Botany 4th Year Semester
under B.A./B.Sc./B.Com Ordinance 2022 of NEP 2020
VII Semester

Course Structure for 4th -Year UG Programme in Botany

Year -4 (VII Semester)

Semester VII

Course Code	Title of Course	Credit
Core Course (CCC)		
BOTC- 701(T)	Cell Biology & Microbiology (Theory)	4
BOTC- 701(P)	Cell Biology & Microbiology (Practical)	2
BOTC- 702(T)	Mycology, Plant Pathology, Cryptogams and Paleobotany (Theory)	4
BOTC- 702(P)	Mycology, Plant Pathology, Cryptogams and Paleobotany (Practical)	2
BOTC- 703(T)	Research Methodology (Theory)	4
BOTC- 703(P)	Research Methodology (Practical)	2
Discipline Specific Elective (DSE) – choose only one		
BOTD-701(T)	Ecology – I (Theory)	4
BOTD-701(P)	Ecology – I (Practical)	2
BOTD-702(T)	Genetics and Cytogenetics – I (Theory)	4
BOTD-702(P)	Genetics and Cytogenetics – I (Practical)	2
BOTD-703(T)	Plant Pathology and Microbiology – I (Theory)	4
BOTD-703(P)	Plant Pathology and Microbiology – I (Practical)	2
BOTD-704(T)	Plant Physiology – I (Theory)	4
BOTD-704(P)	Plant Physiology – I (Practical)	2
Total Credit		**24**

***Elective Papers a, b, c and d are: Ecology, Genetics, Plant Pathology and Microbiology and Plant Physiology.

Note: Paper codes may be modified by the Examination Section as per the approved rules and procedures.

Core Course - Cell Biology & Microbiology

	L	T	P	Total
Credit	**4**	**0**	**2**	**6**
Paper Code	**BOTC-701(T)**		**BOTC-701(P)**	

Course objectives:

This course provides an understanding of cellular structure, genome organization, molecular regulation, and the processes that govern cell division, differentiation, and communication. Learners will also study the fundamentals of viruses, subviral agents, and prokaryotic cell organization, including microbial genetics and mechanisms of genetic transfer.

Course Learning Outcomes:

After completing this course, learners will be able to:

1. Describe the composition, architecture, and dynamic organization of the cell wall, plasma membrane, and cellular organelles.
2. Explain the structure, biogenesis, and coordinated functions of mitochondria, chloroplasts, nucleus, and endomembrane systems in cellular metabolism and growth.
3. Analyze how membrane and organelle interactions regulate cellular transport, communication, and differentiation.
4. Explain the molecular structure, conformational variants, and physicochemical properties of DNA and RNA.
5. Summarize classical experiments that established DNA and RNA as genetic materials, including RNA viruses as examples.
6. Interpret the organization of coding and non-coding regions, gene–promoter architecture, and cis-regulatory elements; compare genome organization in nuclear and organellar systems.
7. Describe the sequential phases of the cell cycle, molecular checkpoints, and regulation of mitosis and meiosis.
8. Explain mechanisms of cell differentiation and programmed cell death (apoptosis) and their significance in development and homeostasis.
9. Analyze cellular communication processes, including signal perception, transduction, and transport of ions, nutrients, and macromolecules across membranes.
10. Explain the origin, evolution, and structural organization of viruses, emphasizing capsid symmetry and nucleic acid diversity.
11. Classify viruses based on host range, genome type, and morphology, and describe genome organization, gene expression, and replication strategies of DNA and RNA viruses, including reverse transcription.
12. Discuss the structure, replication, and biological significance of viroids and prions as subviral agents.
13. Describe the organization of prokaryotic cells, including the structure and function of the bacterial cell wall, cytoplasmic membrane, and ribosomes.
14. Classify major bacterial groups based on morphological, physiological, and genetic characteristics.

15. Explain and evaluate mechanisms of genetic transfer in bacteria—transformation, transduction, and conjugation—and their role in genetic variation and evolution.

Course Code: BOTC-701(T)
Course Title: Cell Biology & Microbiology (Theory)
Credit: 4

Course Content

Unit I: Cellular Structure and Organization

Cell wall: composition, architecture, biogenesis, and dynamic aspects during growth and differentiation; Plasma membrane and cell wall: structural organization, interrelationship, and roles in transport and communication; Cellular organelles – structure and functions of Mitochondria, Chloroplast, Endoplasmic Reticulum, Golgi apparatus, Lysosomes, Peroxisomes, Ribosomes, Nucleus, and Cytoskeleton; Functional integration of organelles in cellular metabolism and physiology.

Unit II: Genetic Material and Genome Organization

Structure of DNA – A, B, Z, and triplex forms; Experimental evidence for DNA and RNA as genetic materials; RNA viruses as examples; Genomic components: coding and non-coding regions; introns, exons, and repetitive DNA; Gene and promoter structure; promoter diversity and cis-regulatory elements (enhancers, silencers, insulators, UTRs); Organization and interaction of nuclear, mitochondrial, and chloroplast genomes.

Unit III: Cell Cycle, Regulation, and Communication

Cell cycle phases and molecular control mechanisms; checkpoints; regulation of mitosis and meiosis; Cell differentiation and programmed cell death (apoptosis); Cellular responses to developmental and environmental signals; signal-transduction pathways (SOS, G-Proteins, Kinase, cMAP); Transport of ions, nutrients, and macromolecules across membranes.

Unit IV: Virology

Origin and evolution of viruses; Structure of viral particles – capsid organization; helical and icosahedral symmetry; nucleic acids; Nomenclature and classification of plant viruses (Baltimore); Genome organization, gene expression, and replication strategies of representative DNA and RNA viruses; Mechanism of reverse transcription; viroids and prions – structure, replication, and significance.

Unit V: Bacteriology

Prokaryotic cell organization; Structure and composition of the bacterial cell wall and cytoplasmic membrane; Structure and function of prokaryotic ribosomes; Classification of bacteria and major characteristics of important bacterial groups; Types of reproduction in bacteria and mechanisms of genetic transfer in bacteria – transformation, transduction, and conjugation.

Course Code: BOTC-702(P):
Course Title: **Cell Biology and Microbiology (Practical)**
Credit: 2
Course Content

1. Study of mitotic and meiotic cell cycles
2. Karyotyping and calculation of mitotic index

3. Micrometry
4. Cell counting and viability
5. Isolation of intact chloroplast
6. Marker enzyme assay for isolated chloroplast
7. Isolation of bacteria from soil samples
8. Gram staining of bacteria.
9. Study of viral particle models (T4 phages, bacteriophages, icosahedral)

Suggested reading

1. Banerjee, A.K. & Banerjee, N. (2006). Fundamentals of Microbiology and Immunology. NCBA, Kolkata.
2. Hull, R. (2002). Matthews' Plant Virology. Academic Press.
3. Moat, A.G., et al. (Eds.). (2001). Bergey's Manual of Systematic Bacteriology (2nd ed.). Wiley-Liss.
4. Reddy, S.R. & Reddy, S.M. (2007). Essentials of Virology. Scientific Pub. (India).

Teaching Learning Process

1. Class lectures
2. Seminars
3. Group discussions and Workshops
4. Peer teaching and learning
5. Question preparation
6. Subjective type
    a. Long answer
    b. Short answer
7. Objective type
    a. Multiple choice questions
    b. One answer/two answer type questions
    c. Assertion and reasoning
8. Practical
9. Field-based learning
10. Substantial laboratory-based practical component and experiments
11. Games
12. Technology-enabled learning
13. Internship in industry, and research establishments

Teaching Learning Plan:

a. Week 1 : Lecture
b. Week 2: Lecture
c. Week 3: Lecture
d. Week 4: Lecture
e. Week 5: Lecture/Practical
f. Week 6: Lecture/Practical
g. Week 7: Lecture/Practical
h. Week 8: Lecture/Practical

i. Week 9: Lecture/Practical
j. Week 10: Mid semester Exam
k. Week 11: Lecture/Practical
l. Week 12: Lecture/Practical/Field-based learning
m. Week 13: Lecture/Practical
n. Week 14: Lecture/Practical
o. Week 15: Lecture/Practical

Assessment Methods

- Drawings and illustrations may be made a compulsory part of practical record books
- Testing the salient features of the biomolecules and cellular components through digital media such as ppt and animations.

Unit No.	Particulars	Teaching and Learning Activity	Assessment Task
I	Cellular Structure and Organization	Classroom lectures, demonstrations, and Practical	Hands-on exercises, PPT, assignments, tests
II	Genetic Material and Genome Organization	Classroom lectures, demonstrations, and Practical	Hands-on exercises, PPT, assignments, tests
III	Cell Cycle, Regulation, and Communication	Classroom lectures, demonstrations, and Practical	Hands-on exercises, PPT, assignments, tests
IV	Virology	Classroom lectures, demonstrations, and Practical	Hands-on exercises, PPT, assignments, tests
V	Bacteriology	Classroom lectures, demonstrations, and Practical	Hands-on exercises, PPT, assignments, tests

Core Course - Mycology, Plant Pathology, Cryptogams and Paleobotany

	L	T	P	Total
Credit	**4**	**0**	**2**	**6**
Paper Code	**BOTC-702(T)**		**BOTC-702(P)**	

Course Objective

This course provides an integrated understanding of fungi, lichens, algae, bryophytes, pteridophytes, and fossil plants, emphasizing their classification, morphology, reproduction, life cycles, and evolutionary relationships. Learners will examine the ecological, economic, and biotechnological significance of cryptogamic groups, along with the principles of plant pathology, disease development, and microbial applications.

Course Learning Outcomes

After completing this course, learners will be able to:

1. Describe the general characteristics, classification, and structural organization of fungi and lichens.
2. Explain the variations in asexual and sexual reproduction, patterns of sexuality, and life-cycle diversity among fungi.
3. Evaluate the ecological and economic importance of fungi and lichens in natural and applied contexts.
4. Summarize the history, scope, and classification of plant diseases and analyze the influence of environmental factors on disease development.
5. Explain the mechanisms of pathogen perennation, dispersal, and management through cultural, chemical, and biological control strategies.
6. Apply basic microbial techniques—including culturing, metagenomics, and enzyme production—to illustrate the industrial and biotechnological roles of microorganisms.
7. Discuss the systematics and interrelationships of algal groups with reference to modern classifications (Fritsch 1935, Guiry 2024, Algae Base).
8. Describe the comparative morphology, reproduction, and life-cycle types of representative algal groups.
9. Analyze the ecological, biotechnological, and economic importance of algae, including cultivation and genetic modification techniques.
10. Compare the morphology, anatomy, and reproductive structures of bryophytes and pteridophytes using current phylogenetic frameworks (BPG, PPG).
11. Explain evolutionary trends in gametophyte–sporophyte relationships, vasculature, and stelar organization, incorporating telome theory.
12. Evaluate the ecological roles, cytological evolution, and distribution patterns of bryophytes and pteridophytes in India.
13. Describe the geological time scale, fossil types, and processes of fossilization relevant to plant evolution.

