Progressive Education Society's

Modern College of Arts, Science and Commerce (Autonomous),

Shivajinagar, Pune 5

(An Autonomous College Affiliated to Savitribai Phule Pune University)

Framework and Syllabus For

T.Y.B.Sc. (Botany)

(Based on NEP 2020 framework)

(To be implemented from the Academic Year 2026-27)

Level: 5.5 (Third Year) Sem: V

Course Type	Course Code	Course Title	Credits		Teaching Scheme Hr/Week		Evaluation Scheme and Max Marks		
			TH	PR	TH	PR	CE	EE	Total
Major Core T (2+2+2+2) P (2+2)	24ScBotU5101	Cell Biology	2		2		20	30	50
	24ScBotU5102	Molecular Biology	2		2		20	30	50
	24ScBotU5103	Genetics	2		2		20	30	50
	24ScBotU5104	Plant Breeding	2		2		20	30	50
	24ScBotU5105	Lab Course on 24ScBotU5101 and 24ScBotU5102		2		4	20	30	50
	24ScBotU5106	Lab Course on 24ScBotU5103 and 24ScBotU5104		2		4	20	30	50
Major Elective (2+2)	24ScBotU5201	Ecology and Plant Pathology	2		2		20	30	50
	24ScBotU5202	Lab Course on 24ScBotU5201		2		4	20	30	50
	24ScBotU5203	Landscaping and Gardening	2		2		20	30	50
	24ScBotU5204	Lab Course on 24ScBotU5203		2		4	20	30	50
VSC P (2)	24ScBotU5501	Lab Course on Plant Analytical Techniques		2		4	20	30	50
FP (2)	24ScBotU5001	Filed Project II		2		4	20	30	50
Minor (T/P) (2)	24ScBotU5302	Plant Physiology and Biochemistry		2		4	20	30	50
Total			**10**	**12**	**10**	**24**			**550**

Level: 5.5 (Third Year) Sem: VI

Course Type	Course Code	Course Title	Credits		Teaching Scheme Hr/Week		Evaluation Scheme and Max Marks		
			TH	PR	TH	PR	CE	EE	Total
Major Core T (2+2+2+2) P (2+2)	24ScBotU6101	Palaeobotany	2		2		20	30	50
	24ScBotU6102	Plant Systematics	2		2		20	30	50
	24ScBotU6103	Plant Physiology	2		2		20	30	50
	24ScBotU6104	Plant Biochemistry	2		2		20	30	50
	24ScBotU6105	Lab Course on 24ScBotU6101 and 24ScBotU6102		2		4	20	30	50
	24ScBotU6106	Lab Course on 24ScBotU6103 and 24ScBotU6104		2		4	20	30	50
Major Elective (2+2)	24ScBotU6201	Biostatistics	2		2		20	30	50
	24ScBotU6202	Lab Course on 24ScBotU6201		2		4	20	30	50
	24ScBotU6203	Industrial and Environmental Microbiology	2		2		20	30	50
	24ScBotU6204	Lab Course on 24ScBotU6203		2		4	20	30	50
VSC P (2)	24ScBotU6501	Lab Course on Gardening Practices and Techniques		2		4	20	30	50
OJT (2)	24ScBotU6004	On Job Training		4		8	40	60	100
Total			**10**	**08**	**10**	**28**			**550**

Progressive Education Society's
Modern College of Arts, Science and Commerce,
Shivajinagar, Pune - 5

Third Year of B.Sc. Botany
(2024 Course under NEP 2020)

Course Code: 24ScBotU5101 **Course Name: Cell Biology**
Teaching Scheme: TH: 2 Hours/Week **Credit: 02**
Examination Scheme: CIE: 20 Marks **End-Sem: 30 Marks**

Prerequisite: A student should have foundational knowledge of General Botany (basic plant structure) and General Chemistry (understanding of macromolecules and chemical bonds). Introductory knowledge of microscopy is helpful.

Course Objectives:

- To understand the historical development and define the scope of cell biology.
- To compare the structural organization of prokaryotic and eukaryotic cells.
- To describe the morphology, ultrastructure, and functions of major plant cell organelles.
- To explain the structure and chemical composition of the nucleus and chromosomes.
- To outline the stages and physiological regulation of the cell cycle, mitosis, and meiosis.
- To differentiate between the processes, outcomes, and significance of mitosis and meiosis.

Course Outcomes:

On completion of the course, students will be able to–

- Distinguish between prokaryotic and eukaryotic cellular organisation with labelled diagrams.
- Correlate the structure of key plant cell organelles (e.g., chloroplast, mitochondria, ER) with their specific functions.
- Interpret a karyotype and differentiate between euchromatin and heterochromatin.
- Describe the sequence of events and significance of each phase of mitosis and meiosis.
- Compare and contrast mitosis and meiosis in terms of process, outcome, and biological role.
- Explain the regulation and importance of the cell cycle in plant growth and development.

Course Contents:

Unit 1	**Introduction**	**2 L**
	1.1 Definition and brief history of cell biology 1.2 Structure of typical prokaryotic and eukaryotic cell	
Unit 2	**Plant Cell - Cytoplasmic constituents**	**16 L**
	2.1 Morphology, ultrastructure, chemical composition, and functions of: Cytoskeleton, plasma membrane, endoplasmic reticulum, Golgi apparatus, lysosomes	

	and peroxisomes, microbodies, mitochondria, plastids, vacuoles, and ribosomes.	
Unit 3	**Plant Cell - Nucleus and Chromosomes**	**6 L**
	3.1 Nucleus- Morphology, ultrastructure, nucleoplasm, nucleolus, functions 3.2 Chromosome- Number, morphology, structure, karyotype and ideogram, chemical composition, euchromatin and heterochromatin, giant chromosomes	
Unit 4	**Cell cycle and cell growth**	**6 L**
	4.1 Cell cycle and mitosis —general events of interphase, prophase, metaphase, anaphase, telophase, cytokinesis 4.2 Physiology of cell cycle and mitosis, significance of mitosis; 4.3 Meiosis and the reproductive cycle, kinds of meiosis, process of meiosis, heterotypic division or first meiotic division, homotypic or second meiotic division; significance of meiosis 4.4 comparison of mitosis and meiosis	

Suggested Readings:

Baltimore, D., Berk, A., Lodish, B., Darnell, J. E., Matsudaira, P., Lodish, H. F., Zipursky, S. L. (2000). Molecular Cell Biology. United Kingdom: W.H. Freeman.

Gupta, P. K. (2008). Molecular Biology and Genetic Engineering. India: Global Media Publications.

Gupta, P. K. (2008). Molecular Biology and Genetic Engineering. India: Global Media Publications.

Jain, J. L. (2004). Fundamentals of Biochemistry. India: S. Chand Limited.

Johnson, A. D., Alberts, B., Raff, M., Hopkin, K. (2019). Essential Cell Biology. United Kingdom: W.W. Norton.

Matsudaira, P., Zipursky, S. L., Berk, A., Darnell, J. E., Baltimore, D., Lodish, B., Lodish, H. F. (2000). Molecular Cell Biology. United Kingdom: W.H. Freeman.

Powar, C. B. (1991). Cell Biology. India: Himalaya Publishing House.

Rastogi, S. C. (2006). Cell And Molecular Biology. India: New Age International (P) Limited.

Rastogi, S. C. (2006). Cell And Molecular Biology. India: New Age International (P) Limited.

Rastogi, V. B. (2008). Fundamentals Of Molecular Biology (2 Colour). India: Ane Books India.

Verma, P. S. (2004). Cell Biology, Genetics, Molecular Biology, Evolution and Ecology. India: S. Chand Limited.

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Modern College of Arts, Science and Commerce,
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Third Year of B.Sc. Botany
(2024 Course under NEP 2020)

Course Code: 24ScBotU5102 **Course Name: Molecular Biology**
Teaching Scheme: TH: 2 Hours/Week **Credit: 02**
Examination Scheme: CIE: 20 Marks **End-Sem: 30 Marks**

Prerequisite: A student should know basics of cell biology, general genetics (Mendelian inheritance), and introductory organic chemistry (nucleotide and protein structure). Familiarity with fundamental biochemical concepts, such as enzymes and metabolic pathways, is also necessary.

Course Objectives:

- To understand the classic experiments that established DNA as the genetic material and explain the central dogma of molecular biology.
- To describe the structure of DNA and RNA, and explain their key physical properties, including denaturation and renaturation.
- To outline the detailed mechanism and enzymes involved in DNA replication in prokaryotes, with an overview of eukaryotic replication.
- To explain gene organization, including promoters, terminators, and split gene structure in eukaryotes.
- To describe the processes of transcription and translation in prokaryotes, with an overview of eukaryotic modifications.
- To explain the basic regulation of gene expression in prokaryotes using the lac operon as a model.

Course Outcomes: On completion of the course, students will be able to–

- Analyze the key historical experiments (Griffith, Avery, Hershey-Chase) that provided evidence for DNA as the genetic material.
- Interpret the physical properties of nucleic acids (UV absorption, denaturation curves) and relate them to their structure and function.
- Compare and contrast the continuous and discontinuous synthesis of DNA on the leading and lagging strands during replication.
- Differentiate between gene organization in prokaryotes and eukaryotes, focusing on promoter structure and the concept of split genes.
- Describe the sequential steps of transcription and translation in prokaryotes and identify key differences in the eukaryotic processes.
- Illustrate the regulation of the lac operon, explaining the mechanisms of both negative and positive control.

Course Contents:

Unit 1	**Introduction to Molecular Biology**	**6 L**
	1.1. Essential features of genetic material and the central dogma of molecular biology 1.2. Evidences favoring DNA as genetic material: Frederick Griffith's contribution, transformation: Avery, MacLeod and McCarty's experiments, Hershey–Chase experiment 1.3. RNA as genetic material and its types (mRNA, rRNA and tRNA) 1.4. Structure of DNA: Base-composition studies, X-ray diffraction analysis, Watson–Crick model, alternative forms of DNA	
Unit 2	**Physical properties of nucleic acids**	**4 L**
	2.1. Absorption of ultraviolet light 2.2. Sedimentation behavior 2.3. Denaturation and renaturation of nucleic acids 2.4. Reassociation kinetics and repetitive DNA	
Unit 3	**DNA replication**	**5 L**
	3.1. The Meselson–Stahl Experiment 3.2. Origins, forks, and units of replication 3.3. Replication in prokaryotes: DNA Polymerases, unwinding the DNA helix, initiation of DNA synthesis, continuous and discontinuous DNA synthesis of antiparallel strands, concurrent synthesis on the leading and lagging strands, integrated proofreading and error correction 3.4. Summary DNA replication in eukaryotes	
Unit 4	**Organization of gene**	**4 L**
	4.1. Promoter-structure and function in prokaryotes and eukaryotes 4.2. Terminators 4.3. Units of gene 4.4. Enhancers, linear genes and split genes	
Unit 5	**Transcription**	**5 L**
	5.1. Mechanism of prokaryotic transcription: Enzymatic synthesis of RNA, prokaryotic RNA polymerases, initiation, elongation and termination of transcription in prokaryotes	

	5.2. Overview of eukaryotic transcription and post-transcriptional modifications	
Unit 6	**Translation**	**4 L**
	6.1. Concept of genetic code and its characteristics 6.2. Mechanism of protein synthesis: Aminoacylation of tRNA 6.3. Mechanism of protein synthesis in prokaryotes and eukaryotes 6.4. Introduction to post-translational modifications	
Unit 7	**Regulation of gene expression in prokaryotes**	**2 L**
	7.1. Concept of operon 7.2. Mechanism of the lac operon, its positive and negative control	

Suggested Readings:

Baltimore, D., Berk, A., Lodish, B., Darnell, J. E., Matsudaira, P., Lodish, H. F., Zipursky, S. L. (2000). Molecular Cell Biology. United Kingdom: W.H. Freeman.

