SHAHEED BENAZIR BHUTTO WOMEN UNIVERSITY PESHAWAR

Revised as per HEC New UEP 2023

SHAHEED BENAZIR BHUTTO WOMEN UNIVERSITY PESHAWARE

DEPARTMENT OF BOTANY

CURRICULUM BS (4YEARS) PROGRAM

SESSION 2023 AND ONWARDS

Submitted by:
Department of Botany
0919224737

SHAHEED BENAZIR BHUTTO WOMEN UNIVERSITY PESHAWAR

Revised as per HEC New UEP 2023

Department Curriculum Committee

1. _____
Dr. Faiza Tawab
Assistant Professor/Incharge

2._____
Dr. Naila Inayat
Assistant Professor

3._____
Dr. Ambrin
Assistant Professor

Curriculum Revamp Committee

_____
Dr. Farhat Amin. Associate Professor
Department of Bioinformatics, SBBWU
(Convener)

_____
Ms.Sadia Nazeer (Member)
Assistant Professor
Department of English. SBBWU

_____
Dr. Soofia Iftikhar (Member)
Assistant Professor
Department of Statistics, SBBWU

_____
Dr. Samra Kiran (Member)
Assistant Professor
Department of Management Science, SBBWU
SBBWU

_____
Dr. Rehana Masood (Member)
Assistant Professor
Department of Biochemistry,

_____
Ms.Mehwish Asmat Ullah (Member)
Deputy Director.
Quality Enhancement Cell, SBBWU

_____
Ms.Tashfeen Zia (Member)
Deputy Director.
Affiliation and Monitoring, SBBWU

_____
Dr.Rubi Bilal (Secretary)
Controller of Examinations, SBBWU

_____
Dr. Safia Ahmed (T.I)
Dean Faculty of Sciences & Social Science, SBBWU

INTRODUCTION

Botany as a subject is multidisciplinary in nature, involving study of plants and their genetic, morphological and physiological attributes, their surrounding environment, and their role in conservation of environment. Botany is a combination of various disciplines such as Genetics, Physiology, Ecology, Embryology, Microbiology, Evolution, Systematics, Plant pathology, Vascular plants etc. This subject has significant role in human resource development, food security, environmental conservation, sustainable development and ultimately in alleviation of poverty.

Eligibility Criteria

Eligibility Criteria for BS:

F.Sc. Pre medical/ A level (with Biology and Chemistry)

VISION STATEMENT OF DEPARTMENT

The department intend to be among the leading departments of Botany country wide and to be a cradle of quality, up-to-date source of education and research which has relevance to local, regional and national needs. The department looks forward to launch post graduate, M.Phil. /Ph.D. programs in future as well.

MISSION STATEMENT OF DEPARTMENT

The mission of the department of Botany is to;

- Utilize the knowledge and expertise in order to train students in plant science.
- Equip them with professional skills and ethical practices relevant to plant sciences.
- Create an attractive and research based innovative department where students want to come for study and contribute their role in the welfare of humanity by finding ways to increase the food production and to preserve rare species by improving their habitat.
- Find different plant diseases and their solution.

PROGRAM OBJECTIVES

The program objectives are;

- To impart knowledge about the major disciplines of Botany. It will enable the students to understand the principles of organizations and inter-relationships in the biological systems with particular reference to plant diversity.

- To train students for advanced studies and specialization on recently emerging technological and multidisciplinary fields such as Genetic Engineering and Biodiversity. After completing the degree the students will be able to apply their knowledge to their respective fields effectively.

- To teach different methods of exploration, investigation and organization of data and its utilization in practical life.
- To equip students with knowledge and skills for better planning and management of plant resources and environment.
- To develop the scientific culture and demonstrate professional skills in teaching/research/ managerial positions in wide range of professions in national and international organizations.

SCHEME OF STUDY BS (4YEARS) PROGRAM SESSION (2023 AND ONWARDS)

STRUCTURE

Sr.	Categories	Credit Hours Min – Max
1.	General Education (Gen Edu) Requirements: Mandatory Courses of General Education.	30
2.	Major (Disciplinary) Requirements: Area of Study in Which the Degree is offered	83
3.	Interdisciplinary/Allied Requirements (To Support Horizon of the Major)	12
4.	Field Experience/Internship (Practical Work Experience related to a Student's Field of Study or Career interest)	03
5.	Capstone Project or Capstone Research Project	06
Total		*134*

- Total number of Credit hours 134
- Duration 4 years
- Semester duration 16-18 weeks
- Semesters 8
- Course Load per Semester 15-18 Cr hr
- Number of courses per semester 4-6 (not more than 3 lab / practical courses)

LAYOUT

General Education (Gen Edu) Requirements: Mandatory Courses of General Education (the student has no choice)	The Distribution of Courses as Per the Area of the Study in Which the Degree is offered			
	Major (Disciplinary) Requirements: Area of Study in Which the Degree is offered	Interdisciplinary/ Allied Requirements (To Support Horizon of the Major)	Field Experience/ Internship (Practical Work Experience related to a Student's Field of Study or Career interest)	Capstone Project or Capstone Research Project
12 courses	26 courses	04 courses	01 courses	1-2 Courses
30 Credit Hours	83 Cr. Hours	12 Cr. Hours	03 Cr. Hours	06 Cr. Hours

SEMESTER WISE BREAKUP OF COURSES

Category	Course Title	Course codes	Lecture	Lab.	Credit hours
YEAR I					
SEMESTER I					
Arts & Humanities	Arts & Humanities	AH-301	2	0	02
Islamic Studies/Religious Education	Islamic Studies/Religious Education/ Ethics in Lieu of Islamic studies only for non-Muslim students	ISL-315	2	0	02
Interdisciplinary/Allied	Cell biology	BIT-303	2	1	03
Functional English	Functional English	ENG-303	3	0	03
Major I	Plant Diversity	BOT-301	2	1	03
Major II	Plant Nomenclature and Embryology	BOT-302	3	1	04
Total Credits Hours			**14**	**3**	**17**
SEMESTER II					
Social Sciences	Social Sciences	XXX	2	0	02
Expository Writing	Expository Writing	ENG-304	3	0	3
Interdisciplinary/Allied	Bacteriology & Virology	MB-301	2	1	3
Ideology and Constitution of Pakistan	Ideology and Constitution of Pakistan	PST-313	2	0	2
Major III	Plant Anatomy	BOT-303	2	1	3
Major IV	Biodiversity and Conservation	BOT-304	3	1	4
Total Credits Hours			**14**	**3**	**17**
YEAR II					
SEMESTER III					
Quantitative reasoning-I	Quantitative reasoning-I	MTH-401	3	0	03
Application of information & Communication technologies	Application of information & Communication technologies	CSC-308	2	1	03
Natural Science	Natural Science	XXX	-	-	03
Entrepreneurship	Introduction to Entrepreneurship	MS-309	2	0	02

Major V	Plant Ecology	BOT-411	3	1	04
Major VI	Plant Biochemistry-I	BOT-412	2	1	03
Total Credits Hours			**12**	**3**	**18**
SEMESTER IV					
Civic and Community Engagement	Civic and Community Engagement	PSC-418	2	0	02
Quantitative reasoning II	Quantitative reasoning II	MTH-402	3	0	03
Major VIII	Genetics & Evolution	BOT-413	3	1	04
Major IX	Molecular Biology	BIT-413	2	1	03
Major X	Environmental Pollution	BOT-414	2	1	03
Major VII	Plant Biochemistry-II	BOT-415	2	1	03
Total Credits Hours			**14**	**4**	**18**
YEAR III					
SEMESTER V					
Allied Courses	Introduction to Bioinformatics	BI-401	2	1	03
Allied Courses	Biostatistics	STAT-401	3	0	03
Major XI	Diversity of Vascular Plants	BOT-521	2	1	03
Major XII	Plant Systematics	BOT-522	3	1	04
Major XIII	Plant Physiology-I	BOT-523	2	1	03
Total Credits Hours			**12**	**4**	**16**
SEMESTER VI					
Major XIV	Research Planning and Writing	BOT-524	3	0	03
Major XV	Plant Physiology-II	BOT- 525	2	1	03
Major XVI	Climate change and Vegetation	BOT-526	3	0	03
Major XVII	Paleobotany	BOT- 527	2	1	03
Major XVIII	Phycology and Bryology	BOT- 528	2	1	03
Major XIX	Plant Interactions with Microbes and Insects	BOT- 529	3	0	03
Total Credits Hours			**15**	**3**	**18**

YEAR IV					
SEMESTER VII					
Internship (Mandatory)	Internship (Mandatory)	BOT-698	-	-	03
Major XXI	Mycology	BOT- 631	2	1	03
Major XXII	Plant Pathology	BOT- 632	2	1	03
Major XX (Elective- I)	Elective-I	BOT-XXX	3	0	03
Major XXIII	Capstone Research Project	BOT-697	-	03	03
Total Credits Hours			**7**	**2**	**15**
SEMESTER VIII					
Major XXIV	Ethnobotany	BOT-641	3	0	03
Major XXV	Medicinal Plants	BOT-642	2	1	03
Major XXVI	Applied Botany	BOT- 643	2	1	03
Major XXVII (Elective-II)	Elective-II	BOT-XXX	3	0	03
Major XXVIII	Capstone Research Project	BOT-697	-	03	03
Total Credits Hours			**10**	**2**	**15**
Grand total credit hours			**98**	**24**	**134**

YEAR-I

SEMESTER–I

Course Title: Cell biology		**Course Code:** BIT-303
Course Structure: Lecture. 2 Lab. 1		**Credit hours:** 3
Pre-requisite	None	

Objectives

This course provides the basic concepts of life science,

- With emphasis on the diversity of life, the physical and chemical nature of living matter, and the form and function of cells and organisms.
- Introduce students to the internal organization of the prokaryotic and eukaryotic cell, organelle and membrane function, cell-cell signaling, cell movement, cell adhesion, and the extracellular matrix.

Course Outline

- Introduction to cell biology, Form and function of the cell, Types of cells, The Chemical Basis of Life, the chemistry of cell, Cells and organelles overview, The Structure, function, and molecular organization of cellular organelles, Roles of different macromolecules, Enzymes Molecular

organization of cells Protoplasm, Cell wall, Cell membrane, transport across membranes, organelles: mitochondria, endoplasmic reticulum, Golgi bodies, plastids, lysosomes, peroxisomes, The Structure and Function of the Plasma Membrane, Cytoplasmic Membrane Systems, cell internal structure, cytoskeleton, microtubules, microfilaments, intermediate filaments, structure of chromosomes, Photosynthesis, Components of Photosynthesis, cell division and cell cycle. The key roles of mitosis and meiosis during the life cycle. Compare and contrast different life cycle strategies, focusing on the human life cycle 13 Stages of mitosis and meiosis, Highlighting similarities and differences. Stages of the cell cycle Apoptosis, cell signaling, Cell visualization techniques.

Outcomes

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

- Acquire the basic concepts of cell biology.
- Understand the metabolic processes of cells in terms of cellular organelles, membranes, and biological molecules.
- Ability to understand the role of macromolecules regulating cellular processes.
- Acquire the critical thinking skills and knowledge on cell.

Lab outlines

Microscopy and staining techniques; study of prokaryotic, eukaryotic, plant and animal cells; cell structure in the staminal hair of Tradescantia; study of different types of plastids; cellular reproduction; Mitosis: smear/squash preparation of onion roots.

Books Recommended

1. Thomas D. Pollard, MD, William C. Earnshaw, PhD, FRS, Jennifer Lippincott-Schwartz, PhD and Graham Johnson, Cell Biology, 4th Edition (2023) ISBN : 9780323758000
2. Bruce Alberts, Rebecca Heald, Alexander Johnson, Molecular Biology of the Cell 7th Edition, 2022. W.W.Norton and Company.
3. Harvey Lodish, Arnold Berk, Chris A. Kaiser- 2016 8th Edition Molecular cell biology
4. Alberts et al., 2009. Essential Cell Biology. 3rd Edition; Garland Publishers, New York.
5. Lodish et al,. 2007. Molecular Cell Biology. 6th Edition; Freeman and Company, New York. (available at www.ncbi.nlm.nih.gov)
6. Thomas D. Pollard, William C. Earnshaw, Jennifer Lippincott-Schwartz 2007 2nd Edition Cell biology
7. Alberts B and Johnson A, 2006. Molecular Biology of the Cell. 4 th Edition; Garland Publishers, New York. (available at www.ncbi.nlm.nih.gov)
8. S C Rastogi 2005 3rd Edition, Cell biology. Newage international Publishers.India.
9. Karp, 2002. Cell and Molecular Biology. 3rd Edition; John Wiley and Sons, New York.

Course Title: Plant Diversity		**Course Code:** BOT-301
Course Structure: Lecture. 2 Lab. 1		**Credit hours:** 3
Pre-requisite	None	

Objectives

The course aims to:

- Provide in-depth knowledge of diversity of plants
- Study general characters, classification, reproduction and affinities

Course Outline

Algae (General structure, occurrence, reproduction and classification); **Fungi** (General structure, occurrence, reproduction and classification, life cycle, economic importance with emphasis on industrial and medicinal significance, Methods of control of pathogenic forms smut and rust); **Lichens** (General account, structure and life history of Physcia); **Bryophyta** (Atracheophyta) (General account, reproduction, classification, affinities and ecological importance with special reference to the life cycle of Anthoceros and Funaria); **Pteridophyta** (General account, structure and life history of Psilotum and its affinities of Psilopsida, Lycopsida, Sphenopsida: General account, structure and life history of equisetum. Pteropsida; Filicinae (Ferns), general account, life history of Adiantum and Marsilea); **Gymnosperms** (General account with reference to structure and life history of Cycas, Pinus and Ephedra and their affinities); **Angiosperms** (Life cycle of a typical angiosperm)

Outcomes

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

- identify the diversity of plant
- know the primary characteristics of plants
- understand reproduction and life cycle of plants

Lab outlines

1. Preparation of an inventory of the flora of a given region.
2. To carry on base line study of any designated category.
3. Identification of wild plants used by local communities
4. Field study for collection of different plant species.