14. Interpret the evolutionary and geological significance of key fossil genera (Lepidodendron, Calamites, Lyginopteris, Cordaites) and the Indian Gondwana system.
15. Assess the economic, ecological, and biotechnological applications of cryptogams and their roles in conservation, biofertilization, phytoremediation, and sustainable resource use.

Course Code: BOTC-702(T)
Course Title: Mycology, Plant Pathology, Cryptogams and Paleobotany (Theory)
Credit: 4

Course Content

Unit I: Mycology

Fungi as a separate kingdom – general characteristics; Classification of fungi (Ainsworth (1973); Kirk *et al.*, 2008) and diagnostic features of major groups; Types of vegetative, asexual and sexual reproduction; sexuality patterns and life-cycle diversity; Parasitic and saprophytic nutrition; parasexual cycle. Economic importance of fungi (fermentation, industry, agriculture)

Lichens – structure, vegetative and reproductive bodies; ecological and economic importance.

Unit II: Plant Pathology and Microbial Technology

History and scope of plant pathology; major historical events of plant diseases; Classification of plant diseases and causal agents (bacteria, fungi, virus); Host-pathogen interaction; Environmental factors affecting disease development; pathogen perennation and dispersal; Principles and methods of disease management – cultural, chemical, and biological control.

Culturing of microorganisms (bacteria, fungi, viruses); maintenance and preservation methods; Industrial and agricultural applications – microbial enzymes, biofertilizers, and biocontrol; Concept of metagenomics and its role in microbial diversity study; Application of microorganisms in recombinant DNA technology and biotechnology.

Unit III: Algae

Systematics and classification of algae – Fritsch (1935) and Guiry (2024); overview of Algae Base; Sub-groups of algae and their interrelationships; Comparative morphology and reproduction of major algal groups; Types of life cycles – haplontic, diplontic, haplobiontic, and diplobiontic; Gametophyte culturing and seeding techniques for kelp cultivation; Genetic modification of algae and their biotechnological potential.

Unit IV: Bryophytes and Pteridophytes

Bryophyte Phylogeny Group (BPG); Bryogeographical distribution in India; Comparative morphology and developmental anatomy of liverworts, hornworts and mosses Evolution of gametophyte and sporophyte; Peristome in mosses; Ecological roles.

Pteridophyte Phylogeny Group (PPG); General characteristics of ferns and fern allies; Telome theory, vasculature, and stelar evolution in pteridophytes; Reproductive biology of extant ferns – gametophytic and sporophytic phases; apospory and apogamy; Cytological evolution.

Unit V: Paleobotany and Applied Cryptogams

Geological time scale and dominant plant groups through ages; Plant fossils – microfossils, megafossils, trace, chemical, and index fossils; Modes of preservation and fossilization; nomenclature and reconstruction; Geological distribution and evolutionary significance of Lepidodendron, Calamites, Lyginopteris, and Cordaites; Indian Gondwana system; contributions of Indian palaeobotanists and institutes; Economic, ecological, and biotechnological importance of cryptogams – food, pharmaceuticals, nutraceuticals, biofertilizers, bioproducts, bioindicators, and phytoremediation; Conservation and preservation of cryptogamic diversity and resources.

Course Code:BOTC-705(P)
Course Title: Mycology, Plant Pathology, Cryptogams and Paleobotany (Practical)
Credit: 2

Course Content

1. Field visits for the collection, documentation, and study of cryptogams, including economically important forms available in local markets of Manipur.
2. Handling and Preparation techniques for wet and dry preservations for the different groups of Cryptogams.
3. Study of permanent slides of Cyanobacteria: *Plectonema , Anabaena, Arthrospira*
4. Study of morphology and reproduction by permanent slides of – *Vaucheria, Hydrodictyon, Spirogyra, Chara, Ectocarpus, Sargassum* and *Polysiphonia.*
5. Study of morphology, anatomy and reproduction – *Conocephalum, Marchantia, Anthoceros, Sphagnum* and *Polytrichum*.
6. Study of morphology and anatomy – *Ophioglossum*, *Huperzia*, *Nephrolepis*. *Pteris* and *Salvinia.*
7. Study of alternation of generation in *Adiantum* and *Diaplazium.*
8. Study of spores of different ferns and fern allies.
9. Collection of spores for deposition in Spore Bank.
10. Study of permanent Paleobotanical slides – *Lepidendron, Lyginopteris, Calamites*.
11. Vegetative, reproductive, and anatomical features of Mastigomycotina, Zygomycotina, Ascomycotina, Basidiomycotina, Deuteromycotina
12. Isolation of fungi from soil samples.
13. Pathological studies of common fungal diseases of crop plants & vegetables found in Manipur
14. Vegetative, reproductive, and anatomical features of different forms of lichen.

Suggested Readings

- Alexopoulos, C.J. & Mims, C.W. (2007). *Introductory Mycology*. Wiley Eastern Ltd., New Delhi.
- Carlile, M.J., Watkinson, S.C. & Gooday, G.W. (2001). *The Fungi*. Academic Press, UK.
- Mehrotra, R.S. & Aneja, K.R. (1998). *An Introduction to Mycology*. New Age International (P) Ltd., New Delhi.
- Dubey, R.C. & Maheshwari, D.K. (2013). *A Textbook of Microbiology*. S. Chand & Company Ltd., New Delhi.
- Mehrotra, R.S. & Agrawal, A. (2017). *Plant Pathology*. McGraw Hill Education, New Delhi.

- Webster, J. & Weber, R.W.S. (2007). *Introduction to Fungi*. Cambridge University Press, Cambridge.
- Dubey, H.C. (2012). *An Introduction to Fungi*. Scientific Publishers (India), New Delhi.
- Agashe, S.N. (1995). *Paleobotany: Plants of the Past, Their Evolution, Paleoenvironment and Allied Plants*. Hutchinson & Co. Ltd., London.
- Li, Y.-F., Luo, L., Liu, Y., He, Q., Yu, N.-N., Gaowa, N., Yi, Z.-Q., Wang, J.-J., Han, W., Peng, T., Ho, B.-C., He, X., Zhang, L., Chen, Z.-D., Jia, Y. & Wang, Q.-H. (2024). The Bryophyte Phylogeny Group: A revised familial classification system based on plastid phylogenomic data. *Journal of Systematics and Evolution*, 62(4), 577–588.
- Siddiqui, K.A. (2002). *Elements of Paleobotany*. Kitab Mahal.
- Guiry, M.D. (2024). How many species of algae are there? A reprise: Four kingdoms, 14 phyla, 63 classes and still growing. *Journal of Phycology*. DOI: 10.1111/jpy.13431
- Rashid, A.R. (1999). *Introduction to Pteridophyta: Diversity, Development and Differentiation* (2nd Rev. ed.). Vikas Publishing Co., New Delhi.
- Sambamurty, A.V.S.S. (2013). *A Textbook of Algae*. I.K. International Pvt. Ltd., New Delhi.
- Sharma, O.P. (2017). *Bryophyta*. McGraw Hill Education, New Delhi.
- Sharma, O.P. (2017). *Pteridophyta*. McGraw Hill Education, New Delhi.
- Smith, G.M. (2021). *Cryptogamic Botany*, Vol. II: Bryophytes and Pteridophytes. Tata McGraw Hill Publishing Co., New Delhi.
- Sporne, K.R. (1982). *The Morphology of Pteridophytes*. Hutchinson University Library, London (Reprinted 1991 by B.I. Publishing Pvt. Ltd., Bombay).
- Stewart, W.N. & Rothwell, G.W. (1993). *Palaeobotany and the Evolution of Plants*. Cambridge University Press, London.

Teaching Learning Process

1. Class lectures
2. Seminars
3. Group discussions and Workshops
4. Peer teaching and learning
5. Question preparation
6. Subjective type
    a. Long answer
    b. Short answer
7. Objective type
    a. Multiple choice questions
    b. One-answer/two-answer type questions
    c. Assertion and reasoning
8. Practical
9. Field-based learning
10. Substantial laboratory-based practical component and experiments
11. Games
12. Technology-enabled learning
13. Internship in industry and research establishments

Teaching Learning Plan:

- Week 1: Lecture
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- Week 12: Lecture/Practical/Field-based learning
- Week 13: Lecture/Practical
- Week 14: Lecture/Practical
- Week 15: Lecture/Practical

Assessment Methods

1. Drawings from the temporary preparations as practical record books
2. Collection of various microbiological samples
3. Highlighting the salient features of microbial diversity, biology, genetics, and applications through digital media such as PowerPoint presentations and animations

Unit No.	**Particulars**	**Teaching and Learning Activity**	**Assessment Task**
I	Mycology	Classroom lectures, demonstrations, and Practical	Hands-on exercises, PPT, assignments, tests
II	Plant Pathology and Microbial Technology	Classroom lectures, demonstrations, and Practical	Hands-on exercises, PPT, assignments, tests
III	Algae	Classroom lectures, demonstrations, and Practical	Hands-on exercises, PPT, assignments, tests
IV	Bryophytes and Pteridophytes	Classroom lectures, demonstrations, and Practical	Hands-on exercises, PPT, assignments, tests
V	Paleobotany and Applied Cryptogams	Classroom lectures, demonstrations, and Practical	Hands-on exercises, PPT, assignments, tests

Core Course - Research Methodology

	L	T	P	Total
Credit	**4**	**0**	**2**	**6**
Paper Code	**BOTC-703(T)**		**BOTC-703(P)**	

Course Objective

This course aims to equip learners with the foundational skills required for scientific research, including problem formulation, literature review, research design, data analysis, and scientific writing. It trains students in Good Laboratory Practices, laboratory safety, and the use of key analytical instruments and techniques essential for experimental work.

Course Learning Outcome

1. After completing this course, learners will be able to:
2. Explain the concept, objectives, and ethical principles of scientific research.
3. Formulate a research question, design basic research methodology, and structure a report including materials, methods, results, and discussion.
4. Apply appropriate statistical methods and prepare effective scientific presentations using visual and digital tools (poster/oral/PowerPoint).
5. Demonstrate the ability to conduct an efficient literature survey using scientific databases and open-access resources.
6. Use referencing tools and citation styles accurately for preparing footnotes, endnotes, and bibliographies.
7. Evaluate the relevance, quality, and credibility of scientific literature for developing a sound research framework.
8. Describe the principles of Good Laboratory Practice (GLP) and maintain accurate experimental records.
9. Implement safety protocols in handling instruments, chemicals, glassware, and biological materials.
10. Demonstrate proper waste disposal, biosafety, and first-aid procedures to ensure a safe and ethical laboratory environment.
11. Identify major laboratory instruments and explain their working principles, calibration, and maintenance.
12. Apply spectroscopic, chromatographic, microscopic, and molecular techniques (UV–Vis, HPLC, PCR, electrophoresis, etc.) for experimental analysis.
13. Analyze experimental data obtained from scientific instruments and interpret results with accuracy and precision.
14. Prepare scientific documents such as dissertations, theses, and research articles following appropriate structure and style.
15. Develop research proposals and review articles adhering to publication standards and responsible authorship guidelines.
16. Assess ethical issues in scientific publishing, recognize plagiarism, and use plagiarism-detection tools to ensure academic integrity.