Cooper, G. M. (2000). The Cell: A Molecular Approach. United Kingdom: ASM Press.

Gupta, P. K. (2008). Molecular Biology and Genetic Engineering. India: Global Media Publications.

Gupta, P. K. (2008). Molecular Biology and Genetic Engineering. India: Global Media Publications.

Jain, J. L. (2004). Fundamentals of Biochemistry. India: S. Chand Limited.

Johnson, A. D., Alberts, B., Raff, M., Hopkin, K. (2019). Essential Cell Biology. United Kingdom: W.W. Norton.

Matsudaira, P., Zipursky, S. L., Berk, A., Darnell, J. E., Baltimore, D., Lodish, B., Lodish, H. F. (2000). Molecular Cell Biology. United Kingdom: W.H. Freeman.

Powar, C. B. (1991). Cell Biology. India: Himalaya Publishing House.

Rastogi, S. C. (2006). Cell And Molecular Biology. India: New Age International (P) Limited.

Rastogi, S. C. (2006). Cell And Molecular Biology. India: New Age International (P) Limited.

Rastogi, V. B. (2008). Fundamentals Of Molecular Biology (2 Colour). India: Ane Books India.

Verma, P. S. (2004). Cell Biology, Genetics, Molecular Biology, Evolution and Ecology. India: S. Chand Limited.

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Modern College of Arts, Science and Commerce,
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Third Year of B.Sc. Botany
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Course Code: 24ScBotU5103 **Course Name: Genetics**
Teaching Scheme: TH: 2 Hours/Week **Credit: 02**
Examination Scheme: CIE: 20 Marks **End-Sem: 30 Marks**

Pre-requisite: An understanding of cell biology, basic genetics, and plant biology is essential. Students should be familiar with cell division (mitosis and meiosis), DNA structure, and basic laboratory skills, such as microscopy and sample handling, which will also be beneficial for conducting genetic analysis.

Course Objectives:

- To understand the fundamental principles of Mendelian genetics, including segregation and independent assortment.
- To analyze deviations from Mendelian ratios through gene interactions and multiple alleles.
- To differentiate between qualitative (Mendelian) and quantitative patterns of inheritance.
- To explain the mechanisms and inheritance patterns of sex-linked and cytoplasmic traits.
- To apply concepts of linkage and crossing over to construct basic genetic maps.
- To understand the genetic consequences of chromosomal aberrations and mechanisms of bacterial recombination.

Course Outcomes:

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

- Predict phenotypic and genotypic ratios for monohybrid and dihybrid crosses using Mendelian principles.
- Interpret deviations from standard Mendelian ratios using appropriate gene interaction models (e.g., complementary, duplicate genes).
- Distinguish between inheritance patterns governed by multiple alleles (e.g., ABO blood groups) and quantitative traits.
- Solve problems related to sex-linked inheritance and explain non-Mendelian patterns like cytoplasmic inheritance.
- Calculate recombination frequencies and construct a simple linkage map from two-point test cross data.
- Describe the basic processes of genetic recombination in bacteria: conjugation, transformation, and transduction.

Course Contents:

Unit 1	**Introduction to Genetics and Mendelism**	**3 L**
	1.1 Definition, concept of heredity and variations 1.2 Mendel's contribution 1.3 Monohybrid cross and principle of dominance 1.4 Law of segregation/law of purity of gametes 1.5 Dihybrid cross 1.6 Law of independent assortment 1.7 Back cross and test cross	
Unit 2	**Interactions of genes**	**4 L**
	2.1 Incomplete dominance (1:2:1) 2.2 Complementary genes (9:7) 2.3 Duplicate genes (15:1) 2.4 Masking genes (12:3:1) 2.5 Supplementary genes (9:3:4) 2.6 Inhibitory genes (13:3) 2.7 Lethal genes in mice (2:1)	
Unit 3	**Multiple alleles**	**3 L**
	3.1 Definition 3.2 Characters of multiple alleles 3.3 Examples of multiple alleles – inheritance of blood group in human, self-incompatibility in *Nicotiana*	
Unit 4	**Quantitative and Cytoplasmic Inheritance**	**4L**
	4.1 Concept of quantitative inheritance 4.2 Difference between qualitative and quantitative traits 4.3 Inheritance of quantitative trait in maize 4.4 Cytoplasmic inheritance - definition and concept 4.5 Cytoplasmic inheritance in plants - variegation in four O'clock plants	
Unit 5	**Sex linked inheritance**	**3 L**
	5.1 Concept of sex chromosomes and autosomes 5.2 Inheritance of X- linked genes – eye colour in *Drosophila* and colour blindness in humans,	
Unit 6	**Linkage and chromosome mapping**	**7 L**
	6.1 Definition and types of linkage 6.2 Definition and types of crossing over 6.3 Construction of a linkage map by two-point test cross and three-point test cross 6.4 Mapping in haploid organisms: Mapping genes in *Neurospora*, gene to centromere mapping, ordered and	

	unordered tetrad analysis	
Unit 7	**Numerical and structural aberrations in chromosomes**	**6 L**
	7.1 Introduction to Chromosomal Aberrations and Aneuploidy 7.2 Concepts, causes, types of numerical changes, and their genetic consequences 7.3 Polyploidy – Types, Origin, and Significance 7.4 Autopolyploidy, allopolyploidy, mechanisms, and applications in evolution and agriculture 7.5 Structural Aberrations – Deletions and Duplications: Types, formation, cytological detection, and genetic effects 7.6 Inversions – Types, Consequences, and Evolutionary Role, paracentric vs. pericentric inversions, crossover suppression, and cytological outcomes 7.7 Translocations – Reciprocal and Robertsonian: Mechanisms, meiotic behavior, semi-sterility, and applications in genetics and breeding, detection, significance, and synthesis	

Suggested readings:

Bhatia, K. N. (2014). Principles of Genetics. Atlantic Publishers & Distributors.

Gardner, E. J., Simmons, M. J., & Snustad, D. P. (2006). Principles of Genetics. John Wiley & Sons.

Gupta, P. K. (2010). Genetics. Rastogi Publications.

Lewin, B. (2008). Genes IX. Jones & Bartlett Learning.

Miglani, G. S. (2009). Advanced Genetics. Narosa Publishing House.

Pierce, B. A. (2008). Genetics: A Conceptual Approach. W. H. Freeman and Company.

Rastogi, V. B. (2008). A Textbook of Genetics and Evolutionary Biology. Kedar Nath Ram Nath.

Singh, B. D. (2012). Genetics. Kalyani Publishers.

Snustad, D. P., & Simmons, M. J. (2012). Principles of Genetics. John Wiley & Sons.

Swaminathan, M. S., & Singh, S. (2010). Cytogenetics and Plant Breeding. Narosa Publishing House.

Tamarin, R. H. (2004). Principles of Genetics. Tata McGraw-Hill Education.

Verma, P. S., & Agarwal, V. K. (2012). Cell Biology, Genetics, Molecular Biology, Evolution and Ecology. S. Chand & Company Ltd.

Progressive Education Society's

Modern College of Arts, Science and Commerce,

Shivajinagar, Pune - 5

Third Year of B.Sc. Botany

(2024 Course under NEP 2020)

Course Code: 24ScBotU5104 **Course Name: Plant Breeding**

Teaching Scheme: TH: 2 Hours/Week **Credit: 02**

Examination Scheme: CIE: 20 Marks **End-Sem: 30 Marks**

Pre-requisite: A student taking this course should have a foundational understanding of General Botany and Principles of Genetics. Specifically, knowledge of plant anatomy, physiology, reproduction (including meiosis and mitosis), and basic Mendelian inheritance (concepts of genes, alleles, dominance, segregation) is essential. Familiarity with cell biology and terminology related to chromosomes (ploidy, etc.) will be highly beneficial.

Course Objectives:

- To introduce students to the history, objectives, and fundamental importance of plant breeding in crop improvement.
- To explain the modes of plant reproduction and their genetic consequences for breeding strategies in self- and cross-pollinated species.
- To acquaint students with the principles, procedure, and applications of plant introduction and acclimatization.
- To describe and compare the methods, steps, and applications of major conventional plant breeding techniques, including selection, hybridization, and mutation breeding.
- To explain the concepts of heterosis and inbreeding depression and their practical significance in developing hybrid cultivars.
- To analyze the role of polyploidy and aneuploidy in plant evolution and their application in the genetic improvement of crops.

Course Outcomes:

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

- Define the fundamental goals of plant breeding and assess its role in addressing global food security challenges.
- Correlate a crop's reproductive system (self- or cross-pollination) with the appropriate breeding methodology and expected genetic structure of its varieties.
- Design a basic procedure for introducing and acclimatizing a new plant genotype to a specific environment.
- Differentiate between the steps, advantages, and limitations of common breeding methods like mass selection, pure-line selection, and inter-varietal hybridization.
- Explain the genetic basis of hybrid vigor (heterosis) and justify the use of backcross breeding for transferring specific traits.
- Classify different types of polyploids (autopolyploid vs. allopolyploid) and cite examples of their application in developing improved crop species.

Course Contents:

Unit 1	**Introduction to Plant Breeding**	**2 L**
	1.1 History and objectives of plant breeding: Importance of plant breeding in crop improvement 1.2 Basic Concepts: Genetic basis of plant breeding (genotype, phenotype, variation)	
Unit 2	**Modes of Reproduction and Pollination Control**	**3 L**
	2.1 Asexual and sexual reproduction: Self-pollination and cross-pollination 2.2 Genetic consequences: Homogeneity in self-pollinated crops, heterogeneity in cross-pollinated crops 2.3 Mechanisms to promote self- and cross-pollination 2.4 Relevance of mode of reproduction to plant breeding	
Unit 3	**Plant Introduction and Acclimatization**	**3 L**
	3.1 Concept of plant introduction and its history 3.2 Procedure of plant introduction 3.3 Purpose of plant introduction 3.4 Important achievements, merits and demerits of plant introduction	
Unit 4	**Methods of Plant Breeding**	**15 L**
	4.1 Selection: Mass selection, pure-line selection, clonal selection, advantages and limitations of different selection methods 4.2 Hybridization: Procedure and types of hybridization (inter-varietal, inter-specific, inter-generic), Production of hybrids and their significance in crop improvement 4.3 Heterosis (Hybrid Vigor) and inbreeding depression: Concept and significance in agriculture 4.4 Backcross breeding: Use of backcrossing in transferring traits 4.5 Mutation breeding: Use of induced mutations for crop improvement	
Unit 5	**Polyploidy in Plant Breeding**	**7 L**
	5.1 History of heteroploidy 5.2 Applications of aneuploidy in crop improvement 5.3 Autopolyploidy – Origin and production 5.4 Morphological and cytological features of autopolyploids 5.5 Applications of autopolypoidy and crop improvement 5.6 Allopolypoidy- Origin and production 5.7 Applications of allopolypoidy in crop improvement	

Suggested readings:

Jain, H. K., & Kharkwal, M. C. (2004). Plant Breeding: Principles and Methods. Narosa Publishing House.

