COURSE STRUCTURE FOR TWO YEAR M. Sc. PROGRAM IN BOTANY

(SEMESTER I AND II)

Course Code	Course Title	Credits
Credit Framework for Semester-I		
Major Core [12 (T) + 6 (P)]		
P2BOTC101	Advances in Phycology, Bryology and Pteridology	4
P2BOTC102	Advanced Microbiology and Virology	4
P2BOTC103	Cytology, Genetics and Cytogenetics	4
P2BOPC104	Practical course based on **P2BOTC101** and **P2BOTC102**	2+2
P2BOPC105	Practical course based on **P2BOTC103**	2
	Total Credits	**18**
Major Elective (any one)		
P2BOTE106	Biosystematics	2
P2BOTE107	Population Genetics	2
P2BOPE108	Practical course based on **P2BOTE106**	2
P2BOPE109	Practical course based on **P2BOTE107**	2
	Total Credits (Major Elective)	**4**
	Total credits to be earned in Semester- I	**22 (18 Core + 4 Elective)**

Course Code	Course Title	Credits
Credit Framework for Semester-II		
Major Core [12 (T) + 6 (P)]		
P2BOTC201	Taxonomy, Systematics and Development of Flowering Plants	4
P2BOTC202	Mycology and Molecular Plant Pathology	4
P2BOTC203	Diversity and Evolution of Gymnosperms	2
P2BOTC204	Reproduction in Flowering Plants	2
P2BOPC205	Practical course based on **P2BOTC201** and **P2BOTC204**	2+2
P2BOPC206	Practical course based on **P2BOTC202** and **P2BOTC203**	2+2
	Total Credits	**20**
Major Elective (any one)		
P2BOTE207	Molecular Biology and Ecology of Reproduction in Plants	2
P2BOTE208	Conservation Biology	2
P2BOPE209	Practical course based on **P2BOTE207**	2
P2BOPE210	Practical course based on **P2BOTE208**	2
	Total Credits (Major Elective)	**4**
	Total credits to be earned in Semester- II	**24 (20 Core + 4 Elective)**
Vocational Courses		
P2BOVC250	Mushroom Cultivation	4
P2BOVC251	Horticultural and Floricultural Techniques	4
P2BOVC252	Cultivation of Medicinal and Aromatic plants	4
P2BOVC253	Plant Tissue Culture and Micropropagation	4

COURSE STRUCTURE FOR TWO YEAR M. Sc. BOTANY PROGRAM

(SEMESTER III AND IV)

Course Code	Course Title	Credits
Credit Framework for Semester-III		
Major Core [10 (T) + 6 (P)]		
P2BOTC301	Physiology and Metabolism of Plants	4
P2BOTC302	Ecology and Conservation	4
P2BOTC303	Cell and Molecular Biology of Plants	4
P2BOTC304	Plant Breeding	2
P2BOPC305	Practical course based on **P2BOTC301** and **P2BOTC302**	2+2
P2BOPC306	Practical course based on **P2BOTC303** and **P2BOTC304**	2+2
	Total Credits	**22**
Major Elective (any one) (2T+2P)		
P2BOTE307	Plant-Based Indigenous Traditional Knowledge Systems in India	2
P2BOTE308	Fundamentals and Applications of Biomimetics	2
P2BOTE309	Mushrooms: Diversity, Cultivation, and Applications	2
P2BOPE310	Practical course based on **P2BOTE307**	2
P2BOPE311	Practical course based on **P2BOTE308**	2
P2BOPE312	Practical course based on **P2BOTE309**	2
	Total Credits (Major Elective)	**4**
P2BOMO320	***MOOC**	**4**
	Total credits to be earned in Semester- III	**26 (22 Core + 4 Elective)**

Following is the breakup:

Total Credits to be earned in Semester III:26

***Over and above 4 credits to be earned through MOOC**

Course Code	Course Title	Credits
Credit Framework for Semester-IV		
Major Core [10 (T)]		
P2BOTC401	Genetic Engineering of Plants and Microbes	2
P2BOTC402	Biostatistics	2
P2BOPC403	Practical course based on **P2BOTC401**	2
P2BOPC404	Practical course based on **P2BOTC402**	2
	Total Credits	**8**
Major Elective (any one) (2T+2P)		
P2BOTE405	Biodiversity Informatics	2
P2BOTE406	Industrial Microbiology and Public Health	2
P2BOTE407	Plant Molecular Stress Physiology	2
P2BOPE408	Practical course based on **P2BOTE405**	2
P2BOPE409	Practical course based on **P2BOTE406**	2
P2BOPE410	Practical course based on **P2BOTE407**	2
	Total Credits (Major Elective)	**4 (2T+2L)**
P2BORC411	**Research Project**	**16**
	Total credits to be earned in Semester- IV	**28 (8 Core + 4 Elective + 16 Research project)**

Following is the breakup:
Total Credits to be earned in Theory: 50;
Total Credits to be earned in Practical courses: 34;
Total Credits to be earned through Project work: 16
Total Credits to be earned: 100
***Over and above 4 credits to be earned through MOOC in Semester III**

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Advances in Phycology, Bryology and Pteridology

Course No.: P2BOTC101
Credits: 4
Duration: 3 hrs

Maximum Marks: 100
Test I: 20 Marks
Test II: 20 Marks
Major Test: 60 Marks

Course Objectives: *Algae, Bryophytes, and Pteridophytes represent Cryptogams. The course is designed to study these groups in detail with emphasis on their morphological, anatomical, reproductive and ecological characteristics. It aims to explore their classification, diversity, evolutionary trends and applied aspects in biotechnology and environmental monitoring.*

Course Outcomes:

- *The course contents will enable students to identify, characterize and classify Cryptogams using modern taxonomic systems and diagnostic features.*
- *It will help them analyze the significance of anatomy, embryology and cytology in determining systematic and phylogenetic relationships among these groups.*
- *Students will be able to understand the ecological and biotechnological applications of algae, bryophytes, and pteridophytes.*

UNIT I: Classification, structure, reproduction and evolutionary aspects of Algae

1.1 Modern trends in classification of algae (Fritsch, 1935 vs Lee, 2008); range of thallus structure.
1.2 Evolution of sex, modes of reproduction and major patterns of life cycles (mono-, di- and tri-genetic types).
1.3 Biotic interactions as drivers of algal origin and evolution.
1.4 Salient features of major algal divisions based on cell wall, chloroplast and storage products.

UNIT II: Systematics, Classification and Morphology of Bryophytes

2.1 Recent trends in classification of Bryophytes (Sandra Holmes, 1986, Troitsky et al., 2007); adaptation of bryophytes to early land environments.
2.2 Comparative morphology, anatomy and reproductive adaptations of Marchantiophyta (Marchantiales, Jungermanniales).
2.3 Comparative morphology, anatomy and reproductive adaptations of Anthocerotophyta.
2.4 Comparative morphology, anatomy, and reproduction in Bryophyta (Funariales and Sphagnales).

UNIT III: Applied Phycology and Bryology – Biotechnological, Evolutionary and Ecological Perspectives

3.1 Algae in biotechnology (cosmetics, food industry); seaweed polysaccharides (Agar, Carrageenan and Alginates); algal biofuels.
3.2 Algae in climate change: CO_2 sequestration and pollution control; algae of extreme environments; culturing of microalgae; algal research in space.
3.3 Growth and differentiation in bryophytes: role of growth regulators in morphogenesis, origin and evolution of bryophytes, phylogenetic relationships among major lineages of mosses.

3.4 Bryophytes as model systems, sex chromosomes in *Marchantia*; bryophytes as indicators of environmental pollution; potential of bryophyte-derived bioactive compounds in applied sciences.

UNIT IV: Classification of Pteridophytes and diversity among early land plants and microphyllous taxa

4.1 Pteridophytes: distinguishing characters and origin (algal and bryophyte origins); apospory, apogamy, parthenogenesis; evolution of stelar types; heterospory and seed habit.
4.2 Classification of pteridophytes (Sporne1975; Parihar1996) up to ordinal level; Comparative morphology, anatomy and reproduction of fossil pteridophytes*: Lepidodendron, Sphenophyllum* and *Calamites*.
4.3 Comparative morphology, anatomy and reproduction of *Psilotum, Lycopodium, Selaginella* and *Isoetes*.
4.4 Morphology, anatomy and reproduction of *Equisetum* with special reference to *E. arvense.*

UNIT V: Diversity among megaphyllous taxa; evolutionary trends and economic aspect of Pteridiophytes

5.1 Comparative morphology, anatomy and reproduction of eusporangiate and proto-leptosporangiate ferns: *Ophioglossum* and *Osmunda*.
5.2 Comparative morphology, anatomy and reproduction of homosporous (*Dryopteris* and *Acrostichum)* and heterosporous leptosporangiate ferns (*Marsilea* and *Salvinia*).
5.3 Soral (Eu- and Lepto-sporangiate) and prothallial evolution with emphasis on the role of cytology, polyploidy and hybridization in speciation of ferns.
5.4 Economic and ecological significance of pteridophytes: as ornamentals and biofertilizers (*Azolla*), in phytoremediation and habitat stabilization.

Suggested readings

Algae

- Barsanti, L. and Gualtieri, P. (2022). Algae: anatomy, biochemistry, and biotechnology. CRC press.
- Bold, H.C. and Wynne, M. J. (1978). Introduction to the Algae: Structure and Function. Prentice Hall of India.
- Fritsch, F.E. (1945). The Structure and Reproduction of Algae. Vol. I & II. Cambridge University Press.
- Hoek, C.V.D, Mann, D.G. and Jahns, H. M. (1995). Algae: An Introduction to Phycology. Cambridge University Press.
- Kumar, H. D. and Singh, H.N. (1982). A Text Book of Algae. East West Press.
- Lee, R. E. (2018). Phycology. 5th ed. Cambridge University Press.
- Sahoo, D., and Seckbach, J. (Eds.). (2015). The Algae World (No. 11564). Dordrecht: Springer Netherlands.
- Singh, B., Bauddh, K. and Bux, F. eds., (2015). Algae and environmental sustainability. New Delhi: Springer India.
- Smith, G. M. (1955). Cryptogamic Botany. Vol. I. McGraw Hill Co. Ltd.
- Trainor, F. R. (1978). Introductory Phycology. John Wiley and Sons Inc.

Bryophytes

- Glime, J. M. (2017). Bryophyte Ecology (Vols. 1–5). E-book. Michigan Technological University.
- Puri, P. (1985). Bryophytes: A Broad Perspective. Atma Ram & Sons, Delhi.
- Rashid, A. (1998). An Introduction to Bryophyta, Vikas Publ. House, Pvt. Ltd.
- Schuster, R. M. (1983). New manual of Bryology Vol. I & II. The Hattori Botanical Laboratory, Japan.
- Smith, G. M. (1955). Cryptogamic Botany Vol II, Tata McGraw Publishing Company, Inc., N.Y.
- Vander Poorten, A. and Goffinet, B. (2009). Introduction to Bryophytes. Cambridge University Press, New York.

Pteridophytes

- Bierhorst, D.W. (1971). Morphology of Vascular Plants. MacMillan Co.
- Bower, F.O. (1923, 1926 and 1928). The Ferns. Vol. I-III, Cambridge University Press.
- Bower, F.O. (1935). Primitive Land Plants. Mac Millan Co.
- Eames, A. J. (1936). Morphology of Vascular Plants. McGraw Hill, NY.
- Foster, A. S. and Gifford, E. M. (1979). Comparative Morphology of Vascular Plants. W.H. Freeman & Co.
- Jenkins, et al. (2017). Annotated checklist of Indian Pteridophytes; pt. 1 (Lycopodiaceae to Thelypteridaceae). Bishen Singh Mahindra Pal Singh, Dehradun.
- Parihar, N. S. (1989). The Biology and Morphology of Pteridophytes (Diversity and Differentiation). Vikas Publishing House.
- Rashid, A. (1976). An Introduction to Pteridophytes (Diversity and Differentiation). Vikas Publishing House.
- Sporne, K. R. (1970). The Morphology of Pteridophytes. Hutchinson University Library, London.
- Vashishta, P. C., Sinha, A. K. and Kumar, A. (2010). Pteridophyta. S. Chand & Co., New Delhi.

Note for Paper Setting

MCQ on LMS + Subjective Test	**Syllabus to be covered in theExamination**	**Time allotted for the Exam**	**% weightage (marks)**
Test I (After 30 days)	Up to 20%	1 hour.	10 +10
Test II (After 60 days)	21% to 40%	1 hour.	10 +10
Theory	**Syllabus to be covered in theExamination**	**Time allotted for the Exam**	**% weightage(marks**
Major Test (After 90 days)	100%	3hours.	60
Total			**100**
Practical/Research (Thesis/project/dissertation)			
MCQ on LMS + Subjective Test	**Time allotted for the Examination**	**% weightage(marks)**	
Mid Term Appraisal (Evaluation of daily practical	4 hours	25%	

performance/ Practical Assignment/ Field Study)				
External Examination	4 hours	75%	50%	Final Practical Performance
			25%	Viva-Voce
Total			**100**	

Test I and Test II

The subjective test of Test I and Test II would consist of three short answer type questions (05 marks each). Students are required to answer two questions. No preparatory holidays shall be provided for the Test I and Test II. Those candidates who have appeared in Test I and Test II and failed to get the minimum required marks i.e. 14 out of 40 will be eligible to re – appear in the Test I and Test II only once.

Major Test

The major test will comprise of two sections, Section-A and Section-B. Section-A will have compulsory questions comprising 08 parts (minimum 01 from each unit) of 03 marks each. Section-B will have 06 questions of 12 marks each to be set from the last three units (02 from each unit). Students are required to attempt 01 question from each unit of section B.

List of Practicals

- Morphological study of representative members of Algae: *Microcystis, Aulosira, Oocystis, Pediastrum, Hydrodictyon, Ulva, Pithophora, Stigeoclonium, Draparnaldiopsis, Closterium, Cosmarium, Ch*ara.
- Study of morphology, anatomy and reproductive structures of bryophytes: *Marchantia, Anthoceros, Polytrichum, Plagiochasma, Asterella.*
- Anatomy of fossil pteridophytes (*Aglaophyton, Rhynia, Asteroxylon, Lepidophloios, Lepidocarpon*, *Sphenophyllum, Calamites*) from permanent slides.
- Morphology and anatomy of fern-allies (*Psilotum, Lycopodium, Selaginella, Isoetes, Equisetum*).
- Diversity in spore bearing organs and anatomy of vegetative and reproductive organs of some ferns (*Ophioglossum, Cyathea, Dryopteris, Gleichenia, Pteris, Asplenium, Salvinia*).

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Advanced Microbiology and Virology

Course No.: P2BOTC102 | **Maximum Marks: 100**
Credits: 4 | **Test I: 20 Marks**
Duration: 3 hrs | **Test II: 20 Marks**
Major Test: 60 Marks

Course Objectives: *This course is designed to provide students with an in-depth understanding of microbial and viral systems, en compassing both fundamental principles and recent advances. It explores the structural and molecular complexity of microbes and viruses, their evolutionary diversity, modes of interaction with plant and animal hosts, and their roles in health, disease, and environmental applications*

Course Outcomes: *After successful completion of this course, students will be able to:*

- *Understand the fundamental principles of microbiology and virology, including microbial structure, evolution, taxonomy, and the molecular mechanisms of microbial and viral interactions with host organisms.*
- *Critically evaluate the structural, functional, and ecological diversity of bacteria, archaea, viruses, viroids, and bacteriophages,*
- *Develop skills in microbial isolation, culturing, staining, and characterization, along with the ability to diagnose plant viral and bacterial diseases using symptomatology and laboratory practices.*
- *Explain the molecular and cellular mechanisms underlying pathogenesis in plant and animal viral infections, with emphasis on case studies like SARS-CoV-2, TMV, and retroviruses.*
- *Assess the role of endophytes, rhizobia, mycorrhizae, and probiotics in promoting plant and human health, environmental sustainability, and bioremediation.*
- *Interpret how viral and viroid pathogens affect global health and crop productivity, and propose integrated disease management strategies.*

UNIT I: Fundamentals of Microbiology

1.1 Scope of Microbiology; Historical perspectives: significant contributions of microbiologists in the development of microbiology; spontaneous generation controversy; Germ theory of disease

1.2 Development of Techniques for Studying Microbial Pathogens; The Golden Age of Microbiology and Immunological Studies

1.3 Microbial Evolution, Microbial Classification: Phenetic, Genotypic and Phylogenetic approaches; Major Domains of Life; Introduction to Bergey's Manual of Systematic Bacteriology

1.4 Microbial Growth: Types of Culture Media and their applications; Growth patterns in open and closed systems of cultures

UNIT II: Diversity and Taxonomy of Eubacteria and Archaea

2.1 Bacteria: Cell structure, function and reproduction; Components of cell envelope: Structure of murein in Gram-positive and Gram-negative bacteria; Capsule, slime layer, structure and mechanism of flagellar movement; Conjugation and attachment fimbriae.

2.2 Structures internal to the cell wall: cytoplasm, nucleoid, Types and significance of storage granules, gas vesicles and magnetosomes; Endospores: structure and composition, mechanism of vegetative and sporulation cycle

2.3 Distinguishing features of Archaebacteria: Form, nutrition, habitat, unique metabolism, cell wall composition; Methanogens: their significance.
2.4 Halophilic Archaea: Haloarchaeal strategies to cope with salinity stress; Thermoacidophiles: Strategies to cope with heat, acid & osmotic stress- Importance & applications

UNIT III: Advanced Plant Virology and Viroid Biology

3.1 Structural and Molecular Features of Plant Viruses: Host range and specificity, Comparative ultrastructure, capsid symmetry and genome types. Molecular mechanisms underlying host-virus interactions and symptom expression (TMV)
3.2 Systematic classification of symptoms: Localised vs. systemic; Symptomatology of major viral diseases: ssRNA (CMV, PVX); ssDNA (ToLCV, BCTV); dsDNA (CaMV, RTBV) viruses.
3.3 Viroids: Host range, genome structure and classification (Pospiviroidae & Avsunviroidae); Molecular mechanisms: rolling circle replication; Case studies of economically significant viroid diseases: PSTVd and CEVd.
3.4 Mechanisms of vertical and horizontal transmission: vector and non-vector mediated pathways: Integrated disease management (IDM) framework and advanced control methods for plant viruses

UNIT IV: Animal Virology and Bacteriophages: Structure, Pathogenesis, and Control

4.1 Structural and Molecular Features of Animal Viruses; Global health implications-Influenza virus-structure, replication, mechanism of acquiring variations.
4.2 Pandemics and Epidemics: SARS-CoV-2: emergence, molecular mechanisms of entry (ACE2), replication, and exit strategies; Retroviridae: genome organization, host-receptor interaction (*CD4, CCR5/CXCR4*), reverse transcription and integration.
4.3 Bacteriophages: Structure and replication of virulent, temperate and filamentous DNA phages; Concept of prions.
4.4 Antiviral strategies for animal viruses: Vaccination approaches: Killed, live-attenuated, subunit, recombinant vector, DNA/RNA vaccines; Antiviral drug development: Challenges and successes in therapeutics.

UNIT V: Plant-Microbe Interactions: Symbiosis and Applications

5.1 Types of plant-microbe interactions: Beneficial: Mycorrhizae (ECM, AMF); Endophytes (systemic & transient)-direct and indirect benefits conferred to the plant and rhizosphere associations.
5.2 Plant growth-promoting rhizobia- (ePGPRs and iPGPRs); Mode of action; Direct and Indirect Mechanisms.
5.3 Environmental Applications of Beneficial Microbes: Bioremediation: Types; Bacterial, Phycoremediation (microalgae and Cyanobacteria) and Mycoremediation of heavy metals and contaminants from polluted sites.
5.4 Probiotics: Concept, Common genera, Mechanism of action and benefits in human health and nutrition.