Course Code: BOTC-703(T)
Course Title: Research Methodology (Theory)
Credit: 4

Course Content

Unit I: Foundations of Scientific Research

Concept, scope, and ethics of scientific research; Selection of a research topic; formulation of research questions and hypotheses; Review of literature – objectives, methods, and critical synthesis; Components of a research report: materials and methods, results, discussion, and referencing; Basics of data analysis and statistical interpretation; Scientific presentation techniques – poster, oral, and digital (LCD/OHP/MS PowerPoint).

Unit II: Literature Survey and Referencing Tools

Importance and methods of literature survey; Keeping up-to-date with current scientific developments; Use of scientific databases – Web of Science, Scopus, ScienceDirect, PubMed, and open-access sources; Referencing styles and citation management; footnotes, endnotes, and bibliography preparation; Introduction to reference management software (e.g., Mendeley, Zotero).

Unit III: Good Laboratory Practices (GLP) and Safety

Setting up experiments and maintaining laboratory records; Principles of Good Laboratory Practice (GLP) – reproducibility, traceability, and documentation; Safety measures and precautionary guidelines for handling instruments, glassware, and toxic or biological materials; Disposal of hazardous and biohazardous wastes; dealing with electrical, fire, and chemical hazards; first-aid protocols; Bio-safety and institutional ethical guidelines.

Unit IV: Tools, Instruments, and Analytical Techniques

Basic laboratory equipment – autoclave, weighing balance, pH meter; Principles and applications of major analytical and imaging tools: Spectroscopy: UV–Visible spectrophotometry, FTIR, NMR, Atomic Absorption Spectrophotometer; Chromatography: HPLC, GC, LC–MS.; Microscopy: Electron, Fluorescence, Confocal; Molecular techniques: PCR, Gel electrophoresis (AGE, PAGE); Calibration, care, and maintenance of instruments.

Unit V: Scientific Writing and Publication Ethics

Structure and preparation of dissertations, theses, and research papers; Writing of review articles and short communications; Preparation of research proposals and project reports; Publication ethics and responsible authorship; Understanding and avoiding plagiarism; use of plagiarism-detection tools.

Course Code: BOTC-707(P)
Course Title: Research Methodology (Practical)
Credit: 2

Course Content

1. Preparation of buffers (phosphate buffer) and media (MS, Nutrient Agar and PDA)
2. Sterilization techniques (dry and wet)
3. Scientific writing and presentation of research papers and thesis

4. Isolation of DNA using CTAB method
5. Quantification of DNA and protein using UV-VIS spectrophotometer
6. Agarose and Polyacrylamide Gel electrophoresis
7. Amplification of DNA (PCR) using ITS, matK and RAPD.
8. Measurement of spore, pollen using light microscope,
9. Stomatal Index counting
10. Chromatography techniques (Paper, TLC and HPLC, GC)

Suggested readings:

1. Day, R.A. (1988). *How to Write and Publish a Scientific Paper* (3rd ed.). Oryx Press, Phoenix, Arizona.
2. Hofmann, A.H. (2009). *Scientific Writing and Communication: Papers, Proposals, and Presentations*. Oxford University Press, USA.
3. Sharma, K.R. (2002). *Research Methodology*. National Publishing House, Jaipur/New Delhi.
4. Sokal, R.R. & Rohlf, F.J. (1995). *Biometry: The Principles and Practice of Statistics in Biological Research* (3rd ed.). W.H. Freeman and Company, USA.
5. Webster, J.G. (2004). *Bioinstrumentation*. John Wiley & Sons (Asia) Pvt. Ltd., Singapore.
6. Whitney, F.L. (2004). *The Elements of Research*. Prentice Hall, Englewood, New Jersey.

Teaching Learning Process

1. Class lectures
2. Seminars
3. Group discussions and Workshops
4. Peer teaching and learning
5. Question preparation
6. Subjective type
    a. Long answer
    b. Short answer
7. Objective type
8. Multiple choice questions
    a. One-answer/two-answer type questions
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Teaching Learning Plan:

1. Week 1: Lecture
2. Week 2: Lecture
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4. Week 4: Lecture
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Assessment Methods

1. Drawings from the temporary preparations as practical record books
2. Collection of various microbiological samples
3. Highlighting the salient features of microbial diversity, biology, genetics, and applications through digital media such as PowerPoint presentations and animations

Unit No.	Particulars	Teaching and Learning Activity	Assessment Task
I	Foundations of Scientific Research	Classroom lectures, demonstrations, and Practical	Hands-on exercises, PPT, assignments, tests
II	Literature Survey and Referencing Tools	Classroom lectures, demonstrations, and Practical	Hands-on exercises, PPT, assignments, tests
III	Good Laboratory Practices (GLP) and Safety	Classroom lectures, demonstrations, and Practical	Hands-on exercises, PPT, assignments, tests
IV	Tools, Instruments, and Analytical Techniques	Classroom lectures, demonstrations, and Practical	Hands-on exercises, PPT, assignments, tests
V	Scientific Writing and Publication Ethics	Classroom lectures, demonstrations, and Practical	Hands-on exercises, PPT, assignments, tests

Discipline Specific Elective – Ecology I

	L	T	P	Total
Credit	**4**	**0**	**2**	**6**
Paper Code	**BOTD-701(T)**		**BOTD-701(P)**	

Course objective

This course aims to provide a comprehensive understanding of how environmental factors such as solar radiation, soil formation, biodiversity patterns, ecological succession, and pollution shape ecosystem structure and function. It enables learners to examine the interactions between biotic and abiotic components, the processes driving ecological change, and the impacts of human activities on global climate and biodiversity.

Course Learning Outcome

After completing this course, learners will be able to:

1. Explain how global patterns of solar radiation, air temperature, and light intensity influence biological processes and ecological adaptations.
2. Describe photoperiodism, vernalisation, homeostasis, and resilience, and analyze their roles in regulating plant and animal responses to environmental cues.
3. Explain soil formation processes, including pedogenesis, humus development, and colloidal complex formation, and describe soil profiles and developmental stages.
4. Compare major soil types of India with emphasis on the characteristics and ecological significance of soils in Northeast India.
5. Define biodiversity, describe its levels and magnitude, and explain its ecological, economic, and social importance.
6. Identify biodiversity hotspots, evaluate threats leading to species extinction, and assess strategies for biodiversity conservation.
7. Describe the types, mechanisms, and stages of ecological succession and interpret patterns of community development leading to climax communities.
8. Explain the causes, effects, and control measures of air, water, and soil pollution, including biomagnification and ecosystem impacts.
9. Discuss global climate issues such as greenhouse effect, global warming, and acid rain, and evaluate their consequences on ecosystems and human societies.
10. Integrate knowledge of radiation, soils, biodiversity, succession, and pollution to interpret ecological patterns and environmental changes at local and global scales.

Course Code: BOTD701(T)
Course Title: Ecology-1 (Theory)
Credit: 4

Course Content

Unit I : Solar radiation

Global stratification of air temperature and light intensity, Effects of temperature & light intensity on Biological activities, Photoperiodism, Vernalisation, Homeostasis, Resilience.

Unit II: Rock and soil in terrestrial environment

Soil formation (Paedogenesis), humus and colloidal complex, Soil Organic Matter, Soil profile and soil developmental processes, Soils of India with special reference to NE India.

Unit III: Biodiversity

Magnitude of biodiversity, levels of biodiversity, uses of biodiversity, biodiversity hotspots, threats to biodiversity, extinction of species, conservation measures of biodiversity.

Unit IV: Ecological succession

Types of succession, mechanism of succession, changes involved in ecological succession, concept of climax, examples of succession

Unit V: Environmental pollution & Global climate

Definition and kinds of Air, Water and Soil pollution their Causes, Effects, and Preventive and Remedial measures, Bio-magnification, Climate Change: Greenhouse effect, Global warming and Acid Rain

Course Code: BOTD701(P)
Course Title: Ecology-1 (Practical)
Credit: 2

Course Content

1. Generation of Species-Area Curve for fixing quadrat size.
1. Enumeration of Frequency, Density & Dominance and determination of Importance Value Index of herbs & shrubs through quadrat method.
2. Study of climatic variables viz. Light intensity, Air temperature, Relative humidity.
3. Study of soil physical parameters, viz. soil moisture, soil texture, soil pH, Bulk density, Water holding capacity.
4. Study of standing biomass & carbon pool in grassland ecosystem.

Suggested readings

1. Ambasht, R.S. & Ambasht, N.K. (2008). A Textbook of Plant Ecology. CBS Publishers & Distributors, New Delhi.
2. Botkin, D.B. & Keller, E.A. (2004). Environmental Science: Earth as a Living Planet. John Wiley & Sons, New York.

3. Kormondy, E.J. (2017). Concepts of Ecology (4th ed.). Pearson India Education Services Pvt. Ltd.
4. Miller, G.T. (1994). Living in the Environment. Wadsworth Publishing Company, Belmont, California.
5. Misra, K.C. (1991). Manual of Plant Ecology. Oxford & IBH Publishing, New Delhi.
6. Odum, E.P. (1983). Fundamentals of Ecology. Saunders College Publishing, Philadelphia.
7. Raven, P.H. & Berg, L.R. (2005). Environment (5th ed.). John Wiley & Sons, New York.
8. Ramakrishnan, P.S. (2000). Ecology and Sustainable Development. National Book Trust, India.
9. Sharma, P.D. (2015). Ecology and Environment (12th ed.). Rastogi Publications, Meerut.
10. Singh, J.S., Singh, S.P. & Gupta, S.R. (2008). Ecology, Environmental Science and Conservation. Anamaya Publishers, New Delhi.
11. Smith, R.L. (1996). Ecology and Field Biology. HarperCollins, New York.
12. Majumdar, R. & Kashyap, R. (2019). Practical Manual of Ecology and Environmental Science. Prestige Publishers, New Delhi.
13. Misra, R. (Year not provided). Ecology Workbook. Today & Tomorrow's Publishers, Allahabad.
14. Michael, P. (Year not provided). Ecological Methods for Field and Laboratory Investigations. Tata McGraw-Hill (TMH)..

