BODOLAND UNIVERSITY

Post-Graduate Syllabus

(NEP 2020)

BOTANY

2024

BODOLAND UNIVERSITY, DEBARGAON, KOKRAJHAR, BTR, ASSAM

M.Sc. Syllabus

Department of Botany Bodoland University

The syllabus for the Botany program at Bodoland University is crafted in alignment with the principles outlined in the National Education Policy (NEP) of 2020. Recognizing the paramount importance of cultivating a robust research ecosystem, our postgraduate curriculum offers a distinctive platform within the Department of Botany where students can refine their critical thinking skills and delve into the realm of research. With a diverse array of courses meticulously designed to cater to both local and global demands, our program stands at the forefront of botanical education and covering all aspects of Plant Sciences. Covering interdisciplinary fields such as taxonomy/systematics, ecology, genetics, plant physiology, biotechnology, nanotechnology, our syllabus transcends traditional boundaries to encompass diverse areas of study. From Indian Knowledge System (IKS) to biodiversity conservation, from medicinal plant research to bioprospecting, our program equips students with a comprehensive understanding of the multifaceted facets of botanical science. Upon completing our program, students not only gain proficiency in botany's theoretical and practical aspects but also emerge with a nuanced understanding of its socio-political implications and global relevance. They are poised to contribute meaningfully to the advancement of botanical research, environmental conservation, and sustainable development on both local and global scales.

PG Structure as per recommendations of NEP 2020

There may be a 2-year programme with the second year devoted entirely to research for those who have completed the 3-year bachelor's programme.

For students completing a 4-year bachelor’s programme with Honours/ Honours with Research, there could be a 1-Year master's programme, and

There may be an integrated 5-year Bachelor’s/Master’s programme
Flexibility for students who qualify UG with a major and minor(s) to opt for either major or minor(s) subject in the Master's programme.

Credit requirement and Eligibility for Master's programme:

A Bachelor's degree with Honours/ Honours with Research with a minimum of 160 Credits for a 1-year/2- semester master's programme at level 6.5 on the NHEQF.

A 3-year/6-semester bachelor's degree with a minimum of 120 credits for a 2-year/4-semester Master's programme at level 6.5 on the NHEQF

A 4-year Bachelor's degree with a minimum of 160 credits for a 2-year/4-semester Master's programme at level 7 of NHEQF

Sl. No.	Qualifications	Level	Credit	Credit Points
1	1-year PG after a 4-year UG	6.5	40	260
2	2-year PG after a 3-Year UG	6.5	40+40	260

Curricular Components:
Group A: Advanced Plant Physiology and Biochemistry
Group B: Angiosperm Taxonomy
Group C: Microbiology

Curricular Components for PG Programs

2-Year PG Program (after a 3-Year UG Program)

Option	First Semester	Second Semester	Third Semester	Fourth Semester
(i)	General coursework	General coursework	Group A/B/C coursework	Group A/B/C coursework
(ii)	General coursework	General coursework	Group A/B/C coursework	Group A/B/C research
(iii)	General coursework	General coursework	Group A/B/C research	Group A/B/C research

1-Year PG Program (after a 4-Year UG Program)

Option	Duration	Description
(i)	Full Year	Only coursework (Group A/B/C)
(ii)	Full Year	Only research (Group A/B/C)
(iii)	Full Year	Coursework and research (Group A/B/C)

Curricular components		Two-Year PG Programme Minimum Credits			
		Course Level	Coursework	Research Thesis/ Project	Total Credits
1st Year (1st & 2nd Semester)		400	24		40
		500	16		
Students who exit at the end of 1st Year shall be awarded a Postgraduate Diploma					
2nd Year (3rd & 4th Semester)	Coursework & research (or)	500	20	20	40
	Coursework (or)	500	40		40
	Research			40	40

5-Year Integrated Program (UG+PG)

- The PG level curricular components will be similar to that of the 2-Year PG program mentioned above.

Credit Distribution:

Curricular Components	PG Programme (One Year) for 4-yr UG (Hons. /Hons. With research) Minimum Credit			
	Course Level	Course Work	Research thesis	Total credits
Coursework + Research	500	20	20	40
Coursework	500	40		40
Research			40	40

For 2-Year PG (BOTANY)

SEMESTER I

Paper Code	Paper Name	Credits	L+T+P	Internal	External (Theory)	Practical (Internal)	Marks
BOTADL14014	Plant Metabolism	4	3+0+1	30	50	20	100
BOTADL14024	Indian Knowledge System (IKS) & Ethnobotany	4	3+0+1	30	50	20	100
BOTADL14034	Industrial Microbiology & Immunology	4	3+0+1	30	50	20	100
BOTADL14044	Research Methodology	4	3+0+1	30	50	20	100
BOTADL14054	Plants & Environmental Biotechnology	4	3+0+1	30	50	20	100

SEMESTER II

Paper Code	Paper Name	Credits	L+T+P	Internal	External	Practical	Marks
BOTADL15014	Plant Breeding & Tissue Culture	4	3+0+1	30	70	20	100
BOTSPL15024	Bioresource Management	4	3+0+1	30	70	20	100
BOTSPL15034	Advanced Biochemistry	4	3+0+1	30	70	20	100
BOTSPL15044	Advanced Plant Pathology	4	3+0+1	30	70	20	100
BOTSPL15054	Plant Pharmacognosy & Pharmacology	4	3+0+1	30	70	20	100

Group A: Advanced Plant Physiology and Biochemistry

SEMESTER III (2-Year PG/1-Year PG)

Paper Code	Courses	Credits	L+T+P	Contact Hours	Internal	External	Marks
BOTSPL 25014	Phytotechnology	4	3+1+0	60	30	70	100
BOTSPL 25024	Photobiology & Signal Transduction	4	3+1+0	60	30	70	100
BOTSPL 25034	Chemistry in Plant Sciences	4	3+1+0	60	30	70	100
BOTSPL 25044	Plant Physiology **(Lab I)**	4	0+0+4	60	30	70	100
BOTSPL 25054	Plant Physiology **(Lab II)**	4	0+0+4	60	30	70	100

SEMESTER IV

Paper Code	Courses	Credits	L+T+P	Contact Hours	Internal	External	Marks
BOTSPL 25064	Hydroponics Technology	4	3+1+0	60	30	70	100
BOTSPL 25074	Stress Biology of Plants	4	3+1+0	60	30	70	100
BOTSPL 25084	Nanomaterials in Plant Sciences	4	3+1+0	60	30	70	100
BOTSPL 25094	Plant Physiology **(Lab III)**	4	0+0+4	60	30	70	100
BOTSPL 25104	Plant Physiology **(Lab IV)**	4	0+0+4	60	30	70	100

Group B: Angiosperm Taxonomy

SEMESTER III (2-Year PG/1-Year PG

Paper Code	**Courses**	**Credits**	**L+T+P**	**Contact Hours**	**Internal**	**External**	**Marks**
BOTSPL 25014	Angiosperm Taxonomy-I	4	3+1+0	60	30	70	100
BOTSPL 25024	Angiosperm Taxonomy-II	4	3+1+0	60	30	70	100
BOTSPL 25034	Angiosperm Taxonomy-III	4	3+1+0	60	30	70	100
BOTSPL 25044	Angiosperm Taxonomy **(Lab I)**	4	0+0+4	60	30	70	100
BOTSPL 25054	Angiosperm Taxonomy **(Lab II)**	4	0+0+4	60	30	70	100

SEMESTER IV

Paper Code	**Courses**	**Credits**	L+T+P	**Contact Hours**	**Internal**	**External**	**Marks**
BOTSPL 25064	Plant Geography & Evolution Biology	4	3+1+0	60	30	70	100
BOTSPL 25074	Advanced Angiosperm Systematics	4	3+1+0	60	30	70	100
BOTSPL 25084	Plant Resources, Conservation Biology & IKS	4	3+1+0	60	30	70	100
BOTSPL 25094	Angiosperm Taxonomy **(Lab III)**	4	0+0+4	60	30	70	100
BOTSPL 25104	Angiosperm Taxonomy **(Lab IV)**	4	0+0+4	60	30	70	100

Group C: Microbiology

SEMESTER III

Paper Code	Courses / Paper Title	Credits	L+T+P	Internal Marks	External Marks	Total Marks
BOTSPL 25014	Microbial Diversity & Physiology	4	3+1+0	30	70	100
BOTSPL 25024	Agriculture Microbiology	4	3+1+0	30	70	100
BOTSPL 25034	Adv. Laboratory Tools & Techniques in Microbiology	4	3+1+0	30	70	100
BOTSPL 25044	Microbiology **(Lab I)**	4	0+0+4	30	70	100
BOTSPL 25054	Microbiology **(Lab II)**	4	0+0+4	30	70	100

SEMESTER IV

Paper Code	Courses / Paper Title	Credits	L+T+P	Internal Marks	External Marks	Total Marks
BOTSPL 25064	Molecular Biology & Genetic Engineering	4	3+1+0	30	70	100
BOTSPL 25074	Food & Environmental Microbiology	4	3+1+0	30	70	100
BOTSPL 25084	Applied Microbiology	4	3+1+0	30	70	100
BOTSPL 25094	Microbiology **(Lab III)**	4	0+0+4	30	70	100
BOTSPL 25104	Microbiology **(Lab IV)**	4	0+0+4	30	70	100

I SEMESTER

Paper Title: Plant Metabolism
Paper Code: BOTADL14014
Paper credit: 04(3T+1P)

Total number of lectures: 60=45+15(L+P) **Total Marks: 100 (T50+P20+IA30)**

Course Objective:

The course objective of Plant Metabolism is to provide students with a comprehensive understanding of the biochemical processes and metabolic pathways in plants, enabling them to analyse and interpret plant metabolism at the molecular, cellular, and physiological levels.

Course Outcome:

- Develop a thorough understanding of the biochemical processes and metabolic pathways involved in plant metabolism, including photosynthesis, respiration, carbohydrate metabolism, lipid metabolism, and secondary metabolite biosynthesis.
- Acquire knowledge and skills to analyze and interpret metabolic regulation and interactions in plants, and understand the physiological and ecological significance of plant metabolism in growth, development, and responses to environmental stimuli.
- Apply critical thinking and problem-solving skills to evaluate and design experiments related to plant metabolism, and effectively communicate scientific findings and concepts related to plant metabolic pathways and their functional implications.

Unit-I: Concept of metabolism and Carbon assimilation (15hrs class, 20 marks)

Introduction, regulation of metabolism, role of regulatory enzymes (allosteric, covalent modulation and Isozymes).

Historical background, photosynthetic accessories, photochemical reactions, photosynthetic electron transport, PSI, PSII, Q cycle, CO_2 reduction, photorespiration, C4 pathways; Crassulacean acid metabolism; Factors affecting CO_2 reduction.

Unit-II: Carbon Oxidation and ATP-Synthesis (15hrs class, 20 marks)

Glycolysis, fate of pyruvate, regulation of glycolysis, oxidative pentose phosphate pathway, oxidative decarboxylation of pyruvate, regulation of PDH, NADH shuttle; TCA cycle, regulation of the cycle, mitochondrial electron transport, oxidative phosphorylation, cyanide-resistant respiration, factors affecting respiration.

Mechanism of ATP synthesis, substrate level phosphorylation, chemiosmotic mechanism (oxidative and photophosphorylation), ATP synthase, Boyers conformational model, Racker's experiment, Jagendorf's experiment; role of uncouplers.

Unit-III: Nitrogen metabolism (15hrs class, 20 marks)

Nitrate assimilation, biological nitrogen fixation; Physiology and biochemistry of nitrogen fixation; Ammonia assimilation and transamination.

Unit-IV: Practical (8 class =15hrs, 20 marks)

1. Chemical separation of photosynthetic pigments.
2. Experimental demonstration of Hill's reaction.
3. To study the effect of light intensity on the rate of photosynthesis.
4. Effect of carbon dioxide on the rate of photosynthesis.
5. To compare the rate of respiration in different parts of a plant.
6. Demonstration of fluorescence by isolated chlorophyll pigments.
7. Demonstration of absorption spectrum of photosynthetic pigments.

Suggested Readings

1. Verma SK and Verma Mohit *A Textbook of Plant Physiology, Chemistry and Biotechnology*
2. Malik CP and Srivastava A. *Text Book of Plant Physiology*
3. Hopkins, W.G. and Huner, A. (2008). Introduction to Plant Physiology. JohnWiley and Sons. U.S.A. 4th edition.

4. Taiz, L., Zeiger, E., MØller, I.M. and Murphy, A (2015). Plant Physiology and Development. Sinauer Associates Inc. USA. 6th edition.
5. Bala, M., Gupta, S., Gupta, N.K. and Sangha, M.K. (2013). Practicals in Plant Physiology and Biochemistry, Scientific Publishers (India).
6. Harborne, J.B. (1973). Phytochemical Methods. John Wiley & Sons. NewYork.

Paper Title: Indian Knowledge System (IKS) & Ethnobotany
Paper Code: BOTADL14024
Paper credit: 04(3T+1P)

Total number of lectures: 60=45+15(L+P) **Total Marks: 100 (T50+P20+IA30)**

Course Objective

This course is designed to sensitize the students about the glorious Indian Knowledge System and heritage. Additionally, this course will help students to explore the interrelationship between plants and human cultures, including traditional knowledge, uses, and conservation of plants for medicinal, cultural, and economic purposes.

Course Outcome

- To sensitize the students about context of Indian Knowledge System and heritage.
- To help student to understand the knowledge, art and creative practices, skills and values in ancient Indian system.
- Understanding the fundamental principles of Indian health systems such as Ayurveda and yoga which are useful in maintaining the health of a healthy person
- Understand the cultural significance of plants and their traditional uses in different societies, including medicinal, culinary, ceremonial, and economic purposes.
- Apply ethnobotanical research methods to document and analyze traditional knowledge related to plants, including indigenous practices, plant identification, and plant use patterns.

Unit-I (15hrs class, 15 marks)

Introduction to IKS: Definition of IKS, An overview of Indian Knowledge System (IKS): Importance of Ancient Knowledge - Classification framework of IKS - Unique aspects of IKS. The vedic corpus: Vedas and Vedangas - Distinctive features of vedic life; Indian philosophical systems: Different schools of philosophy. IKS-Wisdom through the ages. Concepts and Applications in Science; Indian culture & Civilization.

Unit-II (10hrs class, 10 marks)

Indian Knowledge System in Science: Ayurveda for Life, Health and Well-being; Traditional Ayurveda & plant-based medicine; Yoga-the way of life; Historical development of agriculture in India; Texts related to agriculture in India; Importance of some of the traditional methods Water Management in India; Traditional conservation practices of biodiversity in India; IPR & Traditional Knowledge.

Unit-III (10hrs class, 10 marks)

Introduction of Ethnobotany: Overview of Ethnobotany, Folk medicines of ethnobotany, ethnomedicine, ethnoecology, ethnic communities of India. Application of natural products to certain diseases- Jaundice, cardiac, infertility, diabetics, Blood pressure and skin diseases.

Unit-III (10 hrs class, 15 marks)

Indian context of Ethnobotany: Centers of Ethno botanical studies in India, Ethnomedicine and Primary health care; Renewable plant products: Sustainable source of income; Protecting local resources. Commercialization and conservation: Sustainable development - Economic growth and resource conservation. Role of Ethnobotany in conservation and sustainable development, Ethnobotanical study in North East India.

Unit-IV: Practical (15hrs class, 20 marks)

Field trip to tribal settlement to survey, document and frame hypothesis on people-plant relationship.

1. Practical knowledge on IKS -Study Ancient texts related to the course.
2. Collection, processing and preservation of ethnobotanical specimens in the institutional repository.
3. Identify and document plant parts used in preparation of crude drugs/herbal formulations
4. Field survey for ethnomedicinal plants with standard protocol

Suggested Readings

1. Textbook on IKS by Prof. B Mahadevan, IIM Bengaluru

2. Kapur K and Singh A.K (Eds) 2005). Indian Knowledge Systems, Vol. 1. Indian Institute of Advanced Study, Shimla. Tatvabodh of sankaracharya, Central chinmay mission trust, Bombay, 1995.

3. The Cultural Heritage of India. Vol.I. Kolkata:Ramakrishna Mission Publication, 1972.

4. Nair, Shantha N. Echoes of Ancient Indian Wisdom. New Delhi: Hindology Books, 2008.

5. Rao, N. 1970. The Four Values in Indian Philosophy and Culture. Mysore: University of Mysore.

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

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

8. Jain, S. K. (1981). Glimpses of Indian Ethnobotany. Oxford & IBH publishing Co. Pvt. Ltd., New Delhi

9. Cunningham, A. B. (2001). Applied Ethnobotany. Earthscan publishers Ltd. London & Sterling, VA, USA Cotton, C.M. (1996).