Suggested readings

- Black, J. G. (2013). Microbiology. 8th Edn. John Wiley & Sons. New York.

- Cao, et al., (2013). A Single-Molecule View on the Disassembly of Tobacco Mosaic Virus. Biophysical Journal, 105 (12): 2615-2616.
- Cascella, et al., (2023). Features, Evaluation, and Treatment of Coronavirus (COVID-19). In: StatPearls. Treasure Island (FL): StatPearls Publishing.
- Cowan, M. Kelly. (2015). Microbiology: a systems approach. 3rd ed. Mc Graw Hill, New Delhi.
- Flint, et al., (2015). Principles of virology. American Society for Microbiology
- Hu, B. et al., (2015). Structural remodeling of bacteriophage T4 and host membranes during infection initiation. Proc Natl Acad Sci U S A. 1;112 (35)
- John, B. C. and Venetia, A. S. (2007). Virology Principles and Applications. John Wiley & Sons Ltd.
- Madigane, M. T., et al (2009). Brock's Biology of microorganisms. 12th ed. Pearson, Benjamin.
- Singh, D. P., Harikesh, B. S., and Prabha, R., eds. (2017). Plant Microbe Interactions in Agro Ecological Perspectives: Volume 2: Microbial Interactions and Agro Ecological Impacts. Singapore: Springer.
- Sumbali, G. and Mehrotra, R.S. (2025). Fundamentals of Microbiology. Medtech Science Press., A division of Scientific International.
- V'kovski, et al., (2021). Coronavirus biology and replication: implications for SARS-CoV-2. Nature Reviews Microbiology 19, 155–170.
- Wiley, J., Sandman K. and Wood, D. (2020). Prescott's Microbiology. 11th ed. Mc Graw Hill, New Delhi

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<tr><td>Major Test (After 90 days)</td><td>100%</td><td>3hours.</td><td colspan="2">60</td></tr>
<tr><td colspan="3">Total</td><td colspan="2">100</td></tr>
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<tr><td>Mid Term Appraisal (Evaluation of daily practical performance/ Practical Assignment/ Field Study)</td><td>4 hours</td><td colspan="3">25%</td></tr>
<tr><td rowspan="2">External Examination</td><td rowspan="2">4 hours</td><td rowspan="2">75%</td><td>50%</td><td>Final Practical Performance</td></tr>
<tr><td>25%</td><td>Viva-Voce</td></tr>
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</table>

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List of Practicals

- Microscopy and bacterial staining techniques- Demonstration of Simple and differential staining and special staining techniques.
- Basic media preparation techniques for culturing bacteria (NA), potato dextrose agar (PDA), and other basic culture media.
- Isolation and purification of bacteria from soil using the serial dilution technique; subculturing and colony purification.
- Study of Rhizobium spp. in root nodules of legumes using staining techniques.
- Symptomatology of plant diseases caused by bacteria (leaf spot of peach, angular leaf spot of cotton, Kresek of rice, Citrus canker, Bacterial wilt of tomato and Fire blight of apple).
- Symptomatology (Mosaics: Mottling, vein clearing, Vein banding, Chloritic spotting, streaks & stripes, Ring spotting, Stunting/dwarfing, Leaf roll, Enation, Pox, Shoe-string, Tumours, Pitting, Bunchy top, Curly top, Flower breaking, vein necrosis) of plant diseases (TMV, CMV, PLRV, PVY, SMV, CTV, BBTV and PRSV) caused by viruses
- Symptomatology of plant diseases caused by viroids (CSVd, PSTVd, CCCVd and CEVd)
- Microscopic observation and identification of Probiotic cultures (Lactobacillus from curd/yogurt)

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Cytology, Genetics and Cytogenetics

Course No.: P2BOTC103
Credits: 4
Duration: 3 hrs

Maximum Marks: 100
Test I: 20 Marks
Test II: 20 Marks
Major Test: 60 Marks

Course Objectives: *Genetics and cytogenetics provide scientific basis to the art of plant and animal breeding. Genetic improvement of crop plants cannot be sound, unless their genetic architecture has been fully understood. For this cytology allows the students to study the morphology and behaviour of different types of chromosomes of eukaryotes. This course aims at equipping the students with up-to-date knowledge of the nature and structure of genetic material and principles of heredity in diploid, polyploid and aneuploid organisms.*

Course Outcomes:

- *Students will be equipped with knowledge of structure of genetic material and principles of heredity.*
- *Developing skills for utilising information gained on cytological and genetic features for designing breeding experiments.*

UNIT I: Chromatin organization

1.1 Architecture of chromosomes in pro- and eukaryotes; molecular organization of nucleosome, centromere, telomere and nucleolar organizers.
1.2 Cytological techniques; chromosome banding, *In-situ* hybridization methods: FISH, GISH, CGH and SKY (spectral karyotyping).
1.3 Specialized chromosomes: structure, occurrence and behaviour of B-chromosomes, polytene and lamp brush chromosomes.
1.4 Sex chromosomes in relation to sex determining mechanism in plants (*Melandrium*, Papaya), *Drosophila*, birds and human beings; evolution of Y chromosome in man.

UNIT II: Numerical alterations in the genome

2.1 Origin, occurrence, production and meiosis of monoploids, haploids and dihaploids.
2.2 Origin and production of autopolyploids: concept of chromosome and chromatid segregation and double reduction.
2.3 Allopolyploids - types, genome constitution and analysis of wheat, *Brassica* and cotton.
2.4 Aneuploid types-Origin, occurrence, production, meiosis and detection of monosomics and trisomics and their use in chromosome mapping; overview and use of balanced tertiary trisomics.

UNIT III: Genetic recombination and mapping

3.1 Linkage and construction of genetic maps: cytogenetic and linkage maps; two- and three-point test crosses in Maize and *Drosophila*; tetrad analysis; sex-linkage
3.2 Recombination: molecular mechanism in pro- and eukaryotes; site specific recombination; environmental and genetic factors affecting the frequency of crossing over; mapping with molecular markers; development of mapping populations in plants and their importance in crop improvement.
3.3 Correlation of genetic and physical maps; somatic cell genetics; extrachromosomal inheritance.

3.4 Gene mapping in bacteria and viruses; transformation, conjugation, transduction and sexduction.

UNIT IV: Gene structure, expression and sudden changes

4.1 Gene fine structure; allelic complementation; rII locus.
4.2 Regulation of gene expression in prokaryotes (lac operon and trp operon) and eukaryotes (hormonal control and methylation); concept and applications of epigenetics.
4.3 Mutations: causes and detection of mutant types – lethal, conditional, biochemical, loss- of-function, gain-of-function, germinal vs. somatic mutants; insertional mutagenesis and site directed mutagenesis; DNA damage and repair mechanisms.
4.4 Transposable elements in prokaryotes and eukaryotes; IS, Tn3, Tn5, Tn9, Tn10 in prokaryotes; Ac-Ds and Spm-dSpm in maize, Copia and P elements in *Drosophila* and Ty elements of yeast; LINE and SINE in humans; concept of transposon tagging.

UNIT V: Cytogenetics of higher Plants

5.1 Breeding behaviour and genetics of simple and complex translocation heterozygotes, translocation tester sets; Robertsonian translocations; evolutionary perspectives.
5.2 Breeding behaviour and genetics of inversion heterozygotes; effects of single and double crossovers.
5.3 Transfer of whole genome (*Triticale*), individual chromosomes and chromosome segments.
5.4 Production, characterization and utility of alien addition and substitution lines: classical and modern approaches.

Suggested readings

- Alberts, B., Bray, D., Lewis, J., Raff, M., Roberts, K. and Watson, J.D. (1989). Molecular Biology of the Cell. Garland Publishing Inc. NY & London.
- Alberts, et al., (2015). Molecular biology of the cell. 6th ed. Garland Science, New York.
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- Brown, T. A. (1989). Genetics: A Molecular Approach. VNR international.
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- Iwasa, J. and Marshall, W. (2016). Karp's Cell and Molecular Biology-Concepts and Experiments. 8th ed. Wiley Plus, Singapore.
- Jones, Russell, et al., (2017). Molecular life of plants. Wiley Blackwell, New Delhi.
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- Pierce, B. A. (2018). Genetics essentials: Concepts and connections. 4th ed. Macmillan, USA.
- Pollard, T. D. et al., (2017). Cell Biology. 3rd ed. Elsevier, USA.
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- Russell, P.J. (1998). Genetics. Benjamin/Cummings Publishing Co. Inc.
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- Snustad, D. P. and Simmons, M. J. (2019). Principles of Genetics. 7th ed. John Wiley & Sons, NY.
- Snustad, D.P. and Simmons, M.J. (2000). Principles of Genetics. John Wiley & Sons, NY.
- Stansfield, W. D. (1991). Genetics (Schaums outlines), McGraw Hill.
- Strickberger, M.W. (1976). General Genetics. McMillan Publishing Co. Inc. NY.
- Stuart, E. (2023). Introduction to molecular cytogenetics. American Academic Publisher.
- Swanson C.P., Merz, T. and Young, W.J. (1967). Cytogenetics. Prentice Hall of India, Pvt. Ltd.
- Watson, J. D., Hopkins, N. H., Roberts, J. W., Steitz, J. A. and Weiner A. M. L. (1987). Molecular Biology of the Gene. The Benjamin/Cummings Publishing Company Inc.

Note for Paper Setting

MCQ on LMS + Subjective Test	**Syllabus to be covered in theExamination**	**Time allotted for the Exam**	**% weightage(marks)**
Test I (After 30 days)	Up to 20%	1 hour.	10 +10
Test II (After 60 days)	21% to 40%	1 hour.	10 +10
Theory	**Syllabus to be covered in theExamination**	**Time allotted for the Exam**	**% weightage(marks)**
Major Test (After 90 days)	100%	3hours.	60
Total			**100**

Practical/Research (Thesis/project/dissertation)		
MCQ on LMS + Subjective Test	**Time allotted for the Examination**	**% weightage(marks)**
Mid Term Appraisal (Evaluation of daily practical performance/ Practical Assignment/ Field Study)	4 hours	25%

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<table>
<tr><td rowspan="2">External Examination</td><td rowspan="2">4 hours</td><td rowspan="2">75%</td><td>50%</td><td>Final Practical Performance</td></tr>
<tr><td>25%</td><td>Viva-Voce</td></tr>
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</table>

Test I and Test II

The subjective test of Test I and Test II would consist of three short answer type questions (05 marks each). Students are required to answer two questions. No preparatory holidays shall be provided for the Test I and Test II. Those candidates who have appeared in Test I and Test II and failed to get the minimum required marks i.e. 14 out of 40 will be eligible to re – appear in the Test I and Test II only once.

Major Test

The major test will comprise of two sections, Section-A and Section-B. Section-A will have compulsory questions comprising 08 parts (minimum 01 from each unit) of 03 marks each. Section-B will have 06 questions of 12 marks each to be set from the last three units (02 from each unit). Students are required to attempt 01 question from each unit of section B.

List of Practicals

- Karyotype analysis and preparation of ideogram.
- Study of somatic chromosomes from root tip squashes.
- Comparative effect of various pretreating agents on somatic chromosomes.
- Study the effect of various known mutagens and adulterants on somatic chromosomes.
- Study of chromosomes during meiosis (*Aloe vera, Delphinium ajacis. Allium cepa. Tradescantia canaliculata*, *Phlox drummondii, Papaver sominiferum*).
- Attempt silver banding for staining nucleolus – organizing region.
- Study the polytene chromosomes in Chironomus.
- Study the characteristics and behavior of B chromosomes in an appropriate material.
- Study the sex chromosomes of *Spinacea, Rumex/Cannabis, Mirabilis*.
- Study the effect of induced polyploidy on plant phenotype, meiosis, pollen and seed fertility and fruit set.
- Work out the effect of mono and trisomy on fertility and meiotic behaviour.
- Study the effect of translocation heterozygosity on chromosome pairing, chromosome disjunction and pollen and seed fertility.
- Study the meiosis of complex translocation heterozygotes.
- Construction of genetic maps from the given data.
- Calculation of recombination frequencies.
- Determination of linkage relationships.
- Study of Mendelian and non-Mendelian inheritance patterns.

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Biosystematics

Course No.: P2BOTE106 | **Maximum Marks: 50**
Credits: 2 | **Test I: 10 Marks**
Duration: 2 hrs | **Test II: 10 Marks**
Major Test: 30 Marks

Course Objectives: *The living plant species known so far are 3.74 million of which 2.95 are angiosperms. To identify, name and classify such a vast number in a manner which may allude to their inter-relationships and evolutionary lineage is a humongous but most basic task. The course will familiarize the students with this underlying basis; make them understand the inter- and intraspecific variations existing in the germplasm of any species, and their importance in the evolutionary time scale. The course will enable them to realize that species are not static but ever-evolving biological entities, which cannot always be neatly circumscribed.*

Course Outcomes:

- *The students will understand the nuances of plant life at the species level and its interaction with biotic and abiotic factors which is pivotal for any breeding and crop improvement program.*
- *They will gain a deep insight into the nature of genetic resources and their importance for germplasm characterization, evaluation and documentation.*

UNIT I: Synthetic Theory of Evolution

1.1 Charles Darwin and synthetic theory of evolution; evolution through natural selection.
1.2 Populations; evolution at the population level through mutation, recombination, gene flow and selection.
1.3 Variability-kinds and patterns; phenetic and geographical variability; Turesson's experiments; transplant experiments of Clausen, Keck and Hiesey; experiments of MacMillan.
1.4 Races- kinds and dynamics; differentiation of ecads; formation of ecotypes.

UNIT II: Sources of variation

2.1 Breeding systems-overview, advantages, disadvantages and effectiveness of in- and out-breeding in evolution.
2.2 Self-incompatibility-types and genetic control; unisexuality and dioecism; outbreeding and its impact on population structure; inbreeding and its establishment.
2.3 Hybridization-concept and role in evolution; introgressive hybridization.
2.4 Factors causing speciation-hybridization, reproductive isolation, polyploidy, apomixis.

UNIT III: The Species problem

3.1 Speciation-general account and types; development of ecological and geographical barriers, correlation between morphology and reproductive isolation.
3.2 Gradual speciation-geographical isolation, differentiation, merger of range, range overlap and resulting interactions.
3.3 Abrupt speciation-polyploidy and catastrophic selection; leaky isolation barriers, gene flow and selection.
3.4 Concepts of species-morphological, biological and evolutionary concepts; brief account of species complexes.

Suggested readings

- 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.
- Besse, P. (2014). Molecular Plant Taxonomy. Human Press, London.
- Bhattacharya, B. (2009). Systematic Botany. Narosa Publishing House, New Delhi.
- Briggs, D. and Walters, S. M. (2016). Plant Variation and Evolution. Cambridge University Press. (4th ed.).
- Crawford, D.J. (2003). Plant Molecular Systematics. Cambridge University Press, Cambridge, UK.
- Davis P.H. and Heywood V. H. (2011). Principles of Angiosperm Taxonomy Scientific Publications.
- Davis P.H. and Heywood V.S. (1963). Principles of Angiosperm Taxonomy. Oliver and Boyd, Edinburg.
- Grant, V. (1971). Plant Speciation. Columbia University Press, NY.
- Grant, V. (1977). Organismic Evolution. W H. Freeman and Co.
- Grant, W. F. (ed) (1984). Plant Biosystematics. Academic Press, NY.
- Hartl, D. L. and Ruvolo, M. (2012). Genetics-Analysis of Genes and Genomes (8th ed.). Jones and Bartlett India Pvt. Ltd., New Delhi.
- Hartl, D.L. and Jones, E.W. (2000). Genetics – An Analysis of Genes and Genomes. Jones & Bartlett Publishers.
- Heywood, V. H. (ed) (1973) Taxonomy and Ecology: Academic Press, NY
- Heywood, V. H. (ed) (1976) Botanical Systematics. Vol. I; Academic Press, NY
- Hillis, D.M., Moritz C. and Mable, B. K. (1996) Molecular Systematics. Sinauer Associates, Massachusetts.
- Hollingsworth, P.M., Bateman, R.M. and Gornall, R.J. (1999). Molecular Systematics and Plant Evolution. Taylor and Francis, London.
- 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.
- Patané, J.S.L., Martins, J. and Setubal, J.C. (2018). Phylogenomics. In: Setubal J., Stoye J., Stadler P. (eds) Comparative Genomics. Methods in Molecular Biology, vol 1704. Humana Press, New York, NY.
- Radford, A. E. (1986). Fundamentals of Plant Systematics. Harper and Row Publications Inc.
- Ridley, M. (2003). Evolution. Wiley-Blackwell. (3rd ed.).
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- Singh, Gurcharan (2021). Plant Systematics: Theory and Practice (4th ed.) CBS Publishers and Distributors Pvt. Ltd. India.
- Smith, J. M. (1998). Evolutionary Genetics. Oxford University Press.
- Snustad, D.P. and Simmons, M.J. (2000). Principles of Genetics. John Wiley & Sons, NY.
- Sokal, R. R. and Rohlf, F. J. (1973). An Introduction to Biostatistics. W. H. Freeman and Company, New York.
- Sokal, R. R. and Rohlf, F. J. (2001) Biometry-The Principles and Practice of Statistics in Biological Research. W. H. Freeman and Company, New York.
- Solbrig, O. T. (1969) Evolution and Systematics. The MacMillan Company, NY

- Solbrig, O. T. (1970) Principles and Methods of Plant Biosystematics. The Mac Millan Company, NY
- Solbrig, O. T. And Solbrig, D. J. (1979). An introduction to Pollination Biology and Evolution. Addison-Wesley Pyblishing Co.
- Stace, C. A. (1980). Plant Taxonomy and Biosystematics. Edward Arnold.
- Stebbins, G. L. (1950). Variation and Evolution in Plants. Columbia University Press, NY.
- Stebbins, G. L. (1971). Chromosomal Evolution in Higher Plants. Arnold, London.
- Stebbins, G. L. (1974). Flowering Plants-Evolution above species level. Edward Arnold.
- Stuessy, T.F. (2008). Plant Taxonomy: The systematic Evaluation of Comparative Data. Columbia University Press, New York.
- 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.
- Woodland, D. W. (2009). Contemporary Plant Systematics. Andrews University Press, Michigan.

Note for Paper Setting

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Test I (After 30 days)	Up to 20%	30 min	5 +5
Test II (After 60 days)	21% to 40%	30 min	5 +5
Theory	**Syllabus to be covered in theExamination**	**Time allotted for the Exam**	**% weightage (marks)**
Major Test (After 90 days)	100%	2 hours	30
Total			**50**

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<tr><th colspan="5">Practical/Research (Thesis/project/dissertation)</th></tr>
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<tr><td>Mid Term Appraisal (Evaluation of daily practical performance/ Practical Assignment/ Field Study)</td><td>4 hours</td><td colspan="3">25%</td></tr>
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<tr><td>25%</td><td>Viva-Voce</td></tr>
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</table>

Test I and Test II

The subjective test of Test I and Test II would consist of two short answer type questions (05 marks each). Students are required to answer one question. No preparatory holidays shall be provided for the Test I and Test II. Those candidates who have appeared in Test I and Test II and

failed to get the minimum required marks i.e. 7 out of 20 will be eligible to re-appear in the Test I and Test II only once.

Major Test

The major test will comprise of two sections, Section-A and Section-B. Section-A will have compulsory questions comprising 03 parts (minimum 01 from each unit) of 02 marks each. Section-B will have 04 questions of 12 marks each to be set from the last two units (02 from each unit). Students are required to attempt 01 question from each unit of section B.

