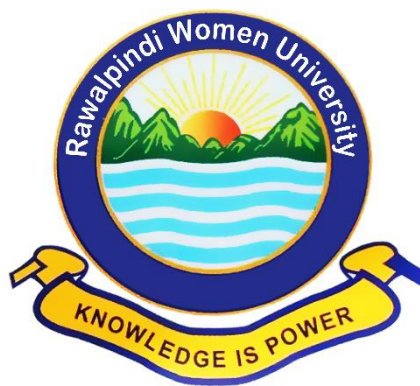


CURRICULUM OF BS BOTANY

(2026)



RAWALPINDI WOMEN UNIVERSITY, RAWALPINDI

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1. Program Vision and Mission

Vision: The vision of BS program is Empowering women to drive sustainable solutions in Botany through critical thinking, innovation and community engagement for greener and healthier tomorrow

Mission: The mission of BS program is to strengthen female graduates with high quality education through theoretical knowledge and practical skills. The program aims to produce socially and ethically responsible graduates, who can contribute in sustainable management of plants, entrepreneurship, conservation, community development and to mitigate food security and climate challenges.

2. Program Objectives and Outcomes

BS Botany Program Objectives

Main objectives of BS botany program are to

- Equip students with a strong foundation of diversified fields of Botany
- Develop understanding of plants in ecosystems and biodiversity conservation for sustainable development
- Prepare students for professional careers by providing Practical Skills and Applications
- Enable students with ethical responsibility, scientific communication, and teamwork to contribute effectively in academia, industry and government sectors.

BS Botany Program Outcomes

Graduates of BS Botany will be able to

- Demonstrate knowledge of Botany including structure, function, identification, classification, and evolution of plants and their interactions with the environment.
- Explain the role of plants in ecosystems, analyze their contribution to biodiversity, and evaluate strategies for plant conservation as a means to support sustainable development.
- Apply botanical principles in fields such as agriculture, biotechnology, environmental management, and conservation
- Conduct and present scientific investigations on plants including microscopy, molecular biology tools, and ecological survey techniques for meaningful contribution in diverse sectors.

3. Admission Criteria for BS Botany

As per approved Admission Policy RWU notified, vide Notification No. RWU/VC/01/341; dated: 10th Mar, 2023

4. Division and Distribution of Courses for BS Botany

Sr. #	Categories	No. of Courses	Credit Hours
1	General Education Courses	15	34
2	Major Courses	26	78
3	Interdisciplinary / Allied Courses	7	21
4	Internship	01	03
5	Capstone Project	01	03

Total Credit Hours	139
Duration	4-6 Years
Semester Duration	16 - 18 Weeks
Semesters	8
Course Load Per Semester	As per HEC and RWU policy

5. Scheme of Studies for BS Botany (Regular Batch)

SEMESTER: 1				
Course code	Course	Credits	Category	Prerequisite
BOT-123	Cell Biology	2	Major	NIL
BOT-123L	Cell Biology (Lab)	1	Major	NIL
BOT-124	Diversity of Plants	2	Major	NIL
BOT-124L	Diversity of Plants (Lab)	1	Major	NIL
GEO-106	Introduction to Environmental Science (Natural Science)	2	General Education	NIL
GEO-106L	Introduction to Environmental Science (Lab) (Natural Science)	1	General Education	NIL
MTH-110	Quantitative Reasoning-I	3	General Education	NIL
ENG-110	Functional English	3	General Education	NIL
CS-107	Applications of Information and Communication Technologies	2	General Education	NIL
CS-107L	Applications of Information and Communication Technologies (Lab)	1	General Education	NIL
	Total Credit Hours	18		
SEMESTER 2				
BOT-125	Fundamentals of Plant Taxonomy	2	Major	Nil
BOT-125L	Fundamentals of Plant Taxonomy (Lab)	1	Major	Nil

ZOO-101	Biodiversity and Conservation	3	Interdisciplinary	Nil
ZOO-102	Fundamentals of Genetics and Evolution	2	Interdisciplinary	Nil
ZOO- 102L	Fundamentals of Genetics and Evolution (Lab)	1	Interdisciplinary	Nil
MGT-110	Time Management and Organizing Skills (Social Sciences)	2	General Education	Nil
STA-112	Quantitative Reasoning II	3	General Education	Nil
ENG-111	Expository Writing	3	General Education	Nil
UHQ-101/ ETH-103	Understanding of Holy Quran-I/ Ethics-I	1	General Education	Nil
	Total Credit Hours	18		
SEMESTER 3				
BOT-204	Phycology and Bryology	2	Major	Nil
BOT-204L	Phycology and Bryology (Lab)	1	Major	Nil
BOT-205	Mycology	2	Major	Nil
BOT-205L	Mycology (Lab)	1	Major	Nil
BOT-206	Plant Anatomy and Embryology	2	Major	Nil
BOT-206L	Plant Anatomy and Embryology (Lab)	1	Major	Nil
	Arts and Humanities	2	General Education	Nil
ISL-101/ ETH-101	Islamic Studies/ Ethics	2	General Education	Nil
PAK-104	Pakistan Studies	2	General Education	Nil
UHQ-102/ ETH-104	Understanding of Holy Quran-II/Ethics-II	1	General Education	Nil

	Total Credit Hours	16		
SEMESTER 4				
BOT-207	Phytogeography	2	Major	Nil
BOT-207L	Phytogeography (Lab)	1	Major	Nil
BOT-208	Principles of Plant Ecology	2	Major	Nil
BOT-208L	Principles of Plant Ecology (Lab)	1	Major	Nil
BOT-209	Principles of Plant Biochemistry	2	Major	Nil
BOT-209L	Principles of Plant Biochemistry (Lab)	1	Major	Nil
BOT-210	Fundamentals of Plant Physiology	2	Major	Nil
BOT-210L	Fundamentals of Plant Physiology (Lab)	1	Major	Nil
CCE-497	Civic and Community Engagement	2	General Education	Nil
MGT-108	Entrepreneurship	2	General Education	Nil
PAK-103	Ideology and Constitution of Pakistan	2	General Education	Nil
	Total Credit Hours	18		
SEMESTER 5				
BOT-315	Advanced Plant Ecology	2	Major	Nil
BOT-315L	Advanced Plant Ecology (Lab)	1	Major	Nil
BOT-316	Advanced Plant Biochemistry	2	Major	Nil
BOT-316L	Advanced Plant Biochemistry (Lab)	1	Major	Nil
BOT-317	Advanced Plant Physiology	2	Major	Nil

BOT-317L	Advanced Plant Physiology (Lab)	1	Major	Nil
BOT-318	Microbial Botany	2	Major	Nil
BOT-318L	Microbial Botany (Lab)	1	Major	Nil
BOT-319	Pteridophytes and Gymnosperms	2	Major	Nil
BOT-319L	Pteridophytes and Gymnosperms (Lab)	1	Major	Nil
STA-120	Biostatistics	2	Interdisciplinary	Nil
STA-120L	Biostatistics (Lab)	1	Interdisciplinary	Nil
	Total Credit Hours	18		
SEMESTER 6				
BOT-320	Systematics of Angiosperms	2	Major	Nil
BOT-320L	Systematics of Angiosperms (Lab)	1	Major	Nil
BOT-321	Plant Pathology	2	Major	Nil
BOT-321L	Plant Pathology (Lab)	1	Major	Nil
ZOO-421	Molecular Genetics	2	Interdisciplinary	Nil
ZOO-421L	Molecular Genetics (Lab)	1	Interdisciplinary	Nil
MGT-109	Sustainable Development Goals	3	Interdisciplinary	Nil
BOT-322	Artificial Intelligence in Botany	3	Interdisciplinary	Nil
	Elective-I	3	Major	Nil
	Total Credit Hours	18		
SEMESTER: 7				
BOT-416	Analytical Techniques in Botany	1	Major	Nil

BOT-416L	Analytical Techniques in Botany (Lab)	2	Major	Nil
BOT-417	Field Botany	2	Major	Nil
BOT-417L	Field Botany (Lab)	1	Major	Nil
BOT-418	Forensic Botany	2	Major	Nil
BOT-418L	Forensic Botany (Lab)	1	Major	Nil
RM-404	Scientific Inquiry and Research Methods	2	Interdisciplinary	Nil
RM-404 L	Scientific Inquiry and Research Methods (Lab)	1	Interdisciplinary	Nil
INT-499	Internship	3	Mandatory	Nil
	Elective-II	3	Major	Nil
	Total Credit Hours	18		
SEMESTER: 8				
BOT-419	Plant Biotechnology	2	Major	Nil
BOT-419L	Plant Biotechnology (Lab)	1	Major	Nil
BOT-420	Economic and Industrial Botany	3	Major	Nil
BOT-421	Evolutionary Trends in Plants	2	Major	Nil
BOT-421L	Evolutionary Trends in Plants (Lab)	1	Major	Nil
	Elective-III	3	Major	Nil
CP-498	Capstone Project	3	Mandatory	Nil
	Total Credit Hours	15		
Total credit hour = 139				

6. Scheme of Studies for BS Botany (Lateral Entry Annual System)

SEMESTER 5				
Course code	Course	Credits	Category	Pre-requisite
BOT-315	Advanced Plant Ecology	2	Major	Nil
BOT-315L	Advanced Plant Ecology (Lab)	1	Major	Nil
BOT-316	Advanced Plant Biochemistry	2	Major	Nil
BOT-316L	Advanced Plant Biochemistry (Lab)	1	Major	Nil
BOT-317	Advanced Plant Physiology	2	Major	Nil
BOT-317L	Advanced Plant Physiology (Lab)	1	Major	Nil
BOT-318	Microbial Botany	2	Major	Nil
BOT-318L	Microbial Botany (Lab)	1	Major	Nil
BOT-319	Pteridophytes and Gymnosperms	2	Major	Nil
BOT-319L	Pteridophytes and Gymnosperms (Lab)	1	Major	Nil
STA-120	Biostatistics	2	Interdisciplinary	Nil
STA-120L	Biostatistics (Lab)	1	Interdisciplinary	Nil
	Deficient Course 1	3	Major/Elective	Nil
	Total Credit Hours	21		
SEMESTER 6				
Course code	Course	Credits	Category	Pre-requisite
BOT-320	Systematics of Angiosperms	2	Major	Nil
BOT-320L	Systematics of Angiosperms (Lab)	1	Major	Nil

BOT-321	Plant Pathology	2	Major	Nil
BOT-321L	Plant Pathology (Lab)	1	Major	Nil
ZOO-421	Molecular Genetics	2	Interdisciplinary	Nil
ZOO-421L	Molecular Genetics (Lab)	1	Interdisciplinary	Nil
MGT-109	Sustainable Development Goals	3	Interdisciplinary	Nil
BOT-322	Artificial Intelligence in Botany	3	Interdisciplinary	Nil
	Elective-I	3	Major	Nil
	Deficient Course 2	3	Major/Elective	Nil
	Total Credit Hours	21		
SUMMER				
Course code	Course	Credits	Category	Pre-requisite
	Deficient Course 3	3	Major/Elective	Nil
	Deficient Course 4	3	Major/Elective	Nil
	Total Credit Hours	6		
SEMESTER 7				
BOT-416	Analytical Techniques in Botany	1	Major	Nil
BOT-416L	Analytical Techniques in Botany (Lab)	2	Major	Nil
BOT-417	Field Botany	2	Major	Nil
BOT-417L	Field Botany (Lab)	1	Major	Nil
BOT-418	Forensic Botany	2	Major	Nil
BOT-418L	Forensic Botany (Lab)	1	Major	Nil
RM-404	Scientific Inquiry and Research Methods	2	Interdisciplinary	Nil
RM-404 L	Scientific Inquiry and Research Methods (Lab)	1	Interdisciplinary	Nil
INT-499	Internship	3	Mandatory	Nil

	Elective-II	3	Major	Nil
	Deficient Course 5	3	Major/Elective	Nil
	Total Credit Hours	21		
SEMESTER 8				
BOT-419	Plant Biotechnology	2	Major	Nil
BOT-419L	Plant Biotechnology (Lab)	1	Major	Nil
BOT-420	Economic and Industrial Botany	3	Major	Nil
BOT-421	Evolutionary Trends in Plants	2	Major	Nil
BOT-421L	Evolutionary Trends in Plants (Lab)	1	Major	Nil
	Elective-III	3	Major	Nil
	Deficient Lab 1	1	Major/Elective	Nil
	Deficient Lab 2	1	Major/Elective	Nil
	Deficient Course 6	3	Major/Elective	Nil
CP-498	Capstone Project	3	Mandatory	Nil
	Total Credit Hours	20		
Total credit hours for BS Lateral Entry Annual System: 50+89=139				

**7. Scheme of Studies for BS Botany Lateral Entry Semester System Having 2 Years BS)
(Previous Credit Hours, 65)**

SEMESTER 05				
Course code	Course	Credits	Category	Pre-requisite
BOT-315	Advanced Plant Ecology	2	Major	Nil
BOT-315L	Advanced Plant Ecology (Lab)	1	Major	Nil
BOT-316	Advanced Plant Biochemistry	2	Major	Nil
BOT-316L	Advanced Plant Biochemistry (Lab)	1	Major	Nil
BOT-317	Advanced Plant Physiology	2	Major	Nil
BOT-317L	Advanced Plant Physiology (Lab)	1	Major	Nil
BOT-318	Microbial Botany	2	Major	Nil
BOT-318L	Microbial Botany (Lab)	1	Major	Nil
BOT-319	Pteridophytes and Gymnosperms	2	Major	Nil
BOT-319L	Pteridophytes and Gymnosperms (Lab)	1	Major	Nil
STA-120	Biostatistics	2	Interdisciplinary	Nil
STA-120L	Biostatistics (Lab)	1	Interdisciplinary	Nil
	Deficient Lab 1	1	Major/Elective	Nil
	Total Credit Hours	19		
SEMESTER 06				
BOT-320	Systematics of Angiosperms	2	Major	Nil
BOT-320L	Systematics of Angiosperms (Lab)	1	Major	Nil
BOT-321	Plant Pathology	2	Major	Nil
BOT-321L	Plant Pathology (Lab)	1	Major	Nil
ZOO-421	Molecular Genetics	2	Interdisciplinary	Nil

ZOO-421L	Molecular Genetics (Lab)	1	Interdisciplinary	Nil
MGT-109	Sustainable Development Goals	3	Interdisciplinary	Nil
BOT-322	Artificial Intelligence in Botany	3	Interdisciplinary	Nil
	Elective-I	3	Major	Nil
	Total Credit Hours	18		
SEMESTER 07				
BOT-416	Analytical Techniques in Botany	1	Major	Nil
BOT-416L	Analytical Techniques in Botany (Lab)	2	Major	Nil
BOT-417	Field Botany	2	Major	Nil
BOT-417L	Field Botany (Lab)	1	Major	Nil
BOT-418	Forensic Botany	2	Major	Nil
BOT-418L	Forensic Botany (Lab)	1	Major	Nil
RM-404	Scientific Inquiry and Research Methods	2	Interdisciplinary	Nil
RM-404 L	Scientific Inquiry and Research Methods (Lab)	1	Interdisciplinary	Nil
INT-499	Internship	3	Mandatory	Nil
	Elective-II	3	Major	Nil
	Deficient Lab 2	1	Major/Elective	Nil
	Total Credit Hours	19		
SEMESTER 08				
BOT-419	Plant Biotechnology	2	Major	Nil
BOT-419L	Plant Biotechnology (Lab)	1	Major	Nil
BOT-420	Economic and Industrial Botany	3	Major	Nil
BOT-421	Evolutionary Trends in Plants	2	Major	Nil
BOT-421L	Evolutionary Trends in Plants (Lab)	1	Major	Nil

	Elective-III	3	Major	Nil
	Deficient Course 1	3	Major/Elective	Nil
CP-498	Capstone Project	3	Mandatory	Nil
	Total Credit Hours	18		
Total credit hours for BS Lateral Entry Semester System: 65+74=139				

8. List of Major Courses

Course Code	Course	Credits	Category	Pre-requisite
BOT-123	Cell Biology	2	Major	NIL
BOT-123L	Cell Biology (Lab)	1	Major	NIL
BOT-124	Diversity of Plants	2	Major	NIL
BOT-124L	Diversity of Plants (Lab)	1	Major	NIL
BOT-125	Fundamentals of Plant Taxonomy	2	Major	NIL
BOT-125L	Fundamentals of Plant Taxonomy (Lab)	1	Major	NIL
BOT-204	Phycology and Bryology	2	Major	NIL
BOT-204L	Phycology and Bryology (Lab)	1		NIL
BOT-205	Mycology	2	Major	NIL
BOT-205L	Mycology (Lab)	1	Major	NIL
BOT-206	Plant Anatomy and Embryology	2	Major	NIL
BOT-206L	Plant Anatomy and Embryology (Lab)	1	Major	NIL
BOT-207	Phytogeography	2	Major	NIL
BOT-207L	Phytogeography (Lab)	1	Major	NIL
BOT-208	Principles of Plant Ecology	2	Major	NIL
BOT-208L	Principles of Plant Ecology (Lab)	1	Major	NIL
BOT-209	Principles of Plant Biochemistry	2	Major	NIL
BOT-209L	Principles of Plant Biochemistry (Lab)	1	Major	NIL
BOT-210	Fundamentals of Plant Physiology	2	Major	NIL
BOT-210L	Fundamentals of Plant Physiology (Lab)	1	Major	NIL

BOT-315	Advanced Plant Ecology	2	Major	NIL
BOT-315L	Advanced Plant Ecology (Lab)	1	Major	NIL
BOT-316	Advanced Plant Biochemistry	2	Major	NIL
BOT-316L	Advanced Plant Biochemistry (Lab)	1	Major	NIL
BOT-317	Advanced Plant Physiology	2	Major	NIL
BOT-317L	Advanced Plant Physiology (Lab)	1	Major	NIL
BOT-318	Microbial Botany	2	Major	NIL
BOT-318L	Microbial Botany (Lab)	1	Major	NIL
BOT-319	Pteridophytes and Gymnosperms	2	Major	NIL
BOT-319L	Pteridophytes and Gymnosperms (Lab)	1	Major	NIL
BOT-320	Systematics of Angiosperms	2	Major	NIL
BOT-320L	Systematics of Angiosperms (Lab)	1	Major	NIL
BOT-321	Plant Pathology	2	Major	NIL
BOT-321L	Plant Pathology (Lab)	1	Major	NIL
BOT-416	Analytical Techniques in Botany	1	Major	NIL
BOT-416L	Analytical Techniques in Botany (Lab)	2	Major	NIL
BOT-417	Field Botany	2	Major	NIL
BOT-417L	Field Botany (Lab)	1	Major	NIL
BOT-418	Forensic Botany	2	Major	NIL
BOT-418L	Forensic Botany (Lab)	1	Major	NIL
BOT-419	Plant Biotechnology	2	Major	NIL
BOT-419L	Plant Biotechnology (Lab)	1	Major	NIL
BOT-420	Economic and Industrial Botany	3	Major	NIL
BOT-421	Evolutionary Trends in Plants	2	Major	NIL
BOT-421L	Evolutionary Trends in Plants Lab	1	Major	NIL

9. Course Outlines for Major Courses

Cell Biology

Course Code: BOT-123

Credit Hours: 2

Objectives:

The course aims to introduce students to the basic unit of life—the cell—focusing on its structure, functions, and molecular organization, develop understanding of the molecular processes within the cell and familiarize students with microscopy and scanning techniques related to the study of plant cells.

Learning Outcomes:

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

- Describe the fundamental concepts of cell biology, including cell theory, types of cells, and basic cell properties.
- Explain the structure and functions of major cellular organelles in plant cells.
- Illustrate the structure and function of the nucleus and explain the processes of DNA replication, transcription, and translation.
- Differentiate between mitosis and meiosis and analyze their roles in growth and reproduction.
- Explain mechanisms of cellular transport and communication in plants, including diffusion, osmosis, and active transport.

Course Outline:

Unit-1. Introduction to Cell Biology

History and significance of cell biology, Cell theory, Types of cells: Prokaryotic and Eukaryotic, Basic properties of cells, Comparative study between plant and animal cells. Microscopy: Simple and compound microscope, Use and care of the compound microscope, Micrometry

Unit-2. Cell Structure and Organelles

Detailed description and functions of Cell Wall, Plasma Membrane, Endoplasmic Reticulum (Smooth and Rough), Plastids, Chloroplasts, Chromoplasts, Leucoplasts), Mitochondria, Ribosomes, Dictyosomes (Golgi Apparatus), Vacuoles.

Unit-3. Nucleus

Structure of nucleus and nucleolus, DNA and RNA, transcription and translation

Unit-4. Cell Division

Overview of the Cell Cycle, Mitosis: Phases and significance, Meiosis: Phases and significance, Differences between Mitosis and Meiosis

Unit-5. Cellular Transport and Communication

Mechanisms of material transport across membranes: Diffusion, Osmosis, Facilitated diffusion, Active transport, Cell-to-cell communication in plants, Plasmodesmata and transport pathways (apoplastic and symplastic).

Recommended Books/Reference Material

1. Alberts, B., Johnson, A., Lewis, J., Raff, M., Roberts, K., and Walter, P. (2022). *Molecular biology of the cell* (7th ed.). Garland Science.
2. Cooper, G. M., and Hausman, R. E. (2022). *The cell: A molecular approach* (9th ed.). Oxford University Press.
3. Hardin, J., Bertoni, G. P., and Kleinsmith, L. J. (2021). *Becker's world of the cell* (10th ed.). Pearson Education.
4. Lodish, H., Berk, A., Kaiser, C. A., Krieger, M., Bretscher, A., Ploegh, H., Amon, A., and Martin, K. C. (2021). *Molecular cell biology* (9th ed.). W. H. Freeman and Company.

Cell Biology (Lab)

Course Code: BOT- 123L

Credit Hours: 1

Pre-requisite: N.A

Objectives:

To equip students with fundamental laboratory skills in microscopy and basic cell biology techniques. To develop the ability to observe, analyze, and report cellular structures and processes scientifically.

Learning Outcomes:

- Students will be able to learn basic laboratory safety rules and demonstrate proper handling of laboratory equipment, including the compound microscope.
- Prepare and observe plant cell slides using appropriate staining and microscopy techniques.
- Measure and analyze cell structures using micrometry and interpret microscopic observations of plant tissues.
- Differentiate stages of mitosis and meiosis and explain cellular structures and physiological processes such as osmosis.
- Perform basic experimental techniques including isolation of nuclei and extraction of DNA, and present findings in a scientific format.

Lab Outline:

1. Introduction to laboratory safety rules and lab etiquette
2. Familiarization with laboratory equipment and glassware, Use and care of the compound microscope
3. Preparation and microscopic observation of onion epidermal cells
4. Micrometry: Calibration and measurements
5. Slide preparation techniques: Simple and differential staining
6. Study of mitosis and meiosis through prepared slides
7. Identification of cellular organelles through diagrams and slides
8. Observation of osmosis using plant tissues
9. Isolation of nuclei from onion or pea cells, Extraction and estimation of DNA from plant cells.

Recommended Books/Reference Material

1. Celis, J. E. (Ed.). (2006). *Cell biology: a laboratory handbook* (Vol. 1). Elsevier..
2. Laboratory Manual Cell Biology Genetics and Evolution (For BS Students) by ilmi kitan khana.
3. Nedu. (2021). *Biology Made Easy: An Illustrated Study Guide For Students To Easily Learn Cellular & Molecular Biology*. NEDU LLC.
4. Reed, R. H., & Reed, R. (2007). *Practical skills in biomolecular sciences*. Pearson education.

5. Thorn, K. (2016). A quick guide to light microscopy in cell biology. *Molecular biology of the cell*, 27(2), 219-222.
6. Warren D. (2008). Biological Investigations: Form, Function and Diversity & Process. McGraw-Hill; eighth edition.

Diversity of Plants

Course Code: BOT-124

Credit Hours: 2

Objectives:

To provide the students with an adequate knowledge about various plant groups and to provide the students with practical skills regarding plant identification

Learning Outcomes:

- Describe the structure, reproduction, and economic importance of algae, fungi, and lichens.
- Explain the morphology, life cycles, and classification of bryophytes with reference to representative genera.
- Analyze the structural and reproductive features of pteridophytes and their ecological and economic significance.
- Compare gymnosperms and angiosperms based on morphology, reproduction, and economic importance.

Course Outline:

Unit-1. Algae and Fungi

Structure, reproduction and economic significance of Algae. Major groups and their characteristics. Structure and reproduction of Spirogyra, *Chara*, *Pinnularia*. Structure, reproduction and economic significance of Fungi, their implication on crop production and industrial applications. Structure and reproduction of different types of fungi. Structure, reproduction and economic significance of lichens with specific reference to *Physcia*.

Unit-2. Bryophytes

Morphology, reproduction and economic significance of Bryophytes, major groups and their characteristics. Morphology and reproduction of genus *Riccia*, *Anthoceros* and *Funaria*.

Unit-3. Pteridophytes

Morphology, reproduction and economic significance of Pteridophytes. Morphology and reproduction of genus *Psilotum*, *Selaginella*, *Equisetum* and Ferns.

Unit-4. Gymnosperms and Angiosperms

Morphology, reproduction and economic significance of Gymnosperms, *Cycas*, *Pinus* and *Ephedra*. Morphology, reproduction and economic significance of Angiosperms.

Recommended Books/Reference Material

1. Antonelli, A., Smith, R. J., Fry, C., Simmonds, M. S., Kersey, P. J., Pritchard, H. W., and Qi, Y. D. (2022). *State of the World's Plants and Fungi (Doctoral dissertation, Royal BOT-anic Gardens (Kew); Sfumato Foundation)*.
2. Christenhusz, M. J., Fay, M. F., and Chase, M. W. (2023). *Plants of the world: an illustrated encyclopedia of vascular plants*. University of Chicago Press.
3. Dehgan, B. (2023). Gymnosperms. In *Garden Plants Taxonomy: Volume 1: Ferns, Gymnosperms, and Angiosperms (Monocots)* (pp. 57-171). Cham: Springer International Publishing.
4. Kunhikannan, C., Anju, M. V., Prasanna, R. (2025). Taxonomy: Importance, Relevance and Application. In *Textbook of Forest Science* (pp. 65-85). Singapore: Springer Nature Singapore.
5. Mauseth, J. D. (2023). *Botany: An Introduction to Plant Biology*. Jones and Bartlett Publishers, UK.
6. Tietje, M., Antonelli, A., Forest, F., Govaerts, R., Smith, S. A., Sun, M., and Eiserhardt, W. L. (2023). *Global hotspots of plant phylogenetic diversity*. *New Phytologist*, 240(4), 1636-1646.

Diversity of Plants (Lab)

Course Code: BOT- 124L

Credit Hours: 1

Pre-requisite: N.A

Objectives:

To develop practical skills in the study and identification of microorganisms and diverse plant groups through laboratory techniques. To enable students to analyze and document plant diversity based on morphological and reproductive characteristics.

Learning Outcomes:

- Describe the major groups of microorganisms and plants
- Identify and classify representative species of different plant groups and microorganisms using morphological, anatomical, and reproductive features observed in laboratory specimens, prepared slides, and fresh collections
- Evaluate the economic, agricultural, medicinal, and environmental importance of different plant groups and microorganisms for sustainable development.

Lab Outline

1. Introduction of microbial and plant diversity.
2. Culturing and staining of microorganisms; Study of morphology and reproductive structures of the Bacteria from prepared slides and fresh collections
3. Culturing and staining of microorganisms; Study of morphology and reproductive structures of the *Cyanobacteria* from prepared slides and fresh collections
4. Study of morphology and reproductive structures of available algae from prepared slides and fresh collections.
5. Study of morphology and reproductive structures of available fungi from prepared slides and fresh collections.
6. Study of morphology and reproductive structures of available lichens from prepared slides and fresh collections.
7. Study of morphology and reproductive structures of different species of bryophytes from prepared slides and fresh collections.
8. Study of morphology and reproductive structures of different species of pteridophytes from prepared slides and fresh collections.
9. Study of morphology and reproductive structures of different species of gymnosperms from prepared slides and fresh collections.
10. Study of morphology and reproductive structures of different species of angiosperms from prepared slides and fresh collections.

Recommended Books/Reference Material

1. Authority, P. N. G. F. (2017). Annex 4: Laboratory Manual For Collecting and Processing Plant Species.
2. Ryan, J., Estefan, G., & Rashid, A. (2021). *Soil and plant analysis laboratory manual*. ICARDA.
3. Stern's Introductory Plant Biology by James Bidlack, Shelley Jansky, and Kingsley Stern. 15th ed. McGraw Hill, 2023. Useful for introductory plant science and diversity.
4. Stohlgren, T. J. (2007). *Measuring plant diversity: lessons from the field*. OUP USA.
5. Storm, M. A. (2025). Introductory Biology II Lab Manual.
6. Tietje, M., Antonelli, A., Forest, F., Govaerts, R., Smith, S. A., Sun, M., and Eiserhardt, W. L. (2023). *Global hotspots of plant phylogenetic diversity*. New Phytologist, 240(4), 1636-1646.

Fundamentals of Plant Taxonomy

Course Code: BOT-125

Credit Hours: 2

Objectives:

To provide students an understanding of plant diversity, identification, classification, and evolutionary relationships, which enable them to accurately recognize, name, and categorize plants according to established taxonomic principles and practices. To provide the students with an adequate knowledge about various plant groups and to understand their phylogenetic relations.

Learning Outcomes:

Students will be able to:

- Understand the principles of plant taxonomy.
- Understand the basics for plant nomenclature, identification, and classification.
- Understand the different systems of classification.

Course Outline:

Unit-1. Introduction to Plant Taxonomy

Definition and importance of plant taxonomy, Relationship between plant taxonomy and systematics. Concepts of species and other taxonomic categories. Principles of classification. Brief Systems of classification: Artificial systems (e.g., Linnaeus system). Natural systems (e.g., Bentham and Hooker's system). Phylogenetic systems (evolutionary relationships, e.g., APG system).

Unit-2. Plant Nomenclature

Importance of scientific names. Botanical nomenclature: Genus and species, Rules and regulations of the International Code of Botanical Nomenclature (ICBN)/International Code of Nomenclature for algae, fungi, and plants (ICN). Principles of priority, typification, and valid publication. Author citation. Synonyms and homonyms.

Unit-3. Plant Identification

Principles and methods of plant identification. Use of taxonomic keys. Botanical descriptions and terminology (morphological characters of different plant parts). Herbarium techniques: Collection, preservation, and preparation of plant specimens. Herbarium management and significance. Botanical illustrations and their importance.

Unit-4. Plant Classification and Systematics

Taxonomic hierarchy: Kingdom, Phylum/Division, Class, Order, Family, Genus, Species, and infra specific ranks. Concepts of taxa and categories. Different approaches to plant classification: Phenetic and Phylogenetic. Sources of taxonomic evidence: Morphology, Anatomy, Cytology, Palynology, Phytochemistry, Molecular data and Phytogeography.

Unit-5. Modern approaches in Plant Taxonomy

Molecular Taxonomy, Chemotaxonomy and cytotaxonomy. Economic importance of different families. Role in agriculture, horticulture, and forestry. Significance in ethnobotany and medicinal plant studies.

Recommended Books/Reference Material

1. Pandey, A. K., and Kasana, S. (2021). *Plant Systematics*. CRC Press.
2. Stuessy, T. F. (2009). *Plant taxonomy: the systematic evaluation of comparative data*. Columbia University Press.
3. Stuessy, T. F., Weiss-Schneeweiss, H., Schneeweiss, G. M., and Villaseñor, J. L. (2025). Systematics. In *Systematics, Ecology, and Chromosomal Evolution of Melampodium (Asteraceae) Analysis of Species from Latin America and the Southwestern United States* (pp. 137-152). Cham: Springer Nature Switzerland.

Fundamentals of Plant Taxonomy (Lab)

Course Code: BOT- 125L

Credit Hours: 1

Pre-requisite: N.A

Objectives

The objective of this course is to equip students with the fundamental skills required to identify, name, and classify plant species based on both classical morphological traits and modern phylogenetic relationships. It aims to foster a deep understanding of the International Code of Nomenclature to ensure scientific accuracy in botanical documentation. Furthermore, the course seeks to provide hands-on training in herbarium techniques and the use of taxonomic keys, preparing students for professional roles in biodiversity conservation, forestry, and plant research.

Learning Outcome

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

- Accurately describe/identify vegetative and reproductive plant structures using standardized botanical terminology.
- Apply the rules of the ICN (International Code of Nomenclature) to correctly name plants and understand the significance of typification and priority.
- Utilize printed and digital dichotomous keys to identify unknown local flora to the family and genus level.
- Master the technical processes of collecting, pressing, mounting, and preserving plant specimens for long-term scientific record-keeping.
- Differentiate between major classification systems, specifically comparing the historical Bentham and Hooker system with the modern APG (Angiosperm Phylogeny Group) system.

Lab Outline

1. Observe different plant specimens.
2. Draw and label different parts of plants. Identify shapes of leaves and flowers with its variation.
3. Dissection of different parts of flowers to study variation among species.
4. Identification of different characteristics of key families. Observation and identification of various fruit types.
5. Study of microscopic structures of plant tissues.
6. Draw and label different tissues of plants.
7. Identification of unknown plant. Collection of plants and Preparation of herbarium sheets from collected specimens, ensuring proper labeling and documentation.
8. Demonstration of pressing and drying techniques.

Recommended Books/Reference Material

1. Pandey, A. K., and Kasana, S. (2021). *Plant Systematics*. CRC Press.
2. Stuessy, T. F. (2009). *Plant taxonomy: the systematic evaluation of comparative data*. Columbia University Press.
3. Stuessy, T. F., Weiss-Schneeweiss, H., Schneeweiss, G. M., and Villaseñor, J. L. (2025). Systematics. In *Systematics, Ecology, and Chromosomal Evolution of Melampodium (Asteraceae) Analysis of Species from Latin America and the Southwestern United States* (pp. 137-152). Cham: Springer Nature Switzerland.

Phycology and Bryology

Course Code: BOT-204

Credit Hours: 2

Objectives:

To provide the students with an adequate knowledge about various algal groups and bryophytes.

Learning Outcomes:

- Describe the history, evolution, distribution, and ecological significance of algae and bryophytes.
- Explain the criteria used in algal classification, including pigments, cell structure, reproduction, and life cycles.
- Compare major algal phyla based on structure, reproduction, and economic importance.
- Explain the classification, origin, evolution, and ecological roles of bryophytes.
- Understand economic importance of algae and bryophytes.

Course Outline:

Unit-1. Introduction of Phycology

Historical account. Evolution. Zonation. Tides. Habitats. Geographical distribution of economically important algae.

Unit-2. Criteria of Algal Classification

Pigment pattern, plastids, flagellation, movement pattern, cell wall structure, storage products of algae. Reproduction and life cycle patterns.

Unit-3. Phylum of Algae

Introduction, general account, classification, reproduction and economic importance of Cyanophyta, Chlorophyta, Charophyta, Xanthophyta, Bacillariophyta, Phaeophyta, Rhodophyta.

Unit-4. Introduction of Bryology

Introduction and general account of bryophytes. Classification. Theories of origin and Evolution. Ecological role of bryophytes. Distribution of bryophytes in Pakistan.

Unit-5. Hepaticopsida and Anthoceropsida

Occurrence, structure and reproduction of thallus in Hepaticopsida (*Marchantia*) and Anthoceropsida (*Anthoceros*).

Unit-6. Bryopsida

Occurrence, structure and reproduction of thallus in Bryopsida (*Polytrichum*)

Recommended Books/Reference Material

1. Bellinger, E. G. and D. C. Sigeo. (2020). *Fresh water algae (Identification and use as bioindicators)*. John Wiley and Sons.
2. Hussain, F. (2023). *Phycology. A text book of Algae*. Pak Book Empire Lahore.
3. Vashishta, B. R., A. K. Sinha and A. Kumar. (2010). *Bryophytes*. S. Chand and Co. New Delhi.