Teaching Learning Process

15. Class lectures
16. Seminars
17. Group discussions and Workshops
18. Peer teaching and learning
19. Question preparation
20. Subjective type
    a. Long answer
    b. Short answer
21. Objective type
22. Multiple choice questions
    a. One-answer/two-answer type questions
    b. Assertion and reasoning
23. Practical
24. Field-based learning
25. Substantial laboratory-based practical component and experiments
26. Games
27. Technology-enabled learning
28. Internship in industry and research establishments

Teaching Learning Plan:

16. Week 1: Lecture
17. Week 2: Lecture
18. Week 3: Lecture
19. Week 4: Lecture
20. Week 5: Lecture/Practical
21. Week 6: Lecture/Practical

22. Week 7: Lecture/Practical
23. Week 8: Lecture/Practical
24. Week 9: Lecture/Practical
25. Week 10: Mid-semester Exam
26. Week 11: Lecture/Practical
27. Week 12: Lecture/Practical/Field-based learning
28. Week 13: Lecture/Practical
29. Week 14: Lecture/Practical
30. Week 15: Lecture/Practical

Assessment Methods

4. Drawings from the temporary preparations as practical record books
5. Collection of various microbiological samples
6. Highlighting the salient features of microbial diversity, biology, genetics, and applications through digital media such as PowerPoint presentations and animations

Unit No.	Particulars	Teaching and Learning Activity	Assessment Task
I	Solar radiation	Classroom lectures, demonstrations, and Practical	Hands-on exercises, PPT, assignments, tests
II	Rock and soil in terrestrial environment	Classroom lectures, demonstrations, and Practical	Hands-on exercises, PPT, assignments, tests
III	Biodiversity	Classroom lectures, demonstrations, and Practical	Hands-on exercises, PPT, assignments, tests
IV	Ecological succession	Classroom lectures, demonstrations, and Practical	Hands-on exercises, PPT, assignments, tests
V	Environmental pollution & Global climate	Classroom lectures, demonstrations, and Practical	Hands-on exercises, PPT, assignments, tests

Discipline Specific Elective - Genetics and Cytogenetics

	L	T	P	Total
Credit	**4**	**0**	**2**	**6**
Paper Code	**BOTD-702(T)**		**BOTD-702(P)**	

Course objectives

This course aims to provide a comprehensive understanding of inheritance patterns, genome organization, genetic recombination, and mechanisms of gene regulation in both eukaryotic and prokaryotic systems. It enables learners to explore microbial genetics, cytogenetics, chromosomal aberrations, and molecular tools used for genome analysis and crop improvement..

Course Learning outcomes

After completing this course, learners will be able to:

1. Explain the chromosome theory of inheritance and apply Mendelian and non-Mendelian principles to predict patterns of genetic transmission.
2. Analyse gene interactions and describe organelle inheritance with reference to maternal, biparental, and non-Mendelian segregation.
3. Describe linkage, crossing over, and recombination, and construct linkage maps using classical and molecular marker data.
4. Explain the molecular mechanisms of recombination and apply concepts of QTL mapping to identify genomic regions controlling quantitative traits.
5. Discuss the structure, organization, and evolution of eukaryotic genomes and explain principles of gene regulation in developmental, behavioural, and population contexts.
6. Explain major concepts in population and quantitative genetics, including allele frequencies, heritability, and genetic variance.
7. Describe viral and bacterial genome organization and compare mechanisms of genetic exchange in microbes such as transformation, conjugation, and transduction.
8. Explain the fine structure of genes and discuss regulatory mechanisms operating in prokaryotes.
9. Describe chromosome structure, nomenclature, and mechanisms of sex determination across organisms.
10. Identify and explain chromosomal aberrations (duplications, deletions, inversions, translocations) and ploidy changes and discuss their applications in crop improvement and genome analysis.
11. Describe principles and applications of molecular cytogenetic techniques including FISH, GISH, Fiber-FISH, flow cytogenetics, and flow karyotyping.

Course Code: BOTD703(T)
Course Title: Genetics and Cytogenetics-1 (Theory)
Credit: 4

Course Content

Unit I: Mendelian and Non-Mendelian Inheritance

Chromosome theory of inheritance; Mendelian laws; Gene interactions; Organelle inheritance.

Unit II: Recombination in Eukaryotes

Linkage and crossing over: basic concepts, linkage maps, correlation of genetic and physical maps, molecular markers and construction of linkage maps; Molecular mechanism of recombination; QTL mapping.

Unit III: Concepts in Eukaryotic genome

Eukaryotic Genome evolution, structure and organization; Gene regulation; Developmental genetics; Behavioral genetics; Population genetics and Quantitative genetics.

Unit IV: Microbial Genetics

Viral and bacterial genomes and derived vectors; Recombination in viruses and bacteria (transformation, conjugation and transduction); Fine structure of gene; Prokaryotic gene regulation.

Unit V: Cytogenetics

Chromosome: Structure and nomenclature; Sex determination: mechanisms, sex chromosomes; Chromosomal aberrations: Duplications, deficiencies/deletions, inversions, interchanges/translocations; Ploidy changes: Haploids, polyploids and aneuploids; Genome analysis in crop plants; Molecular Cytogenetics: FISH, GISH, FIBER-FISH, Flow Cytogenetics, Flow karyotyping, Applications of molecular cytogenetics

Course Code: BOTD703(P)
Course Title: Genetics and Cytogenetics – 1 (Practical)
Credit 2

Course content:

1. Preparation of mitotic and meiotic spreads and analysis of various stages of cell division.
2. Karyotyping
3. Extraction of genomic DNA from plants by CTAB method.
4. Analysis of molecular polymorphism using different types of molecular markers.
5. Construction of a linkage map using available data.
6. Mutagenesis experiments in *Allium sp.*

Suggested Readings:

1. Acquaah, G. (2007). *Principles of Plant Genetics and Breeding*. Blackwell Publishing Ltd., USA.
2. Allard, R.W. (1999). *Principles of Plant Breeding* (2nd ed.). John Wiley & Sons.
3. Hartl, D.L. & Jones, E.W. (2007). *Genetics: Analysis of Genes and Genomes* (7th ed.). Jones & Bartlett Publishers.

4. Hartwell, L.H., Hood, L., Goldberg, M.L., Reynolds, A.E., Silver, L.M. & Veres, R.C. (2006). *Genetics: From Genes to Genomes* (3rd ed.). McGraw-Hill.
5. Lewin, B. (2008). *Genes IX*. Jones & Bartlett Publishers.
6. Singh, R.J. (2002). *Plant Cytogenetics* (2nd ed.). CRC Press.
7. Smartt, J. & Simmonds, N.W. (1995). *Evolution of Crop Plants* (2nd ed.). Longman.
8. Strickberger, M.W. (2008). *Genetics* (3rd ed.). Pearson (Prentice Hall).
9. Weising, K., Nybom, H., Wolff, K. & Kahl, G. (2005). *DNA Fingerprinting in Plants: Principles, Methods and Applications* (2nd ed.). Taylor & Francis Group, Boca Raton, FL.

Teaching Learning Process

29. Class lectures
30. Seminars
31. Group discussions and Workshops
32. Peer teaching and learning
33. Question preparation
34. Subjective type
    a. Long answer
    b. Short answer
35. Objective type
36. Multiple choice questions
    a. One-answer/two-answer type questions
    b. Assertion and reasoning
37. Practical
38. Field-based learning
39. Substantial laboratory-based practical component and experiments
40. Games
41. Technology-enabled learning
42. Internship in industry and research establishments

Teaching Learning Plan:

31. Week 1: Lecture
32. Week 2: Lecture
33. Week 3: Lecture
34. Week 4: Lecture
35. Week 5: Lecture/Practical
36. Week 6: Lecture/Practical
37. Week 7: Lecture/Practical
38. Week 8: Lecture/Practical
39. Week 9: Lecture/Practical
40. Week 10: Mid-semester Exam
41. Week 11: Lecture/Practical
42. Week 12: Lecture/Practical/Field-based learning
43. Week 13: Lecture/Practical
44. Week 14: Lecture/Practical
45. Week 15: Lecture/Practical

Assessment Methods

7. Drawings from the temporary preparations as practical record books
8. Collection of various microbiological samples
9. Highlighting the salient features of microbial diversity, biology, genetics, and applications through digital media such as PowerPoint presentations and animations

Unit No.	Particulars	Teaching and Learning Activity	Assessment Task
I	Mendelian and Non Mendelian Inheritance	Classroom lectures, demonstrations, and Practical	Hands-on exercises, PPT, assignments, tests
II	Recombination in Eukaryotes	Classroom lectures, demonstrations, and Practical	Hands-on exercises, PPT, assignments, tests
III	Concepts in Eukaryotic genome	Classroom lectures, demonstrations, and Practical	Hands-on exercises, PPT, assignments, tests
IV	Microbial Genetics	Classroom lectures, demonstrations, and Practical	Hands-on exercises, PPT, assignments, tests
V	Cytogenetics	Classroom lectures, demonstrations, and Practical	Hands-on exercises, PPT, assignments, tests

Discipline Specific Elective - Plant Pathology & Microbiology – I

	L	T	P	Total
Credit	**4**	**0**	**2**	**6**
Paper Code	**BOTD-703(T)**		**BOTD-703(P)**	

Course objective

This course aims to develop a comprehensive understanding of microbiological techniques, soil microbial processes, agricultural applications of microorganisms, and the mechanisms underlying plant–pathogen interactions. It enables learners to explore how microbes contribute to nutrient cycling, biodegradation, biofertilization, biocontrol, and disease development.

Learning Outcomes

After completing this course, learners will be able to:

1. Describe the essential equipment, microscopy principles, staining techniques, and sterilization methods used in microbiology laboratories.
2. Perform bacterial isolation, plate count, turbidimetric estimation, and pure-culture techniques with accuracy and aseptic skill.
3. Explain the diversity of soil microorganisms and evaluate their roles in organic matter decomposition, biodegradation, and bioremediation of pollutants.
4. Analyze microbial degradation of polysaccharides, pesticides, xenobiotics, hydrocarbons, and heavy metals within soil ecosystems.
5. Describe the functions of biofertilizers, including nitrogen fixers, phosphate solubilizers, and arbuscular mycorrhizal fungi, in enhancing agricultural productivity.
6. Explain the use of viral, bacterial, and fungal biopesticides and assess issues such as biodeterioration and mycotoxin production in agriculture.
7. Describe pathogen infection processes, including inoculation, mechanical penetration, entry through natural openings, and the roles of enzymes, toxins, and growth regulators.
8. Explain pre-existing and inducible structural, physiological, and biochemical defense mechanisms in plants.
9. Discuss the roles of PR-proteins, phytoalexins, hypersensitive responses, and systemic acquired resistance in plant immunity.
10. Integrate knowledge of microbial techniques, soil processes, plant–microbe interactions, and host defense responses to interpret disease development and management strategies.

Course Code: BOTD704(T)
Course Title: Plant Pathology & Microbiology – I (Theory)
Credit: 4

Course Content

Unit I: Techniques in Microbiology

Essential equipment of Microbiology Laboratory, Microscopy, Staining methods- Gram staining, Acid fast staining, Bacterial spore and capsule staining, Methods of sterilization- dry and moist heating, Chemical sterilization, Isolation of bacteria by plate count and turbidimetric methods, Pure culture techniques.

Unit II: Soil Microbiology

Rhizosphere and rhizoplane microorganisms, Soil microbial diversity and their role in organic matter decomposition, Biodegradation of polysaccharides in soil, Biodegradation of pesticides and xenobiotics, Bioremediation of hydrocarbons and heavy metal pollution.

Unit III: Agricultural Microbiology

Biofertilizers – Nitrogen fixers and phosphate solubilizers; Role of arbuscular mycorrhizal fungi in agriculture; Viral, bacterial, and fungal biopesticides; Biodeterioration of agricultural products, and mycotoxin production.

Unit IV: Pathogenesis

Inoculation of pathogen; mechanical force exerted by pathogen; direct penetration; penetration through wounds and natural openings; types and roles of enzymes, toxins, and growth regulators in pathogenicity.

