THE UNIVERSITY OF BURDWAN

SYLLABUS OF TWO YEAR POSTGRADUATE PROGRAMME

IN

BOTANY

Under

Curriculum and Credit Framework for Postgraduate Programme (CCFPP), as per N.E.P. 2020

w.e.f. 2026 – 2027

2- year PG Programme

Semesterwise and Coursewise Distribution of Credit & Marks under CCFPP as per NEP, 2020

SEMESTER	Course Type	Code & Level	Name of the Course	Credit	L – T - P	Marks	Marks Dist. Th. – Pr. - IA
I	Major/Core Course	**PG2 BOTN 1011 (400-499)**	Research Methodology & Ethics	6	5- 0 - 1 (75+30 lecture hrs)	75	40 – 20 – 15
	Major/Core Course	**PG2 BOTN 1012 (400-499)**	Microbiology, Mycology and Plant Pathology	6	4- 0- 2 (60+60 lecture hrs)	75	40 – 20 – 15
	Major/Core Course	**PG2 BOTN 1013 (400-499)**	Archegoniates& Angiosperm Systematics	6	4- 0- 2 (60+60 lecture hrs)	75	40 – 20 – 15
	Major/Core Course	**PG2 BOTN 1014 (400-499)**	Plant Physiology, Biochemistry & Molecular Biology	6	4- 0- 2 (60+60 lecture hrs)	75	40 – 20 – 15
	Minor Course	**PG2 BOTN 1021 (300-399)**	Plant Biodiversity, Informatics & Environmental Sustainability	4	3- 1- 0 (60 lecture hrs)	75	60 – 0 – 15
	Total			**28**		**375**	
II	Major/Core Course	**PG2 BOTN 2011 (400-499)**	Cytogenetics & Plant Breeding	6	4- 0- 2 (60 + 60 lecture hrs)	75	40 – 20 – 15
	Major/Core Course	**PG2 BOTN 2012 (400-499)**	Ecology and Evolutionary Biology	4	3- 0- 1 (45 +30 lecture hrs)	75	40 – 20 – 15
	Major/Core Course	**PG2 BOTN 2013 (400-499)**	Palaeobotany & Reproductive biology	4	3- 0- 1 (45 +30 lecture hrs)	75	40 – 20 – 15
	Major/Core Course	**PG2 BOTN 2014 (400-499)**	Phycology & Indian Knowledge System	4	3- 0- 1 (45 +30 lecture hrs)	75	40 – 20 – 15
	Minor Course	**PG2 BOTN 2021 (300-399)**	Plant Natural Resources & Economic Botany	4	3– 1- 0 (60 lecture hrs)	75	60 – 0 – 15
	Total			**22**		**375**	

SEMESTER I

Course title & Code (Level)	Credit	Distribution of course credits			Eligibility criteria
		Lecture	Tutorial	Practical	
Major/Core Course: Research Methodology & Ethics **PG2 BOTN 1011 (400-499)**	06	05	00	01	B.Sc. 3 yr Botany Hons.

Course title: **RESEARCH METHODOLOGY & ETHICS**

Course Code: **PG2 BOTN 1011**

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; Understanding the language of research – Concept, Construct, Definition, Variable. Research Process.	08
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 (Level)	Credit	Distribution of course credits			Eligibility criteria
		Lecture	Tutorial	Practical	
Major/Core Course: Microbiology & Mycology and Plant Pathology **PG2 BOTN 1012 (400-499)**	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: **PG2 BOTN 1012**

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 (Level)	Credit	Distribution of course credits			Eligibility criteria
		Lecture	Tutorial	Practical	
Major/Core Course: Archegoniates & Angiosperm Systematics **PG2 BOTN 1013 (400-499)**	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: **PG2 BOTN 1013**

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 &	04

Sl. No.	Content	Lecture hours
	Crandall-Stotler (2005 onward).	
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 (Level)	Credit	Distribution of course credits			Eligibility criteria
		Lecture	Tutorial	Practical	
Major/Core Course: Plant Physiology, Plant Biochemistry & Molecular Biology **PG2 BOTN 1014 (400-499)**	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: **PG2 BOTN 1014**

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

Sl. No.	Content	Lecture hours
3	Respiration and photorespiration: Glycolysis, Citric acid cycle& their regulation; plant mitochondrial electron transport and ATP synthesis; alternate oxidase; photorespiratory pathway, GS-GOGAT & Oxalate-Malate shuttle pathway.	04
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	04

Sl. No.	Content	Lecture hours
	protein, chaperone and protein folding, protein targeting.	
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	03

	SDS PAGE gel	
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 (Level)	Credit	Distribution of course credits			Eligibility criteria
		Lecture	Tutorial	Practical	
Minor Course: Plant Biodiversity, Informatics & Environmental Sustainability **PG2 BOTN 1021 (300-399)**	04	03	01	00	B.Sc. 3 yr Botany Hons.

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

Course Code: **PG2 BOTN 1021**

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:	08

Sl. No.	Content	Lecture hours
	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.	
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 II

Course title & Code (Level)	Credit	Distribution of course credits			Eligibility criteria
		Lecture	Tutorial	Practical	
Major/Core Course: Cytogenetics & Plant Breeding **PG2 BOTN 2011 (400-499)**	06	04	00	02	B.Sc. 3 yr Botany Hons.

Course title: **CYTOGENETICS & PLANT BREEDING**

Course Code: **PG2 BOTN 2011**

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 (Level)	Credit	Distribution of course credits			Eligibility criteria
		Lecture	Tutorial	Practical	
Major/Core Course: Ecology and Evolutionary Biology **PG2 BOTN 2012 (400-499)**	04	03	00	01	B.Sc. 3 yr Botany Hons.

Course title: **ECOLOGY AND EVOLUTIONARY BIOLOGY**

Course Code: **PG2 BOTN 2012**

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

Sl. No.	Content	Lecture hours
6	**Ecosystem Energetics:** Gross and net primary productivity; Standing crop biomass; Measurement of productivity: light and dark bottle method; NPP in terrestrial and 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.	04
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 (Level)	Credit	Distribution of course credits			Eligibility criteria
		Lecture	Tutorial	Practical	
Major/Core Course: Palaeobotany & Reproductive biology **PG2 BOTN 2013 (400-499)**	04	03	00	01	B.Sc. 3 yr Botany Hons.

Course title: **PALAEOBOTANY & REPRODUCTIVE BIOLOGY**

Course Code: **PG2 BOTN 2013**

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 (Level)	Credit	Distribution of course credits			Eligibility criteria
		Lecture	Tutorial	Practical	
Major/Core Course: Phycology & Indian Knowledge System **PG2 BOTN 2014 (400-499)**	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: **PG2 BOTN 2014**

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	03

Sl. No.	Content	Lecture hours
	community decision-making processes	
8.	Ethical issues and bioprospecting, Biopiracy, World Trade Organisation (WTO) and TK, provisions of Conventions on Biological Diversity (CBD) related to traditional knowledge.	03
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 (Level)	Credit	Distribution of course credits			Eligibility criteria
		Lecture	Tutorial	Practical	
Minor Course: Plant Natural Resources & Economic Botany **PG2 BOTN 2021 (300-399)**	04	03	01	00	B.Sc. 3 yr Botany Hons.

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

Course Code: **PG2 BOTN 2021**

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	08

Sl. No.	Content	Lecture hours
	and the world; role of NBPGR, CIMAP, IARI and GBPUAT; major bioactive compound classes including phenolics, alkaloids, terpenoids, glycosides and 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

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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.