10. Ethnobotany-Principles and application. John Wiley& Sons Ltd., West Sussex, England

SEMESTER I
Paper Title: Industrial Microbiology and Immunology
Paper Code: BOTADL14034
Paper credit: 04(3T+1P)
Total number of lectures: 60=45+15(L+P) Total Marks: 100 (T50+P20+IA30)

Course Objective:

The course objective of Industrial Microbiology and Immunology is to provide students with a comprehensive understanding of the applications of microorganisms and immunological techniques in various industries, enabling them to analyze and apply microbial and immunological knowledge for industrial processes, product development, and disease diagnosis and prevention.

Course Outcome

- Develop a thorough understanding of the principles and applications of industrial microbiology, including microbial fermentation, biotechnology, enzyme production, and microbial control strategies in various industrial sectors.
- Acquire knowledge and skills in immunological techniques, including serological assays, immunoassays, and molecular diagnostics, and apply them for disease diagnosis, vaccine development, and immunotherapy in industrial and clinical settings.
- Apply critical thinking and problem-solving skills to analyze and evaluate industrial microbiology and immunology processes, and make informed decisions in selecting appropriate techniques and strategies for microbial product development, quality control, and disease prevention.

Unit-I: Scope of microbes in industry and environment, fermentation (15hrs class, 20 marks)

Solid-state and liquid-state (stationary and submerged) fermentations; Batch and continuous fermentations. Components of a typical bioreactor, Types of bioreactors-laboratory, pilot-scale and production fermenters; constantly stirred tank fermenter, tower fermenter, fixed bed and fluidized bed bioreactors and air-lift fermenter. A visit to any educational institute/ industry to see an industrial fermenter, and other downstream processing operations.

Unit-II: Microbial production of industrial products, enzyme and enzyme immobilization (15hrs class, 20 marks)

Microorganisms involved, media, fermentation conditions, downstream processing and uses; Filtration, centrifugation, cell disruption, solvent extraction, precipitation and ultrafiltration, lyophilization, spray drying; Hands on microbial fermentations for the production and estimation (qualitative and quantitative) of Enzyme: amylase or lipase activity, Organic acid (citric acid or glutamic acid), alcohol (Ethanol) and antibiotic (Penicillin), Microorganisms for industrial applications and hands on screening microorganisms for casein hydrolysis; starch hydrolysis; cellulose hydrolysis. Methods of immobilization, advantages and applications of immobilization, large scale applications of immobilized enzymes (glucose isomerase and penicillin acylase**).**

Unit-III: Immunology (15hrs class, 20 marks)

Immunity-mechanism; Innate and adaptive immune system: cells and molecules involved in innate and adaptive immunity. (1hr) 2. Antigens, antigenicity and immunogenicity. B and T cell epitopes. (2hrs) 3. Structure and function of antibody molecules, generation of antibody molecules, 4. Antigen antibody interactions

Unit-IV: Practical (8 Class=15hrs, 20 marks)

1. Principles and functioning of instruments in microbiology laboratory
2. Hands on sterilization techniques and preparation of culture media.
3. Microbial Culturing and Media Preparation: Students will learn basic techniques for microbial culturing and prepare different types of growth media to support the growth of specific microorganisms.
4. Sterilization Techniques: Students will practice various methods of sterilization, such as autoclaving and filtration, to ensure aseptic conditions in the laboratory and prevent microbial contamination.

5. Enzyme Production and Assay: Students will isolate and culture microorganisms capable of producing specific enzymes, and perform enzyme assays to quantify enzyme activity and assess its industrial potential.
6. Antibiotic Sensitivity Testing: Students will conduct antibiotic sensitivity testing using standard methods, evaluating the susceptibility of bacterial strains to different antibiotics, and interpreting the results for effective antibiotic selection.

Suggested Readings

1. Waites MJ, Morgan NL, Rockey JS, Higton G (2001) Industrial Microbiology: An Introduction, Wiley-Blackwell.
2. Introduction to Biotechnology. Blackwell Scientific Publications, Oxford 12.
3. Chawla, H.S, 2000. Introduction to Biotechnology. Oxford & IBH Publishing Co Pvt. Ltd, New Delhi.
4. Satyanarayana, U. (2011). Biotechnology. Books and Allied (p) Ltd..
5. Pelzar, M.J. Jr., Chen E.C. S., Krieg, N.R. (2010). Microbiology: An application based approach. Tata McGraw Hill Education Pvt. Ltd., Delhi.
6. Tortora, G.J., Funke, B.R., Case. C.L. (2007). Microbiology. Pearson Benjamin Cummings, San Francisco, U.S.A. 9th edition.
7. Pommerville, J. C. 2011. Alcamo's fundamentals of microbiology, 9th Edition.
8. Male, D., Brostoff, J., Roth, D. B. and Roitt, I. 2006. Immunology, 7th Edition. Elsevier Limited.
9. Owen, J. A., Punt, J., & Stranford, S. A. (2013). Kuby Immunology (Vol. 27, p. 109). New York: WH Freeman.

SEMESTER I
Paper Title: Research Methodology
Paper Code: BOTADL14044
Paper credit: 04(3T+1P)
Total number of lectures: 60=45+15(L+P) Total Marks: 100 (T50+P20+IA30)

Course Objective:

To equip students with the necessary knowledge and skills to design, conduct, analyze, and communicate research effectively, fostering a strong foundation in research methodology across various disciplines.

Course Outcome

- Develop the ability to design research studies, including formulating research questions, selecting appropriate research methods, and designing data collection instruments, ensuring the integrity and validity of research findings.
- Acquire skills in data analysis, interpretation, and presentation, including the use of statistical techniques and software, enabling students to analyze research data effectively and communicate research findings in a clear and coherent manner.

Unit-I: Introduction to Research Methodology (15hrs class, 20 marks)

Understanding the nature and importance of research; Formulating research questions and objectives; Research ethics and responsible conduct of research; Overview of different research paradigms and approaches

Unit-II: Research Design and Data Collection (15hrs class, 20 marks)

Types of research designs: experimental, observational, survey, and qualitative; Sampling techniques and sample size determination; Data collection methods: surveys, interviews, observations, and archival research, Designing data collection instruments: questionnaires, interview guides, and observation protocols

Unit-III: Data Analysis, Interpretation and Research Communication (15hrs class, 20 marks)

Introduction to quantitative and qualitative data analysis methods; Statistical analysis techniques: descriptive statistics, inferential statistics, correlation, and regression; Qualitative data analysis approaches: thematic analysis, content analysis, and grounded theory; Interpreting and presenting research findings effectively, writing research proposals and

research reports; Creating effective research presentations; Scholarly writing conventions and citation styles; Peer review process and academic publishing

Unit-IV: Practical (15hrs class, 20 marks)

1. Research Proposal Development: Students will learn how to develop a research proposal, including identifying research questions, formulating hypotheses, and designing an appropriate research methodology.
2. Data Collection Techniques: Students will practice various data collection techniques, such as surveys, interviews, observations, and experiments, to gather relevant data for their research projects.
3. Data Analysis and Interpretation: Students will learn statistical analysis techniques and software tools to analyze and interpret research data, drawing meaningful conclusions and identifying patterns or relationships.
4. Literature Review and Critical Analysis: Students will conduct a comprehensive literature review on their research topic, critically analyzing and synthesizing existing studies and identifying research gaps.

Suggested Readings

1. Kothari, C. R. Research Methodology: Methods and Techniques.
2. Pandey, Prabhat, and Meenu Mishra Pandey. Research Methodology: Tools And Techniques.
3. Creswell, J. W., & Creswell, J. D. (2022). Research Design. SAGE Publications.
4. Kumar, R. (2018). Research Methodology. SAGE.
5. Novikov, A. M., & Novikov, D. A. (2019). Research Methodology.

SEMESTER I
Paper Title: Plant and Environmental Biotechnology
Paper Code: BOTADL14054
Paper credit: 04(3T+1P)

Total number of lectures: 60=45+15(L+P) **Total Marks: 100 (T50+P20+IA30)**

Course Objectives:

- Understand ecosystems, pollution, and environmental monitoring.
- Learn waste treatment, biodegradation, and bioremediation.
- Gain practical skills in environmental sample analysis.

Course Outcome

- Describe ecosystem components, pollution impacts, and apply monitoring techniques.
- Explain waste treatment methods and biodegradation principles.
- Perform water quality analyses, report on industrial effluents, and demonstrate composting.

Unit I: Introduction to environmental biology (15hrs class, 20 marks)

Basic components of environment, Concept of ecosystem, abiotic and biotic components. Environmental pollution: Air, water, and soil pollution. Environmental monitoring: environmental impacts and their assessments using bioindicators, Biomarkers, biosensors and toxicity testing Air, water and soil sampling. Analyses of samples by physical, chemical and biological methods.

Unit II: Waste treatment strategies (15hrs class, 20 marks)

Classification and characterization of waste. Principles and mechanisms of waste treatment. Nitrification and denitrification – microbial fundamentals and application. Aerobic processes: Activated sludge, oxidation ditches, trickling filters, towers, rotating discs, rotating drums, oxidation ponds. Anaerobic processes: Anaerobic digestion, anaerobic filters, up flow anaerobic sludge blanket reactor. Economics and special aspects of waste treatment. Examples of treatment schemes for waste waters of dairy, tannery, sugar and antibiotic industry.

Unit III: Biodegradation and bioremediation, Environmental protection and conservation (15hrs class, 20 marks)

Principle and mechanism of biodegradation. Biodegradation of xenobiotic compounds (Lignin, Hydrocarbons, Detergents, Dyes and pesticides). Phytoremediation: Use of plants for removal of organic and metallic pollutants. Microbial interaction with metallic elements, metal toxicity. Biosurfactants: Microbial production and application. Biodetorioration– Principles, prevention and control

Status and Scope of biotechnology in environmental protection. Non-conventional energy sources. Various environmental standards: air, water and noise quality. Environment protection Act: environmental laws, policies, ethics. Environmental protection agencies.

Unit IV: Practical (15hrs class, 20 marks)

1. Quantitative analysis of water conductivity and pH
2. Determination of turbidity of a given sample
3. Quantitative analysis of water alkalinity
4. Quantitative analysis of water acidity
5. Quantitative analysis of water hardness
6. Quantitative analysis of water chloride
7. To prepare a report on various types of local industrial effluents.
8. Demonstration of composting techniques.
9. Demonstration of Microbiological quality of water

Suggested Readings

1. Environmental Biotechnology, Principles and Applications by Bruce E Rittman and Perry L McCarty, McGrawhill Higher education.
2. Environmental Biotechnology Edited by Hans-Joachim Jördening and J Winter, WILEY-VCH Verlag Gmbh & Co.
3. Bioremediation and Natural Attenuation by Pedro J J Alvarage and Walter A Illman, Wiley Interscience.
4. Environmental Biotechnology, Vol 10 Handbook of Environmental Engineering, Edited by L K Wang et al, Humana Press.

SEMESTER II

Paper Title: Plant Breeding and Tissue Culture
Paper Code: BOTADL15014
Paper credit: 04(3T+1P)

Total number of lectures: 60=45+15(L+P) **Total Marks: 100 (T50+P20+IA30)**

Course Objectives:

The course objective of Plant Breeding and Tissue Culture is to provide students with a comprehensive understanding of plant breeding principles and techniques, as well as tissue culture methods, enabling them to develop improved plant varieties through controlled breeding and genetic manipulation in vitro.

Course Outcome

- Develop a solid understanding of the principles and techniques of plant breeding, including selection, hybridization, and genetic manipulation, and apply these concepts to develop improved plant varieties with desired traits.
- Acquire practical skills in tissue culture methods, including callus induction, somatic embryogenesis, and micropropagation, and apply these techniques for mass production of plants and clonal propagation.
- Apply critical thinking and problem-solving skills to analyze and evaluate plant breeding strategies and tissue culture protocols, and make informed decisions in selecting appropriate techniques for specific breeding goals and conservation efforts.

Unit-I (15hrs class, 20 marks)

Historical development, concept, nature and role of plant breeding, major achievements and future prospects; Genetics in relation to plant breeding, modes of reproduction and apomixes, self-incompatibility and male sterility- genetic consequences, cultivar options. Domestication, Acclimatization and Introduction; Centres of origin/diversity, components of Genetic variation; Heritability and genetic advance

Unit-II Principles, genetic basis and methods: Mass selection, pure line selection, clonal selection. (15hrs class, 20 marks)

Hybridization: Objectives. Procedure. Major achievements. Problems and causes of failure of hybridization. Handling of hybrids - Bulk method and pedigree method of selection. Distant hybridization - Role of interspecific and intergeneric hybridization in crop improvement. Role in crop improvement Types of male sterility: Gametic and zygotic sterility. Somatoplastic sterility. Cytoplasmic and genetic sterility. Methods to overcome incompatibility: (4 hrs) 2. Backcross breeding: Theory and procedure. (4 hrs) 3. Inbreeding: inbreeding consequences. Heterosis- Definition. Genetic and physiologic basis. Application in plant breeding. Steps in the production of single cross, double cross, three way cross, synthetic cross, multilines. Ideotype breeding: Concept, Achievements: (Wheat – Asana, Donald. Rice – Super Rice). (6 hrs) 4. Polyploidy breeding: induction of autopolyploidy and allopolyploidy. Centres of crop breeding: International and National

Unit-III Plant Tissue Culture (15hrs class, 20 marks)

Historical perspective, Type, techniques and application of Callus, Suspension, Hapliod and Embryo, and Organ Culture. Embryogensis, organogenesis, synthtic seeds.and Somoclonal variations. Micropropogation- Advantages, Disadvantages and factors influencing micropropogation. Different Methods and stages involved in micropropogations. Hairy root culture, multiple shoot culture and there application. Protoplast culture, isolation and purification of protoplast. Method of Protoplast fusion and protoplast culture, Cryopreservation, Germplasm Conservation.

Unit-IV: Practical (8 Class=15hrs, 20 marks)

1. Emasculation; preparation of the inflorescence for crossing.
2. Estimation of pollen sterility and fertility percentage.
3. Pollen germination: in vitro and in vivo viability tests
4. Study of pollen types using acetolysed and non-acetolysed pollens

5. Developmental stages of anther, ovule, embryo and endosperm.

a. Preparation of MS medium.

b. Demonstration of *in vitro* sterilization and inoculation methods using leaf and nodal explants of tobacco, *Datura*, *Brassica* etc.

6. Study of anther, embryo and endosperm culture, micropropagation, somatic embryogenesis & artificial seeds through photographs.
7. Hands on sterilization techniques and preparation of culture media.
8. Isolation of protoplasts.

Suggested Readings

1. Bhojwani, S.S. and Razdan, M.K., (1996). Plant Tissue Culture: Theory and Practice. Elsevier Science Amsterdam. The Netherlands.
2. Raghavan V., 1976. Experimental embryogenesis in plants. Academic Press.
3. Heywood, V.H. & Watson, R.T. (1995) Global Biodiversity Assessment.
4. Huston, M.A. (1994). Biological Diversity: The coexistence of species on changing landscapes. Cambridge University Press, UK.
5. 5.Trivedi, P. C. (2007) Global Biodiversity status and conservation. Pointer publishers Bhojwani, S.S. (2012). *Plant Tissue Culture: Applications and Limitations*.
6. Razdan, M.K. (2003). *Introduction to Plant Tissue Culture*.
7. Rai, Avinash Chandra, Kumar, Ajay, & Modi, Arpan. (2022). *Advances in Plant Tissue Culture: Current Developments and Applications*.
8. Withers, Lyndsey A. & Alderson, P.G. (2013). *Plant Tissue Culture and Its Agricultural Applications.*
9. Reinert, Jakob & Bajaj, Yashpal S. (2013). *Applied and Fundamental Aspects of Plant Cell, Tissue, and.*
10. Taji, Acram, Kumar, Prakash, & Lakshmanan, Prakash. (2001). *In Vitro Plant Breeding*.

SEMESTER II
Paper Title: Bioresource Management
Paper Code: BOTADL15024
Paper credit: 04(3T+1P)
Total number of lectures: 60=45+15(L+P) Total Marks: 100 (T50+P20+IA30)

Course Objectives:

Bioresource Management - Gain knowledge and skills to effectively manage and sustainably utilize biological resources for various purposes, including conservation, economic development, and environmental stewardship.

Course Outcome

- Understand the principles and concepts of bioresource management, including the sustainable use and conservation of biological resources.
- Apply analytical and problem-solving skills to assess and manage bioresources in various contexts, considering ecological, economic, and social factors.
- Demonstrate knowledge of different bioresource management strategies and techniques, such as biodiversity assessment, habitat restoration, and sustainable harvesting practices.
- Evaluate the impacts of human activities on bioresources and develop strategies to mitigate negative effects and promote sustainable resource management

Unit-I: Biological Resources, Forests (15hrs class, 20 marks)

Biodiversity-definition and types; Significance; Threats; Management strategies; Bio-prospecting; IPR; CBD; National Biodiversity Action Plan). Definition, study of various forests of the world and India. Forest products – Major and minor. Influence of forest on environment. Consequence of deforestation and industrialization. Sustainable use of bioresources

Unit-II: Energy, Contemporary practices in resource management (15hrs class, 20 marks)

Renewable and non-renewable sources of energy, EIA, GIS, Participatory Resource Appraisal, Ecological Footprint with emphasis on carbon footprint, Resource Accounting; Waste management. National and international efforts in resource management and conservation

Unit-III: Acts and policies (15hrs class, 20 marks)

Forest Conservation Act 1981; Environment (protection) Act 1986; Hazardous waste (Management and Handling) Rules 1989; Bio-Medical Waste (Management and Handling) Rules 1998; Environmental Impact Assessment (EIA); Environmental Management Plan (EMP) and Environmental Clearance for Establishing Industry (ECEI); National Biodiversity Action Plan National Biodiversity Act 2002.