Unit V: Host Defence Mechanisms

Pre-existing and induced structural or morphological defense mechanisms; pre-existing and induced physiological or biochemical defense mechanisms; pathogen-related (PR) proteins; hypersensitive responses; phytoalexins; systematically acquired resistance.

Course Code: BOTD704 (P)
Course Title: Plant Pathology & Microbiology – I (Practcal)
Credit: 2

Course Content

1. Methods of sterilization (heating, chemical, and filtration).
2. Preparation of culture media for fungi and bacteria.
3. Isolation and identification of microorganisms (fungi, bacteria) from soil, rhizosphere, rhizoplane, and aerial plant parts
4. Application of antagonists against pathogens in vitro and in vivo conditions.
5. Application of bio-control agents and their compatibility.
6. Detailed study of symptoms and host-parasite interactions of important plant diseases.
7. Measurement of MIC values
8. To study microbial degradation of hydrocarbon(s) or pesticides(s).
9. Study the role of microbial enzymes in bioremediation.

10. Analyse the role of microbes in the degradation of xenobiotic compounds like nitriles

Suggested Readings

1. Heald, F.D. (1980). *Manual of Plant Diseases*. Eurasia Publishing House (Pvt.) Ltd., New Delhi.
2. Walker, J.C. (1985). *Plant Pathology*. Tata McGraw-Hill Publishing Company Ltd., New Delhi.
3. Singh, R.S. (1995). *Plant Diseases*. Oxford & IBH Publishing Co. Pvt. Ltd., New Delhi.
4. Singh, R.S. (1995). *Introduction to Principles of Plant Pathology*. Oxford & IBH Publishing Co. Pvt. Ltd., New Delhi.
5. Bilgrami, K.S. & Dubey, H.C. (1970). *A Textbook of Modern Plant Pathology*. Vikas Publishing House Pvt. Ltd., New Delhi.
6. Rangaswami, K.G. (1988). *Diseases of Crop Plants in India*. Prentice-Hall of India Pvt. Ltd., New Delhi.
7. Gupta, V.K. & Sharma, R.S. (1995). *Integrated Disease Management and Plant Health*. Scientific Publishers, Jodhpur.
8. Baker, K.F. & Cook, R.J. (1979). *Biological Control of Plant Diseases*. S. Chand & Company Ltd., New Delhi.
9. Johnston, A. & Booth, C. (1985). *Plant Pathologist's Pocketbook*. Commonwealth Mycological Institute (CMI), Kew, London.
10. Seth, A. & Mehta, P.K. (2023). *The Chemistry of Nitriles*. Nova Science Publishers, USA. https://doi.org/10.52305/FXHT4172

Teaching Learning Process

43. Class lectures
44. Seminars
45. Group discussions and Workshops
46. Peer teaching and learning
47. Question preparation
48. Subjective type
    a. Long answer
    b. Short answer
49. Objective type
50. Multiple choice questions
    a. One-answer/two-answer type questions
    b. Assertion and reasoning
51. Practical
52. Field-based learning
53. Substantial laboratory-based practical component and experiments
54. Games
55. Technology-enabled learning
56. Internship in industry and research establishments

Teaching Learning Plan:

46. Week 1: Lecture
47. Week 2: Lecture
48. Week 3: Lecture

49. Week 4: Lecture
50. Week 5: Lecture/Practical
51. Week 6: Lecture/Practical
52. Week 7: Lecture/Practical
53. Week 8: Lecture/Practical
54. Week 9: Lecture/Practical
55. Week 10: Mid-semester Exam
56. Week 11: Lecture/Practical
57. Week 12: Lecture/Practical/Field-based learning
58. Week 13: Lecture/Practical
59. Week 14: Lecture/Practical
60. Week 15: Lecture/Practical

Assessment Methods

10. Drawings from the temporary preparations as practical record books
11. Collection of various microbiological samples
12. Highlighting the salient features of microbial diversity, biology, genetics, and applications through digital media such as PowerPoint presentations and animations

Unit No.	Particulars	Teaching and Learning Activity	Assessment Task
I	Techniques in Microbiology	Classroom lectures, demonstrations, and Practical	Hands-on exercises, PPT, assignments, tests
II	Soil Microbiology	Classroom lectures, demonstrations, and Practical	Hands-on exercises, PPT, assignments, tests
III	Agricultural Microbiology	Classroom lectures, demonstrations, and Practical	Hands-on exercises, PPT, assignments, tests
IV	Pathogenesis	Classroom lectures, demonstrations, and Practical	Hands-on exercises, PPT, assignments, tests
V	Host Defense Mechanisms	Classroom lectures, demonstrations, and Practical	Hands-on exercises, PPT, assignments, tests

Discipline Specific Elective – Plant Physiology I

	L	T	P	Total
Credit	**4**	**0**	**2**	**6**
Paper Code	**BOTD-704(T)**		**BOTD-704(P)**	

Course Objective:

This course aims to develop an integrated understanding of mineral nutrition, transport processes, photosynthesis, respiration, and nitrogen metabolism in plants. It enables learners to examine how nutrients, energy flow, carbon fixation, and biochemical pathways interact to regulate plant growth, productivity, and stress responses. By the end of the course, students will appreciate the physiological and metabolic coordination underlying plant function.

Course Learning Outcomes:

After completing this unit, learners will be able to:

1. Identify essential macro- and micro-nutrients and explain their physiological and biochemical roles in plants.
2. Describe symptoms of nutrient deficiency/toxicity and evaluate experimental methods such as foliar feeding, sand culture, and hydroponics for studying plant nutrition.
3. Explain mechanisms of mineral uptake, allocation, and long-distance xylem transport.
4. Describe phloem loading/unloading and analyze how source–sink dynamics regulate assimilate distribution.
5. Explain principles of light absorption, excitation, photochemistry, and quantum yield in photosynthesis.
6. Describe water photo-oxidation, chlorophyll biosynthesis, carbon fixation pathways, and the function of Rubisco.
7. Explain the process and significance of photorespiration in plant metabolism.
8. Discuss biochemical regulation of respiration, including oxidative phosphorylation, ATP synthase, and alternative oxidase pathways.
9. Describe biological nitrogen fixation, nitrogenase function, and regulation of nitrate/nitrite reduction.
10. Explain ammonia assimilation via GDH and GS–GOGAT pathways and relate nitrogen metabolism to photosynthesis and respiration.

Course Code: BOTD705(T)
Course Title: Plant Physiology-1 (Theory)
Credits: 4

Course Content

Unit I: Mineral nutrition

Macro and micro elements, role of various elements in plant metabolism, Methods of studying plant nutrition- foliar nutrition, sand culture, hydroponics and nutrient solution.

Unit II: Mineral assimilation:

Allocation, translocation and Mechanism of xylem and phloem transport, Phloem loading and unloading, source sink relationship. Partitioning of photoassimilates.

Unit III: Photosynthesis

Basic principles of light absorption, excitation and energy transfer, photosynthetic quantum yield, photo oxidation of water, biosynthesis of chlorophylls, carbon dioxide fixation, Rubisco, photorespiration and significance of photorespiration.

Unit IV: Respiration:

Biochemical control of respiration, oxidative -phosphorylation, structure of ATP synthase and mechanism of ATP synthesis, alternate oxidase.

Unit V: Nitrogen fixation and metabolism

Biological nitrogen fixation, Nitrogenase, Nitrate, Nitrite reductase regulation of nitrogen fixation, nitrate assimilation, assimilation of ammonia –GDH,GS-GOGAT pathways, transamination, nitrogen metabolism in relation to photosynthesis and respiration.

Course Code: BOTD705(P)
Course Title: Plant Physiology-1 (Practical)
Credit: 2

Course Content

1. Preparation of the standard curve of protein (BSA) and Estimation of protein content in extracts of plant material by Lowry's or Bradford's method.
2. To study changes in level of metabolites chlorophyll in the leaves of a senescing plant.
3. Estimation of total soluble sugars.
4. Estimation of soluble proteins.
5. To study nitrogen-fixation in leguminous plants by nitrogenase assay method.

Suggested Readings

1. Buchanan, B., Gruissem, G. & Jones, R. (2000). *Biochemistry and Molecular Biology of Plants*. American Society of Plant Physiologists, USA.
2. Davies, P.J. (2004). *Plant Hormones: Biosynthesis, Signal Transduction, Action* (3rd ed.). Kluwer Academic Publishers, Dordrecht, The Netherlands.

3. Jordan, B.R. (2006). *The Molecular Biology and Biotechnology of Flowering* (2nd ed.). CABI Publishing, Oxfordshire, UK.
4. Nelson, D.L. & Cox, M.M. (2008). *Lehninger Principles of Biochemistry* (5th ed.). W.H. Freeman, New York.
5. Taiz, L. & Zeiger, E. (2018). *Plant Physiology*. Sinauer Associates, Massachusetts.
6. Heldt, H.-W. & Piechulla, B. (2010). *Plant Biochemistry* (4th ed.). Academic Press.
7. Bhatla, S.C. & Lal, M.A. (2018). *Plant Physiology, Development and Metabolism*. Springer Nature, Singapore.
8. Sivakumar, R., Boominathan, P. & Chandrasekhar, C.N. (2015). *Practical Plant Physiology*. Narendra Publishing House.
9. Gupta, N.K., Sangha, M.K., Bala, M. & Gupta, S. (2016). *Practicals in Plant Physiology and Biochemistry*. Scientific Publishers (India).
10. Verma, A. & Sachan, R. (2025). *Practical Manual on Plant Physiology*. Bhavya Books.
11. Hopkins, W.G. & Hüner, N.P.A. (2008). *Introduction to Plant Physiology*. Wiley.
12. Kochhar, S.L. & Gujral, S.K. (2020). *Plant Physiology: Theory and Applications* (2nd ed.). Cambridge University Press, UK.
13. Bidwell, R.G.S. (1979). *Plant Physiology*. Macmillan Publishing Co., New York.
14. Salisbury, F.B. & Ross, C. (1992). *Plant Physiology*. Thomson Press (India) Ltd.
15. Leopold, A.C. & Kriedemann, P.E. (1977). *Plant Growth and Development* (2nd ed.). McGraw-Hill, USA.
16. Ting, I.P. (1982). *Plant Physiology*. Addison-Wesley Longman Publishing Co.
17. Wilkins, M.B. (1995). *Advanced Plant Physiology*. John Wiley & Sons, New York.
18. Devlin, R.M. (1983). *Plant Physiology* (4th ed.). Prindle, Weber & Schmidt.

Teaching Learning Process

1. Class lectures
2. Seminars
3. Group discussions and Workshops
4. Peer teaching and learning
5. Question preparation
6. Subjective type
    a. Long answer
    b. Short answer
7. Objective type
    a. Multiple choice questions
    b. One answer/two answer type questions
    c. Assertion and reasoning
8. Practical.