Books Recommended

1. Bush, M.B., Ecology of a Changing Planet, 3rd Edition, 2020. Prentice Hall.
2. De Klemm, C., Wild plant conservation, IUCN, Gland. 1st Ed., 2018.
3. Cornelio Losa, Methods and Techniques in Plant Physiology, 2016, Scitus Academics LLC
4. Cunnighum, A.B, Applied Ethnobotany: People, Wild Plant Use and Conservation (People and Plants International Conservation), 1st Ed., 2016, Routledge Publications.
5. Bhattacharya A. and Laxmi V., Methods and Techniques in Plant Physiology, 2015, New India Publishing Company.

6. Dyke, F.V., Conservation Biology: Foundations, Concepts, Applications, 2nd ED., 2010, Springer Dordrecht
7. William G. Hopkins, Norman P. A. Hüner. Introduction to Plant Physiology. 4th Ed. 2008, Wiley J.
8. Dyke, F.V. 2008. Conservation Biology: Foundations, Concepts, Applications. Springer Science & Business Media
9. Cotton, C.M., Ethnobotany: Principles and Applications 1st Ed., Kindle Edition, 2007, Wiley.
10. Grombridge, B. & Jenkins, M. D. World Atlas of Biodiversity: Earths Living Resources in the 21st. Century, University. California Press, Berkeley Physiology. 4th Ed. 2002, Wiley.

Course Title: Plant Nomenclature and Embryology		**Course Code:** BOT-302
Course Structure: Lecture. 3 Lab. 1		**Credit Hours:** 4
Pre-requisite	None	

Objectives

- To understand various systems of classification, identification and nomenclature of higher plants and structures and functions of tissues and organs at embryonic level.

Course Outline

Plant Nomenclature

Introduction to Plant Systematics: aims, objectives and importance); **Classification** (brief history of various systems of classification with emphasis on Takhtajan. APG-III system of classification and recent trends in phylogeny of plants); **Brief introduction to nomenclature**, importance of Latin names and binomial system with an introduction to International Code of Botanical Nomenclature (ICBN), Vienna code and ICN; **Important rules of botanical nomenclature** including effective and valid publication, typification, principles of priority and its limitations, author citation, rank of main taxonomic categories, conditions for rejecting names; **Phytography/Morphology** (a detailed account of various, morphological characters root, stem, leaf, inflorescence, flower, placentation and fruit types)

Plant Embryology

Early development of plant body: Capsella bursa-pastoris; Structure and development of Anther Microsporogenesis, Microgametophyte; Structure of Ovule Megasporogenesis; Megagametophyte; **Endosperm formation; Parthenocarpy; Polyembryony**

Outcomes

Upon completion of this course, students will be able to understand the naming and classification of plants and they will be able to describe the anatomical features of plants.

Lab outlines

Plant Nomenclature

1. Study of type specimens at various herbaria, preparation of herbarium specimens.
2. Study of International Code of Nomenclature for Plants, algae and Fungi.
3. Study of various kinds of root, stem, leaf, inflorescence, flower, placentation and fruit types.

4. Visits to various herbaria in the country.

Plant Embryology

1. Study of stomata, epidermis,
2. Tissues of primary body of plant
3. Study of xylem 3-dimensional plane of wood.
4. T.S of angiosperm stem and leaf.
5. Anatomy of germinating seeds
6. Study of pollens

Books Recommended

1. Pullaiah, T., Taxonomy of Angiosperms, 4th Ed. 2022, Regency Publications, New Delhi.
2. Murrell, Z. E., Gillespie, E. L., Vascular Plant Taxonomy, United States, 2021, Kendall Hunt Publishing Company.
3. R. Nair, Taxonomy of Angiosperms, 2018, APH Publishing Corporation
4. Bhatnagar, S.P., Dantu, P. K., Bhojwani, S.S., The Embryology of Angiosperms, 6th Ed., 2018, Vikas
5. Soltis, D. E., Soltis, P. S., & Endress, P. K., Comparative Floral Biology, Cambridge, UK, 2018, Cambridge University Press.
6. Lawrence, G. H. M., Taxonomy of Vascular Plants, 2017, Sentific
7. Judd, W. S., Campbell, C. S., Kellogg, E. A., & Stevens, P. F., Plant Systematics: A Phylogenetic Approach, 2016, Sunderland, MA: Sinauer Associates.
8. Panday, B. P. 2004. A textbook of Botany (Angiosperms). S. Chand and Co. New Delhi.

SEMESTER–II

Course Title: Bacteriology & Virology		**Course Code:** MB-301
Course Structure: Lecture. 2 Lab. 1		**Credit hours:** 3
Pre-requisite	None	

Objectives

- To provide a comprehensive understanding of bacteriology, virology, and their significance in various fields.
- To equip students with practical laboratory skills for working with microorganisms.
- To explore the latest research and developments in the field of microbiology.
- To foster critical thinking and problem-solving skills related to microbial interactions and disease control.

Course Outline

Introduction to Microorganisms. Bacterial Morphology, Growth and Reproduction. Bacterial taxonomy and nomenclature, basis of classification of bacteria. General methods of studying

microorganisms: Cultivation, isolation, purification, characterization, and preservation. Control of microorganisms by physical and chemical methods. Chemotherapeutic agents and antibiotics. Modes of action of antibiotics on microorganisms. Host-Pathogen Interactions. Mechanisms of Bacterial Infections. Application in various modern sciences especially agriculture, biotechnology and genetic engineering. Introduction to Viruses. Nature of Plant, animal & Bacteria viruses. Structure and Classification of Viruses. Viral Replication and Assembly. Virus-Host Cell Recognition. Antiviral Strategies. Vaccines and Antiviral Agents. Emerging Viral Diseases

Course Outcomes:

- This course will provide an in-depth exploration of bacteria and viruses, including their structure, function, classification, pathogenesis, and interactions with hosts.
- It will cover fundamental principles of microbiology and virology and their significance in various scientific disciplines, such as medicine, agriculture, and biotechnology.

Lab outlines

1. Methods of sterilization of glassware and media etc.
2. Preparation of different bacterial media.
3. Preparation of slides for the study of various forms, capsule/slime layer, spores and flagella
4. Gram staining.
5. Growth of bacteria, sub-culturing, and identification of bacteria on morphological and
6. biochemical basis (using available techniques).

Books Recommended

1. Plant-Microbe Interactions Gary Stacey, Noel T. Keen (Eds) 2011.springer London
2. Molecular Plant-Microbe Interactions, Kamal Bouarab, Normand Brisson, Fouad Daayf (eds) .2009. MPG Books Group, Bodmin, UK.
3. Black, J.G. 2005 Microbiology - Principles and Exploration, John Wiley and Sons, Inc.
4. Prescott, L.M., Harley, J.P. and Klein, D.A. 2005. Microbiology McGraw-Hill Companies, Inc.
5. Arora, D.R. 2004. Textbook of Microbiology, CBS Publishers and Distributors, New Delhi.
6. Ross F.C. 1995. Fundamentals of Microbiology. John Willey & Sons, New York.
7. Khan, J.A. and Dijkstra J. Plant Viruses as Molecular Pathogens. The Haworth Press, Inc.
8. Hull R. Matthews .2004. Plant Virology, Academic Press.
9. Tortora, G.J: Funke, B.R. and Case C.L.2004. Microbiology. Pearson Education.

Course Title: Plant Anatomy		**Course Code:** BOT-303
Course Structure: Lecture. 2 Lab. 1		**Credit hours:** 3
Pre-requisite	None	

Objectives

- To provide comprehensive knowledge of anatomical features of vascular plants.

Course Outline

The plant body and its development (fundamental parts of the plant body, internal organization, different tissue systems of primary and secondary body); **Meristematic tissues** (classification, cytohistological characteristics, initials and their derivatives); **Apical meristem** (Delimitation, different growth zones, evolution of the concept of apical organization. Shoot and root apices); **Leaf** (types, origin, internal organization, development of different tissues with special reference to mesophyll, venation, bundle-sheaths and bundle-sheath extensions. Enlargement of epidermal cells); **Vascular cambium** (Origin, structure, storied and non-storied cell types, types of divisions: additive and multiplicative, cytoplasmic characteristics, seasonal activity and its role in the secondary growth of root and stem. Abnormal secondary growth); **Origin, structure, development, functional and evolutionary specialization of the following tissues** (Epidermis and epidermal emergences, Parenchyma, Collenchyma, Sclerenchyma, Xylem, Phloem with special emphasis on different types of woods, Periderm); **Secretory tissues** (Laticifers (classification, distribution, development, structural characteristics, functions and Resin Canals); **Anatomy of reproductive parts** (Flower, Seed, Fruit); **Economic aspects of applied plant anatomy** (Anatomical adaptations, Molecular markers in tree species used for wood identification)

Outcomes

- Upon completion of this course, students will be able to demonstrate a comprehensive understanding of vascular plant anatomy through the application of knowledge in various contexts and scenarios.

Lab outlines

1. Study of organization of shoot and root meristem, different primary and secondary tissues from the living and preserved material in macerates and sections, hairs, glands and other secondary structures.
2. Study of abnormal/unusual secondary growth.
3. Peel and ground sectioning and maceration of fossil material.
4. Comparative study of wood structure of Gymnosperms and Angiosperms with the help of prepared slides.

Books Recommended

1. Charles. R. M., 3rd Ed. (2021). Anatomy of the Monocotyledons. Hassell Street Press.
2. Rudall, P. (2020). Anatomy of Flowering Plants: An Introduction to Plant Structure and Development. United Kingdom: Cambridge University Press.
3. Crang, R., Lyons-Sobaski, S., Wise, R. (2018). Plant Anatomy: A Concept-Based Approach to the Structure of Seed Plants. Germany: Springer International Publishing.
4. Steeves, T. A., Sawhney, V. K. (2017). Essentials of Developmental Plant Anatomy. United Kingdom: Oxford University Press.
5. Raymond, E.S. and E. Eichhorn. (2005). Esau's Plant Anatomy; Meristematic cells and tissues of plant body. John Willey Sons.
6. Eames, A.J. and L.H. Mac Daniels. (2002). An introduction to Plant Anatomy. Tat Mac-Graw Hill Publishing Company Limited, New Delhi.
7. Pandey B. P. (2001). Plant Anatomy. India: S. Chand Limited.

8. Dickison, W.C. (2000). Integrative plant anatomy. Academic Press, U.K.

Course Title: Biodiversity and Conservation		**Course Code:** BOT-304
Course Structure: Lecture. 3 Lab. 1		**Credit hours: 4**
Pre-requisite	None	

Objectives

- To familiarize the students with the diversity of nature. Importance of biodiversity for survival and proper functioning of ecosystems.

Course Outline

Biodiversity: Definition, types, Threats to Biodiversity (deforestation, over grazing, erosion, desertification, ecosystem degradation, bio invasion, pollution and climate change, Measuring biodiversity (Alpha, Beta and Gamma diversity; Systematic and functional diversity); **Ecological services** (indirect value of ecosystem by virtue of their ecological functions, direct value of ecosystem i.e. Utility of Bio resources); **Sustainable and unsustainable use of biological resources; Biodiversity Hot spots of Pakistan and the world; International treaties/agreements** regarding Biodiversity and conservation (CBD, CITES, Ramsar); **Conservation strategies** (*in situ, ex situ, in vitro* conservation); **Conservation *vs* preservation;** IUCN categorized protected areas in Pakistan, red listing; Environmental Impact Assessment; Use of herbarium and Botanical Garden in biodiversity and conservation; Concept of pastures and wild life management; Global Biodiversity Information Facility (GBIF)

Outcomes

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

- Know and understand the main basics of plant systematic and phylogeny.
- Recognize and identify plant organisms.

Interpret the plant diversity in the environment, plus their evaluative origin and ecological behavior.

Lab outlines

1. Inventory of plant biodiversity in various habitats.
2. Field survey for baseline studies and Impact Assessment.
3. Identification of wild plant species used by local communities in different ecosystems.

Books Recommended

1. Khasim, S. M., Long, C., Thammasiri, K., & Lutken, H. (2020). Medicinal plants: biodiversity, sustainable utilization and conservation. Singapore: Springer.
2. Ansari, A. A., Gill, S. S., Abbas, Z. K., & Naeem, M. (2016). Plant biodiversity: monitoring, assessment and conservation. CABI.
3. Lindenmayer, D. B., & Franklin, J. F. (2013). Conserving Forest biodiversity: a comprehensive multi scaled approach. Island press.

4. Abbasi, A. M., Khan, M. A., M. Ahmad and M. Zafar. (2012). Medicinal plant biodiversity of Lesser Himalaya Pakistan. Springer Publishers USA.
5. Zachos, F. E., & Habel, J. C. (2011). Biodiversity hotspots: distribution and protection of conservation priority areas. Springer Science & Business Media.
6. Laird, S. A. (2010). Biodiversity and traditional knowledge: equitable partnerships in practice. Routledge.

Year-II

SEMESTER–III

Course Title: Plant Ecology		**Course Code:** BOT-411
Course Structure: Lecture. 3 Lab. 1		**Credit hours:** 4
Pre-requisite	None	

Objectives

- To enable the students to assess the effects of various environmental factors on plant growth and development.