Phycology and Bryology (Lab)

Course Code: BOT- 204L

Credit Hours: 1

Pre-requisite: Nil

Objectives:

To develop practical skills in the collection, identification, and laboratory handling of algae and bryophytes. To enable students to analyze their structure, applications, and present findings through scientific experimentation..

Learning Outcomes:

- Students will be able to collect, preserve, and prepare algal samples from different habitats using standard laboratory techniques.
- Identify and classify common algal and bryophyte genera (e.g., *Porella*, *Anthoceros*, *Polytrichum*) based on morphological characteristics.
- Prepare temporary slides and culture algae under controlled laboratory conditions.
- Assess the role of algae as biofertilizers and determine the chemical composition of algal biomass.

Lab Outline:

1. Collection and preservation of algae from various habitats.
2. Identification of algae.
3. Preparation of temporary slides. Culturing of algae.
4. Evaluation of algae as fertilizer.
5. Determination of the chemical composition of algal biomass.
6. Study of various available genera of bryophytes. For example; *Porella*, *Anthoceros* and *Polytrichum*.

Recommended Books/Reference Material

1. Andersen, R. A. (Ed.). (2005). *Algal culturing techniques*. Elsevier.
2. Barsanti, L., & Gualtieri, P. (2022). *Algae: anatomy, biochemistry, and biotechnology*. CRC press.
3. Bellinger, E. G. and D. C. Sigeo. 2020. *Fresh water algae (Identification and use as bioindicators)*. John Wiley and Sons.
4. Enroth, J., Koponen, T.J., Frahm, J.P., Pocs, T., Piippo, S.S., Rao, P., O'Shea, B. and Fang, Y.M., 2003. Manual of tropical bryology. *Tropical bryology*, 23, pp.1-200
5. Gautam, A. K., & Avasthi, S. (2019). *Methods in fungal biology: a manual of laboratory protocols*. Scientific Publishers.
6. Gupta, V. K., Tuohy, M. G., Ayyachamy, M., Turner, K. M., & O'donovan, A. (2013). *Laboratory protocols in fungal biology* (pp. 114-115). Springer.
7. Hussain, F. 2023. *Phycology. A text book of Algae*. Pak Book Empire Lahore.

Mycology

Course Code: BOT-205

Credit Hours: 2

Objectives:

To provide the students with basic knowledge about various groups of fungi and their economic importance.

Learning Outcomes:

Students will be able to

- Evaluate the taxonomy, morphology, and physiology of fungi and their roles in various ecosystems.
- Identify and understand various fungal groups.
- Apply mycological techniques to identify fungal species and assess their ecological and economic impacts.

Course Outline:

Unit-1. Introduction to Mycology

General characters of thallus, cell structure and ultrastructure of Fungi.

Unit-2. Reproduction

Asexual and sexual reproduction and structure of fruiting bodies. General life cycle of various fungi, haploid, heterokaryotic and diploid states.

Unit-3. Fungal Systematics

Classification, somatic structures and life cycle of Myxomycota, Chytridiomycota, Oomycota (Peronosporales), Zygomycota (Mucrales), Ascomycota (Erysiphales, Pezizales), Basidiomycota (Agaricales, Polyporales, Uredinales, Ustilaginales), Deuteromycota

Unit-4. Lichens and Mycorrhiza

Symbiotic relationships of fungi with other organisms (lichens and mycorrhiza) and their significance, Importance of fungi with special reference to industry and agriculture.

Recommended Books/Reference Material

1. Alexopoulos, C. J., Mims, C. W. and Blackwell, M., (2007). *Introductory Mycology*, 4th Ed. John Wiley and Sons.
2. Khan, A. G. and Usman, R., (2005). *Laboratory Manual in Mycology and Plant Pathology*. Botany Department Arid Agriculture University, Rawalpindi.
3. Trigliano, R. N., Windham, M. T. and Windham, A. S., (2004). *Plant Pathology: Concepts and Laboratory Exercises*. CRC Press, LLC, N.Y.
4. Watkinson, S., Boddy, L. and Money, N. (2015). *The Fungi*. Elsevier, Academic press.

Mycology (Lab)

Course Code: BOT- 205L

Credit Hours: 1

Pre-requisite: N.A

Objectives:

To equip students with practical skills in the isolation, identification, and culturing of fungi using standard laboratory techniques. To develop the ability to analyze fungal diversity and apply mycological knowledge in industrial and food-related applications.

Learning Outcomes:

Students will be able to

- Isolate, culture, and identify fungi from different habitats using standard microbiological techniques.
- Examine fungal morphology including unicellular and mycelial forms, septate and aseptate hyphae, and distinguish major fungal groups.
- Quantify spore/conidial load using a haemocytometer and interpret the results.
- Analyze asexual and sexual reproductive structures in different fungal groups based on laboratory observations.
- Perform applied mycological techniques such as culturing industrially important fungi and cultivating edible mushrooms, and present findings scientifically.

Lab Outline

1. Isolation and identification of fungi from different habitats.
2. Estimation of spore/conidial load in fungal suspension using haemocytometer.
3. Study of unicellular and mycelial forms with septate and aseptate hyphae.
4. Study of distinguishing characters of different phyla
5. Study of asexual and sexual reproductive structures in different groups of fungi
6. Study of fungal specimens collected during field trips
7. Culturing of any industrially important fungus for the production of any enzyme or metabolite
8. Cultivation of any edible mushroom in lab.

Recommended Books/Reference Material

1. Gautam, A. K., & Avasthi, S. (2019). *Methods in fungal biology: a manual of laboratory protocols*. Scientific Publishers.
2. Gupta, V. K., Tuohy, M. G., Ayyachamy, M., Turner, K. M., & O'donovan, A. (2013). *Laboratory protocols in fungal biology* (pp. 114-115). Springer.
3. Khan, A. G. and Usman, R., (2005). *Laboratory Manual in Mycology and Plant Pathology*. Botany Department Arid Agriculture University, Rawalpindi.
4. McGinnis, M. R. (2012). *Laboratory handbook of medical mycology*. Elsevier.

Plant Anatomy and Embryology

Course Code: BOT-206

Credit Hours: 2

Objectives:

To develop the better understanding of the structural organization and developmental processes of plants.

To analyze the knowledge about plant growth, development, reproduction, and adaptation and to solve problems related to plants.

Learning Outcomes:

Students will be able to:

- Describe the internal structure and development of plant cell and tissues.
- Use microscopy techniques to examine plant cells and tissues and embryological stages.
- Explain the stages of plant embryological development, fertilization and seed formation.

Course Outline:

Unit-1. Introduction to Plant Anatomy and Embryology

Scope and importance of plant anatomy and Embryology. Basic concepts of cell, tissue, and organ. The plant body (root, stem, and leaf). Basic concepts in plant reproduction. Structure of plant cells: cell wall, plasma membrane, cytoplasm, and organelles. Cell inclusions: vacuoles, crystals, and pigments. Variations in plant cell structure. Plasmodesmata and intercellular communication.

Unit-2. Meristems, Plant Growth and Tissue Systems

Definition and classification of tissues. Characteristics of meristematic cells. Types of meristems. Organization of shoot and root apex. Permanent Tissues: Simple tissues: parenchyma, collenchyma, and sclerenchyma. Complex tissues: xylem and phloem. Secretory tissues: glands, ducts, and laticifers.

Unit-3. Plant Anatomy

Primary structure and organization of dicot and monocot roots, stems, and leaves. Modifications and adaptations of root, stem and leaves). Secondary growth in dicot stems and roots. Stomatal structure and function in leaf. Vascular cambium: structure and function, Wood anatomy: types of wood and growth rings. Characteristics, and uses of wood. Cork cambium and periderm formation.

Unit-4. Plant Embryology

Structure of flower. Development of floral organs. Types of flowers. Floral symmetry and aestivation. Microsporogenesis and Male Gametophyte: Structure

of anther. Microsporangium development. The formation of pollen grains (Microsporogenesis). Structure and development of the male gametophyte. Megaspороgenesis and the Female Gametophyte: Structure of the ovule. Development of the ovule. The formation of the embryo sac (Megaspороgenesis). Types and development of the female gametophyte (embryo sac). Pollination: Types and mechanisms. Pollen-pistil interaction. Fertilization: double fertilization in angiosperms. Significance of double fertilization.

Unit-5. Embryo, Seed and Fruit Development

Embryogenesis in dicots: stages of embryo development. Embryogenesis in monocots. Variations in embryo development. Factors affecting embryo development. Endosperm development: types and functions. Seed development: development of seed coat and endosperm. Structure and types of seeds. Seed dormancy and germination. Development of the fruit. Types of fruits and their classification. Parthenocarpy. Apomixis: types and significance.

Recommended Books/Reference Material

1. Batygina, T. B. (Ed.). (2019). *Embryology of Flowering Plants: Terminology and Concepts, Vol. 3: Reproductive Systems*. CRC Press.
2. Crang, R., Lyons-Sobaski, S., and Wise, R. (2018). *Plant anatomy: a concept-based approach to the structure of seed plants*. Springer.
3. Pandey, B. P. (2001). *A Textbook of Botany: angiosperms*. S. Chand Publishing.
4. Pandey, S. N., and Chadha, A. (2009). *Plant anatomy and embryology*. Vikas Publishing House.
5. Sharma, P. P., and DINESH, D. V. (2020). *Angiosperms, histology, anatomy and embryology*. Educational Publishers and Distributors.
6. Simpson, M. G. (2019). *Plant systematics*. Academic press.
7. Bhojwani, S.S., Bhatnagar, S. P., and Dantu, P. K. (2015). *The embryology of angiosperms*. Vikas Publishing House.

Plant Anatomy and Embryology (Lab)

Course Code: BOT- 206L

Credit Hours: 1

Pre-requisite: N.A

Objectives:

To equip students with practical skills in plant anatomy and embryology through microscopic observation and dissection techniques, enabling them to analyze plant structures and developmental stages scientifically.

Learning Outcomes:

- Demonstrate proper use of microscopy to observe plant cells and tissues.
- Identify meristematic and permanent tissues in plant sections.
- Examine anatomical structures of roots, stems, and leaves.
- Analyze stages of microsporogenesis, megasporogenesis, and embryo development.
- Identify different types of seeds and fruits through practical observation.

Lab Outline:

1. Observation of plant cell structure: cell wall, cytoplasm, nucleus, vacuoles. Identification of apical meristems in shoot and root tips.
2. Study of organization of shoot and root meristem, different primary and secondary tissues.
3. Observation of transverse sections of dicot and monocot roots, stem and leaves. Study of stomatal structure and distribution.
4. Identification of annual rings, heartwood, and sapwood. Study of cork cambium and periderm formation.
5. Study of the external morphology of different types of flowers. Dissection of flowers to observe floral parts (sepals, petals, stamens, pistils).
6. Observation of different types of placentation. Observation of microsporogenesis in developing anthers.
7. Dissection of ovules to observe megasporogenesis. Study of the structure of different types of embryo sacs (female gametophytes).
8. Identification of different stages of dicot and monocot embryo development. Dissection of seeds to examine embryo and endosperm.
9. Study of seed structure (seed coat, cotyledons, plumule, radicle).
10. Study of the development of different types of fruits.
11. Identification of simple, aggregate, and multiple fruits.

Recommended Books/Reference Material

1. Batygina, T. B. (Ed.). (2019). *Embryology of Flowering Plants: Terminology and Concepts, Vol. 3: Reproductive Systems*. CRC Press.
2. Crang, R., Lyons-Sobaski, S., and Wise, R. (2018). *Plant anatomy: a concept-based approach to the structure of seed plants*. Springer.
3. Pandey, B. P. (2001). *A Textbook of Botany: angiosperms*. S. Chand Publishing.
4. Pandey, S. N., and Chadha, A. (2009). *Plant anatomy and embryology*. Vikas Publishing House.
5. Sharma, P. P., and DINESH, D. V. (2020). *Angiosperms, histology, anatomy and embryology*. Educational Publishers and Distributors.
6. Simpson, M. G. (2019). *Plant systematics*. Academic press.
7. Bhojwani, S.S., Bhatnagar, S. P., and Dantu, P. K. (2015). *The embryology of angiosperms*. Vikas Publishing House.

Phytogeography

Course Code: BOT-207

Credit Hours: 2

Objectives:

To provide students an adequate knowledge of geographical regions and species distribution

Learning Outcomes:

- Students will be able to evaluate the historical, climatic, and ecological factors influencing plant distribution and diversity.
- Understand the concept of different biomes, phytogeographic regions, and endemism.
- Analyze the distribution patterns of plant species and communities across different geographic regions.
- Application of GIS and Geo-locate for plant distribution and mapping.

Course Outline:

Unit-1. Introduction of Phytogeography

History. Geography and geology. Species distributions. Climate.

Unit-2. Communities and Ecosystems

Biomes. Diversification. Distribution areas. Centers of evolution.

Unit-3. Principles of Phytogeography

Wides, endemic and discontinuous species. Endemism – types and causes. Plant Chorology. Cosmopolitanism and endemism – Plant refugia.

Unit-4. Floristic Kingdoms and Regions

History of flora and vegetation, Functional aspects: life form, Physionomic and Syntassonomic. Vegetation dynamics, Anthropogenic impacts on flora and Vegetation, Vegetation types of Pakistan, Phytogeographic regions of Pakistan.

Recommended Books/Reference Material

1. Drossos E. (2022). Phytogeography. Edition of A.U.Th. Thessaloniki.
2. Good, R. (2021). The Geography of flowering Plants (2nd Edn.) Longmans, Green and Co., Inc., London and Allied Science Publishers, New Delhi
3. Lomolino, MV, BR Riddle, RJ Whittaker. (2023). Biogeography (5th Ed.). Sinauer and Assoc.: Sunderland, Massachusetts. ISBN-13: 978-1605354729

Phytogeography (Lab)

Course Code: BOT-207L

Credit Hours: 1

Pre-requisite: N.A

Objectives:

To develop practical skills in vegetation analysis, plant identification, and ecological survey techniques. To enable students to collect, analyze, and interpret ecological data scientifically.

Learning Outcomes:

- Demonstrate proper field and laboratory safety practices.
- Apply quadrat and transect methods for vegetation analysis.
- Identify local flora and prepare herbarium specimens.
- Analyze ecological parameters such as density, frequency, and abundance.
- Interpret ecological data and prepare scientific reports.

Lab Outline

1. Study of field safety and basic ecological survey methods.
2. Application of quadrat and transect techniques to observe plant distribution.
3. Measurement of frequency, density, and abundance of plant species.
4. Identification of local flora in relation to vegetation types.
5. Preparation of herbarium specimens using standard techniques.
6. Basic soil analysis (texture and pH) affecting plant distribution.
7. Field observation of vegetation types and ecological adaptations.
8. Recording and presentation of ecological data in report form.

Recommended Books/Reference Material

4. Drossos E. (2022). Phytogeography. Edition of A.U.Th. Thessaloniki.
5. Good, R. (2021). The Geography of flowering Plants (2nd Edn.) Longmans, Green and Co., Inc., London and Allied Science Publishers, New Delhi
6. Lomolino, MV, BR Riddle, RJ Whittaker. (2023). Biogeography (5th Ed.). Sinauer and Assoc.: Sunderland, Massachusetts. ISBN-13: 978-1605354729

Principles of Plant Ecology

Course Code: BOT-208

Credit Hours: 2

Objectives:

To provide the adequate knowledge of biotic and abiotic factors of environment, their interactions and impacts on plant distribution. To familiarize the students with current scenario of climate change and its impact on water scarcity

Learning Outcomes:

After completion of this course, students will be able to

- Understand the basic principles and scope of plant ecology.
- Explain the interactions between plants and environmental factors.
- Analyze the role of soil, water, light, temperature, and wind in plant growth and distribution.
- Understand ecological relationships, ecosystem functioning, and energy flow.
- Evaluate ecological processes affecting plant communities and succession.
- Recognize the impacts of climate change on ecosystems and water availability.

Course Outline:

Unit-1. Introduction to Ecology

Concept and definition of Ecology: History and Sub fields of Plant Ecology
Environment: Biotic and Abiotic Components. Applications of Ecology

Unit-2. Soil, Water and Wind Factors

Soil - a three-phase system, Structure Texture, Soil profile, water and air in the pore system, soil-plant-atmosphere continuum (SPAC), Salt and drought stress and osmoregulation. Soil erosion: Types and effects. Soil salinity and water logging. Water Cycle, Atmospheric moisture: Rain, snow, hail, fog mist and dew. Grouping of plants based on water requirements. Effects of water on germination, growth, reproduction and metabolic processes of plant. Water scarcity and impacts Wind types and effects on plant and soil

Unit-3. Temperature and Light Factor

Light: Visible and invisible spectrum, Absorption spectrum of plants, groups of plants with respect to light requirement, Effects on growth and metabolism, Temperature: Concept and classification of plants on temperature requirement, effects on germination, growth, reproduction and metabolism.

Unit-4. Biotic Factors and interactions

Introduction: Producers, Consumers, Decomposers, Food chains and food webs, Energy Flow and Pyramid Ecosystem Productivity.

Unit-5. Population and Ecosystem Ecology

Introduction. Species Population and Community ecology. Ecological characteristics of plant community. Biogeochemical cycles. Major vegetation types, Biological succession. Applied ecology: causes, effects and control of climate change

Recommended Books/Reference Material

1. Keddy, P. A. (2017). *Plant ecology*. Cambridge University Press.
2. Keddy, P. A., and Laughlin, D. C. (2021). *A framework for community ecology: species pools, filters and traits*. Cambridge University Press.
3. Krauss, G. J., and Nies, D. H. (2015). *Ecological biochemistry: environmental and interspecies interactions*. John Wiley and Sons.
4. Schulze, E. D., Beck, E., and Müller-Hohenstein, K. (2015). *Plant ecology*. Springer Science and Business Media.
5. Tripathi, D. K., Singh, V. P., Chauhan, D. K., Sharma, S., Prasad, S. M., Dubey, N. K., and Ramawat, N. (Eds.). (2020). *Plant Life Under Changing Environment: Responses and Management*. Academic Press.

Principles of Plant Ecology (Lab)

Course Code: BOT- 208L

Credit Hours: 1

Pre-requisite: N.A

Objectives:

To provide practical understanding of ecological parameters and environmental factors affecting plant growth and distribution. To develop laboratory and field skills for soil analysis, vegetation analysis, and assessment of ecological responses of plants under different environmental conditions.

Learning Outcomes:

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

- Perform analysis of important soil properties.
- Measure soil moisture, field capacity, and water holding capacity.
- Evaluate the effects of environmental stresses on plant growth.
- Conduct vegetation analysis using ecological sampling methods.
- Interpret ecological data related to plant communities and environmental factors.

Lab Outline :

1. Measurement of soil pH.
2. Determination of soil texture.
3. Measurement of soil moisture contents.
4. Determination of soil field capacity.
5. Determination of soil water holding capacity.
6. Study of the effect of drought stress on seed germination and plant growth.
7. Study of the effect of temperature on germination and growth.
8. Measurement of transpiration rate in plants.
9. Vegetation analysis using quadrat method.
10. Vegetation analysis using line intercept method.
11. Measurement of light intensity and its effect on plant growth.
12. Identification of hydrophytes, mesophytes, and xerophytes.

Recommended Books/Reference Material

1. Keddy, P. A. (2017). Plant Ecology. Cambridge University Press.
2. Schulze, E. D., Beck, E., and Müller-Hohenstein, K. (2015). Plant Ecology. Springer Science and Business Media.
3. Tripathi, D. K., Singh, V. P., Chauhan, D. K., Sharma, S., Prasad, S. M., Dubey, N. K., and Ramawat, N. (Eds.). (2020). Plant Life Under Changing Environment: Responses and Management. Academic Press.
4. Misra, R. (2010). Ecology Workbook. Oxford and IBH Publishing Co.
5. Odum, E. P., and Barrett, G. W. (2005). Fundamentals of Ecology. Thomson Brooks/Cole.

Fundamentals of Plant Biochemistry

Course Code: BOT- 209

Credit Hours: 2

Objectives

To equip students with the understanding of metabolism, metabolic energy and plant constituents.

Learning Outcomes

At the end of course students will be able

- To understand metabolic pathways of plants.
- To categorize secondary metabolites and nutrients.
- Able to prepare molar and molal solutions

Course Outline:

Unit-1. Carbohydrates

Occurrence and classification. A general account of ribose, deoxyribose, xylulose, xylose, D-glucose, D-galactose, D - mannose, cellobiose, sucrose, maltose, trehalose, pentosans, fructosans, starch, cellulose, hemicellulose, amino sugars, derived acids and alcohols, glycosides, mucilages, pectins and lignins.

Unit-2. Lipids

Occurrence, classification. Structure and chemical properties of fatty acids, triglycerides, phospholipids, glycolipids, sulpholipids, waxes and sterols.

Unit-3. Proteins

Amino acids and their structure. Electro chemical properties and reactions of amino acids. Classification of proteins. Primary, secondary, tertiary and quaternary structure of proteins. Protein targeting. Protein folding and unfolding. Transport, storage, regulatory and receptor proteins. Protein purification. Protein sequencing. Biological roles.

Unit-4. Nucleic Acids

General introduction. Purine and pyrimidine bases, nucleosides, nucleotides. Structure and properties of DNA and RNA. Types and functions of RNA.

Unit-5. Enzymes

Nature and functions, Isozymes, ribozymes, Enzyme kinetics classification with examples of enzymes. Enzyme specificity and mode of action. I. U. E. typical groups. Nature of active sites enzymes, Allosteric and feedback mechanism, Enzymes inhibitors.

Recommended Books/Reference Material

1. Bonner, J., and Varner, J. E. (Eds.). (2012). *Plant biochemistry*. Elsevier.
2. Buchanan, B. B., Gruissem, W., and Jones, R. L. (Eds.). (2015). *Biochemistry and molecular biology of plants*. John Wiley and sons.
3. Heldt, H. W., and Piechulla, B. (2021). *Plant biochemistry*. Academic Press.
4. Hoffmeister, D. (Ed.). (2016). *Biochemistry and molecular biology* (Vol. 3). Springer.
5. Vance, D. E., and Vance, J. E. (Eds.). (2002). *Biochemistry of lipids, lipoproteins and membranes* (Vol. 36). Elsevier.

Fundamentals of Plant Biochemistry (Lab)

Course Code: BOT- 209L

Credit Hours: 1

Pre-requisite: N.A

Objectives:

To equip students with fundamental laboratory skills in plant biochemistry techniques and to develop the ability to perform qualitative and quantitative analysis of biomolecules present in plants.

Learning Outcomes:

- Students will be able to learn basic laboratory safety rules and demonstrate proper handling of laboratory equipment.
- Perform qualitative tests for identification of carbohydrates, lipids and proteins.
- Prepare molar, molal, normal and percentage (%) solutions and perform serial dilutions.
- Identify plant secondary metabolites and perform pH adjustment of biochemical samples.
- Demonstrate basic enzymatic reactions and interpret experimental results in a scientific format.

Lab Outline:

1. Introduction to laboratory safety rules and lab etiquette
2. Familiarization with laboratory equipment and glassware
3. Preparation of Molar, Molal, Normal and percentage (%) solutions
4. Serial dilution of samples and calculation of concentrations
5. Identification tests for carbohydrates (Benedict's and Iodine test)
6. Identification tests for reducing and non-reducing sugars
7. Biochemical tests for identification of lipids
8. Biochemical tests for identification of proteins
9. Identification tests for plant secondary metabolites (saponins)
10. Adjustment of pH of biochemical samples
11. Demonstration of enzyme activity (e.g., catalase or amylase)

Recommended Books/Reference Material

1. Bonner, J., and Varner, J. E. (Eds.). (2012). Plant Biochemistry. Elsevier.
2. Buchanan, B. B., Gruissem, W., and Jones, R. L. (Eds.). (2015). Biochemistry and Molecular Biology of Plants. John Wiley and Sons.
3. Heldt, H. W., and Piechulla, B. (2021). Plant Biochemistry. Academic Press.
4. Hoffmeister, D. (Ed.). (2016). Biochemistry and Molecular Biology (Vol. 3). Springer.
5. Vance, D. E., and Vance, J. E. (Eds.). (2002). Biochemistry of Lipids, Lipoproteins and Membranes (Vol. 36). Elsevier.

Fundamentals of Plant Physiology

Course Code: BOT- 210

Credit Hours: 2

Objectives:

The course aims to introduce the basic physiological processes in plants and their role in growth and development, to explain mechanisms of water and mineral uptake, transport, and metabolism in plants and to develop students' practical skills in conducting experiments related to plant physiology.

Learning Outcomes:

Upon successful completion of this course, students will be able

- To understand basic physiological processes.
- To describe the requirement and availability of water and nutrients for plant growth and development.
- To explain photosynthesis, respiration and transport.
- Analyze how plants respond to environmental stimuli and regulate internal processes.
- To equip with laboratory techniques to study physiological processes in plants experimentally.

Course Outline:

Unit 1: Water Relations in Plants

Importance of water to plant life, Structure and Properties of water, Diffusion and Osmosis, Water potential and its components, Water in the soil, Water absorption by roots, Water transport through xylem, water movement from the leaf to the atmosphere, Factors affecting transpiration.

Unit 2: Mineral Nutrition and Transport

Essential nutrients, deficiencies and plant disorders, Mechanisms of mineral absorption and translocation, Identify and treat nutrient deficiencies.

Unit 3: Germination and Growth

Seed germination, factors affecting seed germination, seed dormancy, methods to break seed dormancy, growth and development of plants.

Unit 4: Translocation in Phloem

Patterns of translocation (Source to sink), The pressure flow model, Phloem loading and unloading,

Unit 5: Photosynthesis

General concept, Visible light spectrum, Photosynthetic apparatus, light and dark reaction, Factors affecting photosynthesis

Unit 6: Respiration

Glycolysis, Krebs cycle and Electron Transport Chain, Anaerobic vs aerobic respiration, Energy production in plants.

Recommended Books / Reference Material

1. Buchanan, B. B., Gruissem, W., and Jones, R. L. (2015). *Biochemistry and molecular biology of plants* (2nd ed.). Wiley-Blackwell.
2. Hopkins, W. G., and Hüner, N. P. A. (2021). *Introduction to plant physiology* (5th ed.). Wiley.
3. Jain, V. K. (2021). *Fundamentals of plant physiology* (3rd ed.). S. Chand Publishing.
4. Salisbury, F. B., and Ross, C. W. (2020). *Plant physiology* (5th ed.). Cengage Learning.
5. Taiz, L., Zeiger, E., Møller, I. M., and Murphy, A. (2018). *Plant physiology and development* (6th ed.). Sinauer Associates, Oxford University Press.

Fundamentals of Plant Physiology (Lab)

Course Code: BOT- 210L

Credit Hours: 1

Pre-requisite: Nil

Objectives:

To develop practical skills in studying plant physiological processes through laboratory experiments and analytical techniques. To enable students to understand and evaluate factors affecting plant growth, metabolism, and nutrient status.

Learning Outcomes:

Upon successful completion of this course, students will be able

- Perform experiments to assess seed viability and germination under controlled conditions.
- Demonstrate and analyze physiological processes such as plasmolysis, deplasmolysis, and osmotic potential in plant cells.
- Extract, separate, and quantify photosynthetic pigments using spectrophotometry and chromatography techniques.
- Investigate factors affecting photosynthesis and respiration in plants through experimental observations.
- Examine water transport mechanisms and identify visual symptoms of nutrient deficiencies in plants.

Lab Outline:

1. Study viability of seeds for germination
2. Study of plasmolysis and deplasmolysis in plant cells
3. Determination of osmotic potential of plant cell sap
4. Chlorophyll extraction from plant by acetone method
5. Measurement of absorbance of chlorophyll a and b using spectrophotometer
6. Extraction and separation of photosynthetic pigments by chromatography
7. Experiment on factors affecting photosynthesis (e.g., light, CO₂ concentration)
8. Observation of aerobic and anaerobic respiration, Water transport in plants
9. Visual symptoms of nutrient's deficiency.

Recommended Books / Reference Material

1. Meyer, B. S., Anderson, D. B., & Swanson, C. A. (1955). *Laboratory plant physiology* (p. 168). New York: Van Nostrand.
2. Rahmi, M. (2021, June). Development of plant physiology practical guide book with scientific approach for education. In *Journal of Physics: Conference Series* (Vol. 1918, No. 5, p. 052066). IOP Publishing.
3. Jain, V. K. (2021). *Fundamentals of plant physiology* (3rd ed.). S. Chand Publishing.
4. Sharma, S., & Tiwari, G. (2022). *A Practical Manual on Fundamentals of Plant Physiology*. BFC Publications.

Advanced Plant Ecology

Course Code: BOT-315

Credit Hours: 2

Objectives:

To provide the students with an adequate knowledge of plant populations regulation. To familiarize the students with ecological models and estimate future scenario of forests and other ecosystems. To enable students to get insights on global ecological challenges and possible solutions.

Learning Outcomes:

By the end of this course, students will be able to:

- Explain plant population dynamics, including growth models, dispersal mechanisms, and factors regulating population structure.
- Analyze plant competition, spatial distribution patterns, and the impact of invasive species and human activities on plant populations.
- Describe ecological models and apply their principles to climate change and vegetation forecasting.
- Evaluate in situ and ex situ conservation strategies and their role in sustainable habitat management.
- Assess major ecological challenges and propose scientifically sound solutions for biodiversity conservation and environmental sustainability.

Course Outline:

Unit-1. Ecological Dynamics in plant Population

Introduction, Plant population growth models, Factors regulating plant population, Seed dispersal mechanism in population dynamics, Plant Competition and co-existence, Spatial patterns in plant population, Human impacts on plant population, Invasive species and population dynamics

Unit-2. Ecological Models

Introduction to ecological modelling, Model building design and application. Types of models, Analytic models, Simulation models, Empirical and process-based models in climate change applications/ Process based models: Forecast Model, Tree and Stand Simulator (TASS) Model and LANDIS-II.

Unit-3. Strategies For Habitat Conservation

In situ Conservation strategies and limitations *Ex Situ* conservation, Strategies and limitations, Habitat restoration, Sustainable land management, Invasive species control, Climate change mitigation environmental education and awareness

Unit-4. Ecological challenges and Solution

Introduction: Habitat loss and fragmentation, Climate Change, Loss of Biodiversity, Over exploitation of resources, Desertification and land degradation. Water scarcity and Pollution, Urbanization and industrialization, Ocean acidification, Possible mitigations to address challenges

Recommended Books/Reference Material

1. Bolker, B. M. (2022). *Ecological Models and Data in R* (2nd ed.). Princeton University Press
2. Kareiva, P., and Marvier, M. (Eds.). (2018). *Effective Conservation Science: Data Not Dogma*. Oxford University Press
3. Keddy, P. A., and Laughlin, D. C. (2021). *A framework for community ecology: species pools, filters and traits*. Cambridge University Press.
4. Lovejoy, T. E., and Hannah, L. (Eds.). (2019). *Climate Change and Biodiversity* (2nd ed.). Yale University Press.
5. Palmer, M. A., Zedler, J. B., and Falk, D. A. (2016). *Foundations of Restoration Ecology* (3rd ed.). Island Press.

Advanced Plant Ecology (Lab)

Course Code: BOT-315L

Credit Hours: 1

Pre-requisite: Nil

Objectives:

To develop practical skills in ecological sampling, biodiversity assessment, and analysis of plant populations. To enable students to evaluate conservation strategies and ecological issues through field-based learning and scientific reporting.

Learning Outcomes:

By the end of this course, students will be able to:

- Measure and analyze plant biodiversity, density, and frequency using standard ecological sampling techniques.
- Examine spatial patterns of plant population distribution using ecological methods and data interpretation.
- Investigate invasive plant species and evaluate ecological models related to climate change mitigation.
- Assess in situ and ex situ conservation strategies for sustainable management of plant biodiversity.
- Conduct field visits (e.g., botanical gardens, herbariums, national parks) and present ecological observations in a scientific format.

Lab Outline

1. Measurement of species biodiversity, density and frequency.
2. Spatial pattern in Plant Population Distribution.
3. Investigating invasive species of an Area. Working with ecological models in climate change mitigation.
4. In situ and ex situ conservation.
5. Visits to management of a gene bank/seed bank, herbarium, Botanical garden and national park

Recommended Books/Reference Material

1. Henderson, P. A. (2003). *Practical methods in ecology*. John Wiley & Sons.
2. Lovejoy, T. E., and Hannah, L. (Eds.). (2019). *Climate Change and Biodiversity* (2nd ed.). Yale University Press.
3. Ryan, J., Estefan, G., & Rashid, A. (2001). *Soil and plant analysis laboratory manual*. ICARDA.
4. Wheeler, C. P., Bell, J. R., & Cook, P. A. (2020). *Practical field ecology: a project guide*. John Wiley & Sons.

Advanced Plant Biochemistry

Course Code: BOT- 316

Credit Hours: 2

Objectives

To acquire understanding about the fundamentals of metabolic energy, metabolism and plant constituents.

Learning Outcomes

The students will be able to understand

- Explain the principles of bioenergetics, including oxidation-reduction reactions and energy transformations in living systems.
- Describe the biosynthesis, degradation, and regulation of carbohydrates, particularly sucrose and starch metabolism.
- Explain the metabolism of lipids and proteins, including energy balance, genetic code, and protein synthesis.
- Analyze the classification, biosynthesis, and functional roles of secondary metabolites such as phenolics, flavonoids, terpenes, and alkaloids.
- Explain the classification and metabolic roles of vitamins and assess the impact of their deficiencies.

Course Outline:

Unit-1. Bioenergetics

Oxidation and reduction in Living systems, Energy laws, energy changes

Unit-2. Starch metabolism

Biosynthesis and degradation of sucrose and starch, Regulation of sucrose and starch.

Unit-3. Fat and protein metabolism

Biosynthesis and degradation of fats with energy balance, Genetic code, Protein synthesis.

Unit-4. Secondary metabolites

Phenolics, different types, synthesis and functions of phenolics, Flavonoids and, different types, synthesis and functions of phenolics, Terpenes: classification, and their chemical constitution and biosynthesis. Alkaloids: occurrence, chemical nature and their roles, Aflatoxins: nature and their role.

Unit-5. Vitamins

Properties and classification, Role of vitamins in metabolism, Deficiency symptoms.

Recommended Books/Reference Material

1. Bonner, J., and Varner, J. E. (Eds.). (2012). *Plant biochemistry*. Elsevier.
2. Buchanan, B. B., Gruissem, W., and Jones, R. L. (Eds.). (2015). *Biochemistry and molecular biology of plants*. John Wiley and sons.
3. Heldt, H. W., and Piechulla, B. (2021). *Plant biochemistry*. Academic Press.
4. Hoffmeister, D. (Ed.). (2016). *Biochemistry and molecular biology* (Vol. 3). Springer.
5. Vance, D. E., and Vance, J. E. (Eds.). (2002). *Biochemistry of lipids, lipoproteins and membranes* (Vol. 36). Elsevier.

Advanced Plant Biochemistry (Lab)

Course Code: BOT- 316L

Credit Hours: 1

Pre-requisite: Nil

Objectives

To equip students with practical skills in biochemical testing for identification of primary and secondary metabolites in plant materials. To develop the ability to analyze metabolic processes and understand the functional role of biomolecules and vitamins in biological systems.

Learning Outcomes

The students will be able to understand

- Explain the biochemical composition, structure, synthesis, and degradation pathways of major biomolecules
- Perform qualitative biochemical tests for the identification of starch, reducing sugars, lipids, saponins, flavonoids, terpenes, anthocyanins, and essential oils in plant materials using standard laboratory techniques.
- Analyze the physiological roles of vitamins and interpret the consequences of their deficiencies in living organisms with reference to plant and human health.
- Evaluate the significance of bioactive plant metabolites and biochemical compounds in agriculture, medicine, nutrition, and biotechnology for sustainable development.