Teaching Learning Plan:

1. Week 1: Lecture
2. Week 2: Lecture
3. Week 3: Lecture/Practical
4. Week 4: Lecture/Practical
5. Week 5: Lecture/Practical

6. Week 6: Lecture/Practical
7. Week 7: Lecture/Practical
8. Week 8: Lecture/Practical
9. Week 9: Lecture/Practical
10. Week 10: Mid semester Exam
11. Week 11: Lecture/Practical
12. Week 12: Lecture/Practical
13. Week 13: Lecture/Practical
14. Week 14: Lecture/Practical
15. Week 15: Lecture/Practical
16. Week 16: Lecture/Practical

Assessment Methods

1. Drawings from the temporary preparations as practical record books
2. Collection of various microbiological samples
3. Highlighting the salient features of microbial diversity, biology, genetics, and applications through digital media such as PowerPoint presentations and animations

Unit No.	Particulars	Teaching and Learning Activity	Assessment Task
I	Mineral nutrition	Classroom lectures, demonstrations, and Practical	Hands-on exercises, PPT, assignments, tests
II	Mineral assimilation	Classroom lectures, demonstrations, and Practical	Hands-on exercises, PPT, assignments, tests
III	Photosynthesis	Classroom lectures, demonstrations, and Practical	Hands-on exercises, PPT, assignments, tests
IV	Respiration	Classroom lectures, demonstrations, and Practical	Hands-on exercises, PPT, assignments, tests
V	Nitrogen fixation and metabolism	Classroom lectures, demonstrations, and Practical	Hands-on exercises, PPT, assignments, tests

Course Structure for 4-Year UG Programme in Botany

Year 4

Semester VIII

Course Type/Course Code	**Title of Course**	**Credit**
Core Course (CCC)		
Core 18 (T) Core 18 (P)	Higher Plant Systematics (Theory) Higher Plant Systematic (Practical)	4 2
Core 19 (T) Core 19 (P)	Applied Ecology (Theory) Applied Ecology (Practical)	4 2
Core 20 (T) Core 20 (P)	Plant Biochemistry (Theory) Plant Biochemistry (Practical)	4 2
Discipline Specific Elective (DSE)		
DSE 4a/b/c/d (T) DSE 4a/b/c/d (P)	Elective Paper II (Theory) Elective Paper II (Practical)	4 2
Total Credit		**24**

Paper Code: Core 18

Paper Title : Higher Plant Systematics

Credit : 6

Course Objective:

To impart knowledge about the basics and importance of systematics, different classifications and biodiversity, incorporating different fields of botany for the evolutionary study of angiosperms and gymnosperms.

Course Outcomes:

1. Perceive knowledge on relationship and origin of Angiosperms, their taxonomic evidences; herbarium techniques, botanic gardens and Biodiversity hotspots.
2. Acquaintance on Botanical Nomenclature, ICN, typification, Phylogenetics and Cladistics.
3. Acquire knowledge on different types of plant classification based on taxonomic accounts using different evidences.
4. Gains both theoretical and practical knowledge on taxonomic analysis and elaborations on important angiosperm families with suitable example species.
5. Learn about the classification, distribution, and evolution in reproductive features of extant gymnosperms with their economic importance.

Core 18 : Higher Plant Systematics (Theory)

Course Content **Credit : 4**

Unit -I **12 hours**

Introduction to Angiosperms and Biodiversity: Relationship and Evolution of basal angiosperms, ANA grade, Magnoliids, Monocots and Eudicots; Taxonomic evidences from Morphology, Embryology, Palynology and Anatomy; Field studies and Documentation, Herbaria and Database, Botanic Gardens; IUCN categories of Threat, Red Data Book, Biodiversity Hotspots and Conservation.

Unit – II **12 hours**

Basics of Plant Systematics: International Code of Nomenclature (ICN) of Algae, Fungi and Plants, Principles of ICN, Rules of priority and typification, Rules of Valid Publication; Status Definition, Ranks of taxa; Phylogenetics and Cladistics; Importance of Systematics.

Unit – III **12 hours**

Systems of plant classification: Artificial, Natural and Phylogenetic Systems; Cytotaxonomy, Application of DNA markers in angiosperm taxonomy; Chemotaxonomy: Role of phytochemicals (alkaloids, glucosides, flavonoids, terpenoids, silica, Amino acids) in taxonomy; Numerical taxonomy: objectives, characters and attributes, OTUs, Coding, Cluster analysis; Angiosperm Phylogeny Group (APG) - I, II, III & IV.

Unit - IV **12 hours**

Angiosperm families: Taxonomic features, systematic phylogeny and economic importance of the following families: Basal Angiosperms: Nymphaeaceae; Magnoliids: Magnoliaceae; Monocots: Commelinaceae, Amaryllidaceae, Cannaceae, Zingiberaceae; Eudicots: Papaveraceae, Rosaceae, Fabaceae, Acanthaceae, Lamiaceae, Verbenaceae.

Unit V **12 hours**

Gymnosperms: Classification & affinities of Gymnosperms: Chamberlain, Sporne, Christenhusz et al. (2011), distribution in India, alternation of generations, detailed structure and reproduction of extant gymnosperms- *Pinus*, *Cycas*, *Gnetum*; Embryogeny and evolution of pollination mechanism; gymnosperms of India, economic importance.

Paper Code : Core 18 (P)

Paper Title : Higher Plant Systematics (Practical)

Credit : 2 **60 Hours**

Course Content

1. Detailed Taxonomic study of minimum 10 species of plants growing in different types of habitats.
2. Identification of economically important plants and their products.
3. Field study and report: field trips are to be arranged in different forest types of Manipur.
4. The detailed field report along with herbaria of collected materials on herbarium sheets are to be submitted.
5. Morphological and anatomical features of vegetative and reproductive parts of the following Gymnosperms: *Cycas, Pinus, Gnetum*.
6. Examination of male and female cones of some gymnosperms found in Manipur

Suggested Readings:

1. APG (Angiosperm Phylogeny Group) (1998). An ordinal Classification for the families of Flowering plants. Ann. Missouri Bot. Gard. 85: 531-533.
2. APG II (2003). An Update of the Angiosperm Phylogeny Group Classification for the orders and families of Flowering plants. APG II. Bot. J. Linnean Soc. 141: 399-436.
3. APG III (2009). An Update of the Angiosperm Phylogeny Group Classification for the orders and families of Flowering plants. APG III. Bot. J. Linnean Soc. 161: 105-121.

4. APG IV (2016). An Update of the Angiosperm Phylogeny Group Classification for the orders and families of Flowering plants. APG IV. Bot. J. Linnean Soc.
5. Ganguly, A.K. & N.C. Kumar: An Introduction to Systematic Botany, EMKAY, Publication New Delhi,1997.
6. Lawrence, G.H.M.: Taxonomy of Vascular Plants, The Macmillan Co, New York, USA.
7. Pandey, B.P: Taxonomy of Angiosperms , S. Chand & Co. Ltd. New Delhi.1993.
8. Saxena, R.: A Text Book of Plant Taxonomy, Pragati Prakashan, Meerut, 1989.
9. Sharma, O. P.: Plant Taxonomy, 2nd Edition, Mc Graw Hill Education Pvt. Ltd., UP, 2017.
10. Simpson, M.G. : Plant Systematics, ACADEMIC PRESS, ELSEVIER, 2nd Edn. 2010.
11. Singh, G.: Plant Systematics An Integrated Approach, CRC Press, Taylor & Francis Group, 4th Edn. 2019.
12. Bhatnagar, S.P. and Moitra, A.K.: *Gymnosperms*. New Age International(P) . Ltd. Publishers, New Delhi
13. Chamberlain.C.J.: *Gymnosperms, Structure and Evolution*. Univ. of Chicago Press, Chicago.
14. Christenhusz, Maarten J. M., et al. "A new classification and linear sequence of extant gymnosperms." *Phytotaxa* 19.1 (2011): 55-70.

Paper Code: Core 19

Paper Title: Applied Ecology

Credit: 6

Course objective

To impart knowledge on ecosystem, acquire knowledge on community & population characteristics, interactions among organisms, global climate scenarios with ecological modellings.

Course Outcome

1. Gain knowledge on structural components of ecosystem and its tangible & intangible functions. Impart ideas on plant adaptations, ecosystem productivity and biodiversity.
2. Perceive knowledge on community structure and different types of niches for organisms.
3. Acquire knowledge on environmental pollution, climate change, carbon budget and, applications of ecological models & Remote sensing tools in realizing suitable niche for organisms.
4. Perceive knowledge on interactions among organisms in the ecosystems.
5. Gain knowledge on pollution, climate change, carbon budget and Ecological applications of Remote sensing & GIS.

Core 19 (T)

Applied Ecology (Theory)

Course Content **Credit : 4**

Unit -I **12 hours**

Concept of ecosystem: Structure and function of ecosystem, Plant community analysis; Concept of ecotypes and their importance, Plant Adaptations, Primary and secondary production in ecosystems.

Unit – II **12 hours**

Concept of community: Definition & Nature of plant community, Community structure & attributes, Fundamental and Realized Niche, Niche overlap, Keystone species, Edges and Ecotones.

Unit – III **12 hours**

Population characteristics: Demography, Growth models, Survivorship curves, Variation in natural population, carrying capacity, biotic potential, Mechanisms of population regulation, r and k population strategies.

Unit - IV **12 hours**

Ecological interactions: Competition and mutualism; Plant-plant interactions: symbiosis, commensalism, Allelopathy and parasitism; Plant–animal interactions: herbivory, pollination-pollinators and Zoochory, Invasive Alien species.

Unit V **12 hours**

Environmental pollution, Climate change & Ecological modelling: Causes, consequences and mitigation of pollution; Greenhouse effect, Concepts of carbon sequestration, carbon pools & carbon credits, Ecosystem niche modelling; Principles & Applications of Remote Sensing & GIS in ecology.

Paper Code: Core 19 (P)

Paper Title: Applied Ecology (Practical)

Credit: 2 **60 Hours**

Course Content

1. Generation of Species-Area Curve for fixing quadrat size.
2. Enumeration of Frequency, Density & Dominance and determination of Importance Value Index of plant species through quadrat method.
3. Study of climatic variables viz. Light intensity, Air temperature, Relative humidity.
4. Study of soil physical parameters, viz. soil moisture, soil texture, soil pH, Bulk density, Water holding capacity.
5. Study of soil chemical parameters viz. Cation Exchange Capacity, Anion Exchange Capacity, Oxidisable Organic Carbon.
6. Study of standing biomass & carbon pool in grassland ecosystem.

Suggested readings

1) Ambasht, R.S. & N.K. Ambasht (2008). A Text Book of Plant Ecology. CBS Publishers & Distributers, New Delhi
2) Botkin, D.B. & E.A. Keller (2004). *Environment Science*: Earth as a Living Planet, John Wiley & Sons Inc., New York.
3) Kormondy, E.J. 2017. Concepts of Ecology, 4th edn. Pearson India Edn Services Pvt. Ltd.
4) Miller (Jr.) & G. Tyler (1994). *Living in the Environment*. Wadsworth Publishing Company, Belmont, California.
5) Misra, K.C. (1991). *Manual of Plant Ecology*. Oxford & IBH. New Delhi.
6) Odum, E.P. (1983). *Fundamentals of Ecology*. Sanders, Philadelphia.