Purohit, S. S. (2009). Plant Breeding and Biotechnology: Concepts and Perspectives. Agrobios (India).

Singh, B. D. (2014). Plant Breeding: Principles and Methods. Kalyani Publishers.

Swaminathan, M. S., & Singh, S. (2010). Cytogenetics and Plant Breeding. Narosa Publishing House.

Tamarin, R. H. (2004). Principles of Genetics. Tata McGraw-Hill Education.

Progressive Education Society's
Modern College of Arts, Science and Commerce,
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Third Year of B.Sc. Botany
(2024 Course under NEP 2020)

Course Code: 24ScBotU5105 **Course Name: Lab Course on 24ScBotU5101 and 24ScBotU5102**

Teaching Scheme: PR: 4 Hours/Week **Credit: 02**

Examination Scheme: CIE: 20 Marks **End-Sem: 30 Marks**

Prerequisite: Basic knowledge of biochemistry, microbiology, and plant physiology is required. Familiarity with laboratory techniques such as centrifugation, electrophoresis, and spectrophotometry is recommended.

Course Objectives:

- To visualize and analyze different stages of somatic and meiotic cell division, and understand induced chromosomal aberrations.
- To identify major cell organelles from electron micrographs and correlate ultrastructure with function.
- To isolate and quantify genomic DNA from plant tissue and study factors affecting its stability.
- To isolate and separate seed storage proteins using the technique of SDS-Polyacrylamide Gel Electrophoresis (SDS-PAGE).
- To perform basic molecular biology techniques, including plasmid DNA isolation and restriction enzyme digestion.
- To develop skills in scientific documentation, including preparing karyotypes (ideograms) and interpreting gel patterns.

Course Outcomes:

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

- Prepare temporary squashes of onion root tip/flower buds to study, identify, and document the various stages of mitosis and meiosis.
- Induce and observe C-metaphase using a spindle inhibitor (e.g., colchicine) and construct a simple ideogram from the observed metaphase chromosomes.
- Isolate genomic DNA from a plant source (e.g., pea seedlings, onion) and estimate its concentration/purity using a spectrophotometric or colorimetric method.
- Demonstrate the effect of physical (temperature) and chemical (alkali) denaturation on DNA.
- Extract proteins from seeds, separate them based on molecular weight using SDS-PAGE, and analyze the banding pattern.
- Isolate plasmid DNA from bacterial culture, perform restriction digestion, and separate the resulting fragments by agarose gel electrophoresis.

Course Contents:

1. Study of mitosis and meiosis in suitable plants 2P
2. Study of cell organelles from electron micrographs 1P
3. Induction of C-metaphase in the cells of suitable plants 1P
4. Isolation of chloroplast and their microscopic observations 1P
5. Isolation of mitochondria and biochemical confirmation of the isolated fraction 1P
6. Demonstration of cytoplasmic streaming 1P
7. Isolation of DNA from a suitable plant material 1P
8. Estimation of DNA with suitable method 1P
9. Demonstration of denaturation of DNA 1P
10. Isolation of seed storage proteins and separation by SDS-PAGE 2P
11. Isolation of plasmid DNA 1P
12. Demonstration of restriction digestion of plasmid DNA and separation of fragments. 1P

Progressive Education Society's

Modern College of Arts, Science and Commerce,
Shivajinagar, Pune - 5

Third Year of B.Sc. Botany
(2024 Course under NEP 2020)

Course Code: 24ScBotU5106 Course Name: Lab on 24ScBotU5103 and 24ScBotU5104

Teaching Scheme: TH: 4 Hours/Week **Credit: 02**
Examination Scheme: CIA: 20 Marks **End-Sem: 30 Marks**

Pre-requisite: Students should have a foundational understanding of cell biology, including chromosome structure, genetic mutations, and basic lab skills such as microscopy and sample staining. Familiarity with genetic concepts like polyploidy and gene mapping will aid in understanding complex genetic analyses.

Course Objectives:

- To apply Mendelian principles and mapping functions to solve genetic crosses and construct linkage maps from given data.
- To visualize and analyze chromosomal variations, including structural aberrations, polyploidy, and giant polytene chromosomes, through microscopic techniques.
- To identify and document phenotypic expressions of mutations and genetic variations in model plant systems.
- To perform fundamental plant breeding techniques, including artificial hybridization and the induction of genetic variation via mutation and polyploidy.
- To construct a karyotype (ideogram) from cytological preparations and understand its significance in genetics and breeding.
- To evaluate the characteristics and applications of different crop varieties and hybrids in modern agriculture.

Course Outcomes:

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

- Solve numerical problems related to monohybrid, dihybrid, and three-point test crosses, and deduce gene order and map distances.
- Prepare temporary squashes to demonstrate specific cytogenetic phenomena, such as C-metaphase in onion root tips and polytene chromosomes in Chironomus larvae.
- Identify and describe mutant phenotypes (e.g., in Maize kernels) and structural heterozygosity (e.g., in Rhoeo).
- Perform essential steps of plant hybridization, including emasculation, bagging, and pollination, on a suitable flowering plant.
- Induce and observe genetic variations by applying mutagens or spindle inhibitors to plant materials and noting the cytological/phenotypic outcomes.
- Prepare an ideogram from a given set of metaphase chromosomes and critically compare the features of released crop varieties and hybrids.

Course Contents:

1. Problem solving based on monohybrid and dihybrid crosses 2P
2. Study of structural heterozygotes (multiple translocations) in *Rhoeo* 2P
3. Study of mutant phenotypes in Maize and *Arabidopsis* 1P
4. Induction of C-metaphase in suitable plant cells 1P
5. Preparation of salivary gland chromosomes in *Chironomus* larvae 1P
6. Preparation of ideogram and study of karyotype of a suitable plant 1P
7. Analysis of three-point test cross data and mapping of genes 1P
8. Demonstration of plant hybridisation technique 1P
9. Induction of mutations in a suitable plant. 1P
10. Induction of tetraploidy in suitable plant 1P
11. Study of crop varieties and hybrids 1P
12. Excursion tour/Field visit to a plant breeding centre/lab 2P

Progressive Education Society's
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Third Year of B.Sc. Botany
(2024 Course under NEP 2020)

Course Code: 24ScBotU5201 **Course Name: Ecology and Plant Pathology**

Teaching Scheme: TH: 2 Hours/Week **Credit: 02**
Examination Scheme: CIE: 20 Marks **End-Sem: 30 Marks**

Prerequisite: A student taking this course should have a foundational understanding of General Botany and Introductory Microbiology. Specifically, knowledge of plant anatomy, physiology, taxonomy, and basic cell biology is essential. Familiarity with fundamental biological concepts like classification, reproduction, and cell structure of fungi and bacteria will be highly beneficial for the plant pathology units.

Course Objectives:

- To introduce students to the fundamental concepts, components, and interactions within ecological systems, including biotic and abiotic factors.
- To explain the structure, function, and energy dynamics of different ecosystems and the process of ecological succession leading to a climax community.
- To acquaint students with the morpho-physiological adaptations of plants (hydrophytes, xerophytes, etc.) in response to their ecological niches.
- To introduce the causal agents, symptoms, and economic importance of major plant diseases caused by fungi, bacteria, viruses, and other pathogens.
- To describe the mechanisms of host-pathogen interaction, disease development (epidemiology), and principles of plant disease diagnosis.
- To explain the integrated strategies for plant disease management, including cultural, biological, chemical, and host-resistance methods.

Course Outcomes:

On completion of the course, students will be able to–

- Analyze the structure of a given ecosystem by identifying biotic interactions and explaining energy flow through food chains and ecological pyramids.
- Compare and contrast the morphological and physiological adaptations of hydrophytes, mesophytes, xerophytes, and halophytes to their specific environments.
- Explain the process of ecological succession, predicting the changes in species composition and community structure from a pioneer to a climax stage.
- Identify and classify common plant diseases based on visible symptoms and associate them with their respective causal agents (fungal, bacterial, viral, etc.).
- Illustrate the stages of disease development using the disease triangle framework, highlighting the role of the host, pathogen, and conducive environment.
- Design an integrated disease management (IDM) strategy for a given crop disease, combining appropriate principles of avoidance, exclusion, eradication, and protection.

Course Contents:

Unit 1	**Introduction to Ecology**	**3 L**
	1.1. Concept and Definition 1.2. Biotic and Abiotic Environment 1.3. Interactions-Interspecific competition, herbivory, carnivory, pollination, symbiosis. 1.4. Concept of habitat and niche, types of niche	
Unit 2	**Ecosystems and Ecological Succession**	**9 L**
	2.1. Structure and function of ecosystems: terrestrial (forest, grassland) and aquatic (freshwater, marine, and estuarine) 2.2. Energy flow in ecosystems 2.3. Food chains and food webs 2.4. Ecological pyramids 2.5. Biogeochemical cycles 2.6. Productivity in ecosystems 2.7. Concept of ecological succession, its types and mechanisms 2.8. Changes involved in succession 2.9. Concept of climax community	
Unit 3	**Adaptation**	**3 L**
	3.1. Concept 3.2. Ecological grouping of plants: Hydrophytes, Mesophytes, Xerophytes and Halophytes	
Unit 4	**Introduction to Plant Pathology**	**5 L**
	4.1 Introduction to Plant Pathology: scope, importance, historical developments, classification of plant diseases. 4.2 Fungal Pathogens: characteristics, taxonomy, reproduction, infection process; examples: Downy mildew of grapes, Tikka disease of groundnut. 4.3 Bacterial Pathogens: features of phytopathogenic bacteria, modes of infection; examples: citrus canker, Black arm of Cotton.	

	4.4 Viruses and Viroids: structure, transmission, symptoms; examples: Tobacco Mosaic (TMV), Bunchy top of Banana. 4.5 Other Pathogens: nematodes, phytoplasmas, parasitic plants; brief overview of abiotic diseases.	
Unit 5	**Host-Pathogen Interactions and Epidemiology**	**5 L**
	5.1 Pathogenesis: stages of disease development, role of enzymes, toxins, and growth regulators. 5.2 Epidemiology: disease triangle, influence of environment, disease cycles, forecasting. 5.3 Host Defense Mechanisms: pre-existing and induced defenses, hypersensitive response, phytoalexins. 5.4 Genetics of Disease Resistance: vertical vs. horizontal resistance, gene-for-gene hypothesis. 5.5 Disease Diagnosis: field and laboratory methods, serological and molecular techniques (ELISA, PCR basics).	
Unit 6	**Disease Development**	**5 L**
	6.1 Principles of Management: avoidance, exclusion, eradication, chemical control (fungicides, bactericides). 6.2 Biological and Cultural Control: mechanisms, agents (*Trichoderma*, *Pseudomonas*), cultural practices. 6.3 Host Resistance and Breeding: methods for developing resistant varieties, durable resistance. 6.4 Integrated Disease Management (IDM): conc 6.5 epts, components, case studies (e.g., rice blast, grape downy mildew). 6.6 Emerging Trends: impact of climate change, new pathogens, biotechnology in disease management.	