Lab outline

1. Biochemical test/ Identification of reducing and non-reducing sugars from plants.
2. Biochemical test/ Identification test for starch in potato.
3. Biochemical test/ Identification test for lipids
4. Biochemical tests for identification of saponins.
5. Biochemical tests for identification of flavonoids.
6. Qualitative test for the presence of anthocyanin and essential oils in plant flowers, leaves, fruits and vegetables leaves.
7. Biochemical tests for identification of terpenes,
8. 3D animations and interactivity about synthesis and degradation of starch, protein and fats
9. Videos and interactivity about role of vitamins and their deficiency symptoms.

Recommended Books/Reference Material

1. Joy, P. P., Surya, S., & Aswathy, C. (2025). Laboratory manual of biochemistry. *Kerala Agricultural University, Pineapple research station, Vazhakkulam*, 124-125.
2. Shanmugam, S., Kumar, T. S., & Panneer Selvam, K. (2025). *Laboratory handbook on biochemistry*. PHI Learning Pvt. Ltd.
3. Puttaraju, H. P., Prakash, B. M., & Murthy, B. K. (2021). *Molecular Biology and Biochemistry: A Lab Manual with Colour Plates* (Vol. 1). New India Publishing.

Advanced Plant Physiology

Course Code: BOT -317

Credit Hours: 2

Objectives:

This course aims to provide an advanced understanding of physiological, biochemical, and molecular mechanisms in plants, explore how plants regulate internal processes under varying environmental and stress conditions and equip students with the experimental skills needed to study complex physiological traits and stress adaptations.

Learning Outcomes:

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

- Integrate basic concepts to explain complex plant physiological mechanisms.
- Analyze the physiological and biochemical responses of plants to abiotic and biotic stresses.
- Explain regulatory pathways involving plant hormones, signaling molecules, and gene expression in plant development and stress responses.
- Apply advanced laboratory techniques to investigate plant physiological processes.

Course Outline:

Unit 1: Plant Endomembrane System and Transport Across Cell

Plant endomembrane system, Plant Cytoskeleton, Cell cycle regulation, Cell Wall, Plasmodesmata, Aquaporins and their role in water transport, Transport of ions across membranes (Passive and Active transport). Stress-induced modulation of water and nutrient uptake

Unit 2: Advanced Photosynthesis and Respiration

Regulation of photosynthesis under environmental stress, C₄, C₃ and C₂ cycles, Photorespiration: Biochemical pathway and significance, Photoinhibition, chlororespiration, and alternative respiratory pathways, Plant Adaptations for efficient photosynthesis (e.g., C₄ and CAM mechanisms).

Unit 3: Plant Growth Regulators and Responses

Auxins, Gibberellins, Cytokinins, Abscissic Acid, Ethylene, Brassinosteroids, Jasmonates, Physiological effects of plant hormones, plant growth responses (Tropism and nastic movements), Concept of Photoperiodism and Vernalization. Hormonal crosstalk in growth, development, and stress responses, Commercial importance of hormones, ABC model of flowering.

Unit 4: Plant Stress Physiology

Physiological and biochemical responses to: (Drought, Salinity, Heat and cold stress, Heavy metal toxicity), Mechanisms of oxidative stress management, ROS (Reactive Oxygen Species), production and antioxidant defense systems. Physiological adaptations to abiotic stress.

Unit 5: Senescence, Programmed Cell Death (PCD), and Adaptations

Cellular control of senescence, Role of hormones and environmental factors in ageing, Programmed Cell Death (PCD) pathways in plants.

Recommended Books / Reference Material

1. Ashraf, M., and Harris, P. J. C. (2013). *Abiotic stress: Plant responses and applications in agriculture*. Springer.
2. Buchanan, B. B., Gruissem, W., and Jones, R. L. (2015). *Biochemistry and molecular biology of plants* (2nd ed.). Wiley-Blackwell.
3. Hasegawa, P. M., Bressan, R. A., and Zhu, J. K. (2019). *Plant responses to environmental stresses: From molecular mechanisms to applications in biotechnology*. Wiley.
4. Hopkins, W. G., and Hüner, N. P. A. (2021). *Introduction to plant physiology* (5th ed.). Wiley.
5. Taiz, L., Zeiger, E., Møller, I. M., and Murphy, A. (2018). *Plant physiology and development* (6th ed.). Sinauer Associates, Oxford University Press.

Advanced Plant Physiology (Lab)

Course Code: BOT - 317L

Credit Hours: 1

Pre-requisite: Nil

Objectives:

This laboratory course is designed to provide students with hands-on expertise in quantifying physiological, biochemical, and molecular responses of plants to internal and environmental stimuli. It aims to develop technical proficiency in measuring water relations, photosynthetic efficiency, and oxidative stress markers while fostering an analytical approach to studying hormonal crosstalk and stress adaptation mechanisms. By the end of the course, students will be equipped to design and execute controlled experiments that simulate real-world environmental challenges.

Learning Outcomes:

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

- Quantify plant water status and nutrient transport efficiency using advanced physiological instruments.
- Assess the impact of abiotic stressors (drought, salinity, heavy metals) on plant morphological and biochemical traits.
- Demonstrate the role of plant growth regulators in mitigating stress through exogenous application experiments.

Lab Outline:

1. Measurement of plant water potential under stress conditions
2. Study effect of drought stress on morphology and physiology of plants
3. Study effect of salt stress on morphology and physiology of plants
4. Study stomata under microscope under stress and normal conditions
5. Measure heavy metal (Cd) in plants
6. Estimation of photosynthetic pigments under normal and stress conditions
7. Induction and observation of oxidative stress and antioxidant enzyme activities
8. Exogenous application of hormones to plant under stress conditions
9. Study of senescence indicators (chlorophyll degradation, lipid peroxidation).

Recommended Books / Reference Material

1. Ashraf, M., and Harris, P. J. C. (2013). *Abiotic stress: Plant responses and applications in agriculture*. Springer.
2. Buchanan, B. B., Gruissem, W., and Jones, R. L. (2015). *Biochemistry and molecular biology of plants* (2nd ed.). Wiley-Blackwell.

3. Hasegawa, P. M., Bressan, R. A., and Zhu, J. K. (2019). *Plant responses to environmental stresses: From molecular mechanisms to applications in biotechnology*. Wiley.
4. Hopkins, W. G., and Hüner, N. P. A. (2021). *Introduction to plant physiology* (5th ed.). Wiley.
5. Taiz, L., Zeiger, E., Møller, I. M., and Murphy, A. (2018). *Plant physiology and development* (6th ed.). Sinauer Associates, Oxford University Press.

Microbial Botany

Course Code: BOT-318

Credit Hours: 2

Objectives

To provide the students with an adequate knowledge about various microbial groups and to understand their phylogenetic relations, their relationship with plants and their role in entire ecosystem.

Learning Outcomes

- Students will be made familiarize with the morphological and systematic knowledge about different microbial groups.
- Students will be able to learn basic role of Microbes, their identification and basis of their grouping (classification).
- Importance and role of Microbes for plants and whole ecosystem.

Course Outline:

Unit-1. Microbial diversity

Whittaker's five-kingdom system and Carl Richard's three domain system. Microbiologists and their contributions (Leeuwenhoek, Louis Pasteur, Robert Koch, Joseph Lister, Dmitri Iwanowski, Sergius Winogradsky and M W Beijerinck and Paul Ehrlich) Distribution of microbes in soil, air, food and water. Significance of microbial diversity in nature.

Unit-2. Virus and Bacteria

Structure, reproduction and economic significance of viruses, General structure and classification of Viruses; ICTV system of classification, Structure and multiplication of TMV, SARS-COV-2, and Bacteriophage (T2), Cultivation of viruses. Vaccines and types. Economic significance with specific reference to bio fertilizers, pathogenicity and industrial importance. Viroids. General characteristics and classification. Archaeobacteria and Eubacteria. Ultrastructure of Bacteria; Bacterial growth and nutrition. Reproduction in bacteria- asexual and sexual methods. Study of Rhizobium and its applications, A brief account of Actinomycetes and Cyanobacteria. Mycoplasmas and Phytoplasmas, General characteristics and diseases, Economic importance of Bacteria.

Unit-3. Algae and Fungi

Structure, reproduction and economic significance of micro-Algae. Major groups and their characteristics. Chlorophyceae, Phaeophyceae, Rhodophyceae. Structure, reproduction and economic significance of Fungi, Slime molds and protozoa, their implication on crop production and industrial applications. General characteristics

and classification. Thallus organization and nutrition in fungi. Reproduction in fungi (asexual and sexual). Heterothallism and parasexuality. Type study of *Phytophthora*, *Rhizopus*, *Neurospora*, *Puccinia*, *Penicillium* and *Trichoderma*. Economic importance of Fungi.

Unit-4. Lichens

Structure and reproduction, VAM Fungi and their significance, Plant Diseases-Late Blight of Potato, Black stem rust of wheat; Downy Mildew of Bajra, Grain smut of Sorghum, Sandal Spike, Citrus Canker, Root Knot Disease of Mulberry. Mycorrhiza.

Unit-5. Plant Microbiome

Definition, the phyllosphere, the endosphere, and the rhizosphere, The relationships between plants and microorganisms in their environment, including beneficial, neutral, or harmful interactions, Bacterial and Fungal Endophytes. Their role in plant stress regulation, Role of Microbes in Ecosystem balance.

Unit-6. Applications of Microbes in Plant Biotechnology

Healthcare and Pharmaceuticals, Agriculture and Food Industry, Environmental Applications, Bioremediation and Biocontrol, Industrial Production and Manufacturing, Future Potential and Emerging Trends. Sustainable Practices.

Recommended Books/Reference Material

1. Antonelli, A., Smith, R. J., Fry, C., Simmonds, M. S., Kersey, P. J., Pritchard, H. W., and Qi, Y. D. (2020). *State of the World's Plants and Fungi (Doctoral dissertation, Royal Botanic Gardens (Kew); Sfumato Foundation)*.
2. Mauseth, J. D. (2003). *Botany: An Introduction to Plant Biology*. Jones and Bartlett Publishers, UK.
3. Prescott, L.M., Harley, J.P. and Klein, A. D. (2004). *Microbiology*. W. M. C. Brown Publishers.
4. Rao, N.S.S. (2016). *Advances in Agricultural Microbiology*. Butterworth-Heinemann. Elsevier, ISBN 1483100332.
5. Suraja Kumar Nayak (Editor), Bighneswar Baliyarsingh (Editor), Ashutosh Singh (Editor), Ilaria Mannazzu (Editor), Bibhuti Bhusan Mishra (Editor). (2022). *Advances in Agricultural and Industrial Microbiology: Volume-2: Applications of Microbes for Sustainable Agriculture and in-silico Strategies*. Springer.
6. Waghmare, S. D., and Raut, M. S. T. (2023). *A Textbook of Botany: Microbiology, Phycology, Mycology, And Fungal Technology*. Academic Guru Publishing House.

Microbial Botany (Lab)

Course Code: BOT- 318L

Credit Hours: 1

Pre-requisite: Nil

Objectives

This course aims to provide students with a foundational understanding of microbial diversity and the practical skills required to study viruses, bacteria, algae, and fungi. It focuses on the phylogenetic relationships between microbial groups, their specific interactions with plant tissues (pathogenic and symbiotic), and their critical roles in maintaining ecosystem balance and industrial sustainability.

Learning Outcomes

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

- Demonstrate mastery of aseptic techniques and sterilization protocols essential for a microbiology laboratory.
- Identify major microbial groups (bacteria, algae, fungi) using microscopic observations and morphological keys.
- Isolate and culture microorganisms from diverse environmental sources including soil, water, and plant endospheres.
- Apply differential staining techniques (e.g., Gram staining) to characterize bacterial and fungal structures.
- Recognize common plant diseases and the role of microbial symbionts (like VAM and Lichens) in plant health.
- Evaluate the industrial and biotechnological applications of microbes through direct observation and field visits.

Lab outline

1. Laboratory safety and aseptic techniques
2. Preparation and sterilization of media (solid and liquid)
3. Isolation of microorganisms from plant material
4. Microscopy basics: light microscopy, staining techniques (simple and differential)
5. Collection and isolation of freshwater and soil algae
6. Microscopic observation: cyanobacteria, green algae, diatoms,
7. Identification using morphological keys
8. Culturing techniques: preparation of algal culture media (e.g., Bold's Basal Medium)
9. Methods for isolating fungi from soil and plants (serial dilution, direct plating)
10. Staining and microscopic examination of fungal structures (spores, hyphae)
11. Identification of common fungal genera (e.g., Aspergillus, Penicillium, Rhizopus)
12. Introduction to fungal plant pathogens

13. Lichen structure and identification
14. Visit to water purification units/Composting/ microbiology labs/dairy and farms to understand role of microbes in day today life.

Recommended Books/Reference Material

1. Antonelli, A., Smith, R. J., Fry, C., Simmonds, M. S., Kersey, P. J., Pritchard, H. W., and Qi, Y. D. (2020). *State of the World's Plants and Fungi (Doctoral dissertation, Royal Botanic Gardens (Kew); Sfumato Foundation)*.
2. Mauseth, J. D. (2003). *Botany: An Introduction to Plant Biology*. Jones and Bartlett Publishers, UK.
3. Prescott, L.M., Harley, J.P. and Klein, A. D. (2004). *Microbiology*. W. M. C. Brown Publishers.
4. Rao, N.S.S. (2016). *Advances in Agricultural Microbiology*. Butterworth-Heinemann. Elsevier, ISBN 1483100332.
5. Suraja Kumar Nayak (Editor), Bighneswar Baliyarsingh (Editor), Ashutosh Singh (Editor), Ilaria Mannazzu (Editor), Bibhuti Bhusan Mishra (Editor). (2022). *Advances in Agricultural and Industrial Microbiology: Volume-2: Applications of Microbes for Sustainable Agriculture and in-silico Strategies*. Springer.
6. Waghmare, S. D., and Raut, M. S. T. (2023). *A Textbook of Botany: Microbiology, Phycology, Mycology, And Fungal Technology*. Academic Guru Publishing House.

Pteridophytes and Gymnosperms

Course Code: BOT- 319

Credit Hours: 2

Objectives

To acquire understanding about the extinct and extant genera of vascular kingdom, their evolution, distribution, habits, habitat and lifecycle.

Learning Outcomes

- Students will gain understanding about various vascular plants.
- Students will be able to identify pteridophytes, gymnosperm and angiosperms.

Unit-1. Introduction

Introduction, Classification, Role and Economic importance of Pteridophytes and Gymnosperms

Unit-2. Pteridophytes

Description of vascular bundle. First vascular plant- Rhynophyta e.g. Cooksonia. Introduction, origin, history, characteristics features and generalized lifecycle of pteridophytes. Affinities and comparatives of pteridophytes. Introduction, origin, history, characteristics features and generalized lifecycle of Psilopsida (Psilotum), Lycopsidea (Lycopodium), Selaginella. Why Selaginella failed to form seed? Origin and evolution of seed habit. Introduction, origin, history, characteristics features and generalized lifecycle of Sphenopsida (Equisetum), Pteropsida (Dryopteris and Marsilea).

Unit-3. Gymnosperms

Geological history, origin, distribution of ancient and living gymnosperm groups. Major groups of gymnosperms, morphology, anatomy, classification, affinities and life cycles of Cycadales (Cycas), Coniferales (Pinus), Ginkgoales (Ginkgo) and Gnetales (Gnetum, Welwitschia and Ephedra). Polyembryony.

Unit-4. Paleobotany

Paleobotany. Types of fossilizations. Methods of fossilizations, geological time scale. How to measure the geological time? Importance of paleobotany.

Recommended Books/Reference Material

1. Costa, L. M. S., Goetze, M., Rodrigues, A. V., Seger, G. D. D. S., and Bered, F. (2020). *Global rheophytes data set: angiosperms and gymnosperms*. Ecology, 101(8), e03056.
2. Singh, D. K., (2024). *Floristic diversity of the Indian Himalaya. Biodiversity of the Himalaya: Jammu and Kashmir State*, 93-126. CRC Press, United States.

3. Skoog, D.A., and West, D.M. (2009). *Vascular Plants*. (4th ed.) Holt Reinchart and Inc, London, UK.
4. Traverse, A. (2010). *Paleopalynology* (Vol. 28). Springer Science and Business Media Fifield. New Jersey, USA.
5. Taylor, E. L., Taylor, T. N., and Krings, M. (2023). *Paleobotany: the biology and evolution of fossil plants*. Academic Press. UK.
6. Traverse, A. (2007). *Paleopalynology* . Springer Science and Business Media.

Pteridophytes and Gymnosperms (Lab)

Course Code: BOT- 319L

Credit Hours: 1

Pre-requisite: N.A

Objectives:

To develop practical skills in the identification, classification, and herbarium preparation of pteridophytes and gymnosperms. To enable students to study their structure, reproduction, and life cycles through laboratory and field-based learning.

Learning Outcomes:

- Explain and demonstrate key structural features of pteridophytes and gymnosperms using models and AV aids.
- Identify and classify different species of pteridophytes and gymnosperms based on morphological and reproductive characteristics.
- Prepare herbarium specimens of selected pteridophytes and gymnosperms following standard techniques.
- Examine reproductive structures and life cycle stages (sporophyte and gametophyte) of representative groups.
- Conduct field studies and document observations of pteridophytes and gymnosperms in a scientific format.

Lab outline:

1. Model description about Pteridophytes
2. Model description of synangium of Psilotum
3. Microscopic study of Palynomorphs of various groups of Pteridophytes and Gymnosperms
4. Identification and Herbarium preparation of different extant species of pteridophytes
5. Field study of Pteridophytes and Gymnosperms
6. Identification and Herbarium preparation of different extant species of Gymnosperms
7. Use of AV aids to elaborate different species
8. Reproductive structures, sporophyte and Gametophyte generations of Pteridophytes and Gymnosperms

Recommended Books/Reference Material

1. Authority, P. N. G. F. (2017). Annex 4: Laboratory Manual For Collecting and Processing Plant Species.
2. Costa, L. M. S., Goetze, M., Rodrigues, A. V., Seger, G. D. D. S., and Bered, F. (2020). *Global rheophytes data set: angiosperms and gymnosperms*. Ecology, 101(8), e03056.
3. Skoog, D.A., and West, D.M. (2009). *Vascular Plants*. (4th ed.) Holt Reinchart and Inc, London, UK.
4. Taylor, E. L., Taylor, T. N., and Krings, M. (2023). *Paleobotany: the biology and evolution of fossil plants*. Academic Press. UK.

Systematics of Angiosperms

Course Code: BOT-320

Credit Hours: 2

Objectives:

To develop a comprehensive understanding of angiosperm diversity, evolution, and classification among students. To enable students identify, name, and interpret the relationships among flowering plant species and families, and to appreciate the role of systematics in broader biological contexts.

Learning Outcomes:

Students will be able to:

- Understand the principles of plant classification and nomenclature.
- Explain the phylogenetic relationships among different groups of angiosperms.
- Use basic and modern tools to identify plants and construct taxonomic keys. .

Course Outline:

Unit-1. Introduction to Angiosperm systematics, diversity and Evolution

Definition, scope and importance of plant systematics, Relationship between Systematics, Taxonomy and Classification. History of plant systematics. Characteristics of Angiosperms, Origin and Evolution of Angiosperms, Patterns of Angiosperm Diversity, Global distribution of Angiosperms.

Unit-2. Botanical Nomenclature and Plant Identification Methods

ICN: Principles and rules. Scientific Vs Common Names. Typification and author citation, valid publication and priority. Morphological Terminology. Plant Description. Taxonomic Keys (Dichotomous, Polytomous). Use of Floras and Monographs.

Unit-3. Classification Systems and Phylogenetic Principles

Historical Classification Systems (Artificial, Natural, Phylogenetic). Phylogenetic Principles (Cladistics, Molecular Systematics). Phylogenetic Trees: Interpretation and Analysis.

Unit-4. Angiosperm Phylogeny and Major Clades

Major Clades of Angiosperms (Basal Angiosperms, Monocots, Eudicots), Evolutionary Relationships within Angiosperms.

Unit-5. Diversity of Angiosperm families

Detailed study of Selected Angiosperm Families such as (Fabaceae, Poaceae, Asteraceae, Solanaceae, Orchidaceae). Diagnostic Features, Diversity and Distribution, Economic Importance, Evolutionary Relationships). Systematics Resources and Applications: Role of Herbaria and Botanical Gardens, Herbarium Techniques. Applications of Systematics in Agriculture and Medicine.

Recommended Books/Reference Material

1. Dehgan, B. (2023). *Garden Plants Taxonomy: Volume 2: Angiosperms (Eudicots)*. Springer Nature.
2. Erdtman, G. (2023). *Pollen morphology and plant taxonomy: Angiosperms (an introduction to palynology)*. Brill.
3. Simpson, M. G. (2019). *Plant systematics*. Academic press.
4. Spichiger, R. E. (2019). *Systematic botany of flowering plants: a new phylogenetic approach of the angiosperms of the temperate and tropical regions*. CRC Press.
5. Pandey, A. K., and Kasana, S. (2021). *Plant Systematics*. CRC Press.
6. Sharma, P. P., and Dinesh, D. V. (2020). *Angiosperms, histology, anatomy and embryology*. Educational Publishers and Distributors.

Systematics of Angiosperms (Lab)

Course Code: BOT- 320L

Credit Hours: 1

Pre-requisite: N.A

Objectives

To develop practical skills in plant identification, classification, and herbarium techniques through the study of angiosperm diversity and morphology.

Learning Outcomes

- Identify vegetative and reproductive structures of angiosperms.
- Construct and use dichotomous keys for plant identification.
- Analyze diagnostic features of major angiosperm families.
- Examine herbarium specimens and fresh plant materials for classification.
- Interpret floral structure, adaptations, and phylogenetic relationships.

Lab Outline

1. Study of angiosperm characteristics: vegetative and reproductive structures.
2. Observation of diverse forms of angiosperms.
3. Examination of floral diversity: variations in sepals, petals, stamens, and carpels.
4. Construction of simple dichotomous keys.
5. Study of the characteristics of basal angiosperms.
6. Detailed study of some angiosperm families (e.g., Poaceae, Orchidaceae, Liliaceae, Fabaceae, Solanaceae, Rosaceae, Asteraceae).
7. Examination of herbarium specimens and/or fresh material. Identification of diagnostic features.
8. Study of floral structure and adaptations.
9. Discussion of economic importance and distribution.
10. Phylogenetic relationships within the family.

Recommended Books/Reference Material

1. Dehgan, B. (2023). *Garden Plants Taxonomy: Volume 2: Angiosperms (Eudicots)*. Springer Nature.
2. Erdtman, G. (2023). *Pollen morphology and plant taxonomy: Angiosperms (an introduction to palynology)*. Brill.
3. Simpson, M. G. (2019). *Plant systematics*. Academic press.

4. Spichiger, R. E. (2019). *Systematic botany of flowering plants: a new phylogenetic approach of the angiosperms of the temperate and tropical regions*. CRC Press.
5. Pandey, A. K., and Kasana, S. (2021). *Plant Systematics*. CRC Press.
6. Sharma, P. P., and Dinesh, D. V. (2020). *Angiosperms, histology, anatomy and embryology*. Educational Publishers and Distributors.

Plant Pathology

Course Code: BOT-321

Credit Hours: 2

Objectives:

To develop understanding of plant diseases, including their causes, development, and interactions with host plants. Develop the ability to diagnose, manage, and control plant diseases in agricultural and natural ecosystems.

Learning Outcomes:

Students will be able to:

- Identify the symptoms of various diseases and their causal agents.
- Understand the host-pathogen interactions and defense mechanisms.
- Explain the control measures for plant diseases

Course Outline:

Unit-1. Introduction to Plant Pathology

Definition of plant pathology. Importance of plant diseases. Major plant pathogens and their characteristics. Concept of plant disease. Classification of Plant Diseases. Causes of Plant Diseases (Biotic and abiotic causes), Environmental factors. Nutrient deficiencies/toxicities. Biotic and abiotic diseases. Mechanisms of pathogenesis and infection processes. Host-pathogen interactions and disease development.

Unit-2. Plant Disease Development: Concepts and Processes

Mechanisms of pathogenesis and infection processes. Host-pathogen interactions and disease development. Disease cycle. Inoculation, penetration, infection, and colonization. Pathogenesis: Role of enzymes, toxins, and growth regulators. Symptomology of plant diseases. Signs of plant diseases.

Unit-3. Pathogen Attack and Defensive Mechanisms of Plants

Infection mechanisms of fungi, bacteria, viruses and nematodes. Host-parasite interactions. Recognition and signaling in plant diseases. Defense mechanisms of plants against Pathogens: Structural defenses: Pre-existing structural defenses, Induced structural defenses. Biochemical defenses: Pre-existing biochemical defenses, Induced biochemical defenses (e.g., phytoalexins, PR proteins). Molecular basis of plant defense. Systemic acquired resistance (SAR) and induced systemic resistance (ISR).

Unit-4. Plant Disease Epidemiology, Management and Control of Plant Diseases

Basic concepts of epidemiology. Factors affecting disease development and spread. Role of climate change in plant disease epidemiology. Principles of Plant Disease Management. Integrated plant disease management (IPM). Chemical Control of Plant Diseases. Mode of action of major pesticides. Factors affecting efficacy of pesticides. Biological Control of Plant Diseases. Mechanisms of biological control: Competition, Antibiosis, Mycoparasitism, Induced systemic resistance. Applications of biocontrol agents.

Unit-5. Host Resistance in Plant Diseases and Major Diseases of Crops

Host and Pesticide resistance. Genetic engineering for disease resistance, Deployment strategies for resistant varieties. Major Diseases of Field Crops: Important diseases in major field crops, including: Rice, Wheat, Maize, Soybean and Potato. Major Diseases of Horticultural Crops: Fruit diseases (e.g., citrus canker, apple scab). Vegetable diseases (e.g., tomato wilt, cucumber downy mildew). Ornamental plant diseases (e.g., rose black spot, powdery mildews).

Recommended Books/Reference Material

1. Awasthi, L. P., Das, S., Lee, R. F., and Pattanayak, S. (2024). *Plant Pathology*. CRC Press.
2. Divyashree, M., Manjula, C. P., and Patil, S. (2024). *Fundamentals of Plant Pathology*. Chyren Publication.
3. Dongre, M. A., Ashraf, M. S., Koshariya, A. K., and ReddyPriya, P. (2023). *Plant pathology and plant diseases*. AG publishing house (AGPH Books).
4. Lucas, J. A. (2020). *Plant pathology and plant pathogens*. John Wiley and Sons.

Plant Pathology (Lab)

Course Code: BOT- 321L

Credit Hours: 1

Pre-requisite: N.A

Objectives:

To develop skills in identification, isolation, and analysis of plant pathogens and to train students in disease diagnosis and laboratory handling techniques.

Learning Outcomes:

- Demonstrate safe handling of plant pathogens in laboratory conditions.
- Identify plant diseases based on symptoms and signs.
- Perform isolation and culturing of fungal and bacterial pathogens.
- Apply staining and microscopy techniques for pathogen identification.
- Conduct basic disease diagnosis and prepare scientific reports.

Lab Outline

1. Observation and identification of symptoms and signs of diseased plants (leaf spots, wilting, rots, blights etc.).
2. Sterilization techniques.
3. Microscopic examination of fungal spores and hyphae.
4. Identification of common fungal genera (e.g., *Fusarium*, *Rhizopus*, *Aspergillus*).
5. Microscopic identification of bacterial colonies from diseased plant. Observation of plant virus symptoms.
6. Observation and identification of plant-parasitic nematodes.
7. Study of disease development through Koch's postulates.
8. Principles of Plant Disease Management. Evaluation of plant varieties for disease resistance.
9. Collection of diseased samples from agricultural fields or gardens.
10. Preparation of herbarium specimens of infected plants

Recommended Books/Reference Material

1. Awasthi, L. P., Das, S., Lee, R. F., and Pattanayak, S. (2024). *Plant Pathology*. CRC Press.
2. Divyashree, M., Manjula, C. P., and Patil, S. (2024). *Fundamentals of Plant Pathology*. Chyren Publication.
3. Dongre, M. A., Ashraf, M. S., Koshariya, A. K., and Reddy Priya, P. (2023). *Plant pathology and plant diseases*. AG publishing house (AGPH Books).
4. Lucas, J. A. (2020). *Plant pathology and plant pathogens*. John Wiley and Sons.

Analytical Techniques in Botany

Course Code: BOT-416

Credit Hours: 2

Course Objectives

The course aims to introduce students to the fundamental analytical and instrumentation techniques used in plant sciences, develop technical skills for qualitative and quantitative analysis of plant materials and enable students to interpret experimental data and apply analytical techniques in botanical research.

Learning Outcomes

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

- Understand the principles behind key analytical methods used in botany.
- Operate laboratory equipment such as microscopy, spectroscopy, and chromatography used in plant sciences.
- Apply molecular techniques to study plant proteomics and genomics.
- Interpret botanical data using different analytical tools and software.
- Develop practical skills in qualitative and quantitative analysis of plant materials.

Course Outline

Unit 1: Principles of Analytical Techniques

Introduction to analytical methods: Qualitative vs. Quantitative analysis, Accuracy, precision, sensitivity, and specificity in botanical experiments

Unit 2: Microscopy, Imaging and Chromatography Techniques

Light Microscopy: Principles, types (bright field, phase contrast, fluorescence microscopy), Electron Microscopy: SEM and TEM basics and applications in plant studies, Micrometry: Calibration and measurements, Paper chromatography: Principle and applications, Thin Layer Chromatography (TLC): Separation of plant pigments, Basics of High Performance Liquid Chromatography (HPLC).

Unit 3: Analytical Techniques

Principle and working of UV-Visible Spectrophotometry, Application of spectrophotometry in pigment and protein estimation, Introduction to Atomic Absorption Spectroscopy (AAS) for mineral analysis, Basics of DNA extraction and quantification, Polymerase Chain Reaction (PCR), Principle and overview, Gel electrophoresis, Principle and interpretation, Real time PCR (Principle and role in daily life)

Unit 4: Proteomics and Genomics

Protein extraction and measurement, Mass spectrometry for proteomics, metabolomics using NMR and LC-MS/MS.

Recommended Books / Reference Material

1. Buchanan, B. B., Gruissem, W., and Jones, R. L. (2015). *Biochemistry and molecular biology of plants* (2nd ed.). Wiley-Blackwell.
2. Harris, D. C. (2020). *Quantitative chemical analysis* (10th ed.). W. H. Freeman and Company.
3. Ninfa, A. J., and Ballou, D. P. (2019). *Fundamental laboratory approaches for biochemistry and biotechnology* (6th ed.). Wiley.
4. Plummer, D. T. (2017). *An introduction to practical biochemistry* (3rd ed.). Tata McGraw Hill Education.
5. Skoog, D. A., West, D. M., Holler, F. J., and Crouch, S. R. (2017). *Fundamentals of analytical chemistry* (10th ed.). Cengage Learning.

Analytical Techniques in Botany (Lab)

Course Code: BOT-416L

Credit Hours: 1

Pre-requisite: Nil

Course Objectives

To provide hands-on training in the use of analytical instruments and laboratory techniques employed in plant sciences. To develop practical skills for analysis of plant tissues, pigments, proteins, nucleic acids, and minerals using modern analytical approaches.

Learning Outcomes

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

- Operate basic analytical instruments used in botanical laboratories.
- Prepare plant samples for microscopic, chromatographic, spectroscopic, and molecular analyses.
- Perform qualitative and quantitative analysis of plant biomolecules.
- Analyze and interpret laboratory results using standard procedures.
- Apply analytical techniques in botanical and biochemical research.

Lab Outline

1. Use of light microscope for plant tissue observation
2. Micrometry: Measurement of cell size, Preparation of permanent slides
3. Extraction and separation of chlorophyll and carotenoids by paper chromatography
4. Thin Layer Chromatography (TLC) for secondary metabolites
5. Estimation of chlorophyll content using UV-Visible spectrophotometer
6. Quantification of proteins by Bradford or Lowry method
7. DNA extraction from plant tissues (young leaf)
8. DNA quantification using Nanodrop, PCR
9. Agarose gel electrophoresis for DNA separation
10. Determination of mineral content (e.g., iron, zinc) using Atomic absorption spectrophotometer.

Recommended Books / Reference Material

1. Harris, D. C. (2020). Quantitative Chemical Analysis (10th ed.). W. H. Freeman and Company.
2. Ninfa, A. J., and Ballou, D. P. (2019). Fundamental Laboratory Approaches for Biochemistry and Biotechnology (6th ed.). Wiley.
3. Plummer, D. T. (2017). An Introduction to Practical Biochemistry (3rd ed.). Tata McGraw Hill Education.

Field Botany

Course Code: BOT-417

Credit Hours: 2

Objectives:

To provide the students with an adequate knowledge about identifying, classifying, and naming plants in their natural habitats.

Learning Outcomes:

- Students will be able to understand the techniques for plants collection from field to herbarium and botanical gardens.
- Students will be able to Use basic methods to identify and document plant species.
- Conduct survey to develop botanical inventory and report.

Course Outline:

Unit-1. Introduction to Field Botany

Definition, scope, and importance of field botany. Applications of field botany in science and conservation. Overview of the major groups of plants (algae, bryophytes, pteridophytes, gymnosperms, angiosperms).

Unit-2. Principles of Plant Morphology

Basic plant structures: root, stem, leaf, flower, fruit, and seed. Types of leaves, stems, and roots. Inflorescence types and floral formula. Fruit types and seed dispersal mechanisms.

Unit-3. Fundamentals of Plant Taxonomy

Concept and importance of classification. Systems of classification (artificial, natural, phylogenetic). Binomial nomenclature and rules of botanical naming (ICN – International Code of Nomenclature). Major plant families: key diagnostic features.

Unit-4. Tools for Plant Identification

Understanding and using dichotomous keys, Structure and use of field guides, floras, and manuals. Botanical terminology essential for identification, Introduction to herbarium practices.

Unit-5. Ecology of Plants

Plant communities and their classification, Ecological factors affecting plant growth and distribution (light, temperature, soil, water), Succession, adaptation, and habitat types, Endemism and invasive plant species.

Unit-6. Conservation and Ethical Considerations

Importance of plant conservation, Threats to plant biodiversity, Role of field botany in conservation biology, Ethical guidelines for plant collection and research.

Unit-7. Modern Approaches in Field Botany

Role of technology (GPS, GIS, mobile apps) in modern plant documentation, Introduction to molecular tools for plant identification (brief), Remote sensing in vegetation analysis (brief overview).

Recommended Books/Reference Material

1. Anuradha, S., Padmaja, O., & Putta, S. (2025). *Modern Botany: Techniques, Tools and Trends*. Addition Publishing House.
2. Kolbert, E. (2014). *The sixth extinction: An unnatural history*. Henry Holt and Company.
3. Peterson, L. (1978). *A Pocket Guide to Edible Wild Plants* (No. 23). Houghton Mifflin Harcourt.
4. Rheinheimer, M. (2013). Biotechnologische Prozesse mit Basidiomyceten zur Produktion von Enzymen und Aromastoffen.
5. Wohlleben, P. (2016). *The hidden life of trees: What they feel, how they communicate—Discoveries from a secret world* (Vol. 1). Greystone Books.

Field Botany

Course Code: BOT- 417L

Credit Hours: 1

Pre-requisite: Nil

Objectives

To provide students with practical knowledge and field-based skills in identifying, classifying, and documenting plants in their natural habitats.