Unit-IV: Practical (15hrs class, 20 marks)

1. Estimation of solid waste generated by a domestic system (biodegradable and non-biodegradable) and its impact on land degradation.
2. Collection of data on forest cover of specific area.
3. Measurement of dominance of woody species by DBH (diameter at breast height) method.
4. Calculation and analysis of ecological footprint.
5. Ecological modeling.

Suggested Readings

1. Maiti, R., Rodríguez, H. G., & Ghosh, B. (2018). Research trends in bioresource management and technology
2. Maiti, R., González Rodríguez, H., & Kumari, C. A. (2020). Sustainable bioresource management: Climate change
3. Kumar, D., Rajendran, K. V., & Jahageerdar, S. (2011). Bioresource management and climate change
4. Maiti, R., Kumari, A., & Thakur, A. K. (2016). Bioresource and stress management.

5. Maiti, R. K., González Rodriguez, H., & Kumari, C. A. (2021). Sustainable bioresource management: Climate change
6. Thatoi, H., Das, S. K., & Mohapatra, S. (2021). Bioresource utilization and management: Applications in therapeutics, biofuel, agriculture, and environmental protection.
7. Pirzadah, T. B., Malik, B., & Bhat, R. A. (2022). Bioresource technology: Concept, tools and experiences
8. Thatoi, H. N., Das, S. K., & Mohapatra, S. (2021). Bioresource utilization and management: Applications in therapeutics, biofuel, agriculture, and environmental management.
9. Maiti, R., González Rodríguez, H., & Kumari, C. A. (2020). Sustainable bioresource management: Climate change

Paper Title: Advanced Biochemistry
Paper Code: BOTADL15034
Paper credit: 04(3T+1P)

Total number of lectures: 60=45+15(L+P) **Total Marks: 100 (T50+P20+IA30)**

Course Objectives:

Understand the fundamental principles and processes of biological chemistry, including the structure, function, and metabolism of biomolecules, and their roles in cellular and molecular processes.

Course Outcome

- Demonstrate a comprehensive understanding of the structure, properties, and functions of biomolecules, including proteins, carbohydrates, lipids, and nucleic acids, and their roles in cellular processes.
- Apply biochemical techniques and laboratory skills to perform experiments, analyze data, and interpret results related to biochemical processes and enzyme kinetics.
- Explain the principles of metabolic pathways, including energy metabolism, biosynthesis, and regulation, and their significance in cellular and organismal functions.
-

Unit-I: Enzyme (15hrs class, 20 marks)

Introduction to Enzymes and Catalysis, Definition and classification of enzymes, Historical perspective and significance of enzymes in biological systems, Enzyme Kinetics, Mechanisms of Enzymatic Reactions.

Unit-II: Metabolism of Carbohydrates and Lipids (15hrs class, 20 marks)

Classification, synthesis and breakdown, citric acid cycle, fatty acid oxidation, Glycolysis, pentose phosphate, membrane lipids.

Unit-III: Membrane Biology and Bioenergetics Metabolism of Amino Acids and Proteins

(15hrs class, 20 marks)

This subject deals in providing knowledge about Membrane biology, membrane structure, membrane transport, oxidative phosphorylation etcThis subject includes amino acid metabolism, biosynthesis and catabolism of amino acids, biosynthesis of purine and pyrimidine nucleotides

Unit-IV: Practical (15hrs class, 20 marks)

1. Safety practices in the laboratory.
2. Preparation and storage of solutions.
3. Concepts of solution concentration and storing solutions.
4. Concept of a buffer, Henderson-Hasselbach equation, working of a pH meter.
5. Quantitative transfer of liquids.

Suggested Readings

1. Principles of Biochemistry by Albert L. Lehninger
2. Harper's Illustrated Biochemistry by Robert K. Murray
3. Essentials of Biochemistry by Mushtaq Ahmad
4. Biochemistry by U. Satyanarayana
5. Lippincott's Illustrated Reviews: Biochemistry by Pamela C. Champe
6. Biochemistry (1998) by Geoffrey Zubay. Fourth edition, WC Brown Publishers, USA.
7. Biochemistry (2015) by Berg, Tymoczko, Gatto, Stryer. Eighth Edition.

Paper Title: Advanced Plant Pathology
Paper Code: BOTADL15044
Paper credit: 04(3T+1P)

Total number of lectures: 60=45+15(L+P) **Total Marks: 100 (T50+P20+IA30)**

Course Objectives:

Develop an in-depth understanding of plant diseases, their causes, mechanisms, and management strategies, and apply advanced diagnostic and research techniques in the field of plant pathology.

Course Outcome

- Acquire advanced knowledge of plant pathogens, including their classification, biology, and pathogenicity mechanisms, and apply this knowledge in the diagnosis and management of plant diseases.
- Develop expertise in the use of advanced techniques and methodologies for the identification, characterization, and quantification of plant pathogens, as well as the assessment of host-pathogen interactions.
- Demonstrate the ability to critically analyze scientific literature and research findings in the field of advanced plant pathology, and effectively communicate research outcome through oral presentations and written reports.

Unit I (15 class, 20 marks)

The concept of plant diseases in plants, history of plant pathology, Abiotic and Biotic causes of plant diseases; diagnosis of plant diseases, Koch's postulate and germ theory of diseases, Parasitism and disease development**,** pathogenicity and host range; symptoms of plant diseases and dissemination. Epidemiology and disease forecasting, Effects of environmental factors on Epidemiology.

Unit II (15 class, 15 marks)

Plant virology: History of plant viruses, composition and structure of plant virus, symptoms, transmission, host virus interaction, management of plant viruses. Symptomatology, disease cycle, control measures and management of some important plant disease caused

by fungi, bacteria, nematode, fungal like organisms and flagellate protozoa. Diseases and change in physiological functions like photosynthesis, respiration, permeability, transcription and translation.

Unit III (15 class, 15 marks)

Plant defence mechanism, induced and non-induced structural and biochemical defence mechanism, systematic acquired resistance, induced resistance, plantibodies, Genetics of plant disease. Control of plant diseases: and biological disease control, Integrated disease management (IDM), IDM in important crops-rice, tea, mustard, pulses, and vegetable crops.

Unit IV : Practical's (15hrs class, 20 marks)

1. Collection and identification of diseased plants and plant parts
2. Isolation and identification of plant pathogenic fungi from diseased plants.
3. Collection of soil, litter, water, leaf and seed from various sources for the isolation of fungi.
4. Techniques of isolation of fungi, dilution method, soil plate method, agar plate method and blotter method from soil, litter and seed.

Suggested Readings

1. Agrios, G.N. (1997) Plant Pathology, 4th edition, Academic Press, U.K.
2. Alexopoulos, C.J., Mims, C.W., Blackwell, M. (1996). Introductory Mycology, John Wiley &Sons (Asia) Singapore. 4th edition.
3. Webster, J. and Weber, R. (2007). Introduction to Fungi, Cambridge University Press,Cambridge. 3rd edition.

Paper Title: Plant Pharmacognosy & Pharmacology
Paper Code: BOTADL15054
Paper credit: 04(3T+1P)

Total number of lectures: 60=45+15(L+P) **Total Marks: 100 (T50+P20+IA30)**

Course Objectives:

Gain a comprehensive understanding of the medicinal properties and therapeutic applications of plants, as well as the principles and techniques of pharmacognosy, for the development and evaluation of plant-based medicines.

Course learning outcome:

- Develop a deep understanding of the pharmacological properties of various plant compounds, including their mechanisms of action and potential therapeutic applications.
- Acquire knowledge and skills in the identification, collection, processing, and quality assessment of medicinal plants, as well as the extraction and isolation of bioactive compounds.
- Apply principles of pharmacognosy and pharmacological evaluation to assess the safety, efficacy, and quality of plant-based medicines, and critically analyze scientific literature in the field of plant pharmacology and pharmacognosy.

Course contents

Unit-I: Introduction to Plant Pharmacognosy & Pharmacology (15hrs class, 20 marks)

Scope, Nature, and Importance of Pharmacognosy and Pharmacology; Pharmacognosy as a tool for identification of crude drugs and processed medicine. Technique for quality control, monitoring, and Regulation. Types of Adulterations and Substitution of Drugs. Sources of contamination of Herbal drugs-Aflatoxins, Heavy Metals, Pesticides.

Unit-II: Phytochemical Analysis and Characterization (15hrs class, 20 marks)

Extraction techniques for plant bioactive compounds, Chromatographic separation methods, Spectroscopic techniques for compound identification, Structural elucidation of phytochemicals

Unit-III: Pharmacological Activities and Mechanisms of Action (15hrs class, 20 marks)

Bioassays for evaluating pharmacological activities, Pharmacodynamics and pharmacokinetics of plant compounds, Mechanisms of action of bioactive compounds, Interactions with cellular targets and signaling pathways

Unit-IV: Practical

1. Study of microscopic structure of the plant tissues
2. Test for oil: Mustard, coconut, sunflower, castor.
3. Test for gums, resins and tannins.
4. Biochemical evaluation of medicinal plants.

Suggested Readings

1. Natural Products from plants, Ist edn, by Peter B. Kaufman, CRC press, Newyork, 1998 5.
2. Glimpses of Indian Ethanopharmacology by P. Pushpangadam,UIF Nyman, V.George, Tropical botanic Gardon and research institute., 1995
3. Text book of Pharmacognosy, by G.E.Treese nad W.C.Evans, 15th edn, W.B. Saunders Edenburg, NewYork.,
4. Text book of Pharmacognosy by C.K.Kokate, Purohit, Ghokhale, 5th edn nirali prakassan., 1996

Group: Advanced Plant Physiology and Biochemistry

SEMESTER III (2-Year PG/1-Year PG)

Option A – Only Coursework

Paper Code	Courses	Credits	L+T+P	Contact Hours	Internal	External	Marks
BOTSPL 25014	Phytotechnology	4	3+1+0	60	30	70	100
BOTSPL 25024	Photobiology and Signal Transduction	4	3+1+0	60	30	70	100
BOTSPL 25034	Chemistry in Plant Sciences	4	3+1+0	60	30	70	100
BOTSPL 25044	Plant Physiology Lab IV	4	0+0+4	60	30	70	100
BOTSPL 25054	Plant Physiology Lab V	4	0+0+4	60	30	70	100

SEMESTER IV

Paper Code	Courses	Credits	L+T+P	Contact Hours	Internal	External	Marks
BOTSPL 25064	Hydroponics Technology	4	3+1+0	60	30	70	100
BOTSPL 25074	Stress Biology of plants	4	3+1+0	60	30	70	100
BOTSPL 25084	Nanomaterials in Plant Sciences	4	3+1+0	60	30	70	100
BOTSPL 25094	Plant Physiology Lab VI	4	0+0+4	60	30	70	100
BOTSPL 25104	Plant Physiology Lab VII	4	0+0+4	60	30	70	100

III SEMESTER

Paper Title: Phytotechnology
Paper Code: BOTSPL25014
Paper credit: 04

Total number of lectures: 60=45+15(L+T) **Total Marks: 100(T70+IA30)**

Course Objectives

- Provide a thorough understanding of phytotechnology and its environmental management applications.
- Explore the principles and uses of phytoremediation, biosensors, and biomonitors.
- Highlight the importance of sustainability in phytotechnology.

Course Learning Outcome

- Offer a comprehensive understanding of plant-based solutions for environmental challenges.
- Emphasize sustainable and environmentally friendly applications of phytotechnologies

Unit I: Introduction to Phytotechnology

Definition and scope; Historical background; Types of phytotechnologies and their applications; Importance of phytotechnology; Mechanisms of phytoremediation: phytoextraction, phytostabilization, phytodegradation, rhizofiltration, Plant species used in phytoremediation; Advantages and limitations; Case studies in phytoremediation

Unit II: Tools and Techniques environmental monitoring

Definition and importance of environmental monitoring; Types of biomonitors
Plants as biomonitors of environmental pollutants; Bioindicator species; Methods for biomonitoring and data interpretation; Case studies in biomonitoring;

Biosensors:
Principles of biosensors; Types of biosensors: electrochemical, optical, piezoelectric
Plant-based biosensors; Applications in environmental monitoring and pollution control
.

Unit III: Applications of Phytotechnology

Role of plants in solid and liquid waste management; Phytotechnology in landfills and composting; Phytoremediation in wastewater; Constructed wetlands and green roofs;

Green infrastructure: urban greening, green walls and roofs; Role in climate change mitigation; Case studies and successful implementations of phytotechnology

Unit IV: Sustainability and Future Directions in Phytotechnology

Sustainable Practices: Principles of sustainable plant-based technologies; Design and implementation of sustainable phytotechnologies. Environmental Impact: Assessing the environmental impact of phytotechnologies, Life cycle analysis of phytoremediation projects, Case studies of sustainable implementations

Economic and Social Aspects: Cost-benefit analysis of phytotechnologies; Social acceptance and community involvement; Policy implications and regulatory frameworks

Suggested Readings

1. Singh, A. K., & Ward, O. P. (Eds.). (2004). Applied Bioremediation and Phytoremediation. (Soil Biology Series). Springer. ISBN: 978-3-540-21020-7.
2. Sarma, H., & Prasad, M. N. V. (Eds.). (2021). Biosurfactants for a Sustainable Future: Production and Applications in the Environment and Biomedicine. John Wiley & Sons, Incorporated. ISBN 978-1-119-67105-3.
3. Sarma, H., & Joshi, S. (Eds.). (2023). *Land Remediation and Management: Bioengineering Strategies*. Springer. ISBN: 978-981-99-4220-6.
4. Willey, N. (Ed.). (2006). *Phytoremediation: Methods and Reviews*. (Methods in Biotechnology Series). Humana Press. ISBN: 978-1-59745-098-0.
5. Sarma, H., & Joshi, S. (Eds.). (2023). *Biotechnology of Emerging Microbes: Prospects for Agriculture and Environment*. (Progress in Biochemistry and Biotechnology Series). Elsevier Science & Technology. ISBN: 978-0-443-15397-6.
6. Sarma, H., Dominguez, D. C., & Lee, W.-Y. (Eds.). (2022). Emerging Contaminants in the Environment: Challenges and Sustainable Practices. Elsevier. ISBN: 978-0-323-85160-2.

III SEMESTER

Paper Title: Photobiology & Signal Transduction
Paper Code: BOTSPL25024
Paper credit: 04

Total number of lectures: 60=45+15(L+T) **Total Marks: 100 (T70+IA30)**

Course Objectives:

- To understand cell signalling and signal transduction in plants.
- To study the roles of phytochromes, cryptochromes, and light receptors.
- To explore plant hormone biosynthesis and signalling.
- To investigate light signalling networks and their agricultural applications.

Course Learning Outcome

- By the end of this course, students will be able to explain cell signalling and signal transduction mechanisms in plants.
- Students will learn the properties and functions of phytochromes, cryptochromes, and light receptors.
- Students will understand plant hormone biosynthesis and signalling.
- They will analyze the integration of light, hormonal, and environmental signals, and apply this knowledge to optimize plant growth and yield in agriculture.

Unit-I:

Cell signaling and signal transduction: Signal transduction concept; receptors, second messengers; G-proteins, phospholipid signaling, Diversity in protein kinases and phosphatases, calcium-calmodulin cascade, specific signaling mechanisms; two-component sensor-regulator system in plants. Role of signal transduction in plant stress responses and adaptation. Cross-talk between different signaling pathways.

Unit-II:

Photobiology: Photomorphogenesis, Photoreceptors - discovery, photochemical and biochemical properties, photophysiology of light-induced responses; signal perception and execution. Photoperiodism and its significance - endogenous clock and its regulation, floral induction and development, role of vernalization.

Unit-III:

Plant hormones: Biosynthesis, signal perception (receptors), execution, and role in plant growth and development. Jasmonic acid, salicylic acid, strigolactones, and polyamines. Hormonal interactions and cross-talk in plant development and stress responses. Advances in hormone signaling research.

