of organic and inorganic pollutants; In-situ and ex-situ bioremediation techniques; Bioremediation of: Oil spills, Pesticides, Plastics, Heavy metals, Bioaugmentation and biostimulation approaches, Advantages, limitations, risk assessment, and future prospects of bioremediation.	07
8	**Phytoremediation and Phycoremediation** Phytoremediation- Concept, scope, and classification: Phytoextraction, Phytostabilization, Phytodegradation, Role of higher plants in remediation of contaminated soil and water; Mechanisms of metal uptake, translocation, and detoxification. Phycoremediation- Use of algae and cyanobacteria in wastewater treatment; Removal of nutrients, dyes, and potentially toxic elements (PTEs); Biomass utilization and environmental benefits; Case studies and comparative evaluation of biological and conventional remediation methods.	07
		60

Suggested reading:

1. Odum, E. P., & Barrett, G. W. 2005. *Fundamentals of ecology* 5th ed. Brooks/Cole.
2. United Nations. 2015. *Transforming our world: The 2030 agenda for sustainable development*. United Nations Publications.
3. Miller, G. T., &Spoolman, S. 2016. *Environmental science* 15th ed. Cengage Learning.
4. Singh, A., Kuhad, R. C., & Ward, O. P. 2009. *Advances in applied bioremediation*. Springer.
5. Vidali, M. 2001. Bioremediation: An overview. *Pure and Applied Chemistry*, 73, 1163–1172.
6. Gadd, G. M. 2010. Metals, minerals and microbes: Geomicrobiology and bioremediation. *Microbiology*, 156, 609–643.
7. Salt, D. E., Smith, R. D., & Raskin, I. 1998. Phytoremediation. *Annual Review of Plant Physiology and Plant Molecular Biology*, 49, 643–668.
8. Ali, H., Khan, E., & Sajad, M. A. 2013. Phytoremediation of heavy metals—Concepts and applications. *Chemosphere*, 91, 869–881.
9. Olguín, E. J. 2012. Phycoremediation: Key issues for cost-effective nutrient removal processes. *Biotechnology Advances*, 30, 1346–1362.
10. Pires, J. C. M., Alvim-Ferraz, M. C. M., Martins, F. G., & Simões, M. 2012. Carbon capture and algae. *Renewable and Sustainable Energy Reviews*, 16, 3043–3053.

SEMESTER VIII

Hons. With Research Project/Dissertation

Course title & Code	Credit	Distribution of course credits			Eligibility criteria
		Lecture	Tutorial	Practical	
Major/Core Course: Cytogenetics& Plant Breeding **BOTN 8011**	06	04	00	02	B.Sc. 3 yr Botany Hons.

Course title: **CYTOGENETICS & PLANT BREEDING**

Course Code: **BOTN 8011**

Course outcome:

- To introduce the principles of chromosome structure, function, and behavior.
- To understand chromosomal aberrations and their clinical significance.
- To familiarize students with traditional cytogenetic and molecular cytogenetic techniques.
- To develop skills in analyzing and interpreting cytogenetic data in research and diagnostics.

Course specific outcome:

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

- Understand the core principles of genetics, including inheritance, gene interactions, and chromosomal behavior.
- Describe chromosome morphology and organization.
- Explain chromosomal aberrations and their biological consequences.
- Perform basic cytogenetic laboratory techniques (e.g., karyotyping, banding).
- Understand the fundamental concepts of biostatistics, data collection, data management and interpretation in relation to evidence-based decision-making.
- Understand the various components on conceptual and applications of plant breeding programme and principles and applications of plant biotechnology

THEORY

Sl. No.	Content	Lecture hours
1	**Genes, Genomes and Genetic analysis** Historical developments in the field of genetics;organisms suitable for genetic experimentation and their significance.Mendelian genetics and its extension; multiple allele, pseudo-allele, essential and lethal genes, penetrance and expressivity; Genetic linkage, crossing over and chromosome mapping: Linkage and Recombination; Genetic mapping; genetic inheritance in pedigrees, mutation – types, mechanisms and significance; Fine structure of gene (Phage rII locus),	12

	cis-trans complementation test.	
2	**Foundations of genetics and cell biology** Historical development and scope of cytogenetics; Organization of chromatin: euchromatin vs. heterochromatin; Chromosome morphology: centromeres, telomeres, satellites; Chromosome classification systems; Karyotyping and idiogram preparation concept, cellular organization – its origin and evolution, biomembranes, mitochondria and chloroplast, cytoskeletal system, cell cycle and cell signalling.	08
3	**Chromosome dynamics and behavior** Cell cycle regulation and checkpoints; Mitosis: stages, spindle formation, errors leading to aneuploidy; Meiosis: crossing over, chiasmata formation, nondisjunction events;Synaptonemal complex and recombination nodules; Chromosome banding techniques: Chromosome aberrations: Numerical and structural abnormalities: Role of polyploidy in evolution and crop improvement;Case studies in humans: Down syndrome, Turner syndrome, Klinefelter syndrome, Cri-du-chat, Prader–Willi, Angelman syndromes.	08
4	**Molecular and developmental genetics** Molecular markers: Concept and detection of polymorphisms, combining ability, hybrids production, male sterility system, Microsatellites, Single nucleotide polymorphisms (SNPs), DNA sequencing techniques; QTL, marker assisted selection; principles of molecular hybridization: Fluorescence in situ hybridization (FISH); Developmental genetics: Concept on genetic regulation of development – model system: *Drosophila melanogaster* and *Arabidopsis thaliana*; molecular genetic aspects of plant nodulation and N2 fixation; floral organ identity genes and MADS box genes.	12
5	**Biostatistics** **Conceptual understanding of biostatistics** Parameters, population, finite and infinite populations; sample, random sample, Stratified sample, Clustered samples; variables and attributes; discrete and continuous variations, Data Handling; Collection, organization, frequency distribution, and graphical representation of botanical data.	04
6	**Descriptive Statistics, Probability and Distributions** Central tendency; calculation of mean, median, mode, measures of disparsion; standard deviation and standard error.Introduction to Binomial, Poisson, and Normal distributions; Inferential Statistics, Correlation & Regression;Hypothesis, null hypothesis; Chi-square test for goodness of fit; t-test and its applications, paired t-test. Pearson's correlation coefficient, linear regression, and analysis of variance (ANOVA) for data analysis.	08
7	**Plant Breeding and plant biotechnology** Definition, Gene Frequency in population; Genetic Equilibrium; Hardy-Weinberg Law; Speciation Mechanism; Breeding system and genetic consequences in plants; Genetic basis of breeding, breeding in cross pollinated and asexually reproducing plants, Special breeding techniques, Cultivar development, Quantitative genetics: Qualitative and quantitative traits; Polygenic inheritance, heritability and its measurements, QTL mapping; Marker Assisted Breeding for agronomic importance; Plant Biotechnology and crop improvement, concepts of plant regeneration, plant cell, tissue and organ cultures, Principles and methods of genetic transformation, transgenic technology and crop improvement	08
		60