Learning Outcomes

- Students will be able to understand techniques for plant collection, preservation, and herbarium preparation.
- Use basic field methods to identify and document plant species in natural environments.
- Apply taxonomic tools such as dichotomous keys for plant identification.
- Conduct field surveys and develop botanical inventories and reports.
- Demonstrate the use of basic tools and technologies for field-based plant studies.

Lab Outline

1. Introduction to field botany equipment and safety guidelines
2. Study of plant morphology in field conditions (root, stem, leaf, flower, fruit, seed)
3. Field observation and identification of plant species using dichotomous keys
4. Collection techniques and methods of plant specimen preservation
5. Herbarium preparation and labeling techniques
6. Identification of major plant families based on diagnostic features
7. Vegetation sampling methods (quadrat and transect techniques)
8. Recording and documentation of field data
9. Use of GPS and basic mapping for plant distribution studies
10. Mini field excursion for plant survey and inventory preparation

Recommended Books/Reference Material

1. Anuradha, S., Padmaja, O., & Putta, S. (2025). *Modern Botany: Techniques, Tools and Trends*. Addition Publishing House.
2. Kolbert, E. (2014). *The Sixth Extinction: An Unnatural History*. Henry Holt and Company.
3. Popa, M. E. (2011). Field and laboratory techniques in plant compressions: an integrated approach. *Acta Palaeontologica Romaniae*, 7, 279-283.
4. Wohlleben, P. (2016). *The Hidden Life of Trees: What They Feel, How They Communicate—Discoveries from a Secret World*. Greystone Books

Forensic Botany

Course Code: BOT-418

Credit Hours: 2

Objectives:

The course aims to introduce students to the principles and practices of Forensic Botany, exploring various techniques to analyze botanical evidences and implementation in legal cases.

Learning Outcomes:

By the end of this course, students will be able to:

- Understand how plants can be used in forensic investigations.
- Describe methods for analyzing plant-based evidence.
- Explain the role of plant material in forensic science.

Course Outline:

Unit-1. Introduction to Forensic Botany

Definition, historical perspective and the evolution of forensic botany, importance and applications in forensic science, branches of forensic botany

Unit-2. Botanical Evidence and Crime Scene Investigation

The use of biological and botanical evidence in criminal investigations and its importance. Techniques of collection, documentation and transportation of plant evidence, Preservation of leaves, seeds, spores, pollen, and roots.

Unit-3. Role of Various Disciplines of Botany in Forensic investigation

Pollen (Palynology), phytoliths and limnology in forensics, Analysis of diatoms in drowning cases, Dendrochronology, Basics of tree-ring dating and its application in forensics, Plant ecology in forensic botany - Geographical distribution of plant species and its forensic relevance (gravesite analysis, time of deposition, geomorphology)

Unit-4. DNA Analysis in Forensic Botany

Types of sample and collection methods for DNA analysis, Use of genetic data for forensic investigations, genotyping methods.

Unit-5. Ethics and Challenges

Ethical considerations in handling plant evidence, Challenges in plant-based forensic analysis

Recommended Books/Reference Material

1. Arya, N. (2024). *Forensic Botany. In Fundamentals of Forensic Biology* (pp. 401-413). Singapore: Springer Nature Singapore.
2. Avis-Riordan, K. (2020) Plant forensics: *Cracking criminal cases*. Royal Botanic Garden Kew. [Online] Available at: <https://www.kew.org/read-and-watch/how-forensic-botany-plant-science-solve-crimes>
3. Coyle, H. M., Lee, H. C., and Palmbach, T. M. (2023). *Forensic botany plants as evidence in criminal cases and as agents of bioterrorism. In Forensic DNA applications* (pp. 305-316). CRC Press.
4. Gibson, D. J. (2022). *Planting Clues: How plants solve crimes*. Oxford University Press.
5. Kasprzyk, I. (2023). *Forensic botany: who?, how?, where?, when? Science and Justice* 63 (2023) 258–275.
6. Margiotta, G. et al. (2015) *Forensic botany as a useful tool in the crime scene: Report of a case. Journal of Forensic and Legal Medicine*, 34, pp. 22-28.
7. Margiotta, G., Bacaro, G., Carnevali, E., Severini, S., Bacci, M., and Gabbrielli, M. (2015). *Forensic botany as a useful tool in the crime scene: Report of a case. Journal of forensic and legal medicine*, 34, 24-28.
8. Uitdehaag, S., Dragutinovic, A., and Kuiper, I. (2010). Extraction of diatoms from (cotton) clothing for forensic comparisons. *Forensic science international*, 200(1-3), 112-116.

Forensic Botany (Lab)

Course Code: BOT- 418L

Credit Hours: 1

Pre-requisite: Nil

Objectives:

To develop practical skills in the collection, handling, and analysis of botanical evidence for forensic investigations. To enable students to interpret and present scientific findings using standard forensic documentation and reporting methods.

Learning Outcomes:

By the end of this course, students will be able to:

- Demonstrate laboratory safety practices and maintain proper chain-of-custody procedures for forensic botanical evidence.
- Collect, prepare, and examine botanical evidence using microscopy and anatomical identification techniques.
- Identify plant materials (leaves, seeds, wood, pollen, phytoliths, and fibers) for forensic investigation.
- Perform basic molecular and analytical techniques such as DNA extraction and electrophoresis for evidence analysis.
- Interpret forensic findings, document evidence, and present results through reports and mock-court presentations.

Lab Outline

1. Introduction to forensic botany lab safety and chain-of-custody procedures
2. Types and recognition of botanical evidence
3. Crime-scene sampling techniques
4. Microscopic skills and slide preparation
5. Anatomical identification of plant materials including leaves, stems, seeds, and wood
6. Palynology with emphasis on pollen and spores; examination of plant microtraces such as phytoliths and plant hairs; identification of natural and synthetic fibers
7. Introductory plant DNA extraction and electrophoresis demonstrations
8. Comparative identification of known and unknown evidence samples
9. Forensic documentation; preparation of laboratory reports; and a final mock-court presentation.

Recommended Books/Reference Material

1. Avis-Riordan, K. (2020) Plant forensics: *Cracking criminal cases*. Royal Botanic Garden Kew. [Online] Available at: <https://www.kew.org/read-and-watch/how-forensic-botany-plant-science-solve-crimes>

2. Coyle, H. M., Lee, H. C., and Palmbach, T. M. (2023). *Forensic botany plants as evidence in criminal cases and as agents of bioterrorism*. In *Forensic DNA applications* (pp. 305-316). CRC Press.
3. Gibson, D. J. (2022). *Planting Clues: How plants solve crimes*. Oxford University Press.
4. Robertson, J. (2013). *Forensic botany. A practical guide*.
5. Wiltshire, P. E. (2009). Forensic ecology, botany, and palynology: some aspects of their role in criminal investigation. In *Criminal and environmental soil forensics* (pp. 129-149). Dordrecht: Springer Netherlands.

Plant Biotechnology

Course Code: BOT-419

Credit Hours: 2

Objectives:

To introduce students to the principles and applications of biotechnology in plants, and provide practical skills focusing on genetic engineering, plant tissue culture, molecular breeding, and biotechnological solutions to agricultural and environmental challenges.

Learning Outcomes:

By the end of this course, students will be able to:

- Understand the principles of plant biotechnology.
- Describe the techniques of tissue culture, genetic engineering, and Phyto nanotechnology.
- Application of biotechnological methods for commercialization.
- Explain the ethical implications of plant biotechnology.

Course Outline:

Unit-1. Introduction to Plant Biotechnology

History and scope of plant biotechnology, Genetic basis of plant improvement, Overview of conventional vs modern breeding techniques.

Unit-2. Plant Tissue Culture Techniques

Principles of plant tissue culture, Media preparation and sterilization, Micropropagation and somatic embryogenesis.

Unit-3. Genetic Engineering in Plants

Introduction, Vectors, Methods of gene transfer: Agrobacterium-mediated, biolistics, Selection markers and reporter genes, Production of transgenic plants and their applications.

Unit-4. Molecular Breeding and Genomic Tools

Marker-assisted selection (MAS), Genetically modified (GM) crops, CRISPR-Cas9 genome editing in plants.

Unit-5. Applications and Ethical Considerations

Biotechnology in crop improvement (disease resistance, stress tolerance), Biotechnology for environmental sustainability (phytoremediation), Bioethics, biosafety, and regulatory frameworks.

Recommended Books/Reference Material

1. Álvarez, S. P., Ardisana, E. F. H., & Leal, R. P. (2020). Plant biotechnology for agricultural sustainability. In *Resources use efficiency in agriculture* (pp. 389-425). Singapore: Springer Singapore.
2. Bhojwani, S.S., and Razdan, M.K. (2005). *Plant Tissue Culture: Theory and Practice*. Elsevier.
3. Chawla, H.S. (2009). *Introduction to Plant Biotechnology*. CRC Press.
4. Dubey, R. C. (2022). *A textbook of Biotechnology*. S. Chand Publishing.
5. Kartha, K. K. (2024). Cryopreservation of plant cells and organs. CRC press.
6. Kung, S. D., and Arntzen, C. J. (Eds.). (2014). *Plant Biotechnology: Biotechnology* (Vol. 11). Elsevier.
7. Seidman, L. A., Kraus, M. E., Lietzke Brandner, D., and Mowery, J. (2022). *Laboratory Manual for Biotechnology and Laboratory Science: The Basics* (p. 444). Taylor and Francis.

Plant Biotechnology (Lab)

Course Code: BOT-419L

Credit Hours: 1

Pre-requisite: Nil

Objectives:

To develop practical skills in plant tissue culture, genetic transformation, and molecular biology techniques. To enable students to apply biotechnology tools for plant improvement and analyze experimental outcomes scientifically.

Learning Outcomes:

By the end of this course, students will be able to:

- Demonstrate laboratory safety practices, aseptic techniques, and proper handling of biotechnology equipment.
- Prepare culture media (e.g., MS medium), perform sterilization, and establish plant tissue cultures.
- Apply different molecular biology techniques like DNA extraction, PCR and gel electrophoresis and genetic transformation

Lab outline

1. Laboratory safety protocols. Overview of lab equipment and aseptic handling
2. Preparation of Murashige and Skoog (MS) medium.
3. Adjustment of pH and sterilization techniques
4. Surface sterilization of plant explants
5. Callus induction techniques using appropriate growth regulators.
6. Subculturing and maintenance of callus cultures
7. Introduction to *Agrobacterium tumefaciens*.
8. Co-cultivation methods for gene transfer.
9. Selection and regeneration of putative transformants
10. DNA extraction from plant tissues. Polymerase Chain Reaction (PCR) to detect inserted genes.
11. Agarose gel electrophoresis for PCR product analysis. Fingerprinting using markers.

Recommended Books/Reference Material

1. Álvarez, S. P., Ardisana, E. F. H., & Leal, R. P. (2020). Plant biotechnology for agricultural sustainability. In *Resources use efficiency in agriculture* (pp. 389-425). Singapore: Springer Singapore.
2. Giri, C. C., & Giri, A. (2013). *Plant Biotechnology: Practical Manual*. IK International Pvt Ltd.

3. Kumar, N. (Ed.). (2022). *Biotechnology and crop improvement: tissue culture and transgenic approaches*. CRC Press.
4. Punia, M. S. (2018). *Plant biotechnology and molecular biology: A laboratory manual*. Scientific Publishers.
5. Seidman, L. A., Kraus, M. E., Lietzke Brandner, D., & Mowery, J. (2022). *Laboratory manual for biotechnology and laboratory science: the basics* (p. 444). Taylor & Francis.
6. Recent laboratory manuals, research articles, and online tutorials (NCBI, EMBL resources).

Economic and Industrial Botany

Course Code: BOT-420

Credit Hours: 3

Pre-requisite: Nil

Objectives:

This course is designed with the aim to explore the diverse and significant roles that plants play in various industries, including pharmaceuticals, textiles, food and beverages, bioenergy, chemicals, construction.

Learning Outcomes:

By the end of this course, students will be able to:

- Understand the economic importance of different plant species.
- Describe the industrial uses of plants.
- Explain how economically important plants are cultivated and commercialized.
- Understand plant-based business and entrepreneurship.

Course Outline:

Unit-1. Introduction

Introduction to Economic and Industrial Botany, Overview of plant domestication and origin of cultivated species, Classification of economic plants (based on use), Importance of plant biodiversity in economic development

Unit-2. Food and Beverage Plants

Plants as Sources of Food and Beverages, Important Cereals: wheat, rice, corn, maize their morphology, history, cultivation, chemical composition and uses. Sugars and Starches - Sugarcane (Morphology, Ratooning, Products and By-products); Potato (Morphology, Seed Tubers vs True Potato Seeds and Economic uses), Beverages: Tea, Coffee, Cocoa (Morphology, Processing and Economic Importance), Fruits and vegetables of commercial value, Processing and preservation of food plants

Unit-3. Medicinal, Aromatic and Dye Plants

Medicinal and Drug-Yielding Plants - Brief Account of Therapeutic Drugs with Examples; Morphology, Chemical Constituents, Economic Importance of Medicinal plants: Neem, Aloe vera, Ashwagandha, Turmeric, Aromatic plants: Lemongrass, Lavender, Eucalyptus, Dye-yielding plants: Indigo, Henna, Madder

Unit-4. Fiber Industry

Fiber industry, structure and classification of fibers, fiber yielding plants; cotton, lin, jute, sun hemp, Indian hemp, coir, aak, sumbal, paper mulberry, kapas, their morphology, harvesting procedures, importance

Unit-5. Wood and Rubber Industry

Wood for timber, timber industry, ply wood, uses of wood, conversion products of wood, distillation products, secondary products, list of wood yielding plants. Rubber - Para Rubber - (Morphology, Tapping of latex, Processing, Products and Economic Importance).

Unit-6. Oil - Yielding Plants

Oil - Yielding Plants - Fatty Oils and Essential Oils, Comparison between Fatty Oils and Essential Oils; Coconut (Morphology and Economic Importance); Essential Oils (General characteristics, Methods of Extraction and Economic Importance, with examples).

Reference Books/Reference Material

1. Alam, A. (2020). *A textbook of economic botany and ethnobotany*. Techsar Pvt. Ltd.
2. Balick, M. J., and Cox, P. A. (2020). *Plants, people, and culture: the science of ethnobotany*. Garland Science.
3. Husen, A., Bachheti, R. K., and Bachheti, A. (Eds.). (2021). *Non-timber forest products: Food, healthcare and industrial applications*. Springer Nature.
4. Kochhar, S.L. (2016). *Economic Botany: A comprehensive study*, Fifth edition, Cambridge University Press, NY
5. Kuprijanov, A. (2024). *Industrial Botany in the Modern Era*. In BIO Web of Conferences (Vol. 128, p. 00001). EDP Sciences.
6. Mérillon, J. M., Rivière, C., and Lefèvre, G. (Eds.). (2024). *Natural products in beverages: Botany, phytochemistry, pharmacology and processing*. Springer Nature.
7. Pandey, B. P. (2017) *Economic Botany*. S. Chand Publication, New Delhi

Evolutionary Trends in Plants

Course Code: BOT-421

Credit Hours: 2

Objectives:

To provide students with a comprehensive understanding and hands-on experience in understanding the major evolutionary developments in the plant kingdom, including structural, reproductive, and ecological adaptations, of plants over evolutionary time, from primitive forms to more advanced groups and to analyze the phylogenetic relationships among different plant groups.

Learning Outcomes:

By the end of this course, students will be able to:

- Understand the major evolutionary trends in plants.
- Describe the significance of the plant fossil record in understanding evolution.
- Explain the factors driving plant evolution.
- Analyze evolutionary adaptations in different plant groups.
- Use phylogeny and molecular tools to study plant evolution.
- Interpret phylogenetic trees and evolutionary relationships among plants.

Course Outline:

Unit-1. Introduction to Evolutionary Trends

Definition, types, causes of evolution, Overview of evolutionary theory in botany. Key transitions: aquatic to terrestrial adaptations, Describe the significance of the plant fossil record in understanding evolution, Geological Time Scale

Unit-2. Evolution of Algae and Bryophytes

Algal diversity and evolutionary importance, Origin and adaptation of bryophytes to land, Life cycles and alternation of generations.

Unit-3. Vascular Tissue Evolution in Pteridophytes

Development of vascular tissues, Evolution of dominant sporophyte generation, Adaptations for terrestrial life

Unit-4. Evolution of Seed Plants (Gymnosperms and Angiosperms)

Evolutionary significance of seeds, Comparison between gymnosperms and angiosperms. Floral evolution and diversification of angiosperms.

Unit-5. Adaptations to Environmental Conditions

Evolutionary adaptations in xerophytes, hydrophytes, and halophytes. Co-evolution of plants and pollinators.

Unit-6. Current trends in plant evolutionary studies (molecular phylogenetics).

Molecular Evolution, Phylogenetic tree Construction, Biogeography.

Recommended Books/Reference Material

1. Delaux, P. M., and Schornack, S. (2021). Plant evolution driven by interactions with symbiotic and pathogenic microbes. *Science*, 371(6531), eaba6605.
2. Eames, A.J. (1961). *Morphology of Vascular Plants*. McGraw-Hill.
3. Judd, Campbell, Kellogg, Stevens, and Donoghue. 2015. *Plant Systematics: A Phylogenetic Approach* (4th ed.). ISBN: 978-1605353890.
4. Maeda, H. A., and Fernie, A. R. (2021). Evolutionary history of plant metabolism. *Annual Review of Plant Biology*, 72(1), 185-216.
5. Ollerton, J. (2021). *Pollinators and pollination: nature and society*. Pelagic Publishing Ltd.
6. Pearson, L. C. (2023). *The diversity and evolution of plants*. CRC Press.

Evolutionary Trends in Plants (Lab)

Course Code: BOT- 421L

Credit Hours: 1

Pre-requisite: Nil

Objectives

To provide hands-on experience in studying the evolutionary history of plants through fossil records, comparative morphology, microscopy, and phylogenetic analysis. To develop practical understanding of structural and reproductive adaptations in different plant groups and their evolutionary significance.

Learning Outcomes

By the end of this laboratory course, students will be able to:

- Observe and compare major plant groups representing evolutionary transitions.
- Interpret fossil evidence related to plant evolution.
- Identify evolutionary adaptations in different plant taxa.
- Examine vascular tissues and reproductive structures microscopically.
- Construct and interpret phylogenetic trees using morphological and molecular data.
- Analyze ecological adaptations in plants from different environments.

Lab outline

1. Overview of evolutionary theory in plants
2. Geological timeline and major plant evolution milestones
3. Study of key fossil examples (e.g., early land plants, seed evolution)
4. Observation of algae, bryophytes, and pteridophytes under microscope
5. Examination of gymnosperms and angiosperms (cones, flowers)
6. Comparative analysis of roots, stems, leaves, and reproductive organs across plant groups
7. Focus on key adaptations: cuticle, stomata, vascular tissue, seeds, flowers
8. Comparative study of plant adaptations in different environments
9. Evolutionary adaptations in: Xerophytes, Hydrophytes, Halophytes
10. Introduction to DNA-based classification (e.g., chloroplast genes)
11. Use of phylogenetic tools or trait-based methods
12. Construction of cladograms using morphological or molecular data

Recommended Books/Reference Material

1. Delaux, P. M., and Schornack, S. (2021). Plant evolution driven by interactions with symbiotic and pathogenic microbes. *Science*, 371(6531), eaba6605.
2. Judd, W. S., Campbell, C. S., Kellogg, E. A., Stevens, P. F., and Donoghue, M. J. (2015). *Plant Systematics: A Phylogenetic Approach* (4th ed.). Sinauer Associates.
3. Ollerton, J. (2021). *Pollinators and Pollination: Nature and Society*. Pelagic Publishing Ltd.
4. Pearson, L. C. (2023). *The Diversity and Evolution of Plants*. Pearson, L. C. (2023). The diversity and evolution of plants. CRC Press

7. List of Elective courses

Course code	Course	Credits	Category
BOT-404	Bioinformatics	3	Elective
BOT-301	Bacteriology and Virology	3	Elective
BOT-422	Principles of Plant Cell and Tissue Culture	3	Elective
BOT-423	Advanced Molecular Biology	3	Elective
BOT-424	Biology of Halophytes	3	Elective
BOT-425	Plant Nutrition	3	Elective
BOT-426	Medicinal Plants and Phytochemicals	3	Elective
BOT-427	Diversity in Protoctista	3	Elective
BOT-428	Principles of Phytoremediation	3	Elective
BOT-429	Environmental Pollution	3	Elective
BOT-430	Plant Nursery Management	2	Elective
BOT-430L	Plant Nursery Management (Lab)	1	Elective
BOT-431	Organic Farming	2	Elective
BOT-431L	Organic Farming (Lab)	1	Elective
BOT-432	Climate Change	2	Elective
BOT-433	Phytosociology	3	Elective
BOT-434	Kitchen Gardening	3	Elective
BOT-101	Principles of Genetics	2	Elective
BOT-101L	Principles of Genetics (Lab)	1	Elective
BOT-102	Plant Physiology and Ecology	2	Elective
BOT-102L	Plant Physiology and Ecology (Lab)	1	Elective

8. Course Outline for Elective Courses

Bioinformatics

Course Code: BOT-404

Credit Hours: 3

Pre-requisite: Nil

Objectives:

To present key concepts and methods used in bioinformatics. To provide information on the basic principles and concepts in exploring bioinformatics tools, sequence storage, retrieval and analysis methods.

Learning Outcomes:

- Understand the need for database systems in Biology.
- Students will be able to use the different online software to retrieve the data.
- Apply the knowledge of bioinformatics tools for comparison of genomes in different species.

Course Outline:

Unit-1. Basic Introduction

Bioinformatics terminology, introduction to Bioinformatics and online resources. Historical and scientific context of Bioinformatics, accessing NCBI, ENSEMBL, UniProt. Introduction to Bioinformatics branches, scope and applications, accessing Genbank, EMBL, and SWISS-PROT.

Unit-2. Introduction to Biological Databases

Concept and evaluation of database, types of databases (Primary, secondary), accessing structural databases including PDB, and SCOP. Composite and literature based databases, accessing CATH, and EXPASY. Genome databases, sequence databases, structure and derived databases), working with single sequences (nucleotides and proteins).

Unit-3. Bioinformatics Database Search Engines

Text-based search engines (Entrez, SRS, DBGET / LinkDB). Sequence similarity-based search engines (BLAST and FASTA), sequence comparison and similarity searching. Motif-based search engines (ScanProsite and eMOTIF). Structure similarity-based search engines (VAST and DALI). BLAST and its types, applications, gene bank, uses and importance, softwares and online tools for protein structures.

Unit-4. Sequence Alignment, Domain and Motifs

DNA and protein sequence alignment, sequence homology versus sequence similarity, pairwise alignment and Multiple Sequence Alignment (MSA), software and online tools for sequence alignments. Methods for pairwise alignment, global and local alignments, Needleman Wunsch Algorithm, Smith Waterman Algorithm. Alignments and its uses, scoring matrices, protein structure prediction using online server. Tools and softwares for MSA (ClustalW, ClustalX, Clustal Omega, etc.), T-Coffee, MAFFT, and MUSCLE, sequence. Logos, protein structure visualizing using visualization programs. Sequence motifs, protein motifs and domain. Gene regulation motif, protein structures, prediction, alignment, classification, Bioinformatic tools for domain prediction.

Unit-5. Functional Genomics and Molecular Phylogenetics

Genomics, proteomics, transcriptomics, microarray based technology, secondary structure prediction using pfam database. Phylogenetic tree construction methods and programs, use of Bioedit software phylogenetic tree evaluation and MEGA, Use of MEGA software.

Recommended Books/Reference Material

1. Anna Tramontano (2018). *Introduction to Bioinformatics*. CRC Press, p.193
2. Dandekar, T., and Kunz, M. (2023). *Bioinformatics: An Introductory Textbook*. Springer Nature.
3. Jean-Michel C. and Cedric N. (2014). *Bioinformatics for Dummies*, 4th edition Wiley Publishing Inc.
4. Krane D.E. and Raymer M.L. (2003). *Fundamental Concepts of Bioinformatics*, Pearson Education
5. Letovsky S.I. (2009). *Bioinformatics - Databases and Systems*, Kluwer Academic Publishers.
6. Ramsden, J. (2023). *Bioinformatics: an introduction*. Springer Nature.
7. Rastogi, S. C., Rastogi, P., and Mendiratta, N. (2022). *Bioinformatics: Methods and Applications-Genomics, Proteomics and Drug Discovery*. PHI Learning Pvt. Ltd.
8. Shaik, N. A., Hakeem, K. R., Banaganapalli, B., and Elango, R. (2019). *Essentials of Bioinformatics*, Volume I. Springer International Publishing, Cham.

Bacteriology and Virology

Course Code: BOT-301

Credit Hours: 3

Pre-requisite: Nil

Objectives:

The main objective of this course is to establish the basic knowledge on microbes, mostly bacteria and viruses. The course will also cover the biochemical and molecular techniques and strategies used to study and control pathogenic activity of microorganisms.

Learning Outcomes:

- Students will be able to differentiate the classes of medically important viruses and bacteria that will describe the biological and genomic characteristics of the major groups.
- Compare and contrast the principles of the pathogenesis of infections and the immune responses to different bacteria and viruses.
- Explain key processes of evolution and how they shape phylogenetic relationships that link living things.

Course Outline:

Unit-1. Viruses

General features of viruses, structure of virus, viral architecture, Classification, dissemination and replication of single and double stranded DNA/RNA viruses. Plant viral taxonomy. Virus biology and virus transmission. Molecular biology of plant virus transmission. Symptomatology of virus-infected plants: (external and internal symptoms). Metabolism of virus-infected plants. Resistance to viral contamination.

Unit-2. Molecular Techniques in Virology

Methods in molecular virology; PCR, northern blotting, southern blotting, western blotting. Methods in molecular virology: Gel Electrophoresis. DNA sequencing: Sanger method. Maxam Gilbert method. Second generation sequencing. Third generation sequencing.

Unit-3. Bacteriology

History, characteristics and classification. Evolutionary tendencies in Monera (Bacteria, Actinomycetes and Cyanobacteria). Morphology, genetic recombination, locomotion and reproduction in Bacteria. Bacterial metabolism (respiration, fermentation, photosynthesis and nitrogen fixation).

Unit-4. Commercial Applications of Bacteria

Importance of Bacteria with special reference to application in various modern sciences. Agriculture, biotechnology and genetic engineering. Symptoms and control of major bacterial diseases in Pakistan. Biofilms: biofilms in plant and soil health, biofilms infection.

Unit-5. Quorum Sensing

Quorum sensing: QS role in plants. Applications of QS. Plant microbe interaction

Recommended Books/Reference Material

1. Black, J. G. (2005). *Microbiology – Principles and Exploration*. John Wiley and Sons, Inc.
2. Moore, L. S. P. and Hatcher, J. C. (2019). *Infectious Diseases, Microbiology and Virology: A Q and A Approach for Specialist Medical Trainees*. Cambridge: Cambridge University Press.
3. Parija, S. C. (2023). *Textbook of Microbiology and Immunology*. Springer.
4. Prescott, L. M., Harley, J. P. and Klein, D. A. (2005). *Microbiology*. McGraw-Hill Companies, Inc.
5. Saeed, H., A. (2023). *Textbook of Microbiology-I (Bacteriology and Virology)*. Nishtar Publisher.
6. Tortora, G. J., Funke, B. R. and Case C. L. (2004). *Microbiology*. Pearson Education.

Principles of Plant Cell and Tissues Culture

Course Code: BOT-422

Credit Hours: 3

Pre-requisite: Nil

Objectives

This course offers comprehensive knowledge for learning the basics with of cell and tissue culture to obtain high-frequency shoot regeneration, which is also a prerequisite for an efficient transformation system and its practical applications to demonstrate useful tools for the large scale plant propagation, disease elimination, plant improvement (e.g., grain quality, fiber quality, disease resistance, insect resistance, herbicide resistance etc. and production of secondary metabolites.

Learning Outcomes

At the end of the course, the students should be able to:

- Execute/ accomplish micro propagation through bud culture, organogenesis and somatic embryogenesis.
- Demonstrate development or production of artificial seeds.
- Enhance secondary metabolite content in different medicinal plants through in vitro culture techniques.

Course outline

Unit - 1. Introduction

Definition, Concept of cellular totipotency, History, Present status and future, Prospects of plant tissue culture.

Unit - 2. Preparation of Media

Composition of different culture Media, Role of chemicals and growth regulators in plant tissue culture, Sterilization of media, tissues and other accessories, Inoculation of cultures.

Unit - 3. Types of Cultures

Suspension culture, Protoplast isolation, Culture and fusion. Clonal propagation: Shoot-tip and axillary bud culture.

Unit - 4. Techniques of Cell and Tissue Culture

Preparation of explant materials, Initiation of cultures, Micropropagation through organogenesis and embryogenesis, Artificial seeds and embryo culture

Unit - 5. Industrial Applications

Industrial applications of plant tissue culture for production of secondary metabolites

Recommended Books/Reference Material

1. Gamborg, O.L., G.C. Philips (Eds.). 2018. Plant Cell, Tissue and Organ Culture: Fundamental Methods. Springer-Verlag, USA.
2. Orhan E.E. 2012. Biotechnological production of plant secondary metabolites. Bentham Science Publishing.
3. Purohit, S.D. 2013. Introduction to Plant Cell, Tissue and Organ Culture. PHI Learning Pvt. Limited, India.
4. Reinert J. and Bajaj Y.P.S. (eds.). 2013. Applied and Fundamental aspects of Plant Cell, Tissue and Organ Culture. Springer.
5. Ryu, D.D.Y. and S. Furusaki. 2012. Advances in Plant Biotechnology, 1st Edition. Elsevier Science, USA.

Advanced Molecular Biology

Course Code: BOT-423

Credit Hours: 3

Pre-requisite: Nil

Objectives

The main objectives of this course are to develop an understanding of fundamental and applied aspects of genetics and molecular biology with the ability to use that knowledge in a wide range of modern science.

Learning Outcomes

At the end of the course, the students should be able to:

- Understand different techniques used in Molecular Biology
- Analyze and differentiate different types of Polymerase chain reaction
- Equip with molecular methods commonly used in the research and diagnostics

Course outline

Unit - 1. Fundamentals of PCR

Standard PCR reaction, Interpretation of results, Types of PCR, Nested PCR, Multiplex PCR, Reverse transcriptase PCR, Real time PCR, Hot start PCR, Allelic specific PCR, Colony PCR, In situ PCR, Inverse PCR, AFLP PCR, Assembly PCR, Methylation specific PCR, Inter sequence specific PCR, Ligation mediated PCR, Whole genome amplification PCR, Mini primer PCR, Advantages and limitations of PCR, Applications of PCR

Unit - 2. Restriction Endonucleases and DNA Modifying Enzymes

Types of restriction and modification (R-M) system, Nomenclature of restriction endonucleases, Target sites of restriction endonucleases, Number and size of restriction fragments, Summary of restriction endonucleases, Methods of joining DNA fragments, DNA ligase to create covalent recombinant DNA, Alkaline Phosphatase

Unit - 3. Blotting Techniques

Southern blotting: Southern blotting procedure, Transfer methods in southern blotting, Mutations identification by southern blotting, Northern blotting: Northern blot applications, Western blotting: Western blotting procedure, Applications of western blotting, Difference between different blotting techniques.

Unit - 4. Fingerprinting Techniques

DNA profiling process, Types of DNA fingerprinting methods, SNPs, Applications of DNA fingerprinting, Electrophoresis, PAGE, Applications

Unit - 5. Genetic Engineering

Genetic engineering using various techniques.

Recommended Books/Reference Material

1. Bergman, N.H., Editor (2007) Comparative Genomics, Totowa (NJ): Humana Press Inc.
2. Brooker R, 2011. Genetics: Analysis and Principles. 4th Edition, McGraw-Hill.
3. Griffiths, A., J. Doebley, C. Peichel and D.A. Wassarman. (2023). Introduction to Genetic Analysis, 12th Edition. W.H. Freeman and Company, UK
4. Hartl, D.L. and E.W. Jones. (2022). Genetics: Analysis of Gene and Genomes. Jones and Bartlett Publishers, Inc., USA.
5. Harvey Lodish. (2016). Molecular cell biology. 8th Edition. W. H. Freeman. America.
6. Kumar D (2023). Advances in Genetics. 1st Edition. Academic press
7. Snustad DP and Simmons MJ, (2008). Principals of Genetics. 5th Edition, John Willy and Sons, New York.

Biology of Halophytes

Course Code: BOT-424

Credit Hours: 3

Pre-requisite: Nil

Objectives:

To develop understanding about the diversity and ecological roles of halophytes in saline environments. To develop understanding of biological mechanisms, tolerate salt stress and evaluate the potential applications of halophytes in agriculture, environmental management, and biotechnology.

Learning Outcomes:

Students will be able to:

- Identify different types of halophytes.
- Understand the mechanisms of halophytes survival and adaptability to salty environments.
- Evaluate the potential applications of halophytes.

Course Outline:

Unit-1. Introduction to Halophytes and Salinity

Definition, ecological roles and importance, global distribution and economic importance of halophytes. Sources of salinity, types of salts, and their effects on plants. Physiological and biochemical effects of salt stress. Measurement of salinity and salt stress.

Unit-2. Cellular and Physiological Mechanisms of Halophytes

Mechanisms of osmotic adjustment (ion accumulation, compatible solutes, aquaporins). Ion homeostasis (uptake, transport, exclusion, compartmentation, ion transporters). Antioxidant defense (ROS production, antioxidant enzymes, non-enzymatic antioxidants).

Unit-3. Morphological, Anatomical and Photosynthetic Responses of Halophytes

Modifications in root, stem, and leaf anatomy (aerenchyma, succulence, salt glands/hairs). Regulation of stomatal conductance and leaf senescence. Effects of salinity on photosynthesis and respiration. Carbon allocation and energy balance.

Unit-4. Effects of Salinity on Reproduction and Ecology of Halophytes

Effects of salinity on flowering, pollination, seed development, and germination. Vegetative propagation, life cycles, and reproductive strategies. Halophyte community structure, plant-soil interactions, and nutrient cycling. Genetic diversity, salt tolerance inheritance, and the role of molecular markers.

Unit-5. Molecular and Genetic Basis of Salt Tolerance

Signal transduction and stress perception. Gene regulation and expression under salt stress. Key salt tolerance genes and pathways. Advances in genomics and transcriptomics of halophytes. Role in saline agriculture and crop improvement. Biotechnological approaches for engineering salt tolerance. Use in phytoremediation and environmental management.

Recommended Books/Reference Material

1. Alhaddad, F. A., Bibi, S., and Abu-Dieyeh, M. H. (2025). Applications of Endophytes Associated with Halophyte for Sustainable Agriculture. In *Sustainable Utilization and Bioengineering of Halophytes* (pp. 143-168). Singapore: Springer Nature Singapore.
2. Grigore, M. N., and Toma, C. (2020). *Handbook of Halophytes*. Springer International Publishing.
3. Hasanuzzaman, M., Nahar, K., and Öztürk, M. A. (Eds.). (2019). *Ecophysiology, abiotic stress responses and utilization of halophytes* (p. 401). Singapore: Springer.
4. Hasanuzzaman, M., Shabala, S., and Fujita, M. (Eds.). (2019). *Halophytes and climate change: adaptive mechanisms and potential uses* (p. xi). Wallingford: CABI.
5. Mehra, H., Yadav, N., Kumar, A., Sawariya, M., Kumar, N., Devi, S. and Arya, S. S. (2024). Halophytes at the Crossroads: Morphological, Anatomical, Physiological, and Biochemical Responses to Salinity Stress. In *Halophytes vis-à-vis Saline Agriculture: Perspectives and Opportunities for Food Security* (pp. 153-178). Singapore: Springer Nature Singapore.
6. Sen, D. N., and Rajpurohit, K. S. (Eds.). (2012). *Contributions to the Ecology of Halophytes* (Vol. 2). Springer Science and Business Media.
7. Tıpırdamaz, R., Karakas, S., and Dikilitas, M. (2021). Halophytes and the Future of Agriculture. In *Handbook of Halophytes: From Molecules to Ecosystems towards Biosaline Agriculture* (pp. 2225-2239). Cham: Springer International Publishing.