Suggested readings:

Agrios, G.N. Plant Pathology. 5th Ed., 2005. Academic Press.
Arihant Experts. Environment and Ecology. Arihant Publications.
Bharucha, E. Textbook of Environmental Studies for Undergraduate Courses. University Grants Commission.

Joseph, B. Environmental Studies. Tata McGraw Hill Education.
Lucas, J.A., et al. Plant Pathology and Plant Pathogens. 4th Ed., 2015. Wiley-Blackwell.
Maloy, O.C. & T.D. Murray. Encyclopedia of Plant Pathology. 2 Vols., 2001. Wiley.
Matthews, R.E.F. Plant Virology. 4th Ed., 2002. Academic Press.
Mehrotra, R.S. & Ashok Aggarwal. Plant Pathology. 2nd Ed., 2017. McGraw Hill.
Narayanasamy, P. Biological Management of Diseases of Crops. 2013. Springer.
Naqvi, S.A.M.H. Diseases of Fruits and Vegetables. 2004. Springer.
Odum, E. P. Fundamentals of Ecology. Cengage Learning.
Pratiyogita Darpan. CSAT Environmental Ecology, Biodiversity & Climate Change. 2012. Upkar Prakashan.
Rajagopalan, R. Environmental Studies: From Crisis to Cure. Oxford University Press.
Schumann, G.L. & C.J. D'Arcy. Hungry Planet: Stories of Plant Diseases. 2012. APS Press.
Sharma, P. D. Ecology and Environment. Rastogi Publications.
Singh, B. B. Objective Environmental Sciences. McGraw Hill Education.
Singh, J. S., Singh, S. P., & Gupta, S. R. Ecology, Environmental Science & Conservation. 2014. S. Chand Publishing.
Singh, R.S. Plant Diseases. 10th Ed., 2017. Scientific Publishers (India).
Srivastava, A.K. & Ajay Kumar. Integrated Disease Management. 2019. Kalyani Publishers.
Vidhyasekaran, P. Physiology of Disease Resistance in Plants. 1988. CRC Press.

Progressive Education Society's

Modern College of Arts, Science and Commerce,
Shivajinagar, Pune - 5

Third Year of B.Sc. Botany
(2024 Course under NEP 2020)

Course Code: 24ScBotU5202 **Course Name: Lab Course on 24ScBotU5101**

Teaching Scheme: PR: 4 Hours/Week **Credit: 02**
Examination Scheme: CIE: 20 Marks **End-Sem: 30 Marks**

Prerequisite: Students should have foundational knowledge of General Botany, including plant morphology and anatomy, and introductory Microbiology. Basic laboratory skills, such as using a microscope and preparing slides, are assumed.

Course Objectives:

- To familiarize students with the use of common ecological instruments and field sampling techniques.
- To analyze the morphological and anatomical adaptations of hydrophytes and xerophytes.
- To apply analytical methods for assessing water quality (BOD, pH, chloride, phosphate).
- To study plankton diversity and vegetation using ecological sampling methods.
- To learn aseptic techniques, media preparation, and Koch's postulates for plant pathogen isolation.
- To identify symptoms of major plant diseases and understand the use of biopesticides in disease management.

Course Outcomes:

On completion of the course, students will be able to–

- Operate basic ecological instruments and perform vegetation sampling using the quadrat method.
- Identify and compare the adaptive features of hydrophytes and xerophytes through microscopic study.
- Estimate water pollution levels by performing BOD and chemical parameter (pH, chloride, phosphate) analysis.
- Isolate plant pathogens using appropriate culture media and demonstrate Koch's postulates.
- Prepare pure microbial cultures using streak, pour, and spread plate techniques.
- Diagnose common fungal, bacterial, and viral plant diseases and explain the role of biopesticides in their control.

Course Contents

1. Types and uses of ecological instruments 1P
2. Study of ecological adaptations in hydrophytes and xerophytes 2P
3. Determination of BOD from given water sample 2P
4. Determination of pH, chlorides and phosphates from the given sample 1P
5. Study of the plankton communities in a fresh-water ecosystem. 1P

6. Determination of minimal quadrat size for the study of herbaceous vegetation 1P
7. Study of vegetation by list count quadrat method 1P
8. Visit to a forest/ river/ wetland ecosystem. 1P
9. Preparation of any one culture medium for isolation of plant pathogens. 1P
10. Study of Koch's Postulates 1P
11. Culture technique - Streak plate methods, pour plate methods, spread plate and serial dilution method for preparation of pure culture. 1P
12. Study of any two of each fungal, bacterial and viral diseases. 1P
13. Study of any four of biopesticides. 1P

Progressive Education Society's

Modern College of Arts, Science and Commerce,

Shivajinagar, Pune - 5

Third Year of B.Sc. Botany

(2024 Course under NEP 2020)

Course Code: 24ScBotU5203 **Course Name: Landscaping and Gardening**

Teaching Scheme: TH: 2 Hours/Week **Credit: 02**

Examination Scheme: CIE: 20 Marks **End-Sem: 30 Marks**

Prerequisite: A basic understanding of plant biology, horticulture, and environmental aesthetics is recommended. Familiarity with gardening techniques, plant care, and landscape design concepts will be beneficial. Additionally, an interest in art, design, and cultural aspects of gardening will enhance learning.

Course Objectives:

- Introduce students to the history, importance, and scope of gardening and landscaping.
- To develop an understanding of bioesthetic planning and its application in urban and rural settings.
- To explore various garden styles, designs, and their cultural significance.
- To provide knowledge about different types of gardens, their components, and maintenance.
- To familiarize students with popular gardens in India and their unique features.
- To teach the art of flower arrangement, terrarium creation, and bonsai cultivation.

Course Outcomes:

On completion of the course, students will be able to–

- Explain the historical background, principles, and components of gardening and landscaping.
- Demonstrate the ability to plan and design bioesthetic landscapes for various settings, including urban and rural areas.
- Identify and differentiate between formal and informal garden styles and their design elements.
- Gain practical skills in creating and maintaining lawns, rock gardens, vertical gardens, and other specialized garden types.
- Analyze and appreciate the design and cultural significance of popular gardens in India.
- Develop proficiency in flower arrangement, terrarium making, and bonsai cultivation techniques.

Course Contents:

Unit 1	**Introduction**	**2 L**
	1.1. History, importance and scope of gardening 1.2. Landscaping – definition, historical background 1.3. Design, basic principle and components of gardens and landscapes	
Unit 2	**Bioesthetic planning**	**8 L**
	2.1. Definition, need, round country planning 2.2. Concept of urban landscaping 2.3. Planning and planting avenues for schools, villages, beautifying railway stations, dam sites, hydroelectric stations, colonies, and river banks 2.4. Planting material for playgrounds 2.5.	
Unit 3	**Gardens**	**11 L**
	3.1. Concept, garden components and their importance 3.2. Styles of the garden: Formal and Informal 3.3. Concept and design of lawns 3.4. Types of lawns and planting materials 3.5. Care of lawns 3.6. Types of gardens – Persian gardens, Mughal gardens, English gardens, French gardens, Spanish gardens, Japanese gardens	
Unit 4	**Popular gardens in India**	**6 L**
	4.1. Design and components of: Temple Garden, water garden, Vertical gardens, roof gardens, terrace gardens, Rock Gardens (methods of designing rockery, layout of rockery), Clock Gardens, miniature gardens, Table gardens, window gardens, indoor gardens, 4.2. Parks and public gardens	

Unit 5	Flower arrangements and Bonsai	3 L
	5.1 Concept, designs and materials for flower arrangement 5.2 Terrarium 5.3 Bonsai- Concept, styles and methods	

Suggested readings:

Arora, J. S. (1998). Introductory Ornamental Horticulture. Kalyani Publishers.

Bose, T. K., Maiti, R. G., Dhua, R. S., & Das, P. (2003). Floriculture and Landscaping. Naya Prakash.

Bose, T. K., & Yadav, L. P. (Eds.). (1988). Commercial Flowers. Naya Prokash.

Randhawa, G. S. (1986). Floriculture in India. Allied Publishers.

Roy Choudhry, N., & Mishra, H. P. (2005). Textbook on Floriculture and Landscaping. Kalyani Publishers.

Shrivastava, S. S. (2002). Udyan Vigyan. Central Book House. (In Hindi)

Swarup, V. (1997). Ornamental Horticulture. Macmillan India Ltd.

Yadav, I. S., & Choudhary, M. L. (1997). Progressive Floriculture. The House of Sarpan.

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Shivajinagar, Pune – 5

Third Year of B.Sc. Botany

(2024 Course under NEP 2020)

Course Code: 24ScBotU5204 **Course Name: Lab Course on 24ScBotU5202**

Teaching Scheme: TH: 4 Hours/Week **Credit: 02**

Examination Scheme: CIE: 20 Marks **End-Sem: 30 Marks**

Prerequisite: A basic understanding of plant biology, horticulture, and landscape design principles is required. Familiarity with garden tools, plant identification, and propagation techniques will be beneficial. Additionally, an interest in practical gardening and design aesthetics is recommended.

Course Objectives:

- To develop skills in identifying physical elements of landscapes (hardscape) and various ornamental plants.
- To familiarize students with garden tools, implements, and their uses in landscaping.
- To teach the principles and techniques of designing residential and public gardens, water gardens, and rock gardens.
- To provide hands-on experience in preparing Bill of Quantities (BOQ) for garden designs.
- To introduce students to tray landscapes, terrarium designing, and propagation methods for ornamental plants.
- To enhance practical knowledge through visits to botanical gardens and real-world applications of landscaping.

Course Outcomes:

On completion of the course, students will be able to–

- Identify and classify physical elements of landscapes and various ornamental plants.
- Demonstrate proficiency in using garden tools and implements for landscaping purposes.
- Design residential and public gardens, water gardens, and rock gardens using appropriate techniques.
- Prepare accurate Bill of Quantities (BOQ) for given garden designs.
- Create tray landscapes and terrariums, and apply propagation methods for ornamental plants.
- Gain practical insights into landscaping through visits to botanical gardens and real-world applications.