PRACTICAL

Sl. No.	Content	Lecture hours
1	**Preparations of chromosome spreads:** Pre-treatment of tissues (colchicine treatment to arrest metaphase); Fixation (Carnoy's fixative); Slide preparation and staining (aceto-orcein, Giemsa)	06
2	**Karyotyping and ideogram construction:** Key Techniques: Observation of metaphase spreads under microscope; Identification of homologous chromosome pairs; arranging chromosomes according to size, centromere position, and banding pattern; Drawing or using software for idiogram construction.	06
3	**Chromosome banding techniques:**Key Techniques: Orcein banding for heterochromatin, G-banding with trypsin and Giemsa stain; C-banding for constitutive heterochromatin, Chromosome painting (Demonstration/Case Analysis)	06
4	**Detection of chromosomal aberrations:**Key Techniques: Microscopic observation of abnormal metaphase spreads; Case studies: trisomy 21 (Down syndrome), monosomy X (Turner syndrome), translocations (use of photomicrographs/digital karyotyping software.Fluorescence in-situ hybridization (FISH) (Demonstration / Virtual Simulation)	09
5	**Polyploidy and meiosis** Key Techniques: Observation of meiosis in pollen mother cells of plants (onion, maize, lilies); Identification of bivalents, multivalents, univalent.	06
6	**Biostatistics** Calculations of mean, variance, standard deviation, standard error, coefficient of variance, Use of Chi-square test for goodness of fit; use of t-test for comparing two means. Determination of relationship between variables using correlation and regression analysis. Analysis of variance: ANOVA.	09
7	**Plant Breeding** Floral biology in self and cross pollinated species, Selfing and crossing techniques, Selection methods in segregating populations and evaluation of breeding material, Learning techniques in hybrid seed production using male-sterility in field crops, Prediction of performance of double cross hybrid	09
8	**Plant Biotechnology** Organization of a tissue culture laboratory, basic techniques establishment of aseptic plant tissue culture, surface sterilization of seeds, establishment of *in vitro* cultures in different types of basal medium, study of callus and cell suspension cultures, preparation of constructs and competent cells for *Agrobacterium* mediated plant transformation, reporter gene assay using tobacco (*Nicotiana tabacum*); Biosafety: Ethical and safety guidelines (IBT regulations)	09
		60

** (Submission of laboratory records)

Suggested Reading:

1. Gardner, R.J.M., Sutherland, G.R., & Shaffer, L.G. Chromosome Abnormalities and Genetic Counseling (Oxford University Press)
2. Concepts of Genetics - William Klug, Michael Cummings, Charlotte Spencer
3. Principles of Genetics - D. Peter Snustad, Michael J. Simmons
4. Color Atlas of Genetics (Thieme, Indian edition available) – Visual guide to cytogenetics, molecular genetics, and chromosome abnormalities. Indian Editions
5. Cytogenetics - Gupta, P.K. (Rastogi Publications, Meerut, India)

6. Molecular Biology of the Cell (Garland Science, Indian edition) - Bruce Alberts
7. Verma, P.S. &Agarwal, V.K. Cell Biology, Genetics, Molecular Biology, Evolution and Ecology (S. Chand Publishing, India)
8. Biostatistical Analysis (5th Edition) by Jerrold H. Zar
9. Basic Biostatistics and its Application by Animesh Kumar Dutta - New Central Book Agency
10. Biostatistics – An Introduction P Mariappan, Pearson Publisher
11. A Textbook of Biostatistics and Research Methodology, Shashwat Publication
12. Introduction to Biostatistics (A Textbook of Biometry) by Pranab Kumar Banerjee
13. Bajpai, A.K. &Bajpai, P.Advanced Cytogenetics (Aph Publishing Corporation, India) – Focuses on cytogenetic techniques and applications.
14. Bhat, T.A. Plant Cytogenetics (CRC Press, with Indian distribution) – A plant-focused reference, especially for agricultural/plant biology students
15. Practical Manual on Plant Cytogenetics Hardcover – by Ram J. Singh
16. CYTOGENETICS, PLANT BREEDING & NANOTECHNOLOGY - Dr. M.P Singh ,Dr. SumanChauhan, Dr. Sushma Sharma.
17. Gardner EJ and Snustad DP. 1991.
18. Principles and Procedures of Plant Breeding Biotechnological and Conventional approaches. Narosa Publishing House.
19. Principles of Plant Genetics and Breeding. John Wiley & Sons. Russell PJ. 1998.
20. Plant propagation by Tissue Culture Volume 1 George, Edwin F., Hall**,** Michael A., De Klerk, Geert-Jan (Eds.), (Springer 2008)
21. Plant tissue Culture: Theory and Practice by SS Bhojwani and MK Razdan. Elsevier.
22. Principles of Gene Manipulation by Primrose and Twyman. Wiley-Blackwell publishers.

Course title & Code	Credit	Distribution of course credits			Eligibility criteria
		Lecture	Tutorial	Practical	
Minor Course: Plant Natural Resources & Economic Botany **BOTN 8021**	04	04	00	00	B.Sc. 3 yr Botany Hons.

Course title: **PLANT NATURAL RESOURCES & ECONOMIC BOTANY**

Course Code: **BOTN 8021**

Course outcome:

- This course builds a strong understanding of plants as essential natural resources and their economic, ecological and societal significance. It equips students with knowledge of economically important plant diversity, bioactive compounds and sustainable utilization strategies, while fostering practical skills in identification, phytochemical analysis and digital documentation. The course also emphasizes conservation, climate-resilient agriculture and innovative plant-based solutions for sustainable development.

Course Specific Outcome: By the end of this course, students will be able to

- Identify and classify plant natural resources and economically important species across food, medicinal, industrial and ecological sectors.
- Explain biosynthetic pathways of major plant bioactive compounds and relate them to applications in pharmacology, agriculture and industry.
- Analyze crop domestication, plant genetic resource conservation and modern challenges in sustainable agriculture and food security.
- Evaluate the economic significance of cereals, legumes, spices, fibres, oil-yielding and medicinal plants in agroecosystems and rural economies.
- Develop practical skills in plant identification, digital herbarium preparation, phytochemical screening and basic breeding techniques.
- Apply knowledge of sustainable utilization, conservation strategies and plant-based environmental solutions including phytoremediation and climate-resilient agriculture.

THEORY

Sl. No.	Content	Lecture hours
1.	**Plant Natural Resources and Bioactive Compounds** – Introduction to plant natural resources and their significance; domestication and introduction (purpose, procedure, merits, demerits, achievements and examples); classification of plant resources (food, industrial, medicinal, ornamental); role of plants in human evolution, culture and economy; biodiversity hotspots in India and the world; role of NBPGR, CIMAP, IARI and GBPUAT; major bioactive compound classes including phenolics, alkaloids, terpenoids, glycosides and	08