List of Practicals

- Observation and analysis of phenotypic variability in some selected taxa e.g. *Eclipta alba*, *Solanum nigrum*, *Plantago* sp., *Argemone* sp., *Verbascum* sp., etc.
- Floral variability within a genus and its impact on breeding system e.g. species of *Solanum*, *Capsicum*, *Commelina*, *Euphorbia*, cucurbits, etc.
- Statistical analysis of variability using frequency and probability distributions and constants like mean, standard deviation, standard error, coefficient of variation.
- Tests of significance like Students' t-test, F-test, z-test, one-way and two-way ANOVA.
- Non-parametric tests of significance-chi-square, Kruskal-Wallis, Spearman's correlation, Mann-Whitney U, Wilcoxon Tests
- Application of correlation and regression analysis to the data generated and interpretation of results
- Fractionating phenotypic variability; habitat and chromosome analysis
- Karyotypic studies, biochemical and molecular profiling as parameters in determining phylogeny
- Use of statistical software/packages in carrying out Cluster analysis, PCA, RDA and LDA.
- Field and Herbarium study.

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Population Genetics

Course No.: P2BOTE107
Credits: 2
Duration: 2 hrs

Maximum Marks: 50
Test I: 10 Marks
Test II: 10 Marks
Major Test: 30 Marks

Course Objectives: *Population genetics gives an exact understanding of general evolutionary genetic phenomenon such as genetic drift, gene flow and inbreeding along with the extent of intra-and inter-population variability present. Evolutionary genetics provides knowledge regarding the phylogenetic relationship among different organisms based on morphological enzymatic and DNA based markers.*

Course Outcomes:

- *Making students knowledgeable about the agriculturally important traits which show continuous variation.*
- *Assist them in understanding extent of intra and inter-population variability in a species, genetic differentiation inter-population gene flow.*
- *Helping them to determine evolutionary relationship between taxa based on morho-, cyto- and molecular traits.*

UNIT-I: Population genetics: Measurement of Genetic variations

1.1 Qualitative versus quantitative characters; multiple factor hypothesis; Analysis of continuous variation.
1.2 Components of variation; phenotypic and genotypic, nature of gene action (additive, dominance and epistatic).
1.3 The allele frequencies versus genotype frequencies; and Hardy-Weinberg principle of genetic equilibrium: assumption and its derivation.
1.4 Exceptions to Hardy-Weinberg principle, non-random mating, unequal survival, population subdivision, migration.

UNIT-II: Genetic drift and Population Structure

2.1 Natural selection at the level of gene and the phenotype (Directional, disruptive and stabilizing).
2.2 Random genetic drift and effect of population size on random changes in allele frequencies.
2.3 Populations in genetic equilibrium: balancing selection, mutation selection balance, mutation drift balance.
2.4 Population structure: Minimum viable population concept, the continent-Island Model.

UNIT-III: Gene flow and Phylogeny

3.1 Gene flow: mechanism of gene flow and agencies involved (biotic and abiotic).
3.2 Founder effect and its relation with pollen and seed germination.
3.3 Construction of phylogenetic tree employing character based method: Maximum Parsimony and Maximum Likelihood.
3.4 Construction of phylogenetic tree using distance based method: UPGMA.

Suggested readings

- Brown T.A. (1989). Genetics: A Molecular Approach. VNR international.
- Falconer D.S. (1960). Introduction to Quantitative Genetics. Oliver and Boyd, Edinburgh and London. (ISBN- 978-0050008621).
- Hedrick, Philip W., (2011). Genetics of Populations. 4th ed. Jones and Bartlett Publisher, LLC.
- Jha A.P. (1993). Genes and Evolution (reprinted 1997). Macmillan Publishing Company Incorporated. (ISBN- 978-0333927106).
- Klug W.S., Cummings M.R., Spencer C.A., Palladino M.A., & Killian D. (2021). Concepts of Genetics (12th ed.). Pearson. (ISBN 978-0135564776).
- Ridley M. (2004). Evolution. 3rd ed. Blackwell Publishing.
- Snustad D.P. and Simmons M.J. (2000). Principles of Genetics. John Wiley & Sons, NY.
- Snustad D.P. and Simmons M.J. (2019). Principles of Genetics. 7th ed. John Wiley & Sons, NY.

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Theory	**Syllabus to be covered in theExamination**	**Time allotted for the Exam**	**% weightage(marks)**
Major Test (After 90 days)	100%	2 hours	30
Total			**50**

Practical/Research (Thesis/project/dissertation)				
MCQ on LMS + Subjective Test	**Time allotted for the Examination**	**% weightage(marks)**		
Mid Term Appraisal (Evaluation of daily practical performance/ Practical Assignment/ Field Study)	4 hours	25%		
External Examination	4 hours	75%	50%	Final Practical Performance
			25%	Viva-Voce
Total			**50**	

Test I and Test II

The subjective test of Test I and Test II would consist of two short answer type questions (05 marks each). Students are required to answer one question. No preparatory holidays shall be provided for the Test I and Test II. Those candidates who have appeared in Test I and Test II and

failed to get the minimum required marks i.e. 7 out of 20 will be eligible to re-appear in the Test I and Test II only once.

Major Test

The major test will comprise of two sections, Section-A and Section-B. Section-A will have compulsory questions comprising 03 parts (minimum 01 from each unit) of 02 marks each. Section-B will have 04 questions of 12 marks each to be set from the last two units (02 from each unit). Students are required to attempt 01 question from each unit of section B.

List of Practicals

- Determining allelic frequencies for selected morphological traits from naturally occurring populations of a species.
- Isolation of genomic DNA, amplification of specific segments using primers and analysis of DNA profiles for allele frequencies.
- Testing Hardy-Weinberg proportions by analyzing the isozyme profiles.
- Finding relationship between physical and genetic distance on the basis of data generated from various experiments.
- Phylogenetic tree construction using unweighted Pair group method (UPGMA), The Maximum Parsimony method and Maximum Likelihood.
- Estimation of genetic distance, gene flow and population structure Shannon-Weiver, Nei's Genetic diversity indices from data generated.

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Taxonomy, Systematics and Development of Flowering Plants

Course No.: P2BOTC201
Credits: 4
Duration: 3 hrs

Maximum Marks: 100
Test I: 20 Marks
Test II: 20 Marks
Major Test: 60 Marks

Course Objectives: *This course aims to provide students with an advanced understanding of the principles and practices of plant taxonomy and systematics, with a focus on flowering plants. It covers classical and modern classification systems, phylogenetic analysis, molecular approaches, and the developmental anatomy of plants. The course also explores the evolution of key angiosperm families, vegetative and reproductive adaptations, and specialized plant structures, equipping students with both theoretical knowledge and practical tools for taxonomic research.*

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

- *Understand and compare various systems of plant classification, including modern phylogenetic frameworks.*
- *Apply phenetic and cladistic methods to analyze plant relationships using morphological and molecular data.*
- *Identify major angiosperm families and interpret their evolutionary significance.*
- *Explain the developmental anatomy of flowering plants, including meristem organization, fruit development, and specialized structures.*

UNIT I: Taxonomy and systematics

1.1 Evolution of taxonomy: exploratory, consolidation, biosystematics and encyclopedic.
1.2 Systems of classification: comparative account of artificial, natural, phylogenetic and APG systems of classification.
1.3 Phenetics and cladistics: principles, characters and their selection, character-taxon matrix, similarity matric, construction and analysis of phenograms and cladograms.
1.4 Plant nomenclature: recent advances in ICN, types of names and rejection of names.

UNIT II: Advances in plant taxonomy

2.1 Classification of flowering plants: introduction of Angiosperms Phylogeny Group (IV) classification, taxonomic evidence: structural and biochemical characters.
2.2 Plant molecular systematics: DNA sequence data, types of sequence data, sequence alignment.
2.3 Phylogenetic analysis: Parsimony, Maximum Likelihood, Bayesian approaches, Neighbor-Joining.
2.4 Molecular approaches: barcoding concept; standard barcode markers: nrDNA, cpDNA and mtDNA. Phylogenomic approach towards understanding plant systematics.

UNIT III: New approaches in plant taxonomy

3.1 Basal angiosperms: taxonomic description of Magnoliaceae and Piperaceae (Magnoliids).
3.2 Basal, petaloid and commelinid monocots: taxonomic description of Araceae (basal), Liliaceae and Orchidaceae (petaloid), Poaceae and Zingiberaceae (commelinid) monocots.
3.3 Eudiots: taxonomic description of Ranunculaceae and Caryophyllaceae (superasterids).

3.4 Eudicots: taxonomic description of Fabaceae (fabids), Malvaceae (malvids), Asteraceae (campanulids), Lamiaceae and Solanaceae (lamiids).

UNIT IV: Seed germination, seedling growth and establishment

4.1 Unique features of plant growth and anatomy: process of seed germination and its types, geotropism and phototropism: role of hormones- Cholodry-went hypothesis, current models; role of mutants in understanding genetic control.
4.2 Organisation of shoot and root apical meristem: patterns of cell fate, shoot and root development: cell lineages; Leaf growth, development and senescence: physiological, metabolic and molecular pathways.
4.3 Secondary growth: wood development and its diversity; cambial variants; ultra structure and control of xylem and phloem differentiation.
4.4 Stomata and trichomes: structural diversity, genetic control of origin and development.

UNIT V: Specialized structures and propagules

5.1 Specialized secretory and exchange Structures: Structural and functional anatomy of laticifers, lenticles, nectarines, osmophores, salt glands and hydathodes.
5.2 Vegetative propagules and resource allocation: vegetative propagules for perennation and for ramification: diversity, propagules as sinks for photosynthates-process and molecular control.
5.3 Fruit development and ripening mechanisms: fruit development and ripening: dynamics of fruit growth and development: role of hormones, biochemistry and genetics of fruit ripening; parthenocarpic fruits-development and economic significance.
5.4 Seed biology and adaptive strategies: sexual seeds- types and structure: patterns of evolution, anatomical adaptations for survival in diverse habitats, biotic and abiotic stresses.

Suggested readings

- 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.
- Besse, P. (2014). Molecular Plant Taxonomy. Human Press, London.
- Crawford, D. J. (2003). Plant Molecular Systematics. Cambridge University Press, Cambridge, UK.
- Cronquist, A. (1981). An Integrated System of Classification of Flowering Plants. Columbia University Press, New York.
- Davis, P. H. and Heywood V. H. (2011). Principles of Angiosperm taxonomy Scientific Publications.
- Hillis, D. M., Moritz, C. and Mable, B. K., (1996) Molecular Systematics, Sinauer Associates, Massachusetts.
- Hollingsworth, P. M., Bateman, R. M. and Gornall, R. J. (1999). Molecular Systematics and Plant Evolution. Taylor and Francis, London.
- 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.

- Patané, J. S. L., Martins, J. and Setubal, J. C. (2018). Phylogenomics. In: Setubal, J., Stoye, J., Stadler, P. (eds) Comparative Genomics. Methods in Molecular Biology, vol 1704. Humana Press, New York, NY.
- Pullaiah, T. and Karuppusamy, S. (2018). Taxonomy of Angiosperms. 4th rev. ed. Astral International Pvt. Ltd., New Delhi.
- Singh, G. (2021). Plant Systematics: Theory and Practice 4th ed. CBS Publishers and Distributors Pvt. Ltd. India.
- Stuessy, T. F. (2002). Plant Taxonomy. Bishen Singh Mehandra Pal Singh, Dehradun.
- Stuessy, T.F. (2008). Plant Taxonomy: The systematic Evaluation of Comparative Data. Columbia University Press, New York.

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<tr><th>MCQ on LMS + Subjective Test</th><th>Time allotted for the Examination</th><th colspan="3">% weightage(marks)</th></tr>
<tr><td>Mid Term Appraisal (Evaluation of daily practical performance/ Practical Assignment/ Field Study)</td><td>4 hours</td><td colspan="3">25%</td></tr>
<tr><td rowspan="2">External Examination</td><td rowspan="2">4 hours</td><td rowspan="2">75%</td><td>50%</td><td>Final Practical Performance</td></tr>
<tr><td>25%</td><td>Viva-Voce</td></tr>
<tr><th colspan="3">Total</th><th colspan="2">100</th></tr>
</table>

Test I and Test II

The subjective test of Test I and Test II would consist of three short answer type questions (05 marks each). Students are required to answer two questions. No preparatory holidays shall be provided for the Test I and Test II. Those candidates who have appeared in Test I and Test II and failed to get the minimum required marks i.e. 14 out of 40 will be eligible to re – appear in the Test I and Test II only once.

Major Test

The major test will comprise of two sections, Section-A and Section-B. Section-A will have compulsory questions comprising 08 parts (minimum 01 from each unit) of 03 marks each. Section-B will have 06 questions of 12 marks each to be set from the last three units (02 from each unit). Students are required to attempt 01 question from each unit of section B.

List of Practicals

- Description of a specimen from representative, locally available families.
- Description of various species of a genus; identification key characters and preparation of keys at genetic level.
- Compilation of field notes and preparation of herbarium sheets.
- Study of types of corolla borne by angiosperms growing in the botanical garden.
- To study the types and arrangement of androecium in angiosperms growing in the botanical garden.
- Study of inflorescence types in flowering plants.
- To study the types of placentation in flowers of angiosperms.
- Establishing Phylogenetic relationship among species using secondary data.
- Study of structure of dicot and monocot seed; albuminous and exalbuminous seeds.
- Seed storage structures- maize and pulses.
- Study of seed dormancy and methods to break dormancy.
- Study of diversity of vegetative propagation in plants, its comparison to sexual reproduction.
- Study of living shoot apices by dissections using aquatic plants such as *Ceratophyllum* and *Hydrilla*.
- Study of cytohistological zonation in the shoot apical meristem in sectioned and double stained permanent slides of suitable plant such as *Coleus*, *Kalanchoe*, Tobacco.
- Examination of shoot apices in a monocotyledon in both T.S. and L.S. to show the origin and arrangement of leaf primordia.
- Microscopic examination of vertical sections of leaves such as *Cannabis*, Tobacco, *Nerium*, maize and wheat to understand the internal structure of leaf tissues and trichomes, glands etc. Also study the leaf anatomy of C3 and C4 plants.
- To study the development and final structure of stomata and determine stomata index.
- Demonstration of the effect of ABA on stomata closure.
- Study of whole roots in monocots and dicots. Examination of L.S. of root from a permanent preparation to understand the organization of apical meristem and its derivatives (use maize, aerial roots of banyan, *Pistia*). Origin of lateral roots with different types of nodules.
- Study of laticifers, lenticles, hydathods from opium, species of Euphorbias, balsams.

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Mycology and Molecular Plant Pathology

Course No.: P2BOTC202
Credits: 4
Duration: 3 hrs

Maximum Marks: 100
Test I: 20 Marks
Test II: 20 Marks
Major Test: 60 Marks

Course Objectives: *This course is designed to provide students with an in-depth understanding of microbial and viral systems, encompassing both fundamental principles and recent advances. It explores the structural and molecular complexity of microbes and viruses, their evolutionary diversity, modes of interaction with plant and animal hosts, and their roles in health, disease, and environmental applications.*

Course Outcomes: *After successful completion of this course, students will be able to:*

- *Demonstrate a comprehensive understanding of fungal biology, including thallus organization, reproductive strategies, and modes of nutrition in diverse fungal groups.*
- *Explain the classification and phylogenetic relationships among fungal lineages based on both traditional and modern molecular approaches.*
- *Recognize the biotechnological and industrial applications of fungi, including their use in pharmaceuticals, organic acids, and food industries.*
- *Identify major fungal diseases affecting plants and humans, analyze their symptoms, and understand their epidemiology and disease cycles.*
- *Describe the interaction between pathogens and plant hosts, including pre- and post-penetration mechanisms and the molecular basis of pathogenesis and host resistance.*
- *Analyse the role of microbial enzymes, toxins, and other virulence factors involved in the development of disease in plants.*
- *Apply principles of disease forecasting and integrated disease management using regulatory, chemical, and biological approaches.*
- *Develop a research-oriented mindset by critically assessing current advances in molecular plant pathology and proposing practical solutions for sustainable plant disease management.*

UNIT I: Fundamentals of Fungal Biology

1.1 Introduction to mycology, historical perspectives and Importance; General characteristics of fungi and their allies, Thallus organisation, growth, branching, types of septa and aggregations: tissue systems as translocating and surviving structures.
1.2 General account on fungal nutrition: Saprobes, Parasites and Symbionts.
1.3 Reproduction: Methods of fungal propagation; Diversity of spores; Sexual reproduction: types of sexual cycles; Role and types of Pheromones in Ascomycota, Basidiomycota, Mucormycota, and Blastocladiomycota.
1.4 Sexual compatibility: Homothallism: Conventional categories of Homothallism; Types of heterothallism; Mechanism and significance of non-sexual variations.

UNIT II: Systematics and Diversity of Fungal Lineages

2.1 Classification of fungi: Traditional and advanced system of classification; Major highlights and outline of phylogenetic classification by Hibbett *et al*. (2007)

2.2 Phylum Chytridiomycota: General characters; Morphology, reproduction and life cycle of *Synchytrium, Olpidium* and *Monoblepharis*.
2.3 Phylum Neocallimastigomycota, Blastocladiomycota and Glomeromycota: General characters; Morphology, reproduction and life cycle of *Neocallimastix*, *Allomyces* and *Glomus*.
2.4 Phylum Ascomycota, Basidiomycota and Subphylum Mucormycotina: General characters; Morphology, reproduction and life cycle in *Aspergillus*, *Puccinia* and *Rhizopus*.

UNIT III: Applied Mycology and Plant Pathology

3.1 Significance of fungi in drug discovery: antibiotics, immunosuppressants, antimalarial, anticancer, antidiabetic agents; industry: organic acids and food: Cultivation and applications of edible mushrooms (*Agaricus*, *Pleurotus*).
3.2 Mycoses and fungal diseases: Types of mycotic infections in humans; important diseases crop plants caused by fungi and their allies (Powdery and downy mildews, brown spot of rice, black stem rust of wheat, red rot of sugarcane, tikka disease of groundnut).
3.3 Concept and significance of pre- and post-harvest diseases, disease triangle and its modifications.
3.4 Pre-penetration activities of the pathogens, penetration through natural openings, wounds and through intact plant surfaces, post-penetration activity of the pathogens involving growth (inter- and intra-cellular) and reproduction.

UNIT IV: Host defense mechanisms and chemical weapons of the pathogens

4.1 Components of plant disease resistance mechanisms involved in pathogen detection, signal transduction, and the defense response: Morphological (model explaining cuticle-derived resistance to *B. cinerea)*, Molecular basis of stomatal resistance, Root border cells; post-infectional histological Defense structures.
4.2 Biochemical Defense mechanism (post-infectional, including phytoalexins and PR-proteins).
4.3 Microbial enzymes (degradation of cell wall and other cell components) involved in pathogenesis.
4.4 Microbial toxins and toxins (host-specific and non-host specific) involved in pathogenesis.

UNIT V: Plant disease forecasting and management

5.1 Forecasting of epiphytotic diseases, Regulatory and biological methods–quarantine and inspection.
5.2 Chemical methods–requisites of a good fungicide, seed and soil treatment by fungicides.
5.3 Types and mode of action of protective and systemic fungicides.
5.4 Breeding for pathogen-resistant plant varieties.

Suggested readings

- Agrios, G.N. (2012). Plant Pathology. 5th Edn. Academic Press, London.
- Alexopoulos, C. J., Mims, C. W. and Blackwell, M. M. (1996). Introductory Mycology.4th Edition. John Wiley & Sons, New York.
- Borkar, S.G. and Patil. N. (2020) Mushroom: A nutritive food and its cultivation. Daya Publishing House.
- Chand, G. and Kumar, S. (2018). Techniques of mushroom cultivation. Astral International (P) Ltd. New Delhi.