7) Peter H., Raven, P.H. & Berg, L.R. 2005. *Environment,* 5th Edition. John Wiley & Sons Inc., New York.
8) Ramakrishnan, P.S. 2000. *Ecology and Sustainable Development*. National Book Trust, India
9) Sharma, P.D. 2015. Ecology and Environment, 12th edition. Rastogi Publications, Meerut.
10) Singh, J.S., Singh, S.P., Gupta, S.R. 2008. Ecology, Environmental Science and Conservation, Anamaya Publishers, New Delhi.
11) Smith, R.L. 1996. *Ecology and Field Biology*, Harper Collins, New York
12) Majumdar, R. and Kashyap, R. 2019. Practical Manual of Ecology and Environmental Science, Prestige Publishers, New Delhi.
13) Misra ,R. *Ecology Work Book*, Today & Tomorrow Publishers (Allahabad).
14) . Michael, P: Ecological Methods for Field and Laboratory; Investigations, TMH.

Paper Code: Core 20
Paper Title : Plant Biochemistry
Credit : 6

Course Objective:

To impart fundamental knowledge on synthesis, structure, function and properties of important biochemicals (proteins, enzymes, carbohydrates, etc.) involved in different pathways.

Corse Outcomes:

1. Gain knowledge on basic concepts, regulations, kinetics, mechanism of catalysis in plant metabolism and the essential stabilizing interactions of biomolecules.
2. Learn about amino acid sequences, proteins conformations and folding into a distinctive three-dimensional structure that enables to interact with one or more of a highly diverse array of molecules.
3. Perceive knowledge on carbohydrates, nucleic acids, lipids & vitamins, their structural properties and role as mediators of cellular interactions to many biomolecules in the cellular environment.

4. Enables to understand signal transduction pathways in cells where phospholipids, G-proteins and calmodulin cascade are involved.

Core 20 (T): Plant Biochemistry (Theory) **Credit: 4**

Course Content **12 hours**

I **Enzymes :** Principles of catalysis, Enzymes and its nomenclature and enzyme kinetics, Michaelis – Menten equation, enzyme regulations, mechanism of enzyme catalysis, isozyme, prosthetic groups and coenzymes. significance of ribozymes, Abyzymes, artificial enzymes.

12 hours

II. Bioenergetics : Energy thermodynamics, Laws of thermodynamics, Entropy, free energy of reaction, biological oxidation-reduction reaction, oxidation-reduction half reaction, Nernst equation, measurement of standard reduction potentials, calculation of ΔG from standard reduction potentials.

12 hours

III. Conformation of proteins (Ramachandran's plot, secondary, tertiary and quaternary structure). Structure of amino acid, Protein synthesis and processing, formation of initiation complex, initiation factors and their regulation, elongation and elongation factors, termination codon, protein folding and sub-unit assembly, post-translational process.

12 hours

Iv **Carbohydrates metabolism**, structure and function, lipid acid biosynthesis and degradation , nucleotide metabolism. Vitamins structure and occurrence of Ascorbic acid and β Carotene**.**

12 hours

V **Signal transduction :** An Overview, secondary messenger, phospholipids signalings, receptors and G-proteins , role of cyclic nucleotides, calcium-calmodulin cascade.

Paper Code: Core 20 (P): Plant Biochemistry

Paper Title: Plant Biochemistry (Practical) **60 hours**

Course Content **Credit: 2**

1. Qualitative and quantitative analysis of photosynthetic pigments by spectrophotometric and chromatography technics.
2. Detection of free amino acids with the help of paper chromatography.
3. Detection of free amino acids with the help of thin layer chromatography
4. Enzyme assays of invertase.
5. Enzyme assays of amylase.
6. Estimation of ascorbic acid.
7. Estimation of total chlorophyll.
8. Estimation of carbohydrate.

Suggested Readings

1. Goodwin, T.W. & Mercer E.I.: *Plant Biochemistry*, Pergamon Press, Oxford. 2nd En. 1990.
2. Lehninger, A.L., Nelson D.L. & Cox M.M.: *Principles of Biochemistry*. W.H. Freeman 5th En. 2008.
3. Zubay, Geoffrey L.: *Biochemistry* Brown (William C) co. U.S. 1997.
4. Devlin, T.M.: *Text Book of Biochemistry with clinical Correlation*, John Wiley & sons,2011
5. Weil, J.H.: *General Biochemistry*, New Age International Ltd.1990.
6. Rawn, J.David : *Biochemistry*, Neil Patterson Publishers, 1989.
7. Stryer Lupert : *Biochemistry* W.H. Freeman, 2002.
8. Buchanan, B.B, Gruissem,W and Jones R.L : Biochemistry and Molecular Biology of plants, Wiley Blackwell, Sussex, UK. 2015.
9. Agarwal, G.P., Agarwal, K. & Agarwal, O.P.: *Text Book of Biochemistry (Physiological Chemistry)* GOEL Publishing House, Meerut.1995
10. Street, H.E. :, *Plant Metabolism*, Pergamon Press, Macmillan Co., New York 1993.

Paper Code: DSE 4a

Paper Title : Elective Paper (Ecology-II)

Credit : 6

Course Objective:

To impart knowledge on Lotic and lentic ecosystems with reference to fresh water and marine ecosystems, meromixis, influence of solar radiation on aquatic life, trophic levels and energy flow with concepts of productivity in aquatic systems.

Course Outcome:

1. Gain knowledge on aquatic ecosystems for lotic & lentic systems including community compositions. Acquire knowledge on different trophic levels with phenomenon of productivity in aquatic ecosystem.
2. Acquire knowledge on physical parameters of aquatic systems and their influence on stratified distribution of organisms.
3. Learn about different type of aquatic ecosystems and succession processes.
4. Gain knowledge on classification of lakes with their evolutionary trends including succession processes.
5. Perceive knowledge on aquatic biodiversity, trophic levels and productivity in aqatic ecosystems.

DSE4a (T): Elective Paper (Ecology-II) (Theory)

Course Contents **4 credit**

12 Hours

I. Fresh Water Aquatic Ecosystem: Introduction, Lotic and Lentic ecosystems, fresh water lotic communities, fresh water lentic communities.

12 Hours

II. Marine Ecosystems: Introduction, marine communities at the land and sea interface, continental shelf (neritic) benthos communities, marine surface pelagic communities, the deep open benthos communities.

12 Hours

III. Light and Temperature: Factors influencing light penetration, colour, turbidity, classification of fresh water bodies upon light intensity, Influence on plant distribution, vertical migration of Zooplanktons, Importance of temperature in aquatic ecosystems, thermal stratification, temperature inversions and classification of lakes

12 Hours

IV. **Chemical factors**: Influence of on fresh water ecosystems, Lake classification, chemical evolution of freshwater ecosystems, chemical stratification (Meromixis), Eutrophication, Succession in aquatic ecosystems.

12 Hours

V. **Biodiversity & Trophic relationships:** Flora & fauna diversity in fresh water ecosystems, Food chain and Trophic levels, Primary & Secondary productivity in aquatic ecosystems.

Paper Code: DSE4a (P)
Paper Title : Ecology-II (Practical)
Credit : 2

DSE4a (P): Elective Paper (Ecology-II) (Practical) Credit: 2

Course Content 60 Hours

1. Analysis of pH values in vertical zones of freshwater ecosystems.
2. Analysis of dissolved oxygen in vertical zones of freshwater ecosystems.
3. Analysis of dissolved carbon dioxide in vertical zones of freshwater ecosystems.
4. Determination of BOD & COD in vertical zones of freshwater ecosystems.
5. Determination of plant diversity in freshwater ecosystems.
6. Determination of plant biomass in freshwater ecosystems.

Suggested readings

1) Ambasht, R.S. & N.K. Ambasht (2008). A Text Book of Plant Ecology. CBS Publishers & Distributers, New Delhi
2) Botkin, D.B. & E.A. Keller (2004). *Environment Science*: Earth as a Living Planet, John Wiley & Sons Inc., New York.
3) Kormondy, E.J. 2017. Concepts of Ecology, 4th edition. Pearson India Education Services Pvt. Ltd.
4) Miller (Jr.) & G. Tyler (1994). *Living in the Environment*. Wadsworth Publishing Company, Belmont, California.

5) Misra, K.C. (1991). *Manual of Plant Ecology*. Oxford & IBH. New Delhi.

6) Odum, E.P. (1983). *Fundamentals of Ecology*. Sanders, Philadelphia.

7) Peter H., Raven, P.H. & Berg, L.R. 2005. *Environment,* 5th Edition. John Wiley & Sons Inc., New York.

8) Ramakrishnan, P.S. 2000. *Ecology and Sustainable Development*. National Book Trust, India

9) Sharma, P.D. 2015. Ecology and Environment, 12th edition. Rastogi Publications, Meerut.

10) Singh, J.S., Singh, S.P., Gupta, S.R. 2008. Ecology, Environmental Science and Conservation, Anamaya Publishers, New Delhi.

11) Smith, R.L. 1996. *Ecology and Field Biology*, Harper Collins, New York

12) Majumdar, R. and Kashyap, R. 2019. Practical Manual of Ecology and Environmental Science, Prestige Publishers, New Delhi.

13) Misra ,R. *Ecology Work Book*, Today & Tomorrow Publishers (Allahabad).

14) Michael, P: Ecological Methods for Field and Laboratory; Investigations, TMH**.**

Paper Code: DSE4b

Paper Title :Genetics-II (Theory)

Credit : 6

Course Objectives

The course provides the concepts and deep understanding of chromosome variation in numbers and shapes. The students will also learn the significance and application of the role of polyploidy in crop evolution, mapping of genes, Recombination, The Linkage Ratio, Morgan and Crossing Over. Mapping: Locating Genes along a chromosome, Tetrad Analysis, Mitotic Recombination and Genetic Mosaics

Course Learning Outcomes

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

CO1: Understand the concepts, principles and significance of Chromosome Deletion, duplication, inversion, translocation, position effect, copy-number variations, role in crop in evolution.

CO2: Understand the concepts, principles and significance of Euploidy and Aneuploidy

CO3: Understand the concepts, principles and significance of Linkage, Crossing Over & Chromosome Mapping in Eukaryotes

CO4: Understand the concepts, principles and significance of Genetic mapping in bacteria

CO5: Understand the concepts, principles and significance of Molecular Recombination and Transposons

DSE 4b(T) : Elective Paper (Genetics -II) (Theory)

Course Contents **4 credit**

Unit I: Structural changes of chromosomes **(10 hours)**

Deletion, duplication, inversion, translocation, position effect, copy-number variations, role in crop in evolution.

Unit II: Numerical changes in chromosomes **(15 hours)**

Euploidy - haploids, diploids and polyploids; Aneuploidy, Variation in chromosome behavior - somatic segregation and chimeras; - utilization of aneuploids in gene location, crop evolution.

Unit III: Linkage, Crossing Over & Chromosome Mapping in Eukaryotes **(10 hours)**

Recombination, The Linkage Ratio, Morgan and Crossing Over. Mapping: Locating Genes Along a Chromosome, Tetrad Analysis, Mitotic Recombination and Genetic Mosaics

Unit IV: Genetic mapping in bacteria **(10 hours)**

Genetic mapping in bacteria; Genetic basis of plasmids and episomes

Unit V: Molecular Recombination and Transposons **(15 hours)**

Definition and biological significance, types of recombination-homologous recombination, site-specific recombination, non-homologous end joining (NHEJ), molecular mechanism of homologous recombination, introduction to transposable elements, biological importance-types of transposable elements, molecular mechanism of transposition.