Sl. No.	Content	Lecture hours
	saponins.	
2.	**Biosynthetic Pathways of Plant Compounds** – Shikimate and acetate pathways and their intermediates; Mevalonate (MVA) and MEP pathways in terpenoid and steroid biosynthesis; relationship between biosynthetic routes and secondary metabolite production; functional significance in plants and humans; applications in drug development, agriculture and industry.	08
3.	**Agricultural Domestication and Biodiversity Conservation** – Vavilov's centres of origin; impact of industrial agriculture on crop genetic diversity; global diffusion of crops; modern agricultural challenges including climate change, pests and productivity; role of molecular biology in crop improvement; strategies for conserving plant genetic resources including in-situ, ex-situ and seed banks.	08
4.	**Food Security and Climate Resilience through Cereal Crops** – Sustainable practices in rice and wheat cultivation; breeding for climate-resilient varieties; importance of millets in nutrition and ecology; environmental and economic significance of millets.	05
5.	**Legumes and Sustainable Agroecosystems** – Nitrogen fixation in legumes and soil health; legumes in crop rotation; role in ecosystem sustainability, agroecology and rural economy.	05
6.	**Spices and Beverages: Morphology and Economic Role** – Morphology and trade value of clove, black pepper, ginger and turmeric; tea and coffee processing, chemistry and economics; classification and global impact of beverages.	06
7.	**Fibre and Oil-Yielding Plants** – Morphology and uses of jute, cotton, groundnut and other oilseeds; fibre and oil extraction methods; applications in food, textiles, pharmaceuticals, cosmetics and biodiesel industries.	07
8.	**Medicinal and Drug-Yielding Plants** – Traditional medicine systems including Ayurveda, Unani and Siddha; morphology, pharmacology and industrial use of medicinal plants; conservation, cultivation and sustainability challenges.	06
9.	**Economic Plants, Environmental Sustainability and Entrepreneurial Prospects** – Economic importance of algae, fungi, bryophytes, pteridophytes and gymnosperms; role of economic plants in sustainable agriculture, carbon sequestration and phytoremediation; value addition through herbal products, nutraceuticals and bio-based materials; Plant Natural Resources and Economic Plant-Based Entrepreneurship and Green Enterprises.	07
		60

Suggested reading:

1. Taiz, L., Zeiger, E., Møller, I. M., & Murphy, A. 2015. *Plant physiology and development* 6th ed. Sinauer Associates.
2. Buchanan, B., Gruissem, W., & Jones, R. 2015. *Biochemistry and molecular biology of plants* 2nd ed. Wiley Blackwell.
3. Simmonds, N. W., & Smartt, J. 1999. *Principles of crop improvement* 2nd ed. Blackwell Science.
4. Vavilov, N. I. 1992. *Origin and geography of cultivated plants*. Cambridge University Press.

5. Chrispeels, M. J., &Sadava, D. E. 2003. *Plants, genes and crop biotechnology*. Jones & Bartlett.
6. Evans, W. C. 2009. *Trease and Evans pharmacognosy* 16th ed. Saunders Elsevier.
7. Harborne, J. B. 1998. *Phytochemical methods: A guide to modern techniques of plant analysis* 3rd ed. Springer.
8. Wink, M. 2010. *Biochemistry of plant secondary metabolism* 2nd ed. Wiley Blackwell.
9. Food and Agriculture Organization. 2013. *The state of food and agriculture*. FAO.
10. Altieri, M. A. 2018. *Agroecology: The science of sustainable agriculture*. CRC Press.
11. Rao, V. R., & Hodgkin, T. 2002. Genetic diversity and conservation of plant genetic resources. *Plant Cell, Tissue and Organ Culture*, 68, 1–19.
12. Kumar, A., & Sharma, S. 2018. *Economic botany*. S. Chand.
13. Hill, A. F. 1989. *Economic botany: A textbook of useful plants and plant products*. McGraw Hill.

SEMESTER VIII

Hons.

Course title & Code	Credit	Distribution of course credits			Eligibility criteria
		Lecture	Tutorial	Practical	
Major/Core Course: Cytogenetics & Plant Breeding **BOTN 8011**	06	04	00	02	B.Sc. 3 yr Botany Hons.

Course title: **CYTOGENETICS & PLANT BREEDING**

Course Code: **BOTN 8011**

Course outcome:

- To introduce the principles of chromosome structure, function, and behavior.
- To understand chromosomal aberrations and their clinical significance.
- To familiarize students with traditional cytogenetic and molecular cytogenetic techniques.
- To develop skills in analyzing and interpreting cytogenetic data in research and diagnostics.

Course specific outcome:

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

- Understand the core principles of genetics, including inheritance, gene interactions, and chromosomal behavior.
- Describe chromosome morphology and organization.
- Explain chromosomal aberrations and their biological consequences.
- Perform basic cytogenetic laboratory techniques (e.g., karyotyping, banding).
- Understand the fundamental concepts of biostatistics, data collection, data management and interpretation in relation to evidence-based decision-making.
- Understand the various components on conceptual and applications of plant breeding programme and principles and applications of plant biotechnology

THEORY

Sl. No.	Content	Lecture hours
1	**Genes, Genomes and Genetic analysis** Historical developments in the field of genetics;organisms suitable for genetic experimentation and their significance.Mendelian genetics and its extension; multiple allele, pseudo-allele, essential and lethal genes, penetrance and expressivity; Genetic linkage, crossing over and chromosome mapping: Linkage and Recombination; Genetic mapping; genetic inheritance in pedigrees, mutation	12

	– types, mechanisms and significance; Fine structure of gene (Phage rII locus), cis-trans complementation test.	
2	**Foundations of genetics and cell biology** Historical development and scope of cytogenetics; Organization of chromatin: euchromatin vs. heterochromatin; Chromosome morphology: centromeres, telomeres, satellites; Chromosome classification systems; Karyotyping and idiogram preparation concept, cellular organization – its origin and evolution, biomembranes, mitochondria and chloroplast, cytoskeletal system, cell cycle and cell signalling.	08
3	**Chromosome dynamics and behavior** Cell cycle regulation and checkpoints; Mitosis: stages, spindle formation, errors leading to aneuploidy; Meiosis: crossing over, chiasmata formation, nondisjunction events;Synaptonemal complex and recombination nodules; Chromosome banding techniques: Chromosome aberrations: Numerical and structural abnormalities: Role of polyploidy in evolution and crop improvement;Case studies in humans: Down syndrome, Turner syndrome, Klinefelter syndrome, Cri-du-chat, Prader–Willi, Angelman syndromes.	08
4	**Molecular and developmental genetics** Molecular markers: Concept and detection of polymorphisms, combining ability, hybrids production, male sterility system, Microsatellites, Single nucleotide polymorphisms (SNPs), DNA sequencing techniques; QTL, marker assisted selection; principles of molecular hybridization: Fluorescence in situ hybridization (FISH); Developmental genetics: Concept on genetic regulation of development – model system: *Drosophila melanogaster* and *Arabidopsis thaliana*; molecular genetic aspects of plant nodulation and N2 fixation; floral organ identity genes and MADS box genes.	12
5	**Biostatistics** **Conceptual understanding of biostatistics** Parameters, population, finite and infinite populations; sample, random sample, Stratified sample, Clustered samples; variables and attributes; discrete and continuous variations, Data Handling; Collection, organization, frequency distribution, and graphical representation of botanical data.	04
6	**Descriptive Statistics, Probability and Distributions** Central tendency; calculation of mean, median, mode, measures of disparsion; standard deviation and standard error.Introduction to Binomial, Poisson, and Normal distributions; Inferential Statistics, Correlation & Regression;Hypothesis, null hypothesis; Chi-square test for goodness of fit; t-test and its applications, paired t-test. Pearson's correlation coefficient, linear regression, and analysis of variance (ANOVA) for data analysis.	08
7	**Plant Breeding and plant biotechnology** Definition, Gene Frequency in population; Genetic Equilibrium; Hardy-Weinberg Law; Speciation Mechanism; Breeding system and genetic consequences in plants; Genetic basis of breeding, breeding in cross pollinated and asexually reproducing plants, Special breeding techniques, Cultivar development, Quantitative genetics: Qualitative and quantitative traits; Polygenic inheritance, heritability and its measurements, QTL mapping; Marker Assisted Breeding for agronomic importance; Plant Biotechnology and crop improvement, concepts of plant regeneration, plant cell, tissue and organ cultures, Principles and methods of genetic transformation, transgenic technology and crop improvement	08
		60