Course Outline

Introduction, aims and applications of ecology; **Soil** (Nature and properties of soil (Physical and Chemical), Water in the soil- plant-atmosphere continuum, the ionic environment and plant ionic relations, Nutrient cycling, Physiology and ecology of N, S, P and K nutrition. Heavy metals (brief description, Salt and drought stress and osmoregulation, Soil erosion); **Light and temperature** (Nature of light, Factors affecting the variation in light and temperature, Responses of plants to light and temperature, Adaptation to temperature extremes); **Carbon dioxide** (Stomatal responses, water loss and CO2-assimilation rates of plants in contrasting environments, Ecophysiological effects of changing atmospheric CO2 concentration, Functional significance of different pathways of CO2 fixation, Productivity: response of photosynthesis to environmental factors, C and N balance); **Water** (Water as an environmental factor, Role of water in the growth, adaptation and distribution of plants, Water status in soil, Water and stomatal regulation, Transpiration of leaves and canopies); **Oxygen deficiency** (Energy metabolism of plants under oxygen deficiency, Morpho-anatomical changes during oxygen deficiency, Post-anoxic stress); Wind as an ecological factor; Fire as an ecological factor; **Population Ecology**: Introduction. A brief description of seed dispersal; **Community Ecology** (Ecological characteristics of plant community, Succession, Major vegetation types of the local area); **Applied Ecology** (Causes, effects and control of water logging and salinity with respect to Pakistan); **Soil erosion** (types, causes and effects (wind and water)

Outcomes

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

- Identify and describe different environmental factors that can affect plant growth and development, such as light, temperature, humidity, and soil quality.
- Describe the different components of ecosystem and importance of energy as drivers of ecosystem.

Lab outlines

1. Determination of physico-chemical properties of soil and water
2. Measurements of light under different ecological conditions
3. Measurements of temperature under different ecological conditions
4. Effect of light on germination and growth of plants
5. Effect of temperature on germination and growth of plants
6. Effect of moisture on germination and growth of plants
7. Effect of salinity and soil type on germination and growth of plants
8. Determination of seed banks and sampling of vegetation
9. Field trip to study different communities located in different ecological regions of Pakistan
10. Slide show of the vegetation of Pakistan
11. Slide show of the major formations of the world
12. Determination of soil organic matter contents
13. Test for the presence of nitrates in the soil samples
14. Determination of carbonates and bicarbonates of given samples
15. Determination of chloride contents in given samples

Books Recommended

1. Schulze, E., Beck, E., Buchmann, N., Clemens, S., Müller-Hohenstein, K., Scherer-Lorenzen, M., Arneth, A., Dormann, C., Schäfer, M., Sierra, C., Zähle, S. (2019). Plant Ecology. Germany: Springer Berlin Heidelberg.
2. Keddy, P. A. (2017). Plant Ecology: Origins, Processes, Consequences. United Kingdom: Cambridge University Press.
3. Hegazy, A. K., & Doust, J. L. (2016). Plant ecology in the Middle East. Oxford University Press.
4. Krohne T. D. (2015). Ecology: Evolution, Application and Integration. Oxford University Press.
5. Grime, J. P., Hodgson, J. G., & Hunt, R. (2014). Comparative plant ecology: a functional approach to common British species. Springer.
6. Pearcy, R. W., Ehleringer, J. R., Mooney, H., & Rundel, P. W. (Eds.) (2012). Plant physiological ecology: field methods and instrumentation. Springer Science & Business Media.
7. Cao, K. F., & Enright, N. J. (2011). Plant Ecology in China. New York: Springer.
8. Booth, B. D., Murphy, S. D., & Swanton, C. J. (2010). Invasive plant ecology in natural and agricultural systems. CABI.

Course Title: Plant Biochemistry-I		**Course Code:** BOT-412
Course Structure: Lecture. 2 Lab. 1		**Credit hours:** 3
Pre-requisite	None	

Objectives

- To introduce metabolism and provide detailed information on its different components.
- To focus on the structure and function of all biomolecules and a description of the pathways of metabolisms

Course Outline

Introduction to plant biochemistry (definition, history and development of plant biochemistry. Importance and application of plant biochemistry. The biochemical basis of life); **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); **Lipids (**Occurrence, classification. Structure and chemical properties of fatty acids, triglycerides, phospholipids, glycolipids, sulpholipids, waxes and sterols); **Proteins (**Amino acids and their structure. Electro chemical properties and reactions of amino acids. 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 role); **Nucleic Acids (**General introduction. Purine and pyrimidine bases, nucleosides, nucleotides. Structure and properties of DNA and RNA. Types and functions of RNA); **Enzymes (**Nature and functions, Isozymes, ribozymes, Enzyme kinetics classification with examples of abzymes. Enzyme specificity and mode of action. I. U. E. typical groups. Nature of active sites enzymes, Allosteric and feedback mechanism, Enzymes inhibitors)

Outcomes

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

- Get an idea about the involvement of different organs in metabolism.
- Understand the chemical reactions taking place inside the living organisms

Lab outlines

1. Solutions, acids and bases, buffers, pH.
2. To determine the Rf value of monosaccharides on a paper chromatogram.
3. Biochemical tests for carbohydrates, lipids, protein(Biuret or Lowry or Dye-binding method) and nucleic acids (UV-light)
4. To estimate the catalytic property of enzyme catalase or peroxidase extracted from a plant source.

Books Recommended

1. Nelson, D. L., Cox, M. (2017). Lehninger Principles of Biochemistry: International Edition. United Kingdom: Macmillan Learning.
2. Buchanan, B. B., Gruissem, W., & Jones, R. L. (Eds.). (2015). Biochemistry and molecular biology of plants. John wiley & sons.

3. Shah, B., Seth, A. (2014). Textbook of Pharmacognosy and Phytochemistry. India: Elsevier - Health Sciences Division.
4. Moran, L. A., Horton, H. R., Scrimgeour, G., Perry, M. (2013). Principles of Biochemistry. United Kingdom: Pearson.
5. Florence G and Raymond S. 2012. Plant Biochemistry. Jones and Bartlett learning International, UK
6. Wink, M. (2011). Annual Plant Reviews, Biochemistry of Plant Secondary Metabolism. Germany: Wiley.
7. Heldt, and Piechulla (2010). Plant Biochemistry. 4th Edition, Academic Press, U.K.
8. Smith, E. L., Hill, R L, Lehman, R I., Lefkowits, R J. Handler and Abraham. (2003). Principles of Biochemistry, (General Aspects). White. International Student Edition. McGraw Hill International Book Company.

SEMESTER–IV

Course Title: Genetics & Evolution		**Course Code:** BOT-413
Course Structure: Lecture. 3	Lab. 1	**Credit hours:** 4
Pre-requisite	None	

Objectives

- To understand structure, functions and nature of genetic material and hereditary process and familiarization with evolutionary processes.

Course Outline

Genetics (Introduction, scope and brief history of Genetics); **Mendelian Inheritance** (Laws of segregation and independent assortment, back cross, test cross, dominance and incomplete dominance); **Extensions of Mendelian Analysis** (Variations on dominance, Genetic Interaction, Lethal Genes, Penetrance, Expressivity and Pleiotropism); Quantitative Genetics, Inheritance of Multiple Genes); **Linkage** (The discovery of linkage, recombination, linkage symbolism, linkage of genes on the X chromosome, linkage maps, three-point testcross, interference, Basic Eukaryotic Chromosome Mapping, coupling and repulsion, kinds of Linkage: complete linkage, incomplete linkage; Linkage groups, significance of Linkage); **Crossing over** (definition, types of crossing over: somatic crossing over, meiotic crossing over, Mechanism of meiotic crossing over, construction of linkage maps, two point test cross, three point test cross, determination of gene order, detection of linkage); **Multiple Alleles** (symbolism for multiple alleles, examples: ABO Blood group, C gene in rabbit, Rh factor and eye color in *Drosophila);* **Sex linked inheritance**, sex linkage in Drosophila and man (colour blindness), XO, XY, WZ mechanisms, sex limited and sex linked characters, sex determination); **The Structure of DNA** (DNA: The genetic material, DNA replication in eukaryotes, DNA and the gene); **The Extranuclear Genome** (Cytoplasmic or Extra-Nuclear inheritance: Variegation in leaves of higher plants, cytoplasmic inheritance in fungi, extranuclear genes in chlamydomonas, mitochrondrial genes in yeast, extragenomic plasmids in eukaryotes.chloroplast inheritance); Introduction to Germplasm conservation.

Evolution (The nature of evolutionary forces, adaptive radiations, differential reproductive potential, first plant cell, origin of organized structures, early aquatic and terrestrial ecosystem, first vascular plant)

Outcomes

- Upon completion of this course, students will be able to gain knowledge in gene concepts and genetic code, gene expression, gene regulation and also learn about mutation.

Lab outlines

1. Genetical problems related to transmission and distribution of genetic material.
2. Identification of DNA in plant material. Carmine/orcein staining.
3. Study of salivary gland chromosomes of Drosophila.

Books Recommended

1. Benjamin, A. (2022) Genetics a conceptual approach. Sixthe edition. John Wiley & Sons, Inc.
2. Bonduriansky, R., Day, T. (2020). Extended Heredity: A New Understanding of Inheritance and Evolution. United States: Princeton University Press.
3. Waddington, C. H. (2016). An introduction to modern genetics. Routledge.
4. Snustad, D. P., & Simmons, M. J. (2015). Principles of genetics. John Wiley & Sons.
5. Wright, S. (2013). Evolution and the genetics of populations, volume 1: genetic and biometric foundations (Vol. 1). University of Chicago press.
6. Carroll, S. B., Grenier, J. K., Weatherbee, S. D. (2013). From DNA to Diversity: Molecular Genetics and the Evolution of Animal Design. Germany: Wiley.
7. Verma, P. S. and Agarwal, V. K. (2009). Genetics. S. Chand and Co. Ltd, New Delhi.
8. Ingrouille M. J. and Eddie, B. (2006). Plant Diversity and Evolution. Cambridge University Press.
9. Lodish, H. (2001). Molecular Cell Biology. W. H. Freeman and Co.

Course Name: Molecular Biology	**Course Code:** BIT-413
Course Structure: Lectures: 2, Labs: 1	**Credit Hours:** 3
Prerequisites: Biochemistry I	

Course Objectives

- To study classical and molecular aspects of cell.
- The course emphasizes about the chromosome structure, transfers of genetic information, gene expression and regulation of gene activity.
- The course is basis for structural biology, it aids in the simulation and modeling of DNA, RNA, and protein structures as well as molecular interactions.

Course Outline

Introduction to Molecular Biology. Basic concepts about DNA, RNA and proteins with special emphasis on nature of genetic material and its organization in viruses, prokaryotes and eukaryotes, Structure function and replication of DNA, DNA as Heritable material structure of DNA, Chromatin and Chromosome organization: physical structure of genes. Gene Expression Genetic Code, Codon, Anticodon, Ribosome, Translation, Gene Expression in Prokaryotes, the lac operon, Gene Expression in eukaryotes, Molecular Basis of Mutation Basis of mutation. DNA damage, DNA Repair Recombination. Types of mutations. Replication errors and their repairs: DNA repair – Single step and multistep: RNA processing, splicing and editing, translation and post-translational modifications, Regulation of gene expression in prokaryotes and eukaryotes. Introduction about plasmids and vectors. Recombinant DNA Technology, CRISPR/CAS9-Targeted Genome Editing. Molecular evolution; DNA based phylogenetic trees and their applications.

Course Outcomes

- Equip students with a comprehensive understanding of molecular biology.
- Preparing them for careers in research, biotechnology, and various fields where molecular biology principles are applied.

Lab Outline

1. Isolation of DNA from plant cells, Protocols for isolation of DNA from blood. Protocols for Amplification of DNA by PCR. Gel Electrophoresis.

Recommended Books

1. David M. P. Academic Press London, Methods in Cell Biology Lowery Sekivetz. Cell Structure and Function. John Willey and Sons Publication. 3 edition (October 7, 2011).
2. Jordanka Zlatanova. Molecular Biology: Structure and Dynamics of Genomes and Proteomes 2nd Edition Garland Science ISBN-13: 978-0367678098 April 21, 2023
3. Gerald Karp - Cell and molecular biology concepts and experiments - Hoboken, NJ - John Wiley - 2010 - 5th Ed.
4. Brown T. A. Gene Cloning and DNA Analysis: An Introduction, 6th Edition, 2010
5. Robert Weaver. Molecular Biology. McGraw Hill, 5th Edition, 2007.
6. James D. Watson, Tania A. Stephen P. Bell, Alexander Gann, Michael Levine, Richard Losick, Molecular Biology of the Gene, Pearson,7th Edition.2014.

Course Title: Environmental Pollution		**Course Code:** BOT-414
Course Structure: Lecture. 2 Lab. 1		**Credit hours:** 3
Pre-requisite	None	

Objectives

- To provide updated knowledge of environmental problems and sustainable environmental management.

Course Outline

Environment (Introduction, scope, pressure; **Pollution** (definition, classification and impact on habitats); **Air pollution** (Sources and effect of various pollutants (inorganic, organic) on plants, prevention, control, remediation. Photochemical smog. Smog. Acid rain: 1. Theory of acid rain, 2. Adverse effects of acid rains. Chlorofluorocarbons and its effects); **Water pollution** (Major sources of water pollution and its impact on vegetation, prevention, control remediation, eutrophication, thermal pollution); **Sediments pollution** (fungicide, pesticides, herbicide, major sources of soil pollution and its impact. Prevention, control remediation. Heavy metal pollution. Tanneries. Hospital waste. Treatments of sewage, sludge, and polluted waters); **Noise pollution** (Radiation pollution (including nuclear): Measurement, classification and effects, Principle of radiation protection, waste disposal); **Forest** (importance, deforestation, desertification and conservation**); Ozone layer** (Formation, Mechanism of depletion, Effects of ozone depletion, Greenhouse effect and global warming: causes, impacts); **Human population explosion** (impact on environment); **Impact assessment** (Industrial urban, civil developments); **National conservation strategy** (Brief review of major problems of Pakistan and their solutions); Sustainable Environmental management; **Wetlands and sanctuaries protection** (The pressures, problems and solutions); **Range management** (Types of rangelands, potential threats, sustainable management); **Aerobiology** (Pollen allergy & dust allergy).