Plant Nutrition

Course Code: BOT-425

Credit Hours: 3

Pre-requisite: N.A

Objectives:

The course aims to understand the basic concept of plant nutrition, to explore mechanism of nutrients uptake, transport and assimilation, to study the role of nutrients in plant growth and metabolism, to examine the deficiency symptoms, toxicity and nutrient interactions and to understand sustainable nutrient management practices.

Learning Outcomes:

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

- Enlist the essential and beneficial nutrients in plants.
- Describe and differentiate the deficiency symptoms of different macro and micronutrients.
- Explain the mechanisms by which nutrients are taken up and translocated by plants.
- Suggest environment friendly practices for nutrient management.

Course Outline:

Unit-1. Introduction to Plant Nutrition

History and significance of plant nutrition, Essential and beneficial elements, Criteria for essentiality of macro and micronutrients, Macronutrients (N, P,K, Ca, Mg, S), Micronutrients (Fe, Zn, Cu, Mn, Mo, B, Cl, Ni), Nutrient mobility in soil and plant, deficiency and toxicity symptoms of nutrients.

Unit-2. Soil-Plant Relationship

Soil composition and properties, Soil pH and nutrient availability, Role of organic matter, Cation Exchange Capacity, Transport of nutrients in plants, Root morphology and mycorrhizal associations.

Unit-3. Nutrient Transport and Translocation

Xylem and phloem transport, Long distance nutrient movement, Role of chelators and transporters, Nutrient storage in plants, Soil-less cultures to study nutrition in plants.

Unit-4. Role of Nutrients in Plants

Nutrient interactions in plants, Role of nutrients in physiological processes, nutrients roles in stress tolerance

Unit-5. Nutrient Management in Plants

Organic and inorganic fertilizers, application methods and timings, Environmental impact of fertilizers, Principles of integrated nutrient management.

Recommended Books/Reference Material

1. Kirkby, E. A. (2001). *Principles of plant nutrition* (Vol. 1). Springer science and Business Media.
2. Marschner, H. (1995). *Mineral nutrition of higher plants*. Springer science and Business Media
3. Marschner, H. (2011). *Marschner's mineral nutrition of higher plants*. Academic press.
4. Salisbury, F. B., and Ross, C. W. (2020). *Plant physiology* (5th ed.). Cengage Learning.
5. Taiz, L., Zeiger, E., Møller, I. M., and Murphy, A. (2018). *Plant physiology and development* (6th ed.). Sinauer Associates, Oxford University Press.

Medicinal Plants and Phytochemicals

Course Code: BOT-426

Credit Hours: 3

Pre-requisite: N.A

Objectives:

To provide the students with an adequate knowledge of diversity of medicinal plants and phytochemicals and to make the students familiar with traditional and modern uses of medicinal plants and their products

Learning Outcomes:

By the end of this course, students will be able to understand traditional and modern uses of medicinal plants.

- Students will learn the role of secondary metabolites (phytochemicals) in plant defense and human health
- Students will get awareness on diversity of medicinal plants.
- Students will be familiar with extraction, isolation, and analysis of phytochemicals.

Course Outline:

Unit-1. Introduction to Medicinal Plants

Introduction and historical background of medicinal plant use. Ethnomedicinal surveys and documentation. Cultural importance of medicinal plants. Conservation of indigenous knowledge, Role in traditional systems (Ayurveda, Unani, Chinese medicine). Importance in modern drug discovery.

Unit-2. Classification of Medicinal Plants

Classification based on active constituents (alkaloids, glycosides, tannins, etc.). Classification based on therapeutic uses (antipyretic, analgesic, etc.). Botanical classification and identification.

Unit-3. Pharmacognosy and Phytochemicals

Organoleptic and microscopic evaluation of crude drugs. Extraction techniques (maceration, Soxhlet, etc.). Phytochemicals Categories: Alkaloids, Flavonoids, Terpenoids, Tannins, Saponins, Phenolics and Biosynthesis pathways (basic introduction).

Unit-4. Medicinal Plants of Pakistan

Common local medicinal plants and their uses. *Azadirachta indica* (Neem), *Withania somnifera* (Ashwagandha). *Mentha arvensis* (mint), *Zingiber officinale*

(ginger) , *Curcuma longa* (turmeric), *Nigella sativa* (kalonji)etc. Conservation strategies for endangered medicinal plants.

Unit-5. Industrial Applications and Regulations

Drug discovery from Plants. Role of phytochemicals in pharmaceuticals, nutraceuticals, and cosmetics. Biotechnology in medicinal plant research. Legal and regulatory issues (e.g., WHO guidelines, patenting)

Recommended Books/Reference Material

1. Evans, W.C. (2009). *Pharmacognosy* 16th Edition Saunders Elsevier ISBN: 9780702029332
2. Stankovic M S. (2020). Medicinal Plants and Natural Product Research. MDPI ISBN: 978-3-03928-118-3
3. Robiansyah, I. and Primananda, E. (2023). Medicinal Plants: Biodiversity, Biotechnology and Conservation. Springer ISBN: 9789811999369
4. Shah, B. and Seth A.K. (2010). *Textbook of Pharmacognosy and Phytochemistry*. 2nd Edition. Elsevier Health Sciences, ISBN: 9788131228255
5. Shoaib S. and Jahan, R. (2024). Medicinal Plants and Their Bioactive Compounds in Human Health. Springer ISBN: 9789819768943

Diversity in Protoctista

Course Code: BOT-427

Credit Hours: 3

Pre-requisite: Nil

Objectives:

To provide the students with an adequate knowledge of diversity of protists and to make the students familiar with traditional and modern protists and the product obtained from them.

To familiarize students about the economic and commercial importance of protists.

Learning Outcomes:

By the end of this course, students will be able to

- Identify and collect different types of protists.
- Enlist the economic importance of protists.

Course Outline:

Unit-1. Introduction to Protoctista

What are eukaryotes? Introduction and evolutionary background of Protoctista, characteristics, General classification, Protists in soil, protists in water.

Unit-2. Phylum Protozoa

Introduction and evolutionary background of protozoa, Rhizopoda with amoeba reference example, Phylum Flagellata with Euglena reference example, Ciliated protozoans with paramecium reference example, Phylum sporozoa with plasmodium reference example

Unit-3. Phylum chlorophyta

Introduction and evolutionary background of green algae, ecological niche of chlorophytes, Location and pigments, Reproduction and Economic importance

Unit-4. Phylum Pheophyta

Introduction and evolutionary background of brown algae, ecological niche of pheophytes, Location and pigments, Reproduction and Economic importance.

Unit-5. Phylum Rhodophyta and Phylum cyanophyta

Introduction and evolutionary background of red algae, ecological niche of rhodophytes, Location and pigments, Reproduction and Economic importance, Introduction and evolutionary background of cyanophytes, Algal blooms and visual

pollution, ecological niche of cyanophytes, Location and pigments, Reproduction and Economic importance.

Unit-6. Slime moulds

What are slime moulds? Introduction and evolutionary background of slime moulds, characteristics, general classification, How slime moulds are different from ordinary moulds?

Recommended Books/Reference Material

1. Amaresan, N., and Chandarana, K. A. (Eds.). (2024). *Practical Handbook on Soil Protists*. Springer US.
2. Corliss, J. O. (2019). A Salute to Fifty-Four Great Microscopists of the Past: A Pictorial Footnote to the History of Protozoology. Part II. *Transactions of the American Microscopical Society*, 26-58.
3. Mehner, T. (2023). *Encyclopedia of inland waters*. Academic Press.
4. Turan, V. (2024). Initial Observation of Protist from Soil. In *Practical handbook on Soil protists* (pp. 7-11). New York, NY: Springer US.

Principles of Phytoremediation

Course Code: BOT-428

Credit Hours: 3

Pre-requisite: Nil

Objectives:

This course introduces the fundamental principles of phytoremediation, focusing on the use of plants and their associated microorganisms to detoxify, remove, or stabilize pollutants in soil, water, and air. Students will explore the biological, ecological, and biochemical mechanisms behind plant-based remediation, along with practical applications and case studies. Emphasis is placed on plant physiology, hyperaccumulators, and the integration of phytotechnologies into environmental management strategies.

Learning Outcomes:

By the end of this course, students will be able to:

- Explain the mechanisms of phytoremediation and its role in environmental sustainability.
- Identify plant species and microbial partners critical for remediation.
- Evaluate the advantages and limitations of phytoremediation in real-world scenarios.
- Design basic phytoremediation strategies for contaminated sites.

Course Outline

Unit-1. Introduction to Phytoremediation

Definition and historical development. Types of contaminants: Heavy metals (e.g., cadmium, lead), organic pollutants (e.g., PAHs, pesticides), and radionuclides. Comparison with traditional remediation methods (e.g., excavation, chemical treatment).

Unit-2. Mechanisms of Phytoremediation

Phytoextraction: Metal uptake and hyperaccumulation (e.g., *Thlaspi caerulescens* for zinc), Phytostabilization: Reducing contaminant mobility via root binding, Phytodegradation: Enzymatic breakdown of organic pollutants, Rhizodegradation: Microbial interactions in the root zone.

Unit-3. Plant Physiology and Hyperaccumulators

Cellular detoxification mechanisms (e.g., chelation, vacuolar sequestration), Traits of hyperaccumulators (e.g., *Pteris vittata* for arsenic), Genetic engineering to enhance remediation (e.g., transgenic poplars for mercury uptake).

Unit-4. Environmental and Soil Factors

Soil pH, organic matter, and moisture effects on metal bioavailability, Role of mycorrhizal fungi and rhizobacteria in nutrient cycling, Challenges in acidic or saline environments

Unit-5. Application and Case Studies

Coal mine reclamation in Appalachia using *Robinia pseudoacacia* and grasses, Sunflowers (*Helianthus annuus*) for cesium-137 removal post-Chernobyl, Urban phytoremediation (e.g., willow trees for groundwater purification)

Unit-6. Advantages, Limitations, and emerging trends

Cost-effectiveness and eco-friendliness vs. slow remediation rates, Regulatory and ethical considerations, Phytomining for metal recovery (e.g., nickel from Alyssum species), Integration with nanotechnology and AI for monitoring, Climate resilience and carbon sequestration potential, Student-led case study analyses of real-world phytoremediation projects.

Recommended Books/Reference Material

1. Aransiola, S. A., and Maddela, N. R. (Eds.). (2024). *Phytoremediation in Food Safety: Risks and Prospects*.
2. Lambers, H., Chapin III, F. S., and Pons, T. L. (2008). *Plant physiological ecology*. Springer Science and Business Media.
3. Madhav, S., Sughosh/Gupta Madhav (Gyan Prakas), and Yadav, R. K. (2024). *Phyto-remediation*.
4. Malik, J. A., Goyal, M. R., and Wani, K. A. (Eds.). (2022). *Bioremediation and Phytoremediation Technologies in Sustainable Soil Management: Volume 1: Fundamental Aspects and Contaminated Sites*. CRC Press.
5. McCutcheon, S. C., and Schnoor, J. L. (2004). *Phytoremediation: transformation and control of contaminants*. John Wiley and Sons.

Environmental Pollution

Course Code: BOT-429

Credit Hours: 3

Pre-requisite: N.A

Objectives:

This course is designed with the aim to Understand the fundamental concepts and types of environmental pollution, Identify the major sources and effects of different pollutants on ecosystems and human health and to explore monitoring techniques and pollution control technologies.

Learning Outcomes:

By the end of this course, students will be able to:

- Define and classify various types of environmental pollution (air, water, soil, noise, etc.).
- Assess the impact of pollution on human health, biodiversity, and climate.
- Evaluate pollution sources using appropriate assessment tools and monitoring methods.
- Recommend mitigation and control strategies based on environmental regulations and technologies.

Course Outline:

Unit-1. Introduction

Definition and concepts; History of Pollution, Classification: air, water, soil, noise, radioactive, thermal, plastic, and causes

Unit-2. Air and Noise Pollution

Sources and types of air pollutants (natural and anthropogenic), Effects on climate, human health, and ecosystems, Air quality standards and monitoring, Sources and effects of noise pollution, Control measures and policies for air and noise pollution

Unit-3. Water and Soil Pollution

Sources of water pollutants (industrial, agricultural, domestic), Eutrophication and groundwater contamination, Soil contamination: pesticides, heavy metals, and solid waste, Impact on agriculture and aquatic life, Wastewater treatment and bioremediation techniques

Unit-4. Solid Waste, Plastic, and Hazardous Waste Management

Types and sources of solid waste, Biomedical and hazardous waste, Plastic pollution: microplastics and marine pollution, Waste collection, segregation, and disposal, Recycling, composting, and modern waste management strategies importance

Unit-5. Environmental Laws, Policies, and Sustainable Solutions

National and international environmental regulations (e.g., EPA, UNEP, Kyoto Protocol, Paris Agreement), Environmental Impact Assessment (EIA), Role of technology in pollution monitoring and control, Community participation and environmental ethics, Green practices and sustainability approaches.

Unit-6. Environmental Crisis

Environmental Crisis: Ozone Hole, Green House, Effect, Acid Rains, Chemical and Biological Warfare, and Impact on human health.

Reference Books/Reference Material

1. Goodstein, E.S. (2008). Economics and the Environment. Prentice Hall Publishers. New Jersey.
2. Harrison, R. M. (Ed.). (2023). Pollution: causes, effects and control. Royal society of chemistry.
3. Koziol, M.J. and Whatley, F.R. (2009). Gaseous Air Pollution and Plant Metabolism, Butterworths. U.K.
4. Wang, L. K., Wang, M. H. S., Hung, Y. T., and Aziz, H. A. (Eds.). (2021). Solid waste engineering and management. Springer.
5. Xu, H., Jia, Y., Sun, Z., Su, J., Liu, Q. S., Zhou, Q., and Jiang, G. (2022). Environmental pollution, a hidden culprit for health issues. Eco-Environment and Health, 1(1), 31-45.

Plant Nursery Management

Course Code: BOT-430

Credit Hours: 2

Objectives:

To impart practical knowledge about setting up and managing a plant nursery. To understand propagation techniques, nursery tools, and commercial plant production. To develop entrepreneurship skills in horticulture and plant sales.

Learning Outcomes:

By the end of this course, students will be able to

- Apply an appropriate layout design, infrastructure setup, and maintenance practices to set up a plant nursery
- Demonstrate practical skills in plant propagation techniques such as seed propagation, cutting, grafting, budding,
- Identify and effectively use nursery tools and equipment required for plant production and maintenance.
- Plan and manage small-scale horticulture enterprises with a focus on profitability and sustainability.

Course Outline:

Unit-1. Introduction to Nursery Management

Definition and scope of plant nurseries. Types of nurseries: commercial, private, government, institutional. Site selection and layout planning. Nursery structures: polyhouses, shade nets, greenhouses

Unit-2. Propagation Techniques

Methods of plant propagation: sexual (seed) and asexual (cutting, grafting, layering, budding). Media used in nurseries (soil, sand, peat, cocopeat, etc.). Use of plant growth regulators (auxins, cytokinins) in propagation

Unit-3. Nursery Tools, Containers and Equipment

Nursery tools and equipment: sprayers, pruning tools, trays, labels. Containers: earthen pots, plastic bags, seed trays, grow bags. Irrigation systems: manual, sprinkler, drip

Unit-4. Nursery Practices and Management

Sowing, transplanting, spacing, pruning, pinching. Hardening of seedlings. Nutrient and water management. Weed, pest, and disease control in nurseries. Record keeping and labeling

Unit-5. Commercial Aspects and Entrepreneurship

Marketing strategies for nursery plants. Government schemes and subsidies. Budgeting, cost analysis, and pricing. Certification and legal aspects (especially for forest and fruit plants).

Recommended Book: Reference Material:

1. Bose, T.K., Maiti, R.G., Dhua, R.S., and Das, P. (2020). *Plant Propagation and Nursery Management*. Naya Udyog.
2. Hartmann, H.T., Kester, D.E., Davies, F.T., and Geneve, R.L. (2014). *Plant Propagation: Principles and Practices*. 8th ed., Pearson Education.
3. Kumar, N. (2021). *Introduction to Horticulture*. Oxford and IBH Publishing.
4. Singh, R., and Choudhary, R.C. (2018). *Plant Nursery Management*. Agrotech Publishing.

Plant Nursery Management (Lab)

Course Code: BOT- 430L

Credit Hours: 1

Pre-requisite: N.A

Objectives:

To develop practical skills in plant propagation, nursery management, and sustainable cultivation practices. To enable students to apply nursery techniques and basic business planning for horticultural production.

Learning Outcomes:

By the end of this course, students will be able to

- Demonstrate plant propagation techniques including seed propagation, cuttings, and grafting under nursery conditions.
- Select and prepare appropriate growing media for nursery plants based on plant requirements.
- Perform potting, repotting, and transplanting of seedlings using standard nursery practices.
- Maintain nursery records and develop basic business plans for plant nursery management.

Lab Outline

1. Learning of different plant propagation methods like seed propagation, stem cuttings root cuttings.
2. Grafting etc. Suitable growing media for nursery plants like soil, sand, peat moss compost.
3. Potting, repotting, and transplanting seedlings.
4. Understand irrigation scheduling and water-saving techniques.
5. Foliar vs soil fertilizer application comparison.
6. Nursery Record Keeping and Business Planning.

Recommended Book: Reference Material:

1. Bose, T.K., Maiti, R.G., Dhua, R.S., and Das, P. (2020). *Plant Propagation and Nursery Management*. Naya Udyog.
2. Ray, P. K. (2012). *Plant Nursery Management: How to Start and Operate a Plant Nursery*. Scientific Publishers.
3. Kumar, N. (2021). *Introduction to Horticulture*. Oxford and IBH Publishing.
4. Singh, A. K., & Kumar, A. (2021). *Plant propagation and nursery management*. Bhavya Books (BET)

Organic Farming

Course Code: BOT-431

Credit Hours: 2

Objectives:

Understanding students with the basic principles and methods of organic agriculture and comparison of organic and conventional farming systems. The students will also learn about soil health, pest management, and certification in organic farming.

Learning Outcomes:

Students will be able

- To learn the concept of different procedures of organic farming
- Understand the organic and conventional farming systems.
- To practice nutrient rich organic farming

Course Outline:

Unit-1. Introduction to Organic Farming

Definition, concept, and history of organic farming. Importance and scope of organic agriculture in India and globally. Differences between organic and conventional farming. Challenges and opportunities in organic agriculture

Unit-2. Soil and Nutrient Management

Soil as a living system. Soil fertility and nutrient cycling. Use of organic manures: compost, green manure, vermicompost, farmyard manure. Biofertilizers (Rhizobium, Azospirillum, Azotobacter, PSB, etc.)

Unit-3. Pest and Disease Management

Principles of pest management in organic farming. Biological control methods. Use of botanicals (neem, garlic extracts, etc.). Integrated pest and disease management (IPM and IDM) in organic systems.

Unit-4. Crop Production and Practices

Organic cultivation practices of cereals, pulses, vegetables, and fruits. Intercropping, crop rotation, mulching, and cover cropping. Use of indigenous seeds and traditional practices

Unit-5. Organic Certification and Marketing

National and international standards (NPOP, IFOAM). Certification agencies and procedures. Packaging, labeling, and marketing of organic products. Organic food markets and export potential.

Recommended books/ Reference material

1. Francis, C., Lieblein, G., Gliessman, S., Breland, T. A., Creamer, N., Harwood, R., and Salomonsson, L. (2016). *Agroecology: The Ecology of Sustainable Food Systems* (3rd ed.). London, UK: Routledge. ISBN: 9781138193439
2. Lampkin, N. (2019). *Organic Farming: Sustainable Agriculture in Practice* (Updated Edition). Wallingford, UK: CABI Publishing. ISBN: 9781786392830
3. Reddy, S.R. (2021). *Organic Farming and Sustainable Agriculture*. Hyderabad: Kalyani Publishers. ISBN: 978932729065
4. Willer, H., and Lernoud, J. (Eds.). (2023). *The World of Organic Agriculture: Statistics and Emerging Trends 2023*. Frick, Switzerland: Research Institute of Organic Agriculture FiBL and IFOAM – Organics International. ISBN: 9783038480802

Organic Farming (Lab)

Course Code: BOT- 431L

Credit Hours: 1

Pre-requisite: N.A

Objectives:

To develop practical skills in organic farming techniques, including soil management, organic inputs preparation, and application of eco-friendly agricultural practices.

Learning Outcomes:

- Perform organic seed treatment and germination techniques
- Analyze soil properties relevant to organic farming
- Prepare and apply organic manures and biofertilizers
- Practice small-scale organic cultivation methods

Lab Outline:

1. Germination tests by Organic seed treatment methods (ash, cow urine, plant extracts).
2. Soil sampling and preparation.
3. Testing soil pH, EC, and Organic carbon.
4. Testing soil micronutrients.
5. Preparation of FYM (Farmyard Manure), compost, green manure.
6. Working with biofertilizers: Inoculating seeds with biofertilizers.
7. Kitchen gardening exercises.
8. Establishment and management of kitchen gardening practices

Recommended books/ Reference material

1. Francis, C., Lieblein, G., Gliessman, S., Breland, T. A., Creamer, N., Harwood, R., and Salomonsson, L. (2016). *Agroecology: The Ecology of Sustainable Food Systems* (3rd ed.). London, UK: Routledge. ISBN: 9781138193439
2. Lampkin, N. (2019). *Organic Farming: Sustainable Agriculture in Practice* (Updated Edition). Wallingford, UK: CABI Publishing. ISBN: 9781786392830
3. Reddy, S.R. (2021). *Organic Farming and Sustainable Agriculture*. Hyderabad: Kalyani Publishers. ISBN: 978932729065
4. Willer, H., and Lernoud, J. (Eds.). (2023). *The World of Organic Agriculture: Statistics and Emerging Trends 2023*. Frick, Switzerland: Research Institute of Organic Agriculture FiBL and IFOAM – Organics International. ISBN: 9783038480802

Climate Change

Course Code: BOT-432

Credit Hours: 2

Pre-requisite: Nil

Objectives:

The objective of this course is to understand the science behind climate change and global warming and to explore the impacts of climate change on plants, ecosystems, and biodiversity, learn mitigation and adaptation strategies, especially in the context of plant sciences.

Learning Outcomes:

Course Contents:

Unit 1. Introduction and History

Definition and distinction between climate and weather, Evidence and indicators of climate change, Historical trends in global climate, Greenhouse effect and major greenhouse gases

Unit 2. Causes of Climate Change

Natural versus anthropogenic factors, Carbon cycle and its disruption, Role of fossil fuels, deforestation and agriculture, Climate feedback mechanisms (positive and negative)

Unit 3. Climate Change and the Biosphere

Effects on photosynthesis, respiration and transpiration, Plant physiology and phenology changes, Shifts in plant distribution and biomes, Invasive species and extinction risks

Unit 4. Ecosystems and Biodiversity

Climate effects on terrestrial and aquatic ecosystems, Species migration and ecosystem imbalance, Forests, wetlands, and coastal ecosystems under stress, Biodiversity hotspots and climate vulnerability

Unit 5. Agriculture and Food Security

Impacts on crop productivity and nutritional value, Plant diseases and pest dynamics, Soil degradation and desertification, Adaptive farming

Recommended books/ Reference material

1. Böhm, S., and Sullivan, S. (Eds.). (2021). *Negotiating climate change in crisis*. Open Book Publishers.
2. Irwin, R. (2024). *Economic Futures: Climate Change and Modernity*. Rowman and Littlefield.
3. Kennish, M. J., Paerl, H. W., and Crosswell, J. R. (Eds.). (2023). *Climate change and estuaries*. CRC Press.
4. Seo, S. N., and Seo. (2021). *Climate Change and Economics*. Springer International Publishing.

Phytosociology

Course Code: BOT-433

Credit Hours: 3

Pre-requisite: Nil

Objectives:

To provide a clear understanding of the communities and their dynamics.

Learning Outcomes:

- Students will be able to understand the concept of phytosociological methods for vegetation analysis.
- Interpret the vegetation pattern for ecological and conservation application.

Course Outline:

Unit-1. Introduction to Phytosociology

Understanding the study of plant communities and their relationships, Evolution of phytosociology as a discipline.

Unit-2. Concept of Plant Communities and Vegetation

Structure and dynamics of communities of plant communities, Vegetation classification: Methods and approaches, Species interactions: Competition, facilitation, and mutualism, Environmental factors: Climate, soil, topography, and disturbance, Vegetation classification system (zonation, succession).

Unit-3. Sampling Techniques

Vegetation sampling: Quadrat, transect, and plot methods, Data analysis: Multivariate statistics and ordination techniques, Classification and ordination: Methods for understanding plant community structure.

Unit-4. Measurement of Phytosociological Attributes

Frequency. Density. Abundance. Importance Value Index (IVI) and Relative Values, Species richness. Shannon-Wiener, Simpson's Index, Vegetation mapping and community description.

Unit-5. Applications in biodiversity conservation and land use

Conservation biology: Understanding and managing plant communities for conservation, Ecological restoration: Restoring degraded or damaged ecosystems, Land use planning: Applying phytosociological knowledge to land use decisions, Global change: Impacts of climate change, invasive species and other global drivers on plant communities

Recommended Books/Reference Material

1. Barbour, M.G., Burk, J.H., and Pitts, W.D. (1999). Terrestrial Plant Ecology.
2. Joshi, E. B., Soni, H. B., & Joshi, P. N. *Floristic Study of Arid Ecosystem: Ecology and Phytosociology*. Google Book Publishers.
3. Kent, M. (2012). Vegetation Description and Data Analysis.
4. Lori, T. (2022). Use of Phytosociology and Remote Sensing to Classify and Map the. *Protected Area Management: Recent Advances*, 305.
5. Mueller-Dombois, D. and Ellenberg, H. (1974). Aims and Methods of Vegetation Ecology.

Kitchen Gardening

BS-Botany

Course Code: BOT-434

Credit Hours: 3

Pre-requisite: N.A

Objectives:

To introduce the students to the principles and practices of kitchen gardening, including site selection, soil preparation, plant propagation, seasonal planning, sustainable practices, pest management, and harvesting techniques.

Learning Outcomes:

- Understand the fundamentals of kitchen gardening and its importance.
- Plan and design a kitchen garden based on climate, soil, and available space.
- Implement eco-friendly gardening practices including composting, mulching, crop rotation, and organic pest control.

Course Outline:

Unit-1. Introduction to Kitchen Gardening

Definition, scope, and benefits of kitchen gardening, Types of kitchen gardens (traditional beds, containers, raised beds, rooftop, vertical gardens), Understanding plant needs: sunlight, air, water, nutrients, Garden tools and materials, Safety measures and best practices.

Unit-2 Site Selection, Garden Planning and Layout

Assessing site conditions: sunlight, soil type, space availability, Designing Garden layouts for small and large spaces, planning for seasonal variations (cool-season vs warm-season crops), Crop selection based on climate and household needs, Companion planting principles.

Unit-3. Soil Management and Plant Propagation

Soil composition, texture, and fertility, Soil testing and amendment techniques, Composting and organic matter management, Potting media preparation for containers, Seed selection and seedling production, Transplanting techniques, Use of organic and inorganic fertilizers (with emphasis on sustainable practices).

Unit-4. Vegetable, Herb, and Fruit Cultivation

Cultivation techniques for common vegetables (leafy, root, fruiting crops), Growing culinary herbs (basil, mint, coriander, rosemary, etc.), Small fruit production suitable for home gardens (strawberries, small citrus, berries), Irrigation methods: manual,

drip, and container watering strategies, Mulching for moisture control and weed suppression, Crop rotation and intercropping for kitchen gardens.

Unit-5. Pest, Disease Management, Harvesting and Post-Harvest Care

Identification of common pests and diseases, Organic pest control (biological control, neem extracts, traps), Integrated Pest Management (IPM) techniques, weed identification and eco-friendly control, Harvesting techniques for different crop types, Proper storage, handling, and use of harvested produce, Seasonal Garden maintenance and off-season care.

Recommended Books/Reference Material

1. Wallace, H. D. (2014). Authentic Learning in the Kitchen and Garden: Synthesising planning, practice and pedagogy (Doctoral dissertation, Victoria University).
2. Townsend, M., Gibbs, L., Macfarlane, S., Block, K., Staiger, P., Gold, L., Johnson, B. and Long, C. (2014). Volunteering in a school kitchen garden program: Cooking up confidence, capabilities, and connections!. VOLUNTAS: International Journal of Voluntary and Nonprofit Organizations, 25(1), pp.225-247.
3. Nag, A., Mukherjee, A., Shubha, K., Bhattacharyya, S., Ray, R.K., Roy, P., Roy, A. and Feroze, S.M. (2023). Kitchen Gardening for Nutritional Security Under Changing Climate. In Advances in Research on Vegetable Production Under a Changing Climate Vol. 2 (pp. 203-228). Cham: Springer International Publishing.
4. Dominguez-Hernandez, E., Hernandez, C., & Dominguez Hernandez, M. E. (2022). Sustainability in home garden interventions to improve food security: Results, challenges, and future directions. Transdisciplinary Journal of Engineering and Science, 13, 111-140.

Principles of Genetics

BS-Botany

Course Code: BOT-101

Credit Hours: 2

Pre-requisite: N.A

Objectives

To develop understanding of the principles of genetics among students. To develop the ability to analyze genetic data, understand patterns of inheritance and variation, and explain genetic mechanisms.

Learning Outcomes

Students will be able to:

- Explain the principles of genetic variation and Mendelian inheritance.
- Use basic genetic techniques to study plant traits.
- Construct genetic maps from linkage and crossing over data.

Course Outline

Unit 1. Introduction to Genetics

Definition, scope and importance of plant genetics and evolution. Mendelian genetics.

Unit 2. Mendelian, Chromosomal and Molecular Genetics

Mendel's Laws of Inheritance (Segregation, Independent Assortment). Monohybrid and Dihybrid Crosses. Punnett squares and probability. Incomplete Dominance, Codominance. Multiple alleles and polygenic inheritance. Epistasis and pleiotropy. Sex-linked Inheritance. Chromosomal Genetics (Chromosome Structure and Function. Mitosis and Meiosis.

Unit 3. Chromosomal Genetics

Chromosomal Genetics (Chromosome Structure and Function. Mitosis and Meiosis. Karyotyping and chromosomal abnormalities. Linkage, recombination, and gene mapping). Molecular Genetics: (DNA Structure and Replication. Gene Expression (Transcription and Translation). Genetic Code. Regulation of Gene Expression. Mutations).

Unit 4. Chromosomal Variation and Mutations.

Types of mutation, Mutation on chromosomal number, mutation on the basis of codons, Human genome and inherited traits, Genetic disorders and counseling.

Principles of Genetics (Lab)

BS-Botany

Course Code: BOT-101L

Credit Hours: 1

Pre-requisite: N.A

Objectives

To develop practical skills in genetic analysis, problem-solving, and interpretation of inheritance patterns using experimental and statistical approaches. To enable students to understand genetic variation, population genetics, and evolutionary relationships through data analysis and modeling.

Learning Outcomes

Students will be able to:

- Solve genetic problems using Punnett squares and interpret inheritance patterns including monohybrid, dihybrid, and sex-linked crosses.
- Analyze genetic data using statistical tools such as the chi-square test and interpret results for hypothesis testing.
- Examine patterns of inheritance including dominance, codominance, multiple alleles, and pedigree analysis.
- Investigate genetic mechanisms such as linkage, crossing over, and gene mapping using experimental or simulated data.
- Evaluate population genetics concepts (Hardy-Weinberg equilibrium, genetic drift, gene flow) and construct phylogenetic relationships using genetic data.

Lab Outline

1. Monohybrid and dihybrid crosses Punnett squares.
2. Chi-square test for data interpretation.
3. Study of pedigrees and inheritance patterns.
4. Identification of dominant, recessive, sex-linked traits.
5. Incomplete dominance and codominance (examples and problems).
6. Multiple alleles (e.g., ABO blood groups).
7. Sex-linked inheritance (e.g., Drosophila crosses, human pedigrees).
8. Mitosis and meiosis (microscopic observation of prepared slides).
9. Linkage and crossing over (Drosophila crosses or simulations).
10. Construction of linkage maps. Three-point crosses.
11. Hardy-Weinberg equilibrium: simulation and calculation of allele frequencies.
12. Modeling genetic drift, gene flow, and selection pressures.
13. Phylogenetic tree construction using morphological or molecular data.

Recommended Books/Reference Material

1. Bujakowska, K. M., & Dryja, T. P. (2021). *Fundamentals of Genetics*. In *Albert and Jakobiec's Principles and Practice of Ophthalmology* (pp. 1–32). Springer International Publishing.
2. Meneely, P. M., Hoang, R. D., Okeke, I. N., & Heston, K. (2017). *Genetics: Genes, Genomes, and Evolution*. Oxford University Press.
3. Snustad, D. P., & Simmons, M. J. (2015). *Principles of Genetics*. John Wiley & Sons.
4. Verma, P. S., & Agarwal, V. K. (2004). *Cell Biology, Genetics, Molecular Biology, Evolution and Ecology: Evolution and Ecology*. S. Chand Publishing.
5. Waddington, C. H. (2016). *An Introduction to Modern Genetics*. Routledge.
6. Tietje, M., Antonelli, A., Forest, F., Govaerts, R., Smith, S. A., Sun, M., & Eiserhardt, W. L. (2023). *Global Hotspots of Plant Phylogenetic Diversity*. *New Phytologist*, 240(4), 1636-1646.

Plant Physiology and Ecology

BS-Botany

Course Code: BOT-202

Credit Hours: 2

Pre-requisite: N.A

Objectives

This course will provide basic knowledge of different metabolic processes occurring in plants in addition to the relationships of plants with their environment. The course also aims to enable the students to assess the effects of various environmental factors and stresses on plant growth and development.

Learning Outcomes

- Students will be familiarized with the different metabolic processes occurring in plants, as well as the relationships of plants with their environment.
- Students will be able to know the effects of various environmental factors on plant growth and development.

Course Outline

Unit 1. Water Relations and Mineral Nutrition

Water potential, osmotic potential, pressure potential and matric potential. Absorption and translocation of water. Stomatal regulation. Soil as source of minerals. Passive and active transport of nutrients. Essential mineral elements. Role and deficiency symptoms of Macronutrients.

Unit 2. Photosynthesis and Respiration

Introduction, oxygenic and non-oxygenic photosynthesis, mechanism of light reactions (electron transport and photophosphorylation) and dark reactions (Calvin cycle). Definition and respiratory substrates, mechanism of glycolysis. Krebs cycle Electron transport and oxidative phosphorylation. Anaerobic respiration. Energy balance in aerobic and anaerobic respiration. Respiratory quotients.

Unit 3. Growth, Dormancy and Plant Movements

Introduction, role of auxin and abscisic acid. Photoperiodism: definition, classification of plants based on photoperiodic response. Dormancy: introduction, causes and importance of seed dormancy. Plant movements' classification, tropic movements-Photoperiodism and Gravitropism. Introduction aims and application of ecology, field capacity & water holding capacity of soil. Characteristics of xerophytes and hydrophytes.

Unit 4. Ecological Factors

Introduction, aims and applications of ecology. Soil: physical and chemical properties of soil (soil formation, texture pH, EC, organism and organic matter

etc.) and their relationship to plants. Quality of light, diurnal and seasonal variations, Eco- physiological responses. Field capacity and soil water holding capacity. Characteristics of xerophytes and hydrophytes. Effect of precipitation on distribution of plants. Wind: wind as an ecological factor and its importance.