PRACTICAL

Sl. No.	Content	Lecture hours
1	**Preparations of chromosome spreads:** Pre-treatment of tissues (colchicine treatment to arrest metaphase); Fixation (Carnoy's fixative); Slide preparation and staining (aceto-orcein, Giemsa)	06
2	**Karyotyping and ideogram construction:** Key Techniques: Observation of metaphase spreads under microscope; Identification of homologous chromosome pairs; arranging chromosomes according to size, centromere position, and banding pattern; Drawing or using software for idiogram construction.	06
3	**Chromosome banding techniques:**Key Techniques: Orcein banding for heterochromatin, G-banding with trypsin and Giemsa stain; C-banding for constitutive heterochromatin, Chromosome painting (Demonstration/Case Analysis)	06
4	**Detection of chromosomal aberrations:**Key Techniques: Microscopic observation of abnormal metaphase spreads; Case studies: trisomy 21 (Down syndrome), monosomy X (Turner syndrome), translocations (use of photomicrographs/digital karyotyping software.Fluorescence in-situ hybridization (FISH) (Demonstration / Virtual Simulation)	09
5	**Polyploidy and meiosis** Key Techniques: Observation of meiosis in pollen mother cells of plants (onion, maize, lilies); Identification of bivalents, multivalents, univalent.	06
6	**Biostatistics** Calculations of mean, variance, standard deviation, standard error, coefficient of variance, Use of Chi-square test for goodness of fit; use of t-test for comparing two means. Determination of relationship between variables using correlation and regression analysis. Analysis of variance: ANOVA.	09
7	**Plant Breeding** Floral biology in self and cross pollinated species, Selfing and crossing techniques, Selection methods in segregating populations and evaluation of breeding material, Learning techniques in hybrid seed production using male-sterility in field crops, Prediction of performance of double cross hybrid	09
8	**Plant Biotechnology** Organization of a tissue culture laboratory, basic techniques establishment of aseptic plant tissue culture, surface sterilization of seeds, establishment of *in vitro* cultures in different types of basal medium, study of callus and cell suspension cultures, preparation of constructs and competent cells for *Agrobacterium* mediated plant transformation, reporter gene assay using tobacco (*Nicotiana tabacum*); Biosafety: Ethical and safety guidelines (IBT regulations)	09
		60

** (Submission of laboratory records)

Suggested Reading:

23. Gardner, R.J.M., Sutherland, G.R., & Shaffer, L.G. Chromosome Abnormalities and Genetic Counseling (Oxford University Press)
24. Concepts of Genetics - William Klug, Michael Cummings, Charlotte Spencer
25. Principles of Genetics - D. Peter Snustad, Michael J. Simmons

26. Color Atlas of Genetics (Thieme, Indian edition available) – Visual guide to cytogenetics, molecular genetics, and chromosome abnormalities. Indian Editions
27. Cytogenetics - Gupta, P.K. (Rastogi Publications, Meerut, India)
28. Molecular Biology of the Cell (Garland Science, Indian edition) - Bruce Alberts
29. Verma, P.S. &Agarwal, V.K. Cell Biology, Genetics, Molecular Biology, Evolution and Ecology (S. Chand Publishing, India)
30. Biostatistical Analysis (5th Edition) by Jerrold H. Zar
31. Basic Biostatistics and its Application by Animesh Kumar Dutta - New Central Book Agency
32. Biostatistics – An Introduction P Mariappan, Pearson Publisher
33. A Textbook of Biostatistics and Research Methodology, Shashwat Publication
34. Introduction to Biostatistics (A Textbook of Biometry) by Pranab Kumar Banerjee
35. Bajpai, A.K. &Bajpai, P.Advanced Cytogenetics (Aph Publishing Corporation, India) – Focuses on cytogenetic techniques and applications.
36. Bhat, T.A. Plant Cytogenetics (CRC Press, with Indian distribution) – A plant-focused reference, especially for agricultural/plant biology students
37. Practical Manual on Plant Cytogenetics Hardcover – by Ram J. Singh
38. CYTOGENETICS, PLANT BREEDING & NANOTECHNOLOGY - Dr. M.P Singh ,Dr. SumanChauhan, Dr. Sushma Sharma.
39. Gardner EJ and Snustad DP. 1991.
40. Principles and Procedures of Plant Breeding Biotechnological and Conventional approaches. Narosa Publishing House.
41. Principles of Plant Genetics and Breeding. John Wiley & Sons. Russell PJ. 1998.
42. Plant propagation by Tissue Culture Volume 1 George, Edwin F., Hall**,** Michael A., De Klerk, Geert-Jan (Eds.), (Springer 2008)
43. Plant tissue Culture: Theory and Practice by SS Bhojwani and MK Razdan. Elsevier.
44. Principles of Gene Manipulation by Primrose and Twyman. Wiley-Blackwell publishers.

Course title & Code	Credit	Distribution of course credits			Eligibility criteria
		Lecture	Tutorial	Practical	
Major/Core Course: Ecology and Evolutionary Biology **BOTN 8012**	04	03	00	01	B.Sc. 3 yr Botany Hons.

Course title: **ECOLOGY AND EVOLUTIONARY BIOLOGY**

Course Code: **BOTN 8012**

Course outcome:

- Introduce students to the concept of environmental stress in plants, including tolerance limits and physiological responses to physical stress factors.
- Develop a comprehensive understanding of adaptation mechanisms in plants, encompassing morphological, anatomical, biochemical, and eco-physiological strategies across diverse habitats.
- Provide in-depth knowledge of population ecology, including population structure, growth models, life-history strategies, and regulatory mechanisms.
- Explain the principles of community ecology, focusing on community structure, diversity patterns, succession processes, and climax concepts.
- Examine species interactions as ecological and evolutionary processes, highlighting competition, predation, mutualism, niche differentiation, and coevolution.
- Familiarize students with ecosystem energetics, including productivity, energy flow, trophic organization, and global patterns of biomass and net primary productivity.
- Explain nutrient cycling and decomposition processes, emphasizing soil–plant interactions and ecosystem functioning.
- Build awareness of global environmental issues, particularly climate change, greenhouse effects, and mitigation and adaptation strategies.
- Provide an evolutionary perspective on plant diversity, speciation processes, hybridization, and the role of polyploidy in plant evolution.
- Develop practical and analytical skills in ecological field methods, data interpretation, and experimental approaches relevant to plant ecology and evolution.