- Dube, H. C. (2013). An Introduction to Fungi. 4th rev ed. Scientific Publishers, New Delhi. Eastern Ltd. New Delhi Graw Hill Publ. Co.
- Hibbett, et al. (2007). A higher level of phylogenetic classification of the fungi. Mycological Research. Vol3: 509-547.
- Lucas, J. A. (2020). Plant pathology and plant pathogen. Wiley-Blackwell pp. 432
- Mehrotra, R. S. and Aggarwal, A. (2017). Plant Pathology. 3rd ed. McGraw Hill, Chennai.
- Mehrotra, R.S. and Aneja, K.R. (1990). An Introduction to Mycology. Wiley
- Mishra, A. (2012). Plant Pathology: diseases and management. Agrobios, New Delhi. Oxford & IBH Publishing Co. Pvt. Ltd.
- Nene, Y.L. and Thapiyal, P.N. (1971). Fungicides in Plant Diseases Control.
- Roberts, P. and Evans, S. (2011). Book of Fungi. Ivy Press, Great Britain.
- Sethi, I. K. and Walia, S. K. (2018). Textbook of fungi and their allies. 2nd ed. MedTech, New Delhi.
- Singh, R. S. (2018). Introduction to principles of plant pathology. 5th ed. MEDTECH, New Delhi.
- Sreekumar, S., Remya, R. and Nair, K. V. (2016). Microbiology, Phycology, Mycology, Lichenology and Plant Pathology. MEDTECH, New Delhi.
- Strange, R. N. (2014). Introduction to plant pathology. Wiley, New Delhi.
- Sumbali, G. (2010). The Fungi. 2nd Edn. Narosa Publishing House, New Delhi.
- Sumbali, G. (2025). The Fungi. 3rd Edn.
- Vyas, S. C. (1993). Handbook of Systemic Fungicides. Vol. I, II & III. Tata McGraw Hill Publishing Co., New Delhi.
- Waller, J. M., Lenne, J. M. and Waller S. J. (2001). Plant Pathologist's Pocket Book, CAB International, UK
- Webster, J. and Roland, W. S. (2007). Introduction to Fungi. 3rd ed. Cambridge University Press, New Delhi.
- Wilson, et al., (2015). Homothallism: An umbrella term for describing diverse sexual behaviours. MA Fungus 6:207-14.

Note for Paper Setting

MCQ on LMS + Subjective Test	**Syllabus to be covered in theExamination**	**Time allotted for the Exam**	**% weightage (marks)**
Test I (After 30 days)	Up to 20%	1 hour.	10 +10
Test II (After 60 days)	21% to 40%	1 hour.	10 +10
Theory	**Syllabus to be covered in theExamination**	**Time allotted for the Exam**	**% weightage(marks**
Major Test (After 90 days)	100%	3hours.	60
Total			**100**

Practical/Research (Thesis/project/dissertation)		
MCQ on LMS + Subjective Test	**Time allotted for the Examination**	**% weightage(marks)**
Mid Term Appraisal (Evaluation of daily	4 hours	25%

practical performance/ Practical Assignment/ Field Study)				
External Examination	4 hours	75%	50%	Final Practical Performance
			25%	Viva-Voce
Total			**100**	

Test I and Test II

The subjective test of Test I and Test II would consist of three short answer type questions (05 marks each). Students are required to answer two questions. No preparatory holidays shall be provided for the Test I and Test II. Those candidates who have appeared in Test I and Test II and failed to get the minimum required marks i.e. 14 out of 40 will be eligible to re – appear in the Test I and Test II only once.

Major Test

The major test will comprise of two sections, Section-A and Section-B. Section-A will have compulsory questions comprising 08 parts (minimum 01 from each unit) of 03 marks each. Section-B will have 06 questions of 12 marks each to be set from the last three units (02 from each unit). Students are required to attempt 01 question from each unit of section B.

List of Practicals

- Observation of different fungal thallus organizations- unicellular, mycelial (septate vs. coenocytic forms); types of fungal aggregations in fungi.
- Microscopic observation of asexual spores (Amerospores, Didymospores, Phragmospores, Dictyospores, Arthrospores and Sporangiospores) in different fungal groups and sexual stages (Cleistothecia, Perithecia and Chasmothecia)
- Post-harvest fungal diseases of fruits and vegetables.
- Field diseases of local crop plants. Symptomatology and histopathological observations of important fungal diseases.

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Diversity and Evolution of Gymnosperms

Course No.: P2BOTC203
Credits: 2
Duration: 2 hrs

Maximum Marks: 50
Test I: 10 Marks
Test II: 10 Marks
Major Test: 30 Marks

Course Objectives: *This course aims at acquainting the students with the diversity of vegetative and reproductive parts of major orders of Gymnosperms, their comparison with fossil gymnosperms, along with the evolution of seed habit and economic importance of this group.*

Course Outcomes: *Upon successful completion of this course, students will be able to:*

- *Identify and describe the vegetative and reproductive organs of major living gymnosperm orders.*
- *Compare and contrast the morphological and anatomical features of extant and fossil gymnosperms.*
- *Interpret the evolutionary trends leading to the development of seed habit in gymnosperms.*
- *Evaluate recent taxonomic updates and classification systems within gymnosperms.*
- *Discuss the ecological and economic importance of gymnosperms in modern contexts.*

UNIT I: Morphological and anatomical features of primitive gymnosperms

1.1 General characteristics of gymnosperms.
1.2 Recent trends in the classification of gymnosperms (Sporne, 1965 and Yang *et al*., 2022).
1.3 Morphology and vegetative anatomy of Cycadales and Ginkgoales.
1.4 Reproductive morphology of Cycadales and Ginkgoales.

UNIT II: Morphological and anatomical features of advanced gymnosperms

2.1 Morphology and vegetative anatomy of Coniferales.
2.2 Reproductive morphology of Coniferales.
2.3 Morphology and vegetative anatomy of Ephedrales, Welwitschiales and Gnetales.
2.4 Reproductive morphology of Ephedrales, Welwitschiales and Gnetales.

UNIT III: Evolutionary trends and economic importance of gymnosperms

3.1 Concept of progymnosperms and seed development in gymnosperms.
3.2 Morphology, vegetative anatomy and reproduction in Cycadeoidales.
3.3 Morphology, vegetative anatomy and reproduction in Cordaitales.
3.4 Economic importance of gymnosperms.

Suggested readings

- Bhatnagar, S. P. and Moitra, A. (2018). Gymnosperms. New Age International, New Delhi.
- Biswas, C. and Johri, B. M. (2013). The Gymnosperms. Springer Science & Business Media.p
- Coulter, J. M. and Chamberlain, C. J. (2019). Morphology of Gymnosperms. Alpha Edition. India.
- Foster, A. S. and Gifford, E.M. (1979). Comparative Morphology of Vascular Plants. W.H. Freeman & Co.
- Kramer, K. U. and Green, P. S. (Eds.). (1990). Pteridophytes and Gymnosperms. Springer Berlin, Heidelberg.

- Sporne, K.R. (2015). The Morphology of Gymnosperms. Bio-Green Books
- https://www.conifers.org. The Gymnosperm Database.

Note for Paper Setting

<table>
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<tr><td>Theory</td><td>Syllabus to be covered in theExamination</td><td>Time allotted for the Exam</td><td colspan="2">% weightage (marks)</td></tr>
<tr><td>Major Test (After 90 days)</td><td>100%</td><td>2 hours</td><td colspan="2">30</td></tr>
<tr><td colspan="3">Total</td><td colspan="2">50</td></tr>
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</table>

Test I and Test II

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Major Test

The major test will comprise of two sections, Section-A and Section-B. Section-A will have compulsory questions comprising 03 parts (minimum 01 from each unit) of 02 marks each. Section-B will have 04 questions of 12 marks each to be set from the last two units (02 from each unit). Students are required to attempt 01 question from each unit of section B.

List of Practicals

- Comparative study of the anatomy of vegetative and reproductive parts of *Cycas, Ginkgo, Pinus, Cedrus, Abies, Picea, Cupressus, Araucaria, Podocarpus, Agathis, Taxus* and *Ephedra.*
- Study of important fossil gymnosperms from prepared slides and specimens.

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Reproduction in Flowering Plants

Course No.: P2BOTC204
Credits: 2
Duration: 2 hrs

Maximum Marks: 50
Test I: 10 Marks
Test II: 10 Marks
Major Test: 30 Marks

Course Objectives: *This course is designed to acquaint the students with diversity of reproduction modes and the complexity of sexual reproduction in flowering plants. It will help them to appreciate the diversity by which genetic variability is generated and explained for evolutionary flexibility. Parallelism with animals in this context can also be drawn.*

Course Outcomes:

- *Since knowledge of reproduction forms the basis by which a species can be genetically altered, this course, as the basis of science of plant breeding, will be well appreciated by the students.*

UNIT I: Reproductive strategies with emphasis on sexual mode

1.1 General account of sexual and asexual modes; variability in sex expression and its control (chromosomal, genetic and hormonal); Apomixis- types and genetics, evolutionary significance.

1.2 Stamen- structure and development of anthers, details of tapetum, microsporogenesis & microgametogenesis, origin and deposition of pollen wall and pollen surface components.

1.3 The Pistil- structure of stigma and style, extracellular components on the surface of stigma and in the style, ovule structure and embryo sac development.

1.4 Pollination and breeding systems: self and cross pollination- agents, contrivances and syndromes. Concept and diversity of breeding systems.

UNIT II: Pollen-pistil interaction and fertilization

2.1 Screening of pollen for compatibility and quality by the pistil, pollen tube growth and guidance towards ovule and embryo sac.

2.2 Double fertilization: universality, details of events, cytological genetic and molecular perspectives.

2.3 In-vitro approaches to study fertilization: test-tube pollination, in-vitro fertilization with isolated gametes- details, success and drawbacks.

2.4 Self-incompatibility; types, genetics and molecular control in Brassicaceae, Solanaceae & and Papaveraceae

UNIT III: Fertilization products

3.1 Embryo development: diversity with emphasis on differences in mono- and dicots. Specialised embryos in Poaceae. Suspensor- diversity and role.

3.2 Endosperm- diversity in development, details of developmental stages in cereals, coconut and *Arabidopsis*. Polymerization of reserve food in albuminous seeds.

3.3 Fruits: types and developmental biology. Biochemistry and molecular biology of fruit ripening.

3.4 Seed development: general account and patterns, mobilization of food reserves; their polymerization and storage in exalbuminous seeds.

Suggested readings

- Faegri, K. and Vander Pijl, L. (1979). The principles of Pollination Ecology. Pergamon press, Oxford.
- Fosket, D. E. (1994). Plant growth and development: a molecular approach. Academic press, San Diego.
- Geber, M. A., Dawson, T.E. and Delph, L.F. (1999). Gender and sexual dimorphism in flowering plants. Springer berlin-heidelberg.
- Howell, S. H. (1998). Molecular genetics of plant development. Cambridge university press, Cambridge.
- Johri, B. M. ed. (1984). Embryology of angiosperms. Springer, berlin.
- Johri, B. M. et al (2015). Comparative embryology of angiosperms. Vol. 1-2. Springer, New Delhi.
- Mangla, Y., Khanduri, P. and Charu, K. G. (2022) reproductive biology of Angiosperms concepts and laboratory methods. Cambridge University Press.
- Raghavan, V. (1997). Molecular embryology of flowering plants. Cambridge University Press, Cambridge.
- Raghavan, V. (1999). Developmental biology of flowering plants. Springer- Verlag, New York.
- Raghvan, V. (2006). Double fertilization. Springer Verlag, Berlin-Heidelberg.
- Shivanna, K. R. and Rangaswamy, N. S. (1992). Pollen biology-a laboratory manual. Springar-Verlag, Berlin.
- Shivanna, K. R. and Tandon, R. (2014). Reproductive ecology of flowering plants: a manual. Springer, New Delhi.
- The plant cell. Special issue on reproductive biology of plants, vol. 5(10) (1993). The american society of plant physiologists. Rockville, Maryland, USA.
- Willmer, P. (2011). Pollination and floral ecology. Princeton university press.

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Theory	**Syllabus to be covered in theExamination**	**Time allotted for the Exam**	**% weightage (marks)**
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Total			**50**
Practical/Research (Thesis/project/dissertation)			
MCQ on LMS + Subjective Test	**Time allotted for the Examination**	**% weightage(marks)**	
Mid Term Appraisal (Evaluation of daily	4 hours	25%	

practical performance/ Practical Assignment/ Field Study)				
External Examination	4 hours	75%	50%	Final Practical Performance
			25%	Viva-Voce
Total			**50**	

Test I and Test II

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Major Test

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List of Practicals

- Study of diversity of vegetative propagation in plants, its comparison to sexual reproduction.
- Study flower as organ of sexual reproduction: accessory vs. essential organs, reproductive apparatus.
- Study of microsporogenesis and microgametogenesis by making acetocarmine squashes of anthers of different developmental stages.
- Examination of modes of anther dehiscence and collection of pollen grains for microscopic examination (Maize, Grasses, Solanum, Petunia, Acacia, Canna, Calotropis, etc.).
- Test for pollen viability using stains and in-vitro germination. Pollen germination using hanging drop and sitting drop cultures: Suspension culture and surface culture.
- Field study of several types of flowers with different pollination mechanisms i.e., pollination effected by wind, thrips, bees, butterflies and birds.
- Study of nuclear and cellular endosperm through dissections and staining.
- Isolation of zygotic, globular, heart-shaped, torpedo shaped and mature embryo from suitable material.

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Molecular Biology and Ecology of Reproduction in Plants

Course No.: P2BOTE207
Credits: 2
Duration: 2 hrs

Maximum Marks: 50
Test I: 10 Marks
Test II: 10 Marks
Major Test: 30 Marks

Course Objectives: *To enable students to identify the effect of ecological and molecular parameters in defining and organizing the reproductive aspects of flowering plants.*

Course Outcomes:

- *The students will be able to understand the behavior of plants and flowering towards changing environmental conditions.*
- *They will be able to scrutinize the evolutionary relationship between blossoms and visitors and understand the life history strategies existing in nature.*
- *This course will enable students to comprehend and analyse the molecular pathways and mechanisms underlying the physical changes and shifts of flowering and reproduction.*

UNIT I: Genetics of floral evocation and gender expression

1.1 Genetics of floral evocation-Transition to floral meristem as regulated by FLC, FRI, CO, FT and FD, role of microRNAs, light and temperature in regulation of these genes.

1.2 Floral organogenesis following ABC, ABCD and ABCE models; homeotic mutants in *Arabidopsis*, *Antirrhnum* and *Petunia*, MAPS genes: structure and types, mode of action: Dimer and Tetramer model.

1.3 Genetics of gender expression in flowering plants: study of details in *Melandrium album*, *Zea mays*, *Carica papaya* and Cucurbits.

1.4 Apomixis: genetic loci implicated in the phenomenon, inputs from *Pennisetum* baby boom; Dyad/Switch1 and Mi-one from *Arabidopsis*, engineering apomixis in crop plants.

UNIT II: Male and female gametophyte interaction and fertilization

2.1 Male gametophyte development with emphasis on tapetum function, insights from *Arabidopsis*, deposition of pollen wall and diversity of pollen surface components, genetic and molecular control of megasporogenesis and megagametogenesis.

2.2 Embryogenesis and embryonic pattern formation-Hormonal and genetic control, cell lineages and cell fates. Ultra-structure and cytology of endosperm development and differentiation; genome imprinting and patterning in endosperm; embryo-endosperm relationship.

2.3 Concept and types of pollination; pollination syndromes: biotic and abiotic vectors, associated pollinations and syndromes, generalized, specialized, diurnal and nocturnal pollination systems; floral rewards and advertisements.

2.4 Crisis due to human induced environmental changes and their impact on crop productivity and sustenance of flowering plant diversity; nursery pollination and global pollinators.

UNIT III: Mating strategies and seedling recruitment

3.1 Breeding systems: concept and types, various in- and outbreeding devices and contrivances thereof. Evolution of breeding systems: evolution of dioecy, self-incompatibility and self-pollination from cross pollination.

3.2 Life-history strategies: classification (Grime, 1979 and Winemiller and Rosel, 1992), concepts of opportunistic, equilibrium and periodic life histories, variations among and within species of semelparity and iteroparity and the continuum between them.

3.3 r- and k- selections, carrying capacity; trade-off between reproductive output and survival in different environments; paradigm shift from annuality to perenniality.

3.4 Seedling recruitment and effect of human activities (hunting, habitat degradation and fragmentation) on seed dispersal, recruitment and sustenance of populations.

Suggested readings

- Bewley, J.D. and Black, M. (1994). Seeds-Physiology of Development and Germination. Plenum Press, New York.
- Bhojwani, S. S., Bhatnagar, S. P. and Dantu, P. K. (2018) The embryology of angiosperms. 6th ed. Vikas Publishing House, Noida.
- Bradford, K. J. and Nonogaki, W. eds. (2007) Seed development, dormancy and germination. Blackwell Publications, Oxford.
- Burgess, J. (1985) An Introduction to Plant Cell development. Cambridge University Press, Cambridge.
- Faegri, K. and Pijl, L.V. D. (1979) The Principles of Pollination Ecology. Pergamon Press, Oxford.
- Howell, S.H. (1998) Molecular Genetics of Plant Development. Cambridge University press, Cambridge.
- Lawrence, D. H. and Spencer C. H. B. (2006) Ecology and Evolution of Flowers. Oxford University. Press Inc, New York.
- Levis, P., Tucker, S.C. and Endress, P.K. (1988) Aspects of Floral Development. J. Cramer, Germany.
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- Salisbury, F.B. and Ross, C.W. (1992) Plant Physiology. 4th Edn. Wadsworth Publishing, Belmont, California.
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- Taiz, L., et al., (2018) Plant Physiology and Development. 6th ed. Oxford, New York.
- Tandon, R., Shivanna, K. R. and Koul, M. (2020) Reproductive Ecology of Flowering Plants: Patterns and Processes. Springer Singapore.
- The Plant Cell. Special issue on Reproductive Biology of Plants, Vol. 5(10) (1993). The American society of Plant Physiologists. Rockville, Maryland, USA.
- Willmer, P. (2011) Pollination and floral ecology. Princeton University Press.

Note for Paper Setting

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Test I and Test II

The subjective test of Test I and Test II would consist of two short answer type questions (05 marks each). Students are required to answer one question. No preparatory holidays shall be provided for the Test I and Test II. Those candidates who have appeared in Test I and Test II and

failed to get the minimum required marks i.e. 7 out of 20 will be eligible to re-appear in the Test I and Test II only once.

Major Test

The major test will comprise of two sections, Section-A and Section-B. Section-A will have compulsory questions comprising 03 parts (minimum 01 from each unit) of 02 marks each. Section-B will have 04 questions of 12 marks each to be set from the last two units (02 from each unit). Students are required to attempt 01 question from each unit of section B.

List of Practicals

- Study shoot apical meristem from an appropriate material and study its transition to floral meristem.
- Analyse wild populations of *Arabidopsis* for floral structure and mutants, if any.
- Study pollen germination and pollen tube growth in compatible and incompatible pollinators.
- Study details of Embryogenesis in any cucurbit.
- Details of mature embryo and endosperm in maize at various developmental stages.
- Study flower as organ of sexual reproduction: accessory vs. essential organs, reproductive apparatus.
- Study the vegetative propagaules and its comparison to sexual reproduction.
- Study the pollination syndromes in nature and the predict the type of pollination and pollinators associated with them.
- Study of cleistogamous flowers and their adaptations.
- Trade off of resources between reproductive and vegetative parts.
- Effect of environmental condition on seed germination.
- Seed dispersal mechanisms.
- Predict life history strategies of plants based on primary and secondary data.