Suggested Readings

1. Russel P. J. (2010). Genetics-A Molecular Approach, Pearson Education Inc.

2. Strickberger M.W. (2008). Genetics, Pearson (Prentice Hall).

3. Griffiths, A. J. F., Miller, J. H., Suzuki, D. T., Lewontin, R. C., Gelbart, W. M. An Introduction to Genetic Analysis, W. H. Freeman & Company, New York.

4. Gardner, E. J., Simmons, M. J. and Snustad, D. P. Principles of Genetics, 8th Edition, John Wiley & Sons, New York.

5. An Introduction to genetic analysis. Anthony A. J. F. Griffiths; Susan R. Wessler; Sean B. Carroll; John Deebly. 11th Edition

6. Genetics: A Conceptual approach. Benjamin A. Pierce. 5th Edition

7. Alberts, B., Johnson, A.D., Lewis, J., Morgan, D., Raff, M. and Roberts, K. (2014). Molecular Biology of the Cell. CRC Press, Taylor & Francis Group, USA.

8. Karp, J.G. (2007) Cell and Molecular Biology. John Wiley & Sons, USA.

9. Berk, A., Kaiser, C.A., Lodish, H., Amon, A., Ploegh, H, Bretscher (Author), Monty Krieger, A., Martin, K.C. (Eds). (2016) Molecular Cell Biology. Freeman & Co., USA.

DSE4b(P): Elective Paper (Genetics-II) (Practical)

Course Description

This practical course provides hands-on practical experience on karyotyping, analysis and understanding of diploid and polyploids. It also provides the perfect skill set learning for analysis of chromosome shape and structures, calculation of recombination frequency and gene mapping.

Course Learning Outcomes

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

CO1: Prepare and analyze the karyotype of a diploid plant

CO2: Prepare and analyze the karyotype of a polyploid plant

CO3: Calculation and analysis of chromosome shapes and indexing

CO4: Understand and calculation of recombination frequency and gene mapping by three-point test cross

CO5: Evaluation of the effect of colchicine treatment in plant chromosomes.

DSE4b(P) : Elective Paper (Genetics-II) (Practical)

Course Contents **2 credit**

Detailed Syllabus Content (Credit-2; Contact Hours-60)

1. Analysis of diploid karyotyped chromosomes
2. Analysis of polyploid karyotyped chromosomes
3. Calculation and analysis of chromosome shapes and indexing
4. Calculation of recombination frequency and gene mapping by three-point test cross
5. Effect of colchicine treatment in plant chromosomes.

Paper Code: DSE4c

Paper Title : Plant Pathology and Microbiology-II

Credit : 6

Course objective

- The primary aim of this course is to disseminate scientific information about distribution of microorganisms in different habitats of the environment including food materials, techniques of food preservation, plant pathogenesis, plant-microbe interactions, plant disease epidemics, and disease forecasting.
- This course will also spread awareness about plant pathology's relevance in botany and agriculture.

Learning Outcomes

After studying the course, students will be able to do so.

1. To understand different forms and occurrence of microorganisms in various habitats of the environment and food materials and also to gain knowledge on food preservation techniques.
2. To illustrate and explain types of pathogens and their relevance in plant pathology.
3. To gain exposure to various aspects of plant disease development and disease aetiology.
4. To understand the role of mechanical and biochemical defence mechanisms in plant pathology.

5. To learn about the history of the spread of epidemic disease in different parts of the world and understand the various models of disease development.
6. To gain a better perspective on the traditional and modern disease forecasting methods.

DSE4c (T) : Plant Pathology and Microbiology-II (Theory)

Course Content **Credit: 4**

Unit I: Microbial Ecology **12 Lectures**

Diversity of microbes in terrestrial and aquatic habitats. Occurrence, diversity, adaptability, and utility of various oligotrophic, thermophilic, psychrophilic, barophilic, acidophilic, alkalophilic, and halophilic microorganisms.

Unit II: Food Microbiology **12 Lectures**

Microbiology of food items- Fermented foods and milk products, Microbial spoilage of food products including meat, poultry, and dairy products, Physical and chemical methods of food preservation, Food-borne diseases and food poisoning by microbial agents, Microbial toxins produced in food items.

Unit III: Epidemiology **12 Lectures**

Epidemic diseases of past and present; elements of an epidemic; environmental factors affecting the development of outbreaks; measurement of disease amount and yield loss; development and patterns of epidemics; modelling and computer simulation of plant disease epidemics.

Unit IV: Disease forecasting **12 Lectures**

Evaluation of epidemic threshold and economic damage threshold; assessment of initial inoculum and disease; monitoring weather factors that affect epidemic development; disease forecast based on the amount of initial inoculum, based on weather conditions favouring development of secondary inoculum, and based on initial and secondary inoculum.

Unit V: Detection of Plant Pathogens **12 Lectures**

Use of Haemocytometer. Serological and Molecular Techniques for detection of plant pathogens. Simple, Complex, and differential or selective media for cultivating specific microbes. Role of chemosensors and biosensors for detection of plant pathogens

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Paper Code: DSE4c (P)

Paper Title : Plant Pathology and Microbiology-II (Practical)

Credit : 2

Course Content

1. Isolation and morphological identification of microorganisms (fungi & bacteria) from
   a. Soil. Rhizosphere and Rhizoplane
   b. Aerial plant parts
2. Isolation and identification of microorganisms (fungi & bacteria) from food materials (milk, diary- and fermented food products)
3. Application of antagonists against pathogens *in vitro* and *in vivo* conditions.
4. Application of bio-control agents and their compatibility.
5. Detailed study of symptoms and host-parasite interactions of important plant diseases.
6. Measurement of disease development and inoculum size
7. *In vitro* and *in vivo* evaluation of chemical pesticides against plant pathogens
8. Measurement of Minimum Inhibitory Concentration values

Suggested Readings

1. Madigan, M.T., Martinko, J,M., Bender, K.S., Buckley, D.H. and Stahl, D.A. 2017. *Brock Biology of Microorganisms*, 14th Edition. Pearsons India Educations Service Pvt. Ltd, Noida.
2. Barton, Larry L. and Northup, Diana E. 2011. *Microbial Ecology*. John Wiley & Sons, Inc., Hoboken, New Jersey
3. Adams, M.R. and Moss, M.O. 2008. *Food Microbiology*, 3rd Edition. The Royal Society of Chemistry, Cambridge, UK.
4. Jay, J.M. 1996. *Modern Food Microbiology.* Chapman & Hall, London.
5. Garg, N., Garg, K.L. and Mukerji, K.G. 2020. Laboratory Manual of Food Microbiology. I.K. International Pvt. Ltd., New Delhi

6. Singh, R.S. 2024. *Plant Diseases*, 11th Edition. MedTech Science Press (Scientific International Pvt. Ltd.), New Delhi.
7. Sharma, P.D. 2023. Plant Pathology. 2nd Revised Edition. Rastogi Publications, Meerut.
8. Mehrotra, R.S. and Aggarwal, A. 2024. Plant Pathology, 3rd Edition. MacGraw Hill Education (India) Pvt. Ltd., Chennai.
9. Heald, F.D. 1980.*Manual of Plant Diseases*. Eurasia Publishing House (Pvt.) Ltd., New Delhi.
10. Walker, J.C. 1985.*Plant Pathology*. Tata McGraw-Hill Publishing Company Ltd., New Delhi.
11. Bilgrami, K.S. and Dubey, H.C. 1970. A *Text Book of Modern Plant Pathology*. Vikas Publishing House Pvt. Ltd., New Delhi.
12. Rangaswami, K.G. 1988.*Diseases of Crop Plants in India*. Prentice-Hall of India Pvt. Ltd., New Delhi.
13. Gupta, V.K. and Sharma, R.S. 1995. *Integrated Disease Management and Plant Health.* Scientific Publishers, Jodhpur.
14. Baker, K.F. and Cook, R.J. 1979.*Biological Control of Plant Diseases*. S. Chand & Company Ltd., New Delhi.
15. Johnston, A. and Booth, C. 1985.*Plant Pathologist's Pocketbook*, CMI, Kew, London.

Paper Code: DSE4d

Paper Title : Plant Physiology-II

Credit : 6

Course Objective:

To understand various physiological mechanisms and responses involved in in plant systems subject to water, temperature and salt stress conditions.

Course Outcomes

1: Gain knowledge on Stress and Strain terminology, UV and Ionizing Radiation. It also explains the abiotic and biotic Stress, Stress injury and Resistance and UV and Ionizing radiation injury.

2: The course provides information on water stress flooding, its mechanism on Tolerance and Avoidance of stress and strain

3: Acquire knowledge on chilling and freezing stress, High temperature stress and Mechanism of tolerance.

4: Learn about Salt stress and accumulation of metabolic products under saline condition, nutrient deficiency stress and osmotic stress, physiological adaptation.

DSE 4d(T) : Elective Paper (**Plant Physiology**-II) (Theory)

Course Content **Credit: 4**

12 Hours

I. **Stress and Strain terminology**: UV and Ionizing Radiation; Abiotic and Biotic Stress, Stress injury and Resistance, A general comparative stress and strain response, UV and Ionizing radiation injury.

12 Hours

II. **Water stress**: Flooding and drought stress, Mechanism, Physiological and biochemical processes, Tolerance and Avoidance mechanism.

12 Hours

III. **Temperature stress**: chilling and freezing stress, High temperature stress, Mechanism of tolerance.

12 Hours

IV. **Salt stress**: Accumulation of Metabolic products under saline condition, nutrient deficiency stress and osmotic stress, physiological adaptation.

12 Hours

V. Heavy Metal Stress: Heavy metal stress injury and its effects on plants, accumulation of metabolic products under heavy metal stress condition, physiological plant adaptation.

Paper Code: DSE4d(P)

Paper Title : Plant Physiology-II (Practical)

Credit : 2

Course Content : 60 hours

1. To study changes in level of metabolites chlorophyll in the leaves of a stress plant.

2. Study of seed germination under stress condition.
3. Study of amino acid accumulation in plants under stress.
4. Changes in carbohydrates in pea under chilling stress.
5. Chlorophyll Stability Index (CSI) test for drought tolerance.

Suggested Readings

1. Bidwell, R.G.S.: *Plant Physiology*, Macmillan Pub .Co., Inc., New York.
2. Salisbury, F.B. & C. Ross : *Plant Physiology.*
3. Leopold AC & PE.: *Plant Growth & Development.*
4. Ting IP.: *Plant Physiology.*
5. Wilkins MB. *Advanced Plant Physiology*, John Wiley & Sons, Inc. New York. 1995.
7. Devlin RM. *Plant Physiology.*
8. Noggle G.& G. Fritz. *Introductory Plant Physiology*.
9. Taiz L & Zeige E. *Plant Physiology*, Sinauer Associates, Inc. Pub., Massachusetts. 1998.