Course Contents:

1. Identification of physical elements in landscape (Hardscape) 1P
2. Identification of plants- ground cover plants and bulbous plants, hedge and edge, pergolas, arches, palms, foliage and flowering shrubs, foliage and flowering, climbers and ramblers, lawn grasses and plantation of lawn. 2P
3. Identification of garden tools and implements. 1P
4. Landscape designing of residential area and Public Garden 2P
5. Designing of Water Garden and Rock Garden 2P

6. Estimation of given garden design- BOQ preparation 1P
7. Designing of tray landscape. 1P
8. Study of terrarium designing. 2P
9. Study of propagation methods of ornamental plants. 2P
10. Visit to a botanical garden. 1P

Progressive Education Society's
Modern College of Arts, Science and Commerce,
Shivajinagar, Pune - 5

Third Year of B.Sc. Botany
(2024 Course under NEP 2020)

Course Code: 24ScBotU5501 Course Name: Lab on Plant Analytical Techniques
Teaching Scheme: PR: 4 Hours/Week Credit: 02
Examination Scheme: CIE: 20 Marks End-Sem: 30 Marks

Prerequisite: A student should have fundamental knowledge of Plant Biochemistry, proficiency in basic laboratory skills, familiarity with core instruments and prior exposure to the basic principles and operation of a light microscope, and a conceptual grasp of colorimetry, spectrophotometry, titration, and basic separation techniques.

Course Objectives:

- To master fundamental extraction techniques (Soxhlet, maceration, percolation) for isolating phytochemicals from plant material.
- To apply basic chromatographic techniques (Thin Layer Chromatography and Column Chromatography) for the separation of plant compounds.
- To perform quantitative colorimetric and spectrophotometric assays to estimate major primary metabolites (carbohydrates, amino acids) and photosynthetic pigments.
- To quantify key groups of secondary metabolites (phenolics, flavonoids, alkaloids) and nutrients (Vitamin C) using standard biochemical protocols.
- To develop precision in microscopic biometry by calibrating and using stage and ocular micrometres for cell measurement.
- To systematically record experimental procedures, analyze generated data, and interpret results within a biochemical context.

Course Outcomes:

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

- Operate standard extraction apparatus (Soxhlet) and perform maceration and percolation to obtain crude plant extracts.
- Separate and analyze plant compounds (e.g., alkaloids, pigments) using Thin Layer Chromatography (TLC) and demonstrate the principle of column chromatography.
- Quantify the concentration of total carbohydrates, reducing sugars, starch, and free amino acids in a given plant sample using specific colorimetric methods.
- Estimate the content of total chlorophyll, phenolics, flavonoids, and alkaloids from plant tissues through spectrophotometric and gravimetric techniques.
- Determine the ascorbic acid (Vitamin C) content in fruit/plant samples via volumetric titration.
- Calibrate a compound microscope and accurately measure the dimensions of plant cells and organelles using a stage and ocular micrometre.

Course Contents:

1.	Demonstration of Soxhlet extraction, maceration, and percolation to extract phytochemicals.	1P
2.	TLC separation of alkaloids from suitable plant material	1P
3.	Demonstration of column chromatography for the separation of a mixture of phytochemicals	1P
4.	Quantification of total phenolic content	1P
5.	Quantification of total flavonoid content	1P
6.	Isolation of tannins from suitable plant material	1P
7.	Separation of plant pigments based on solubility	1P
8.	Estimation of total carbohydrates by anthrone method	1P
9.	Quantitative estimation of reducing sugars by DNSA method	1P
10.	Estimation of starch content by acid hydrolysis method	1P
11.	Estimation of total free amino acids by ninhydrin method	1P
12.	Spectrophotometric estimation of chlorophyll 'a', 'b' and total chlorophyll	1P
13.	Quantitative estimation of total alkaloids	1P
14.	Determination of vitamin c (ascorbic acid) by titration	1P
15.	Linear measurement of plant cells/tissues/organs by using stage and ocular micrometres	1P

Progressive Education Society's
Modern College of Arts, Science and Commerce,
Shivajinagar, Pune - 5

Third Year of B.Sc. Botany
(2024 Course under NEP 2020)

Course Code: 24ScBotU5301 **Course Name: Plant Physiology and Biochemistry (Practical)**

Teaching Scheme: TH: 2 Hours/Week **Credit: 02**
Examination Scheme: CIE: 20 Marks **End-Sem: 30 Marks**

Prerequisite: A student should have foundational knowledge of General Botany (especially plant structure and basic processes like photosynthesis and transpiration) and Introductory Chemistry (understanding of pH, solutions, and biomolecules). Basic laboratory skills in handling glassware, preparing solutions, and using a microscope are assumed.

Course Objectives:

- To learn techniques for measuring key plant water relations parameters like Diffusion Pressure Deficit (DPD) and stomatal frequency.
- To demonstrate fundamental physiological processes such as photosynthesis, transpiration, and mineral nutrition.
- To perform qualitative and quantitative biochemical analyses of plant constituents (sugars, proteins, pigments, metabolites).
- To develop skills in chromatography for separating and identifying plant pigments and amino acids.
- To study the factors affecting enzyme activity and understand the fundamentals of enzyme kinetics.
- To perform classical demonstration experiments illustrating core physiological principles (e.g., plasmolysis, imbibition, transpiration pull).

Course Outcomes:

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

- Measure stomatal frequency and calculate DPD to assess plant-water relations.
- Demonstrate oxygen production in photosynthesis using the floating disc assay and separate photosynthetic pigments via paper chromatography.
- Perform quantitative estimations of reducing sugars and proteins from plant tissues using standard colorimetric methods.
- Separate and identify amino acids using paper chromatography and conduct qualitative tests for primary and secondary metabolites.
- Analyze the effects of pH and substrate concentration on enzyme activity to understand basic enzyme kinetics.
- Set up and explain classical physiology demonstrations (e.g., transpiration pull, plasmolysis) to illustrate core concepts.

Course Contents:

1.	Determination of diffusion pressure deficit (DPD)	1P
2.	Determination of stomatal frequency	1P
3.	Determination of the rate of transpiration under different conditions.	1P
4.	Determination of water holding capacity (WHC) and pH of soil.	1P
5.	Floating disc assay to demonstrate photosynthesis	1P
6.	Separation of chlorophyll pigments by chromatography	1P
7.	Demonstration of mineral deficiencies	2P
8.	Plant physiology demonstration experiments - transpiration pull, plasmolysis, imbibition, effect of PGRs, ringing experiment	2P
9.	Estimation of reducing sugars by a suitable method	1P
10.	Estimation of proteins by Lowry's method	1P
11.	Qualitative tests for primary and secondary metabolites	1P
12.	Separation of amino acids by paper chromatography	1P
13.	Effect of pH and substrate concentration on enzyme activity	2P

Progressive Education Society's
Modern College of Arts, Science and Commerce,
Shivajinagar, Pune - 5

Third Year of B.Sc. Botany
(2024 Course under NEP 2020)

Course Code: 24ScBotU6101 **Course Name: Palaeobotany**
Teaching Scheme: TH: 2 Hours/Week **Credit: 02**
Examination Scheme: CIE: 20 Marks **End-Sem: 30 Marks**

Pre-requisite: Knowledge of General Botany, including the morphology, anatomy, and life cycles of major plant groups (Algae, Bryophytes, Pteridophytes, Gymnosperms, and Angiosperms). Familiarity with basic geological time periods is beneficial.

Course Objectives:

- To understand the fundamentals of palaeobotany, including fossil formation, types, and key fossil localities in India.
- To study the morphology and anatomy of significant fossil plants representing major groups (*Psilopsida, Lycopsida, Sphenopsida*).
- To examine the characteristic features of fossil groups crucial to seed plant evolution (Pteridosperms, Pentoxylae, Bennettitales).
- To correlate the evolution of major plant groups with the geological time scale.
- To analyze the major theories concerning the origin and evolution of angiosperms.
- To appreciate the practical applications of palaeobotanical studies

Course Outcomes:

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

- Explain the processes of fossil formation and classify different types of fossils.
- Identify and describe the key morphological and anatomical features of representative fossil plants like *Rhynia*, *Lepidodendron*, and *Calamites*.
- Distinguish between the salient features of important fossil gymnosperm groups: Pteridosperms, Pentoxylae, and Bennettitales.
- Correlate the emergence of major plant groups (e.g., first vascular plants, first seed plants) with specific geological eras/periods.
- Compare and contrast the major theories related to the origin of angiosperms.
- Discuss the applications of palaeobotany in fields like geology, evolution, and climate studies.

Course Contents:

Unit 1	**Introduction**	**5 L**
	1.1. Definition and concept 1.2. Paleobotanical studies and fossil localities in India 1.3. Fossil formation and Form genera concept 1.4. Types of fossils	

Unit 2	**Fossil groups of plants**	**12 L**
	3.1. Psilopsida- Salient features of order Psilophytales, external and internal morphology of Rhynia. 3.2. Lycopsida- Salient features of order Lepidodendrales, external and internal morphology of *Lepidodendron*, 3.3. Sphenopsida- Salient features of Calamitales, external and internal morphology of *Calamites* 3.4. Pteridosperms- External and internal morphology of *Lyginopteris oldhamia*. 3.5. Pentoxylae- Salient feature, external and internal morphology of stem [*Pentoxylon*], Leaf [*Nipaniophyllum*]. 3.6. Bennettitales – Salient features, external morphology of *Cycadeoidea*, *Williamsonia* and *Williamsoniella*	
Unit 3	**Origin of Angiosperms**	**11 L**
	4.1. Geological time scale and evolution of major plant groups 4.2. Origin of Angiosperms – Theories 4.3. Speciation 4.4. Endemism	
Unit 4	**Applications of palaeobotany**	**2 L**

Suggested readings:

Spicer, R. A., & Collinson, M. E. (2014). Introduction to plant fossils. Cambridge University Press.

Stewart, W. N., & Rothwell, G. W. (1993). Paleobotany and the evolution of plants (2nd ed.). Cambridge University Press.

Taylor, T. N., Taylor, E. L., & Krings, M. (2009). Paleobotany: The biology and evolution of fossil plants (2nd ed.). Academic Press.

Vasishta, P. C., Sinha, A. K., & Singh, V. P. (2010). Botany for degree students: Part III—Plant taxonomy (1st ed.). S. Chand Publishing.

Progressive Education Society's
Modern College of Arts, Science and Commerce,
Shivajinagar, Pune - 5

Third Year of B.Sc. Botany
(2024 Course under NEP 2020)

Course Code: 24ScBotU6102 **Course Name: Plant Systematics**
Teaching Scheme: TH: 2 Hours/Week **Credit: 02**
Examination Scheme: CIE: 20 Marks **End-Sem: 30 Marks**

Pre-requisite: Knowledge of basic plant morphology, including floral parts, fruit types, and vegetative structures, as covered in introductory Botany courses.

Course Objectives:

- To understand the principles, scope, and phases of plant systematics and taxonomy.
- To compare the basis, merits, and limitations of major historical and modern plant classification systems (Linnaeus, Bentham & Hooker, APG).
- To apply the key rules of the International Code of Nomenclature (ICN) for correct plant naming.
- To explore the practical tools and resources used in taxonomy, including herbaria, botanical gardens, and taxonomic literature.
- To study the diagnostic morphological characters and economic importance of selected angiosperm families.
- To prepare and interpret floral formulas and diagrams for family identification.