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Conservation Biology

Course No.: P2BOTE208
Credits: 2
Duration: 2 hrs

Maximum Marks: 50
Test I: 10 Marks
Test II: 10 Marks
Major Test: 30 Marks

Course Objectives: *The course on Conservation biology is designed to acquaint students to a vast array of life on Earth, from genes to ecosystems. The course deals to develop an understanding towards how human activities, such as habitat destruction, pollution, biodiversity erosion and climate change affect species' survival. Through this course students will be made to understand and learn about the strategies to protect and restore habitats, species and ecosystems aiming for their long-term persistence. This course also aims at identifying and prioritize areas and species for conservation based on their vulnerability and importance to overall biodiversity.*

Course Outcomes:

- *Students will be understanding the Concept and process of categorization of species based on the magnitude of threat and other IUCN guidelines*
- *Understanding towards the scientific process as related to conservation biology, including the relevance of theories and hypotheses will be developed.*
- *Students will be knowing the Application of general ecological principles to assess and address conservation threats to particular species, communities, and ecosystems.*
- *Legal foundations of conservation will be known to the students to develop a wider understanding towards conservation laws and policies*
- *After studying this course, the students will be able to identify, interpret, and communicate conservation ideas, needs and programs to others.*

UNIT I: Conservation biology and extinction

1.1 History and guiding principles of conservation biology; its goals and values.
1.2 Genetic variation magnitude, loss and its consequences.
1.3 Species extinction, concept and causes; ultimate and proximate.
1.4 The IUCN scheme of threatened species, summary of latest IUCN Red list, IUCN scheme of threatened ecosystems, ecosystems at risk (tropical rain forests, coral reefs, mangroves, wetlands).

UNIT II: Biodiversity assessment

2.1 Concept of biodiversity (a historical perspective); alpha, beta, gamma diversity, dark diversity.
2.2 Magnitude of global biodiversity (an overview); components of biodiversity (species richness and evenness).
2.3 Levels of biodiversity organizational (genetic species and ecosystem), spatial (alpha, beta, gamma, delta), values of biodiversity (direct use, indirect use, option and existence values).
2.4 Biodiversity and ecosystem functioning, ecological economics, biogeography, biological resources, ecological principles biodiversity and ecosystem services.

UNIT III: Conservation challenges and techniques

3.1 Threats to biodiversity: anthropogenic and natural; endemism, extinction, habitat loss.
3.2 Meta-population dynamics, habitat fragmentation and degradation.

3.3 Overexploitation, sustainable harvest models, Invasive alien species
3.4 Biodiversity conservation: in situ and *Ex-situ* conservation strategies (concept of protected areas network), IUCN's scheme of PA management categories

Suggested readings

- Bawa, K., Primack, R. B. and Oommen, M. A. (2011). Conservation biology: a primer for South Asia. Orient Blackswan.
- Carroll, S. P. and Fox, C. W. (2008). Conservation Biology: Evolution in Action. Oxford University Press.
- Groom, M. J., Meffe, G. K. and Carroll, C. R. (2006). Principles of Conservation Biology. Sinauer Associates, U.S.A.
- Joshi, P. and Joshi, P. (2020). Textbook of Conservation Biology. Evincepub Publishing.
- Prasad, G. (2012). Handbook of Conservation Biology. Discovery Publishing House Pvt Ltd.
- Primack, R. B. (2006). Essentials of Conservation Biology. 4th Edn. Sinauer Associates, U.S.A.
- Primack, R. B. (2012). A Primer of Conservation Biology. Sinauer Associates, Incorporated Publishers.
- Primack, R. B. (2014). Essentials of Conservation Biology. Oxford University Press.
- Rodgers, N.A. and Panwar, H.S. (1988). Planning a Wildlife Protected Area Network in India. Vol. I. The Report Wildlife Institute of India, Dehradun.
- Sodhi, N. S., and Ehrlich, P. R. (Eds.). (2010). Conservation biology for all. Oxford University Press.
- Van Dyke, F. (2008). Conservation biology: foundations, concepts, applications. Springer Science & Business Media.

Note for Paper Setting

MCQ on LMS + Subjective Test	**Syllabus to be covered in theExamination**	**Time allotted for the Exam**	**% weightage(marks)**
Test I (After 30 days)	Up to 20%	30 min	5 +5
Test II (After 60 days)	21% to 40%	30 min	5 +5
Theory	**Syllabus to be covered in theExamination**	**Time allotted for the Exam**	**% weightage(marks)**
Major Test (After 90 days)	100%	2 hours	30
Total			**50**
Practical/Research (Thesis/project/dissertation)			
MCQ on LMS + Subjective Test	**Time allotted for the Examination**	**% weightage(marks)**	
Mid Term Appraisal (Evaluation of daily practical performance/ Practical Assignment/ Field Study)	4 hours	25%	

External Examination	4 hours	75%	50%	Final Practical Performance
			25%	Viva-Voce
Total			**50**	

Test I and Test II

The subjective test of Test I and Test II would consist of two short answer type questions (05 marks each). Students are required to answer one question. No preparatory holidays shall be provided for the Test I and Test II. Those candidates who have appeared in Test I and Test II and failed to get the minimum required marks i.e. 7 out of 20 will be eligible to re-appear in the Test I and Test II only once.

Major Test

The major test will comprise of two sections, Section-A and Section-B. Section-A will have compulsory questions comprising 03 parts (minimum 01 from each unit) of 02 marks each. Section-B will have 04 questions of 12 marks each to be set from the last two units (02 from each unit). Students are required to attempt 01 question from each unit of section B.

List of Practicals

- Quadrat and transect sampling, biodiversity surveys.
- Sampling of seeds and their viability and germination tests.
- Calculation of Normalized Difference Vegetation Index (NDVI) and habitat mapping using Google Earth Engine.
- Categorization of plants following IUCN scheme and guideline.
- Assessment of genetic diversity following molecular and morphological approaches.
- Designing and designation of protective areas making use of secondary data.
- Field-based mini-projects on conservation assessment.

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Physiology and Metabolism of Plants

Course No.: P2BOTC301
Credits: 4
Duration: 3 hrs

Maximum Marks: 100
Test I: 20 Marks
Test II: 20 Marks
Major Test: 60 Marks

Course Objectives: *The course is designed to make students understand how different enzymes, molecular signals and hormones regulate important reactions and activities in plants. Another aim is to impart students' knowledge regarding the mechanisms underlying absorption of water and minerals, solute transport, photosynthesis, respiration, nitrogen and sulphur metabolism*

Course Outcomes: *The students will be able to:*

- *Understand the structure, classification, kinetics and regulation of plant enzymes, along with their role in photosynthesis, respiration and nitrogen metabolism.*
- *Explain the mechanisms of signal transduction and hormone signaling pathways, including the physiological roles of plant growth regulators and stress signals.*
- *Analyze the processes of water and mineral absorption, photochemistry, carbon assimilation and energy production in plants.*
- *Evaluate the importance of nitrogen and sulfur metabolism in plant nutrition, growth and environmental adaptation.*
- *Apply knowledge of emerging concepts like scotobiology, hydroponics and root-based climate resilience strategies in the context of sustainable agriculture.*

UNIT I: Enzymology and its role in life processes

1.1 Enzymes: International Union of Biochemists classification system, special reference to latest developments.
1.2 Enzyme structure analysis and predictions: databases of pre-computed models of key enzymes of photosynthesis, molecular docking for enzyme activity analysis.
1.3 Enzyme kinetics: Michaelis-Menton equation, line Weaver Burk plots, double reciprocal plots, ping pong mechanism with suitable examples.
1.4 Protein data banks: 2D and 3D structural and functional relation in enzymes, molecular factors regulating enzymes of CO_2 fixation and nitrogen metabolism.

UNIT II: Photobiology and signal transduction

2.1 Signal transduction: concept, receptors, G-proteins, phospholipid signaling, second messengers- a general account.
2.2 Diversity in protein kinases and phosphatases, calcium-calmodulin cascade, specific signaling mechanisms; two component sensor-regulator system in bacteria.
2.3 Plant roots and climate resilience: root modifications, their morphological and anatomical changes, impact on water and nutrient uptake. Root flexibility and its climate resilience in important cash crops (with suitable examples).
2.4 Scotobiology- overview, impact of darkness on plant growth and development, ecological responses of night pollution on plant habits.

UNIT III: Plant hormone signaling and perception

3.1 Auxins, cytokinins, gibberellins and brassinosteroids – biosynthesis (overview) and signal transduction in plants.
3.2 Abscisic acid, ethylene, jasmonic acid, salicylic acid and strigolactones- biosynthesis (overview) and signal transduction in plants.
3.3 Hydroponics as a future of urban agriculture: types of hydroponics, methods and procedures with suitable examples (lettuce, bak-choi, red lettuce, exotic fruits etc.), developments of hydroponics to combat the climate crisis.
3.4 Hydrogen peroxide, hydrogen sulfide, reactive oxygen species and reactive nitrogen species interaction with plant hormones and role in stress management.

UNIT IV: Photochemistry and photosynthesis.

4.1 Evolution of photosynthetic apparatus, light harvesting complexes, photo-oxidation of water.
4.2 Mechanism of electron and proton transport, energy flow pathways, cyclic, non-cyclic and pseudo cyclic pathways.
4.3 Carbon assimilation-Calvin cycle, C4 cycle, difference between C3 and C4 pathways, CAM pathways, photorespiration and its significance.
4.4 Biosynthesis of starch and sucrose and their regulation.

UNIT V: Respiration, Nitrogen and Sulphur metabolism

5.1 Overview of plant respiration, glycolysis, TCA cycle.
5.2 Electron transport system and recent advances in mechanism of ATP synthesis.
5.3 Nitrogen fixation-overview, biological nitrogen fixation, nodule formation and nod factors, mechanism of nitrate uptake and reduction; ammonium assimilation (GS/GOGAT cycle).
5.4 Sulphur metabolism- overview, sources and mechanism of sulphur uptake, transport, assimilation and its significance.

Suggested readings

- Bhatla, S. C. and Lal, M. A. (2018). Plant Physiology, development and metabolism Springer.
- Brown, T. A. (2017) Biochemistry. Viva Publishers.
- Buchanan, B. B., Gruissem, W. and Jones, R. L. (2015). Biochemistry and Molecular Biology of Plants. American Society of Plant Physiologist, Maryland, USA.
- Gardner, F. P., et al., (2013). Physiology of Crop Plants. Scientific Publishers, Jodhpur.
- Garrett, R. H. and Grisham, C. M. (2013). Biochemistry. 5th ed. Brooks/ Cole, Australia.
- Heldt, H-W. (2016). Plant Biochemistry. 4th ed. Academic Press, USA.
- Hopkins, G.W. and Hiinner, N. P. A. (2008). Introduction to Plant Physiology. 4th Edn. Wiley and Sons. Inc. New York, U.S.A.
- Nelson, D. L. and Cox, M. M. (2013). Lehninger-Principles of Biochemistry. Worth Publishers Inc. New York, USA.
- Nobel, P. S. (1999). Physio-chemical and Environmental Plant Physiology. 2nd Edn. Academic Press, San Diego, U.S.A.
- Prasad, M. N. V. (2014). Plant Ecophysiology. John Wiley, New York.
- Salisbury, F.B. and Ross, C.W. (1992). Plant Physiology. 4th Edn. Wadsworth Publishing Co., California, U.S.A.

- Srivastava, L.M. (2002). Plant Growth and Development. Academic Press, USA.
- Taiz, L. and Zeiger, E. (2010). Introduction to Plant Physiology. 5th Edn. Sinauer Associates, Inc.
- Taiz, L. et al., (2018). Plant Physiology and Development. 6th ed. Oxford, New York.
- Voet, D., Voet, J. G. and Pratt. C. W. (2016). Voet's Principles of Biochemistry. 5th ed. John Wiley & Sons, Singapore.
- Willey, Neil. (2016). Environmental Plant Physiology. Garland Science, New York.

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Test I and Test II

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Major Test

The major test will comprise of two sections, Section-A and Section-B. Section-A will have compulsory questions comprising 08 parts (minimum 01 from each unit) of 03 marks each. Section-B will have 06 questions of 12 marks each to be set from the last three units (02 from each unit). Students are required to attempt 01 question from each unit of section B. In major test there should not be a gap of more than two days in between two tests.

List of Practicals

- Extraction of chloroplast pigments from leaves and preparation of the absorption spectrum of chlorophylls and carotenoids.
- Determination of chlorophyll a and chlorophyll b and its ratio in C3 and C4 plants.
- Extraction of seed proteins depending upon the solubility.
- Determination of the respiratory quotient (RQ) for germinating seeds by Ganong's Respirometer.
- Preparation of the standard curve of protein (BSA) and estimation of the protein content in extracts of plant material by Lowry's and Bradford's method.
- Extraction and qualitative estimation of amino acids from plant tissue by using paper chromatography.
- Extraction and qualitative estimation of sugars and organic acids by paper chromatography.
- Ascorbic acid extraction and quantitative estimation from plant tissues.
- Determination of effect of time and enzyme concentration on the rate of reaction of enzyme. eg. acid phosphatase, nitrate reductase, catalase.
- Determination of effect of substrate concentration of activity of an enzyme.
- Determination of the effect of anaesthetics, temperature and high pressure on the permeability of beet root tissue.
- Principles of colorimeter, spectrophotometer and fluorimeter.
- Study of degree of dissociation of an electrolyte by plasmolytic method.
- Determination of temperature coefficient (Q10) of water absorption by wheat seeds and potato tubers.

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Ecology and Conservation

Course No.: P2BOTC302
Credits: 4
Duration: 3 hrs

Maximum Marks: 100
Test I: 20 Marks
Test II: 20 Marks
Major Test: 60 Marks

Course Objectives: *The objective of this course is to provide postgraduate students with a comprehensive, interdisciplinary understanding of ecological systems and the science of biodiversity conservation. Students will gain theoretical knowledge and practical skills to analyze, interpret, and address complex ecological challenges facing natural ecosystems in a rapidly changing world. The course integrates advanced ecological principles, conservation theory, quantitative tools, and policy frameworks to foster critical thinking and problem-solving abilities in real-world environmental contexts.*

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

- *Apply ecological theory to real-world biodiversity and conservation challenges*
- *Use statistical and computational tools to analyze ecological data*
- *Design conservation strategies informed by ethics, policy, and science*
- *Work across disciplines and scales, from local fieldwork to global conservation planning*

UNIT I: Ecological systems and processes

1.1 Foundations of modern ecology: historical development and paradigm shifts in ecology; ecosystem organization and hierarchy (individuals to biosphere).
1.2 Trophic dynamics and energy flow: primary production, trophic efficiency, food web theory; energetics in terrestrial and aquatic systems.
1.3 Biogeochemical cycles and ecosystem function: Carbon, Nitrogen, Phosphorus cycles and human disruption; stoichiometry and nutrient limitation.
1.4 Disturbance ecology and succession: natural vs. anthropogenic disturbances, community assembly, resilience, thresholds and ecological succession.

UNIT II: Population, community and landscape ecology

2.1 Population dynamics and life-history strategies: age-structured models (Leslie matrices), stochasticity, extinction risk, reproductive strategies and life history evolution.
2.2 Species interactions and community ecology: competitive exclusion, mutualism, facilitation, keystone species, guilds, trait-based community ecology.
2.3 Biodiversity patterns and metrics: alpha, beta, gamma and functional diversity.
2.4 Landscape ecology and spatial Processes: Patch dynamics, fragmentation, metapopulations, use of GIS/Remote sensing and landscape metrices.

UNIT III: Quantitative and computational ecology

3.1 Ecological statistics and modeling: hypothesis testing, regression, ANOVA; species distribution models (SDMs), occupancy models.
3.2 Programming in R and data analysis: biodiversity indices, ordination, clustering; time-series analysis and forecasting.
3.3 Remote sensing and GIS for ecological applications: land use/land cover change detection; habitat suitability analysis.

3.4 Citizen science and big data in ecology: iNaturalist, GBIF, eBird, camera traps, acoustic sensors; data quality and bias in ecological datasets.

UNIT IV: Conservation biology– science and practice

4.1 Principles of conservation biology: Small population paradigm, minimum viable population; conservation genetics, evolutionary potential.
4.2 Threats to biodiversity: overexploitation, invasive species, habitat loss, climate change; extinction debt and anthropocene extinction.
4.3 Conservation strategies and protected area design: In-situ (national parks, biosphere reserves); ex-situ (seed banks, cryopreservation), conservation prioritization tools (Zonation, Marxan).
4.4 Species and ecosystem recovery programs: flagship and umbrella species approaches; success stories and challenges (global case studies).

UNIT V: Conservation policy, ethics and emerging frontiers

5.1 Conservation policy and international treaties: CBD, UNFCCC, Ramsar, CITES, IPBES; environmental law and governance.
5.2 Environmental ethics and justice: deep ecology, biocentrism, rights of nature; conservation and human rights, equity, and inclusion.
5.3 Indigenous and local knowledge (ILK): traditional ecological knowledge (TEK), biocultural diversity; community-led conservation and participatory approaches
5.4 Future of conservation: innovations and challenges: eDNA, AI, drones, satellite monitoring; rewilding, assisted migration, synthetic biology in conservation

Suggested readings

- Groom, M. J., Meffe, G. K. and Carroll, C. R. (2020). Principles of Conservation Biology (4th Edition) Sinauer Associates (an imprint of Oxford University Press).
- Hone, J. (2022). Applied Population and Community Ecology: The Case of Patchy Populations (2nd Edition) Oxford University Press.
- Hunter Jr, M. L. and Gibbs, J. P. (2006). Fundamentals of conservation biology. John Wiley & Sons.
- Jeffries, M. J. (2022) Biodiversity and Conservation (3rd Edition) Routledge (Taylor & Francis Group).
- Kareiva, P. and Marvier, M. (2021) Conservation science: Balancing the needs of people and nature (3rd ed.). Macmillan Learning.
- Robert, E. R. and Rick, R. (2021) Ecology: The Economy of Nature (9th Edition) W. H. Freeman / Macmillan Learning.
- Sodhi, N. S. and Ehrlich, P. R. (Eds.). (2010). Conservation Biology for All. Oxford University Press.
- Townsend, C., R., Begon, M. and Harper, J. L. (2021). Essentials of Ecology (5th Edition) Wiley-Blackwell.
- Vellend, M. (2016). The Theory of Ecological Communities (1st Edition) Princeton University Press.
- Wegmann, M., Leutner, B. and Dech, S. (2020). Remote Sensing and GIS for Ecologists: Using Open-Source Software (2nd Edition) Pelagic Publishing.

- Wickham, H. and Grolemund, G. (2017). R for data science: Import, tidy, transform, visualize, and model data. O'Reilly Media.

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List of Practicals

- Field identification of flora and fauna.

- Quadrat and transect sampling, biodiversity surveys.
- NDVI and habitat mapping using Google Earth Engine.
- Analysis of biodiversity datasets in R.
- Field-based mini-projects on conservation assessment.
- Physico-chemical analysis of water samples.
- Productivity studies of terrestrial and aquatic ecosystems.
- Change detection using the temporal satellite scenes.