Unit 5. Population and Ecosystem Ecology

Introduction. A brief description of seed dispersal and seed bank. Community ecology. Ecological characteristics of plant community. Methods of sampling vegetation (quadrat and line intercept). Major vegetation types of the local area. Definition, types and components of ecosystem. Food chain and food web. Applied ecology: causes, effects and control of water logging and salinity with respect to Pakistan. Soil salinity and water logging identification. Effects on plants and reclamation strategies. Biological succession.

Recommended Books/Reference Material

1. Ambasht, R.S. & Ambasht, N.K. (2022). *A Text Book of Ecology*. (16th Ed.) CBS Publishers & Distributors.
2. Andrew, L. (2022). *Plant Ecology and Conservation*. CRC Press.
3. Ricklefs, R. E. (2020). *Ecology*. W. H. Freeman and Co., UK
4. Schultz, J. C. (2005). *Plant Ecology*. Springer-Verlag, Berlin.
5. Salisbury, F. B. & Ross, C. B. (1992). *Plant Physiology*. (5th Ed.) Wadsworth Publishing Co. Belmont CA.
6. Taiz, L. & Zeiger, E. (2006). *Plant Physiology*. (4th Ed.) Sinauers.

Plant Physiology and Ecology (Lab)

BS-Botany

Course Code: BOT-202L

Credit Hours: 1

Pre-requisite: N.A

Objectives:

To develop experimental skills in plant physiological processes and ecological observations through laboratory and field-based studies.

Learning Outcomes:

- Perform experiments related to plant physiology (osmosis, transpiration, photosynthesis). Analyze plant responses to environmental factors.
- Identify ecological adaptations in plants. Record and interpret experimental data scientifically.
- Conduct basic ecological field observations.

Lab Outline

1. Preparation of solutions of specific normality of acids/bases, salts, sugars.
2. Determination of uptake of water by swollen seeds when placed in Sodium Chloride solution of different concentrations
3. Measurement of leaf water potential by the dye method.
4. Determination of the temperature at which beetroot cells lose permeability.
5. Determination of the effects of environmental factors on the rate of transpiration of a leafy shoot
6. Extraction of chlorophyll from the leaves and separation of component pigments on a paper chromatogram.
7. Study of absorption spectra using spectrophotometer.
8. Estimation of oxygen utilized by a respiring plant by Winkler's method
9. Determination of physical characteristics of soil.
10. Determination of chemical characteristics of soil.
11. Measurement of vegetation by line intercept methods.
12. Measurement of vegetation by Quadrat methods
13. Effect of light on seed germination. Effect of pH on seed germination.

Recommended Books/Reference Material

1. Ambasht, R.S. & Ambasht, N.K. (2022). *A Text Book of Ecology*. (16th Ed.) CBS Publishers & Distributors.
2. Andrew, L. (2022). *Plant Ecology and Conservation*. CRC Press.
3. Ricklefs, R. E. (2020). *Ecology*. W. H. Freeman and Co., UK

4. Schultz, J. C. (2005). *Plant Ecology*. Springer-Verlag, Berlin.
5. Salisbury, F. B. & Ross, C. B. (1992). *Plant Physiology*. (5th Ed.) Wadsworth Publishing Co. Belmont CA.
6. Taiz, L. & Zeiger, E. (2006). *Plant Physiology*. (4th Ed.) Sinauers.

9. List of General Education Courses

Course code	Course	Credits	Category	Pre-requisite
GEO-106	Introduction to Environmental Science	2	General Education	NIL
GEO-106L	Introduction to Environmental Science (Lab)	1	General Education	NIL
MTH-110	Quantitative Reasoning I	3	General Education	NIL
ENG-110	Functional English	3	General Education	NIL
CS-107	Applications of Information and Communication Technologies	2	General Education	NIL
CS-107L	Applications of Information and Communication Technologies (Lab)	1	General Education	NIL
STA-112	Quantitative Reasoning II	3	General Education	NIL
ENG-111	Expository Writing	3	General Education	NIL
ISL-101/ ETH-101	Islamic Studies / Ethics	2	General Education	NIL
MGT-110	Time Management and Organizing Skills	2	General Education	NIL
PAK-103	Ideology and Constitution of Pakistan	2	General Education	NIL
CCE-497	Civic and Community Engagement	2	General Education	NIL
MGT-108	Entrepreneurship	2	General Education	NIL
PAK-104	Pakistan Studies	2	General Education	NIL
UHQ-101/ ETH-103	Understanding of Holy Quran–I/ Ethics-I	1	General Education	NIL
UHQ-102/ ETH-104	Understanding of Holy Quran–II/ Ethics-II	1	General Education	NIL

10.Course Outlines for General Education Courses

Course Title: Introduction to Environmental Science

Course Code: GEO-106

Credit Hours: 2

Pre-requisite: None

Course Objectives

The course aims to provide foundational knowledge of environmental systems, processes, and major environmental challenges, develop an understanding of the interaction between biological, physical, and chemical components of the environment and introduce basic concepts of sustainability, natural resources management, and environmental protection.

Learning Outcomes

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

- Understand basic concepts of interdisciplinary nature of environmental science
- Identify major components of environment i.e lithosphere, hydrosphere, atmosphere and biosphere and their interactions.
- Understand main environmental problems
- Analyze the impact of human activities on natural systems.
- Appreciate the importance of sustainable resource management and environmental stewardship.

Course Outline:

Unit 1. Fundamentals of Environmental Science

Definition, Scope, and Importance of Environmental Science, Components of the Environment: Atmosphere, Hydrosphere, Lithosphere, Biosphere, Interdisciplinary nature of Environmental Science, Human-environment interactions

Unit 2. Ecology, Ecosystems, and Natural Resources

Concepts of Ecology and Ecosystem, Structure and Functions of Ecosystems, Food Chains, Food Webs, Trophic Levels, Biogeochemical Cycles: Carbon, Nitrogen, Water, and Phosphorus, Natural Resources: (Renewable and Non-renewable Resources, Forest, Water, Land, and Mineral Resources, Conservation of Natural Resources)

Unit 3. Environmental Pollution

Types of Pollution: Air, Water, Soil, and Noise, Causes, Effects, and Control Measures
Case Studies: Major Environmental Disasters (Bhopal Gas Tragedy, Minamata Disease),
Floods in Pakistan, Industrial and traffic sources of pollution

Unit 4. Biodiversity and Environmental Conservation

Biodiversity: Definition, Types, and Levels, Importance of Biodiversity, Threats to Biodiversity, Concept of Sustainable Development, Conservation Methods: (In-situ and Ex-situ Conservation, National Parks and Wildlife Sanctuaries)

Unit 5. Population Dynamics, Environmental Policies, and Global Movements

Human Population Growth and Urbanization, Impacts of Population on the Environment, Environmental Laws and Policies, Pakistan Environmental Protection Act, 1997 International Environmental Agreements (Kyoto Protocol, Paris Agreement), Environmental Movements (Chipko Movement, Green Belt Movement).

Recommended Books/Reference Material

1. Cunningham, W. P., and Cunningham, M. A. (2020). Environmental science: A global concern (15th ed.). McGraw-Hill Education.
2. Cunningham, W. P., and Cunningham, M. A. (2021). Principles of environmental science: Inquiry and applications (9th ed.). McGraw-Hill Education.
3. Enger, E. D., and Smith, B. F. (2020). Environmental science: A study of interrelationships (15th ed.). McGraw-Hill Education.
4. OER Commons. (2022). Environmental biology. <https://www.oercommons.org>
5. OpenStax. (2023). Environmental science. OpenStax, Rice University. <https://openstax.org/details/books/environmental-science>
6. Pakistan Environmental Protection Act, 1997 (Primary legal framework for environmental policies in Pakistan; important for understanding local regulations.)
7. Sherman, D. J., and Montgomery, D. R. (2025). Environmental science and sustainability (1st ed.). W.W. Norton and Company.
8. Withgott, J. (2021). Environmental science: Your world, your turn. Savvas Learning Company

Course Title: Introduction to Environmental Science (Lab)

Course Code: GEO-106L

Credit Hours: 1

Pre-requisite: None

Course Objectives

To develop practical skills in ecological sampling, environmental monitoring, and analysis of soil, water, and biodiversity parameters. To enable students to assess environmental pollution and conservation practices through laboratory experiments and field-based investigations.

Learning Outcomes

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

- Measure and analyze ecological parameters including population density, frequency, biodiversity indices, soil pH, water pH, and electrical conductivity using standard laboratory and field techniques.
- Identify and evaluate different environmental contaminants and assess their potential impacts on ecosystems, biodiversity, and environmental health.
- Conduct and communicate field-based scientific observations through visits to herbaria, gene banks, national parks, and related institutions, and prepare reports on biodiversity conservation and environmental management practices

Lab Outline

1. Determination of Population Density of selected plant species in a given area using quadrat method.
2. Measurement of Frequency of plant species in a community using quadrat sampling technique.
3. Estimation of Relative Density, Relative Frequency, and Importance Value Index (IVI) of vegetation in a selected habitat.
4. Assessment of Species Diversity using Shannon-Wiener and Simpson's biodiversity indices.
5. Study of Plant Community Structure through line transect and belt transect methods.
6. Measurement of Soil pH from different habitats using digital pH meter and indicator methods.
7. Measurement of Water pH from tap water, pond water, canal water, and wastewater samples.
8. Determination of Electrical Conductivity (EC) of soil extracts to assess salinity levels.
9. Determination of Electrical Conductivity (EC) of different water samples for water quality analysis.
10. Detection of Heavy Metal Contaminants in soil or water samples using standard qualitative methods.

11. Study of Air Pollutants and their effects on plants through visible injury symptoms on leaves.
12. Identification of Organic and Plastic Waste Contaminants in local environments and classification of waste types.
13. Visit to Herbarium for study of preserved plant specimens, plant identification, and documentation methods.
14. Visit to Gene Bank / Botanical Garden to study germplasm conservation techniques and seed preservation methods.
15. Visit to National Park / Protected Area to observe biodiversity conservation practices, ecosystem management, and environmental protection strategies.

Recommended Books/Reference Material

1. Cunningham, W. P., and Cunningham, M. A. (2020). Environmental science: A global concern (15th ed.). McGraw-Hill Education.
2. Cunningham, W. P., and Cunningham, M. A. (2021). Principles of environmental science: Inquiry and applications (9th ed.). McGraw-Hill Education.
3. Enger, E. D., and Smith, B. F. (2020). Environmental science: A study of interrelationships (15th ed.). McGraw-Hill Education.
4. OER Commons. (2022). Environmental biology. <https://www.oercommons.org>
5. OpenStax. (2023). Environmental science. OpenStax, Rice University. <https://openstax.org/details/books/environmental-science>
6. Pakistan Environmental Protection Act, 1997 (Primary legal framework for environmental policies in Pakistan; important for understanding local regulations.)
7. Sherman, D. J., and Montgomery, D. R. (2025). Environmental science and sustainability (1st ed.). W.W. Norton and Company.
8. Withgott, J. (2021). Environmental science: Your world, your turn. Savvas Learning Company

Quantitative Reasoning-I

Course Code: MTH-110

Pre-requisite: Nil

Credit Hours: 3

Objectives:

Quantitative Reasoning-I is an introductory-level undergraduate course that focuses on the fundamentals related to the quantitative concepts and analysis. The course is designed to familiarize students with the basic concepts of mathematics to develop students' abilities to analyze and interpret quantitative information. Through a combination of theoretical concepts and practical exercises, this course will also enable students cultivate their quantitative literacy and problem-solving skills while effectively expanding their academic horizon and breadth of knowledge of their specific major / field of study.

Learning Outcomes:

By the end of this course,

- The students shall have fundamental numerical literacy to enable them work with numbers, understand their meaning and present data accurately.
- Understanding of fundamental mathematical concepts. Basic ability to interpret data presented in various formats including but not limited to tables, graphs, charts, and equations etc.

Course Outline:

Unit-1. Numerical Literacy

Number system and basic arithmetic operations. Units and their conversions, dimensions, area, perimeter and volume. Rates, ratios, proportions and percentages. Types and sources of data; Measurement scales. Tabular and graphical presentation of data. Quantitative reasoning exercises using number knowledge.

Unit-2. Fundamental Mathematical Concepts

Basics of geometry (lines, angles, circles, polygons etc. Relations, functions, and their graphs. Exponents, factoring and simplifying algebraic expressions. Algebraic and graphical solutions of linear and quadratic equations and inequalities. Quantitative reasoning exercises using fundamental mathematical concepts.

Unit-3. Mathematical Modeling and Analyses

Introduction to deterministic models. Use of linear functions for modeling in real-world situations. Modeling with the system of linear equations and their solutions. Elementary introduction to derivatives in mathematical modeling. Linear and

exponential growth and decay models. Quantitative reasoning exercises using mathematical modeling.

Unit-4. Introduction to Logic

Introduction and importance of logic. Inductive, deductive and abductive approaches of reasoning. Propositions, arguments (valid, invalid), logical connectives.

Unit-5. Truth Tables and Logical Reasoning Concepts

Truth tables and propositional equivalences. Logical fallacies. Venn Diagrams. Predicates and quantifiers. Quantitative reasoning exercises using logical reasoning concepts and techniques.

Recommended Books/Reference Books

1. Bennett, J., and Briggs, W.L and Badalamenti. A. (2019). *Using and understanding mathematics: A quantitative reasoning approach*. Pearson.
2. Mesquita, E.B., and Fowler, A. (2021). *Thinking Clearly with Data: A Guide to Quantitative Reasoning and Analysis*. Princeton University Press.
3. Rosen, K. H. (2007). *Discrete mathematics and its applications*. The McGraw Hill Companies.
4. Schröder, B. (2010). *Fundamentals of Mathematics*. Wiley.
5. Zaslowsky, E. (2020). *Quantitative Reasoning: Thinking in Numbers*. Cambridge University Press.

Functional English

Course Code: ENG-110

Credit Hours: 3

Pre-requisite: Nil

Objectives:

This course is designed to equip students with essential language skills for effective communication in diverse real-world scenarios. It focuses on developing proficiency in English language usage: word choices, grammar and sentence structure. In addition, the course will enable students to grasp nuanced messages and tailor their communication effectively through application of comprehension and communication aspects including professional writing, public speaking, and everyday conversation. Ensuring that students are equipped in both academic and professional spheres. An integral part of the course is fostering a deeper understanding of the impact of language on diverse audiences. Students will learn to communicate inclusively and display a strong commitment to cultural awareness in their language use. Additionally, the course will enable them to navigate the globalized world with ease and efficacy, making a positive impact in their functional interactions.

Learning Outcomes:

- Apply enhanced English communication skills through effective use of word choices, grammar and sentence structure
- Comprehend a variety of literary non-literary written and spoken texts in English.
- Effectively express information, ideas and opinions in written and spoken English.
- Recognize inter-cultural variations in the use of English language and to effectively adapt their communication style and content based on diverse cultural and social contexts.

Course Outline:

Unit-1. Introduction

Ice breaking Activities. Types and modes of Communication. Intrapersonal, Intrapersonal and group Communication.

Unit-2. Rules for Structure of Sentences

Types of sentences on the basis of function (Declarative, Interrogative, Imperative, Exclamatory and structure (simple, compound, complex). Synthesis of sentences. Punctuation and Spellings. Vocabulary, lexical and functional categories.

Unit-3. Concept of Time and Tense (present, past, future).

Discussion: General topics and everyday conversation. Concept of Voice: active and passive voice. Functional use of Voice in different situations.

Unit-4. Direct and Indirect Reporting.

Discussion regarding description of things persons, places, pictures, events etc. Salutation and Greeting, Introduction, asking and answering questions.

Unit-5. Practicing Everyday Conversation

Request and Permission, Agreement and Disagreement. Apologizing, Expressing likes and Dislikes, expressing opinion. Expressing approval, Disapproval.

Unit-6. Articulating Expression

Expressing appreciation, regret, and indifference. Expressing certainty, uncertainty, and obligation. Expressing suggestion, warning, Expressing possibility, impossibility and logical conclusion.

Unit-7. Art of Inviting

Accepting, declining invitation. Expressing and inquiring about preferences. Stating intentions and Making Plans. Giving directions. Instructing people how to do things.

Unit-8. Discussing Past and Present

Future prospects, Talking about the past.

Recommended Books/ Reference Material

1. Azar, B. S. (2003). *Fundamentals of English grammar*. Longman.
2. Beebe, S. A., Beebe, S. J., and Ivy, D. K. (2010). *Communication: Principles for a lifetime* (p. 483). Boston, MA: Allyn and Bacon.
3. Eastwood, J. (1994). *Oxford guide to English grammar*. Oxford University Press.
4. Floyd, K., and Cardon, P. (2023). *Business and Professional Communication*. McGraw-Hill US Higher Ed USE.)
5. Kortmann, B. (2020). *English linguistics: essentials*. Springer Nature.
6. Langan, J. (2001). *College writing skills with readings*. New York.
7. Murphy, R. (2003). *English grammar in use*. Cambridge: Cambridge University Press.
8. Sharma, Gajendra Dutt (2023) *A Comprehensive Resource Book of Functional English*, OEP, New Delhi.

Application of Information and Communication Technologies

Course Code: CS-107

Credit Hours: 2

Pre-requisite: Nil

Objectives:

This course provides a very broad range of topics and prepares the students for various DOMAINS in computing that they will face in upcoming semesters. This course is very comprehensive as it provides every student a set of productivity tools that they will be able to use for the rest of their lives. It provides knowledge and skills for use of computing and communication technologies to solve real life problems. This is an introductory course about Information and Communication Technologies that includes ICT terminologies, hardware and software components, the internet and World Wide Web, and ICT based applications.

Learning Outcomes:

- **Define** various types and components of computer including input/output devices, memory, storage media.
- **Describe** different types of software from operating systems to system utilities and productivity apps.
- **Describe** the basic concepts of computer networks, database management and computer security from a user point of view, components of a computer including input/output devices, memory, storage media.

Course Outline:

Unit-1. Technology

Types of Computers, Mobile and Game Devices, Data and Information, The Web, Web Searching, Online Social Networks, Internet Communications. Digital Security and Privacy, Viruses and Other Malware, Privacy, Health Concerns, Environmental Issues, Programs and Apps, Operating Systems, Applications, Installing and Running Programs, Developing Programs and Apps, Communications and Networks, Wired and Wireless Communications, Networks, Technology Uses, Government, Finance, Retail, Entertainment, Health Care, Science, Travel, Publishing, Manufacturing, Technology Users.

Unit-2. Online Web

The Internet, Websites and Media, The Internet, Evolution of the Internet, connecting to the Internet, Internet Service Providers, How Data Travels the Internet, IP and MAC Addresses and Domain Names, The World Wide Web, Navigating the Web, Web Addresses, Web Apps and Mobile Apps. Types of

Websites, Digital Media on the Web, Graphics, Audio, Video, Plug-Ins, Other Internet Services, Email, Email Lists, Internet Messaging, Chat Rooms, Online Discussions, VoIP, FTP, Netiquette.

Unit-3. Evaluating Computers and Mobile Devices

Mobile Computers and Desktops, Laptops, Tab and Other Mobile Computers, Handheld Computers, Desktops and All-in-Ones, Servers, Terminals, Point-of-Sale Terminals, Wearable Devices, Game Devices, Embedded Computers. Inside the Case, The Motherboard, Processors, The Control Unit, The Arithmetic Logic Unit, Machine Cycle, Registers, The System Clock, Personal Computer and Mobile Device Processors, Processor Cooling, The Internet of Things, Cloud Computing, Cloud Computing Services. Memory, Bytes and Addressable Memory, Types of Memory, RAM, Cache, ROM, Flash Memory, CMOS, Memory Access Times, Adapters, Adapter Cards, USB Adapters, Buses, Bus Width, Types of Buses, Power Supply and Batteries, Data Representation and Number System.

Unit-4. Programs and Apps

Role of the Operating System, Obtaining Software, Installing Software, Categories of Programs and Apps, Multimedia and Interest Applications, Communications Applications, File, Disk, and System Management Tools.

Unit-5. Digital Security Ethics, and Privacy: Threats, Issues, and Defenses

Digital Security Risks, Cybercrime, Internet and Network Attacks Malware, Botnets, Encryption, Digital Signatures and Certificates, Hardware Theft, Vandalism, and Failure, Backing Up — The Ultimate Safeguard, Wireless Security, Ethics and Society, information Accuracy, Intellectual Property Rights, Codes of Conduct, Cookies, Phishing, Spyware and Adware, Social Engineering, Privacy Laws, Employee Monitoring, Content Filtering. What is data base and data base management system, Evolution of database management, Data Concepts and Characteristics, Data Organization. Operating Systems, Operating System Functions, Starting Computers and Mobile Devices, Shutting Down Computers and Mobile Devices, providing a User Interface, Managing Programs, Managing Memory.

Recommended Books/Reference Material:

1. Campbell, J. T., Freund, S. M., Frydenberg, M., Last, M. Z., and Pratt, P. J. (2016). Shelly Cashman Series Discovering Computers and Microsoft Office 365 and Office 2016: A Fundamental Combined Approach. Cengage Learning.
2. Hafez, K., Skinner, A., and Grüne, A. (2022). Foundations of Global Communication: A Conceptual Handbook. Routledge.
3. Hawkrigde, D. (2022). New information technology in education. Taylor and Francis.

4. Pearlson, K. E., Saunders, C. S., and Galletta, D. F. (2016). Managing and using information systems: A strategic approach. John Wiley and Sons.
5. Pearlson, K. E., Saunders, C. S., and Galletta, D. F. (2024). Managing and using information systems: A strategic approach. John Wiley and Sons.

Application of Information and Communication Technologies (Lab)

Course Code: CS-107L

Credit Hours: 1

Pre-requisite: Nil

Objectives:

This course provides a very broad range of topics and prepares the students for various DOMAINS in computing that they will face in upcoming semesters. This course is very comprehensive as it provides every student a set of productivity tools that they will be able to use for the rest of their lives. It provides knowledge and skills for use of computing and communication technologies to solve real life problems. This is an introductory course about Information and Communication Technologies that includes ICT terminologies, hardware and software components, the internet and World Wide Web, and ICT based applications.

Learning Outcomes:

- **Define** various types and components of computer including input/output devices, memory, storage media.
- **Describe** different types of software from operating systems to system utilities and productivity apps.
- **Describe** the basic concepts of computer networks, database management and computer security from a user point of view, components of a computer including input/output devices, memory, storage media.

Course Outline:

1. Introduction to the lab equipment and SOPs of the labs. Introduction to computer hardware and system information.
2. Introduction to the Web, Web Searching, Online Social Networks, Internet Communications. Digital Security and Privacy, Viruses and Other Malware, Privacy.
3. IP and MAC Addresses and Domain Names, The World Wide Web, Navigating the Web, Web Addresses, Web Apps and Mobile Apps.
4. Types of Websites, Digital Media on the Web, Graphics, Audio, Video, Plug-Ins, Other Internet Services, Email, Email Lists, Internet Messaging, Chat Rooms, Online Discussions, VoIP, FTP, Netiquette.
5. Inside world: The Motherboard, Processors, The Control Unit, The Arithmetic Logic Unit, Machine Cycle, Registers, The System Clock, Personal Computer and Mobile Device Processors, Processor Cooling
6. The Internet of Things, Cloud Computing, Cloud Computing Services. Memory, Bytes and Addressable Memory, Types of Memory, RAM, Cache, ROM, Flash Memory, CMOS, Memory Access Times, Adapters, Adapter Cards, USB Adapters, Buses, Bus Width, Types of Buses, Power Supply and Batteries, Data Representation and Number System.

7. File, Disk, and System Management Tools. MS office
8. Digital Security Risks, Cybercrime, Internet and Network Attacks Malware, Botnets, Encryption, Digital Signatures and Certificates, Hardware Theft, Vandalism, and Failure. Backing Up, The Ultimate Safeguard, Wireless Security, Ethics and Society, information Accuracy, Intellectual Property Rights, Codes of Conduct, Cookies, Phishing, Spyware and Adware, Social Engineering, Privacy Laws, Employee Monitoring, Content Filtering.
9. What is data base and data base management system, Evolution of database management, Data Concepts and Characteristics, Data Organization.
10. Operating Systems, Operating System Functions, Starting Computers and Mobile Devices, Shutting Down Computers and Mobile Devices, providing a User Interface, Managing Programs, Managing Memory.

Recommended Books/Reference Material

1. Campbell, J. T., Freund, S. M., Frydenberg, M., Last, M. Z., and Pratt, P. J. (2016). Shelly Cashman Series Discovering Computers and Microsoft Office 365 and Office 2016: A Fundamental Combined Approach. Cengage Learning.
2. Hafez, K., Skinner, A., and Grüne, A. (2022). Foundations of Global Communication: A Conceptual Handbook. Routledge.
3. Hawkrigde, D. (2022). New information technology in education. Taylor and Francis.
4. Pearlson, K. E., Saunders, C. S., and Galletta, D. F. (2016). Managing and using information systems: A strategic approach. John Wiley and Sons.
5. Pearlson, K. E., Saunders, C. S., and Galletta, D. F. (2024). Managing and using information systems: A strategic approach. John Wiley and Sons.

Time Management and Organizing Skills

Course Code: MGT-110

Credit Hours: 2

Pre-Requisites: N.A

Objectives

This course introduces students to the principles and techniques of effective time management and personal organization. Through practical exercises, reflective assessments, and real-world application, students will develop habits that enhance productivity, reduce stress, and lead to more balanced and goal-oriented lives.

Course Objectives

By the end of the course, students will be able to:

- Identify time-wasting behaviors and develop strategies to overcome them.
- Create and implement a personal time management system.
- Set SMART goals and prioritize tasks effectively.
- Understand the role of habits, routines, and self-discipline in managing time.
- Use digital and physical tools to enhance organization.
- Reflect on their personal productivity styles and continuously improve.

Course Outline

Unit 1. Introduction to Time Management

Importance of time management in college and life. Self-assessment: Time management questionnaire. Common myths and barriers

Unit 2. Understanding Your Time

Time tracking and analysis. Identifying time wasters. Energy mapping and optimal performance times

Unit 3. Goal Setting

Long-term vs. short-term goals. SMART goals framework. Vision board activity (optional)

Unit 4. Prioritization Techniques

Eisenhower Matrix. ABCDE method. Time blocking vs. task batching

Unit 5. Planning and Scheduling

Weekly and daily planning methods. Using planners, calendars, and to-do lists. Digital tools overview (Google Calendar, Trello, Notion)

Unit 6. Procrastination and Productivity Hacks

Causes and types of procrastination. Overcoming procrastination (Pomodoro Technique, 2-minute rule). Building motivation and accountability

Unit 7. Organizational Skills

Organizing physical and digital spaces. File management and note-taking systems. Minimalism and decluttering for mental clarity

Unit 8. Habits, Routines and Life Balance

The science of habit formation (cue-routine-reward loop). Morning and evening routines. Work-life balance and mental well-being

Final Project

Personal Productivity Plan

Recommended Books/ Reference Material

1. Covey, S. R. The 7 Habits of Highly Effective People
2. Tracy, B. Eat That Frog!
3. Selected articles and case studies (provided in class)

Tools Recommended

1. Google Calendar or equivalent
2. Task manager (e.g., Todoist, Notion, or Trello)
3. Journal or notebook for self-reflection

Quantitative Reasoning-II

Course Code: STA-112

Credit Hours: 3

Pre-requisite: Nil

Objectives:

The main purpose of the course is to enable students to understand the significance of statistics in the real world, particularly in the field of other sciences. The course focuses on the methods of collection presentation and analysis of data using measures of central tendency and measures of dispersion. The course also focuses on basic principles of probability and distributions, regression and correlation analysis, estimation and testing of hypothesis. It will prepare students to apply the quantitative reasoning skills in solving quantitative problems which they will experience in their practical lives.

Learning Outcomes:

- Student will understand the basic statistical concepts and have basic ability to interpret data presented in various formats including but not limited to tables, graphs, charts and equation etc.
- Understand basic quantitative modeling and analyses.
- Ability to critically evaluate quantitative information to make evidence-based decision through appropriate statistical tools.

Course Outline:

Unit-1. Introduction of Statistic and Data Condensation

Types and sources of data. Measurement scales. Population and sample. Tabular and graphical presentation of data. Quantitative reasoning exercises using fundamental statistical concepts.

Unit-2. Measure of Central Tendency and Dispersion

Measure of central tendency. Measure of dispersion. Data interpretation. Quantitative reasoning exercises using statistical concepts.

Unit-3. Probability and Probability Distributions

Basic probability theory. Rules of counting (multiplicative, permutation, combinations). Introduction to random variables and their probability distributions. Quantitative reasoning exercises using probability theories and distribution concepts.

Unit-4. Regression and Correlation Analysis

Introduction to probabilistic models. Bivariate analysis. Scatter plots. Simple linear regression model. Correlation analysis. Quantitative reasoning exercises using statistical modelling.

Unit-5. Estimation and Testing of Hypothesis

Basics of estimation and confidence interval. Testing of Hypothesis (z-test; t-test). Statistical inference in decision making. Quantitative reasoning exercises using estimation and Statistical inference concepts and techniques.

Recommended Books/Reference Material

1. Chaudhry S.M., and Kamal. S. (2018). *Introduction to statistical theory part I*. Lahore, Pakistan: Ilmi Kitab Khana.
2. Chaudhry S.M., and Kamal. S. (2018). *Introduction to statistical theory part II*. Lahore, Pakistan: Ilmi Kitab Khana.
3. Hogg, R., Mckean, J., and Craig, A. (2021). *Introduction to mathematical statistics*, (8th ed.). Boston: Pearson Education.
4. Mendenhall, W., Beaver, R. J., and Beaver, B. M. (2012). *Introduction to probability and statistics*. Cengage Learning.
5. Mood, A.M., Graybill, F.A., and Boes, D.C. (1974). *introduction to the theory of statistics*, (3rd ed.). New York: McGraw Hill.
6. Moore, D. S., McCabe, G.P., and Craig, B. A. (2021). *Introduction to the practice of statistics*, (10th ed.). New York: WH Freeman.
7. Walpole, R. E. (2002). *Introduction to statistics*, (7th ed.). New York: Macmillan publishing company.
8. Walpole, R.E., Myers, R.H., and Myers, S.L. (1998). *probability and statistics for engineers and scientist*, (6th ed.). New York: Prentice Hall.

Expository Writing

Course Code: ENG-111

Credit Hours: 3

Pre-requisite: Nil

Objectives:

Expository Writing is a sequential undergraduate course aimed at refining writing skills in various contexts. Building upon the foundation building pre-requisite course, Functional English, this course will enhance students' basic skills of producing clear, concise and coherent written texts in English. The course will also enable students to dissect intricate ideas, to amalgamate information and to express their views and opinions through well-organized essays. The students will further be able to refine their analytical skills to substantiate their viewpoints using credible sources while adhering to established ethical writing norms. Additionally, the course will highlight the significance of critical thinking enabling students to produce original and engaging written texts.

Learning Outcomes:

- Understand the essentials of the writing process integrating pre-working, drafting, editing and proofreading to produce well-structured essays.
- Uphold ethical practices to maintain originality in expository writing.

Course Outline:

Unit-1. Introduction to Expository Writing

Understanding expository writing (definition, types, purpose and applications). Characteristics of effective expository writing (clarity, coherence and organization). Introduction to paragraph writing.

Unit-2. The Writing Process

Pre-writing techniques (brainstorming, free-writing, mind-mapping, listing, questioning and outlining etc.). Drafting (three stage process of drafting techniques). Revising and editing (ensuring correct grammar, Clarity, coherence, conciseness etc.). Proofreading (fine-tuning of the draft). Peer review and feedback (providing and receiving critique).

Unit-3. Essay Organization and Structure

Introduction and hook (engaging readers and introducing the topic). Thesis statement (crafting a clear and focused central idea). Body Paragraphs (topic sentences, supporting evidence and transitional devices). Conclusion (types of concluding paragraphs and leaving an impact). Ensuring cohesion and coherence (creating seamless connections between paragraphs).

Unit-4. Types of Expository Writing

Description, Illustration, Classification. Cause and effect (exploring causal relationships and outcomes). Process analysis (explaining step-by-step procedures). Comparative analysis (analyzing similarities and differences)

Unit-5. Writing for Specific Purposes and Audiences

Different types of purposes (to inform, to analyze, to persuade, to entertain etc.). Writing for academic audiences (formality, objectivity, and academic conventions). Writing for public audiences (engaging, informative and persuasive language). Different tones and styles for specific purposes and audiences.

Unit-6. Ethical Considerations

Ensuring original writing (finding credible sources, evaluating information etc.). Proper citation and referencing (APA, MLA, or other citation styles), Integrating quotes and evidences (quoting, paraphrasing, and summarizing), Avoiding plagiarism (ethical considerations and best practices)

Recommended Books/ Reference Material

1. Axelrod, R. B., and Cooper, C. R. (2010). *The St. Martin's guide to writing*. Macmillan.
2. Faigley, L., Selzer, J., Enoch, J., and Wible, S. (2009). *Good reasons with contemporary arguments*. Pearson Longman.
3. Floyd, K., and Cardon, P. (2023). *Business and Professional Communication*. McGraw-Hill US Higher Ed USE.
4. Graff, G., Birkenstein, C., and Maxwell, C. (2014). *They say, I say: The moves that matter in academic writing* (p. 245). Gildan Media Corp Book Publisher.
5. Johnson-Sheehan, R., Paine, C., and Paine, C. (2010). *Writing today*. Pearson Education India.
6. Keizer, E. (2015). *A functional discourse grammar for English*. Oxford University Press.
7. Rosenwasser, D., and Stephen, J. (2011). *Writing analytically*. Cengage Learning Press.
8. Straaijer, R. (2018). Modern English usage from Britain to America: Bryan Garner follows Henry Fowler from A Dictionary of Modern American English Usage to Garner's Modern English Usage. *English Today*, 34(4), 39-47.
9. Wachal, R. S. (2000). The Elements of Style, by William Strunk, Jr., and EB White; and A Dictionary of Modern American Usage, by Bryan A. Garner. *American speech*, 75(2), 199-207.
10. Williams, J. M., and Bizup, J. (2022). *Lessons in clarity and grace*. Pearson.

Islamic Studies

Course Code: ISL-101

Credit Hours: 2

Pre-Requisites: Nil

Objectives:

Students will be able to demonstrate enhanced knowledge of Islamic Fundamentals, beliefs, practices, historical development, spiritual values and Ethical Principles. Describe Basic sources of Islamic Law and their application in daily life. Also, Identify and discuss contemporary issues being faced by the Muslim world Including Social Challenges, Gender Role and Interfaith dialogue.

Learning Outcomes:

- Evaluate and discuss their understanding about the beliefs, history and Ethical values of Islam.
- Be able to apply and relate the Articles of faith in their life according to present world.
- Be able to analyze the importance of Quran and Sunnah in their life and also to refute many relating misconceptions
- Engage in Discussions and write about Contemporary issues specifically related to Women.

Course Outline:

Unit-1. Introduction to Islam

Definition of Islam and its core Beliefs (Tawheed, Akhirat and Risalat), Pillars of Islam and their significance (Tawheed, Prayers, Fasting, Zakat and Hajj), The Holy Quran (Introduction, Revelation and Compilation), Sunnah and Hadith (Introduction, Revelation and Compilation)

Unit-2. Seerah of the Holy Prophet pbuh

Life of Prophet pbuh in Makkah, Life of Holy Prophet pbuh in Medina, Diverse roles of Holy Prophet pbuh (individual, leader, peacemaker, educator etc)

Unit-3. Islamic History and Civilization

World before Islam, The Rashidun Caliphate and its expansion, Contributions of Muslim Scientists and Philosophers.