Outcomes

Upon completion of this course, students will be able to demonstrate a comprehensive understanding of various environmental problems, including climate change, pollution, deforestation, and loss of biodiversity.

Lab outlines

1. Examination of industrial waste water and Municipal sewage and sludge for; Total dissolved solids, pH and EC., BOD/COD., Chlorides, carbonate, and Nitrates.
2. Examination of water samples forms different sites for the presence and diversity of organisms.
3. Effect of air pollutants on plants.
5. Visits to environmentally compromised sites and evolution of remediation methods.

Books Recommended

1. Lambers, H., Oliveira, R. S. (2021). Plant Physiological Ecology. Germany: Springer International Publishing.
2. Juniper, T. (2021). The Science of Our Changing Planet: From Global Warming to Sustainable Development. United States: DK.
3. Enger, E. D., Smith, B. F. (2017). Environmental Science: A Study of Interrelationships. United Kingdom: McGraw-Hill Education.
4. French, H. (2013). Vanishing Borders: Protecting the Planet in the Age of Globalization. United Kingdom: Taylor & Francis.
5. Bell, S., Morse, S. (2013). Measuring Sustainability: Learning From Doing. United Kingdom: Taylor & Francis.Bazzaz,

6. Physiological Mechanisms and Adaptation Strategies in Plants Under Changing Environment: Volume 1. (2013). Netherlands: Springer New York.
7. Marsh, W. M., Marshall, W. M. (2013). Environmental Geography: Science, Land Use, and Earth Systems. United Kingdom: John Wiley & Sons, Incorporated.
8. Ashfaq, M., Saleem, M. A. (2012). Environmental Pollution & Agriculture: Pakistan Perspective. Pakistan: Pak Book Empire.
9. Handbook Of Environment And Waste Management: Air And Water Pollution Control. (2012). Hong Kong: World Scientific Publishing Company.
10. Mulholland, K. L., Dyer, J. A. (2010). Pollution Prevention: Methodology, Technologies and Practices. Germany: Wiley.

Course Title: Plant Biochemistry-II		**Course Code:** BOT-415
Course Structure: Lecture. 2 Lab. 1		**Credit hours:** 3
Pre-requisite	Plant Biochemistry-I	

Objectives

- To explicit the fundamentals of metabolic energy, Metabolism and Plant constituents.

Course Outline

Bioenergetics (Energy, laws about energy changes. Oxidation and reduction in living systems); **Metabolism** (Biosynthesis, degradation and regulation of sucrose and starch); Biosynthesis of fats; Breakdown of fats with special reference to beta-oxidation and its energy balance); Protein metabolism; **Secondary metabolites** (**Alkaloids** Occurrence, physiological effects, chemical nature with special reference to solanine, nicotine, morphine, theine and caffeine. Aflatoxins, their nature and role); **Terpenoids**: Classification: monoterpenes, sesquiterpenes, diterpenes, triterpenes, tetraterpenes, polyterpenes and their chemical constitution and biosynthesis; **Phenolic compounds**, biosynthesis, classification, physiological effects, their role in plant metabolism; **Vitamins**: General properties, classification, role in metabolism and deficiency symptoms.

Outcomes

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

- Explain basic metabolic pathways of plants and formation of different secondary metabolites through various biosynthetic pathways in plants
- Explain source, chemistry, therapeutic uses of various secondary metabolites containing drugs.

Lab outlines

1. Separation of soluble proteins by polyacrylamide gel (PAGE) electrophoresis.
2. To estimate the amount of vitamin C in a plant organ (orange, apple juice).
3. To determine potential alkaloids in plants.
4. To estimate terpenoids in plants.
5. To estimate phenolics in plants.

Books Recommended

1. Singh, B., Sharma, R. A. (2020). Secondary Metabolites of Medicinal Plants: Ethnopharmacological Properties, Biological Activity and Production Strategies. Germany: Wiley.
2. Vijayakumar, R., & Raja, S. S. (Eds.). (2018). Secondary Metabolites: Sources and Applications. BoD–Books on Demand.
3. Tiwari, B. K., Brunton, N., & Brennan, C. S. (2015). Handbook of plant food phytochemicals. Wiley-Blackwell.
4. Wink, M. (2011). Annual Plant Reviews, Biochemistry of Plant Secondary Metabolism. Germany: Wiley.
5. Bowsher, C., Steer, M., Tobin, A. (2008). Plant Biochemistry. United States: CRC Press.
6. Verma, S. K., Verma, M. (2008). A Textbook of Plant Physiology, Biochemistry and Biotechnology. India: S. Chand Limited.

YEAR-III

SEMESTER–V

Course Title: Introduction to Bioinformatics	**Course Code:** BI-401
Course Structure: Lecture. 2 Lab. 1	**Credit hours:** 3
Pre-requisite	None

Objectives

- This course is designed for students with little to no prior experience in bioinformatics. It provides a foundational understanding of the core concepts, tools, and techniques in bioinformatics.

Course Outline

Introduction to Bioinformatics, Biological Databases, Types of Biological databases, Human genome and browsers, Genome sequencing methods, sequencing of human genome, DNA, RNA, and protein sequences retrieval and analysis, Sequence alignment and BLAST, Pairwise and Multiple Sequence Alignment, Sequence Polymorphism, What is Phylogenetics, Phylogenetic tree construction and analysis, Structural Bioinformatics, Introduction to protein structure, PDB (Protein Data Bank), Protein structure visualization, Primer designing, Genomics and Proteomics, students Projects.

Outcomes

By the end of the course, students will be able to analyze biological data, perform basic sequence analysis, and grasp key principles in genomics and proteomics

Lab outlines

1. Introduction to NCBI, Navigating the NCBI website, Comparison of sequences using Basic Local Alignment Search Tool (BLAST), Interpretation of BLAST search results, UCSC genome browser, Pairwise and multiple sequence alignment using ClustalW, Protein Data Bank, Swiss Prot, Pymol viewer or any available protein structure visualizer, Primer 3 and Oligo analyzer 3.1.

Books Recommended

1. Bioinformatics Sequence and Genome Analysis, D.W. Mount, Cold Spring Harbor Laboratory Press 2004 2nd Edition. ISBN 0-87969-597-8.
2. Zvelebil, M. J., & Baum, J. O. (2008). Understanding bioinformatics. New York (N.Y.): Garland science.
3. Arthur M. Lesk, Introduction to Bioinformatics.5th Edition (2019). Oxford University Press.
4. Jin Xiong, Essential Bioinformatics, (2006), Cambridge University Press
5. Thomas Dandekar, Meik Kunz, Bioinformatics An Introductory Textbook, (2023), Springer-Verlag GmbH Germany, part of Springer Nature
6. Ignacimuthu SJ. Basic Bioinformatics, 2nd Edition (2005) Narosa Publishing House

Course Title: Biostatistics		**Course Code:** STAT-401
Course Structure: Lecture. 3 Lab. 0		**Credit hours:** 3
Pre-requisite	None	

Objectives

- To provide knowledge of importance of and its application in Biological Sciences. Understanding of use of statistical techniques to summarize and analyze Biological data.

Course Outline

Introduction to Biostatistics, scope. Types of data, variables; Categorical, numerical and censored data. Descriptive Statistics; Measure of central tendency; mean, median, mode. Measure of dispersion; Variance and standard deviation. Simple linear regression; model fitting. Correlation; correlation co-efficient, co-efficient of determination. Logistic regression. Logit transformations and their analysis, p values and its importance and role. Hypothesis testing.

Outcomes

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

- Understand the applications of statistical tools in biological science.
- Demonstrate an understanding of the central concepts of statistical theory in Biological Sciences.
- Apply appropriate statistical techniques to biological data and analyze and communicate the results of statistical analysis effectively

Books Recommended

1. Forthofer, R. N., Lee, E. S. (2014). Introduction to Biostatistics: A Guide to Design, Analysis, and Discovery. United States: Elsevier Science.
2. Islam, M. A., AlShiha, A. (2018). Foundations of Biostatistics. Germany: Springer Nature Singapore.

Course Title: Diversity of Vascular Plants		**Course Code:** BOT-521
Course Structure: Lecture. 2 Lab. 1		**Credit hours:** 3
Pre-requisite	None	

Objectives

- To enable the students to understand and appreciate the biology and evolution of plant architecture

Course Outline

Pteridophytes (Introduction, origin, history, features and a generalized life cycle; Methods of fossilization, types of fossils, geological time scale and importance of paleobotany; First vascular plant - Rhyniophyta e.g. *Cooksonia*); **General characters, classification, affinities and comparative account of evolutionary trends of the following division**: Psilopsida (*Psilotum*), Lycopsida (*Lycopodium, Selaginella*), Sphenopsida (*Equisetum*), Pteropsida (*Ophioglossum, Dryopteris* and *Marsilea*); **Origin and Evolution of seed habit; Gymnosperms** (Geological history, origin, distribution, morphology, anatomy, classification and affinities of Cycadofillicales, Bennettitales, Ginkgoales, Cycadales and Gnetales. Distribution of gymnosperms in Pakistan. Economic importance of gymnosperms. An introduction to the Gondwana flora of world); **Angiosperms** (Origin, general characteristics, Importance, and life cycle of angiosperms)

Outcomes

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

- Understand the major lineages of vascular plants, including the ferns, gymnosperms and flowering plants.
- Introduced to basic plant structure (anatomy and morphology) and diversity.

Lab outlines

1. To study the morphological and reproductive features of available genera.
2. Study trips to different parts of Pakistan for the collection and identification of important pteridophytes, gymnosperms and angiosperms.
3. Study of pollen morphology

Books Recommended

1. Beck, C.B. 1992. Origin and Evolution of Gymnosperms. Vol-1&II, Columbia University Press, New York.
2. Christenhusz, M. J., Fay, M. F., & Chase, M. W. (2020). *Plants of the world: an illustrated encyclopedia of vascular plants*. University of Chicago Press.
3. Ingerpuu, N. (2002). *Bryophyte diversity and vascular plants*. Tartu: Tartu University Press.
4. Gifford, E. M., & Foster, A. S. (1989). Morphology and evolution of vascular plants.
5. Barooha, C., & Ahmed, I. (2014). *Plant Diversity of Assam: A Checklist of Angiosperm & Gymnosperms*. Guwahati: Assam Science Technology and Environment Council.
6. B.P. Panday. 2006. College Botany. Vol 1 & II. S.7th Edition. Chand & Co. New Delhi
7. Vashishta, B. R., A.K. Sinha and A. Kumar. 2010. Gymnosperms. S. Chand & Co.
8. Tilman, D., Knops, J., Wedin, D., & Reich, P. (2002). Plant diversity and composition: effects on productivity and nutrient. *Biodiversity and ecosystem functioning: Synthesis and perspectives*, 21.

9. Kaur, Inderdeep and Prem Lal Uniyal (2019). Textbook of Gymnosperms. Published by Daya Publishing House

Course Title: Plant Systematics		**Course Code:** BOT-522
Course Structure: Lecture. 3	Lab. 1	**Credit hours:** 4
Pre-requisite	None	

Objectives

- To know floral composition/ system of classification focusing on identification, classification, description nomenclature and flora writings, monographs.

Course Outline

Introduction (Importance and relationship with other sciences, Phases of plant taxonomy. Origin and radiation of angiosperm, their probable ancestors, when, where and how did the angiosperms evolve; the earliest fossil records of angiosperms); Concept of Species (What is a species? Taxonomic species, Biological species, Micro and macro species, Species aggregate. Infra specific categories); Speciation (Mechanism of speciation, Mutation and hybridization Geographical isolation, Reproductive isolation, Gradual and abrupt); Variation (Types of variation, Continuous and discontinuous variation, Clinal variation); Systematics and Genecology / Biosystematics (Introduction and importance, Methodology of conducting biosystematics studies, Various biosystematics categories such as ecophene, ecotype, ecospecies, coenospecies and comparium); Taxonomic Evidence (Importance and types of taxonomic evidences: anatomical, cytological, chemical, molecular, palynological, geographical and embryological); General characteristics, distribution, evolutionary trends, phyletic relationships and economic importance of the following families of angiosperm: Monocot families (Arecaceae (Palmae); Liliaceae; Poaceae (Gramineae); Cyperaceae). Dicot families (Ranunculaceae; Malvaceae; Caryophyllaceae; Apiaceae (Umbelliferae); Asteraceae (Compositae); Moraceae; Brassicaceae (Cruciferae); Chenopodiaceae; Euphorbiaceae; Fabaceae (Leguminosae); Lamiaceae (Labiatae); Papaveraceae;; Rosaceae; Solanaceae; Cucurbitaceae)

Outcomes

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

- Develop a comprehensive understanding of floral composition and the system of classification.
- Gain knowledge of different plant families, genera, and species.
- Understand the characteristics and features used for plant identification and classification.
- Identify and classify plants based on their floral composition.

Lab outlines

1. Technical description of plants of the local flora and their identification up to species level with the help of a regional/Flora of Pakistan
2. Preparation of indented and bracketed types of keys

3. Preparation of permanent slides of pollen grains by acetolysis method and study of different pollen characters.
4. Study of variation pattern in different taxa.
5. Submission of properly mounted and fully identified hundred herbarium specimens at the time of examination
6. Field trips shall be undertaken to study and collect plants from different ecological zones of Pakistan.