Unit-IV: Light Signaling Networks and Applications

Light signaling networks: Integration of light signals with hormonal and environmental signals. Molecular mechanisms of light signal transduction networks. Role of light signaling in plant development and adaptation to environmental changes. Applications of light signaling in agriculture - manipulation of light conditions to optimize plant growth and yield, use of light-emitting diodes (LEDs) in controlled environment agriculture

Suggested Readings

1. Palme, K. Signals and signal Transduction pathways in plants, Kluwer Academic Publishers.
2. Taiz, L. and Zeiger, E. (2010). Plant Physiology, (5th Edition). Sinauer Associates Inc. Publishers. Sunderland Massachusetts, USA.
3. Singhal G.S., Renger G., Sopory, S.K. Irrgang K.D and Govindjee (1999). Concept in Photobiology; Photosynthesis and Photomorphogenesis. Narosa Publishing House, New Delhi.
4. Alberts B. Johnson A, Lewis J. et al. Molecular Biology of the cell. Garland Science, New York.

III SEMESTER
Paper Title: Chemistry in Plant Sciences
Paper Code: BOTSPL25034
Paper credit: 04(4T+0P)

Total number of lectures: 60=45+15(L+T) **Total Marks: 100 (T70 +IA30)**

Course Objectives:

- To understand the biosynthesis of secondary metabolites in plants.
- To study the pharmaceutical importance of phytochemicals.
- To explore metabolites from special sources like lichens.
- To learn methods of phytochemical analysis and quality control.

Course Outcome

By the end of this course, students will be able to explain the biosynthesis of secondary metabolites, identify key phytochemicals and their pharmaceutical importance, explore metabolites from special sources, and apply methods for phytochemical analysis and quality control.

Unit I: Secondary Metabolites

Overview of the origin of secondary metabolites, role of compartmentation and metabolite trafficking. Key biosynthetic pathways: acetate pathway (fatty acids and polyketides), mevalonate and deoxyxylulose phosphate pathways (terpenoids and steroids), and shikimate pathway (phenols and amino acids).

Unit II: Phytochemistry and Pharmaceutical Importance

Phytochemical sources and classification within the plant kingdom. Key phytoconstituents and their biological activities: carbohydrates (sugar alcohols, starch, gums), glycosides (general properties and biosynthesis), alkaloids (definition, properties, classification, and examples such as Datura and Atropa), phenolic compounds (types and biological activity), steroidal compounds, and volatile oils.

Unit III: Metabolites from Special Sources

Lichens and their metabolites: significance and metabolic pathways. Overview of lichen derived chemicals and their pharmacological activities

Unit IV: Phytochemical Analysis and Quality Control

Fundamental methods for extraction, separation, and characterization of secondary metabolites (chromatographic and spectroscopic techniques). Basics of quality control for plant drugs. Introduction to phytochemical analysis methods, tissue culture, biotechnology for phyto-molecule discovery, and ethnopharmacology.

Suggested Readings

1. Bruneton J., 1999. Pharmacognosy, Phytochemistry, Medicinal Plants, Intercept Ltd., Paris.

2. Dewick P.M., 2002. Medicinal Natural Products: A biosynthetic approach, John Wiley & Sons Ltd.

3. Evans W.C., 2002, Trease and Evan's Pharmacognosy, W.B. Saunders.

4. Harborne, J.B., 1998. Phytochemical Methods, Chapman and Hall.

5. Houghton P.J. and A. Raman, 1998. Laboratory handbook for fractionation of natural extracts, Chapman and Hall.

6. Kokate C.K., 1991. Practical Pharmacognosy, VallabhPrakashan, Delhi.

7. Samuelsson G., 1999. Drugs of natural origin: A text book of Pharmacognosy, Apotekarsocieteten, Swedish Pharmaceutical Society, Swedish Pharmaceutical Press, Stockholm, Sweden.

8. Tyler V.E., L.R. Brady and J.E.. Robbers, 1988. Pharmacognosy, Indian Edition, K.M. Varghese Company, Bombay.

9. Vickery M.L. and B. Vickery, 1981. Secondary Plant Metabolism, The MacMillan Press Ltd.

10. Wallis T. 1967. Text Book of Pharmacognosy, J & A Churchill, London.

11. Wagner H., S. Bladt and E.M. Zgainski (Translated by A. Scott) 1984, Plant Drug Analysis, Springer-Verlag.

12. Vermerris Wilfred & Nicholson Ralph, 2006, Phenolic compound Biochemistry.

Paper Title: Plant Physiology (Lab I)
Paper Code: BOTSPL25044
Paper credit: 04

Total number of Practical Class: 60=45+15(L+T) **Total Marks: 100 (P70+IA30)**

Course Objectives:

- To develop practical skills in plant physiology experimentation.
- To understand the physiological processes and responses in plants under various conditions.

Course Learning Outcome

By the end of this course, students will adeptly estimate key plant metabolites, analyze physiological responses, and comprehend the role of plant growth regulators. They will gain practical skills in experimentation, including chromatography and enzyme activity assays, enabling them to interpret and apply findings in various plant stress scenarios.

List of Experiments

1. Estimation of Ascorbic acid, Polyphenols, Cellulose.
2. Study of Oxalic acid accumulation in leaf tissue.
3. Hormonal regulation of leaf and petal senescence.
4. Study of changes in starch/protein content during seed development.
5. Study of lipid accumulation during development of oil seeds.
6. To study the effect of different PGRs on seedling growth
7. Sugar and amino acids analysis of phloem sap, with paper chromatography.
8. Determination of Chlorophyll a / b ratio of C3 and C4 plants.
9. Estimation of nitrate in different plant parts.
10. Study of the effect of PEG-induced water stress on seed germination
11. Study of protein/ free protein/ amino acid profile in plants under stress.
12. Study of the effect of fungal infection on peroxidase activity.
13. Study of free radicals scavenging enzymes, Catalase, and superoxide dismutase.
14. Study of seed germination under stress conditions.

*Visit to Premier Research Institutes in NE India / Mainland

Paper Title: Plant Physiology (Lab II)

Paper Code: BOTSPL25054

Paper credit: 04

Total number of Practical Class: 30=30x2hrs Total Marks: 100 (P70+IA30)

Course Objectives:

- Enhance practical skills in plant physiology and biochemistry experimentation.
- Develop proficiency in enzyme assays, protein quantitation, and kinetics studies.
- Understand extraction and analysis techniques for plant proteins and pigments.
- Explore physiological responses to stress in plants, focusing on stomatal behavior.

Course Learning Outcome

By the end of this course, students will master enzyme assays, protein analysis techniques, and understand plant responses to stress, particularly stomatal behavior. They will develop expertise in spectrophotometric and chromatographic methods for pigment analysis and gain practical skills in quantitative and qualitative protein analysis.

List of Experiments

1. Assay for different enzymes in leaf tissues.
2. Study of enzyme kinetics for determination of Km value, nature of inhibition: Competitive/non-competitive.
3. Study on effect of time/ enzyme concentration/ pH on enzyme kinetics.
4. Comparative assessment of methods for protein quantitation.
5. Extraction of proteins from plant tissue and their qualitative and quantitative (Bradford's) (SDS, PAGE gel) analysis.
6. Qualitative and quantitative analysis of photosynthetic pigments and anthocyanins by spectrophotometric and chromatographic techniques.
7. Impact of stress on stomatal opening and closing using potassium chloride.
8. Choice of solvent for extraction of plant metabolites.

9. Phytochemical screening of plants, lichens extract for secondary metabolites.
10. Estimation of alkaloids, phenols, anthraquinones, cardenolides, betacyanins, carotenoids, steroids.
11. Study of unorganized drugs – starches, gums, resins etc.
12. Extraction and chromatographic detection of some common plant drugs.

IV SEMESTER

Paper Title: Hydroponics Technology

Paper Code: BOTSPL25064

Paper credit: 04

Total number of lectures: 60=45+15(L+T) **Total Marks: 100 (80 +IA20)**

Course Objectives:

- Define hydroponics and its historical evolution.
- Contrast hydroponics with traditional agriculture.
- Explore various hydroponics systems.
- Understand the opportunities and challenges in hydroponics entrepreneurship.

Course Learning Outcome

- Identify essential mineral elements and their functions
- Analyse environmental factors affecting plant growth
- Formulate nutrient solutions and manage pH effectively
- Implement crop management techniques for hydroponic cultivation

Unit I: Introduction to Hydroponics Technology

Definition and concepts of hydroponics; History of soil-less culture; Contrast hydroponics with traditional soil-based agriculture, types of hydroponics systems, applications and future developments in hydroponics.

Unit II: Hydroponics Entrepreneurship

Hydroponics entrepreneurship and its significance; opportunities in the hydroponics field; challenges including family, social, technological, financial, and policy-related. Role of government in promoting hydroponics entrepreneurship. Stages involved in establishing a small-scale hydroponics industry.

Unit III: Plant Nutrition and Environmental Factors

Essential mineral elements and their functions; deficiency symptoms of minerals such as N, P, Ca, etc., Effect of environmental factors including light, temperature, humidity, and CO_2 on plant nutrition; management techniques for pH, PPM/TDS levels, heating, cooling, and CO_2 regulation.

Unit IV: Nutrient Solutions, Media, and Crop Management

Formulation of nutrient solutions using inorganic salts. Balance macronutrients and micronutrients for optimal plant growth. Adjustment of pH and nutrient levels for hydroponic systems. Fertilizers and media for hydroponic systems; weed management, disease, and pest control strategies. Application of pollination techniques and cloning methods in hydroponics.

Suggested Readings

1. Keith Roberto. How to Hydroponics. The future garden press New York. 4th Edition.
2. Howard M. Resh. Hobby Hydroponics.CRC Press USA.
3. Prasad S and Kumar U. Green House Management for Horticultural Crops. Agrobios India
4. Dahama A K. Organic Farming for Sustainable Agriculture. Agrobios India.
5. Subbarao N.S. (1995). Biofertilizers in Agriculture and Forestry. Oxford and IBH publishing Company Pvt. LTd. New Delhi
6. B. A. Kratky. A Suspended Net-Pot, Non-Circulating Hydroponic Method for Commercial.
7. Asao, T. 2012. Hydroponics: A Standard Methodology for Plant Biological Researches. Intech Open, UK.
8. Texier, W. 2016. Hydroponics for everybody, Mama publishing, France.
9. K A El-Kazzaz, A A El-Kazzaz. 2017. Soilless Agriculture a New and Advanced Method for Agriculture Development: an Introduction. Agri Res & Tech: Open Access J. 3(2): 555610. DOI: 10.19080/ARTOAJ.2017.03.555610.
10. Sharma, N., Acharya, S., Kumar, K., Singh, N., and Chaurasia, O. P. 2018. Hydroponics as an advanced technique for vegetable production: An overview. Journal of Soil and Water Conservation, 17(4), 364-371
11. https://www.agrifarming.in/hydroponic-tomato-farming-nutrient-solution-yield.

https://gardeningtips.in/growing-leafy-greens-in-hydroponics-a-full-guide.

https://www.agrifarming.in/growing-medicinal-plants-hydroponically-a-full-guide.

Paper Title: Nanomaterials in Plant Sciences

Paper Code: BOTSPL25084

Paper credit: 04

Total number of lectures: 60=45+15(L+T) **Total Marks: 100 (70 +IA30)**

Course Objectives

- Explore the transition from biotechnology to nanobiotechnology.
- Investigate the applications of nanomaterials in crop improvement.
- Examine nanocides and their role in pest control.
- Introduce precision farming and environmental remediation using nanotechnology.

Course Learning Outcome

- Gain an understanding of the properties and applications of nanomaterials in agriculture.
- Explore the use of nanomaterials in seed treatment and nutrient delivery for crop improvement.
- Examine different types of nanocides and their effectiveness in pest and disease management.
- Understand the principles of precision farming and nano-sensor applications for plant health diagnostics.
- Evaluate the use of nanoparticles in environmental remediation and address safety concerns related to their use in agriculture.

Unit I:

From Biotechnology to Nanobiotechnology:

The transition from biotechnology to nanobiotechnology, focusing on the properties, characterization, and applications of nanomaterials.

Unit II:

Nanomaterials in Crop Improvement:

Use of nanomaterials in seed treatment to improve crop stand, the development of controlled release nanocarriers for nutrient delivery, and the enhancement of plant growth for better yield using nanomaterials.

Unit III:

Nanocides and Pest Control:

Types of pests and diseases, the various types of nanocides for fungus, insects, and weeds, the methods of forming nanocides, and recent developments in this field.

Unit IV:

Precision Farming and Environmental Remediation

Introduction to precision farming and the use of nano-sensors for plant health diagnostics. Remediation of contaminated agricultural soils, water, and air using nanoparticles, including groundwater treatment using nanoscale catalysts, nanoadsorbents, nanoporous membranes, nanoporous/microporous zeolites, mesoporous carbon, and nano-alumina. Safety issues related to the use of nanomaterials in agriculture.

Suggested Readings

1. Sarma, H., Joshi, S. J., Prasad, R., & Jampilek, J. (Eds.). (2022). Biobased Nanotechnology for Green Applications. Nanotechnology in the Life Sciences Ser. Springer International Publishing AG. doi:10.1007/978-3-030-61987-9
2. Sarma, H., Gupta, S., Narayan, M., Prasad, R., & Krishnan, A. (Eds.). (2023). Engineered Nanomaterials for Innovative Therapies and Biomedicine. Nanotechnology in the Life Sciences Ser. Springer International Publishing AG. doi:10.1007/978-3-030-82920-9
3. Abd-Elsalam K and Prasad R (2019) Nanobiotechnology Applications in Plant Protection.Volume 2. Springer International Publishing (ISBN 978-3-030-13295-8)https://www.springer.com/gp/book/9783030132958
4. Thangadurai D, Sangeetha J, and Prasad R (2020) Nanotechnology for Food, Agriculture,and Environment. Springer International Publishing (ISBN 978-3-030-31938-0)https://www.springer.com/gp/book/9783030319373
5. Joshi, S. J., Deshmukh, A., & Sarma, H. (Eds.). (2021). Biotechnology for Sustainable Environment. Springer. doi:10.1007/978-981-16-1954-0

Paper Title: Plant Physiology (Lab III)

Paper Code: BOTSPL25094

Paper credit: 04

Total number of lectures: 30×2 h Total Marks: 100 (T70+IA30)

Course Objectives

- Develop skills in microscopic techniques, fractionation methods, and spectroscopy.
- Learn radiolabelling and histochemical techniques.
- Understand statistical methods and bioinformatics in plant biology.

Course Learning Outcome

By the end of this course, students will master microscopic observation, fractionation, and spectroscopic techniques. They will demonstrate proficiency in radiolabelling, histochemical, and statistical methods, and apply bioinformatics tools in plant biology research.

Unit I: Microscopic Techniques

- Understand the principles and applications of various microscopic techniques in biological research.

- Practical Activities:

1. Light Microscopy: Demonstration: Setup and use, resolution, and magnification.
2. Comparative Study of Microscopes: Resolving powers, advantages, and limitations.
3. Microscopy for Living Cells: Preparation and observation, maintaining cell viability.
4. Electron Microscopy: Introduction, sample preparation.
5. Confocal Microscopy Workshop: Principles, hands-on session.

Unit II: Fractionation Methods

- Learn various fractionation techniques used in biological research.

- Practical Activities:

1. Centrifugation: Demonstration and hands-on practice.
2. Electrophoresis Techniques: Paper and gel setup, separation based on charge and size.

3. Chromatography Workshop: Paper and column techniques, separation and analysis.
4. Spectrophotometry Lab: UV/visible principles, absorbance, and concentration.
5. Atomic Absorption Spectroscopy (AAS) Demo: Introduction, metal ion analysis.

3. Fluorescence Microscopy Workshop: Immunofluorescence techniques.

Unit III: Statistical Methods

- Introduction to statistical methods and their applications in biological data analysis.
- Practical Activities:
  1. Descriptive Statistics Workshop: Calculation, central tendency, and dispersion measures.
  2. Probability Distributions Experiment: Analysis of distributions, confidence limits.
  3. Statistical Tests Demonstration: T-test, Chi-square, ANOVA.
  4. Correlation and Regression Analysis: Calculation, interpretation.

Unit IV: Introduction to Bioinformatics

- Introduce bioinformatics tools and databases.
- Practical Activities:
  1. Database Exploration: Introduction to NCBI, EMBL, Genbank.
  2. Sequence Analysis Workshop: Alignment, phylogenetic relationships.
  3. Gene and Protein Analysis: Prediction algorithms, classification, structure.
  4. Bioinformatics Software Tutorial: BLAST, ORF finder, Primer 3.