Unit-4. Islamic Jurisprudence

Fundamental sources of Islamic Jurisprudence, Major Schools of Islamic Jurisprudence, Significance and principle of Ijtihad

Unit-5. Family and Society in Islam

Status and Rights of Women in Islam, Marriage, Family and Gender roles in Muslim Society, Family values and Structure in Muslim Society

Unit-6. Islam and Modern world

Relevance of Islam in Modern World. (Islamophobia, Interfaith dialogue and Multiculturalism), Islamic viewpoint towards socio-cultural and technological changes.

Recommended Books/Reference Material

1. Ahmed, Dr. A. (1996). *Women and Social Justice: An Islamic Paradigm*, The Islamic Foundation UK
2. Ahmed, K. (1971) *Islami Nazria e Hayat*, Karachi University press.
3. Ahmed, K. (1980). *Islam, Its meaning and message*, The Islamic Foundation UK.
4. Al-Mubarikpuri, M. S. (2002), *Al Raheeq ul Makhtoom (The Sealed Nector)*, Dar ul Salam.
5. Al-Suhaym, Dr. M.B., A. (2006) *Islam, Its foundation and concepts*, Darussalam
6. An Introduction to Islamic Theology by John Renard.
7. Bokhari, A.S, Zafar, M.D., Prof. Shakir, A.S. (2021). *A textbook of Islamic Education*, Akram Printing Press, Lahore.
8. Hussain, M. *The Five Pillars of Islam: A Framework for Islamic Values and Character building*, Kube Publishing, The Islamic Foundation UK
9. Maududi, Abul A. (2008). *Islamic Civilization Foundations, Beliefs and Principles*, Kube Publishing, Islamic Foundation UK
10. Maududi, Abul. A. (2007). *Towards understanding Islam*, The Islamic foundation UK
11. Phillip, Dr. A. A., B. (2018) *Islamic Studies*, International Islamic Publishing House.
12. Prof. Dr. Chaudary, M.N., Prof. Malik, M.A (2022). *Tafheem e Islamiyat*, Qureshi Brothers Publishers, Lahore.

Ethics (in lieu of Islamic Studies)

Course Code: ETH-101

Course Title: Ethics

Credit Hours: 2

Pre-Requisite: Nil

Objectives:

Upon successful completion of the course, students will be able to know the basics of Ethics and Morality and develop Ethical approach, Identify the concept of Ethics in Different Religions and Relate the ethical values with their lives business ethics, journalism ethics etc.

Learning Outcomes:

- Students will be able to demonstrate their understanding about the meaning of Ethics and Morality.
- Analyze the Similarities and Differences between ethical teachings of various religions.
- Develop sense of belongingness to the ethical values as a student, being member of the society etc

Course Outline:

Unit-1. Meaning and Scope of Ethics

Meaning and Definition of Ethics and Morality, Difference between Ethics and Morality, Relation of Ethics with: Religion, Science, Law.

Unit-2. Historical development of Morality

Instinctive Moral Life, Customary Morality, Reflective, Morality.

Unit-3. Moral Theories, Moral Ethics and Society

Hedonism (Mill), Intuitionism (Butler), Kant's Moral Theory, Freedom and Responsibility, Tolerance, Justice, Punishment.

Unit-4. Moral Teaching of Major Religions

Judaism, Christianity, Islam, Islam and Minorities.

Unit-5. Professional Ethics

Medical Ethics, Ethics of Student, Ethics of Teacher, Business Ethics.

Recommended Books/ Reference Material

1. R. Shafer-Landau. (2020). *The Fundamentals of Ethics*, 5th Edition.
2. S. Blackburn. (2021). *Ethics: A Very Short Introduction (Very Short Introductions)* 2nd Edition.
3. S. Liautaud, L. Sweetingham. (2022). *The Power of Ethics: How to Make Good Choices in a Complicated World*.
4. S. M. Cahn, P. Markie. (2019). *Ethics: History, Theory, and Contemporary Issues*, 7th Edition.

Ideology and Constitution of Pakistan

Course Code: PAK-103

Credit Hours: 2

Pre-requisite: Nil

Objectives:

This course is designed to provide students with a fundamental exploration of the ideology and the constitution of Pakistan. The course focuses on the underlying principles, beliefs, and aspirations that have been instrumental in shaping the creation and development of Pakistan as a sovereign state. Moreover, the course will enable students to understand the core provisions of the Constitution of the Islamic Republic of Pakistan concerning the fundamental rights and responsibilities of Pakistan citizens to enable them function in a socially responsible manner.

Learning Outcomes:

- Demonstrate enhanced knowledge of the basis of the ideology of Pakistan with special reference to the contributions of the founding fathers of Pakistan.
- Demonstrate fundamental knowledge about the Constitution of Pakistan 1973 and its evolution with special reference to state structure.
- Explain about the guiding principles on rights and responsibilities of Pakistani citizens are enshrined in the Constitution of Pakistan 1973.

Course Outline:

Unit-1. Introduction to the Ideology of Pakistan:

Definition and significance of ideology. Historical context of the creation of Pakistan (with emphasis on socio-political. Religious and cultural dynamics of British India between 1857 till 1947). Contributions of founding fathers of Pakistan in the freedom movement including but not limited to Allama Muhammad Iqbal, Muhammad Ali Jinnah etc. Contributions of women and students in the freedom movement or separate homeland.

Unit-2. Two-Nation Theory:

Evolution of the Two-Nation Theory (Urdu-Hindi controversy. Partition of Bengal. Simla Deputation 1906, Allama Iqbal Presidential Address 1930, Congress Ministries 1937 Lahore Resolution 1940). Role of communalism and religious differences.

Unit-3. Introduction to the Constitution of Pakistan:

Definition and importance of a constitution. Ideological factors that shaped the Constitution(s) of Pakistan. Overview of constitutional developments in Pakistan.

Unit-4. Constitution and State Structure

Structure of government (executive, legislature, and judiciary). Distribution of powers between federal and provincial governments. Eighteenth Amendment and its impact of federalism.

Unit-5. Fundamental Rights, Principles of Policy and Responsibilities

Overview of fundamental rights guaranteed to citizens by the Constitution of Pakistan 1973 (Articles R-28). Overview of Principles of Policy (Articles 29-40). Responsibilities of the Pakistani citizen.

Unit-6 Constitutional Amendments:

Procedures for amending the Constitution. Notable constitutional amendments and their implications

Recommended Books/Reference Material

1. Ahmed, A. S. (1997). *Jinnah, Pakistan and Islamic Identity: The Search for Saladin*. Routledge.
2. Aziz, K. K. (2002). *The Making of Pakistan: A Study of Nationalism*. Sang-e-Meel Publishers.
3. Choudhury, G. W. (1969). *Constitution-Making in Pakistan: The Dynamics of Political*. Columbia: University of British.
4. Cohen, S. P. (2004). *The Idea of Pakistan*. Washington: Brookings Institution Press.
5. Hussain, M. (2020). *The Parliament of Pakistan*. London:Oxford University press.
6. Iqbal, J. (2005). *Ideology of Pakistan*. Sang-e-Meel.
7. Jalal, A. (2014). *The Struggle for Pakistan: A Muslim Homeland and Global Politics*. Belknap Press: An Imprint of Harvard University Press.
8. Khan, H. (2020). *Constitutional and Political Development of Pakistan*. London: Oxford University Press.
9. Mahmood, S. (2003). *Pakistan: Political Roots and Development*. Sterling: University of Michigan.
10. Mujahid, S. u. (2001). *Ideology of Pakistan*. Progressive Publishers.
11. Qureshi, I. H. (1965). *The Struggle for Pakistan*. Karachi: University of Karachi Press.
12. Sayeed, K. B. (1960). *Pakistan: The Formative Phase*. London: Oxford University Press
13. Talbot, I. (2015). *Pakistan: A New History*. London: Oxford University Press.

Civic and Community Engagement

Course Code: CCE-497

Credit Hours: 2

Pre-requisite: N.A

Objectives:

This course is designed to provide students with fundamental knowledge about civics, citizenship and community engagement. In this course the students will learn about the essential of civil society, government, civic responsibilities, inclusivity and effective ways to participate in shaping the society which will help them apply the theoretical knowledge to the real-world situation to make a positive impact on their communities.

Learning Outcomes:

By the end of this course, student will be able to:

- Demonstrate fundamental understanding of civics, government, citizenship and civil society.
- Understand the concept of community and recognize the significance of community engagement for individuals and groups.
- Recognize the importance of diversity and inclusivity for societal harmony and peaceful co-existence.

Course Outline:

Unit-1. Civics and Citizenship

Concepts of civics, citizenship, and civic engagement. Foundations of modern society and citizenship. Types of citizenship: active, participatory, digital etc.

Unit-2. State, Government and Civil Society

Structure and function of government in Pakistan. The relationship between democracy and civil society. Right to vote and importance of political participation and representation.

Unit-3. Rights and Responsibilities

Overview of fundamental rights and liberties of citizens under constitution of Pakistan 1973. Civic responsibilities and duties. Ethical consideration in civic engagement (accountability, non-violence, peaceful dialogue, civility etc.).

Unit-4. Community Engagement

Concept, nature and characteristics of community. Community development and social cohesion. Approaches to effective community engagement. Case studies of successful community driven initiatives.

Unit-5. Advocacy and Activism

Public discourse and public opinion. Role of advocacy in addressing social issues. Social action movements.

Unit-6. Digital Citizenship and Technology

The use of digital platform for civic engagement. Cyber ethics and responsible use of social media. Digital divides and disparities (access, usage, socio-economic, geographic etc.) and their impact on citizenship.

Unit-7. Diversity, Inclusion and Social Justice

Understanding diversity in society (ethnic, cultural, economic, political etc.). Youth, women and minorities engagement in social development. Addressing social inequalities and injustices in Pakistan. Promoting inclusive citizenship and equal rights for social harmony and peaceful co-existence.

Suggested Practical Activities (Optional)

Apart of the overall learning requirements, the course may have one or a combination of the following practical activities

1. **Community Storytelling:** Students can collect and share stories from community members. This could be done through oral histories, interviews or multimedia presentations that captured the lived experiences and perspectives of diverse individuals.
2. **Community Event Planning:** Student can organize a community event or workshop that addresses a specific issue or foster community interaction. This could be a health fair, environmental cleanup, cultural festival or educational workshop
3. **Service Learning:** Student can collaborate with a local nonprofit organization or community group. They can actively contribute by volunteering their time, and skills to address a particular community need, such as tutoring, mentoring or supporting vulnerable population.
4. **Cultural Exchange Activities:** Student can organize a cultural exchange event that celebrates the diversity within the community. This could include food tastings, performances and presentations that promote cross cultural understanding.

Recommended Books/Reference Material

1. Džankić, J., and VINK, M. P. (2022). Citizenship and migration.
2. Kymlicka, W. and Norman, W. (2010). *Citizenship in Diverse Societies*. University Press, United Kingdom.

3. Mackert, J., and Turner, B. S. (2017). *The Transformation of Citizenship, Volume 2. Boundaries of Inclusion and Exclusion.*
4. Mattson, K. (2017). *Digital Citizenship in Action: Empowering Students to Engage in Online Communities.* : International Society for Technology in Education, United Kingdom.
5. McGraw-Hill Education, (2009). *Civics Today: Citizenship, Economics, and You*, Student Edition. United States.
6. Weinstock, D. (2017). *Citizenship and Cultural Diversity.* The Oxford Handbook of Citizenship.
7. Youniss, J. and Levine, J. (2009). *Engaging Young People in Civic Life.* Vanderbilt University Press, Ukraine.

Entrepreneurship

Course Code: MGT-108

Credit Hours: 2

Pre-requisite: Nil

Objectives:

This course is designed to promote entrepreneurial spirit and outlook among students, encouraging them to think critically, identify opportunities, and transform their ideas into successful ventures. It aims at imparting them with the requisite knowledge, skills, abilities, enabling them to seize the identified opportunities for initiating ventures and successfully navigating the challenges that come with starting a business and managing it. The course covers topics relevant to entrepreneurship including setting up and initiation of business, market research, opportunity identification, business planning, financial literacy for managing finances and securing funding, marketing and sales, team building and innovation.

Learning Outcomes:

By the end of this course, students shall have:

- Knowledge of fundamental entrepreneurial concepts, skills and process.
- Understanding on different personal, social and financial aspects associated with entrepreneurial activities.
- Basic understanding of regulatory requirements to set up an enterprise in Pakistan, with special emphasis on export businesses;
- Ability to apply knowledge, skills and competencies acquired in the course to develop a feasible business plan.

Course Outline:

Unit 1. Introduction to Entrepreneurship:

Definition and concept of entrepreneurship. Why to become an entrepreneur? Entrepreneurial process. Role of entrepreneurship in economic development.

Unit 2. Entrepreneurial Skills:

Characteristics and qualities of successful entrepreneurs (including stories of successes and failures). Areas of essential entrepreneurial skill and ability such as creative and critical thinking, innovation and risk taking abilities etc.

Unit 3. Opportunity Recognition and Idea Generation:

Opportunity identification, evaluation and exploitation. Innovative idea generation techniques for entrepreneurial ventures.

Unit 4. Marketing and Sales

Target market identification and segmentation. Four P's of Marketing. Developing a marketing strategy. Branding.

Unit 5. Financial Literacy:

Basic concepts of income, savings and investments. Basic concepts of assets, liabilities and equity. Basic concepts of revenue and expenses. Overview of cash-flows. Overview of banking products including Islamic modes of financing. Sources of funding for startups (angel financing, debt financing, equity financing etc.).

Unit 6. Team Building for Startups:

Characteristics and features of effective teams. Team building and effective leadership for startups.

Unit 7. Regulatory Requirements to Establish Enterprises in Pakistan:

Types of enterprises (e.g., sole proprietorship; partnership; private limited companies etc.). Intellectual property rights and protection. Regulatory requirements to register an enterprise in Pakistan, with special emphasis on export firms. Taxation and financial reporting obligation.

Suggested Practical Activities (Optional)

As part of the overall learning requirements, students shall be tasked with creating and presenting a comprehensive business plan at the end of the course for a hypothetical or real business idea. This practical exercise shall allow them to apply the knowledge, skills and competencies acquired in the course to develop a feasible business plan.

Recommended Books/ Reference Material

1. Barringer, B. R., and Ireland, R. D. (2016). Successfully launching new ventures.
2. Gupta, S. (2020). *Fundamentals of Entrepreneurship by Sanjay Gupta (eBook): SBPD Publications*. SBPD publications.
3. Hägg, G., and Kurczewska, A. (2022). *Entrepreneurship education: Scholarly progress and future challenges* (p. 101). Taylor and Francis.
4. Pruthi, S., and Mitra, J. (2023). *Global Entrepreneurship and Innovation*. SAGE.
5. Ries, E. (2022). The lean startup: how Today's entrepreneurs use continuous innovation to create radically successful businesses. E-book, Crown Business, New York.
6. Singh, K. K. (2023). *Women Entrepreneurship*. Guarav book center.

Pakistan Studies

Course Code: PAK-104

Credit Hours: 02

Pre-requisite: Nil

Objectives

This course is designed to provide students with a comprehensive exploration of Pakistan's identity, spanning geographical, historical, and cultural dimensions. It delves into the diverse landscapes, ancient civilizations, and rich cultural heritage that define Pakistan. Moreover, it examines the socio-cultural and political transformations in Pakistan over time including democratic transitions and military interventions. The aim of this course is to inculcate in students a nuanced understanding of Pakistan's past, present, and potential future trajectories, enabling them to critically evaluate the complex dynamics shaping the nation's development.

Learning Outcomes

After studying this course, the student will be able to:

- Have enhanced knowledge of the geographical, historical, and political aspects of Pakistan.
- Understand the society and culture of Pakistan.
- Understand and explain the socio-economic developments in Pakistan.
- Explore contemporary issues and challenges faced by Pakistan and their implications for the future.

Course Outline

Unit 1. Introduction to Pakistan

Geographical location and significance. Historical background: Ancient civilizations in the region. Factors leading to the creation of Pakistan.

Unit 2 Political History of Pakistan

Formative phase. Military interventions and democratic transitions.

Unit 3. Geography of Pakistan

Physiography: Mountains, plains, plateaus, deserts, valleys and coastal areas. River systems: Indus River and its tributaries. Climatic regions of Pakistan.

Unit 4. Society and Culture of Pakistan

Socio-cultural diversity. Languages and literature of Pakistan

Unit 5. Economic Development of Pakistan

Agriculture and industrial sectors of Pakistan. Economic challenges of Pakistan.

Unit 6. Contemporary Issues

Foreign relations of Pakistan. Security challenges: terrorism, extremism, and regional conflicts. Environmental problems and sustainable development (SDGs). Media and social change.

Recommended Books/ Reference Material

1. "Jinnah of Pakistan" by Stanley Wolpert
2. "The Sole Spokesman: Jinnah, the Muslim League, and the Demand for Pakistan" by Ayesha Jalal
3. "The struggle for Pakistan" by Ishtiaq Husain Qureshi
4. "Pakistan, the Formative Phase, 1857-1948" by Khalid B. Sayeed
5. "Pakistan Studies: A Book of Readings" by Sikandar Hayat
6. "Constitutional and Political History of Pakistan" by Hamid Khan
7. "Trek to Pakistan" by Ahmad Saeed and Kh. Mansur Sarwar
8. "Pakistan: A Modern History" by Ian Talbot
9. "Politics in Pakistan: The Nature and Direction of Change" by Khalid B. Sayeed
10. "Physical Geography of Pakistan" by Umar Jahangir

11. "A Geography of Pakistan: Environment, People, and Economy" by Fazle Karim Khan
12. "Pakistan's Foreign Policy: An Historical Analysis" by S. M. Burke
13. "Separatism in East Pakistan" by Rizwan Ullah Kokab
14. "Being Pakistani: Society, Culture and the Arts" by Raza Rumi
15. "Pakistan's Cultural Heritage: Socio-Economic and Technological Aspects" edited by Abdul Jabbar Khan
16. "Language and Politics in Pakistan" by Tariq Rahman
17. "Sociology" by Horton and Hunt
18. "Pakistan in the Twentieth Century: A Political History" by Lawrence Ziring
19. "Economic Development of Pakistan" by Ishrat Husain
20. "Issues in Pakistan's Economy" by S. Zaidi

Understanding of Quran/ Fahm e Quran-I

Course Title: Understanding of Holy Quran - I

Course Code: UHQ-101

Credit Hours: 1(0-1)

Contact Hours: 3 per week

Weeks: 15-16 (45-48 hours)

Pre-Requisites: Nil

Course Objectives:

This course will enable the students to understand the Holy Quran by learning Arabic in a simple and easy way. Through relating their basic Urdu vocabulary with Quran, and without engaging them in complex Arabic Grammar, Sarf or Balagha. Students will gradually build the skills to read and understand Quranic verses directly—without needing translation. The course focuses on making Arabic accessible for everyone, even those with no prior background.

Learning Outcomes:

This course will enable the students to:

1. Develop the ability to understand basic words of the Quran, phrases and sentences that do not contain verbs (unit 1 to 5 of Muallim ul Quran Book) and then sentences having present tense (first half of unit 6 of Muallim ul Quran Book).
2. Acquire a strong foundation for understanding long verses of the Quran with clarity.
3. Comprehend Quranic vocabulary, particles (operative and non operative particles), compounds (Adjective and Possessive compound), pronouns (singular and plural) and types of plurals through hundreds of Quranic sentences.
4. Recognize and understand different styles of Quranic sentences, including nominal sentence, emphatic sentence, double emphatic sentence, negative sentence, interrogative sentence, oath –based sentences.
5. Strengthen understanding of fundamental Quranic linguistic styles, expressions and idioms.
6. Understand at least 30 to 40 % of each page of the Holy Quran.

Course Outline:

Unit 1. Simple Quranic Words

Muallim ul Quran: Book 1: Unit: Lesson 1-19

Unit 2. Words that comes before (The simple Quranic words)

Muallim ul Quran: Book 1: Unit#2: Lesson 1-13

Unit 3. Quranic words in terms of their relationship and characteristics

Muallim ul Quran: Book 1: Unit#3: Lesson 1-10

Unit 4. Singular Pronouns

Muallim ul Quran: Book 2: Unit#4: Lesson 1-17

Unit 5. Singular pronouns and Demonstrative Pronouns

Muallim ul Quran: Book 2: Unit#5: Lesson 1-23

Unit 6. Present Tense

Muallim ul Quran: Book 3: Unit#6: Lesson 1-5

Reference Books:

1- بشير، دكتور. عبيد الرحمن - معلم القرآن - اسلام آباد: دار العلم، ٢٠٢٤. جلد ١، ٢ and ٣

Ethics (in lieu of Understanding of Quran)

Course Title: Ethics-I

Course Code: ETH-103

Credit hours: 1

Contact Hours: 3 per week

Weeks: 15-16 (45-48 hours)

Pre-Requisites: Nil

Objectives

Upon successful completion of the course, students will be able to know the basics of ethics, and know how to develop an ethical approach. Also, analyze the importance of ethical and ethical values for a human being. And identify the Semitic and Non-Semitic Religions. Moreover, develop the concept of Ethics in Semitic and Non-Semitic religions. Also, analyze the similarities and differences between ethical teachings of various religions.

Learning Outcomes:

- Students will be able to demonstrate their understanding about the concept of ethics and ethical approach.
- Analyze the difference between the concept of Ethics in Semitic and Non-Semitic religions.

Course Outline:

Unit 1. Introduction and Importance of Ethics and Basic Ethical Principles

Definition of Ethics, Importance of Ethics, Beneficence, Non-maleficence, Autonomy, Justice as basic ethical behaviors.

Unit 2. Theories of Moral Standards

Moral Standards as Law, Moral Standards as Pleasure, Moral standards as Perfection. (Theories of various philosophers such as Kant, Spencer, John S. Mackenzie etc)

Unit 3. The concept of Ethics in Major Religions- Christianity, Judaism

Introduction of the Religion, Its Basic Concepts and major ethical teachings.

Unit 4. The concept of Ethics in Major Religions- Hinduism and Buddhism

Introduction of the Religion, Its Basic Concepts and major ethical teachings.

Unit 5. The concept of Ethics in Major Religions- Islam

Introduction of the Religion, Its Basic Concepts and major ethical teachings.

References/Recommended Books:

1. Davis, N.K. (2023). *Elements of Ethics*, Legare Street Press.
2. Edmonds, D. (2019). *Ethics and the Contemporary World*, Taylor and Francis,
3. Hastings, J. Alexander, J. Gray S.L. (2023). *The Encyclopedia of Religion and Ethics*, Creative Media Partners, LLC
4. Robinson, D. Garratt C. (2008). *Introducing Ethics-a Graphic Guide*, Icon Books Ltd.Uk.
5. اخلاق اور فلسفہ اخلاق، سیوہاروی، حفظ الرحمن، ندوۃ المصنفین، دہلی، ۱۹۷۶
6. دنیا کے بڑے مذاہب، فاروقی، عماد الحسن، مکتبہ جامعہ لمیٹڈ، دہلی، ۱۹۸۶

Websites and Articles

1. Articles on Ethics www.infotrac-college.com
2. Brown. (2017). The ethical dimensions of Global Environmental Issues. American Academy of Arts and Sciences. Retrieved July 7 ,2017 from amacad.org
3. Business Ethics Magazine www.business-ethics.com/annual.htm
4. Bussmann, J. (2016). Top 9 ethical Issues in artificial intelligence. Retrieved 7 July2017 from world Economic Forum weforum.org
5. Ethics and Religion, Shefali Narange <http://www.paperpublications.org/>
6. <http://www.jstor.com/stable/resrep12025.7>
7. <http://www.learnwell.org/ethicalproblems.htm>
8. Institute for Global Ethics www.globalethics.org
9. Klimes, Rudolf e. (2000). Ethical Problems.
10. Ten Ethical Problems of the Present World <https://www.lifepersona.com/10-ethical-problems-of-the-present-world>
11. Ward, Stephen J.A (March 2005). “Philosophical Foundations for Global Journalism Ethics” *Journal of Mass Media Ethics*:20(1)

Understanding of Quran/ Fahm e Quran-II

Course Title: Understanding of Holy Quran - II

Course Code: UHQ-102

Credit Hours: 1 (0-1)

Contact Hours: 3 per week

Weeks: 15-16 (45-48 hours)

Pre-Requisites: Nil

Course Objectives:

This course will enable the students to understand the Holy Quran by learning Arabic in a simple and easy way. Through relating their basic Urdu vocabulary with Quran, and without engaging them in complex Arabic Grammar, Sarf or Balagha. Students will gradually build the skills to read and understand Quranic verses directly—without needing translation. The course focuses on making Arabic accessible for everyone, even those with no prior background.

Learning Outcomes:

This course will enable the students to:

1. Directly comprehend hundreds of Quranic sentences and verses.
2. Understand at least 80 to 85 % of each page of the holy Quran.
3. Understand common verses across different Quranic topics.
4. Achieve proficiency in the basic and advance linguistic aspects of the Arabic language.
5. Understand the difference between Quranic verbs in various forms, such as present, past and imperative.
6. Develop the ability to understand long verses of the holy Quran independently and then comprehend their interpretation.

Course Outline:

Unit 1. Past Tense

Muallim ul Quran: Book 4: Unit#7: Chapter 1: Lesson 1-9

Unit 2. Past Tense

Muallim ul Quran: Book 4: Unit#7: Chapter 2: Lesson 1-7

Unit 3. Past Tense

Muallim ul Quran: Book 4: Unit#7: Chapter 3: Lesson 1-9

Unit 4. Past Tense

Muallim ul Quran: Book 5: Unit#7: Chapter 4: Lesson 1-5

Unit 5. Past Tense and Passive Voice

Muallim ul Quran: Book 5: Unit#7: Chapter 5 - 9

Unit 6. imperative Verbs for Singulars

Muallim ul Quran: Book 6: Unit#8: Lesson 1-8

Reference Books:

1- بشير، دكتور. عبید الرحمن - معلم القرآن - اسلام آباد: دار العلم، ۲۰۲۴. جلد ۳، ۴، ۵، ۶

Ethics (in lieu of Understanding of Quran)

Course Title: Ethics-II

Course Code: ETH-104

Credit hours: 1

Contact Hours: 3 per week

Weeks: 15-16 (45-48 hours)

Pre-Requisites: Nil

Objectives

Upon successful completion of the course, students will be able to have better understanding of ethics in various walks of life like in workplace, in business, journalism etc. Moreover, they will be able to be familiarize with Contemporary World's Ethical Issues. And, try to develop answers about them.

Learning Outcomes:

- Students will be able to demonstrate their understanding about the importance of ethics in their lives today.
- Identify Contemporary World's Ethical Issues.
- Create problem solving for these contemporary Ethical issues.

Course Outline:

Unit 1. Professional Ethics and Bioethics

Meaning of Work/Professional Ethics, Professional Ethics and Human Values, Elements of professional Ethics: Person attitude, Beliefs about work, Positive Attributes (honesty, integrity, dedication, commitment, responsibility, interpersonal relationship), Genetic engineering, Organ Donation, Cloning, Head Transplant

Unit 2. Ethical Conduct in Business Ethics and it's important

Types of Business Ethics, Common Business Ethical Challenge, Conflict of interest, honesty and integrity, whistle blowing, loyalty vs truth

Unit 3. Journalism

Principles of Ethical Journalism: Truth and Accuracy, Independence, Fairness and Impartiality, Humanity, Public Accountability

Unit 4. Environmental Ethics

Core Principles of environmental ethics: Justice and sustainability, Sufficiency and compassion, Solidarity and public participation, Pollution prevention, Current

issues of environmental ethics: Pollution, The depletion of natural resources, Loss of biodiversity, Destruction of ecosystem, Global climate change

Unit 5. Social Inequalities

Meaning of Social Inequalities, Issues related to social inequality, Difference in source of income, Health care, Freedom of speech, Gender inequality, Toxic workplace culture, Education, Political representation and participation

Unit 6. Social Media Ethics

Facebook, YouTube, WhatsApp, Instagram, TikTok, Snapchat, LinkedIn, X Current Ethical issues in social media: Plagiarism, Fake news, Harassment, Photo ethics, Post without caution, inappropriate behavior privacy

References/Recommended Books:

Books

- 1.Davis, N.K. (2023). *Elements of Ethics*, Legare Street Press.
- 2.Edmonds,D. (2019). *Ethics and the Contemporary World*, Taylor and Francis,
- 3.Hastings, J. Alexander, J. Gray S.L. (2023). *The Encyclopedia of Religion and Ethics*, Creative Media Partners, LLC
- 4.Robinson, D.Garratt C. (2008). *Introducing Ethics-a Graphic Guide*, Icon Books Ltd.Uk.

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دنیا کے بڑے مذاہب، فاروقی، عماد الحسن، مکتبہ جامعہ لمیٹڈ، دہلی، ۱۹۸۶

Websites and Articles

1. Articles on Ethics www.infotrac-college.com
2. Brown. (2017). The ethical dimensions of Global Environmental Issues. American Academy of Arts and Sciences. Retrieved July 7 ,2017 from amacad.org
3. Business Ethics Magazine www.business-ethics.com/annual.htm
4. Bussmann, J. (2016). Top 9 ethical Issues in artificial intelligence. Retrieved 7 July2017 from world Economic Forum weforum.org
5. Ethics and Religion, Shefali Narange <http://www.paperpublications.org/>
6. <http://www.jstor.com/stable/resrep12025.7>
7. <http://www.learnwell.org/ethicalproblems.htm>
8. Institute for Global Ethics www.globalethics.org
9. Klimes, Rudolf e. (2000). Ethical Problems.
10. Ten Ethical Problems of the Present World <https://www.lifepersona.com/10-ethical-problems-of-the-present-world>
11. Ward, Stephen J.A (March 2005). “Philosophical Foundations for Global Journalism Ethics” *Journal of Mass Media Ethics*:20(1)

Pool of Arts and Humanities

Course Code	Course	Credit Hours	Category	Pre-requisite
BFA-119	History of Ancient civilizations	2	General Education	NIL
BFA-129	Art and Humanities	2	General Education	NIL
BFA-120	Photography	2	General Education	NIL
BFA-118	Digital Art	2	General Education	NIL

History of Ancient Civilizations

Course Code: BFA-119

Credit Hours: 2

Pre-requisite: Nil

Objectives:

Students will compare and analyse how the accomplishments made by ancient civilizations during their transition still affect our world today. They will also develop understanding about how geography played a role in the development of early civilizations.

Learning Outcomes:

- Through understanding, students will be equipped to respect the diversity of contemporary society.
- Upon learning that the environment was a deciding element in the emergence of ancient complex societies, students will be able to realize and uphold a sense of communal, environmental responsibility.

Course Outline:

Unit-1. Man, Aesthetic Culture and Civilization

History, Art, Evolution of man: from prehistoric to civilized stance: definition of history, evolution, and civilization. Aesthetic culture of man that differentiates him from all other living beings (Story of ornamentation and anthropology of art). Primitive and Prehistoric culture: Upper, Middle, and Lower eras. 1st civilized stance on the earthen globe (Indus Valley Civilization).

Unit-2. Civilizations (An Overview)

Mesopotamian and Egyptian (An overview of their art and architecture, defining general characteristics and important artifacts). Assignment: Egyptian themed pot painting.

Unit-3. Advanced Civilizations

Greek (Innovations in architecture, sculpture, and painting). Assignment: Geometric designs in 3D forms.

Unit-4. Advanced Civilizations Continued

Roman (Innovations in architecture, sculpture, and painting). Assignment: Mosaic work.

Unit-5. Sub-Continent

Buddhist Art (sculpture and painting; Sanchi, Bharut, Gandhara, and Ajanta. People and their cultural values. Assignment: Study of Signs and Symbols in Buddhist Art.

Recommended Books/Reference Material

1. Blattner. (2012). *World Civilizations and Cultures*, Mark Twain Media,
2. Brown. (2023). *Indian Architecture*. Palmer Press, United States.
3. Edwards. (2023). *Ancient Civilizations of History - Trivia Adventures*. United States.
4. Kleiner, S. (2016). *Gardner's Art Through the Ages, 15th Edition*. Thomson Wadsworth, United States.

Photography

Course Code: BFA-120

Credit Hours: 02

Pre-requisite: Nil

Objectives

This course will help students to understand camera functionality and technical settings for creative control. Master the principles of light and its role in photography. Develop compositional skills to create visually compelling images. Learn basic post-processing techniques to enhance photographs. Build a foundation for continued growth in photography.

Learning Outcomes

- Students will understand the basics of light and how their eyes perceive light effects.
- Students will capture what they envision through technical camera control.
- Students will master essential camera features and functions.
- Students will produce a beginning portfolio demonstrating technical and creative skills.
- Students will develop basic editing skills to enhance their photographs.

Course Outline

Unit 1. Know Your Camera (6 hours)

Camera Types and Basic Functions. DSLR vs Mirrorless vs Smartphone. Understanding your specific camera model. Essential accessories and equipment. **Exposure Triangle.** Aperture: controlling depth of field (hands-on exercises). Shutter Speed: freezing vs blurring motion (hands-on exercises). ISO: managing sensitivity and noise (hands-on exercises). Exposure compensation and metering modes. **Focus and White Balance.** Auto vs. manual focus techniques. Focus modes and focusing points. Understanding white balance and color temperature. Common camera issues and troubleshooting.

Unit 2. Composition (6 hours)

Core Compositional Principles. Rule of thirds and grid systems. Leading lines and visual flow. Framing and perspective. Symmetry vs. Asymmetry. **Subject and Background.** Depth of field for landscape photography. Filling the frame effectively. Subject isolation techniques. Background considerations and management. **Advanced Composition.** Breaking the rules purposefully. Using negative space. Creating visual balance. Composition exercises across different genres.

Unit 3. Directions Of Light (4 hours)

Fundamental Light Directions. Front lighting: characteristics and applications (studio exercises). Side lighting: creating dimension (studio exercises). Top and bottom lighting: mood and drama (studio exercises). Back lighting: silhouettes and rim lighting (studio exercises). **Creative Applications.** Bulb photography and long exposures. Mixed lighting direction techniques. Problem-solving challenging lighting directions. **Digital Workflow Basics.** File formats and management. Organizing and backing up images. Software options (free and paid).

Unit 4. The Quality Of Light (4 hours)

Artificial Light Sources. Tungsten lighting characteristics and challenges. Fluorescent lighting techniques. Flash and strobe basics. LED and continuous lighting options. **Natural Light Qualities.** Hard vs. soft light. Diffused light techniques. Reflected light applications. Light modifiers for natural light. Introduce AI image generators (Midjourney, DALL-E) as conceptual tools for photography planning. Assign projects that combine AI-generated concepts with original photography. **Essential Adjustments.** Exposure, contrast, and brightness. Color correction and white balance. Cropping and straightening. Basic retouching techniques.

Unit 5. Creative Applications of Light (4 hours)

Outdoor Lighting Scenario. Golden hour photography (morning/evening light). Handling harsh midday sun. Overcast and cloudy day techniques. Night and low-light photography basics. **Genre-Specific Lighting.** Portrait lighting fundamentals. Landscape lighting considerations. Street photography lighting challenges. Action and movement photography. **Creative Editing.** Black and white conversions. Vignettes and borders. Export settings for different uses. Before and after analysis.

Recommended Books/Reference Material

1. Parashar, L. G. Exploring The World Through The Lens: A Journey Into Photography. *Worldwide International Inter Disciplinary Research*, 10.
2. Ross, E. S. (2023). *Insects Close Up: A Pictorial Guide for the Photographer and Collector Featuring 125 Photographs and Drawings*. Univ of California Press.
3. Safori, A., and Ananbey, A. (2023). The Photo Manipulation from the Perspective of Photographers: Study from Jordan. *Mutah Journal of Humanities and Social Sciences (MJHSS)*, 38(2).
4. Shaw, M. (2023). *The Beginner's Guide to Astrophotography: How to Capture the Cosmos with Any Camera*. Bruce Birnbaum.
5. Stillman, W. (2023). *The Amateur's Photographic Guide Book*. BoD–Books on Demand.