Course Outcomes:

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

- Distinguish between the concepts of taxonomy and systematics and outline the phases of taxonomic work.
- Compare the fundamental principles and approaches of artificial, natural, and phylogenetic classification systems.
- Apply the basic rules of botanical nomenclature to write and interpret scientific plant names correctly.
- Describe the purpose and use of key taxonomic tools such as herbaria, botanical gardens, and standard literature.
- Identify plants to the family level using diagnostic characters and describe their economic importance.
- Construct floral formulas and diagrams for the families studied.

Course Contents:

Unit 1	**Introduction to Plant Systematics**	**2 L**
	1.1. Concept of Plant Taxonomy and Systematics 1.2. Aspects of Plant Taxonomy 1.3. Phases of Plant Taxonomy	

Unit 2	**Classification systems for plants**	**5 L**
	2.1. Types of classification systems 2.2. Linnaeus's artificial system (basis, outline, merits and limitations) 2.3. Bentham and Hooker's natural system (basis, outline, merits and limitations) 2.4. Engler and Prantl's phylogenetic system (basis, outline, merits and limitations) 2.5. APG 4.0 system of classification	
Unit 3	**Botanical nomenclature**	**7 L**
	3.1 Introduction and Objectives 3.2 ICN: Rules, recommendations; Principles 3.3 Important rules of nomenclature 3.4 (Priority of publication, Nomina conservanda, Author's citation, Rank and ending of taxa names and valid and effective publication) 3.5 Typification and its types	
Unit 4	**Tools of Taxonomy**	**4 L**
	4.1 Introduction 4.2 Herbaria and Museums 4.3 Botanic Gardens 4.4 Taxonomic literature	
Unit 5	**Study of plant families**	**12 L**
	(Diagnostic characters, floral formula, floral diagrams, systematic position and economically important plants from each family) 5.1 Magnoliaceae 5.2 Meliaceae 5.3 Fabaceae 5.4 Rubiaceae 5.5 Apocynaceae 5.6 Solanaceae 5.7 Lamiaceae 5.8 Euphorbiaceae 5.9 Amaryllidaceae 5.10 Poaceae	

Suggested readings:

Datta, S. C. (1988). Systematic botany (4th ed.). New Age International Publishers.

Judd, W. S., Campbell, C. S., Kellogg, E. A., Stevens, P. F., & Donoghue, M. J. (2016). Plant systematics: A phylogenetic approach (4th ed.). Sinauer Associates.

Maheshwari, J. K. (2000). Taxonomy of Indian plants (1st ed.). International Scientific Publishing Academy.

Naik, V. N. (1984). Taxonomy of angiosperms (1st ed.). Tata McGraw-Hill Education.

Pandey, B. P., & Trivedi, P. C. (2008). A textbook of botany: Angiosperms (1st ed.). S. Chand Publishing.

Raven, P. H., Evert, R. F., & Eichhorn, S. E. (2013). Biology of plants (8th ed.). W.H. Freeman and Company.

Sharma, O. P. (2009). Plant taxonomy (2nd ed.). Tata McGraw-Hill Education.

Shukla, P., & Misra, S. P. (2014). Plant systematics and evolution (1st ed.). Rastogi Publications.

Singh, G. (2012). Plant systematics: An integrated approach (3rd ed.). Science Publishers.

Progressive Education Society's

Modern College of Arts, Science and Commerce,

Shivajinagar, Pune - 5

Third Year of B.Sc. Botany

(2024 Course under NEP 2020)

Course Code: 24ScBotU6103 **Course Name: Plant Physiology**

Teaching Scheme: TH: 4 Hours/Week **Credit: 04**

Examination Scheme: CIE: 40 Marks **End-Sem: 60 Marks**

Pre-requisite: A foundational understanding of plant biology, including cell structure, basic biochemistry, and physiological processes, is essential. Familiarity with concepts like photosynthesis, respiration, and mineral nutrition will be beneficial. Additionally, basic knowledge of plant growth regulators and secondary metabolites is recommended to grasp advanced topics.

Course Objectives:

- To understand the scope and importance of plant physiology in agriculture and environmental biology.
- To explain the principles of mineral nutrition, including uptake mechanisms and deficiency symptoms.
- To classify and describe various plant movements (tropic, nastic) and their underlying mechanisms.
- To explain photoperiodism, vernalization, and the role of phytochrome in plant development.
- To analyze plant-water relations, including water potential and the mechanism of water transport.
- To describe the discovery, function, and agricultural applications of major plant growth regulators and hormones.

Course Outcomes:

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

- Design a basic hydroponic setup and correlate specific mineral deficiencies with visual symptoms in plants.
- Differentiate between tactic, tropic, and nastic movements with examples and explain their adaptive significance.
- Classify plants based on photoperiodic response (LDP, SDP, DNP) and explain the role of phytochrome in flowering.
- Explain the concept of water potential and illustrate the passive absorption and transport of water in the xylem.
- Compare and contrast the physiological roles and practical applications of auxins, gibberellins, cytokinins, abscisic acid, and ethylene.
- Describe the process of vernalization and its significance in crop improvement and seasonal adaptation.

Course Contents:

Unit 1	**Introduction to Plant Physiology**	**1 L**
	1.1 Definition and concept 1.2 Scope and importance	
Unit 2	**Plant Water Relations**	**4 L**
	2.1 Role of water 2.2 Physical and chemical properties of water 2.3 Concept of water potential and capillary water 2.4 Aquaporins 2.5 Mechanism of water absorption - active absorption, passive absorption, factors affecting rate of water transport Mineral deficiencies in plants	
Unit 3	**Mineral Nutrition**	**5 L**
	3.1 Major and minor elements 3.2 Role and deficiency of essential elements 3.3 Mechanism of salt uptake in plants 3.4 Concept of hydroponics 3.5 Methods of hydroponics	
Unit 4	**Photosynthesis**	**8 L**
	4.1 Structure of chloroplast 4.2 Photosynthetic pigments and their role 4.3 Light reaction (Photosystems, Electron Transport system) 4.4 Dark Reaction (C3, C4, and CAM pathways) 4.5 Salient features of C4 plants 4.6 Introduction to artificial photosynthesis 4.7 Significance of photosynthesis	
Unit 5	**Respiration**	**7 L**
	5.1 Structure of mitochondrion 5.2 Respiratory substrates 5.3 Types of respiration 5.4 Mechanism of aerobic respiration – Glycolysis, TCA cycle, Pentose Phosphate Pathway, Electron transport system 5.5 Chemi-osmotic hypothesis of ATP synthesis 5.6 Balance sheet of ATP generation in respiration and 5.7 Significance of respiration	
Unit 4	**Photomorphogenesis**	**5 L**
	4.1 Photoperiodism: Definition and concept 4.2 Long-day, short-day and day-neutral plants	

	4.3 Photoperiodic induction 4.4 Phytochromes 4.5 Importance of Photoperiodism 4.6 Vernalization: Concept, definition and perception of stimulus 4.7 Mechanism of vernalization 4.8 Significance	

Suggested readings:

Bidwell, R. G. S. (1979). Plant Physiology (Revised ed.). Macmillan Publishing Co.

Buchanan, B. B., Gruissem, W., & Jones, R. L. (2000). Biochemistry and Molecular Biology of Plants. American Society of Plant Physiologists.

Dennis, D. T., Turpin, D. H., Lefebvre, D. D., & Layzell, D. B. (Eds.). (1997). Plant Metabolism (2nd ed.). Longman.

Galston, A. W. (1989). Life Processes in Plants. Scientific American Library, Springer-Verlag.

Hopkins, W. G. (1995). Introduction to Plant Physiology. John Wiley & Sons.

Lehninger, A. C. (1987). Principles of Biochemistry. CBS Publishers & Distributors.

Moore, T. C. (1989). Biochemistry and Physiology of Plant Hormones. Springer-Verlag.

Pandey, S. N., & Sinha, B. K. (2014). Plant Physiology. Vikas Publishing House Pvt. Ltd.

Salisbury, F. B., & Ross, C. W. (1992). Plant Physiology (4th ed.). Wadsworth Publishing Company.

Taiz, L., & Zeiger, E. (1998). Plant Physiology (2nd ed.). Sinauer Associates.

Taiz, L., & Zeiger, E. (2003). Plant Physiology (3rd ed.). Panima Publishing Corporation.

Verma, S. K., & Verma, M. (2007). A Textbook of Plant Physiology, Biochemistry, and Biotechnology. S. Chand Publications.

Progressive Education Society's

Modern College of Arts, Science and Commerce,
Shivajinagar, Pune - 5

Third Year of B.Sc. Botany
(2024 Course under NEP 2020)

Course Code: 24ScBotU6104 **Course Name: Biochemistry**
Teaching Scheme: TH: 2 Hours/Week **Credit: 02**
Examination Scheme: CIE: 20 Marks **End-Sem: 30 Marks**

Prerequisite: A student should have a foundational understanding of General Chemistry (concepts of chemical bonds, acids, bases, pH, and basic organic structures) and Introductory Biology (cell structure and functions). Basic knowledge of high school-level physics related to energy is beneficial.

Course Objectives:

- To understand the fundamental chemical principles underlying biological systems, including bonding, water properties, and buffer action.
- To classify, describe the structure, and explain the biological significance of major biomolecules: carbohydrates, lipids, proteins, and nucleic acids.
- To apply the principles of bioenergetics, including thermodynamics, free energy, and the role of ATP in cellular energy transfer.
- To describe enzyme structure, classification, and the mechanism of action, including models of substrate binding.
- To analyze enzyme kinetics using the Michaelis-Menten equation and explain the effects of inhibitors and environmental factors on enzyme activity.
- To correlate the structure of biomolecules with their specific biological functions in living organisms.

Course Outcomes: On completion of the course, students will be able to–

- Explain the role of water, hydrogen bonding, and buffers in maintaining biological systems.
- Classify carbohydrates and lipids based on their structure and relate them to their storage or structural roles.
- Predict the properties of amino acids and describe how primary structure determines the higher-order structure and function of proteins.
- Differentiate between the structures of DNA/RNA nucleotides and identify the nitrogenous bases.
- Apply the concepts of free energy and coupled reactions to explain how ATP drives endergonic cellular processes.
- Interpret basic enzyme kinetic data using the Michaelis-Menten model and explain the mechanisms of competitive and non-competitive inhibition.

Course Contents:

Unit 1	**Biomolecules**	**20 L**
	1.1. Types and significance of chemical bonds 1.2. Structure and properties of water 1.3. pH and buffers 1.4. Carbohydrates: Nomenclature and classification 1.5. Monosaccharides 1.6. Disaccharides 1.7. Oligosaccharides and polysaccharides. 1.8. Lipids: Definition and major classes of storage and structural lipids 1.9. Fatty acids- structure and functions 1.10. Essential fatty acids 1.11. Triacyl glycerols structure, functions, and properties 1.12. Phosphoglycerides 1.13. Proteins: Structure of amino acids 1.14. Levels of protein structure-primary, secondary, tertiary, and quaternary 1.15. Protein denaturation and biological roles of proteins. 1.16. Nucleic acids: Structure of nitrogenous bases 1.17. Structure and function of nucleotides	
Unit 2	**Bioenergetics**	**4 L**
	2.1. Laws of thermodynamics 2.2. Concept of free energy 2.3. Endergonic and exergonic reactions, coupled reactions, and redox reactions 2.4. ATP: structure, its role as an energy currency molecule	
Unit 3	**Enzymes**	**6 L**
	3.1. Structure of enzyme: holoenzyme, apoenzyme, cofactors, coenzymes and prosthetic groups 3.2. Classification of enzymes	

	3.3. Features of the active site, substrate specificity, mechanism of action (activation energy, lock and key hypothesis, induced-fit theory) 3.4. Michaelis – Menten equation 3.5. Enzyme inhibition and factors affecting enzyme activity.	