Course Specific Outcome: By the end of this course, students will be able to

- Explain the concept of environmental stress in plants, including tolerance limits, physiological norms, and responses to physical stress factors.
- Analyze different types of plant adaptations and relate structural and functional traits to ecological conditions in mangroves, epiphytes, parasites etc.
- Apply principles of population ecology to interpret population distribution patterns, growth models, life tables, survivorship curves, and population regulation mechanisms.
- Evaluate metapopulation dynamics and life-history strategies, including r- and K-selection, CSR strategies, and trade-offs influencing population persistence and evolution.

- Describe the structure and dynamics of ecological communities, quantify species diversity using standard indices, and explain succession and climax concepts.
- Interpret species interactions using ecological and mathematical models, and assess their roles in natural selection, coevolution, and community organization.
- Explain ecosystem energetics, including primary productivity, energy flow through trophic levels, ecological efficiencies, and global patterns of biomass distribution.
- Analyze nutrient cycling and decomposition processes, including litter decomposition, rhizosphere interactions, and factors influencing nutrient turnover.
- Assess major global environmental issues, particularly climate change, global warming, ozone depletion, and associated mitigation and adaptation strategies.
- Explain the evolutionary processes underlying plant diversity, including speciation mechanisms, reproductive isolation, hybridization, introgression, and polyploidy.
- Perform ecological field and laboratory techniques, including vegetation analysis, productivity estimation, life table construction, and assessment of environmental parameters, and interpret ecological data scientifically.

THEORY

Sl. No.	Content	Lecture hours
1	**Environment and Stress:** Environment as a complex of stress factors; concept of stress in plants; physical stress concept (Levitt, 1980); physiological normal type and tolerance limits.	03
2	**Adaptation:** Concept and types of adaptation; morphological, anatomical, biochemical, and eco-physiological adaptations; adaptive strategies of epiphytes, parasites, halophytes and mangroves.	05
3	**Population Ecology:** Unitary and modular organisms; population distribution patterns and sampling techniques; population growth models: geometric and logistic; life tables: dynamic and time-specific; survivorship curves and mortality patterns; population regulation: density-dependent and density-independent factors; carrying capacity; scramble and contest competition; exploitation and interference. *Metapopulation Dynamics:* Concept and conditions of metapopulation; core and satellite populations; colonization and extinction; habitat heterogeneity; rescue effect; allee effect; iterative evolution *Life-History Strategies:* Life-history trade-offs; Age-specific mortality patterns; Trade-off between offspring size and number; r- and K-selection; Grime's CSR life-history strategies.	12
4	**Community Ecology:** Nature and structure of communities; Community attributes; Species diversity: alpha, beta, gamma diversity; Measurement of diversity indices; Ecological edges and ecotones; Ecological succession: types and mechanisms; Climax concepts.	05
5	**Species Interactions:** Types of species interactions; Species interactions as agents of natural selection; Coevolution and diffuse coevolution; Geographic mosaic of species interactions; Fundamental and realized niche; Interspecific competition: Lotka–Volterra model; Predation: types and predator–prey model; Keystone species (predators and mutualists); Flagship and umbrella species.	04
6	**Ecosystem Energetics:** Gross and net primary productivity; Standing crop biomass; Measurement of productivity: light and dark bottle method; NPP in terrestrial and	04

Sl. No.	Content	Lecture hours
	aquatic ecosystems; Global patterns of NPP and plant biomass; Compensation depth in oceans; Food chains and food webs; Energy flow through trophic levels; Ecological efficiencies; Energy flow models and energy pyramids.	
7	**Nutrient Cycling and Decomposition:** Nutrient cycling and retranslocation; Decomposition processes: leaching, fragmentation, ingestion, mineralization; Litterbag experiments; Factors affecting decomposition rate; Rhizosphere and soil organic matter decomposition.	04
8	**Global Environmental Issues:** Greenhouse gases and global warming; Climate change and sea-level rise; Ozone layer depletion; Mitigation and adaptation strategies.	03
9	**Evolution of Plant Diversity:** Theories of organic evolution; Sources and patterns of variation; Local and geographical variation; Speciation: allopatric, sympatric, parapatric, peripatric; Reproductive isolation barriers and their origin; Hybridization and introgression; Hybrid speciation; Polyploidy and plant evolution.	05
		45

PRACTICAL

Sl. No.	Content	Lecture hours
1	Quadrat and transect methods for vegetation analysis and determination of Relative frequency, Relative density and Relative dominance.	09
2	Construction and interpretation of life tables.	03
3	Study of reproductive isolation mechanism in plants.	06
4	Studies of ecological adaptation of xerophytes, hydrophytes, epiphytes, parasites, halophytes and mangroves.	06
5	Determination of some environmental parameters (organic carbon and dissolve oxygen).	06
		30

Suggested reading:

1. Begon, M., Townsend, C. R., & Harper, J. L. (2006). Ecology: From Individuals to Ecosystems (4th ed.). Blackwell Publishing.
2. Connell, J. H. &Slatyer, R. O. (1977). Mechanisms of Succession. American Naturalist.
3. Cunningham, W. P. & Cunningham, M. A. (2018). Environmental Science: A Global Concern. McGraw-Hill.
4. Gotelli, N. J. (2008). A Primer of Ecology (4th ed.). Sinauer.
5. Grant, V. (1981). Plant Speciation. Columbia University Press.
6. Grime, J. P. (2001). Plant Strategies, Vegetation Processes, and Ecosystem Properties (2nd ed.). Wiley.
7. Gurevitch, J., Scheiner, S.M. and Fox, G.A. (2013) Ecology of Plants, Oxford University Press
8. Hanski, I. (1999). Metapopulation Ecology. Oxford University Press.

9. Harper, J. L. (1977). Population Biology of Plants. Academic Press.
10. Kent, M. & Coker, P. (1992). Vegetation Description and Analysis. Wiley.
11. Kozlowski, T. T., Kramer, P. J., & Pallardy, S. G. (1991). The Physiological Ecology of Woody Plants. Academic Press.
12. Krebs, Charles J. (2014) Ecology: the experimental analysis of distribution and abundance, Pearson Education Limited.
13. Larcher, W. (2003). Physiological Plant Ecology (4th ed.). Springer.
14. Lieth, H. & Whittaker, R. H. (1975). Primary Productivity of the Biosphere. Springer.
15. Magurran, A. E. (2004). Measuring Biological Diversity. Blackwell.
16. Misra, R. (1968). Ecology Workbook. Oxford & IBH.
17. Molles, M. C. (2016). Ecology: Concepts and Applications. McGraw-Hill.
18. Odum, E. P. & Barrett, G. W. (2005). Fundamentals of Ecology (5th ed.). Cengage Learning.
19. Paine, R. T. (1966). Keystone species concept (classic papers).
20. Peter Stiling (2012) Ecology: Global Insights and Investigations, McGraw-Hill.
21. Ricklefs, R. E. & Relyea, R. A. (2014). Ecology: The Economy of Nature (7th ed.). W.H. Freeman.
22. Ricklefs, R. E. (2010). The Economy of Nature.
23. Smith, T. M. & Smith, R. L. (2015). Elements of Ecology (9th ed.). Pearson.
24. Stebbins, G. L. (1950). Variation and Evolution in Plants. Columbia University Press.
25. Thompson, J. N. (2005). The Geographic Mosaic of Coevolution. University of Chicago Press.
26. Tomlinson, P. B. (2016). The Botany of Mangroves (2nd ed.). Cambridge University Press.
27. Walter, H. (1985). Vegetation of the Earth and Ecological Systems of the Geo-Biosphere. Springer.