Art and Humanities

Course Code: BFA-129

Credit Hours: 2

Pre-requisite: Nil

Objectives

Students will develop critical understanding and analysis of art through varied perspectives. They will enhance their knowledge to make informed aesthetic judgments and differentiate between genuine pieces of art and imitations. The course aims to cultivate sensitive perception paired with analytical reasoning about artistic elements.

Learning Outcomes

- Students will develop a systematic understanding of art elements, progressing from basic components (dot, line, shape) to complex compositions enhanced by color.
- Students will acquire the ability to identify and analyze stylistic elements that contribute to artistic individuality.
- Students will demonstrate enhanced perceptual sensitivity paired with logical analysis of artistic components.
- Students will build confidence in making aesthetic judgments based on established critical frameworks.

Course Outline

Unit 1. Foundations of Art Criticism and Appreciation

Explore the distinctions and relationships between criticism, appreciation, and history in approaching artistic works. Examine various forms of artistic expression including visual arts, performing arts, and applied arts with special emphasis on visual arts. Study fundamental frameworks for engaging with art meaningfully and developing a personal critical voice. Students will use AI visual recognition tools to analyze compositional elements in masterworks across different periods, helping them identify critical patterns and approaches used by established art critics throughout history.

Unit 2. The Multi-dimensional Framework of Art Analysis

Investigate the comprehensive framework for art appreciation through six key dimensions: Subject (thematic content), Function (purpose), Medium (materials), Organization (compositional structure), Style (individual expression), and Judgment (critical evaluation). Examine how these dimensions interconnect to create meaningful artistic experiences. Explore varied sources of artistic subject matter including nature, mythology, religion, and history.

Unit 3. Artistic Medium and Technical Execution

Study the intimate relationship between artists and their chosen media, examining how material selection influences artistic expression and technical execution. Analyze how medium-specific techniques develop across artistic movements and how critical judgments must account for medium constraints and possibilities. Students will experiment with AI tools that simulate different artistic media, allowing them to understand technical challenges and expressive possibilities of various materials without requiring specialized studio equipment. They'll compare their AI-generated experimental works with historical examples to deepen their understanding of medium-specific artistry.

Unit 4. Compositional Organization and Visual Elements

Examine diverse organizational plans in visual composition including symmetrical, pyramidal, vertical, and radial arrangements. Analyze how artists create centers of interest and direct viewer attention through strategic organization of visual elements. Study the fundamental elements of visual arts (line, shape, color, texture, space) and principles of design (balance, rhythm, proportion, emphasis). Students will use AI composition analysis tools to create interactive maps of visual flow in masterworks, revealing hidden structural patterns. They'll then apply these insights to reorganize famous compositions through AI manipulation, exploring how organizational changes impact viewer experience and artistic meaning.

Unit 5. Cultural Contexts and Critical Judgment

Explore the complex relationships between art and broader cultural domains including beauty, religion, nature, history, and conceptual thought. Investigate how artistic styles develop within cultural contexts and reflect historical movements. Examine frameworks for critical judgment based on sincerity, scope, levels of meaning, truth, and magnitude. Students will engage with an AI-powered cultural simulation tool that contextualizes artworks within their original environments, demonstrating how cultural factors influenced artistic decisions. Working with this tool, students will develop critical essays that evaluate artworks through historically appropriate critical frameworks, enhanced by AI-generated visual comparisons that illustrate stylistic evolution across cultures and time periods.

Recommended Books/Reference Material

1. All latest editions of Art Appreciation books.
2. Arthur Danto. *After the End of Art: Contemporary Art and the Pale of History*. Princeton University Press, 2022
3. D. J. Sporre. *Perceiving the Arts: An Introduction to Humanities*. New Jersey: Prentice Hall, 2015
4. Stephen Davies. *Definitions of Art*. New York: Cornell University Press, 2018

5. Terry Barrett. *Criticizing Art: Understanding the Contemporary*. Mountain View: Mayfield Publishing, 2023

Digital Art

Course Code: BFA-118

Credit Hours: 02

Pre-requisite: Nil

Objectives

This comprehensive course introduces students to essential digital art and design tools, focusing on Adobe Photoshop, Adobe Illustrator and Canva. Students will develop foundational skills in both raster and vector-based design, preparing them to create professional artwork for print and digital platforms. The course emphasizes practical application of art and design principles and incorporates contemporary AI tools to enhance creativity.

Learning Outcomes

- Students will be able to demonstrate proficiency in using relevant softwares
- Apply digital art techniques for both print and interactive media
- Implement effective visual communication strategies through digital media
- Create cohesive brand identities and marketing materials
- Work effectively with both raster and vector graphics
- Solve technical and aesthetic challenges in digital art production
- Explore AI-assisted digital art creation methods

Course Outline

Unit 1. Digital Imaging Foundations

Introduction to Photoshop and Illustrator interfaces; Understanding raster vs. vector graphics; File types and formats for different media; Tool options and interface navigation; Basic selection and transformation techniques; Working with the pen tool for precision vector work; Creating and managing layers. "Style Exploration Lab" - Students will use AI image generation tools to explore various artistic styles, then recreate selected elements manually in Photoshop and Illustrator to understand the underlying techniques.

Unit 2. Digital Composition and Design

Advanced selection techniques; Working with layers and masks in Photoshop; Creating and manipulating vector shapes in Illustrator; Understanding color theory and color modes for digital and print; Typography fundamentals for digital media; Layout principles for effective visual communication. "Composition Assistant" - Students will generate AI-based compositions as inspiration, then analyze the

compositional principles at work and create their own refined versions with proper design principles.

Unit 3. Visual Graphics and Branding

Logo design principles and techniques; Creating vector graphics for brand identity; Digital illustration techniques; Building a cohesive visual identity; Preparing files for different media platforms; Managing design assets across applications. "Brand Persona Generator" - Using AI tools to develop brand personality concepts that students will then translate into visual branding elements using Illustrator.

Unit 4. Digital Media Applications

Designing for print versus digital platforms; Creating effective advertisements; Introduction to digital marketing concepts; Social media graphics and assets; Preparing and exporting files for various media; Building a basic portfolio of digital work. "Marketing Mockup Maker" - Students will use AI tools to generate marketing concepts, then develop finished digital media pieces based on the most promising ideas.

Recommended Books/Reference Material

1. Bakhromovna, K. Z. (2023). Innovative Process of Computer Graphics. *EUROPEAN JOURNAL OF INNOVATION IN NONFORMAL EDUCATION*, 3(4), 45-49.
2. Cetinic, E., and She, J. (2022). Understanding and creating art with AI: Review and outlook. *ACM Transactions on Multimedia Computing, Communications, and Applications (TOMM)*, 18(2), 1-22.
3. Chaffey, D., and Smith, P. R. (2022). *Digital marketing excellence: planning, optimizing and integrating online marketing*. Taylor and Francis.
4. Kelby, S. (2023). *How Do I Do That In Photoshop?*. Rocky Nook, Inc.
5. Pattinson. (2018). *A Beginners Guide for Adobe Photoshop, Adobe Illustrator, Adobe In-Design Basics*. Amazon Digital Services.
6. Paul, C. (2023). *Digital art*. Thames and Hudson.

14. List of Interdisciplinary/Allied Courses

Course code	Course	Credits	Category	Pre-requisite
ZOO-101	Biodiversity and Conservation	3	Interdisciplinary	NIL
ZOO-102	Fundamentals of Genetics and Evolution	2	Interdisciplinary	NIL
ZOO-102L	Fundamentals of Genetics and Evolution (Lab)	1	Interdisciplinary	NIL
ZOO 421	Molecular Genetics	2	Interdisciplinary	NIL
ZOO 421L	Molecular Genetics (Lab)	1	Interdisciplinary	NIL
STA-120	Biostatistics	2	Interdisciplinary	NIL
STA- 120L	Biostatistics (Lab)	1	Interdisciplinary	NIL
MGT-109	Sustainable Development Goals	3	Interdisciplinary	NIL
BOT-322	Artificial Intelligence in Botany	3	Interdisciplinary	NIL
RM-404	Scientific Inquiry and Research Methods	2	Interdisciplinary	NIL
RM-404L	Scientific Inquiry and Research Methods (Lab)	1	Interdisciplinary	NIL

15. Course Outlines for Interdisciplinary/Allied Courses

Biodiversity and Conservation

Course Code: ZOO-101

Credit Hours: 3

Pre-requisite: Nil

Objectives:

To provide the students with an adequate knowledge of biodiversity, causes and threats to biodiversity decline. To familiarize the student's international standards and criteria for species conservation status and protected areas.

Learning Outcomes:

By the end of this course, students will be able to understand the basic techniques to assess the factors that influence biodiversity

- Students will learn strategies for conservation of biodiversity
- Students will get knowledge about red list categories and species conservation status
- Students will be familiar regarding importance of conservation policies and actions in Protected Areas

Course Outline:

Unit-1. Biodiversity: Introduction, Levels and Significance

Introduction and importance of biodiversity. Ecological, economic, ethical and scientific role of Biodiversity. Sustainable and unsustainable use of biological resources. Levels of Biodiversity. α , β and γ diversity, systematic and functional diversity. Services offered by biodiversity to society. Biodiversity of Pakistan: Phytogeographic regions. Endemic Species of Pakistan

Unit-2. Causes and Threats to Biodiversity

Anthropogenic and natural causes of biodiversity loss. Habitat loss and fragmentation, ecosystem degradation: deforestation, over grazing, erosion and desertification. Pollution and global climate changes, invasive species, over exploitation of species. Biodiversity hot spots of Pakistan and the world.

Unit-3. Measurement of Biodiversity and Conservation Strategies

Measurements of Biodiversity: Conventional and advanced Techniques. Biodiversity indices to measure species richness and evenness. Shannon index, Simpson index. Conservation strategies: major techniques of *In situ* conservation. Conservation vs preservation. Major techniques of *Ex situ* conservation

Unit-4. Global Efforts for Biodiversity Conservation (IUCN Red List and Protected Areas)

Global strategy for biodiversity conservation. IUCN: Organizational structure. Red list: categories and transfer. IUCN categories of protected areas. Key Biodiversity Areas (KBA). Biodiversity action plan of Pakistan

Recommended Books/Reference Material

1. Bawa, K., Primack, S., Oommen, R.B. and Anna, M. (2020). *Conservation Biology: A Primer for South Asia*. Orient Black Swan
2. Dyke, F.V. (2021). *Conservation Biology: Foundations, Concepts, Applications*. Springer.
3. Lekevicius, E. (2022). *Biodiversity: Maintenance, Function Origin and Self Organization to Life Support Ecosystems*. Springer
4. Primack, R.B. and Sinauer, P.R.B. (2020). *Essentials of Conservation Biology*. Associates Inc. Publishers USA.

Fundamentals of Genetics and Evolution

Course Code: ZOO-102

Credit Hours: 2

Objectives:

To develop understanding of the principles of genetics and evolution among students.

To develop the ability to analyze genetic data, understand patterns of inheritance and variation, and explain genetic mechanisms which contribute to the diversity and evolution of life through integrated theoretical and practical approaches.

Learning Outcomes:

Students will be able to:

- Explain the principles of genetic variation and Mendelian inheritance.
- Use basic genetic techniques to study plant traits.
- Construct genetic maps from linkage and crossing over data.
- Understand the evolutionary processes in plants.

Course Outline:

Unit-1. Introduction to Genetics and Evolution

Definition, scope and importance of plant genetics and evolution. Mendelian genetics and evolutionary theory. Evidence for Evolution (Fossil Record, Comparative Anatomy, Embryology, Molecular Biology).

Unit-2. Mendelian, Chromosomal and Molecular Genetics

Mendel's Laws of Inheritance (Segregation, Independent Assortment). Monohybrid and Dihybrid Crosses. Punnett squares and probability. Incomplete Dominance, Codominance. Multiple alleles and polygenic inheritance. Epistasis and pleiotropy. Sex-linked Inheritance. Chromosomal Genetics (Chromosome Structure and Function. Mitosis and Meiosis. Chromosomal Variation and Mutations. Karyotyping and chromosomal abnormalities. Linkage, recombination, and gene mapping). Molecular Genetics: (DNA Structure and Replication. Gene Expression (Transcription and Translation). Genetic Code. Regulation of Gene Expression. Mutations).

Unit-3. Population Genetics and Evolutionary Biology

Hardy-Weinberg Equilibrium. Inbreeding. Natural selection and adaptation. Evolutionary mechanisms: mutation, gene flow, genetic drift. Factors Affecting Allele Frequencies (Mutation, Gene Flow, Genetic Drift, Selection).

Unit-4. Speciation, Macroevolution and Evolutionary development

Definition of Species. Modes of Speciation (Allopatric, Sympatric). Speciation and reproductive isolation. Macroevolution: Patterns of Macroevolution. Adaptive Radiation. Extinction. Evolutionary Development (Evo-Devo). Molecular Evolution: Molecular Basis of Variation. Phylogenetics and the Tree of Life.

Unit-5. Human Genetics and Evolution

Primate Evolution. Hominin Evolution. Origin of Modern Humans. Human genome and inherited traits. Genetic disorders and counseling. Evolution of Homo sapiens and genetic diversity

Recommended Books/Reference Material

1. Bujakowska, K. M., and Dryja, T. P. (2021). Fundamentals of Genetics. In *Albert and Jakobiec's Principles and Practice of Ophthalmology* (pp. 1-32). Cham: Springer International Publishing.
2. Meneely, P. M., Hoang, R. D., Okeke, I. N., and Heston, K. (2017). *Genetics: genes, genomes, and evolution*. Oxford University Press.
3. Snustad, D. P., and Simmons, M. J. (2015). *Principles of genetics*. John Wiley and Sons.
4. Verma, P. S., and Agarwal, V. K. (2004). *Cell Biology, Genetics, Molecular Biology, Evolution and Ecology: Evolution and Ecology*. S. Chand Publishing.
5. Waddington, C. H. (2016). *An introduction to modern genetics*. Routledge.

Fundamentals of Genetics and Evolution (Lab)

Course Code: ZOO-102L

Credit Hours: 1

Pre-requisite: Nil

Objectives

To provide students with practical understanding of genetic principles, inheritance patterns, and evolutionary processes through laboratory-based experiments and problem-solving approaches.

Learning Outcomes

- Students will be able to understand patterns of inheritance and genetic variation.
- Use basic genetic tools and methods to analyze biological data.
- Apply statistical methods for interpretation of genetic ratios.
- Construct and interpret pedigrees and linkage maps.
- Understand population genetics and evolutionary mechanisms through simulations.

Lab outlines

1. Introduction to basic genetic laboratory techniques and safety guidelines
2. Monohybrid and dihybrid crosses using Punnett squares
3. Chi-square test for analysis of genetic data
4. Study and construction of pedigrees for inheritance patterns
5. Identification of dominant, recessive, and sex-linked traits
6. Incomplete dominance, codominance, and multiple alleles (ABO blood groups)
7. Observation of mitosis and meiosis using prepared slides
8. Linkage and crossing over (simulation or *Drosophila*-based models)
9. Construction of genetic linkage maps and three-point crosses
10. Hardy-Weinberg equilibrium calculations and simulations
11. Genetic drift, gene flow, and natural selection models
12. Phylogenetic tree construction using morphological or molecular data

Recommended Books/Reference Material

1. Meneely, P. M., Hoang, R. D., Okeke, I. N., & Heston, K. (2017). *Genetics: Genes, Genomes, and Evolution*. Oxford University Press.
2. Snustad, D. P., & Simmons, M. J. (2015). *Principles of Genetics*. John Wiley & Sons.
3. Verma, P. S., & Agarwal, V. K. (2004). *Cell Biology, Genetics, Molecular Biology, Evolution and Ecology*. S. Chand Publishing.
4. Waddington, C. H. (2016). *An Introduction to Modern Genetics*. Routledge.
5. Bujakowska, K. M., & Dryja, T. P. (2021). *Fundamentals of Genetics*. Springer.

Molecular Genetics

BS-Botany

Course Code: ZOO-421

Credit Hours: 02

Pre-requisite: N.A

Objectives

To provide students with a comprehensive understanding of the molecular basis of genetic processes and to equip them with laboratory skills essential for studying molecular genetics in plants and other organisms.

Learning Outcomes:

By the end of this course, students will be able to:

- Explain structure of different forms of DNA and RNA.
- Describe gene structure and organization of genomes.
- Understand gene expression and its regulation at various levels.
- Apply molecular techniques to investigate genetic variation and gene function in plants.

Course Outline

Unit 1. Nucleic Acids - Structure and Replication

Molecular structure and chemical composition of DNA and RNA. DNA replication mechanisms in prokaryotes and eukaryotes. DNA damage and repair pathways.

Unit 2. Gene Expression - Transcription and Translation

Transcription process: Initiation, elongation, termination. RNA processing: Capping, polyadenylation, splicing. Translation and the role of ribosomes and tRNAs.

Unit 3. Regulation of Gene Expression

Gene regulation in prokaryotes: lac and trp operons. Gene regulation in eukaryotes: transcription factors, enhancers, silencers. Epigenetic modifications: DNA methylation and histone modifications.

Unit 4. Molecular Techniques and Applications

PCR: Principle and applications. Agarose gel electrophoresis for DNA analysis. Basic principles of recombinant DNA technology.

Unit 5. Advances in Molecular Genetics

CRISPR-Cas9 genome editing. Next-generation sequencing (NGS) technologies. Applications of molecular genetics in biotechnology, agriculture, and medicine.

Recommended Books/Reference Material

1. Lewin, B. (2017). *Genes XII*. Jones & Bartlett Learning.
2. Lodish, H., Berk, A., Kaiser, C. A., Krieger, M., Bretscher, A., Ploegh, H., Amon, A., & Martin, K. C. (2021). *Molecular Cell Biology* (9th ed.). Macmillan Learning.
3. Snustad, D. P., & Simmons, M. J. (2015). *Principles of Genetics* (7th ed.). Wiley.
4. Stewart, C. N., Jr. (Ed.). (2025). *Plant Biotechnology and Genetics: Principles, Techniques, and Applications* (2nd ed.). John Wiley & Sons.
5. Watson, J. D., Baker, T. A., Bell, S. P., Gann, A., Levine, M., & Losick, R. (2017). *Molecular Biology of the gene* (7th ed.). Pearson.

Molecular Genetics (Lab)

BS-Botany

Course Code: ZOO-421L

Credit Hours: 01

Pre-requisite: N.A

Objectives

To develop practical laboratory skills in molecular genetics, enabling students to perform basic molecular techniques and analyze genetic data relevant to plant systems.

Learning Outcomes

- Demonstrate laboratory safety and aseptic techniques.
- Extract and analyze DNA and RNA from plant tissues.
- Perform PCR and electrophoresis techniques.
- Apply bioinformatics tools for sequence analysis and comparison.
- Interpret molecular data to understand genetic relationships.

Lab Outline:

1. Laboratory safety protocols and aseptic techniques
2. Introduction to molecular biology equipment
3. Extraction of genomic DNA from plant tissues
4. RNA extraction and purification methods
5. Quantification using spectrophotometry/Nanodrop
6. Polymerase Chain Reaction (PCR): principles and protocols
7. PCR optimization and troubleshooting
8. Agarose gel preparation and electrophoresis
9. Plasmid extraction (mini-prep techniques)
10. DNA ligation and bacterial transformation concepts
11. Screening of transformed colonies
12. Introduction to biological databases (NCBI, EMBL)
13. Primer designing and sequence alignment
14. Phylogenetic analysis and tree construction
15. Comparative analysis of plant DNA sequences (e.g., chloroplast genes)

Recommended Books/Reference Material

1. Brown, T. A. (2016). Gene Cloning and DNA Analysis: An Introduction (7th ed.). Wiley.
2. Green, M. R., & Sambrook, J. (2019). Molecular Cloning: A Laboratory Manual (4th ed.). Cold Spring Harbor Laboratory Press.
3. Primrose, S. B., & Twyman, R. M. (2013). Principles of Gene Manipulation and Genomics (7th ed.). Wiley-Blackwell.

Biostatistics

Course Code: STA-120

Credit Hours: 2

Pre-requisite: Nil

Objectives:

The main purpose of the course is to enable students to understand the significance of statistics in the real world, particularly in the field of biological sciences. The course focuses on the methods of collection presentation and analysis of data using measures of central tendency and measures of dispersion. The course focuses on the basic concepts of probability and probability distributions. Furthermore, the students will learn the methods of hypothesis testing for various parameters to draw inferences about them.

Learning Outcomes:

- Students will understand the concept of modern statistical theory and their probabilistic foundation.
- Students will gain understanding about basic probability concepts and probability distributions as an aid to business decision making.
- Students will be capable to apply regression and correlation analysis on data and interpret its results.
- Students should be able to design and analyze an experiment for a real-life problem.

Course Outline:

Unit-1. Frequency Distribution

Introduction and importance of biostatistics, limitations, population and sample sizes. Variable types, formation of frequency table from raw data. Summation, notation and statistical inference, data transformation.

Unit-2. Measures of Central Tendency and Dispersion

Arithmetic mean, median, mode. Range, variance, standard deviation, mean deviation.

Unit-3. Probability Distributions

Introduction of Probability, types of probabilities. Random variables, sampling distribution. Binomial, Poisson and Normal distributions, their properties and applications.

Unit-4. Basic Experimental Design

Basic concept and principles of experiments. Observational studies, planning of experiments, replication and randomization. Basic One-way ANOVA: types of sum of squares, how ANOVA works, ANOVA table. Two-way ANOVA. Field plot

technique, layout and analysis of completely randomized design, randomized completely block design, latin square, factorial design, Linear combinations, multiple comparisons, treatment comparison.

Unit-5. Mean, Association, Correlation, Regression and Variance Testing

T-Test: Basic idea, Confidence limits of means, significant difference of means. Chi square test: Basic idea, testing goodness of fit to a ratio, testing association (Contingency table). F-Test: Introduction and application in analysis of variance. LSD test, Duncan's New Multiple Range test (for comparison of individual means), Bonferroni test. Correlation and Regression.

Recommended Books/Reference Material

1. Bacci, S., and Chiandotto, B. (2021). *Introduction to statistical decision theory*. Taylor and Francis Group.
2. Chaudhry S.M., and Kamal. S. (2018). *Introduction to statistical theory part I*. Lahore, Pakistan: Ilmi Kitab Khana.
3. Chaudhry S.M., and Kamal. S. (2018). *Introduction to statistical theory Part II*. Lahore, Pakistan: Ilmi Kitab Khana.
4. Dean, A., Morris, M., Stufken, J., and Bingham, D. (2020). *Handbook of design and analysis of experiments*. CRC Press.
5. Kuzma, J. W., and Bohnenblust, S. E. (2004). *Basis statistics for the health sciences*, (5th ed.). USA: McGraw Hill Education.
6. Rosner, B. (2010). *Fundamentals of biostatistics*, (7th ed.). John Wiley and Sons.
7. Triola, M. M., Triola, M. F., and Roy, J. (2017). *Biostatistics for biological and health sciences*, (2nd ed.). Landon: Pearson press.
8. Walpole, R. E. (2002). *Introduction to statistics*, (7th ed.). New York: Macmillan publishing company.
9. Weiss, N. A., and Hassett, M. J. (1999). *Introductory statistics*. Boston: Addison-Wesley.
10. Zar, J. H. (2009). *Biostatistical analysis*, (5th ed.). India: Pearson Education.

Biostatistics (Lab)

Course Code: STA-120L

Credit Hours: 01

Pre-requisite: Nil

Objectives

The main purpose of the course is to enable students to understand the significance of statistics in the real world, particularly in the field of biological sciences. Students will use statistical software such as **R** and **SPSS** to apply theoretical concepts to real biological datasets. This hands-on experience will help them in analyzing, interpreting, and drawing meaningful conclusions from data collected in various biological, medical, and health-related studies.

Learning Outcomes

- Students will understand biological concepts, categorize variables, and apply statistical tools using R/SPSS.
- Students will be capable to apply regression, correlation, and experimental design to solve biological problems using R/ SPSS.

Course Outline

Unit-1. Introduction

Introduction to biostatistics and types of variables using R/SPSS, including data entry and variable classification. Explore categorical data, population concepts, and perform basic sampling techniques within R/SPSS.

Unit-2. Biological variables and binomial

Explore the distributional behavior of biological variables and apply binomial, Poisson, and normal distributions using R/SPSS for real-life biological data modeling. Use built-in functions in R or SPSS procedures to simulate, visualize, and interpret probability distributions in biological contexts.

Unit-3. Use of various statistical tests

Perform Z-test, T-test, and F-test in R/SPSS to compare means and evaluate confidence limits and significance in biological data. Use Chi-square tests to assess goodness of fit and test associations using contingency tables for categorical biological variables.

Unit-4. Correlation and regression analysis

In R/SPSS, explore correlation and regression analysis to assess relationships between biological variables. Conduct hypothesis testing and compute confidence intervals for regression coefficients, including regression models for categorical response variables.

Unit-5. Use of ANOVA

In R/SPSS, learn the basic concepts and principles of experimental design, including observational studies, replication, and randomization. Conduct One-way and Two-way ANOVA, analyze sum of squares, interpret ANOVA tables, and apply experimental designs like completely randomized designs, randomized block designs, and Latin squares for multiple treatment comparisons.

Recommended Books/Reference Material

1. Amork, N.M. (2013). *IBM SPSS statistics 24 core system user's guide*. International Business Machine Corporation.
2. George, D., & Mallery, P. (2020). *IBM SPSS Statistics 23 Step by Step: A simple guide and reference*, (14th ed.). Routledge.
3. Gray, C.D., & Kinnear, P.R. (2012). *IBM SPSS statistics 19 made simple*. Psychology Press.
4. Denis, D.J. (2020). *Univariate, bivariate, and multivariate statistics using R: Quantitative tools for data analysis and data science*. John Wiley & Sons.
5. Xanthidis, D., Manolas, C., Xanthidou, O.K., & Wang, H.I. *Handbook of computer programming with Python*. (2022). CRC Press.
6. McNulty, K. (2021). *Handbook of regression modeling in people analytics: With examples in R and Python*. CRC Press.
7. Thulin, M. (2021). *Modern statistics with R: From wrangling and exploring data to inference and predictive modelling*. BoD-Books on Demand.

Sustainable Development Goals (SDGs)

MGT-109

Course Code:

Credit Hours: 3(3-0)

Pre-requisite: Nil

Objectives

This course is basically designed to enhance students understanding of the SDGs to create a better- informed citizenry, which will lead to a more sustainable action by all and for all. The course will cover the fundamental principles, explore the environmental, social, and economic dimensions, and delve into the Sustainable Development Goals (SDGs). The course will also examine practical applications, case studies, and potential solutions for achieving sustainable development.

Learning Outcomes

After studying this course, the student will be able to understand:

- The difference between sustainability, sustainable development, and the sustainable development goals, why and how they came to be, and their current applications;
- The role of the United Nations, the 2030 Agenda, and other international agreements (e.g., the Paris agreement and post-2020 Global Biodiversity Framework);
- An overview of the 17 SDGs and their targets, and why they matter;
- Pathways for solutions and how students can become active agents of change;
- How governments, businesses, and civil societies can also be active participants in the implementation of the SDGs;
- How countries make decisions on their selection of SDGs and targets they want to focus on and how they establish indicators of progress;
- How the SDGs are monitored, tracked, and reported;
- The role of thinking beyond sustainability to the transformations necessary to meet and exceed the 2030 Agenda.

Course Outline

Unit 1. Sustainability, sustainable development, and the sustainable development goals

History of sustainability, and what it means. The United Nations, sustainable development, and the path to the SDGs.

Unit 2. What are the SDGs?

SDGs overview, goals, and targets

Unit 3. Building a Better World-Global Goals for Sustainable Futures

Study the 17 Sustainable Development Goals (SDGs) as a blueprint for a fair, inclusive, and resilient world. How eradicating poverty and hunger, ensuring

health, education, equality, and access to essential services can uplift societies everywhere. Innovative solutions for sustainable cities, responsible production, and clean energy, alongside urgent climate action to protect life on land and below water. Global partnerships, peace, justice, and strong institutions as cornerstones for achieving these interconnected goals.

Unit 4. Implementing the SDGs

Solutions and best practices at the individual, local, national, and international level

Unit 5. Monitoring, Evaluation, Reporting

Measuring SDG success through indicators, monitoring, evaluation, and reporting

Unit 6. Beyond Sustainability to Radical Transformation

The course will close with an introduction to taking the SDGs to the next level – changing world-views and perspective through radical transformation and thinking beyond sustainability

Recommended Books/ Reference Material

There is no required textbook for this course. Readings from journal articles, book chapters, and internet sources will be assigned on a weekly basis. The course will also utilize materials from the United Nations (UN) Sustainable Development Solutions Network (SDSN), and the SDG Academy.

Artificial Intelligence in Botany

Course Code: BOT-322

Credit Hours: 3

Pre-requisite: Nil

Objectives:

To introduce the fundamentals of Artificial Intelligence (AI) and its relevance in botany and to explore AI applications in agriculture, plant breeding, and crop monitoring.

Learning Outcomes:

- By the end of this course, students will be able to:
- Understand the applications and ethical aspects of AI in plant Sciences.
- Describe how AI can be used for plant identification, ecological processes, and conservation.
- Explain how machine learning can be applied as predictive models.

Course Outline:

Unit-1. Introduction to AI

Introduction to AI and its relevance to Botany. Historical overview of AI-based work in Botany. Current developments in AI based research work in plant sciences. Emerging trends in AI-based techniques in Botany.

Unit-2. Machine Learning

Basics of Machine Learning in Botany, Understanding supervised and unsupervised Learning, Regression, Tree-based methods.

Unit-3. Neural network and Deep Learning

Basics of Neural Networks with a focus on plant image analysis and phenotype prediction, Introduction to Deep Learning.

Unit-4. Application of AI approaches in Botany

AI in Botanical Data Collection and Analysis, AI Applications in Plant Identification and Classification (PlantNet, iNaturalist), Image Processing for Plant Classification, Drone-based imaging and remote sensing, AI for yield prediction and soil health monitoring, AI in Ecosystem and Biodiversity Analysis - AI Tools for Ecosystem Monitoring and Management, Disease and pest prediction using AI models, AI in plant breeding and genetic selection. Genomic data analysis in botany using AI. AI Applications in Gene Sequencing and Analysis

Unit-5. Ethical considerations and future prospects

Potential ethical, social and legal issues of AI application in plants sciences and agriculture, Future prospects of AI in sustainable agriculture and biodiversity conservation.

Recommended Books/Reference Material

1. Chatterjee, I. (2021). Machine Learning and Its Application: A Quick Guide for Beginners. (n.p.): Bentham Science Publishers.
2. Kelleher, J. D., Mac Namee, B., D'Arcy, A. (2020). Fundamentals of Machine Learning for Predictive Data Analytics, Second Edition: Algorithms, Worked Examples, and Case Studies. United Kingdom: MIT Press.
3. Russell, S. J., Norvig, P., Davis, E. (2009). Artificial Intelligence: A Modern Approach. United Kingdom: Prentice Hall.
4. Techniques: A Systematic Literature Review. Arch Computat Methods Eng 25, 507– 543 <https://doi.org/10.1007/s11831-016-9206-z>
5. Tensor, O. (2020). Machine Learning for Beginners: The Beginner's Guide to Understand Artificial Intelligence, Business Applications, and Machine Learning for Business: Includes Deep Learning and Data Science for Business. (n.p.): Francesca Bandu.
6. Wäldchen, J., Mäder, P. 2018. Plant Species Identification Using Computer Vision
7. Zhang, A., Lipton, Z. C., Li, M., Smola, A. J. (2023). Dive Into Deep Learning. India: Cambridge University Press.

Scientific Inquiry and Research Methods

Course Code: RM-404

Credit Hours: 2

Pre-requisite: Nil

Objectives:

To introduce the students to the principles of scientific thinking, inquiry-based learning, and systematic research methods. To develop critical skills in formulating research questions, designing studies, analyzing data, and report findings ethically and effectively.

Learning Outcomes:

- By the end of this course, students will be able to understand the principles of scientific research
- Students will learn how to use research techniques to conduct botanical experiments
- Students will get awareness on ethical considerations for research scientific writing

Course Outline:

Unit-1. Introduction to Scientific Inquiry

Science: Nature and scope. Scientific thinking. The Scientific Method: Types of Scientific Research: Basic research, applied research, exploratory research, descriptive research

Unit-2. Research: Problem, Design and Data Collection

Identifying and Defining Research Problems. Reviewing the Literature. Formulating Hypotheses and Research Questions. Experimental Design. Principles and types of designs. Experimental vs. Non-experimental Research. Sampling Methods: Probability and Non-Probability Sampling. Validity and Reliability in Research. Qualitative/Quantitative Data.

Unit-3. Communicating Research

Structuring a research report or Thesis. Writing an Abstract, Introduction, Methods Results Discussion and Conclusions. Referencing and Citation Styles (APA). Presenting Research: Posters, Oral Presentations, Conferences

Unit-4. Ethical Challenges and Considerations

Ethical issues in data collection (Informed Consent, Anonymity, Confidentiality). Research misconduct. Data fabrication. Plagiarism and Academic Integrity.

Recommended Books/Reference Material

1. Crang, R., Lyons-Sobaski, S., and Wise, R. (2018). *Plant Anatomy: A Concept-Based Approach* (2nd ed.). Cham, Switzerland: Springer International Publishing. ISBN: 978-3319773155.
2. Creswell, J. W., and Creswell, J. D. (2018). *Research design: Qualitative, quantitative, and mixed methods approaches* (5th ed.). Los Angeles, CA: SAGE Publications. ISBN: 978-1506386706.
3. Field, A. (2017). *Discovering statistics using IBM SPSS statistics* (5th ed.). London: SAGE Publications. ISBN: 978-1526419529
4. Neuman, W. L. (2017). *Understanding research* (2nd ed.). Boston, MA: Pearson Education. ISBN: 978-0134041032.
5. Patten,, M. L., and Newhart, M. (2017). *Understanding research methods: An overview of the essentials* (10th ed.). New York, NY: Routledge. ISBN: 978-0415790529.

Scientific Inquiry and Research Methods (Lab)

Course Code: RM-404L

Credit Hours: 1

Pre-requisite: Nil

Objectives:

To develop practical skills in applying the scientific method, conducting basic research, analyzing data, and presenting findings in a structured and ethical manner.

Learning Outcomes

By the end of this lab, students will be able to:

- Apply the scientific method to investigate simple biological problems
- Conduct literature surveys and identify relevant scientific information
- Collect, analyze, and interpret experimental data
- Present scientific findings in the form of reports and presentations

Lab Outline:

1. Observation of a simple phenomenon and identification of a research problem
2. Application of the scientific method to formulate hypotheses
3. Designing a basic experiment based on the identified problem
4. Conducting a literature survey on an assigned topic
5. Collection of experimental or observational data
6. Analysis and interpretation of collected data
7. Presentation of results in appropriate formats (tables, graphs, charts)
8. Writing a structured scientific report
9. Submission of the final lab report

Recommended Books/Reference Material

1. Dawson, C. (2019). Introduction to Research Methods (5th ed.). How To Books.
2. Kumar, R. (2019). Research Methodology: A Step-by-Step Guide for Beginners (5th ed.). SAGE Publications.
3. Creswell, J. W. (2014). Research Design: Qualitative, Quantitative, and Mixed Methods Approaches (4th ed.). SAGE Publications.
4. Booth, W. C., Colomb, G. G., and Williams, J. M. (2016). The Craft of Research (4th ed.). University of Chicago Press.
5. Day, R. A., and Gastel, B. (2016). How to Write and Publish a Scientific Paper (8th ed.). Cambridge University Press.