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Cell and Molecular Biology of Plants

Course No.: P2BOTC303
Credits: 4
Duration: 3 hrs

Maximum Marks: 100
Test I: 20 Marks
Test II: 20 Marks
Major Test: 60 Marks

Course Objectives: *The present course envisages making the students aware of the nature and scope of plant life at the cellular and molecular levels including those of other pro- and eukaryotes.*

Course Outcomes:

- *The students will gain knowledge and updated information on the structural and functional aspects of cell and its related organelles at micro- and macro-molecular levels as well as the fine structure of gene and gene expression in pro- and eukaryotes.*
- *They will be able to carry out any study related to analyzing life at sub-cellular or molecular level.*

UNIT I: Cell and its envelopes

1.1 Diversity of cell and its evolution: cell wall-physical diversity in various life forms; details of structure and biogenesis of cell wall in plants.
1.2 Structure of model membranes in pro- and eu-karyotes; evolution of fluid- mosaic model of plasma membrane; details of lipid bilayer and membrane proteins in terms of structural diversity; concept of lipid rafts, asymmetrical and artificial membranes.
1.3 Transport across membrane-passive (simple and facilitated) and active transport; details of membrane channels, pumps and carriers.
1.4 Electric properties of membranes-Neurotransmission and its regulation; concept of action potential; neurotransmitters and neuroreceptors (GABA and NMDA).

UNIT II: Cellular communication, cytoskeleton and internal compartments

2.1 Cell adhesion and role of different adhesion molecules; structure and functions of plasmodesmata and gap junctions.
2.2 Structure and organization of microfilaments and microtubules; their role in intracellular motility with emphasis on vesicular traffic and chromosome movement during cell division
2.3 Structural organization, biogenesis and an overview of functions of plant cell specific organelles (vacuole, plastids and peroxisomes).
2.4 Structural organization and overview of functions of mitochondria, chloroplasts, endoplasmic reticulum, Golgi apparatus, lysosomes and melanosomes.

UNIT III: Nuclear contents-structure, synthesis and functions

3.1 Nucleus: structure, molecular organization and function of nuclear envelope, nuclear pore complex and transport; ultra structure of nucleolus; nuclear bodies
3.2 DNA: structure and geometry of A, B and Z forms; single stranded DNA; topology and super coiling of DNA; organelle genomes.
3.3 DNA replication: enzymology; mechanism in pro- and eukaryotes; rolling circle replication.
3.4 Transcription: machinery, mechanism and regulation; plant promoters and transcription factors.

UNIT IV: RNA and Proteins-structure, synthesis and function

4.1 RNA types: mRNA, tRNA and rRNA; overview of their structure and biosynthesis; formation and significance of micro-RNAs and non-coding RNAs.

4.2 Introns: types and their significance; mechanisms of RNA splicing; mRNA processing and transport.

4.3 Genetic code: nature, degeneracy, universality, Wobble hypothesis; Translation: ribosomes; mechanism in pro- and eukaryotes; factors involved thereof.

4.4 Protein structure and trafficking: protein structure and modification; concept and role of chaperones, co-translation and post-translation transport.

UNIT V: Cell cycle and cell death

5.1 Cell cycle: control mechanism; role of cyclins and cyclin dependent kinases, and CAKs, CKIs and CIPs; checkpoints in cell cycle regulation; ATM/ATR surveillance operators.

5.2 Cancers: concept of hereditary and non-hereditary cancers; role of p53, Rb and E2F proteins; oncogenes and cancer suppressor genes.

5.3 Cell division: dynamics of cytokinesis and cell plate formation.

5.4 Cell death: types, importance, programmed cell death in the life cycle of plants

Suggested readings

- Alberts, et al., (2015). Molecular biology of the cell. 6th ed. Garland Science, New York.
- Brown, T. A. (1989). Genetics: A molecular Approach. VNR International
- Brown, T. A. (2010). Gene cloning and DNA Analysis- An introduction. 6th Edn. Wiley Blackwell.
- Brown, T. A. (2010). Genomes. John Wiley and Sons (Asia) Pvt. Ltd.
- Cooper, G. M. and Hausman, R. E. (2018). The Cell: A molecular approach. 7th ed. Sinauer Association, USA.
- De, D. N. (2000). Plant Cell Vacuoles: An introduction. CSIRO Publication, Colling wood, Australia.
- Freifelder, D. and Malacinski (1993). Essentials of Molecular Biology. Jones and Bartlett Publishers.
- Gardner, E. J., Simmons, M. J. and Snustad, D. (1991). Principles of Genetics. 8th Edn. John Wiley.
- Gupta, P. K. (1997). Elements of Biotechnology. Rastogi Publications, Meerut.
- Gupta, P. K. (2002). Cell and Molecular Biology. Rastogi Publications, Meerut.
- Hardin, Jeff. (2012). Becker's world of the cell. 8th ed. Pearson, Harlow.
- Hartl, D. L. and Jones, E. W. (2000). Genetics – An Analysis of Genes and Genomes. Jones and Bartlett Publishers.
- Helms, V. (2019). Principles of Computational Cell Biology. 2nd ed. Wiley, Germany.
- Iwasa, J. and Marshall, W. (2016). Karp's Cell and Molecular Biology-Concepts and Experiments. 8th ed. Wiley Plus, Singapore
- Jones, R., et al., (2017). Molecular Life of Plants. Wiley Blackwell.
- Karp, G. (1999). Cell and Molecular Biology – Concepts and Experiments. John Wiley and Sons Inc.
- Kleinsmith, L. J and Kish, V. M. (1995). Principles of Cell and Molecular Biology. Harper Collins College Publishers, NY.

- Krishna Murthy, K.V. (2000). Methods in Cell Wall Cytochemistry. CRC Press, Boca Raton, Florida.
- Lewin, B. (2000). Genes VII. Oxford University Press. N.Y.
- Lodish., et al. (2016). Molecular Cell Biology. 8th ed. Macmillan, New York.
- Old, R.W. and Primrose, S. B. (1994). Principles of Gene Manipulation. Blackwell Scientific Publication, London.
- Pollard, T. D., et al., (2017). Cell Biology. 3rd ed. Elsevier, USA.
- Russel, P. J. (1998). Genetics. Benjamin/Cummings Publishing Co. Inc.
- Sadava, D. E. (1992). Cell Biology – Organelle Structure and Function. Jones & Bartlett Publishers.
- Snustad, D. P. and Simmons, M. J. (2000). Principles of Genetics. John Wiley and Sons, NY.
- Stansfield, W. D. (1991). Genetics (Schaums outlines). McGraw Hill.
- Watson, J. D., Hopkins, N. H., Roberts, J. W., Steitz, J. A. and Weiner, A. M. L. (1987). Molecular Biology of the Gene. The Benjamin/Cummings Publishing Company Inc.
- Wolfe, S. L. (1993) Molecular and Cellular Biology. Wadsworth Publishing Co. Calfornia, USA.

Note for Paper Setting

<table>
<tr><th>MCQ on LMS + Subjective Test</th><th>Syllabus to be covered in theExamination</th><th>Time allotted for the Exam</th><th colspan="2">% weightage (marks)</th></tr>
<tr><td>Test I (After 30 days)</td><td>Up to 20%</td><td>1 hour.</td><td colspan="2">10 +10</td></tr>
<tr><td>Test II (After 60 days)</td><td>21% to 40%</td><td>1 hour.</td><td colspan="2">10 +10</td></tr>
<tr><td>Theory</td><td>Syllabus to be covered in theExamination</td><td>Time allotted for the Exam</td><td colspan="2">% weightage (marks)</td></tr>
<tr><td>Major Test (After 90 days)</td><td>100%</td><td>3hours.</td><td colspan="2">60</td></tr>
<tr><td colspan="3">Total</td><td colspan="2">100</td></tr>
<tr><td colspan="5">Practical/Research (Thesis/project/dissertation)</td></tr>
<tr><td>MCQ on LMS + Subjective Test</td><td>Time allotted for the Examination</td><td colspan="3">% weightage(marks)</td></tr>
<tr><td>Mid Term Appraisal (Evaluation of daily practical performance/ Practical Assignment/ Field Study)</td><td>4 hours</td><td colspan="3">25%</td></tr>
<tr><td rowspan="2">External Examination</td><td rowspan="2">4 hours</td><td rowspan="2">75%</td><td>50%</td><td>Final Practical Performance</td></tr>
<tr><td>25%</td><td>Viva-Voce</td></tr>
<tr><td colspan="3">Total</td><td colspan="2">100</td></tr>
</table>

Test I and Test II

The subjective test of Test I and Test II would consist of three short answer type questions (05 marks each). Students are required to answer two questions. No preparatory holidays shall be provided for the Test I and Test II. Those candidates who have appeared in Test I and Test II and failed to get the minimum required marks i.e. 14 out of 40 will be eligible to re – appear in the Test I and Test II only once.

Major Test

The major test will comprise of two sections, Section-A and Section-B. Section-A will have compulsory questions comprising 08 parts (minimum 01 from each unit) of 03 marks each. Section-B will have 06 questions of 12 marks each to be set from the last three units (02 from each unit). Students are required to attempt 01 question from each unit of section-B. In major test there should not be a gap of more than two days in between two tests.

List of Practicals

- Demonstration of SEM using an appropriate plant material and detailed study of electron micrograph of the plant cell thus taken to see the distribution of cell organelles.
- Isolation of chloroplasts and SDS-PAGE profiles of proteins to demarcate the two subunits of Rubisco.
- Fluorescence staining with FDA for cell viability and cell wall staining with calcoflour.
- Work out various problems associated with DNA replication process from the given data.
- Calculation of replication rates from the provided data.
- Preparation of agarose gel.
- Isolation of plasmid DNA from an appropriate host by alkali lysis method.
- Study the effect of some restriction enzymes on DNA.
- Estimation of the molecular weight of different DNA fragments.
- Work out the biochemical pathways operative in Neurospora on the basis of experimental data.
- Study the genic and extragenic inheritance patterns.
- Work out the gene maps using data from crosses, ordered and unordered tetrads.
- Detection of structural changes in the chromosomes using FISH technique.
- Bring out the phylogenetic relation between different taxa (varieties, species, genera) on the basis of enzyme profiles.
- Work out inter-specific variation using zymograms and mt DNA-RFLP.
- Isolation of DNA and its quantification by spectrophotometric method.
- Isolation of DNA and preparation of ‘Cot’ curve.
- Northern and southern blot analysis using a gene specific probe.

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Plant Breeding

Course No.: P2BOTC304
Credits: 2
Duration: 2 hrs

Maximum Marks: 50
Test I: 10 Marks
Test II: 10 Marks
Major Test: 30 Marks

Course Objectives: *Knowledge of genetic basis and techniques of various plant breeding methods is a must for evolving new varieties and improved crops to meet the ever-increasing demand of food in a progressing country like India. Understanding developed by the students on these aspects will be of great practical application and will help them to appreciate the importance of conventional plant breeding in context of advancements in the field.*

Course Outcomes:

- *This course will help the students to appreciate difference in approaches for genetic amelioration of crops with diverse breeding strategies.*
- *They would also appreciate the role novel genetic interventions in augmenting the achievements of conventional breeding.*

UNIT I: Genetic basis of plant breeding and population improvement

1.1 Introduction-aims and scope of plant breeding; methods of crop improvement, their correlation with reproductive modes operative in a species; concept of homozygous and heterozygous balance; Frequencies of genes and genotypes- Hardy-Weinberg equilibrium and its deviations.
1.2 Genetic basis of breeding self and cross-pollinated crops: pure line theory, hybrid vigour and inbreeding depression; genetic and physiological basis of heterosis, various theories. Role of microRNAs and gene interactions in heterosis.
1.3 Self-incompatibility, male sterility and apomixis in crop plants: details and their implications for hybrid production and fixation of heterosis.
1.4 Pure line and mass selection methods for self-pollinated crops. Mass selection and ear-to-row methods in cross-pollinated taxa. Clonal selection for vegetatively propagating taxa.

UNIT II: Hybridization for crop improvement

2.1 Population breeding in self-pollinated crops with special reference to Transgressive breeding. Pedigree, bulk and backcross methods: details, benefits and limitations.
2.2 Hybrid breeding in cross-pollinated crops: production of inbred, recurrent selection and its types. Details of differences in production of hybrid, synthetic and composite varieties, comparative benefits and drawbacks.
2.3 Clonal hybridization- details, possibilities and benefits.
2.4 Distant hybridization-concept and techniques, barriers to production of distant hybrids, applications in crop improvement with specific examples.

UNIT III: Special breeding techniques

3.1 Special breeding techniques: concept and achievements of mutation breeding, polyploidy breeding and double haploidy.
3.2 Prebreeding: concept and process. Strategies of prebreeding- convergent breeding, bridge crosses and interspecific hybridization.

3.3 Ideotype breeding: steps involved, advantages, genome editing as a tool to achieve plant ideotype, advantages for making stress resilient crops.
3.4 Cultivar development: testing, release and notification, maintenance and participatory breeding.

Suggested readings

- Acquaah, G. (2020). Principles of Plant Genetics and Breeding, Wiley-Blackwell, USA
- Allard, R. W. (2018). Principles of plant breeding. 2nd ed. Wiley, New Delhi.
- Atwell, B. J., Kriedemann, P. E. and Turnbull, C. G. N. (1999). Plants in action: adaptation in nature, performance in cultivation. McMillan Education, Australia.
- Ayiecho, P. O. and Nyabundi, J. O. (2025) Conventional and contemporary practices of plant breeding. Springer
- Brown, J., Caligeri, P. and Compos, H. (2014). Plant Breeding. 2nd ed. Wiley Blackwell, U. K. 14.
- Sharma, J. R. (1994) Principles and practice of Plant Breeding. Tat-McGraw Hill Publishers.
- Sharma, J. R. (1998) Statistical and Biometrical Techniques in Plant Breeding. New Age International Publishers.
- Singh, B. D. (2022) Plant Breeding; principles and methods, Med Tech Science press, India.

Note for Paper Setting

MCQ on LMS + Subjective Test	**Syllabus to be covered in theExamination**	**Time allotted for the Exam**	**% weightage(marks)**
Test I (After 30 days)	Up to 20%	30 min	5 +5
Test II (After 60 days)	21% to 40%	30 min	5 +5
Theory	**Syllabus to be covered in theExamination**	**Time allotted for the Exam**	**% weightage(marks)**
Major Test (After 90 days)	100%	2 hours	30
Total			**50**

Practical/Research (Thesis/project/dissertation)				
MCQ on LMS + Subjective Test	**Time allotted for the Examination**	**% weightage(marks)**		
Mid Term Appraisal (Evaluation of daily practical performance/ Practical Assignment/ Field Study)	4 hours	25%		
External Examination	4 hours	75%	50%	Final Practical Performance
			25%	Viva-Voce
Total			**50**	

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Test I and Test II

The subjective test of Test I and Test II would consist of two short answer type questions (05 marks each). Students are required to answer one question. No preparatory holidays shall be provided for the Test I and Test II. Those candidates who have appeared in Test I and Test II and failed to get the minimum required marks i.e. 7 out of 20 will be eligible to re-appear in the Test I and Test II only once.

Major Test

The major test will comprise of two sections, Section-A and Section-B. Section-A will have compulsory questions comprising 03 parts (minimum 01 from each unit) of 02 marks each. Section-B will have 04 questions of 12 marks each to be set from the last two units (02 from each unit). Students are required to attempt 01 question from each unit of section B.

List of Practicals

- Study of natural modes of vegetative propagation using appropriate methods (bulb, corm, tuber, runner and sucker).
- Attempting different types of grafts using proper stock and scion.
- Demonstrating various types of layering.
- Studying the floral characters, pollen-ovule ratio and pollen stigma interactions in any self-pollinated crop preferably legumes.
- Studying various contrivances for out-crossing in common cross-pollinated crops available in the season (maize, bajra, jowar, trifoliums).
- Demonstrating various steps involved in carrying out hand/manual pollinations

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Plant-based Indigenous Traditional Knowledge Systems in India

Course No.: P2BOTE307 | **Maximum Marks: 50**
Credits: 2 | **Test I: 10 Marks**
Duration: 2 hrs | **Test II: 10 Marks**
Major Test: 30 Marks

Course Objectives: *The course aims to introduce students to the plant-based Indigenous Traditional Knowledge (ITK) systems of Indian origin. It focuses on understanding ethnobotanical practices, their cultural and ecological relevance, and methods of documentation and validation. Students will also learn about ethnobotanical indices, ethical issues, and legal frameworks related to traditional knowledge. The course encourages integration of traditional wisdom with scientific approaches for sustainable development.*

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

- *Explain the principles, scope, and cultural context of plant-based Indigenous Traditional Knowledge systems in India.*
- *Identify and document traditional uses of plants through ethnobotanical field methods and participatory approaches.*
- *Apply ethnobotanical indices and quantitative tools to analyze traditional knowledge data.*
- *Critically evaluate the relevance of ITKs in biodiversity conservation, healthcare, and sustainable livelihoods.*
- *Understand the ethical, legal, and policy frameworks governing traditional knowledge.*

UNIT I: Foundations of plant-based ITK in Indian context

1.1 Conceptual framework: definition, characteristics, and typologies of indigenous traditional knowledge, theoretical frameworks of ITK.
1.2 Historical evolution: historical evolution of plant-based knowledge in India (Rigvedic references, Ayurveda, Siddha, Unani).
1.3 Knowledge holders: vaidyas, siddhas, hakims, tribal elders, folk practitioners-comparison and practices.
1.4 Knowledge transmission: modes of transmission (oral, apprenticeship, palm-leaf manuscripts, modern documentation).

UNIT II: Advanced applications of plant-based ITK

2.1 Healthcare systems: ethnopharmacology, polyherbalism and synergistic formulations, disease-specific plant remedies (malaria, skin disorders, diabetes).
2.2 Cultural and religious dimensions: ritual plants, totem species, sacred groves, seasonal calendars (phenology).
2.3 Ethnocosmology and plant symbolism: cosmologies and symbolism associated with plant use.
2.4 Modern interface: integrative health (AYUSH), agroecology, community biodiversity registers

UNIT III: Documentation and research methods

3.1 Methodologies for ITK documentation: field techniques: participant observation, freelisting, questionnaires and interviews (structured, semi structured and unstructured).

3.2 Participatory approaches and ethics: PRA (Participatory Rural Appraisal), focus groups; taxonomic validation and herbarium development; ethics of working with knowledge holders (prior informed consent) and benefit sharing.
3.3 Bridging qualitative data and quantitative validation: Use Value (UV), Fidelity Level (FL), Informant Consensus Factor (ICF), Cultural Importance Index (CI) and Relative Frequency of Citation (RFC).
3.4 Scientific and interdisciplinary validation: phytochemical screening and bioactivity assays, cross-disciplinary linkages (Ethnobotany, Anthropology, Pharmacognosy); integrating ITK with AI/ML for big data ethnobotany.

Suggested readings

- Alexiades, M.N. (1996). Selected Guidelines for Ethnobotanical Research: A Field Manual. The New York Botanical Garden.
- Berkes, F. (2012). Sacred Ecology (3rd Edition). Routledge.
- Jain, S.K. (Ed.) (2000). Manual of Ethnobotany (2nd Edition). Scientific Publishers.
- Narayanan, M.K.R. (2017). Indigenous Knowledge Systems in India. Rawat Publications.
- National Biodiversity Authority (2002). Biological Diversity Act and Rules. Government of India.
- Posey, D.A. (Ed.) (1999). Cultural and Spiritual Values of Biodiversity. United Nations Environment Programme (UNEP).
- Pushpangadan, P., George, V. & Kumar, B. (2007). Ethnomedicine and Ethnopharmacology: Traditional Medicine and Modern Drug Discovery. New India Publishing Agency.
- Rout, S.D. & Panda, T. (2019). Ethnobotany: A Practical Approach. New India Publishing Agency.
- Singh, K.K. & Kumar, A. (2000). Indian Folk Medicines and Other Plant-Based Products. Scientific Publishers.
- World Health Organization (2002). WHO Traditional Medicine Strategy 2002–2005. World Health Organization Publications.