Course title & Code	Credit	Distribution of course credits			Eligibility criteria
		Lecture	Tutorial	Practical	
Major/Core Course: Palaeobotany & Reproductive biology **BOTN 8013**	04	03	00	01	B.Sc. 3 yr Botany Hons.

Course title: **PALAEOBOTANY & REPRODUCTIVE BIOLOGY**

Course Code: **BOTN 8013**

Course outcome:

- To define stratigraphy and corelation principles with the physiological and fundamental idea about rocks, and fossils.
- To study earth's environmental and ecological history, standard geological time scale with events of plant evolution.
- To understand the Earth crust's drifting concept and movement plate tectonic, and early life forms.
- Provide a comprehensive understanding of spore and pollen morphology, including polarity, symmetry, shape, size, and apertural organization.
- Familiarize students with standardized palynological terminology and systems, particularly the NPC system for numerical expression of apertural characters.
- Develop conceptual clarity on the ultrastructure of sporoderms, including exine stratification, surface sculptures, and the chemical nature and biological significance of sporopollenin.
- Highlight the applied aspects of palynology and palaeopalynology, including forensic investigations, aeropalynology and allergy studies, melissopalynology, and fossil fuel exploration.
- Develop hands-on practical skills in pollen and spore preparation, identification, and interpretation using standard laboratory techniques.

Course Specific Outcome: By the end of this course, students will be able to

- It enables the identification and interpretation of fossils as vital records of ancient life
- It enables the basic idea of stratigraphy and its corelation principles, identify different rocks, their age and changes over time can tell the story of Earth's past.
- It will provide a fundamental understanding of Earth's early environments, the standard geological time scale, and the progression of plant evolution through time
- They can explore the earliest evidence of life forms in the Precambrian era, the mechanics of continental drift and plate tectonics, and the role of plant fossils in reconstructing ancient ecosystems.
- Describe and classify spores and pollen grains based on polarity, symmetry, shape, size, and aperture patterns.
- Apply the NPC system accurately for numerical expression and comparison of apertural characters in pollen grains.
- Evaluate the applications of palynology in forensic science, allergy diagnosis (aeropalynology), honey analysis (melissopalynology), and hydrocarbon exploration.

- Prepare and process spore and pollen samples from pteridophytes, gymnosperms, and angiosperms using acetolysis and alkali maceration techniques.
- Identify pollen morpho-types and construct diagnostic keys based on morphological characters.
- Extract and analyze pollen from honey samples, and perform qualitative and quantitative assessments relevant to botanical and geographical origin studies.

THEORY

Sl. No.	Content	Lecture hours
1	Definition, scope, objectives and significance of Palaeobotany; Types of fossils; Fossilization Processes; Environment for fossilization; Geologic Time Scale and plant life through the ages.	04
2	Structure of the Earth, major rock types, Stratigraphy and Principals of correlation; Rock cycle;Dating of rocks.	05
3	The theory of Continental Drift and Plate Tectonics, mid-ocean ridges, different plate boundaries and its evidences on earth.	03
4	Chemical evolution and origin of life:Age of the Earth, The Prebiotic environment,Different theories of origin of life.	04
5	Early life forms as known from Precambrian:evolution of eukaryotes.	04
6	Evolution of early land plants: A brief overview of fossil Pteridophytes (Rhyniopsida, Trimerophytopsida, Lycopodiopsida), Progymnospermsand fossil Gymnosperms (Pteridospermopsida, Cycadopsida, Ginkgopsida andConiferopsida).	05
7	The Gondwana System, Gondwana countries; Bipartite and tripartite division of Indian Gondwana, Macrofloral assemblages of Indian Gondwana; Fundamentals of Paleofloristics, Palaeogeography, palaeoecology and Palaeoclimatology.	05
8	**Spore-pollen morphology**: polarity, symmetry, shape, size, aperture patterns, NPC system for numerical expression of apertural details; exine stratification, surface structure and sculptures of sporoderms; LO analysis; sporopollenin- chemical nature, biological significance; development of pollen wall-Ubischbody;viscin threads, pollen kitt.	05
9	**Pollen dispersal units**, concept of anthesis, pollination modes, floral construction, pollination syndromes with special reference to melittophilous, miophilous, sapromyophilous, lepidophilous flowers.	05
10	**Application of palynology& paleopalynology**: forensic palynology, aeropalynology with reference to allergy; Melissopalynology; exploration of fossil fuel.	05
		45

PRACTICAL

Sl. No.	Content	Lecture hours
1	Identification of different types of fossils (petrifaction, compression, impression, cast, mold etc.), Identification of fossil Pteridophytes and Gymnosperms (using fossil specimens/photographs/permanent slides); determination of their age and mode of preservation.	06
2	Visit to a Palaeobotanical/Palynological laboratory/Institute/Museum or Collection of fossils in the field.	09
3	Spore and pollen morphological study: selected pteridophytes, gymnosperms, and angiosperms using acetolysis/alkali maceration method; preparation of key to pollen sample.	09
4	Extraction of pollen grains from honey sample and qualitative and quantitative analyses of pollen morpho-types.	06
		30

Suggested reading:

1. Agashe, S.N. (1995), Palaeobotany, Oxford & IBH, New Delhi.
2. Arnold, C.A. (1947): Introduction to Palaeobotany, Mc-Graw Hill Book Co. Inc., New York and London.
3. Bierhorst D.W. (1971): Morphology of vascular plants McMillan, New York.
4. Eames, A.J.(1974): Morphology of Vascular Plants-lower groups, Tata Mc-Graw Hill publishing Co., New Delhi.
5. Foster A.S. & Gifford F.M. (1967): Comparative morphology of vascular plants, FreemanPublishers, San Fransisco.
6. Kakkar, R.K.and Kakkar, B.R. (1995), The Gymnosperms (Fossils & Living), Central Publishing House, Allahabad.
7. Pant, D.D. (2003): Cycas and allied Cycadophytes, BSIP, Publications.
8. Siddiqui, K.A. (2002) Elements of Palaeobotany, Kitab Mahal, Allahabad.
9. Spicer, R.A. & Thomas, B.A. (1986) Systematic and taxonomic approaches in Palaeobotany. Systematic Association Special Volume.
10. Stewart, W.N. and Rothwell G.W. (1993), Palaeobotany and the Evolution of Plants, Cambridge University Press.
11. Thomas, B.A. & Spicer R.A. (1987): The Evolution and Palaeobiology of land plants. Discordies Press, Fortland, USA.
12. Bhattacharya, K., M R Majumdar and S G Bhattacharya 2006: A Text book of Palynology.
13. Erdtman, G.1988 : Pollen morphology and plant taxonomy.
14. Fageri, K and J Inversen, 1964: Text book of pollen analysis.
15. Gregory, P H, 1973: Microbiology of atmosphere.
16. Heslop-Harrison, Y. 1971: Pollen development and physiology.
17. Nair, P K K1964 : Advances in Palynology.
18. Nair, P K K1966 : Essentials of Palynology.
19. Shivanna K R and N S Rangaswami 1992 : Pollen Biology, A Laboratory manual.
20. Tilak, S T. 1989 : Airborne pollen and fungal spores.