Books Recommended

1. Dehgan, B. (2023). Garden Plants Taxonomy: Volume 2: Angiosperms (Eudicots). Springer Nature.
2. Besse, P. (2021). Molecular Plant Taxonomy. Springer US.
3. Simpson, M. G. (2019). Plant systematics. Academic press.
4. Lawrence, G. H. M. (2017). Taxonomy of vascular plants. Scientific Publishers.
5. Kellogg, E. A. (2016). Flowering Plants. Monocots. Springer International Publishing.
6. Sambamurty, A. V. S. S. (2013). Taxonomy of angiosperms. IK International Pvt Ltd.
7. Gupta, R. (Ed.). (2012). Plant Taxonomy: past, present, and future. The Energy and Resources Institute (TERI).
8. Verma, B. K. (2011). Introduction to taxonomy of angiosperms. Phi Learning Pvt. Ltd.
9. Stuessy, T. F. (2009). Plant taxonomy: the systematic evaluation of comparative data. Columbia University Press.
10. Reddy, S. M. (2007). University Botany-iii:(Plant Taxonomy, Plant Embryology, Plant Physiology) (Vol. 3). New Age International.
11. Pullaiah, T. 2007 Taxonomy of Angiosperms 3rd Ed. Regency Publication, New Delhi.
12. Simpson, M.G. 2006. Plant Systematics. Elsevier Academic Press.
13. Soltis, D.E. P.S. Soltis, P.K Endress, and M.W. Chase, 2005. Phylogeny & evolution of angiosperms. Sinauers associates, Inc. Publishers.

Course Title: Plant Physiology-I		**Course Code:** BOT-523
Course Structure: Lecture. 2 Lab. 1		**Credit hours:** 3
Pre-requisite	None	

Objectives

- To provide comprehensive knowledge on some vital functions and mechanisms of plants.

Course Outline

Photosynthesis (History of photosynthesis. Nature and units of light. Determination of oxygenic and anoxygenic photosynthesis. Ultrastructure of thylakoid vesicle. Various pigments and photosynthetic activity. Ultrastructure and composition of photosystem-I and II. Absorption and action spectra of different pigments. Mechanism of photosynthesis - light absorption, charge separation or oxidation of water (water oxidizing clock), electron and proton transport through

thylakoid protein-pigment complexes. Photophosphorylation and its mechanism. CO_2 reduction (dark reactions) - C_3 pathway and Photorespiration, Regulation of C_3 pathway, C_4 pathway and its different forms, C_3-C_4 intermediates, CAM pathway. Methods of measurement of photosynthesis); **Respiration** (Synthesis of hexose sugars from reserve carbohydrates. Mechanism of respiration-Glycolysis, Differences between cytosolic and chloroplastidic glycolysis, Oxidative decarboxylation, Krebs cycle, Regulation of glycolysis and Krebs cycle, Electron transport and oxidative phosphorylation. Aerobic and anaerobic respiration. Energetics of respiration. Pentose phosphate pathway. Glyoxylate cycle. Cyanide resistant respiration); **Translocation of Food** (Pathway of translocation, source and sink interaction, materials translocated, mechanism of phloem transport, loading and unloading); **Leaves and Atmosphere (**Gaseous exchange, mechanism of stomatal regulation. Factors affecting stomatal regulation); **Assimilation of Nitrogen, Sulphur and Phosphorus** (Nitrogen fixation, Assimilation of sulphur and phosphorus)

Outcomes

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

- Develop an understanding of the vital functions of plants.
- Understand the processes of photosynthesis, respiration, transpiration, and nutrient uptake in plants.
- Learn about the role of hormones in plant growth and development.
- Understand the importance of plant-microbe interactions in nutrient cycling and soil health.

Lab outlines

1. To determine the volume of CO_2 evolved during respiration by plant material.
2. To determine the amount of O_2 used by respiring water plant by Winkler Method.
3. Separation of chloroplast pigments on column chromatogram and their quantification by spectrophotometer.
4. To extract and separate anthocyanins and other phenolic pigments from plant material and study their light absorption properties.
5. To categorize C_3 and C_4 plants through their anatomical and physiological characters.
6. To regulate stomatal opening by light of different colours and pH.

Books Recommended

1. Meena, M. M. (2021). Plant physiology. Horizon Books (A Division of Ignited Minds Edutech P Ltd).
2. Hopkins, G. W. (2009). Introduction to plant physiology. John wiley & sons, Inc..
3. Cobb, A. H. (2022). Herbicides and plant physiology. John Wiley & Sons.
4. Ellison, A. M., & Adamec, L. (Eds.). (2018). Carnivorous plants: physiology, ecology, and evolution. Oxford University Press.
5. Hopkins, N. G. (2008). William; PA Huner. Introduction to Plant Physiology.
6. Jain, V. K. (2017). Fundamentals of plant physiology. S. Chand Publishing.
7. Bhatla, S. C., & Lal, M. A. (2018). Plant physiology, development and metabolism. Springer.

8. Hess, D. (2012). Plant physiology: molecular, biochemical, and physiological fundamentals of metabolism and development. Springer Science & Business Media.
9. Sharma, S., & Tiwari, G. (2022). A Practical Manual on Fundamentals of Plant Physiology. BFC Publications.
10. Taiz, L., Zeiger, E., Møller, I. M., & Murphy, A. (2015). Plant physiology and development (No. Ed. 6). Sinauer Associates Incorporated.
11. Mohr, H., & Schopfer, P. (Eds.). (2012). Plant physiology. Springer Science & Business Media.
12. Lazar, T. (2003). Taiz, L. and Zeiger, E. Plant physiology. 3rd edn.
13. Hemsley, A. R., & Poole, I. (Eds.). (2004). The evolution of plant physiology (No. 21). Elsevier.
14. Kochhar, S. L., & Gujral, S. K. (2020). Plant physiology: Theory and applications. Cambridge University Press.
15. Pessarakli, M. (Ed.). (2021). Handbook of plant and crop physiology. CRC press.

SEMESTER–VI

Course Title: Research Planning and Writing	**Course Code:** BOT-524
Course Structure: Lecture. 3 Lab. 0	**Credit hours:** 3
Pre-requisite	None

Objectives

- Enhance knowledge about research process and thesis writing.

Course Outline

Introduction to research (Principles of research, Basic and Applied research, Quantitative and Qualitative research, Characteristics of Successful research proposal, Selection of research topic, Hypothesis, The idea of validity in research); **reliability of measures and ethics, Research plan**, **Structure of research proposal** (Title, Background, Problem statement, Purpose statement, Time span, Research design, Methodology, Significance, Bibliography, Ethnic Statement, Experimental designs (Factorial, CRD and RCBD), Data collection, Statistical analysis of data; **Introduction to report writing**; **Thesis writing** (Title page, Acknowledgment, Contents page, Introduction , Review of literature, Materials and Methods, Results and discussion, Conclusion, Recommendations, Appendices, References, Bibliography, Glossary); **Review paper writings**, **Research paper writings**; publications, journal categories and impact factors; **Plagiarism and its types**

Outcomes

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

- Demonstrate the ability to choose methods appropriate to research aims and objectives.
- Understand the limitations of particular research methods.

- Develop skills in qualitative and quantitative data analysis.
  Develop advanced critical thinking skills.

Books Recommended

1. Alan G. Clewer and David H Scarisbrick. 2013. Practical Statistics and Experimental Design for Plant and Crop Sciences. Wiley Science Publishers
2. Shank, G. D. 2002. Qualitative research: a personal skills approach. Upper Saddle River, N.J.Columbus, Ohio: Prentice Hall; Merrill/Prentice Hall.
3. Brizuela, B. M. 2000. Acts of inquiry in qualitative research. Cambridge, MA: Harvard Educational Review
4. Shank, G. D. 2001, Qualitative Research: A Personal Skills Approach
5. Paul Leedy, 2004, Practical Research: Planning and Design (8th, Edition), Jeanne Ellis Ormrod
6. Bhattacharyya, D. K. (2009). Research methodology. Excel Books India.
7. Singh, Y. K. (2006). Fundamental of research methodology and statistics. New Age International.
8. Creswell, J. W., & Creswell, J. D. (2017). Research design: Qualitative, quantitative, and mixed methods approaches. Sage publications.
9. Creswell, J. W. (2014). A concise introduction to mixed methods research. SAGE publications.
10. Zina, O. (2021). The essential guide to doing your research project. Sage.

Course Title: Plant Physiology-II		**Course Code:** BOT-525
Course Structure: Lecture. 2 Lab. 1		**Credit hours:** 3
Pre-requisite	Plant physiology-I	

Objectives

- To give it comprehensive and advance knowledge of growth regulators, mechanism of water uptake and role of essential nutrients in plant metabolism

Course Outline

Plant Growth Regulators (Major natural hormones and their synthethic analogues. Bioassay, structure, biosynthesis, receptors, signal trasduction and mode of action, transport, physiological effects of Auxins , Gibberellins, Cytokinins, Abscisic acid, Ethylene, Polyamines, Brassinosteriods, Jasmonates, and Salicylic acid); **Water Relations**: The soil -plant -atmosphere continuum - an overview. Structure of water. Physico-chemical properties of water. Absorption of water in plants (pathways and driving forces, Aquaporins, their structure and types; Osmoregulation, Methods for measurement of water, osmotic and turgor potentials; **Plant Mineral Nutrition**: Inorganic composition of plant and soil. Absorption of mineral nutrients - roots, mycorrhizae. Effect of soil pH on nutrient availability. Ion traffic into root. The nature of membrane carriers, channels and electrogenic pumps. Passive and active (primary and secondary) transports and their energetics.

Essential and beneficial elements-their functions and deficiency symptoms in plants. Fertilizers and their significance in Agriculture) **Phytochromes** (Discovery of phytochromes and cryptochromes. Physical and chemical properties of phytochromes. Distribution of phytochromes among species, cells and tissues and their role in biological processes. Phytochromes and gene expression); **Control of Flowering** (Autonomous versus environmental regulation. Circadian rhythms. Classification of plants according to photoperiodic reaction, photoperiodic induction, locus of photoperiodic reaction and dark periods in photoperiodism. Role of photoperiodism in flowering. Biochemical signaling involved in flowering. Vernalization and its effect on flowering. Floral meristem and floral organ development; **Dormancy**; (definition and causes of seed dormancy; methods of breaking seed dormancy; types and physiological process of seed germination); **Plant Movements** (Tropic movement-phototropism, gravitropism and their mechanism. Nastic movements)

Outcomes

Upon completion of this course, students will be able to acquire knowledge in various physiological processes occur in plants and to learn about the response of plants to various biotic and abiotic stresses.

Lab outlines

1. To investigate the preferential absorption of ions by corn seedlings and potato slices.
2. To determine osmotic potential of massive tissue by freezing point depression method or by an osmometer.
3. To investigate water potential of a plant tissue by dye method and water potential apparatus.
4. Determination of K uptake by excised roots.
5. Measurement of stomatal index and conductance.
6. Qualitative determination of K content in Guard cells by Sodium cobalt nitrite method.

Books Recommended

1. Pandey, S. N., & Sinha, B. K. (2009). Plant physiology. Vikas Publishing House.
2. Sadras, V., & Calderini, D. (2009). Crop physiology: applications for genetic improvement and agronomy. Academic Press.
3. Moore, T. C. (2012). Research experiences in plant physiology: a laboratory manual. Springer Science & Business Media.
4. Hemantaranjan, A. (2003). Advances In Plant Physiology (Vol. 6) (Vol. 6). Scientific Publishers.
5. Nguyen, H. T., & Blum, A. (Eds.). (2004). Physiology and biotechnology integration for plant breeding. CRC Press.
6. Hemantaranjan, A. (2000). Advances In Plant Physiology (Vol. 3) (Vol. 3). Scientific Publishers.
7. Rout, G. R., & Das, A. B. (Eds.). (2013). Molecular stress physiology of plants. Springer Science & Business Media.
8. Gardner, F. P., Pearce, R. B., & Mitchell, R. L. (2017). Physiology of crop plants. Scientific publishers.
9. Bala, M., Gupta, S., & Gupta, N. K. (2013). Practicals in plant physiology and biochemistry. Scientific Publishers.
10. Hemantaranjan, A. (2005). Advances in Plant Physiology (Vol. 7) (Vol. 7). Scientific Publishers

11.Fitter, A. and Hay, R.K.M. 2001. Environmental Physiology of Plants. Academic Press, UK.

Course Title: Climate Change and Vegetation		**Course Code:** BOT-526
Course Structure: Lecture. 3 Lab. 0		**Credit hours:** 3
Pre-requisite	None	

Objectives

- The course aims to equip students with the knowledge and skills needed to understand the complex interactions between climate change and vegetation, and to develop strategies for addressing the challenges posed by these interactions.

Course Outline

Introduction to Climate Change and Vegetation (Climate change and its causes; Importance of vegetation in the ecosystem; Introduction to different types of vegetation and their characteristics); **Impact of climate change on vegetation and Forests (**Effects of temperature and precipitation changes on forest ecosystems**;** Case studies on the impact of climate change on different forest types**;** Strategies for mitigating the impact of climate change on forests); **Impact of Climate Change on Grasslands and Wetlands (**Vulnerability of grasslands and wetlands to climate change; Role of grasslands and wetlands in carbon sequestration; Conservation efforts to protect grasslands and wetlands from the effects of climate change); **Impact of Human Activities on Vegetation (**Deforestation and its impact on climate change; Agriculture and its contribution to greenhouse gas emissions; Urbanization and its effects on vegetation and the environment; rising CO2, warming, topospheric zone and nitrogen deposition, land atmosphere interactions and modeling); **Adapting Vegetation to Climate Change** (Plant breeding and genetic modification for climate resilience; Restoration and reforestation efforts to combat the effects of climate change; Sustainable land management practices to support healthy vegetation); **Important implications for ecosystem services** (such as food security, forest production, biodiversity, livelihood in low-income regions, and the regulation of biogeochemical cycles, hydrology and climate); **Effects of climate change in Pakistan (**National Climate change policy, Impact of climate change on Agriculture in Pakistan, The representation of plants and vegetation in ecosystem and climate models, Microclimates and vegetation).