Suggested Readings

1. Buchanan, B. B., Gruissem, W. and Jones, R. L. 2000. Biochemistry and Molecular Biology of Plants. American Society of Plant Physiologists. Maryland, USA

2. Gustafson, J. P. 2000. Genomes. Kluwer Academic Plenum Publishers, New York, USA

3. Brown, T. A. 1999. Genomes. John Wiley & Sons (Asia) Pvt. Ltd., Singapore.

4. Primrose, S. B. 1995. Principles of Genome Analysis. Blackwell Science Ltd., Oxford, UK

5. Singer, M. and Berg, P. 1991. Genes and Genomes: A Changing Perspective. University Science Books, CA, USA

6. Attwood, T.K. and Parry-Smith, D.J. 2004. Introduction to Bioinformatics. Pearson Education (Singapore) Pvt. Ltd

7. David, E. (Ed.) 2007. Plant Bioinformatics: Methods and Protocol. Humana Press, New Jersey, USA

8. Wilson, K., Walker, J. (2005) Principles and Techniques of Biochemistry and Molecular Biology, 6th Edition, Cambridge University Press

9. Ruzin, S.E. (1999). Plant Microtechnique and Microscopy, Oxford University Press, New York. USA

10. Ausubel, F., Brent, R., Kingston, R. E., Moore, D.D., Seidman, J.G., Smith, J.A., Struhl, K. (1995). Short Protocols in Molecular Biology. John Wiley & Sons

11. Mishra, B.N. and Mishra M.K. 1989.Introductory Practical Biostatistics. Naya Prokash Publication, Calcutta

12. Rao, Sundar P.S.S. and Richard, J. 2011.Introduction to Biostatistics and Research Methods.(4th Ed), PHI Learning Pvt. Ltd., New Delhi

13. Edmondson, A., Druce, D. (1996) Advanced Biology Statistics, Oxford University Press

14. Williams, Brain. 1993. Biostatistics- Concepts and Applications for Biologist. Chapman & Hall, London

Paper Title: Plant Physiology (Lab IV)

Paper Code: BOTSPL25104

Paper credit: 04

Total number of lectures: 30×2 h **Total Marks: 100 (T70+IA30)**

Course Objectives

1. Synthesize nanoparticles using plant extracts and assess their properties.
2. Investigate the effects of nanoparticles on plant growth and development.
3. Design and implement hydroponic systems for efficient plant cultivation.
4. Analyze stress responses in plants under different environmental conditions.

Course Learning Outcome

By the end of this course, students will have acquired practical skills in synthesizing nanoparticles and understanding their impact on plant biology. They will demonstrate proficiency in designing and managing hydroponic systems for plant cultivation. Additionally, they will be able to assess and interpret stress responses in plants, contributing to advancements in plant stress biology research.

Nanomaterials in Plant Sciences

1. To synthesize silver nanoparticles using plant extracts and characterize them.

2. To study the impact of zinc oxide nanoparticles on the germination and early growth of seeds.

3. To investigate how gold nanoparticles are absorbed and transported within plants.

4. To evaluate the phytotoxicity of titanium dioxide nanoparticles on plant growth and development.

5. To examine the efficiency of nanoparticle-mediated delivery of fertilizers and pesticides to plants.

6. To synthesize nanoparticles using medicinal plant extracts and assess their bioactivity.

7. To study the effect of carbon nanotubes on the photosynthetic efficiency of plants.

8. To explore the role of various nanoparticles in promoting plant growth and yield.

Hydroponics Technology

9. To design and construct a basic hydroponic system and understand its components.

10. To compare the growth of plants in hydroponic systems versus traditional soil cultivation.

11. To formulate and optimize nutrient solutions for different plant species in hydroponic systems.

12. To monitor and adjust the pH levels in hydroponic nutrient solutions and observe its effects on plant growth.

13. To cultivate leafy greens using hydroponics and evaluate their growth and yield.

14. To explore the feasibility of growing medicinal plants hydroponically and assess their phytochemical content.

Molecular Stress Biology of Plants

15. To analyze the expression of stress-responsive genes in plants exposed to drought conditions.

16. To profile and identify proteins that are differentially expressed in plants under salt stress.

17. To measure the levels of oxidative stress markers in plants exposed to heavy metals.

18. To study the activity of antioxidant enzymes in plants subjected to various abiotic stresses.

- Visit to Premier Research Institutions located in NE India / Mainland

2-Year PG/1-Year PG

Option B – Only Research

Research thesis/ Project with minimum 2 conferences papers. Peer reviewed research publication should be encouraged

Guidelines for Syllabus Option B – Only Research

- Overview: Emphasize research focus and academic contribution.
- Research Thesis/Project: Choose relevant topics, conduct thorough literature reviews, and formulate research questions.
- Conference Papers: Produce a minimum of two papers for reputable conferences.
- Peer-Reviewed Publication: Aim for publication in reputable journals; emphasize rigor and ethical standards.
- Research Methodology: Provide guidance on methodologies, data collection, and analysis.
- Supervision and Support: Assign dedicated supervisors, facilitate regular meetings, and offer additional support.
- Presentation and Defense: Prepare presentations and defend research findings before faculty and peers.
- Evaluation Criteria: Establish clear criteria for assessing originality, depth, clarity, and contribution.
- Ethical Considerations: Educate on research ethics and ensure adherence to ethical guidelines.
- Resources and Support Services: Provide access to research facilities, training, and funding opportunities.
- Timeline and Milestones: Set clear milestones and monitor progress to meet deadlines.
- Students are encouraged for collaborative research with renown research institutes

***Option C* – Coursework + Research**

SEMESTER III

Paper Code	Courses	Credits	L+T+P	Contact Hours	Internal	External	Marks
BOTSPL 25014	Phytotechnology	4	3+1+0	60	30	70	100
BOTSPL 25024	Photobiology and signal transduction	4	3+1+0	60	30	70	100
BOTSPL 25034	Chemistry in Plant Sciences	4	3+1+0	60	30	70	100
BOTSPL 25044	Plant Physiology **(Lab I)**	4	0+0+4	60	30	70	100
BOTSPL 25054	Plant Physiology **(Lab II)**	4	0+0+4	60	30	70	100

SEMESTER IV

Research thesis/ Project with minimum 1 conferences paper. Peer-reviewed research publication should be encouraged.

- Research Thesis/Project: Choose relevant topics, conduct thorough literature reviews, and formulate research questions.
- Conference Papers: Produce a minimum of one papers for reputable conferences.
- Peer-Reviewed Publication: Peer-reviewed research publication should be encouraged.
- Research Methodology: Provide guidance on methodologies, data collection, and analysis.
- Supervision and Support: Assign dedicated supervisors, facilitate regular meetings, and offer additional support.

- Presentation and Defence: Prepare presentations and defend research findings before faculty and peers.
- Evaluation Criteria: Establish clear criteria for assessing 8, depth, clarity, and contribution.6543Ethical Considerations: Educate on research ethics and ensure adherence to ethical guidelines.
- Resources and Support Services: Provide access to research facilities, training, and funding opportunities.
- Timeline and Milestones: Set clear milestones and monitor progress to meet deadlines.
- Students are encouraged for collaborative research with renown Research Institutes

Group: Angiosperm Taxonomy

Paper Code	Courses	Credits	L+T+P	Contact Hours	Internal	External	Marks
BOTSPL 25014	Angiosperm Taxonomy-I	4	3+1+0	60	30	70	100
BOTSPL 25024	Angiosperm Taxonomy-II	4	3+1+0	60	30	70	100
BOTSPL 25034	Angiosperm Taxonomy-III	4	3+1+0	60	30	70	100
BOTSPL 25044	Angiosperm Taxonomy (**Lab I)**	4	0+0+4	60	30	70	100
BOTSPL 25054	Angiosperm Taxonomy (**Lab II)**	4	0+0+4	60	30	70	100

Option B– Only Coursework

SEMESTER III

SEMESTER IV

Paper Code	Courses	Credits	L+T+P	Contact Hours	Internal	External	Marks
BOTSPL 25064	Plant Geography & Evolution Biology	4	3+1+0	60	30	70	100
BOTSPL 25074	Advanced Angiosperm Systematics	4	3+1+0	60	30	70	100
BOTSPL 25084	Plant Resources, Conservation Biology & IKS	4	3+1+0	60	30	70	100
BOTSPL 25094	Angiosperm Taxonomy **(Lab III)**	4	0+0+4	60	30	70	100
BOTSPL 25104	Angiosperm Taxonomy **(Lab IV)**	4	0+0+4	60	30	70	100

Paper Title: Angiosperm Taxonomy-I
Paper Code: BOTSPL25014
Paper Credit: 04

Total number of lectures: 60=45+15(L+T) **Total Marks: 100 (T70+IA30)**

Course Objectives:

The course objective of Angiosperm Taxonomy-I is to provide students with a comprehensive understanding of the higher plant taxonomy, enabling them to knowledge of concepts, aims, conceptual bases of classification, plant nomenclature, and history of the botanical exploration in India.

Course Outcome:

- Develop a thorough understanding of the higher plants Taxonomy.
- To develop knowledge on naming plants, the principles and rules of plant nomenclature
- Understanding the basics of taxonomy, taxonomic structure, materials basis of taxonomy, classification including APG

Unit-I

Basics of Taxonomy: Concept, Aims and Principles, Alpha and Omega taxonomy; Classificatory Systems: Pre- and Post Darwinian Classifications.

Conceptual bases of the classifications of the following: Bentham & Hooker, Engler & Prantl, Hutchinson & APG System of classification with emphasis on major clades.

Unit-II

Taxonomic structure: Taxonomic structure, taxonomic hierarchy, taxonomic categories – supraspecific and infraspecific categories; concept of species, genus and family.

Unit-III

Introduction to Taxonomic characters : Concept of character, good and bad characters, qualitative and quantitative characters, analytical and synthetic characters, character weighting, Character variations.

Unit-IV

Plant Nomenclature: Brief History on the origin and development of nomenclature; scientific v/s vernacular names; detailed study of the major provisions of the International Code of Nomenclature for Algae, Fungi and Plants (ICN) Major changes from the preceding Code - Effective and Valid Publication, Rule of Priority and its limitations, Typification, Different kinds of types, Author citation, Rejection and retention of names, Conserved names; Naming a new species; Nomenclature of hybrids; Nomenclature of cultivated plants. Common technical terms used in Plant nomenclature; Draft Biocode and Phylocode.

Suggested Readings:

1. Angiosperm Phylogeny Group (2003). An update of the Angiosperm Phylogeny Group classification for the orders and families of flowering plants: APG II, *Botanical Journal of the Linnaean Society*, **141**: 399–436.
2. Angiosperm Phylogeny Group (2009). An update of the Angiosperm Phylogeny Group classification for the orders and families of flowering plants: APG III, *Botanical Journal of the Linnean Society*, **161** (2): 105–121.
3. 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 Linnean Society*, **181** (1): 1–20.
4. Brickell, C.D. et al., eds. (2016). International Code of Nomenclature for Cultivated Plants" *Scripta Horticulturae* (9th ed.). International Society of Horticultural Science. **18.**
5. Cronquist A (1981). An integrated system of classification of flowering plants. Columbia University Press, New York.
6. Simpson MG (2006). Plant Systematics. Elsevier, Amsterdam
7. Lawrence, GHM. Taxonomy of Vascular Plants, Oxford & IBH.
8. Sivarajan, V.V. (Ed. Robson). Introduction to Principles of Plant Taxonomy.
9. Heywood, V.H. (1968). Modern methods in Plant Taxonomy, United Book Prints (India)
10. Naik, V.N. (1988). Taxonomy of Angiosperms, Tata Mc Graw Hill, New Delhi.
11. Stace, C.R. Plant Taxonomy and biosystematics (2nd Ed.)

12. Hutchinson, J. (1973). The families of flowering plants (3rd Ed.).
13. Cronquist, (1981). An integrated system of classification of flowering plants
14. Takhtajan, K. (1980).Outline of classification of flowering plants. Botanical Rev. 46:225-359).
15. Davis, P.H. & V.H. Heywood. Principles of Angiosperm Taxonomy.
16. Takhtajan, (1997). Diversity and Classification of flowering plants. Columbia Univ. Press, New York.
17. International Code of Nomenclature for algae, fungi, and plants (Shenzhen Code, July 2017) adopted by the Nineteenth International Botanical Congress Shenzhen, China.

Paper Title: Angiosperm Taxonomy-II
Paper Code: BOTSPL25024
Paper Credit: 04

Total number of lectures: 60=45+15(L+T) **Total Marks: 100 (T70+IA30)**

Course Objectives:

The course objective of Angiosperm Taxonomy-II is to provide students with a comprehensive understanding of the higher plant taxonomy, enabling them to comprehensive evidences of taxonomy, biosystematics, molecular markers, tools of taxonomy and materials basis of taxonomy.

Course Outcome:

- To gained the knowledge on recent trends / systematic evidences of higher plant taxonomy.
- To develop knowledge on molecular systematic, biosystematics characters.
- To understand the tools and material basis of taxonomy.
- To develop skills of making plant collections and preserving them in suitable forms

Unit-I

Systematic evidence: Morphology, Anatomy, Palynology, Embryology, Cytology, Phytochemistry, Serology, molecular taxonomy-DNA barcoding in plants

Unit-II

Biosystematics: Definition, Steps in biosystematics, Biosystematic categories, importance of Biosystematic studies.

Unit-III

Molecular markers in plant Taxonomy: Diagnostic tools, Restriction Fragment Length Polymorphism (RFLP's), Random Amplified Polymorphic DNA (RAPD), P

olymerase Chain Reaction (PCR) analysis, specific applications of RAPD in molecular systematic.

Unit-IV

Tools of Taxonomy: Botanical keys-their construction and use, Flora, Manuals, check list, annotated list, revisionary study, world flora, Indian flora, preparation of flora.

Material Basis of taxonomy: Herbarium techniques: Methods of Collection, Identification and Documentation, source of taxonomic materials, plant introduction and domestication.

Suggested Readings:

1. Singh, G. Plant systematic. Oxford IBH.
2. Baruah, A. Plant Taxonomy, Eastern Book House.
3. R.Jain, S.K. & Rao, .R. A Handbook of Field and Herbarium Methods. Today & Tomorrow publications, New Delhi.
4. Crawford DJ (2003) Plant Molecular Systematics. Cambridge University Press, Cambridge, UK.
5. Cracknell AP, Hayes L (2009). Introduction to Remote Sensing. CRC Press, Boca Raton, USA (Special Indian Edition).
6. Lawrence, GHM. Taxonomy of Vascular Plants, Oxford & IBH.
7. Sivarajan, V.V. (Ed. Robson). Introduction to Principles of Plant Taxonomy.
8. Heywood, V.H. Modern Methods in Plant Taxonomy
9. Naik, V.N. Taxonomy of Angiosperms (1988), Tata Mc Graw Hill, New Delhi.
10. Stace, C,A. Plant taxonomy and Biosystematics, Edward Amord, London.
11. Sivarajan, V.V. (Ed. Robson). Introduction to Principles of Plant Taxonomy.
12. Herborne, J.B. & B.L. Turner. Plant Chemosystematics
13. Davis, P.H. & V.H. Heywood. Principles of Angiosperm Taxonomy.
14. Stafleu, F. & Richard Cowan. 1967. Taxonomic Literature: A selective guide to botanical publications and collections with dates, commentaries and types (Vol. I-VII).
15. Hooker, J.D. (1872-1897), The Flora of British India, 7 vols. Reeve & Co. Ltd., London.
16. Kanjilal, U.N. et al. (1934-1940), Flora of Assam. 5 vols. Government press, Shillong.
17. Pandey and Chadha, 1992: Plant Anatomy and Embryology.
18. Nair, P K K1964: Advances in Palynology.
19. Maheshwari, P.1963: Recent advances on the embryology of Angiosperm

Paper Title: Angiosperm Taxonomy-III
Paper Code: BOTSPL25034
Paper Credit: 04

Total number of lectures: 60=45+15(L+T) **Total Marks: 100 (T70+IA30)**

Course objectives

Gain knowledge on the historical development of plant taxonomy in India in the contemporary period and about the floristic diversity of north east India, Botanical Survey of India (BSI), including phylogeny of the major orders.

Course outcome

- To have an understanding on the historical relevance of plant taxonomy
- To explore flora and forest types of north east India
- Knowledge on BSI, Herbaria details, and flora of NE India
- Knowledge on phylogeny of major orders of angiosperms

Unit-I

Historical development of plant taxonomy in India with special reference to the contribution by William Roxburgh, J.D. Hooker, J.S. Gamble, K.S. Manilal, UN Kanjilal, Major centers of taxonomic and floristic studies in India.

Unit-II

Flora of North East India: Flora and forest types of North East India; endemic and exotic elements in North East flora; rare and endangered plants of India with special reference to NE India and their conservation.

Unit-III

Herbaria and Botanic Gardens: Role and importance of herbaria and gardens in taxonomic studies, major Herbaria and Botanic Gardens in world and in India. **Botanical Survey of India:** History, Activities, Publications

Unit-IV

Phylogeny of Angiosperms: Origin and evolutionary trends of angiosperms with special reference to their ancestral stock, concept of primitive angiosperms, cradle of flowering plants.

Phylogeny and Evolution of the Angiospermic Taxa: Magnoliales, Rananculales, Euphorbiales, Scrophulariales, Lamiales, Asterales, Alismatales, Orchidales, Poales, Zingiberales.