Course title & Code	Credit	Distribution of course credits			Eligibility criteria
		Lecture	Tutorial	Practical	
Major/Core Course: Phycology & Indian Knowledge System **BOTN 8014**	Unit I: (Phycology): 02 + Unit II (Indian Knowledge System): 02= 04	Unit I: (Phycology): 1.5 + Unit II (Indian Knowledge System): 1.5= 03	00	Unit I: (Phycology): 0.5 + Unit II (Indian Knowledge System): 0.5= 1	B.Sc. 3 yr Botany Hons.

Course title: **PHYCOLOGY & INDIAN KNOWLEDGE SYSTEM**

Course Code: **BOTN 8014**

Unit I

Unit title: **PHYCOLOGY**

Course outcome:

- To introduce modern principles and criteria of algal classification with emphasis on chloroplast ultrastructure, flagellar organization, pigments, and molecular phylogeny.
- To develop an understanding of endosymbiotic theory and its significance in the origin and evolution of algal groups.
- To provide detailed knowledge of major algal divisions, including Cyanophyta, Rhodophyta, Chlorophyta, and photosynthetic stramenopiles, with reference to structure, reproduction, ecology, and economic importance.
- To explain evolutionary trends in algae and their role in the origin of land plants in the light of contemporary research.
- To highlight the ecological and economic significance of algae in natural ecosystems and applied sectors.
- To familiarize students with emerging areas of algal biotechnology such as aquaculture, biofuel production, carbon sequestration, bioremediation, and industrial applications.
- To develop practical skills in the collection, preservation, identification, and microscopic examination of freshwater and marine algae.
- To train students in phytoplankton sampling techniques and the study of representative algal forms from diverse habitats.

Course Specific Outcome: By the end of this course, students will be able to

- Explain modern criteria used in algal classification and evaluate the significance of ultrastructural, biochemical, and molecular characters in algal systematics.
- Describe the concept of endosymbiosis and interpret its role in the evolution of plastids and diversification of algal lineages.
- Characterize major algal groups such as Cyanophyta, Rhodophyta, Chlorophyta, and stramenopiles in terms of morphology, reproduction, ecology, and economic value.
- Analyse reproductive strategies and post-fertilization changes in selected algal groups and relate them to evolutionary trends.
- Discuss the evolutionary significance of green algae in the origin of land plants using modern

phylogenetic evidence.

- Evaluate the ecological roles of algae and their applications in biotechnology, including biofuel production, carbon sequestration, aquaculture, and industrial uses.
- Demonstrate proficiency in the collection and identification of local freshwater and marine algae using standard taxonomic keys and microscopic techniques.
- Apply appropriate methods for sampling and studying phytoplankton and interpret their ecological significance.
- Prepare laboratory records and identify representative algal specimens based on morphological and anatomical characters.

THEORY

Sl. No.	Content	Lecture hours
1.	Modern criteria of algal classification with special emphasis on chloroplast ultrastructure, flagella, molecular data and pigments.	03
2.	Endosymbiosis and its significance in algae.	04
3.	**Cyanophyta:** General features & ecology; genetic recombination; heterocyst structure and function; affinities, economic aspects.	03
4.	**Rhodophyta:** General features; specialities in sexual reproduction and post-fertilization changes, economic aspects.	03
5.	**Chlorophyta:** Characteristic features of different classes highlighting distinctive features of different orders; evolutionary trends in light of modern findings; origin of land plants from algae.	04
6.	**Photosynthetic Stramenopiles**: distinctive features	03
7.	**Algal biotechnology:** aquaculture, bioremediation, biodiesel, bioethanol and hydrogenproduction by algae, carbon sequestration by algae, algae as health food; Industrial use of algae, photobioreactors and raceway ponds, modern trends.	03
		23

PRACTICAL

Sl. No.	Content	Lecture hours
1.	Collection & identification of local algae of West Bengal.	06
2.	Study of common phytoplankton and its method of collection.	06
3.	Study of representative marine algae.	03
		15

Suggested reading:

1. Phycology by Robert Edward Lee, 5th Edition
2. Algae by James E. Graham , Linda E. Graham, Lee W. Wilcox , M.E. Cook, 3rd Edition
3. Freshwater Algae: Identification, Enumeration and Use as Bioindicators by Edward G.

Bellinger, David C. Sigee, 2nd Edition

4. Algae: Anatomy, Biochemistry, and Biotechnology, By Laura Barsanti, Paolo Gualtieri, 2nd Edition.
5. The Algae World, by Dinabandhu Sahoo and Joseph Seckbach.
6. A beginner's guide to freshwater algae, by Hilary Belcher , Erica Swale.
7. Freshwater Algae of North America, by John Wehr Robert Sheath, J. Patrick Kociolek, 2nd Edition.

Unit II

Unit title:: **INDIAN KNOWLEDGE SYSTEM**

Course outcome:

- To introduce students to the science of how people use plants in different cultures and societies (ethnobotany), with emphasis on current research and issues. Introduce students with the basic concepts of ethnobotany with emphasis plant-human interactions.

Course Specific Outcome: By the end of this course, students will be able to

- Understand the importance of ethanobotany and use of traditional knowledge in India. Ø¬ Know about the ethnobotanical survey techniques.
- Understand the ethnobotanical knowledge and analyze the data for research and drug discovery.

THEORY

Sl. No.	Content	Lecture hours
1.	Indian Knowledge Systems (IKS) in plant and agricultural sciences. Vrikshayurveda (10th Century): Attributed to Surapala, land classification, plant propagation, and the treatment of plant diseases.	02
2.	Krishi Parashara: An ancient text focusing on climate-based agro-techniques and the socio-economic aspects of farming.	02
3.	Bijotpatti (Seed Science): Techniques for seed selection and preservation; Barahnaja (Agro-Biodiversity): The traditional "twelve seeds" system	02
4.	Introduction to Ethnobotany, Traditional Knowledge (TK), Traditional Knowledge Resource Classification (TKRC), importance of traditional knowledge, Traditional plant knowledge of Indian tribes - sources and problems, Traditional Knowledge Digital Library (TKDL).	03
5.	Usage of indigenous plants in different cultures of the world for various purposes, Interactions of humans and plants in the past in cultures around the world: archaeobotany, paleoethnobotany, ethnohistory.	03
6.	Evidences in favour of biodiversity and sustainability as ethnobotanical principles of human interactions with plants.	02
7.	Global movement of plants and human cultures, importance of ethnobotany in traditional and modern culture, Cultural relevance of the native flora to the indigenous cultures of the World. Importance of ethnobotanical knowledge in community decision-making processes	03
8.	Ethical issues and bioprospecting, Biopiracy, World Trade Organisation (WTO) and TK, provisions of Conventions on Biological Diversity (CBD) related to	03

Sl. No.	Content	Lecture hours
	traditional knowledge.	
9.	Ethnobotany and Plant Conservation, Ethnobotany and Germplasm diversity.	02
		22