Outcomes

Upon completion of this course, students will be able to understand and describe global climate change and critically analyse the ways in which its effects may have impacts on plant biology

Books Recommended

1. Sengar, R. S and K. Sengar. 2014. Climate Change Effect on Crop Productivity. CRC Press
2. Ali, M.2013. Climate change Impacts on Plant Biomass Growth. Springer
3. Adams, J. Vegetation-Climate Interactions. How Vegetation Makes the Global Enviornment. Praxis Publishing, Chichester, UK.
4. Dodson, J. 2010. Changing Climates, Earth Systems and Society. SpringerRozema, J, R. Aerts and H. Cornerlissen. 2006. Plants and Climate Change. Springer

5. Fahad, S., Hasanuzzaman, M., Alam, M., Ullah, H., Saeed, M., Khan, I. A., & Adnan, M. (Eds.). (2020). Environment, climate, plant and vegetation growth. Springer International Publishing.
6. Fahad, S., Sonmez, O., Saud, S., Wang, D., Wu, C., Adnan, M., & Turan, V. (Eds.). (2021). Climate change and plants: biodiversity, growth and interactions. CRC press.
7. Singh, R. B., Schickhoff, U., & Mal, S. (2016). Climate change, glacier response, and vegetation dynamics in the Himalaya. Cham, Switzerland: Springer International Publishing.
8. Fahad, S., Adnan, M., & Saud, S. (Eds.). (2022). Improvement of plant production in the era of climate change. CRC Press.
9. Jackson, M., Ford-Lloyd, B., & Parry, M. (Eds.). (2014). Plant genetic resources and climate change. Cabi.

Course Title: Paleobotany		**Course Code:** BOT-527
Course Structure: Lecture. 2 Lab. 1		**Credit hours:** 3
Pre-requisite	None	

Objectives

- To give knowledge to the students regarding the field of Palaeobotany, various processes and importance of fossilization and its use in phylogenetic and evolutionary studies of plants.

Course Outline

Introduction to Paleobotany (traditional and integrative approaches, study of paleobotany at different levels, Palaeobotanical nomenclature); **Introduction to fossilization**, fossilization process, Natural preservation of fossils in different environmental conditions; **Geological Time Scale** (The sequence of the plant world in geologic time. Various geologic eras, periods and epoch (million years); **Fossilization in rocks** (different types of rocks: Igneous rocks, Sedimentary rocks, Metamorphic); **Fossilization of non-vascular plants** (Bacteria, Fungi, Algae, Nematophytales, Bryophytes); **Fossilized Pteridophytes (Psilophytales):** Characteristics and Classification, Rhyniaceae, Zosterophylleaceae, Psilophytaceae, Asteroxylaceae, Lycopods, Lepidodendron, Medullosaceae, Calamopityaceae and Coryatospermaceae). **Position of the seed on plant**; **Cycadales & Ginkgoales. Ancient Conifers** (Paleozoic, Mesozoic and Cenozoic conifers, Phylogeny of conifers).

Outcomes

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

- Gain a comprehensive understanding of the field of Palaeobotany, which involves the study of ancient plant life based on fossil evidence.
- Learn about the different methods and techniques used in Palaeobotany research and the significance of studying ancient plant species for understanding Earth's history and evolutionary processes.

Lab outlines

1. Laboratory techniques for study of Fossils.
2. Observation of fossilized Prokaryots, Algae and Fungi, Living fossils and extinct fossils (Psilophytales, Pteridosperms, Cycadales & Ginkgos, The Ancient Conifers.
3. Coal ball cutting & Peel Technique.
4. Study trips to different archaeological and palaeobotanical sites for observation of different types of geological formation.

Books Recommended

1. Arnold, C. A. 1947. Introduction to Paleobotany. McGraw-Hill Book Company, Inc. New York & London.
2. Arkell, W. J. and Moy, J. A. 1940. Paleontology and the Taxonomic Problem. The New Systematic (Julian Huxley, editor), Oxford press, 1940.
3. Cleal, C. J. and Thomas, B. A. 2009. An Introduction to Plant Fossils. Cambridge University Press, New York.
4. Stewart, N. W. and G. W. Rothwell. 2010. Paleobotany and the Evaluation of Plants. Cambridge University Press, New York.
5. Taylor, E. L., Taylor, T. N., & Krings, M. (2009). Paleobotany: the biology and evolution of fossil plants. Academic Press.
6. Arnold, C. A. (2013). An introduction to paleobotany. Read Books Ltd.
7. Milsom, C., & Rigby, S. (2009). Fossils at a glance. John Wiley & Sons.
8. Retallack, G. J. (2008). Soils of the past: an introduction to paleopedology. John Wiley & Sons.
9. Traverse, A. (2007). Paleopalynology (Vol. 28). Springer Science & Business Media.

Course Title: Phycology and Bryology		**Course Code:** BOT-528
Course Structure: Lecture. 2 Lab. 1		**Credit hours:** 3
Pre-requisite	None	

Objectives

- To understand the classification, morphology and economic importance of Algae and Bryophytes

Course Outline

Phycology (Introduction, general account, evolution, classification, ecology and economic importance of the following divisions of algae: Chlorophyta (Oedogonium), Charophyta (Chara) Xanthophyta (Botrydium), Bacillariophyta (Diatoms), Phaeophyta (Ectocarpus) and Rhodophyta (Polysiphonia/Batrachospermum)**.**

Bryology (Introduction and general account, classification, Reproduction, theories of origin, evolution and economic importance of following classes of Bryophytes: Hepaticopsida (Marchantia), Anthoceropsida (Anthoceros) and Bryopsida (Polytrichum/ Funaria).

Outcomes

Upon completion of this course, students will be able to understand the physiology, reproduction and classification of Algea and Bryophytes.

Lab outlines

Phycology:

1. Field trips for Collection of fresh water algae.
2. Identification of benthic and planktonic algae
3. Section cutting of thalloid algae and Preparation of temporary slides
4. Use of camera lucida/micrographs.

Bryology

1. Field trip of Hilly areas for collection of Bryophytes
2. Section cutting of Bryophytes and preparation and identification of temporary slides.

Books Recommended

1. Bold, H. C. and M.J. Wynne 1985. Introduction to Algae: structure and reproduction. Prentice Hall Inc. Engle Wood Cliffs
2. Lee. R.E. 1999. Phycology. Cambridge University Press, U.K.
3. Dawson, E.Y., Halt. 1966. Marine Botany. Reinhart and Winstan, New York.
4. Chapman, V.J. and D.J. Chapman. 1983. Sea weed and their uses. McMillan and Co. Ltd. London.
5. Vashishta. B. R. 1991. Botany for degree students. Bryophytes 8th ed. S. Chand and Co. Ltd. Delhi.
6. Schofield, W.B. 1985. Introduction to Bryology. Macmillan Publishing Co. London.
7. Hussain, F. and I. Ilahi. 2004. A text book of Botany. Department of Botany, University of Peshawar.
8. Kim, S. K. (Ed.). (2011). Handbook of marine macroalgae: biotechnology and applied phycology. John Wiley & Sons.
9. Hoek, C., Mann, D., & Jahns, H. M. (2006). Algae: an introduction to phycology. Cambridge university press.
10. Gordon, R., & Seckbach, J. (Eds.). (2012). The science of algal fuels: phycology, geology, biophotonics, genomics and nanotechnology (Vol. 25). Springer Science & Business Media.
11. Chopra, R. N. (2005). Biology of bryophytes. New Age International.
12. Hanson, D. T., & Rice, S. K. (Eds.). (2014). Photosynthesis in bryophytes and early land plants (Vol. 37). Dordrecht, Netherlands: Springer.
13. Lockhart, N., Hodgetts, N., Holyoak, D. T., & National Museums Northern Ireland. (2012). Rare and threatened bryophytes of Ireland (pp. 470-1). Holywood: National Museums Northern Ireland.
14. Goffinet, B. (2008). Bryophyte biology. Cambridge University Press.
15. Vanderpoorten, A., & Goffinet, B. (2009). Introduction to bryophytes. Cambridge University Press.

Course Title: Plant Interactions with Microbes and Insects		**Course Code:** BOT-529
Course Structure: Lecture. 3 Lab. 0		**Credit hours:** 3
Pre-requisite	None	

Objectives

- This course provides an in-depth exploration of the fascinating interactions between plants and microorganisms, as well as plants and insects.

Course Outline

Introduction to Plant-Microbe and Plant-Insect Interactions (Types of interactions and importance; **Plant-Microbe Interactions** (Mutualistic interactions: mycorrhizal associations, nitrogen-fixing bacteria, Pathogenic interactions: fungal, bacterial, and viral diseases in plants, Beneficial microbes: plant growth-promoting rhizobacteria, endophytes); **Plant-Insect Interactions** (Herbivory: feeding strategies, plant defenses, and adaptations; Mutualistic interactions: pollination, seed dispersal; Plant-insect chemical communication: plant volatiles and insect pheromones); **Ecological and Evolutionary Dynamics of Interactions** (Coevolutionary relationships between plants and microbes/insects, Impact of environmental factors on these interactions, Role of plant secondary metabolites in shaping interactions); **Physiological and Molecular basis of Interactions** (Plant immune responses to microbial pathogens and insect herbivores, Signal transduction pathways involved in plant defenses); Molecular basis of plant-microbe symbiosis and insect-plant interactions)

Outcomes

Upon completion of this course, students will be able to gain a comprehensive understanding of the diverse relationships that exist between plants and these organisms, including mutualistic, commensal, and parasitic interactions.

Books Recommended

1. Stacey, G., & Shan, L. (2018). Plant-Microbe Interactions. Hoboken, NJ: Wiley-Blackwell.
2. Maheshwari, D. K. (2015). Plant-Microbe Interactions in Agro-Ecological Perspectives. Cham, Switzerland: Springer International Publishing.
3. Agarwal, G. S., & Upadhyay, R. S. (2018). Plant-Microbe Interactions and Biological Control. Boca Raton, FL: CRC Press.
4. Stacey, G., & Shan, L. (2005). Plant-Microbe Interactions: Molecular and Genetic Perspectives. New York, NY: McGraw-Hill Education.
5. Hashmi, M. Z., & Khan, A. L. (2019). Plant-Microbe Interactions in Sustainable Agriculture. Cham, Switzerland: Springer International Publishing.
6. Maheshwari, D. K. (2017). Plant-Microbe Interactions: Nutrient Management. Cham, Switzerland: Springer International Publishing.
7. Mauch-Mani, B., & Sharma, P. (2019). Plant-Microbe Interactions: Beneficial and Harmful Interactions. Cham, Switzerland: Springer International Publishing.
8. Silva, F. J., & Santiago-Álvarez, J. A. (2016). Plant-Insect Interactions. Boca Raton, FL: CRC Press.

9. Price, P. W., Stewart, I. D. R. H. B., & Hambäck, P. A. (2018). Plant-Insect Interactions: Evolutionary Ecology across Trophic Levels. Boca Raton, FL: CRC Press.
10. Mitchell, C., & Fitzgerald, T. D. (2017). Plant-Insect Interactions: Adaptation and Resistance. Oxford, UK: Oxford University Press.

YEAR-IV

SEMESTER–VII

Course Title: Mycology	**Course Code:** BOT-631
Course Structure: Lecture. 2 Lab. 1	**Credit hours:** 3
Pre-requisite	None

Objectives

- To introduce the students to Mycology and Diseases caused by Fungi.

Course Outline

Study of the structure, characteristics and economic importance with respect to following groups: **Mastigomycotina**: General characteristics classification reproduction (life cycle) and relationship with other classes of fungi, Classes – Chytridiomycetes. Oomycetes and plamodiophoromycetes; **Zygomycotina** (General characteristics classification reproduction (life cycle) and relationship with other classes of fungi, Class – Zygomycetes); **Ascomycotina** (General characteristics classification reproduction (life cycle) and relationship with other classes of fungi, **Classes**: Hemiascomycetes, Plectomycetes, Pyenomycetes, Discomycetes; Loculoascomycets; **Basidiomycotina** (General characteristics classification reproduction (life cycle) and relationship with other classes of fungi, Class: Ustilaginomycetes (smuts), Class: Urediniomycetes, Class: Tremellomycetes/Phragmobasidiomycetes, Class: Dacrymycetes Class: Agaricomycetes/Hymenomycetes; **Deuteromycotina** (General characteristics classification reproduction (life cycle) and relationship with other classes of fungi, Classes – class: Blastomycetes class: Hyphomycetes class: Coleomycetes class: Mycelia Sterilia); **Lichens** (General characteristics classification, reproduction (life cycle) of the major, classes of Lichens); **Mycorrhiza** (General account, Types of mycorrhiza and their significance); **Economic Importance of fungi** (Importance of fungi in human affairs with special reference to industry and agriculture)

Outcomes

Upon completion of this course, students will be able to describe the essential concepts of mycology to demonstrate the nature and major components of fungi, classification and reproduction.

Lab outlines

1. General characters and morphology of fungi.
2. Study of unicellular and mycelial forms with septate and aseptate hyphae.