Suggested readings:

Berg, J. M., Tymoczko, J. L., & Stryer, L. (2011). *Biochemistry*. W. H. Freeman and Company.Campbell, M. K. (2012). *Biochemistry* (7th ed.). Cengage Learning.

Campbell, P. N., & Smith, A. D. (2011). *Biochemistry illustrated* (4th ed.). Churchill Livingstone.

Cooper, G. M., & Hausman, R. E. (2009). *The cell: A molecular approach* (5th ed.). ASM Press & Sinauer Associates.

Hardin, J., Becker, G., & Skliensmith, L. J. (2012). *Becker's world of the cell* (8th ed.). Pearson Education.

Karp, G. (2010). *Cell biology* (6th ed.). John Wiley & Sons.

Nelson, D. L., & Cox, M. M. (2008). *Lehninger principles of biochemistry* (5th ed.). W. H. Freeman and Company.

Tymoczko, J. L., Berg, J. M., & Stryer, L. (2012). *Biochemistry: A short course* (2nd ed.). W. H. Freeman.

Progressive Education Society's

Modern College of Arts, Science and Commerce,
Shivajinagar, Pune - 5

Third Year of B.Sc. Botany
(2024 Course under NEP 2020)

Course Code: 24ScBotU6105 Course Name: Lab on 24ScBotU6101 and 24ScBotU6102
Teaching Scheme: TH: 4 Hours/Week Credit: 02
Examination Scheme: CIA: 20 Marks End-Sem: 30 Marks

Pre-requisite: Students should have a foundational understanding of cell biology, including chromosome structure, genetic mutations, and basic lab skills such as microscopy and sample staining. Familiarity with genetic concepts like polyploidy and gene mapping will aid in understanding complex genetic analyses.

Course Objectives:

- To develop student skills in analyzing chromosomal structures and abnormalities in plants and model organisms.
- To introduce methods for inducing and observing genetic mutations and polyploidy.
- To provide hands-on experience in genetic mapping and data analysis techniques, including three-point test crosses.

Course Outcomes:

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

- Demonstrate proficiency in identifying structural chromosomal variations, including translocations and polyploid cells.
- Gain skills in experimental techniques for inducing genetic mutations and polyploidy in plants.
- Conduct genetic mapping using test cross data, interpreting chromosomal arrangements and gene linkage patterns.

Course content – (Any fifteen practicals)

1. Study of Types of fossils 1P
2. Study of fossil groups of plants (Psilopsida, Lycopsida, Sphenopsida, Pteridosperms and Pentoxylae) 1P
3. Study of plant families (Any eight from the theory course) 8P
4. Use of flora to find the genus and species, and preparation of an artificial key 2P
5. Preparation of herbarium of suitable plants 1P
6. Excursion tour 2P

Progressive Education Society's
Modern College of Arts, Science and Commerce,
Shivajinagar, Pune - 5

Third Year of B.Sc. Botany
(2024 Course under NEP 2020)

Course Code: 24ScBotU6306 **Course Name: Lab Course on 24ScBotU6103 and 24ScBotU6104**

Teaching Scheme: TH: 2 Hours/Week **Credit: 02**
Examination Scheme: CIE: 20 Marks **End-Sem: 30 Marks**

Prerequisite: A student should have foundational knowledge of General Botany (especially plant structure and basic processes like photosynthesis and transpiration) and Introductory Chemistry (understanding of pH, solutions, and biomolecules). Basic laboratory skills in handling glassware, preparing solutions, and using a microscope are assumed.

Course Objectives:

- To learn techniques for measuring key plant water relations parameters like Diffusion Pressure Deficit (DPD) and stomatal frequency.
- To demonstrate fundamental physiological processes such as photosynthesis, transpiration, and mineral nutrition.
- To perform qualitative and quantitative biochemical analyses of plant constituents (sugars, proteins, pigments, metabolites).
- To develop skills in chromatography for separating and identifying plant pigments and amino acids.
- To study the factors affecting enzyme activity and understand the fundamentals of enzyme kinetics.
- To perform classical demonstration experiments illustrating core physiological principles (e.g., plasmolysis, imbibition, transpiration pull).

Course Outcomes:

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

- Measure stomatal frequency and calculate DPD to assess plant-water relations.
- Demonstrate oxygen production in photosynthesis using the floating disc assay and separate photosynthetic pigments via paper chromatography.
- Perform quantitative estimations of reducing sugars and proteins from plant tissues using standard colorimetric methods.
- Separate and identify amino acids using paper chromatography and conduct qualitative tests for primary and secondary metabolites.
- Analyze the effects of pH and substrate concentration on enzyme activity to understand basic enzyme kinetics.
- Set up and explain classical physiology demonstrations (e.g., transpiration pull, plasmolysis) to illustrate core concepts.

Course Contents:

1.	Determination of diffusion pressure deficit (DPD)	1P
2.	Determination of stomatal frequency	1P
3.	Determination of the rate of transpiration under different conditions.	1P
4.	Determination of water holding capacity (WHC) and pH of soil.	1P
5.	Floating disc assay to demonstrate photosynthesis	1P
6.	Separation of chlorophyll pigments by chromatography	1P
7.	Study of mineral deficiencies in suitable plants in hydroponics	2P
8.	Plant physiology demonstration experiments: transpiration pull, plasmolysis, imbibition, effect of PGRs, ringing experiment	2P
9.	Estimation of reducing sugars by a suitable method	1P
10.	Estimation of proteins by Lowery's method	1P
11.	Qualitative tests for primary and secondary metabolites	1P
12.	Separation of amino acids by paper chromatography	1P
13.	Effect of pH and substrate concentration on enzyme activity	2P

Progressive Education Society's
Modern College of Arts, Science and Commerce,
Shivajinagar, Pune - 5

Third Year of B.Sc. Botany
(2024 Course under NEP 2020)

Course Code: 24ScBotU6201 **Course Name: Biostatistics**
Teaching Scheme: TH: 2 Hours/Week **Credit: 02**
Examination Scheme: CIE: 20 Marks **End-Sem: 30 Marks**

Prerequisite: A student should have a foundational understanding of basic mathematics (algebra, arithmetic operations) and logical reasoning. No prior statistical knowledge is required, but familiarity with biological data concepts from earlier coursework is helpful.

Course Objectives:

- To introduce the fundamental concepts, scope, and applications of biostatistics in biological research.
- To distinguish between different types of data, variables, and sampling methods used in biological studies.
- To compute and interpret measures of central tendency (mean, median, mode) and dispersion (range, variance, standard deviation) for biological data sets.
- To understand and apply correlation and regression analysis to examine relationships between biological variables.
- To explain the principles of hypothesis testing, including null and alternative hypotheses, and significance levels.
- To perform and interpret basic tests of significance (t-test and chi-square test) using biological data.

Course Outcomes: On completion of the course, students will be able to–

- Classify types of variables and data, and select appropriate sampling methods for a given biological study.
- Calculate and compare measures of central tendency and dispersion for both grouped and ungrouped biological data.
- Construct scatter diagrams, calculate correlation coefficients, and interpret the strength and direction of relationships between two variables.
- Formulate null and alternative hypotheses for a given biological research question.
- Perform an independent samples t-test and a chi-square test for goodness of fit using provided data sets and statistical tools.
- Interpret the results of statistical tests (p-values) in the context of biological significance and draw appropriate conclusions.

Course Contents:

Unit 1	**Introduction to Biostatistics**	**6 L**
	1.3 Definitions of statistics and biostatistics 1.4 Types of statistics: Descriptive and inferential 1.5 Population verses sample 1.6 Basic terms: Element or member, variable, observation or measurement, data set, accuracy and precision in data collection, parameter and statistic, statistical error, linear and non-linear functions of statistics, frequency, and its distribution 1.7 Types of variables: Quantitative and qualitative or categorical variables 1.8 Cross section verses time series data 1.9 Sources of data: Primary and secondary data 1.10 Summation notation 1.11 Scope, applications and uses of biostatistics	
Unit 2	**Sample and sampling**	**4 L**
	2.1 Definition 2.2 Sampling unit, sample and population 2.3 Types of sampling 2.4 Random sampling – with replacement, without replacement, systematic sampling, stratified sampling 2.5 Non-random sampling- Purpose, quota sampling 2.6 Need for randomness and how to achieve it 2.7 Lottery methods 2.8 Use of random number table 2.9 Merits and limitations of sampling	
Unit 3	**Measures of central tendency**	**4 L**
	6.1 Simple arithmetic mean, its merits and limitations 6.2 Averages of position: Median and mode, their merits and limitations	
Unit 4	**Measures of dispersion**	**6 L**
	7.1 Concept 7.2 Range: Computation in individual, discrete and continuous series, coefficient of range, merits and	

	limitations 7.3 Mean deviation and standard deviation: computation for grouped and ungrouped data, merits and limitations, standard error of mean. 7.4 Variance: Definition, coefficient of variance	
Unit 6	**Correlation and regression**	**6 L**
	3.1 Definition and types of correlation 3.2 Coefficient of correlation and its properties 3.3 Methods of studying correlation: Scatter diagram and Karl Pearson's, coefficient of correlation, coefficient of determination (r^2) 3.4 Regression analysis: Definition and types of regression, linear regression	
Unit 8	**Tests of significance of mean**	**4 L**
	5.1 Introduction 5.2 Statistic and standard error 5.3 Meaning of statistical hypothesis, level of significance, null hypothesis and alternative hypothesis 5.4 Student's t-test: unpaired and paired test 5.5 Chi-square (χ^2) test as a test of goodness of fit and its significance	

Sugested readings:

Annadurai, B. (2007). A Textbook Of Biostatistics. India: New Age International (P) Limited.

Banerjee, P. K. (2007). Introduction to Biostatistics (A Textbook of Biometry). India: S. Chand Limited.

Campbell, R. C. (1967). Statistics for Biology. Kiribati: Cambridge University Press.

Huber, W., Holmes, S. (2018). Modern Statistics for Modern Biology. United States: Cambridge University Press.

McCleery, R. H., Watt, T. A., Hart, T. (2007). Introduction to Statistics for Biology. United Kingdom: CRC Press.

Prasad, S. (2012). Elements of Biostatistics: For Undergraduate Students. India: Rastogi Publications.

Satyanarayana, L., Indrayan, A. (2006). Biostatistics for Medical, Nursing and Pharmacy Students. India: Prentice-Hall of India.