PRACTICAL

Sl. No.	Content	Lecture hours
1.	Quantitative Ethnobotany and survey field methods.	04
2.	Methods of collecting plant-use information from indigenous cultures, and ways that this information contributes to other fields of study, such as resource management, community development, and human health	05
3.	Taxonomic and Herbarium Studies. Identification of local medicinal, edible, wild, and sacred plants using floras and botanical keys.	03
4.	Applications of multivariate and statistical methods (Cluster and Principal Component Analysis, ANOVA, Regression Analysis, Correlation etc.) in Ethnobotany. Ethics in ethnobotany research.	03
		15

Suggested reading:

1. Levitin E and MacMohan K. 2011. Plants and Society. The McGraw-Hill Companies, Inc., 1221, Avenue of the Americas, New York, NY.
2. Indian Knowledge Systems. B. Mahadevan
3. Cunningham, A B. 2001. Applied Ethnobotany: People, Wild Plant Use and Conservation. Earthscan Publications Ltd. London and Sterling, VA.
4. Gary J Martin 1995. Ethnobotany: A Methods Manual by. Springer-Science+Media, B.V.
5. Balick, M. and P A. Cox. 1996. Plants, People, and Culture: The Science of Ethnobotany. Scientific American Library, A division of HPHLP, New York.
6. Cotton, C M. 1997.Ethnobotany – Principles and Applications. John Wiley and Sons Limited. New York, USA. 6. Jain, SK. 1989.
7. Methods and Approaches in Ethnobotany. Society of Ethnobotanists. Lucknow.
8. Schultes, RE., & Reis Sv. 1995. Ethnobotany. Evolution of a discipline. Chapman & Hall. London

Course title & Code	Credit	Distribution of course credits			Eligibility criteria
		Lecture	Tutorial	Practical	
Minor Course: Plant Natural Resources & Economic Botany **BOTN 8021**	04	04	00	00	B.Sc. 3 yr Botany Hons.

Course title: **PLANT NATURAL RESOURCES & ECONOMIC BOTANY**

Course Code: **BOTN 8021**

Course outcome:

- This course builds a strong understanding of plants as essential natural resources and their economic, ecological and societal significance. It equips students with knowledge of economically important plant diversity, bioactive compounds and sustainable utilization strategies, while fostering practical skills in identification, phytochemical analysis and digital documentation. The course also emphasizes conservation, climate-resilient agriculture and innovative plant-based solutions for sustainable development.

Course Specific Outcome: By the end of this course, students will be able to

- Identify and classify plant natural resources and economically important species across food, medicinal, industrial and ecological sectors.
- Explain biosynthetic pathways of major plant bioactive compounds and relate them to applications in pharmacology, agriculture and industry.
- Analyze crop domestication, plant genetic resource conservation and modern challenges in sustainable agriculture and food security.
- Evaluate the economic significance of cereals, legumes, spices, fibres, oil-yielding and medicinal plants in agroecosystems and rural economies.
- Develop practical skills in plant identification, digital herbarium preparation, phytochemical screening and basic breeding techniques.
- Apply knowledge of sustainable utilization, conservation strategies and plant-based environmental solutions including phytoremediation and climate-resilient agriculture.

THEORY

Sl. No.	Content	Lecture hours
1	**Plant Natural Resources and Bioactive Compounds** – Introduction to plant natural resources and their significance; domestication and introduction (purpose, procedure, merits, demerits, achievements and examples); classification of plant resources (food, industrial, medicinal, ornamental); role of plants in human evolution, culture and economy; biodiversity hotspots in India and the world; role of NBPGR, CIMAP, IARI and GBPUAT; major bioactive compound classes including phenolics, alkaloids, terpenoids, glycosides and	08

Sl. No.	Content	Lecture hours
	saponins.	
2	**Biosynthetic Pathways of Plant Compounds** – Shikimate and acetate pathways and their intermediates; Mevalonate (MVA) and MEP pathways in terpenoid and steroid biosynthesis; relationship between biosynthetic routes and secondary metabolite production; functional significance in plants and humans; applications in drug development, agriculture and industry.	08
3	**Agricultural Domestication and Biodiversity Conservation** – Vavilov's centres of origin; impact of industrial agriculture on crop genetic diversity; global diffusion of crops; modern agricultural challenges including climate change, pests and productivity; role of molecular biology in crop improvement; strategies for conserving plant genetic resources including in-situ, ex-situ and seed banks.	08
4	**Food Security and Climate Resilience through Cereal Crops** – Sustainable practices in rice and wheat cultivation; breeding for climate-resilient varieties; importance of millets in nutrition and ecology; environmental and economic significance of millets.	05
5	**Legumes and Sustainable Agroecosystems** – Nitrogen fixation in legumes and soil health; legumes in crop rotation; role in ecosystem sustainability, agroecology and rural economy.	05
6	**Spices and Beverages: Morphology and Economic Role** – Morphology and trade value of clove, black pepper, ginger and turmeric; tea and coffee processing, chemistry and economics; classification and global impact of beverages.	06
7	**Fibre and Oil-Yielding Plants** – Morphology and uses of jute, cotton, groundnut and other oilseeds; fibre and oil extraction methods; applications in food, textiles, pharmaceuticals, cosmetics and biodiesel industries.	07
8	**Medicinal and Drug-Yielding Plants** – Traditional medicine systems including Ayurveda, Unani and Siddha; morphology, pharmacology and industrial use of medicinal plants; conservation, cultivation and sustainability challenges.	06
9	**Economic Plants, Environmental Sustainability and Entrepreneurial Prospects** – Economic importance of algae, fungi, bryophytes, pteridophytes and gymnosperms; role of economic plants in sustainable agriculture, carbon sequestration and phytoremediation; value addition through herbal products, nutraceuticals and bio-based materials; Plant Natural Resources and Economic Plant-Based Entrepreneurship and Green Enterprises.	07
		60

Suggested reading:

14. Taiz, L., Zeiger, E., Møller, I. M., & Murphy, A. 2015. *Plant physiology and development* 6th ed. Sinauer Associates.
15. Buchanan, B., Gruissem, W., & Jones, R. 2015. *Biochemistry and molecular biology of plants* 2nd ed. Wiley Blackwell.
16. Simmonds, N. W., & Smartt, J. 1999. *Principles of crop improvement* 2nd ed. Blackwell Science.
17. Vavilov, N. I. 1992. *Origin and geography of cultivated plants*. Cambridge University Press.

18. Chrispeels, M. J., &Sadava, D. E. 2003. *Plants, genes and crop biotechnology*. Jones & Bartlett.
19. Evans, W. C. 2009. *Trease and Evans pharmacognosy* 16th ed. Saunders Elsevier.
20. Harborne, J. B. 1998. *Phytochemical methods: A guide to modern techniques of plant analysis* 3rd ed. Springer.
21. Wink, M. 2010. *Biochemistry of plant secondary metabolism* 2nd ed. Wiley Blackwell.
22. Food and Agriculture Organization. 2013. *The state of food and agriculture*. FAO.
23. Altieri, M. A. 2018. *Agroecology: The science of sustainable agriculture*. CRC Press.
24. Rao, V. R., & Hodgkin, T. 2002. Genetic diversity and conservation of plant genetic resources. *Plant Cell, Tissue and Organ Culture*, 68, 1–19.
25. Kumar, A., & Sharma, S. 2018. *Economic botany*. S. Chand.
26. Hill, A. F. 1989. *Economic botany: A textbook of useful plants and plant products*. McGraw Hill.