3. Distinguishing characters of different phyla: study of suitable examples.
4. Study of asexual and sexual reproductive structures in different groups of fungi.
5. Study of some common examples of saprophytic, parasitic and air-borne fungi belonging to different phyla.

Books Recommended

1. Alexopoulos, C.J., Mims, C.W. and Blackwell, M., 1996. Introductory Mycology, 4th ed. John Wiley & Sons.
2. Mehrotra, R.S. and Aneja, K.R., 1990. An Introduction to Mycology. Wiley and Eastern Ltd., New Delhi, India.
3. Moore-Landecker, E., 1996. Fundamentals of Fungi. 4th ed. Prentice Hall Inc., New Jersey, USA.
4. Mehrotra, R. S., & Aneja, K. R. (2008). An introduction to mycology. New Age International.
5. Reiss, E., Shadomy, H. J., & Lyon, G. M. (2011). Fundamental medical mycology. John Wiley & Sons.
6. Chander, J. (2017). Textbook of medical mycology. JP Medical Ltd.
7. Ulloa, M., & Hanlin, R. T. (2000). Illustrated dictionary of mycology. APS press.
8. An, Z. (Ed.). (2004). Handbook of industrial mycology. CRC Press.

Course Title: Plant Pathology		**Course Code:** BOT-632
Course Structure: Lecture. 2	Lab. 1	**Credit hours:** 3
Pre-requisite	None	

Objectives

- To introduce the students to Pathology and Diseases caused by Fungi virus, Bacteria and nematodes in plants.

Course Outline

History (History of plant pathology, Concept of Plant Pathology, symptoms and its classification, causes of plant diseases, disease relationship and establishment); **Nature and classification of plant pathogens; Epidemeology of diseases; Dispersal of pathogens; Physiology of Parasitism;** Pre-penetration, penetration and post- penetration, general methods of plant disease control and principles, Biochemical basis of disease resistance. Phytoalexins, elicitors and plant disease protection; **Control of Plant diseases**; Exclusion, eradication, protection, breeding resistant varieties, Major types of fungicides; Influence of environmental factors on plant diseases; General account of non-parasitic diseases; **Important diseases** (Important diseases of crops, plants and fruit trees in Pakistan such as Damping off (Crucifers, tomatoes); Loose Smut (wheat); Covered smut of wheat; Black stem rust; Yellow stripe rust of wheat; Apple scab; Peach leaf curl; Late blight of potatoes; Red rot of sugarcane; Bacterial wilt of cucurbits; Tobacco Mosaic disease)

Outcomes

Upon completion of this course, students will be able to acquire knowledge about plant pathogens, diseases, and their management and gain skills in the isolation and identification of plant pathogens.

Lab outlines

1. Identification of major plant pathogens under lab and field conditions, cultural studies of some important plant pathogenic fungi, application of Koch's postulates for confirmation of pathogenicity. Demonstration of control measures through chemotherapeutants.
2. Basic plant pathological culture techniques
3. Pathogenicity of a pathogen
4. Effects of fungicides on spore germination
5. Macroscopic and microscopic examination of diseases specimens of the types studied.
6. Growth of aerial contaminants in culture
7. Isolation of pathogenic fungi from soil waters and air
8. Candidates will submit a collection of 20 properly preserved fungi or diseased specimen.

Books Recommended

1. Agrios, G.N., 2005. Plant Pathology, Academic Press, London.
2. Ahmad, I. and Bhutta, A.R., 2004. Textbook of Introductory Plant Pathology. Book Foundation, Pakistan.
3. Alexopoulos, C.J., Mims, C.W. and M. Blackwell. 1996. Introductory Mycology. 4th ed. John Wiley & Sons.
4. Khan, A.G. and R. Usman. 2005. Laboratory Manual in Mycology and Plant Pathology. Botany Department Arid Agriculture University, Rawalpindi.
5. Moore-Landecker, E. 1996. Fundamentals of Fungi. 4th ed. Prentice Hall Inc., New Jersey, USA.
6. Trigiano, R.N., Windham, M.T. and Windham, A.S., 2004. Plant Pathology: Concepts
7. and Laboratory Exercises. CRC Press, LLC, N.Y
8. Tronsmo, A. M., Collinge, D. B., Djurle, A., Munk, L., Yuen, J., & Tronsmo, A. (2020). Plant pathology and plant diseases. CABI.
9. Lucas, J. A. (2009). Plant pathology and plant pathogens. John Wiley & Sons.
10. Strange, R. N. (2003). Introduction to plant pathology. John Wiley & Sons.
11. Sinclair, J. B., & Dhingra, O. D. (2017). Basic plant pathology methods. CRC press.

SEMESTER–VIII

Course Title: Ethnobotany		**Course Code:** BOT-641
Course Structure: Lecture. 3	Lab. 0	**Credit hours:** 3
Pre-requisite	None	

Objectives

- To provide traditional knowledge about the uses of plant resources and their possible conservation.

Course Outline

An Introduction Ethnobotany (Definition and Concepts, History of Ethnobotany, Vegetation and Change: Spatial and Time Scales, Human Influence: Landscape and Species); **Ethnobotanical Perspectives** (Plants in Religion, Religious Usage, Oral Narratives: Folktales and Legends, Origin Myths); **Categories of Plant Resources** (Food, clothing, currency, ritual, medicine, dye, construction, cosmetics); **Medicinal Plants** (Preservation and Storage, Field collections, Plant Press and Identification, Effect of Pathogens and Storage); **Methods in Ethnobotany** (Methods of Propagation of Medicinal Plants Productions of Drugs, Isolation of Products, extraction of volatile oils, etc); **Medicinal Plants of Pakistan** (Openness in Trade Policy Making, Environmental assessment of trade agreements); **Applied Ethnobotany** (Commercialization, Introduction to Local Markets, Characteristics of Markets, Marketing chains and Type of Sellers, Inventory and Frequency of Sales); **Conservation (**Distribution: Degree of Threat and Disturbance, Land and Resource Use, Common Property Management, Harvesting Impacts, Conservation Behaviour); Brief review of ethnobotanical Work Done in Pakistan.

Outcomes

Upon completion of this course, students will be able to gain a deep understanding of traditional knowledge related to plant resources and their uses. They become aware of the importance of preserving this knowledge for future generations.

Books Recommended

1. Adnan, M., Patel, M., & Snoussi, M. (Eds.). (2023). Ethnobotany and Ethnopharmacology of Medicinal and Aromatic Plants: Steps Towards Drug Discovery. CRC Press.
2. Balick, M. J., Cox, P. A. (2020). Plants, People, and Culture: The Science of Ethnobotany. United States: CRC Press.
3. Martin, G. J. (2014). Ethnobotany: A Methods Manual. United Kingdom: Springer US.
4. Ali, R. 2012. An Introduction to Herbal Medicine in Ethnobotany. Vista International Pub House.
5. Abbasi, A. M., Khan, M. A., Ahmad, M., Zafar, M. 2011. Medicinal Plant Biodiversity of Lesser Himalayas-Pakistan. Germany: Springer.
6. Panda, H. (2010). Handbook On Drugs From Natural Sources. India: NIIR Project Consultancy Services.
7. Jain, S.K. (2010). (n.p.). Manual of Ethnobotany, 2nd Revised Ed.: Scientific Publishers.

Course Title: Medicinal Plants		**Course Code:** BOT-642
Course Structure: Lecture. 2	Lab. 1	**Credit hours:** 3
Pre-requisite	None	

Objectives

- To impart knowledge about use of plants to cure different diseases.

Course Outline

History of medicinal plants, occurrence and classification of crude drugs; Description, chemical constituents, local uses and Agro-ecological distribution of medicinal plants; National policy on the conservation of medicinal plants and the role of Greek medicine (Unanitib) and allied, and pharmaceutical industries; **Indigenous systems**, medicinal plant industry, medicinal plant trade, adulteration and authentication; **Scientific investigation of traditional Remedies and medicinal plants**, Ethnobotany and Ethnomedicine, Databases containing information on Medicinal plants, ethnobotany, ethnomedicine and phytochemistry

Outcomes

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

- Identify medicinal plants (family/genus -level)
- Identify by name and understand the effects of plant chemical constituents on humans and other organisms.

Lab outlines

1. Medicinal Plant Surveys
2. Conservation of medicinal plants
3. Laboratory Methods for Analysis of Medicinal Plants
4. Testing Hypotheses for medicinal plantsAmplification using PCR.

Books Recommended

1. Indigenous medicinal plants and tribals by Sarkar, Nandini 2013. Verlag: Random Publications
2. M. K. Rai, Geoffrey A. Cordell, Jose L. Martinez, 2012. Medicinal Plants: Biodiversity and Drugs, Taylor & Francis Group.
3. Ahmad, M., M. A. Khan and M. Zafar. 2010. Chemotaxonomic authentication of problematic medicinal plants. Lambert Academic Publishing (LAP) Germany & USA.
4. Kokwaro, J. O. (2009). Medicinal plants of east Africa. University of Nairobi press.
5. Koh, H. L., Chua, T. K., & Tan, C. H. (2009). Guide to medicinal plants, a: An illustrated scientific and medicinal approach. World scientific.
6. Hasan, A., M. A. Khan and M. Ahmad. 2007. Authenticity of Folk Medicinal Plants of Pakistan. Quaid-i-Azam University Islamabad Pakistan.
7. Dhananjay J. Deshpande, Agrobios, 2006, A Handbook of Medicinal Herbs : ISBN : 81-7754-298-2.
8. Trivedi, P. C. (2006). Medicinal plants: traditional knowledge. IK International Pvt Ltd.
9. Academic Dictionary of Medicinal Plant by Anita Chatterjee (Edi), 2005. New Delhi, ISHA
10. P.Y. Ansary, 2005. A Hand Book on the Plant Sources of Indigenous Drugs: International Book Distributors
11. Medicinal Plants by Kurian, Alice 2007. New Delhi, New India Publishing

Course Title: Applied Botany	**Course Code:** BOT-643
Course Structure: Lecture. 2 Lab. 1	**Credit hours:** 3
Pre-requisite None	

Objectives

- To enable the students to utilize their Botanical knowledge in their practical life for developing linkage with other subjects for the improvement of socioeconomic rehabilitation.

Course Outline

Definition, scope and interrelationship of Applied Botany; Establishment and maintenance of plant Nurseries; Town planning, Gardening, and interior decoration; **Commercial growth of High Valued Medicinal and Aromatic Plants**; **Wood technology and generation of foreign exchange; Development of Biofertilizers** e.g. Azolla mat, Blue Green algae, use of root nodules and mycorrhiza; **Plant Biodiversity and its role in controlling natural disasters** e.g. flood and soil erosion; Plant Biodiversity and its role in national economy; **Role of botanical knowledge in EIA for diverse developmental projects**; Green paperless office and its role in national economy; Mitigation of Climate Change and Carbon sequestration through Biodiversity Conservation; Role of Botany in tracing the archaeological traces; Using plants as mineral indicators

Outcomes

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

- Develop a conceptual understanding of principles and importance of Botany.
- To develop laboratory skill and be able to test soil, water, different physiological experiment.
- To demonstrate written and oral communication skills in communicating Botany – related topics and will provide and wok independently

Lab outlines

1. Various techniques used for propagation of plants in nursery
2. Training regarding town planning and interior decoration.
3. Growth techniques of various High Valued Medicinal and Aromatic Plants
4. Visits to various furniture industries to understand the Wood technology and generation of foreign exchange
5. Development of Azolla mat, Nostoc and Anabena colonies
6. Study the role of root nodules and mycorrhiza in bringing soil Fertility
7. Plantation of riparian vegetation
8. One day workshop on Green paperless office and Mitigation of Climate Change and Carbon sequestration

Books Recommended

- The instructor will involve the students in developing the existing Botanical knowledge for converting it in to a skill. For this purpose diverse books, scientific journals, news papers and internet will consulted.

COMPLETE LIST OF OPTIONAL COURSES OFFERED BY DEPARTMENT OF BOTANY

S. No.	Course Code	Course Title	Credit Hours
1.	BOT-666	DNA Recombinant Technology	3
2.	BOT-667	Industrial Aspects of Plants	3
3.	BOT-668	Ecosystem Management	3
4.	BOT-669	Plant Biotechnology for Sustainable Development	3
5.	BOT-671	Plant Tissue Culture	3
6.	BOT-672	Biofuel Technology	3

Course Title: Recombinant DNA Technology		**Course Code:** BOT-666
Course Structure: Lecture. 3 Lab. 0		**Credit hours:** 3
Pre-requisite	None	

Objectives

- To familiarize students with the mechanisms of gene cloning, practical aspects of recombinant DNA technology, model organisms in recombinant DNA technology, recombinant gene expression systems.