Progressive Education Society's
Modern College of Arts, Science and Commerce,
Shivajinagar, Pune - 5

Third Year of B.Sc. Botany
(2024 Course under NEP 2020)

Course Code: 24ScBotU6202 **Course Name: Lab course on 24ScBotU6201**
Teaching Scheme: PR: 4 Hours/Week **Credit: 02**
Examination Scheme: CIE: 20 Marks **End-Sem: 30 Marks**

Prerequisite: Students should have a foundational understanding of basic chemistry and introductory biostatistics concepts. Familiarity with fundamental biological and biochemical laboratory techniques will also be beneficial for grasping the methods involved in this course.

Course Objectives:

- Understand the principles and applications of centrifugation, chromatography, electrophoresis, and photometry techniques.
- Develop practical skills in isolating and separating biomolecules such as pigments and proteins.
- Gain competency in statistical analysis methods, including mean, mode, median, variance, standard deviation, and graphical data representation.
- Learn how to execute and interpret statistical tests like the Student's t-test, chi-square test, correlation, and regression.
- Recognize the significance of isoenzyme analysis and storage protein profiling in various biological contexts.
- Integrate laboratory techniques and statistical analysis to interpret biochemical data accurately.

Course Outcomes:

On completion of the course, students will be able to-

- Determine relative centrifugal force (RCF) and understand its application in different rotor systems.
- Proficiently separate chlorophyll pigments using paper chromatography and demonstrate knowledge of adsorption chromatography.
- Demonstrate competence in protein separation techniques for isoenzyme analysis.
- Conduct flame photometry, analyze the data obtained, and understand its relevance in quantitative analysis.
- Gain proficiency in statistical calculations, including measures of central tendency and variability, and present data effectively.
- Apply statistical tests to biological data, interpret the results accurately, and draw meaningful conclusions from correlation and regression analyses.

Course Contents:

1.	Methods of data collection and organisation	1P
2.	Types and use of sampling methods	1P
3.	Construction of frequency distribution tables	1P
4.	Representation of data by various graphical methods	2P
5.	Computation of mean, mode, median, variance, standard deviation, and standard error from the given data	4P
6.	Construction and analysis of a scatter diagram	1P
7.	Formulation of hypotheses and introduction to t-test (one-sample t-test)	1P
8.	Student's t-test: Unpaired (Independent Samples)	
9.	Chi-Square (χ^2) test for goodness of fit	2P
10.	Statistical problem-solving based on data for correlation and regression	2P

Progressive Education Society's
Modern College of Arts, Science and Commerce,
Shivajinagar, Pune - 5

Third Year of B.Sc. Botany
(2024 Course under NEP 2020)

Course Code: 24ScBotU6203 **Course Name: Industrial and Environmental Microbiology**

Teaching Scheme: TH: 2 Hours/Week **Credit: 02**

Examination Scheme: CIE: 20 Marks **End-Sem: 30 Marks**

Pre-requisite: Basic knowledge of microbiology, biochemistry, and environmental science is required.

Course Objectives:

- To understand the role of microorganisms in industrial and environmental processes.
- To explore the applications of microbiology in biotechnology, agriculture, and waste management.
- To develop practical skills in isolating, culturing, and analysing microorganisms.
- Explain the principles of industrial microbiology and its applications in production systems.
- Analyse the role of microorganisms in environmental sustainability and biodegradation.
- Apply microbiological techniques in solving industrial and environmental challenges.

Course Outcomes:

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

- Recall microbial processes in industries like brewing, enzyme production, and pharmaceuticals.
- Explain the ecological roles of microbes in nutrient cycling and bioremediation.
- Design experiments to isolate and utilize microbes for industrial purposes.
- Compare microbial bioprocesses and their environmental impact.
- Assess the efficiency of microbial systems in waste treatment and resource recovery.
- Develop sustainable strategies using microbial technologies for industrial and environmental applications.

Unit 1	**Introduction to Industrial Microbiology**	**8 L**
	1.1. Scope and history of industrial microbiology. 1.2. Types of fermentation processes (batch, fed-batch, continuous). 1.3. Bioreactors: Types, design, and operation.	

	1.4. Downstream processing: Recovery and purification of products.	
Unit 2	**Microbial Products of Industrial Use**	**8 L**
	2.1. Primary metabolites: Alcohols, organic acids. 2.2. Secondary metabolites: Antibiotics, vitamins, and enzymes. 2.3. Microbial production of bioplastics and biofuels. 2.4. Quality control in microbial industries.	
Unit 3	**Environmental Microbiology and Bioremediation**	**7 L**
	3.1. Role of microbes in the biogeochemical cycles (carbon, nitrogen, sulfur, phosphorus). 3.2. Microbial bioremediation: Types, mechanisms, and case studies. 3.3. Wastewater treatment: Microbial processes in primary, secondary, and tertiary treatment. 3.4. Phytoremediation and microbial interactions in the rhizosphere.	
Unit 4	**Applied Microbial Ecology**	**7 L**
	4.1. Microbial communities in extreme environments (halophiles, thermophiles). 4.2. Microbes in agriculture: Biofertilizers, biopesticides, and plant growth-promoting rhizobacteria (PGPR). 4.3. Industrial pollution and biodegradation of xenobiotics. 4.4. Emerging trends: Metagenomics, synthetic biology in environmental microbiology.	

Suggested readings:

Pelczar, M.J., Chan, E.C.S., & Krieg, N.R. (1993). *Microbiology: Concepts and Applications*. McGraw-Hill.

Prescott, L.M., Harley, J.P., & Klein, D.A. (2008). *Microbiology*. McGraw-Hill.

Atlas, R.M., & Bartha, R. (1998). *Microbial Ecology: Fundamentals and Applications*. Addison Wesley Longman.

Casida, L.E. (1968). *Industrial Microbiology*. Wiley Eastern Limited.

Stanbury, P.F., Whitaker, A., & Hall, S.J. (1995). *Principles of Fermentation Technology*. Pergamon Press.

Progressive Education Society's
Modern College of Arts, Science and Commerce,
Shivajinagar, Pune - 5

Third Year of B.Sc. Botany
(2024 Course under NEP 2020)

Course Code: 24ScBotU6204 **Course Name: Lab course on 24ScBotU6203**
Teaching Scheme: TH: 4 Hours/Week **Credit: 02**
Examination Scheme: CIE: 20 Marks **End-Sem: 30 Marks**

Prerequisite: Students should have a basic understanding of microbiology and biochemistry, including microbial structure, function, and metabolism. Prior experience with aseptic techniques, microbial culturing, and basic laboratory skills is recommended. Familiarity with industrial and environmental microbiology concepts will be beneficial for performing the experiments effectively.

Course Objectives:

- To provide students with a fundamental understanding of industrial and environmental microbiology concepts.
- To develop skills in culturing, isolating, and analysing microorganisms for their industrial and environmental applications.
- To equip students with knowledge of microbial processes for production, bioremediation, and enzymatic applications.
- To foster the ability to apply microbiological techniques for addressing environmental and industrial challenges.

Course Outcomes:

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

- Recall sterilization techniques and microbial media preparation while identifying biochemical tests for microbial identification.
- Understand microbial growth patterns and the ecological roles of rhizobium and soil microbes.
- Apply microbiological techniques to perform alcohol fermentation, enzyme assays, and microorganism isolation.
- Analyze antibiotic sensitivity patterns and investigate wastewater microbiology for coliform contamination.
- Evaluate microbial diversity using advanced methods and compare enzymatic activities of different microbial isolates.
- Create case studies on microbial applications in bioremediation and design experiments to screen industrial microbes for enzyme production.

Course Contents (Any fifteen):

1. Sterilization techniques and preparation of culture media. 2P
2. Isolation and maintenance of industrially important microorganisms. 2P
3. Study of microbial growth pattern. 1P
4. Alcohol fermentation and estimation. 2P
5. Screening of microbes for the production of amylase. 1P
6. Antibiotic sensitivity testing of microbial isolates. 1P
7. Biochemical tests for microbial identification (Catalase, Oxidase). 1P
8. Microbial production of citric acid. 2P
9. Isolation of *Rhizobium* from root nodules. 1P
10. Isolation of microorganisms from soil (serial dilution and plating). 2P
11. Study of wastewater microbiology: Isolation of coliforms. 1P
12. Biofilm formation and its analysis. 1P
13. Analysis of microbial diversity using culture-independent methods. 1P
14. Enzyme activity assays: Protease and lipase. 2P
15. Case study presentation: Application of microbial technology in bioremediation. 1P

Progressive Education Society's
Modern College of Arts, Science and Commerce,
Shivajinagar, Pune - 5

Third Year of B.Sc. Botany
(2024 Course under NEP 2020)

Course Code: 24ScBotU6501 **Course Name: Lab course on Gardening Practices and Techniques**

Teaching Scheme: PR: 4 Hours/Week **Credit: 02**

Examination Scheme: CIE: 20 Marks **End-Sem: 30 Marks**

Prerequisite: A student should have successfully completed the foundational botany courses to possess a basic understanding of Plant Anatomy & Morphology, Plant Physiology, Plant Taxonomy and Fundamentals of Ecology along with basic laboratory skills.

Course Objectives:

- To understand the principles of soil health and prepare suitable growing media for different horticultural purposes.
- To master the fundamental techniques of plant propagation, both sexual (seed) and asexual (cutting, layering, grafting, budding).
- Learn to apply essential garden management skills, including potting, pruning, and pest/disease identification using eco-friendly methods.
- To execute specialized gardening techniques such as lawn establishment, terrarium construction, and bonsai preparation.
- To identify, select, and correctly use common garden tools and implements for various horticultural operations.
- To analyze the design and components of a functional garden through structured observation.

Course Outcomes:

After successful completion of the practical course, the student will be able to:

- Prepare standardized potting mixes and perform physical soil analysis to assess suitability for plant growth.
- Propagate a wide range of plants through various seed treatments and vegetative methods (cutting, layering, grafting).
- Demonstrate key garden maintenance operations including potting, repotting, pruning, and preparing natural pesticides.
- Identify common garden pests, diseases, and tools, and propose basic integrated management strategies.
- Construct specialized garden features such as a seed bed, lawn patch, or a terrarium.
- Document and analyze the design elements and plant composition of a visited garden.

Course Contents (Any fifteen)

1.	Physical analysis of garden soils and preparation of standard potting mixes	1P
2.	Techniques of potting and repotting plants	1P
3.	Compost and composting methods	1P
4.	Methods of breaking seed dormancy	1P
5.	Vegetative propagation of plants by cutting and layering	2P
6.	Vegetative propagation of plants by grafting and budding	2P
7.	Pruning techniques for garden plants	1P
8.	Preparation of natural pesticides	1P
9.	Identification and management of common garden pests and diseases	1P
10.	Study of garden tools and implements	1P
11.	Preparation and care of seed beds	1P
12.	Preparation of the lawn	1P
13.	Construction of a terrarium/bottle garden	1P
14.	Preparation and care of bonsai	1P
15.	Visit to gardens to study garden components	1P

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