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Theory	**Syllabus to be covered in theExamination**	**Time allotted for the Exam**	**% weightage(marks**
Major Test (After 90 days)	100%	2 hours	30
Total			**50**

Practical/Research (Thesis/project/dissertation)		
MCQ on LMS + Subjective Test	**Time allotted for the Examination**	**% weightage(marks)**
Mid Term Appraisal	4 hours	25%

(Evaluation of daily practical performance/ Practical Assignment/ Field Study)				
External Examination	4 hours	75%	50%	Final Practical Performance
			25%	Viva-Voce
Total			**50**	

Test I and Test II

The subjective test of Test I and Test II would consist of two short answer type questions (05 marks each). Students are required to answer one question. No preparatory holidays shall be provided for the Test I and Test II. Those candidates who have appeared in Test I and Test II and failed to get the minimum required marks i.e. 7 out of 20 will be eligible to re-appear in the Test I and Test II only once.

Major Test

The major test will comprise of two sections, Section-A and Section-B. Section-A will have compulsory questions comprising 03 parts (minimum 01 from each unit) of 02 marks each. Section-B will have 04 questions of 12 marks each to be set from the last two units (02 from each unit). Students are required to attempt 01 question from each unit of section B.

List of Practicals

- To collect data through various Ethnobotanical Interview Techniques.
- To Prepare of Herbarium Specimens with Traditional Use Data.
- To analyse qualitative data using various Ethnobotanical Indices.
- Comparative Analysis of Classical Texts and Local Knowledge.
- To document ITK through Digital tools.
- Pharmacognostic studies of medicinal plants.

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Fundamentals and Applications of Biomimetics

Course No.: P2BOTE308	**Maximum Marks: 50**
Credits: 2	**Test I: 10 Marks**
Duration: 2 hrs	**Test II: 10 Marks**
	Major Test: 30 Marks

Course Objectives: *Biomimetics is the scientific method of learning new principles and processes based on systematic study, observation and experimentation with plants, animals, micro-organisms, and ecosystems. Biomimicry is a field of design that uses engineering, architecture, and design techniques to address man-made challenges while attempting to find sustainable solutions by mimicking nature's tried-and-true patterns. Plants, animals, and microorganisms are the ultimate engineers and designers. They have discovered what functions, what is suitable, and—above all—what endures in this world. Following connects with the nature, education, and innovation, biomimicry represents a transformative approach to design and problem-solving, offering a pathway to more sustainable and efficient products and infrastructure. Its growing popularity and the increasing availability of resources and educational opportunities signal a promising future for this field.*

Course Outcomes: *To expose the students' minds to nature's solutions in terms of innovation, adaptation and evolution.*

- *Introduce and explain the basic concepts of biomimicry and/or bioinspiration.*
- *Stimulate creativity and the use of non-obvious solutions in Bioinspired design (BID) and processes.*
- *Enhance the students' critical thinking and problem-solving skills.*
- *Demonstrate the advantages of learning from nature to design new materials with enhanced structural and (multi)functional properties.*
- *Revise basic concepts related to materials science (supramolecular chemistry, surface physics, mechanical properties, soft matter, etc.) using natural systems as case studies*

UNIT I: Introduction to biomimicry

1.1 Concept of biomimicry, the nine laws of nature, doctrine of signature, the three levels of inspiration of biomimicry.

1.2 Functional morphology of plants – a key to biomimetic applications; morphology, anatomy and biomechanics of the respective plant or plant part.

1.3 Bioinspiration; nature inspired circular economy, self-repairing materials inspired by nature, efficient water and material mixing systems.

1.4 Plants as idea providers or concept generators, resurrection plants.

UNIT II: Nature, architecture and design

2.1 Bioinspiration in design and architecture: termite mounds (temperature control), honeybee hives. Giant lily and load-bearing platforms in architecture.

2.2 Shotgun fungus, bombardier beetles and spray technology.

2.3 Biomineralization, nacre: a strong material, source of inspiration for new materials (from mollusk shells, sponge spicules, etc.).

2.4 Learning from chromosomes; inventions and discoveries based on chromosomes.

UNIT III: Biomimetics and sustainable development goals

3.1 Biomimicry for society and sustainability; biomimetic innovations for health, partnership, and life on land.

3.2 Plant- based light harvesting complexes- inspired solar panel design; artificial photosynthesis, Forest-inspired, myco-based nutrient cycling to break down toxic petrochemicals and construction debris.

3.3 Water harvesting by desert plants and animals: lessons from nature: an overview of desert plants and water harvesting mechanisms.

3.4 An overview of desert animals and water harvesting mechanisms; energy-efficient designs (use of cool materials and windbreaks).

Suggested readings

- Benyus, J. M. (2002) Biomimicry: Inventions Inspired by Nature. William Morrow & Company, pp. 320
- Gurera, D. and Bhushan, B. (2020) Passive water harvesting by desert plants and animals: lessons from nature. Phil. Trans. R. Soc. A 378: 20190444.
- https://www.learnbiomimicry.com/
- Lecointre, G., Aish, A., Améziane, N., Chekchak, T., Goupil, C., Grandcolas, P., et al., (2023) Revisiting nature's "unifying patterns": A biological appraisal. Biomimetics 8(4): 362.
- MacKinnon, R. B., Oomen, J. and Pedersen, Z., M. (2020) Promises and presuppositions of biomimicry. Biomimetics 5(3): 33.
- Raman, R., Sreenivasan, A., Suresh, M. and Nedungadi, P. (2024) Mapping biomimicry research to sustainable development goals. Scientific Reports 14(1): 18613.
- Slosar, N. (2021) Avians to Airplanes: Biomimicry in Flight and Wing Design. Berkeley Scientific Journal, Springer.

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Major Test (After 90 days)	100%	2 hours	30
Total			**50**
Practical/Research (Thesis/project/dissertation)			
MCQ on LMS + Subjective Test	**Time allotted for the Examination**	**% weightage(marks)**	
Mid Term Appraisal (Evaluation of daily practical performance/	4 hours	25%	

Practical Assignment/ Field Study)				
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List of Practicals

- To study floral morphology and symmetry in different plant species and explore their relevance in biomimetic design (e.g., radial symmetry in engineering, pollination mechanisms).
- Analyze termite mound structures and their role in passive cooling.
- To examine leaf anatomy (arrangement, venation, cuticle) and understand their role in optimizing light absorption for solar panel design inspiration.
- Observation of adaptations (such as waxy coating, sunken stomata, and spines, and relate them to water conservation technologies) in desert plant (e.g., *Opuntia*, *Agave*, *Aloe vera* etc.).
- To observe spore discharge in macrofungi (application in spray or propulsion technologies).
- Field visit to a biomimetic innovation centre, botanical garden, or bioinspired architecture.
- Design a bioinspired model/system for sustainability (e.g., biodegradable packaging, plant-inspired shade structures).

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Mushrooms: Diversity, Cultivation, and Applications

Course No.: P2BOTE309
Credits: 2
Duration: 2 hrs

Maximum Marks: 50
Test I: 10 Marks
Test II: 10 Marks
Major Test: 30 Marks

Course Objectives: *This course aims to develop a comprehensive understanding of mushroom taxonomy, diversity, and identification, along with practical skills in the cultivation of edible and medicinal mushrooms. It highlights their nutritional, pharmaceutical, and industrial relevance, and explores their role in sustainability, ecosystem restoration, circular economy and entrepreneurship*

Course Outcomes: *Upon completion of the course, students will be able to:*

- *Identify and classify mushroom species using morphological, chemical, and molecular tools.*
- *Cultivate selected edible and medicinal mushrooms under controlled systems.*
- *Understand the nutritional and therapeutic value of mushrooms.*
- *Explore post-harvest applications of mushrooms.*
- *Assess the ecological and socio-economic roles of mushrooms in sustainable agriculture.*
- *Apply mushroom-based knowledge to develop innovations in: Functional foods, bioplastics and ecological restoration.*

UNIT I: Diversity and characteristics of mushrooms

1.1 Introduction to fungal taxonomy: overview of mushroom-forming fungi: Agaricomycotina and Pezizomycotina.
1.2 Collection and identification of wild mushrooms; macro- and micro morphological details, chemical tests and reagents.
1.3 Molecular characterization of mushrooms: various tools and softwares (MEGA, RAxML etc.), multigene phylogeny.
1.4 Mushroom poisoning - types, diagnosis and treatment.

UNIT II: Mushroom cultivation and value-additions

2.1 Cultivation of some commercially important edible mushrooms: *Lentinula edodes* and *Hericium erinaceus*.
2.2 Cultivation of some commercially important medicinal mushrooms: *Ganoderma lucidum* and *Cordyceps* sp.
2.3 Integrated mushroom farming, recent advances: automated cultivation systems, environmental control systems.
2.4 Nutritional and medicinal value of mushrooms, post-harvest processing, preservation, and value-added products (nutraceuticals, powders, ready to eat snacks, tea, etc.) from mushrooms, applications in pharmaceuticals and functional foods.

UNIT III: Mushrooms in sustainability

3.1 Mushrooms and circular economy: waste-to-wealth, organic farming integration, socio-economic impact: rural livelihood generation and entrepreneurship.
3.2 Ectomycorrhizal mushrooms in ecosystem restoration and forestry, mushrooms in sustainable development goals (SDGs).

3.3 Role of edible mushrooms in food security and biocultural conservation, mushrooms in mycosilviculture and mycotourism.

3.4 Mushrooms in modern Industry and Innovation, modern applications of mushrooms: mushroom-based bioplastics, cosmetics, mushroom meat, bricks and leather.

Suggested readings

- Aggarwal, A., Sharma, Y. P. and Jangra, E. (2022) A textbook on Mushroom Cultivation theory and Practice. Newrays Publishing House, New Delhi.
- Arya, A. and Rusevska, K. (2022) Biology, Cultivation and Applications of Mushrooms. Singapore: Springer Nature Singapore.
- Gogoi, R. Rathaiah, Y. and Borah, T.R. (2019) Mushroom Cultivation Technology. (n.p.): Scientific Publishers.
- Hall, I. R., Stephenson, S. L., Buchanan, P. K., Cole, A. L. J. and Yun, W. (2010) Edible and Poisonous Mushrooms of the World. United States: Timber Press.
- Husen, A., Semwal, K.C. and Stephenson, S.L. (2023) Wild Mushrooms and Health: Diversity, Phytochemistry, Medicinal Benefits, and Cultivation. United States: CRC Press.
- Largent, D. L. and Stuntz, D.E. (1986) How to identify mushrooms to genus I: Macroscopic features. Mad River Press. Inc. Eureka.
- Largent, D.L, Johnson, D. and Watling R. (1977) How to identify mushrooms to genus III: Microscopic features. Mad River Press Inc. Eureka.
- Miles, P. G. and Chang, S. 2004. Mushrooms: Cultivation, Nutritional Value, Medicinal Effect, and Environmental Impact. United Kingdom: CRC Press.
- Pardo-Giménez A. and Zied, C. D. (2017) Edible and Medicinal Mushrooms: Technology and Applications. Germany: Wiley.
- Pouliot, A. and May, T. (2021) Wild Mushrooming: A Guide for Foragers. Australia: CSIRO Publishing.

Note for Paper Setting

MCQ on LMS + Subjective Test	**Syllabus to be covered in theExamination**	**Time allotted for the Exam**	**% weightage(marks)**
Test I (After 30 days)	Up to 20%	30 min	5 +5
Test II (After 60 days)	21% to 40%	30 min	5 +5
Theory	**Syllabus to be covered in theExamination**	**Time allotted for the Exam**	**% weightage(marks)**
Major Test (After 90 days)	100%	2 hours	30
Total			**50**
Practical/Research (Thesis/project/dissertation)			
MCQ on LMS + Subjective Test	**Time allotted for the Examination**	**% weightage(marks)**	

Mid Term Appraisal (Evaluation of daily practical performance/ Practical Assignment/ Field Study)	4 hours	25%		
External Examination	4 hours	75%	50%	Final Practical Performance
			25%	Viva-Voce
Total			**50**	

Test I and Test II

The subjective test of Test I and Test II would consist of two short answer type questions (05 marks each). Students are required to answer one question. No preparatory holidays shall be provided for the Test I and Test II. Those candidates who have appeared in Test I and Test II and failed to get the minimum required marks i.e. 7 out of 20 will be eligible to re-appear in the Test I and Test II only once.

Major Test

The major test will comprise of two sections, Section-A and Section-B. Section-A will have compulsory questions comprising 03 parts (minimum 01 from each unit) of 02 marks each. Section B will have 04 questions of 12 marks each to be set from the last two units (02 from each unit). Students are required to attempt 01 question from each unit of section B.

List of Practicals

- Field visit for collection of wild mushrooms and their identification.
- To study macroscopic (cap, gills, stipe, etc.) and microscopic features (spores, basidia, cystidia, pileipellis, etc.) for mushroom identification.
- Chemical spot tests for identification (e.g., Melzer's reagent, KOH, $FeSO_4$, Schäffer reaction).
- To study key differences between edible and poisonous species.
- Molecular phylogeny analysis using software tools like MEGA, RAxML (demo/tutorial-based).
- Hands-on demonstration of substrate preparation and mushroom cultivation.
- Estimation of nutritional content: basic tests for proteins, carbohydrates, and antioxidant content.
- Visit to a mushroom farm or rural mushroom-based enterprise.
- Preparation of a short project report on local mushroom diversity.
- Preparation of some value-added mushroom products.

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Genetic Engineering of Plants and Microbes

Course No.: P2BOTC401
Credits: 2
Duration: 2 hrs

Maximum Marks: 50
Test I: 10 Marks
Test II: 10 Marks
Major Test: 30 Marks

Course Objectives: *Genetic Engineering is one of the most important fields of genetic research. Making students knowledgeable about the methods involved in modifying and manipulating genes within and between species, creating new medicines, producing disease resistant plants and diagnosing human diseases is the main aim of this course*

Course Outcomes:

- *Making students knowledgeable about the methods involved in modifying and manipulating genes within and between species,*
- *Familiarizing them with the methods employed for creating new medicines, producing disease resistant plants and diagnosing human diseases.*

UNIT I: Recombinant DNA technology

1.1 Principles and techniques of gene cloning; use of vectors (plasmids, phage, phagemids, cosmids, and artificial chromosomes- BAC, YAC, PAC and MAC) and enzymes therein.
1.2 Genomic and cDNA libraries – construction, different methods of screening and choice of vectors.
1.3 DNA isolation and amplification; Polymerase Chain Reaction and its variations (RT-PCR, Real-time –PCR).
1.4 DNA sequencing techniques- Sanger's sequencing method and Next-Generation sequence technologies (Pyro- and Illumina based sequencing); DNA fingerprinting techniques and application.

UNIT II: Genetic improvement of plants and microbes

2.1 Aims and strategies for development of transgenic plants. Transgenic plants for modified nutritional content, herbicide tolerance, insecticidal and viral resistance and delayed ripening; molecular pharming.
2.2 Agrobacterium-mediated gene transfer; binary vector and co-integration vector strategy; direct gene transfer methods: anti-sense RNA technology and gene knockout.
2.3 Genetic improvement technique of microbes for production of antibodies, polymers, bioplastics and edible vaccines.
2.4 Intellectual property rights with reference to genetically engineered organisms; GM crops in India (Bt Brinjal and Bt Mustard); issues and concerns.

UNIT III: Genomics, Proteomics and Bioinformatics

3.1 Physical mapping of genes, DNA markers (RFLP, RAPD, AFLP, SSLPs, SNPs).
3.2 Human genome project–aims, objectives, achievements and risks, technologies used; genome editing through ZFN, TALEN and CRISPR/Cas systems.
3.3 Introduction to proteomics and transcriptomics, techniques (Microarray) and applications.
3.4 Basic bioinformatics tools- NCBI, BLAST, ORF finder; genome annotation, sequence alignment.

Suggested readings

- Bhat, T.A. and Al-Khayri, J. M. (Eds.). (2023). Genetic Engineering: Volume 1: Principles Mechanism, and Expression (1st ed.). Apple Academic Press.
- Brown, T. A. (1998). Genetics: A Molecular Approach. Chapman and Hall, London.
- Brown, T. A. (2010). Gene cloning and DNA Analysis- An introduction. 6th Edn. Wiley Blackwell.
- Brown, T. A. (2016). Gene Cloning and DNA Analysis: An Introduction (7th ed.). Wiley-Blackwell, UK.
- Brown, T. A. (2018). Genomes 4. Garland Science, New York.
- Brown, T.A. (2010). Genomes. John Wiley and Sons Pvt. Ltd., Singapore.
- Chrispeels, M. J. and Sadava, D. E. (1994). Plants, Genes and Agriculture. Jones & Bartlett Publishers, Boston, USA.
- Das, H. K. (2007). A Textbook of Biotechnology. 3rd Edn. Wiley India Pvt. Ltd. U.P., India.
- Daugherty, E. (2017). Biotechnology: Science for the New Millennium, EMC Paradigm, US.
- Glezer, A. N. and Nikaido, H. (1995). Microbial Biotechnology. W.H. Freeman and Company, New York, USA.
- Glick, B. R., Pasternak J. J. and Patten, C.L. (2010). Molecular Biotechnology: Principles and Applications of Recombinant DNA. 4th Edn. A.S.M. Press, Washington, DC.
- Henry, R. J. (1997). Practical Applications of Plant Molecular Biology. Chapman & Hall, London, UK.
- Jolles, O. and Jornvall, H. (2000). Proteomics in Functional Genomics. Birkhauser Verlag, Basel, Switzerland.
- Nicholl, D. S. T. (2023). An Introduction to Genetic Engineering (4th ed.). Cambridge: Cambridge University Press.
- Primose, S. B. and Twyman, R. M. (2014). Principles of Gene Manipulation and Genomics. 7th ed. Wiley Blackwell, New Delhi.
- Primrose, S. B. (1995). Principles of Genome Analysis. Blackwell Science Ltd., Oxford, UK.
- Raghavan, V. (1997). Molecular Biology of Flowering Plants. Cambridge University Press, New York, USA.

Note for Paper Setting

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Total			**50**
Practical/Research (Thesis/project/dissertation)			

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MCQ on LMS + Subjective Test	**Time allotted for the Examination**	**% weightage(marks)**		
Mid Term Appraisal (Evaluation of daily practical performance/ Practical Assignment/ Field Study)	4 hours	25%		
External Examination	4 hours	75%	50%	Final Practical Performance
			25%	Viva-Voce
Total			**50**	

Test I and Test II

The subjective test of Test I and Test II would consist of two short answer type questions (05 marks each). Students are required to answer one question. No preparatory holidays shall be provided for the Test I and Test II. Those candidates who have appeared in Test I and Test II and failed to get the minimum required marks i.e. 7 out of 20 will be eligible to re-appear in the Test I and Test II only once.

Major Test

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List of Practicals

- Isolation of plasmid DNA from *E. coli* by alkaline lysis method and its quantization using spectrophotometer.
- Restriction digestion of the plasmid and estimation of the size of various DNA fragments.
- Cloning of a DNA fragment in a plasmid vector, transformation of the given bacterial population and Selection of recombinants.
- Demonstration of DNA sequencing by Sanger’s dideoxy method.
- DNA isolation from microbial cultures and plant tissues.
- Isolation of plasmid from *E. coli* by alkaline lysis method.
- Preparation of agarose gel and preparation of buffers.
- Southern blotting of DNA from agarose gel.
- Study of restriction digestion of DNA.
- DNA sequencing studies from autoradiographs of sequencing gels and construction of autoradiographs of sequencing gels from provided template
- sequence.
- DNA fingerprinting studies from data on various cases of disputed parentage and forensic applications.