Suggested Readings:

1. Good R. (1974). The geography of flowering plants. Longman, London
2. Cain, S.A. (1944). Foundations of Plant Geography, Harper & Brothers, N.Y.
3. Singh, G. Plant systematic. Oxford IBH.
4. Bharucha, F.R. (1983). A text book of plant geography of India, Oxford University Press.
5. Puri, G.S.Indian Forest Ecology, Vol I, II, Oxford, New-Delhi.
6. Champion HG, Seth SK. (1968). A revised survey of the forest types of India. (Reprinted in 2005). Dehara Dun, India: Natraj Publishers. P. 251–337.
7. Cracknell A.P., Hayes L. (2009). Introduction to Remote Sensing. CRC Press, Boca Raton, USA (Special Indian Edition).
8. Mabberly, D.J. The Plant Book. Cambridge University Press, London.
9. Soltis, D.E. *et al.*, (2005). Phylogeny and Evolution of Angiosperms," *Economic Botany* 59(4), 421-422.
10. Soltis, D.E. *et al.*, (2018). Phylogeny and Evolution of the Angiosperms, University of Chicago Press,
11. Kress, W.J. (1990).The phylogeny and classification of the Zingiberales. Annals of the Missouri Botanical Garden.

Paper Title: Angiosperm Taxonomy (Lab I)
Paper code: BOTSPL 25044
Paper Credit: 04

Total number of Practical classes: 30 [30×2hrs] **Total Marks: 100 (T70+IA30)**

Course objectives

Gain a practical understanding of the major taxonomic families, taxonomic knowledge on locally available taxa, as well as the handling of the taxonomic literature.

Course Outcome

- Practical knowledge on locally available taxa and their identification
- To develop familiarity with the local flora, identification of flowering plants using taxonomic keys
- Appraise different systems of plant classifications
- Practices on solving nomenclatural problems, herbarium specimens

Experiments:

1. Descriptions, Sketching, classification and identification of families **(Dicots):** Ranunculaceae, Magnoliaceae, Lauraceae, Piperaceae, Aristolochiaceae, Nymphaeaceae, Moraceae, Urticaeae
2. Practical knowledge on locally available taxa and their identification.
3. Handling of floras, manuals, icons and Index Kewensis.
4. Knowledge of botanical keys, analytical drawing and description.
5. Practices on Nomenclatural problems
6. Classification exercise
7. Identification of taxa/Plant parts/herbarium specimens.
8. Familiar with modern tools and techniques employed in plant systematics.

Suggested readings:

1. Cronquist, A. 1981. An Integrated System of Classification of Flowering Plants.
2. Hickey M and King C. 2000. The Cambridge Illustrated Glossary of Botanical Terms. Cambridge University Press, UK
3. Jain S. K. and Rao R. R. Handbook of Field and Herbarium Methods, Today and Tomorrow Publishers, New Delhi.
4. Heywood, V.H. Modern Methods in Plant Taxonomy
5. Naik, V.N. Taxonomy of Angiosperms (1988), Tata Mc Graw Hill, New Delhi.
6. Singh, G. Plant systematic. Oxford IBH.
7. Stace, C.A. Plant taxonomy and Biosystematics, Edward Amord, London.
8. Radford, A. E. 1986. Fundamentals of Plant Systematics. Harper & Row, London
9. Hooker, J.D. (1872-1897), The Flora of British India, 7 vols. Reeve & Co. Ltd., London.
10. Kanjilal, U.N. et al. (1934-1940), Flora of Assam. 5 vols. Government press, Shillong.

Paper Title: Angiosperm Taxonomy (Lab II)
Paper Code: BOTSPL 25054
Paper Credit: 04

Total number of Practical classes: 30 [30×2hrs] **Total Marks: 100 (T70+IA30)**

Course objectives

Gain a practical understanding of the major taxonomic families, taxonomic knowledge on locally available taxa, as well as the handling of the taxonomic literature.

Course Outcome

- Practical knowledge on locally available taxa and their identification
- Practices on solving nomenclatural problems, herbarium specimens
- Familiar with field collections and processes of plant samples, preparation and preservation of herbarium specimens
- Knowledge on palynological and chemotaxonomy

1. Study the Bentham and Hooker's system of classification using any 3 type specimens and preparation of artificial keys for identification of any two unknown specimen.
2. Descriptions, Sketching, classification and identification of families **(Monocots):** Cyperaceae, Poaceae, Mussaceae, Smilacaceae, Orcdidaceae
3. Identification of monocots plant specimens using floras and identification keys.
4. Describing new taxon.
5. Studies on anatomy of different types of wood
6. Use of palynological, chemical methods in taxonomy.
7. **Field trips within and around the campus; compilation of field notes and preparation of herbarium sheets of such plants, wild or cultivated, as are abundant.**

Suggested readings:

1. Cronquist, A. 1981. An Integrated System of Classification of Flowering Plants.

2. Dilcher, D D 1974: Approaches to the identification of angiosperms leaf remains.

3. Easau, K. 1962: Plant anatomy –anatomy of seed plants

4. Erdtman, G.1988: Pollen morphology and plant taxonomy.

5. Jain S. K. and Rao R. R. Handbook of Field and Herbarium Methods, Today and Tomorrow Publishers, New Delhi.

6. Hooker, J.D. (1872-1897), The Flora of British India, 7 vols. Reeve & Co. Ltd., London.
7. Kanjilal, U.N. et al. (1934-1940), Flora of Assam. 5 vols. Government press, Shillong.

Paper Title: Plant Geography & Evolution Biology
Paper Code: BOTSPL 25064
Total Credit: 04
Total number of lectures: 60=45+15[L+T] **Total Marks: 100 (T70+IA30)**

Course Objectives:

The course objective of Plant Geography and Evolution Biology is to provide students with a comprehensive understanding of the phytogeography and major theories related to Phyto diversity, Geographical Information System (GIS), Geographical Positioning System (GPS), and evolutionary biology including evolutionary changes, species concepts etc.

Course Outcome:

- Become familiar with aims, principles, and different theories of phytodiversity.
- To develop knowledge on GIS and GIP and their role in taxonomical/ecological study.
- Understanding concepts of evolution, pattern, process, fossils records, and species concept

Unit-I

Historical Development, Aims of Phytogeography, Physical Geography of Earth, Static and Dynamic Phytogeography, Phytochoria and botanical provinces of India; Major theories, Ranges, Migration and Barriers, Centre of Origin, Vicariance, Endemism; India as megadiversity centre.

UNIT II

Geographical Information System (GIS) - basic principles and techniques, types of geographical data; data structure; vector and raster data: their advantages and disadvantages; Input, verification, storage and output of geographical data; Importance of Geographical Information System in Taxonomic studies. Global Positioning System (GPS): basic principles, Applications in ecological studies.

Unit III: Introduction - Pattern and process components of scientific theories: biological variation and evolutionary change (evidence for evolution). Darwin and Wallace – natural selection, adaptation; Microevolution, macroevolution; Evolutionary history: reading trees, monophyly, Tree of life.

Unit IV: The fossil record and Species

Geological fundamentals; Phylogeny and the fossil record; Evolutionary trends; The geography of life. Major patterns of distribution; Historical biogeography, phylogeography. Reproductive isolation.

Species concepts and processes of speciation. Drivers of speciation. Geographic patterns. Evolutionary mechanisms. Post-zygotic and pre-zygotic isolation in allopatry and sympatry

Suggested readings:

1. Chapman and Riss. Ecology: Principles and Applications, Latest Ed., Cambridge University Press

2. Mani, M.S. Bio-Geography of India, Latest Ed., Springer-Verlag. Futuyma, D. J. (1998)

3. Lo, C.P. & Yeung, A.K.W. Concepts and Techniques of Geographic Information Systems, 2002, Printice-Hall of India.

4. Takhtajan AL 1986. The Floristic Regions of The World. University of California Press, Berkeley. Good 5.R 1964. The Geography of the Flowering Plants. John Wiley & Sons, Inc., New York

4. Evolutionary Biology (3rd Edition). Sinauer Associates. Ridley, M. (2003).

5. Evolution (3rd edition), Blackwell. Page, R. D. M. and Holmes E. C. (1998).

6. Molecular Evolution: A Phylogenetic Approach, Blackwell.

7. Herron J. C. and Freeman, S. C. (2015). Evolutionary Analysis (5th Edition). Prentice Hall. ISBN-13: 978-0321616678. ISBN-10: 0321616677.

10. Hall, B. K. and HallgrÃmsson, B. (2014). Strickberger's Evolution (4th Edition). Jones & Bartlett. Department of Botany, University of Delhi

11. Stuessy, T.F. (2009). Plant Taxonomy: The systematic Evaluation of Comparative Data. Columbia University Press, New York.

Paper Title: Advanced Angiosperm Systematics
Paper Code: BOTSPL 25074
Total Credit: 04

Total number of lectures: 60=45+15[L+T] **Total Marks: 100 (T70+IA30)**

Course Objective:

This course aims to introduce the students to the advanced concepts and principles of taxonomy, evolutionary inference of important morphological characters, Molecular Systematics and application of barcoding.

Course Outcome:

- The students will be learning about the components of systematics are phylogenetic trees and their importance in modern biology.
- Understanding of the Evolutionary history; Basal angiosperms
- Ability to learn Phylogenetic analysis etc.

Unit I: Plant systematics: The Components of systematics, Major objectives of systematics; Relevance to society and science.

Taxonomic History: Natural systems to cladistics: Natural systems; Phyletic systems; Phenetics; Cladistics.

Unit II: Angiosperms history: General characteristics; Evolutionary history; Basal angiosperms and Magnoliids; Basal monocots; Petaloid monocots; Commelinids; Basal eudicots and Caryophyllids; Rosids; Asterids.

Unit III: Classification: The components of classification; Characters and their states; Sources of characters; Evaluation of characters.

Unit IV: Molecular Systematics and Plant Barcoding: Plant genomes: nuclear, mitochondrial, chloroplast; Molecular markers; Generating molecular data: restriction site mapping, gene sequencing; Analysis of molecular data: alignment of sequences, methods of

phylogeny reconstruction. Phylogenetics: The nature of phylogeny; The importance of homology, Polarizing characters; Rooting Trees; The problem of homoplasy.

DNA barcoding and its practical implications. standard barcode markers: nrDNA, cpDNA and mtDNA. Phylogenetic analysis (parsimony, Maximum Likelihood, Bayesian approaches, Neighbor-Joining).

Suggested Readings:

1. APG III, 2009. An update of the Angiosperm Phylogeny Group classification for the orders and families of flowering plants: APG III. Botanical Journal of the Linnean Society 161: 105 –121.

2. Barry G. Hall, 2007. Phylogenetic Trees Made Easy: A How-To Manual, Third Edition.Sinauer Associates, Inc., Publishers, Sunderland, USA.

3. Benson,L.D. 1962. Plant Taxonomy: Methods and Principles. Ronald Press, New York.

4. Cronquist, A. 1981. An Integrated System of Classification of Flowering Plants. Columbia University Press, New York.

5. Cracknell AP, Hayes L .2009. Introduction to Remote Sensing. CRC Press, Boca Raton, USA (Special Indian Edition).

6. Crawford DJ .2003. Plant Molecular Systematics. Cambridge University Press, Cambridge, UK. Central University of Kerala DEPARTMENT OF PLANT SCIENCE M.Sc.Botany Programme syllabus 22

7. Cronquist A .1981. An integrated system of classification of flowering plants. Columbia University Press, New York.

8. Davis, P.H. and V.M. Heywood. 1963. Principles of Angiosperm Taxonomy. Oliver and Boyd, Edinburgh.

9. Douglas E. Soltis, Pamela E. Soltis, Peter K. Endress, and Mark W. Chase, 2005. Phylogeny and Evolution of Angiosperms. Sinauer Associates, Inc., Publishers, Sunderland, USA.

10. Hollingsworth PM, Bateman RM and Gornall RJ (1999). Molecular systematics and Plant Evolution. Taylor and Francis, London.

11. Jones, S.B. and A.E. Luchsinger. 1987. Plant Systematics (2nd Ed.) McGrawHill Book Company. New York.

12. Judd WS, Campbell CS, Kellogg EA, Stevens PA and Donoghue MJ (2002) Plant Systematics: A Phylogenetic Approach. SinauerAssociaes, Inc., Massachusetts.

13. Lawrence, G.H.M. 1951. Taxonomy of Vascular. Plants. Oxford and IBH Publishing Co.

14. Michael George Simpson, 2006. Plant systematics. Elsevier Academic Press.

15. Quicke, D.L.J. 1993. Principles and Techniques of Contemporary Taxonomy. Blackie Academic and Professional (An imprint of Chapman & Hall.).

Paper title: Plant Resources, Conservation Biology & IKS
Paper Code: BOTSPL 25084
Total Credit: 04
Total number of lectures: 60=45+15[L+T] **Total Marks: 100 (T70+IA30)**

Course Objectives:

The course objective of Plant resources, Conservation biology and IKS is to provide students with a comprehensive understanding of the plant resources, sustainable development, biodiversity and conservation biology.

Course Outcome:

- Become familiar with plant resources, utilization and sustainable management.
- Knowledge on conservation biology and case studies on conservation/management strategy.
- Understanding the biodiversity, ecosystem services and biodiversity act.
- Understanding of Indian knowledge system- wisdom of thoughts.

UNIT I

Plant diversity: Concept, utilization and concerns, status in India. Plant resource utilization – centres of primary diversity and secondary centres of cultivated plants; crop domestication genes. Sustainable Development: Basic concepts. Green revolution: Benefits and adverse consequences.

UNIT II

Introduction to conservation biology- principles, postulates and ethics, genetic variation and its loss, variation in natural populations, Species and habitat conservation- prioritizing species and habitat, protected area networks; major approaches to their management, Indian case studies on conservation/management strategy.

Unit-III

Methods for biodiversity monitoring, megadiversity zones and hot spots; biodiversity and ecosystem services; threats to biodiversity: Causes of biodiversity loss, species extinction, vulnerability of species to extinction, IUCN threat categories, Red data book; keystone and flagship species.

Biodiversity act and biodiversity action plan; National and international programs for biodiversity conservation, wildlife values and eco-tourism, wildlife distribution in India, problem in wildlife protection.

Unit -IV

Indian knowledge system-an introduction, wisdom thoughts of age, Indigenous people and plant diversity, Traditional plant conservation practices, Plants in Indian tradition and culture, Plant animal interactions, IKS in Botany, Indian Contribution; Traditional methods of agriculture; Traditional water harvest practices in NE India; IPR & Traditional Knowledge IPR and WTO (TRIPS, WIPO).

Suggested Readings:

1. The Wealth of India – Raw Materials Series. CSIR publications, New Delhi.

2. Paroda, R.S. & Arora, R.K. 1991. Plant Genetic Resources Conservation and Management. IPGRI

3. Sharma, O.P. 1996. Hill's Economic Botany. Tata McGrow Hill, New Delhi. 3. Kocchar, S.L. 1998. Economic Botany of the Tropics. McMillan India Ltd., Delhi.

4. Das, A.P. & Pandey, A.K. 2007. Advances in Ethnobotany. Bishen Singh Mahendra Pal Singh, Dehra Dun.

5. Copsey, J. A., Black, S. A., Groombridge, J. J., & Jones, C. G. (Eds.). (2018). Species Conservation: Lessons from Islands. Cambridge University Press.

6. Dudgeon, D. (2020). Freshwater Biodiversity. Cambridge University Press.

7. Fiedler P.L and Kareiva, P.M. (1997) Conservation biology Chapman and Hall International Thompson Publishing. USA

8. Gabriel M. (2000) Biodiversity and conservation Oxford and IBH publishing company Pvt Ltd. New Delhi.

9. Heywood, V.H. & Watson, R.T. (1995) Global Biodiversity Assessment.

10. Huston, M.A. (1994). Biological Diversity: The coexistence of species on changing landscapes. Cambridge University Press, UK.

11. Trivedi, P. C. (2007) Global Biodiversity status and conservation. Pointer publishers Jaipur India.

12. Wilson E.D (1999). Diversity of Life. W.W. Norton, USA.

13. Leadlay, E. and Jury, S. (eds.). 2006. Taxonomy and Plant Conservation.

Paper Title: Angiosperm Taxonomy (Lab III)
Paper Code: BOTSPL 25094
Total Credit: 04

Total number of practical classes: 30 [30×2hrs] **Total Marks: 100 (T70+IA30)**

Course objectives:

The students will be learning practical knowledge of the plant geography, evolution, advanced systematics, conservation related knowledge, IKS as well as the applied taxonomy.

Course Outcome

- Practical skill on Phyto diversity and their identification
- To develop skills on plants systematics
- Appraise to different systems of plant classifications
- Practical knowledge on IKS

Plant Geography & Evolution Biology

1. Practical knowledge on Phytography: Preparation of scientific botanical description of a plant specimen
2. Study of Endemic plants of India in light of IUCN Red List Categories.
3. Vegetation assessment through GIS-remote sensing

Advanced Systematics

1. Knowledge of phylogeny of major orders of Angiosperm.
2. Study of morphology and general evolutionary trends in flowers, stamens and carpels of primitive families viz. Magnoliaceae, Ranunculaceae, Papaveraceae, Dilleniaceae, Alismataceae, Aponogetonaceae, Nymphaeaceae, Nelumbonaceae, Lauraceae, Hydatellaceae.
3. Tools and Technique of molecular systematic.
4. Use of molecular markers to determine genetic relatedness between species
5. Construction of dendrograms using appropriate software.