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Biostatistics

Course No.: P2BOTC402
Credits: 2
Duration: 2 hrs

Maximum Marks: 50
Test I: 10 Marks
Test II: 10 Marks
Major Test: 30 Marks

Course Objectives: *Variability is an inherent characteristic of biological material. To understand the nature of this variability, assess and represent it quantitatively and convert it into meaningful information, knowledge of Biostatistics is very important. It will prove helpful in designing biological experiments, collecting, analyzing and interpreting the data generated. Understanding developed by the student on these aspects will be of great practical application.*

Course Outcomes:

- *The students will get an overview of statistical concepts and help them in applying theoretical knowledge and computation skills in analysing biological data.*
- *These can be used in plant breeding, crop improvement and computational biology.*

UNIT I: Data collection, presentation and descriptive statistics

1.1 Biostatistics: conceptual understanding of statistic; variations-discrete and continuous; variable and its types.
1.2 Descriptive statistics of the distribution of any variable: mean, mode, median, variance, standard deviation, coefficient of variation, Merits and demerits of each; partitioning of data-concept of quartiles, deciles and percentiles.
1.3 Descriptive statistics of averages, dispersion, skewness and kurtosis.
1.4 Sample and population; finite and infinite populations; random and non-random methods of sampling; determination of sample size.

UNIT II: Probability distributions and various tests of significance

2.1 Probability distributions: concept, computation steps and applications of normal, binomial and Poisson distributions.
2.2 Hypothesis testing: concept, two types of errors; concept of and major differences between parametric and non-parametric tests.
2.3 Non-parametric tests: computation steps and applications of Spearman correlation, Mann Whitney U, Wilcoxon and Kruskal-Wallis tests.
2.4 Parametric tests: computation steps and applications of Z-, F and paired and unpaired t-tests.

UNIT III: Experimental designs, analysis of data and their significance

3.1 Designs of experiments: general account, principles and applications; examples of CRD, RBD; brief concept of Latin Squares, split plot and strip plot designs
3.2 Regression and correlation analyses: coefficients of correlation, regression and determination; concept and applications of logistic and non-linear regression and ANCOVA; a brief idea of GLM and HLM.
3.3 One way and two-way analysis of variance: methods and their importance in the study of variation: concept of MANOVA.
3.4 Use and importance of statistical software and/or packages in modern biology; concept and applications of PCA, LDA and RDA

Suggested readings

- Balaam, L. N. (1972). Fundamentals of Biometry. Unwin Publishers Inc. London (Halsted Press; John Wiley & Sons).
- Datta, A. K. (2006). Basic Biostatistics and its Applications. New Central Book Agency (P) Ltd., Kolkata, India.
- Dhar, M. K. and Kaul, S. (1997). Statistics in Biology. Malhotra Publishers, Jammu.
- Gupta, S. P. (2019). Statistical Methods. Sultan Chand, New Delhi.
- Khan and Khanum. (2018). Fundamentals of Biostatistics. 5th rev ed. Ukaaz Publications, Hyderabad.
- Norman, G. R. and Streiner, D. L. (2008) Biostatistics - the Bare Essentials. B C Decker Inc., Hamilton, Canada.
- Roy, D. (2012). Plant breeding: a biometrical approach. Narosa, New Delhi.
- Senedecor, G. and Cochran, W. (1980). Statistical Methods. 7th Edn. Iowa State University Press.
- Sharma, J. R. (1998). Statistical and Biometrical Techniques in Plant Breeding. New Age International Publishers.
- Singh, R. K. and Chaudhary, B. D. (1999). Biometrical methods in Quantitative Genetic Analysis. Kalyani Publishers, New Delhi.
- Sokal, R. R. and Rohlf, F. J. (1973). An Introduction to Biostatistics. W. H. Freeman and Company, New York.
- Sokal, R. R. and Rohlf, F. J. (2001). Biometry-The Principles and Practice of Statistics in Biological Research. W. H. Freeman and Company, New York.
- Sukhatme, P.V. and Amble, V. N. (1976). Statistical Methods for Agricultural Workers. ICAR, New Delhi.

Note for Paper Setting

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Theory	**Syllabus to be covered in theExamination**	**Time allotted for the Exam**	**% weightage(marks)**	
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Total			**50**	
Practical/Research (Thesis/project/dissertation)				
MCQ on LMS + Subjective Test	**Time allotted for the Examination**	**% weightage(marks)**		
Mid Term Appraisal (Evaluation of daily practical performance/ Practical Assignment/ Field Study)	4 hours	25%		
External Examination	4 hours	75%	50%	Final Practical

				Performance
			25%	Viva-Voce
Total			**50**	

Test I and Test II

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List of Practicals

- Calculation of mean, mode, median, standard deviation and coefficient of variation.
- Skewness and Kurtosis- coefficients and probability.
- Frequency and probability distributions.
- Students't-test, F-test, z-test, one-way and two-way ANOVA.
- Non-parametric tests-chi-square, Kruskal-Wallis, Spearman's correlation, Mann-Whitney U, Wilcoxon Tests
- Correlation and regression analysis.
- ANCOVA and MANOVA
- Cluster analysis
- PCA, RDA and LDA
- Use of statistical software/packages in data entry, computation and analyses

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Biodiversity Informatics

Course No.: P2BOTE405
Credits: 2
Duration: 2 hrs

Maximum Marks: 50
Test I: 10 Marks
Test II: 10 Marks
Major Test: 30 Marks

Course Objectives: *The objective of this course is to introduce students to the foundational concepts, standards, and tools of biodiversity informatics. It aims to develop skills for managing, digitizing, and validating biodiversity data from diverse sources, including field surveys, herbaria, and citizen science. Students will learn about key data standards such as Darwin Core and ABCD scheme, geospatial data applications, and data quality control techniques. The course also emphasizes practical applications of biodiversity data in conservation planning, species distribution modeling, and policy-making, preparing students to effectively utilize informatics in biodiversity research and management.*

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

- *Understand the scope, importance, and global initiatives of biodiversity informatics, along with the challenges in biodiversity data management.*
- *Identify various types and sources of biodiversity data and apply methods for data collection and digitization, including herbarium digitization techniques.*
- *Apply international data standards and protocols (e.g., Darwin Core, ABCD Schema) for biodiversity data integration and sharing.*
- *Demonstrate skills in biodiversity data validation, cleaning, and quality control using tools like OpenRefine and GBIF Validator.*
- *Design and manage biodiversity databases using DBMS principles and evaluate the use of cloud platforms for scalable biodiversity data storage.*

UNIT I: Biodiversity informatics and biodiversity data

1.1 Concepts & challenges: definition, scope, applications and importance of biodiversity informatics, global initiatives and challenges of biodiversity informatics.

1.2 Data types & sources: definition and importance of biodiversity data and data sources; field surveys, herbarium records, literature, and citizen science; types of biodiversity data (occurrence, taxonomic, trait, ecological, genetic, spatial)

1.3 Data acquisition: data collection and digitization, data collection tools (open data kit, mobile apps), herbarium digitization methods.

1.4 Practical uses: applications of biodiversity data in conservation planning and prioritization, species distribution modelling, climate change studies, policy and decision-making, biodiversity indicators and red lists.

UNIT II: Data standardization and protocols

2.1 Biodiversity Information Standards: Darwin Core (DwC) taxonomic databases, working groups: structure, elements, importance.

2.2 ABCD (Access to Biological Collection Data) Schema and tools: structure and elements, tools or editors (BioCASe provider software, XML editors).

2.3 Geospatial data basics: use of GPS and maps in biodiversity research, coordinate systems and formats.

2.4 Data quality control: data cleaning, common issues (duplicates, taxonomic errors, missing data), tools for validation (OpenRefine, GBIF validator, Taxon Match tools)

UNIT III: Database Management System (DBMS)

3.1 DBMS basics & components: brief introduction to DBMS, components of DBMS (engine, query processor, storage).
3.2 Entity-Relationship (ER) modeling: database design principles, ER diagrams (entities, attributes, relationships).
3.3 Normalization: basic concepts of 1NF, 2NF, 3NF; designing schema for ethnomedicinal plant data.
3.4 Cloud database platforms: google firebase, google cloud SQL and mongoDB atlas-advantages and challenges of cloud databases.

Suggested readings

- Bisby, F.A., Roskov, Y., Orrell, T., Nicolson, D., Paglinawan, L., Bailly, N., Kirk, P.M., Bourgoin, T., Baillargeon, G., and Ouvrard, D. (Eds.) (2021). Species 2000 & ITIS Catalogue of Life, Naturalis.
- Dubois, E., and Bizer, C. (2011). Linked Data: Structured Data on the Web, Morgan & Claypool.
- Elmasri, R. and Navathe, S.B. (2015). Fundamentals of Database Systems, 7th Edition, Pearson.
- Kroenke, D.M. and Auer, D.J. (2019). Database Concepts, 7th Edition, Pearson.
- Pillai, R.N. and Sharma, V.K. (2018). Biodiversity Informatics, Elsevier.
- Wheeler, Q.D., and Meier, R. (2000). Species Concepts and Phylogenetic Theory: A Debate, Columbia University Press.

Note for Paper Setting

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Theory	**Syllabus to be covered in theExamination**	**Time allotted for the Exam**	**% weightage(marks**
Major Test (After 90 days)	100%	2 hours	30
Total			**50**
Practical/Research (Thesis/project/dissertation)			
MCQ on LMS + Subjective Test	**Time allotted for the Examination**	**% weightage(marks)**	
Mid Term Appraisal (Evaluation of daily practical performance/ Practical Assignment/ Field Study)	4 hours	25%	

<table>
<tr><td rowspan="2">External Examination</td><td rowspan="2">4 hours</td><td rowspan="2">75%</td><td>50%</td><td>Final Practical Performance</td></tr>
<tr><td>25%</td><td>Viva-Voce</td></tr>
<tr><td colspan="3">Total</td><td colspan="2">50</td></tr>
</table>

Test I and Test II

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Major Test

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List of Practicals

- Downloading and cleaning occurrence data from GBIF.
- Visualizing species distribution using QGIS.
- Conducting a simple MaxEnt modeling exercise.
- Data mining from public databases (e.g., BOLD, IUCN).
- Creating a biodiversity dataset and publishing a mock Darwin Core Archive.
- Integrating local field data with global datasets.

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Industrial Microbiology and Public Health

Course No.: P2BOTE406
Credits: 2
Duration: 2 hrs

Maximum Marks: 50
Test I: 10 Marks
Test II: 10 Marks
Major Test: 30 Marks

Course Objectives: *This course aims to introduce students to the foundational concepts of industrial microbiology and public health microbiology. It provides an overview of microbial roles in fermentation processes, enzyme production, and bioreactor applications. The course also explores the beneficial aspects of microbes in gut health, fermented foods, and probiotic functions, alongside essential insights into microbial infections, antimicrobial resistance, and the basic principles of antibiotic sensitivity testing. The course emphasizes the contrasting roles of beneficial and pathogenic microbes, highlighting their impact on food systems, human health, and sustainable biotechnological applications.*

Course Outcomes:

After successful completion of this course, students will be able to:

- *Understand fundamental concepts of industrial microbiology, including microbial fermentation, enzyme production, and bioreactor design.*
- *Recognise the role of beneficial microbes in gut health, food fermentation, and sustainable applications.*
- *Identify common microbial pathogens and describe basic mechanisms of infection and disease.*
- *Demonstrate awareness of antimicrobial resistance and interpret basic antibiotic sensitivity testing methods.*
- *Develop practical microbiology skills, including microbial isolation, media preparation, and microscopic identification of industrial and clinical microbes.*
- *Apply microbiological knowledge to address real-world issues in food, health, and public sectors with a focus on safety and sustainability.*

UNIT I: Fundamentals of industrial microbiology

1.1 Overview of industrial microbiology; important characteristics of industrial microbes; taxonomic groupings of industrial microbes.
1.2 Fermentation: batch, fed-batch and continuous fermentation; dilution rate and microbial growth in a chemostat and a turbidostat.
1.3 Bioreactor design, types and key components; commercial production of ethanol and citric acid, importance.
1.4 Microbial enzymes: industrial production and application of amylase and protease.

UNIT II: Microbes for life in health and sustainability

2.1 Composition and diversity of gut microbiota; factors influencing gut microbiome (diet, antibiotics, lifestyle); role in digestion, immunity, and metabolic health
2.2 Gut-brain axis and microbial influence on mental health; prebiotics- concept, classification, dietary sources and importance
2.3 Probiotic foods and beverages: mechanisms of health promotion-nutrient competition, barrier function, antimicrobial production, nervous system signalling, immunomodulation.

2.4 Fermented foods: fruits, vegetables, and cereal- or legume-based products.

UNIT III: Microbial risks: infections, diseases and resistance

3.1 Clinical syndromes and pathogenesis of bacterial (staphylococcal diseases) and fungal (*Candida*, *Aspergillus*) infections.
3.2 Mechanism of action and diseases caused by viruses (seasonal flu) and prions (Creutzfeldt–Jakob disease, Scrapie, Kuru, Bovine Spongiform Encephalopathy).
3.3 Resistance to antimicrobial drugs: mechanisms of antibiotic resistance, non-genetic and genetic basis of drug resistance.
3.4 Antibiotic sensitivity testing: disc diffusion tests (Kirby–Bauer, Stokes and Primary disc diffusion tests), dilution tests (Broth & Agar dilution method and Epsilometer test).

Suggested readings

- Flint, S.J., et al., (2015) Principles of Virology. American Society for Microbiology.
- Carter, J. B. and Saunders, V. A. (2007) Virology Principles and Applications John Wiley & Sons Ltd.
- Okafor, N. and Okeke, B. C. (2018) Modern Industrial Microbiology and Biotechnology (2nd ed.). CRC Press.
- Parija, S. C. (2012) Textbook of Microbiology & Immunology (2nd rev. ed.). Elsevier India.
- Parija, S. C. (2020) A textbook of microbiology and immunology (3rd ed.). Elsevier.
- Pepper, I. L., Gerba, C. P. and Gentry, T. J. (Eds.). (2014) Environmental Microbiology (3rd ed.). Elsevier/Academic Press.
- Saxena, S. (2015) Applied Microbiology. Springer India.
- Sumbali, G. (2010) The Fungi. 2nd Edn. Narosa Publishing House, New Delhi.
- Sumbali, G. and Mehrotra, R.S. (2009) Principles of Microbiology. 1st Edn. Tata McGraw-Hill Publishing Co. Ltd. New Delhi.
- Waites, M. J., Morgan, N. L., Rockey, J. S. and Higton, G. (2001) Industrial Microbiology: An Introduction (1st ed.). Wiley Blackwell.

Note for Paper Setting

MCQ on LMS + Subjective Test	**Syllabus to be covered in theExamination**	**Time allotted for the Exam**	**% weightage(marks)**
Test I (After 30 days)	Up to 20%	30 min	5 +5
Test II (After 60 days)	21% to 40%	30 min	5 +5
Theory	**Syllabus to be covered in theExamination**	**Time allotted for the Exam**	**% weightage(marks**
Major Test (After 90 days)	100%	2 hours	30
Total			**50**
Practical/Research (Thesis/project/dissertation)			
MCQ on LMS + Subjective Test	**Time allotted for the Examination**	**% weightage(marks)**	
Mid Term Appraisal	4 hours	25%	

(Evaluation of daily practical performance/ Practical Assignment/ Field Study)				
External Examination	4 hours	75%	50%	Final Practical Performance
			25%	Viva-Voce
Total			**50**	

Test I and Test II

The subjective test of Test I and Test II would consist of two short answer type questions (05 marks each). Students are required to answer one question. No preparatory holidays shall be provided for the Test I and Test II. Those candidates who have appeared in Test I and Test II and failed to get the minimum required marks i.e. 7 out of 20 will be eligible to re-appear in the Test I and Test II only once.

Major Test

The major test will comprise of two sections, Section-A and Section-B. Section-A will have compulsory questions comprising 03 parts (minimum 01 from each unit) of 02 marks each. Section-B will have 04 questions of 12 marks each to be set from the last two units (02 from each unit). Students are required to attempt 01 question from each unit of section B.

List of Practicals

- Isolation and purification of Microorganisms (Fungi/bacteria) from soil.
- Screening of Industrially Important Microorganisms for the production of enzymes.
- Preparation and Sterilisation of Fermentation Media
- Identification of probiotic microbes from commercial yoghurt/probiotic drinks.
- Preparation of curd/idli batter/pickles and identification of dominant microbes.
- Microscopic examination and identification of causal agents of different types of mycoses.

UNIVERSITY OF JAMMU
Syllabus for PG Program in BOTANY
(As per NEP–2020)
PG SEMESTER–IV
(Syllabus for the examinations to be held in the years December 2026, 2027, 2028)

Plant Molecular Stress Physiology

Course No.: P2BOTE407	**Maximum Marks: 50**
Credits: 2	**Test I: 10 Marks**
Duration: 2 hrs	**Test II: 10 Marks**
	Major Test: 30 Marks

Course Objectives: *This course is designed to enhance students' knowledge of the molecular adaptations and methods developed to evaluate a plant's potential for abiotic stress management.*

Course Outcomes: *The students will be able to:*

- *Understand the molecular mechanisms, including DNA/RNA modifications and regulatory proteins, that enable plants to tolerate abiotic stresses.*
- *Analyze the roles of gene regulatory networks, transcription factors and protein interactions in stress response pathways.*
- *Apply advanced molecular techniques such as transcriptome analysis, RNA-seq, scRNA-seq and GWAS to assess and enhance plant stress tolerance.*

UNIT I: Molecular adaptations to combat abiotic stresses

1.1 DNA modifications: types, and their role in stress management in plants.
1.2 RNA modifications: types and functions in abiotic stress mitigation in plants.
1.3 Regulatory proteins: diversity (writers, readers, and erasers) and importance in stress tolerance in plants.
1.4 Plant metabolome: brief overview and significance in stress management.

UNIT II: Regulation of abiotic stress through different routes

2.1 Gene regulatory network: overview, types, and role in stress management in plants.
2.2 Transcription factors: databases, main types, and their role in salinity, heat, and cold tolerance.
2.3 Zinc Finger Nucleases: overview, their engineering, and applicability role in plant stress management.
2.4 Protein-protein interactions: concept and their impact on abiotic stress management in plants.

UNIT III: Stress potential of plants

3.1 Transcriptome analysis: concept, overview of procedure, and importance in the discovery of potential factors conferring abiotic stress tolerance.
3.2 RNAseq analysis: concept, overview of procedure, and applications in stress management studies in plants.
3.3 Single-cell RNAseq (scRNA-seq): general idea, procedural overview, difference between RNA-seq and scRNA-seq, applications in the discovery of potential genetic factors implicated in stress management in plants.
3.4 Genome Wide Association Studies (GWAS): brief overview, latest types, SNP discovery and analysis.

Suggested readings

- He, C. (2015) RNA modification (Vol. 560). Academic Press. In Methods in Enzymology Volume 560.
- Kulski, J. (Ed.). (2016) Next generation sequencing: advances, applications and challenges.
- Mandal, S. (Ed.). (2024) Reverse Engineering of Regulatory Networks. Humana Press.
- Song, Q. and Tao, Z. (Eds.). (2023) Transcription factor regulatory networks. Springer US.
- Yadav, C. B., Pandey, G., Muthamilarasan, M. and Prasad, M. (2018) Epigenetics and epigenomics of plants. Plant Genetics and Molecular Biology, 237-261.
- Latest review and research articles.

Note for Paper Setting

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List of Practicals

- Learning of metabolome shift in wheat, rice/maize under drought and salinity stress.
- Designing a gene regulatory network for typical phosphate-deficient conditions.
- Data mining using Transcription Factor Databases for WRKY and bHLH for their role in salinity tolerance.
- STRING analysis and UNIPROT analysis for analyzing interactions of proteins
- Learning RNAseq analysis using publicly available databases.
- Methods of analyzing transcriptome data and its validation using publicly available data.
- TASSEL software learning for genomic data filtration.
- R-project for handling genomic data.