Plant Resources, Conservation Biology & IKS

1. Comparative study of morphological and structural adaptations of hydrophytes, mesophytes, xerophytes, halophytes
2. *Ex-situ* conservation methods of biodiversity – through seed, vegetative and micro-propagation methods.
3. Study of indigenous knowledge on Botany
4. Quantitative approach of the ethnobotanical study
5. Visit to village markets to survey the marketing status of different wild /cultivated plants.

Paper title: Angiosperm Taxonomy (Lab IV)

Paper Code: BOTSPL 25104
Total credit: 04

Total number of Practical classes: 30[30×2hrs] **Total Marks: 100 (T70+IA30)**

Course Objective

This course is designed to equip students with essential practical skills in taxonomy, tools of biological sciences including Biostatistics and Bioinformatics (at basic and advanced levels). It will introduce applications of microscope and Microtomy in diverse areas of biological sciences and provide skills to Biostatistics, Bioinformatics, practical uses of taxonomic databases and Phylogenetic tree construction.

Course outcome

- The students will be learning on microscopy and microtomy techniques.
- Students will learn necessary skills in the use of databases and online tools related to taxonomy.
- Students will gain the knowledge on Bioststistics, Bioinformatics and phylogenetic tree construction.

Applied Angiosperm Taxonomy

1. Practical uses databases in Taxonomy: IPNI, POWO, WCSP, The Plant List, Tropicos, GBIF, Digitizing herbaria.
2. Collection of special groups of plants: Aquatic Plants, Succulents, Banana, Bamboos, Palms; Preparation and preservation of Specimens.
3. Procedure involved in the recognition and publication of new plant species.
4. Best practices for publishing new names.

Microscopy & Microtomy

1 Skill on Light Microscopy Demonstration: Setup and use, resolution, and magnification.

2. Comparative Study of Microscopes: Resolving powers, advantages, and limitations.

3. SEM and TEM studies and plant systematics; SEM and plant surface structure, TEM internal structure, applications of data in the classification of higher taxa.

4. Microtomy – fixation, dehydration, serial sectioning and staining of plant tissues.

5. Exercises on nomenclature problems: Author citation, principle of priority, transfer of taxa, effective and valid publication etc.

Biostatistics &Bioinformatics

1. Descriptive Statistics Workshop: Calculation, central tendency, and dispersion measures.
2. Probability Distributions Experiment: Analysis of distributions, confidence limits.
3. Statistical Tests Demonstration: T-test, Chi-square, ANOVA.
4. Correlation and Regression Analysis: Calculation, interpretation.
5. Database Exploration: Introduction to NCBI, EMBL, Genbank.
6. Sequence Analysis Workshop: Alignment, phylogenetic relationships.
7. Construction of Dendrograms and Cladograms.

Visit to the Field survey/or Institution and prepare a report on it

Suggested readings:

1. Jerom Mertz, (2009) “Introduction to Optical Microscopy” Roberts & Company Publishers; 1st edition

2. Ruzin, S.E. (1999). Plant Micro technique and Microscopy, Oxford University Press, New York. USA

3. Hickey M and King C. 2000. The Cambridge Illustrated Glossary of Botanical Terms. Cambridge University Press, UK

4. Jain S. K. and Rao R. R. Handbook of Field and Herbarium Methods, Today and Tomorrow Publishers, New Delhi.

5. Mishra, B.N. and Mishra M.K. 1989.Introductory Practical Biostatistics. Naya Prokash Publication, Calcutta

6. Rao, Sundar P.S.S. and Richard, J. 2011.Introduction to Biostatistics and Research

Methods. (4th Ed), PHI Learning Pvt. Ltd., New Delhi

7. Edmondson, A., Druce, D. (1996) Advanced Biology Statistics, Oxford University Press

8. Attwood, T.K. and Parry-Smith, D.J. 2004. Introduction to Bioinformatics. Pearson Education (Singapore) Pvt. Ltd

9. David, E. (Ed.) 2007. Plant Bioinformatics: Methods and Protocol. Humana Press, New Jersey, USA

Group C: Microbiology

SEMESTER III

Paper Code	Courses / Paper Title	Credits	L+T+P	Internal Marks	External Marks	Total Marks
BOTSPL 25014	Microbial Diversity & Physiology	4	3+1+0	30	70	100
BOTSPL 25024	Agriculture Microbiology	4	3+1+0	30	70	100
BOTSPL 25034	Adv. Laboratory Tools & Techniques in Microbiology	4	3+1+0	30	70	100
BOTSPL 25044	Microbiology **(Lab I)**	4	0+0+4	30	70	100
BOTSPL 25054	Microbiology **(Lab II)**	4	0+0+4	30	70	100

SEMESTER IV

Paper Code	Courses / Paper Title	Credits	L+T+P	Internal Marks	External Marks	Total Marks
BOTSPL 25064	Molecular Biology & Genetic Engineering	4	3+1+0	30	70	100
BOTSPL 25074	Food & Environmental Microbiology	4	3+1+0	30	70	100
BOTSPL 25084	Applied Microbiology	4	3+1+0	30	70	100
BOTSPL 25094	Microbiology **(Lab III)**	4	0+0+4	30	70	100
BOTSPL 25104	Microbiology **(Lab IV)**	4	0+0+4	30	70	100

Paper Title: Microbial Diversity & Physiology

Paper Code: BOTADL24014

Paper credit: 04

Total number of lectures: 60 (45L+15T) Total Marks: 100 (T70+IA 30)

Course Objectives:

- To recognize and identify major groups of microbes.
- To understand the phylogeny and study of their classification.
- To explore the morphological and anatomical details as well as the economic importance of bacteria and virus.
- To understand the metabolic processes and Microbial cell growth.
- To understand the bacterial photosynthesis.

Course Outcome:

- The students to will acquire in-depth knowledge about the prokaryotic and eukaryotic micro-organisms.
- This will help to understand the major bacterial phyla and know the characteristics of each group.
- The students will know about the growth of microbes, growth curves and understand the anabolic and metabolic process of micro-organisms.

UNIT-I

The beginning of Microbiology- historical perspective and concept; The Prokaryotic and Eukaryotic paradigm; Diversity of Bacteria, Bacterial cell: Ultra structure, cell wall; Classic and new approaches to bacterial taxonomy, Bergey's manual of determinative and systematic Bacteriology.

UNIT –II

Virus: Structural organization, types and nomenclature of viruses; Viral genome organization; Process of infection; Replication of RNA and DNA viruses;

Bacteriophages: General properties, lytic and lysogenic cycle; Tobacco mosaic virus; Tumor virus, Viroids and Prions.

Eukaryotic micro-organisms (cell structure, reproduction, diversity and taxonomy).

UNIT-III

Microbial Metabolism: Microbial cell growth, division, growth conditions and growth curves & Nutritional Categories of microorganisms based on carbon; energy and electron sources; Bioenergetics; Glucose catabolic pathways found in microbes (Glycolysis, Citric Acid Cycle, Glyoxylate Cycle, Electron Transport Chain; Oxidative Phosphorylation); Fermentation.

UNIT IV

Photosynthesis of Prokaryotes: Pigment systems; Bacterial photosynthesis (anoxygenic and oxygenic); Classification of photosynthetic bacteria.

Suggested Readings:

1. Prescott's Microbiology. 9th edition. McGraw Hill Higher Education.
2. Principles of Microbiology by R. M. Atlas. 2nd edition. W.M.T. Brown Publishers, USA. 1997.
3. Microbiology by M. J. Pelczar, E. C. S. Chan and N. R. Krieg. 5th edition. McGraw Hill, USA. 1993.
4. Leninger A.C (1987). Principles of Biochemistry, CBS Publishers and Distributors (Indian Reprint)
5. Buchanan B.B, GruissemW. and Jones R.L (2000). Biochemistry and Molecular.
6. Hogg, S. (2013). *Essential microbiology*. John Wiley & Sons.
7. Randal Schwartz, Tom Phoenix and Brian d Foy (2005) Learning Perl (4th edition), O'Reilly & Associates, ISBN: 0-596-10105-8.

8. Rex A. Dwyer (2004) Genomic Perl: From Bioinformatics Basics to Working Code, Cambridge University Press, 1st South Asian Edition.

9. Dubey, R. C., & Maheshwari, D. K. (2023). *A textbook of Microbiology*. S. Chand Publishing.

10. Maheshwari, D. K. (1999). *A textbook of microbiology*. S. Chand Publishing.

Paper Title: Agriculture Microbiology

Paper Code: BOTADL25024

Paper credit: 04

Total number of lectures: 60 (45L+15T) **Total Marks: 100 (T70+IA 30)**

Course Objectives:

- Understand agriculturally important microorganisms and their impact on plant growth.
- Explore soil microbiology, including microbial diversity and nutrient cycling.
- Gain insight into biological nitrogen fixation and its role in agriculture.
- Identify and comprehend plant pathogens and pests, as well as control mechanisms.

Course outcome:

- The students will develop the ability to analyze the role of agriculturally important microorganisms in plant growth.
- Proficiency in evaluating soil microbiology, microbial diversity, biological nitrogen fixation and nutrient cycling.
- Competence in identifying and analyzing plant pathogens and pests, as well as implementing effective control mechanisms.

UNIT I

Agriculturally important microorganisms; rhizosphere, phyllosphere; phosphate solubilizing microbes, Plant growth promoting rhizobacteria (PGPR), Microbial pesticides and bio-fertilizers.

UNIT II

Soil microbiology: Soil environment, microbial diversity in soil, microbial interaction in soil, organic matter decomposition, cycling of soil nutrients, methods to detect and quantify soil bacteria and their functional characterization, soil metagenomics, bio-sensors to monitor soil health and toxicity.

UNIT III

Biological nitrogen fixation: Free-living and symbiotic nitrogen fixers, nif operon, mechanism & biochemistry of N2-fixation, Rhizobium-Legume association; Actinorhizal relationships, Role of ectomycorrhizae and endomycorrhizae—and VAM in agriculture & Biofertilizers.

UNIT IV

Pathogens and pests of crop plants: General characteristics of plant pathogenic organisms and pests including viruses, bacteria, and fungi concerning their Life cycles, Nature of disease(s) damage caused, and Host range. Stages in disease development, Host-pathogen relationship, plant defence mechanism, Microbial control of Plant pathogens and pests, Control mechanisms based on genetics, chemical treatments, biological control, bio-pesticides, and genetic engineering; integrated pest management.

Suggested Readings:

1. Barton LL & Northup DE (2011). Microbial Ecology. 1st edition, Wiley Blackwell, USA
2. Campbell RE. (1983). Microbial Ecology. Blackwell Scientific Publication, Oxford, England.
3. Lynch JM & Hobbie JE. (1988). Microorganisms in Action: Concepts & Application in Microbial Ecology. Blackwell Scientific Publication,
4. U.K. Madigan MT, Martinko JM and Parker J. (2014). Brock Biology of Microorganisms. 14th edition. Pearson/ Benjamin Cummings
5. Maier RM, Pepper IL and Gerba CP. (2009). Environmental Microbiology. 2nd edition, Academic Press
6. Martin A. (1977). An Introduction to Soil Microbiology. 2nd edition. John Wiley & Sons Inc. New York & London.
7. P.D. Sharma (2005) Microbiology – Rastogi Publication, India. Subba Rao NS. (1999).
8. Soil Microbiology. 4th edition. Oxford & IBH Publishing Co. New Delhi. Willey JM, Sherwood LM, and Woolverton CJ. (2013).
9. Bagyaraj, D. J., & Rangaswami, G. (2007). *Agricultural microbiology*. PHI Learning Pvt.Ltd..

10. Prescott’s Microbiology. 9th edition. McGraw Hill Higher Education.
11. Agrios GN (2005) Plant Pathology, 5th Edition. 2. Buchanan B, Gruissem G and Jones R (2000) Biochemistry and Molecular Biology of Plants", American Society of Plant Physiologists, USA.
12. Singh, R. S. (2017). *Introduction to principles of plant pathology*. Oxford and IBH Publishing.

Paper Title: Advanced Laboratory Tools & Techniques in Microbiology

Paper Code: BOTSPL 25034

Paper credit: 04

Total number of lectures: 60 (45L+15T) **Total Marks: 100 (T70+IA 30)**

Course Objectives:

- To understand microscopy & microbial techniques
- To understand laboratory techniques like electrophoresis, immunological techniques, spectroscopic techniques, and chromatographic techniques.

Course outcome:

- Upon successful completion of the course, students will demonstrate an understanding of microscopy principles and applications,
- The students will develop skills on microbial techniques, electrophoresis, immunological techniques, spectroscopic techniques, and chromatographic techniques.

UNIT I

Microscopy: Principles, instrumentation, working and applications of fluorescence microscope, Electron microscopy: scanning and transmission electron microscopy.

Microbial techniques: Cataloging microorganisms; Growth media, Isolation of microbes, Types of culture, pure culture, and preservation techniques, Control of Microorganisms: Physical, chemical and biological control; Antibiotics, mode of action of antibiotics, multidrug resistance in bacteria, and principles of Microbial Assay.

UNIT II

Electrophoresis: theory and applications.Immunological techniques: Antibody generation, Detection of molecules using ELISA, RIA, western blot, flow cytometry

and immunofluorescence microscopy, *In-Situ* localization techniques (FISH and GISH).

UNIT III

Spectroscopic Techniques: Basic concept of Visible, UV, IR Spectrophotometry, NMR & ESR Spectroscopy, MALDI-TOF, atomic absorption and mass spectrometry.

UNIT IV

Chromatographic techniques: General Principle of Chromatography; Types of Chromatography; Paper, Thin Layer, Gas chromatography, High Performance Liquid Chromatography.

Suggested Readings:

1. Green, L. H., & Goldman, E. (Eds.). (2021). *Practical handbook of microbiology*. CRC press.
2. Wilson & Walker 1986. Practical biochemistry: Principles & Techniques. Cambridge Univ.Press. 2.
3. Berlyn GP and Miksche JP. 1976. Botanical microtechnique and cytochemistry.
4. Garry D Christian, James E O'reilly (1986). Instrumentation analysis. Alien and 4. Bacon, Inc.
5. Gordon MH and Macrae M. 1987. Instrumental analysis of the biological sciences 5.
6. Glasel A. and M.P.Deutscher.1995. Introduction to Biophysical Methods for protein and nucleic acid Research. Academic Press.
7. Goon,A.M., Gupta,M.K. and Dasgupta,B.(1986) Fundamentals of Statistics (Vol.2). The world press Private limited, Calcutta.
8. Stanford J R (1975). Foundation of Biophysics. Academic press
9. Friefelder. D. (1982) Physical Biochemistry, Application to Biochemistry and Molecular Biology, 2 nd ed. W.H. Freemen and Company, San Fransisco.
10. Griffiths, O. M. (1983). Techniques of Preparative, Zonal and Continuous Flow Ultracentrifugation.
11. William, B.L. and Wilson, K. (1986). A Biologist Guide to Principles and Techniques Practical Biochemistry, 3 rd ed., Edward Arnold Publisher, Baltimore, Maryland (USA).

Paper Title: Microbiology (Lab I)

Paper Code: BOTSPL25044

Paper credit: 04

Total number of Class: 30 (30x2hrs) **Total Marks: 100 (P70+IA30)**

Course Objectives:

To give practical knowledge on microbial diversity, microbial metabolism and soil microbiology.

Course Outcome:

- Students will learn to isolate, stain, and characterize different types of microorganisms.
- They will learn the sterilization techniques, preparation of culture media, pure cultures, and growth curves of microbes in controlled environment.

Experiments:

1. Simple and differential staining (Gram staining), Spore staining.
2. Photographic study of Plant viruses and demonstration of isolation technique of Virus.
3. Study of Eukaryotic micro-organisms.
4. Enumeration of bacterial numbers by serial dilution and plating (viable count).
5. Isolation of pure cultures by streak spread and pours plate techniques.
6. Isolation and pure culture of microbes from soil.
7. Turbidometric measurement of bacterial growth and plotting growth curve.
8. Effect of physical and chemical factors on growth of microbes.
9. IMViC test - Indole test, Methyl red test, Voges-Proskauer test, Citrate utilization test
10. Catalase test & Oxidase test
11. Fermentation of carbohydrates

Suggested readings:

1. Green, L. H., & Goldman, E. (Eds.). (2021). *Practical handbook of microbiology*. CRC press.
2. Dubey, R. C., & Maheshwari, D. K. (2002). *Practical Microbiology, 4/e*. S. Chand Publishing.
3. Linday, E. M. (1962). Practical introduction to microbiology.
4. O'Leary, W. M. (1989). *Practical handbook of microbiology*. CRC press.
5. Sharma, K. (2007). *Manual of Microbiology*. Ane Books Pvt Ltd.
6. Frankland, J. C., Latter, P. M., & Poskitt, J. (1995). A laboratory guide to soil microbiology: Some general principles and practice.

Paper Title: Microbiology (Lab II)

Paper Code: BOTSPL 25054

Paper credit: 04

Total number of Class: 30 (30x2hrs) **Total Marks: 100 (P70+IA30)**

Course Objectives:

To give practical knowledge on agriculturally important micro-organisms.

Course Outcome:

- Students will learn to isolate, stain and characterize different type of microorganism from rhizosphere, phyllosphere and other regions of agriculturally important crops.
- They will learn the sterilization techniques, preservation techniques, antibiotic sensitivity tests, and plant pathogens.

Experiments:

1. Sterilization techniques: Autoclave, Hot air oven and filtration.
2. Preparation of media for culturing autotrophic and heterotrophic microorganisms – algal medium, nutrient agar medium, McConkey agar and Czapeck dox agar.
3. Preservation of microbial cultures- Slant, Stab, Sand cultures, mineral oil overlay and glycerol stocks.
4. Antibiotic sensitivity testing – Disc diffusion method (Demonstration with photographs)
5. Isolation of microbes from rhizosphere of agriculturally important crops.
6. Isolation and characterization of PGPR.
7. Isolation of root nodule bacteria.
8. Isolation of microbes from phyllosphere
9. Study of Mycorrhizal association – spore population and root colonization.
10. Study of symptoms and causal organisms of some important plant diseases prevalent in the state.

Suggested readings:

1. Green, L. H., & Goldman, E. (Eds.). (2021). *Practical handbook of microbiology*. CRC press.
2. Dubey, R. C., & Maheshwari, D. K. (2002). *Practical Microbiology, 4/e*. S. Chand Publishing.
3. Linday, E. M. (1962). Practical introduction to microbiology.
4. O'Leary, W. M. (1989). *Practical handbook of microbiology*. CRC press.
5. Sharma, K. (2007). *Manual of Microbiology*. Ane Books Pvt Ltd.
6. Frankland, J. C., Latter, P. M., & Poskitt, J. (1995). A laboratory guide to soil microbiology: Some general principles and practice.
7. Amaresan, N., Patel, P., & Amin, D. (Eds.). (2022). *Practical handbook on agricultural microbiology*. Springer US.

Paper Title: Molecular Biology &Genetic Engineering

Paper code: BOTSPL 25064

Paper credit: 04

Total number of lectures: 60=45+15(L+T) **Total Marks: 100 (T70+IA 30)**

Course Objectives:

The syllabus aims to provide a comprehensive understanding of Microbial genetics, Molecular biology, Immunology, Microbial biotechnology, Genetic engineering tools and techniques and their applications for human welfare.

Course Outcome:

- Upon completion of the course, students will be able to demonstrate a comprehensive understanding of microbial genetics, molecular biology & immunology.
- Students will be able to demonstrate a comprehensive understanding and microbial biotechnology, including genetic engineering tools and techniques and their applications for human welfare.

UNIT I

Microbial Genetics: Genetic materials, genes, and chromosomes; Prokaryotic and Eukaryotic genome organization, Transposons, Plasmids; Vertical and horizontal gene transfer, Genetic recombination: Molecular mechanism of Conjugation, Transformation, and Transduction.

UNIT II

Molecular biology: DNA replication, RNA transcription, and protein synthesis, genome evolution, proteomics, transcriptomics, metabolomics, genomics, gene regulation in prokaryotes and eukaryotes, operon concept (lac, ara, and trp operons), RNA processing (RNA capping, Poly (A) tail formation, RNA splicing), Quorum sensing. Cell cycle,

Cancer & tumor cells, genetic abnormalities of cancer cells, metastasis, apoptosis, oncogenes, Tumor suppressors, RB and p53 protein.

UNIT III

Immunology: The origin of immunology; Inherent immunity; Specific and non-specific immunity; Cells of the immune system; Complement system; Immune responses, Antigens, B, and T cells, Antigen-presenting cells, Major histocompatibility complex (MHC); Humoral and cell-mediated immunity; Antibodies, Antigen-antibody reaction, functions of antibody; immune diseases.

UNIT IV

Microbial biotechnology: Microbial biotechnology for human welfare, genetic engineering – tools and techniques, vectors (plasmids, bacteriophage, and other viral vectors, cosmids, Ti plasmid, bacterial artificial chromosomes, and yeast artificial chromosome), cDNA and genomic DNA library, gene cloning, expression of cloned genes, GMOs, micro RNAs, RNAi

Suggested Readings:

1. Karp. G. 2013. Cell and Molecular Biology – Concepts and Experiments. 7th Edition. Wiley Global Education, USA 3.
2. Roy S.C and KKDe 2005 (Second Edition). Cell Biology, New central Book Agency Private Ltd., Kolkata.
3. Verma P.S and Agarwal V.K 2006 Cell Biology, Genetics, Molecular Biology, Evolution, Ecology. S.Chand and Company, New Delhi.
4. Robertis, D. (1987). Cell and molecular biology.
5. Davis, L. (2012). *Basic methods in molecular biology*. Elsevier.
6. Buchanan, B. B., Gruissem, W., & Jones, R. L. (Eds.). (2015). *Biochemistry and molecular biology of plants*. John wiley& sons.

7. Alberts, B., Bray, D., Hopkin, K., Johnson, A. D., Lewis, J., Raff, M.,& Walter, P. (2015). *Essential cell biology*. Garland Science.
8. Lodish, H. F. (2008). *Molecular cell biology*. Macmillan.
9. Gupta, P. K. (2008). *Molecular biology and genetic engineering*. Deep and Deep Publications.

Food & Environmental Microbiology

Paper code: BOTSPL 25074

Paper credit: 04

Total number of lectures: 60=45+15(L+T) **Total Marks: 100 (T70+IA 30)**

Course Objectives:

- The course aims to cover the fundamentals of food microbiology & food preservation.
- The course covers the microbial ecology, and water microbiology, providing students with a comprehensive understanding of these key areas.

Course Outcome:

- Students will have a key understanding of the principles of food microbiology, including the factors influencing microbial growth and sources of microorganisms in foods.
- They will be able to evaluate and apply various methods of food preservation, including irradiation, heat processing, and chemical preservatives.
- They will be able to analyze the role of fermentation in food production and evaluate the nutritional value of fermented food products.
- The students can examine microbial ecology and its interaction with other organisms in different environments, including water microbiology and aeromicrobiology
- They will cultivate basic understanding of Bioremediation.

UNIT I

Food microbiology: Introduction and scope; Food Microbiology- A many-faceted science, Primary sources of microorganisms in foods; Factors influencing microbial growth in foods-extrinsic and intrinsic; Microbial spoilage of foods – meat, milk, fruits, vegetables, and their products; Food poisoning and Foodborne pathogenic bacteria.

UNIT II

Food Preservation: Principles of food preservation; preservation methods – irradiations, drying, heat processing, chilling and freezing, high pressure, modification of packaging atmosphere, and chemical preservatives. Fermented food products and their nutritional values; Fermented dairy, vegetable, and meat products; concept of prebiotics and probiotics; Bacteriocins and their applications.

UNIT III

Microbial Ecology: Interaction of microbes with other microbes, plants and animals; Microbial diversity in different environments & extremophiles. Aeromicrobiology: microbes in air-bio-aerosols, Air sampling techniques, allergies, airborne diseases. Water microbiology: Microbial flora of water; water quality, detection of the coliform group in water drinking water; water pollution; domestic & waste treatment systems;

UNIT IV

Microbial remediation: Microbial pesticides; bioremediation of contaminated sites with xenobiotics, inorganic pollutants, pesticides, etc. Microorganisms in mining, mineral and energy recovery, MEOR, Microbes in nanotechnology, and biosensors.

Suggested Readings:

1. Satyanarayana, U. (2011). *Biotechnology*. Books and Allied (p) Ltd.
2. Doyle, M.P., Beuchat, L.R. and Montville, T.J. (1997). Food Microbiology: Fundamentals and Frontiers.ASM Press, Washington D.C., USA.
3. Verma, D. K., Patel, A. R., Srivastav, P. P., Mohapatra, B., &Niamah, A. K. (Eds.). (2019). *Microbiology for Food and Health: Technological Developments and Advances*. CRC Press.
4. Frazier, W.C. and Westhoff, D.C. (1988). Food Microbiology, McGraw-Hill, New York. 4. Jay, J.M. (1996). Modern Food Microbiology, Chapman and Hall, New York. 15 5. Ray, B. (1996). Fundamentals of Food Microbiology, CRC Press, USA.

5. Atlas, R.M. and Bartha, R. (1998). Microbial Ecology - Fundamentals and Applications, Addison Wesley Longman, Inc., USA Prescott L, Harley J, Klein D (2005) Microbiology, 6 th edition, Mc Graw-Hill. 2.
6. Singh VP and Stapleton RD (Eds.) (2002) Biotransformations: Bioremediation Technology for Health and Environmental Protection. “Progress in Industrial Microbiology Vol. 36”, Elsevier Science. 3.
7. Introduction to Biotechnology. Blackwell scientific publications, Oxford 12.
8. Chawla, H.S, 2000. Introduction to Biotechnology. Oxford & IBH Publishing Co Pvt. Ltd, New Delhi

Paper Title: Applied Microbiology

Paper code: BOTSPL 25084

Paper credit: 04

Total number of lectures: 60=45+15(L+T) **Total Marks: 100 (T70+IA 30)**

Course Objectives:

- Explore industrial microbiology, fermentation processes, microbial biomass, enzymes, bioreactors, kinetics of microbial growth, and the production of primary and secondary metabolites.
- Discover the potential of algae in producing pigments, polysaccharides, biofuels, and as a source of food, and nutrition.
- Industrial applications of fungi, including biocontrol and their use as a source of various biologically active compounds

Course Outcome:

- The course will provide an understanding of the industrial importance of microorganisms, fermentation processes, and the production of valuable microbial products.
- Additionally, it covers the application of algae and fungi in various industrial processes and other applications.

UNIT I

Industrial Microbiology: Industrial importance of microorganisms, Types of the Fermentation process, microbial biomass, microbial enzymes, bioreactors, isolation, preservation and maintenance of industrial microbes, the kinetics of microbial growth in STR, microbial products, primary and secondary metabolites, downstream processing, application and immobilization of enzymes, selection, and strain improvement strategies.

UNIT II

Industrial production of Enzyme-Amylase; Antibiotics-Penicillin; Organic acid- Citric acid; Organic solvents- Ethanol; Single Cell Proteins (SCP), Baker's Yeast.

UNIT III

Production technology of Algal pigments & polysaccharides; Algal biofuels – algal biodiesel, bio-ethanol, and biological hydrogen production; Algae as Food & nutrition; Laboratory Cultivation techniques of Algae, Photo-bioreactors and raceway ponds, Environmental application of Algae.

UNIT IV

Industrial application of fungi as a source of vitamins, amino acids, organic acids, enzymes, and proteins & Ecological services. Fungi as biocontrol agents (Mycoherbicides, Mycofungicides, Myconematicides), Edible and poisonous mushrooms, cultivation of mushrooms, and economic value of mushrooms.

Suggested readings:

1. Prescott L, Harley J, Klein D (2005) Microbiology, 6 th edition, Mc Graw-Hill. 2.
2. Singh VP and Stapleton RD (Eds.) (2002) Biotransformations: Bioremediation Technology for Health and Environmental Protection. "Progress in Industrial Microbiology Vol. 36", Elsevier Science. 3.
3. Waites MJ, Morgan NL, Rockey JS, Higton G (2001) Industrial Microbiology: An Introduction, Wiley-Blackwell.
4. Introduction to Biotechnology. Blackwell scientific publications, Oxford 12.
9. Chawla, H.S, 2000. Introduction to Biotechnology. Oxford & IBH Publishing Co Pvt. Ltd, New Delhi.
10. Satyanarayana, U. (2011). *Biotechnology*. Books and Allied (p) Ltd..

11. Stanbury, P. F., Whitaker, A., & Hall, S. J. (2013). *Principles of fermentation technology*. Elsevier.
12. Pandey, R. K. G. V. D. (2007). *Advances in Applied Phycology*. Daya Books.
13. Satyanarayana, T., Deshmukh, S. K., & Johri, B. N. (Eds.). (2017). *Developments in fungal biology and applied mycology*. Singapore: Springer Singapore.
14. An, Z. (Ed.). (2004). *Handbook of industrial mycology*. CRC Press.

Paper Title: Microbiology (Lab III)

Paper code: BOTSPL 25094

Total number of lectures: 30(30x2 hrs.) **Total Marks: 100 (P70+IA30)**

Course Objectives:

The course aims to give practical hands-on training of Molecular Biology, Biostatistics & Bioinformatics

Course Outcome:

- The students will learn to isolate microbial genome, plasmids, and Proteins.
- The students will develop the skills to operate various bioinformatics tools.
- They will. The biostatics will give the students' knowledge about experimental design.

A. Practical/ Demonstration on Molecular Biology

1. Purification of microbial protein.
2. Electrophoretic separation of protein (SDS-PAGE)
3. Isolation of Genomic & Plasmid DNA from *E.coli*.
4. Visit to Research Institute/Instrumentation laboratory to Study advanced microscopy / chromatography techniques

B. Statistical Methods (Combined practical and theory)

Introduction to biostatistics & its applications in biological data analysis.

1. Descriptive Statistics Workshop: Calculation, central tendency, and dispersion measures.
2. Probability Distributions Experiment: Analysis of distributions, confidence limits.
3. Statistical Tests Demonstration: T-test, Chi-square, ANOVA.
4. Correlation and Regression Analysis: Calculation, interpretation.

C. Bioinformatics: (Combined practical and theory)

1. Databases - NCBI, EMBL, DDBJ, Genebank, Pubmed, Patent databases, PDB
2. Online tools - BLAST, ORF finder, Primer3, protein motif and structure prediction tools

3. Sequence alignment and homologous sequence search.
4. Construction of Phylogenetic tree.
5. Bioinformatics in drug designing, molecular docking and modelling.

Suggested readings:

1. Wilson & Walker 1986. Practical biochemistry: Principles & Techniques. Cambridge Univ.Press
2. Antonisamy, B., Premkumar, P. S., & Christopher, S. (2017). *Principles and Practice of Biostatistics-E-book: Principles and Practice of Biostatistics-E-book*. Elsevier Health Sciences.
3. Randal Schwartz, Tom Phoenix and Brian d Foy (2005) Learning Perl (4th edition), O'Reilly & Associates, ISBN: 0-596-10105-8.
4. Attwood TK and Parry-Smith DJ (2004) Introduction to Bioinformatics, Pearson Education (Singapore) Pvt. Ltd.
5. David Edwards (Ed.) (2007) Plant Bioinformatics: Methods and Protocols, Humana Press, New Jersey, USA.
6. Kulas JT (2008) SPSS Essential: Managing and Analyzing Social Science Data. John Wiley & Sons, New York.
7. Pagano M, Gauvreau K (2007) Principles of Biostatistics. Thomson India Edition, New Delhi. 5. Randal Schwartz, Tom Phoenix and Brian d Foy (2005) Learning Perl (4th edition), O'Reilly & Associates, ISBN: 0-596-10105-8. 6.
8. Rosenkrantz WA (2009) Introduction to Probability and Statistics for Science, Engineering and Finance. CRC Press, Boca Raton.

Paper Title: Microbiology (Lab IV)

Paper Code: BOTSL 25104

Total number of lectures: 30 (30x2hrs) **Total Marks: 100 (P70+IA30)**

Course Objectives:

- To determine milk and water quality.
- Mushroom cultivation and algal cultivation.
- To isolate micro-organisms from air, spoiled food substances, and fermented food products.

Course Outcome:

- The students will learn to determine the quality of milk and water.
- The students will learn to isolate micro-organisms from air, spoiled food substances, and fermented food products.

Experiments:

5. Determination of microbiological quality of milk by MBRT method.
6. Isolation of fungi/bacteria from spoiled fruits/vegetables/Milk/Meat products.
7. Isolation of microorganisms from air.
8. Analysis of soil – pH, Moisture content and water holding capacity
9. Microbiological examination of water by coliform test.
10. Isolation and identification of probiotic bacteria.
11. Cultivation of Cynobacteria in Laboratory.
12. Study of production of organic acids by fungi.
13. Mushroom cultivation.
14. Preparation of Wines from Grapes.

Suggested readings:

1. Green, L. H., & Goldman, E. (Eds.). (2021). *Practical handbook of microbiology*. CRC press.
2. Dubey, R. C., & Maheshwari, D. K. (2002). *Practical Microbiology, 4/e*. S. Chand Publishing.
3. Linday, E. M. (1962). Practical introduction to microbiology.

4. O'Leary, W. M. (1989). *Practical handbook of microbiology*. CRC press.
5. Sharma, K. (2007). *Manual of Microbiology*. Ane Books Pvt Ltd.
6. Frankland, J. C., Latter, P. M., & Poskitt, J. (1995). A laboratory guide to soil microbiology: Some general principles and practice.