Course Outline

Overview and scope of Biotechnology, Principles and methods of recombinant DNA technology- Restriction modification enzymes used in recombinant DNA technology. Hybridization, cloning, sequencing, polymerase chain reaction, gene manipulations; **Cloning vectors** (cloning in E. Coli, plasmids, bacteriophages, cosmid vectors and yeast cloning vector. cloning strategies, genomic and cDNA library; Screening of gene libraries - screening by DNA hybridization, immunological assay); **DNA delivery methods** - physical methods and biological methods, expression of cloned genes in *E. coli*, products made in *E. coli* by genetic engineering); **Gene expression in prokaryotes** (Tissue specific promoter, wound inducible promoters, Strong and regulatable promoters); **Directed mutagenesis** (transposon mutagenesis, Gene targeting, Site specific recombination)

Outcomes

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

- Explain the underlying mechanisms of gene cloning,
- Discuss the practical aspects of applying recombinant DNA technology,
- Explain the significance of model organisms in recombinant DNA technology,

Describe recombinant gene expression systems

Books Recommended

1. Glick, B. R., Patten, C. L. (2022). Molecular Biotechnology: Principles and Applications of Recombinant DNA. United Kingdom: Wiley.
2. Wong, D. W. S. (2018). The ABCs of Gene Cloning. Switzerland: Springer International Publishing.
3. Zyskind, J. W., Bernstein, S. I. (2014). Recombinant DNA Laboratory Manual. United States: Elsevier Science.
4. Chaudhuri, K. (2013). Recombinant DNA Technology. India: Energy and Resources Institute.
5. Glover, D. M. (2013). Gene Cloning: The Mechanics of DNA Manipulation. Germany: Springer US.
6. Brown, T. A. (2013). Gene Cloning and DNA Analysis: An Introduction. Germany: Wiley.
7. Primrose SB, Twyman RM 2013, Principles of Gene Manipulation and Genomics (8th ed). Wiley-Blackwell, Oxford UK.
8. Primrose, S. B., Twyman, R. M. (2008). Gene and genome technology: principles and applications of recombinant DNA and genomics. United Kingdom: Blackwell.

Course Title: Industrial Aspects of Plants		**Course Code:** BOT-667
Course Structure: Lecture. 3 Lab. 0		**Credit hours:** 3
Pre-requisite	None	

Objectives

- To impart knowledge to the students on the industrial aspects of plants, sustainable agriculture and heritability of economically important traits.

Course Outline

Agricultural science, Agroforestry, Agronomy, Animal husbandry; **Extensive farming**, factory farming Farm Free range Industrial agriculture, Mechanised agriculture, Ministries Intensive farming, Organic farming; **Permaculture Stock-free agriculture**, Sustainable agriculture, Universities Urban agriculture plant domestication; **mating systems in crop plants**, continuous versus discontinuous variation traits, heritability of economically important traits, genetics of self and cross-pollinated crops, breeding methods with self and cross-pollinated crops, design of field experiments

Outcomes

At the end of the course, the students should be able to gain knowledge about industrial agriculture mating systems in plant domestication and different breeding methods.

Books Recommended

1. Van der Ent, A., Baker, A. J., Echevarria, G., Nicolas-Simonnot, M. O., & Morel, J. L. (Eds.). (2021). Agromining: Farming for metals. Springer.

2. Mohan, V. R., Tresina, P. S., & Doss, A. (Eds.). (2021). The Phytochemical and Pharmacological Aspects of Ethnomedicinal Plants. CRC Press.
3. Neumann, K., Kumar, A., Imani, J. (2020). Plant Cell and Tissue Culture – A Tool in Biotechnology: Basics and Application. Germany: Springer International Publishing.
4. Khan, A. S. (2017). Flowering Plants: Structure and Industrial Products. United Kingdom: Wiley.
5. Broertjes, C., & Van Harten, A. M. (2013). Applied mutation breeding for vegetatively propagated crops. Elsevier.
6. Hodson, M. J., Bryant, J. A. (2012). Functional Biology of Plants. United Kingdom: Wiley.
7. Hui, Y. H., Lisbeth Meunier-Goddik, JytteJosephsen and Wai-Kit Nip (2004). Handbook of Food and Beverage Fermentation Technology (Food Science and Technology). Edition: 2nd. CRC press

Course Title: Ecosystem Management		**Course Code:** BOT-668
Course Structure: Lecture. 3 Lab. 0		**Credit hours:** 3
Pre-requisite	None	

Objectives

- To understand the organization of communities at various spatial scales
- To investigate the functioning of communities, through time, in relation with environmental constrains (dispersal, environmental stress and disturbance)

Course Outline

Ecosystem (Definition, types and components of ecosystem, Food chain and Food web**); Biogeochemical cycles** (Definition, types with emphasis on Nitrogen & Hydrological cycles)**; Definitions and history of ecosystem management (**Laws that govern ecosystem management**,** Ecosystem goods and services**,** Ecosystem stressors**,** Threats to Public lands**,** Species approach to management**,** Ecological processes approach to management**,** Landscape approach to management)**; Ecological processes** (Disturbance**,** Historical range of variability**,** Restoration**,** Adaptive management**,** Monitoring)**; Managing for complexity and uncertainty** (Temporal and spatial scales of ecosystem management**,** Strategic approaches to ecosystem management, Barriers to ecosystem management and Sustainability)

Outcomes

Upon completion of this course, students will be able to

- Assess the role of individual species (e.g. keystone species) and functional groups in communities
- Understand the sapatio-temporal dynamics of communities within complex systems and biodiversity change

Books Recommended

1. Weathers, K. C., Strayer, D. L., & Likens, G. E. (Eds.). (2021). Fundamentals of ecosystem science. Academic Press.

2. Lipschutz, R. D. (2023). Ecological Security: Climate Change and the Construction of Security.
3. Alagona, P. S. (2022). The accidental ecosystem: People and wildlife in American cities. Univ of California Press.
4. Akiva, T., & Robinson, K. H. (Eds.). (2022). It Takes an Ecosystem: Understanding the People, Places, and Possibilities of Learning and Development Across Settings. IAP.
5. Weathers, K. C., Strayer, D. L., & Likens, G. E. (Eds.). (2021). Fundamentals of ecosystem science. Academic Press.
6. Wondolleck, J. M., & Yaffee, S. L. (2017). Marine ecosystem-based management in practice: different pathways, common lessons. Island Press.
7. Handmer, J. (2017). Ecology, uncertainty and policy: managing ecosystems for sustainability. Routledge.
8. Mulvihill, P., & Ali, S. H. (2016). Environmental management: critical thinking and emerging practices. Routledge.

Course Title: Plant Biotechnology for Sustainable Development		**Course Code:** BOT-669
Course Structure: Lecture. 3	Lab. 0	**Credit hours:** 3
Pre-requisite	None	

Objectives

- To know about concept of bioremediation
- To learn about biofuels and bioenergy

Course Outline

Biotechnology and its scope (Nothing is waste, an approach towards sustainable development); **Biofuels and bioenergy and 'bioplastics'** (Biodegradation and bio-deterioration, pollution and the principles of bioremediation, Microbial population dynamics, Environmental Impact Statement (EIS) for bioremediation and phytoremediation); **Environmental or 'green' biotechnology** (Phytoremediation, Bioremediation of organics, inorganics and phyto mining, Marine biotechnology and biofouling); Agricultural biotechnology and biocontrol.

Outcomes

Upon completion of this course, students will be able to to understand role of soil degradable bioplastics for a Sustainable Modern

Books Recommended

1. Srivastava, D. K., Thakur, A. K., & Kumar, P. (Eds.). (2021). Agricultural biotechnology: Latest research and trends (pp. 1-36). Singapore: Springer.
2. Khurana, S. P., & Gaur, R. K. (Eds.). (2019). Plant biotechnology: Progress in Genomic era. Springer.

3. Sahni, S., Prasad, B. D., & Kumar, P. (Eds.). (2017). Plant Biotechnology, Volume 2: Transgenics, Stress Management, and Biosafety Issues. CRC Press.
4. Abdin, M. Z., Kiran, U., & Ali, A. (Eds.). (2017). Plant biotechnology: principles and applications. Springer Singapore.
5. Prasad, B. D., Sahni, S., Kumar, P., & Siddiqui, M. W. (Eds.). (2017). Plant Biotechnology, Volume 1: Principles, Techniques, and Applications. CRC Press.
6. Sahni, S., Prasad, B. D., & Kumar, P. (Eds.). (2017). Plant Biotechnology, Volume 2: Transgenics, Stress Management, and Biosafety Issues. CRC Press.
7. Govil, C. M., Aggarwal, A., & Sharma, J. (2017). Plant biotechnology and genetic engineering. PHI Learning Pvt. Ltd..
8. Stewart Jr, C. N. (Ed.). (2016). Plant biotechnology and genetics: principles, techniques, and applications. John Wiley & Sons.

Course Title: Plant Tissue Culture		**Course Code:** BOT-671
Course Structure: Lecture. 3 Lab. 0		**Credit hours:** 3
Pre-requisite	None	

Objectives

- To enable the students to utilize their Botanical knowledge in their practical life for developing linkage with other subjects for the improvement of socioeconomic rehabilitation.

Course Outline

Introduction to plant tissue and cell culture; Concepts of totipotency; History and development of plant tissue culture techniques; **Culture media** (types of media used for tissue- and cell cultures. Preparation of media); **Callus cultures** (Choice and selection criteria of explants. Preparation and sterilization of explants. Callus induction, sub-culturing and maintenance. Different types of calluses); **Cell suspension cultures** (Initiation of cell suspension cultures from callus and mesophyll cells. Sub culturing and measurement of growth. Growth dynamics. Continuous cultures); **Plant protoplasts** (definition, preparation of protoplasts from plant tissue and cell cultures. Parameters of protoplast preparation, fusion, maintenance of plant protoplasts. Somatic hybridization and genetic manipulation); **Germplasm storage and cryopreservation** (basic concept, storage and conservation techniques, cryopreservation and cryoprotactants. Storage procedures. Minimal growth medium and slow growth); **Virus and Pathogen free plants** (Preparation of virus and pathogen free plants. Advantages and productivity of virus free plant. Preparation of virus free potato plants as a model system); **Embryogenesis, organogenesis and plant regeneration** (mode of plant regeneration. Ex-plant factors. Nutrition and growth regulator requirements. Indirect somatic and direct asexual embryogenesis); **Organogenesis and plant regeneration** (potential and problems in plant regeneration. Micropropagation); **Organ culture** (root culture. Practical applications and current trends in plant tissue and cell culture techniques); **Growth hormones** (Role of growth hormones in plant tissue and cell cultures)

Outcomes

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

- Develop a conceptual understanding of principles and importance of Botany.
- To develop laboratory skill and be able to test soil, water, different physiological experiment.
- To demonstrate written and oral communication skills in communicating Botany – related topics and will provide and wok independently

Books Recommended

1. Nhut, D. T., Tung, H. T., & Yeung, E. C. (Eds.). (2022). Plant Tissue Culture: New techniques and application in horticultural species of tropical region (pp. 383-397). Singapore:: Springer.
2. Rai, A. C., Kumar, A., Modi, A., & Singh, M. (Eds.). (2022). Advances in Plant Tissue Culture: Current Developments and Future Trends. Academic Press.
3. Gupta, S., & Chaturvedi, P. (2022). Commercial scale tissue culture for horticulture and plantation crops (pp. 1-21). Singapore: Springer.
4. Park, S. (2021). Plant tissue culture: techniques and experiments. Academic Press.
5. Neumann, K. H., Kumar, A., & Imani, J. (2019). Plant cell and tissue culture: a tool in biotechnology (Vol. 12). Berlin: Springer.
6. Neumann, K. H., Kumar, A., & Imani, J. (2018). Plant cell and tissue culture: a tool in biotechnology (Vol. 12). Berlin: Springer.y
7. Pullaiah, T., Rao, M. S., & Sreedevi, E. (2017). Plant Tissue Culture: Theory & Practicals 2nd Ed. Scientific Publishers.
8. Trigiano, R. N., & Gray, D. J. (Eds.). (2016). Plant tissue culture, development, and biotechnology. CRC Press.
9. Kumar, S., Mishra, S., & Mishra, A. P. (2016). Plant tissue culture: theory and techniques. Scientific Publishers.

Course Title: Biofuel Technology		**Course Code:** BOT-672
Course Structure: Lecture. 3 Lab. 0		**Credit hours:** 3
Pre-requisite	None	

Objectives

- To enable the students to acquire knowledge of principles and processes involved in biofuel production.
- To Understand alternative renewable fuels comprehensively.

Course Outline

Introduction to Bioenergy and Biofuel (Background and introduction to bioenergy and biofuel; First, second and third generation fuels; drivers of bioenergy development; current trends in energy production and consumption; Bioenergy and sustainability); **Biomass** (Introduction, biomass fuel characterization; types of biomass (woody and non woody; supply, harvesting, transport and processing of biomass); **Biomass Conversion into Products and Transport** (Background; thermochemical conversion by combustion and steam cycle; thermochemical conversion by gasification and pyrolysis; biochemical conversion; cogeneration of combined heat and power; biofuels transport); **Small Scale Bioenergy Systems-Present and Future** (Primary energy conversion technologies; secondary energy conversion technologies; electricity generation system); **Bioenergy, Sustainability and Future Potential** (Sustainability issues using biomass production; carbon sinks, greenhouse gases and use of biomass; future potential for bioenergy and the barriers)

Outcomes

Upon completion of this course, students will be able to evaluate and demonstrate the process of bio fuel production.

Books Recommended

1. Shadangi, K. P. (Ed.). (2021). Liquid Biofuels: Fundamentals, Characterization, and Applications. John Wiley & Sons.
2. Srivastava, N., Srivastava, M., Mishra, P. K., & Gupta, V. K. (Eds.). (2020). Biofuel production technologies: critical analysis for sustainability (p. 167). Singapore: Springer.
3. Srivastava, N., Srivastava, M., Mishra, P. K., & Gupta, V. K. (Eds.). (2020). Substrate analysis for effective biofuels production. Springer Nature.
4. Kumar, N. (Ed.). (2020). Biotechnology for biofuels: a sustainable green energy solution. Springer Nature.
5. Sarangi, P. K., Nanda, S., & Mohanty, P. (Eds.). (2018). Recent advancements in biofuels and bioenergy utilization (Vol. 232). Berlin, Germany: Springer.
6. Nageswara-Rao, M., & Soneji, J. (Eds.). (2018). Advances in Biofuels and Bioenergy. BoD–Books on Demand.
7. Srivastava, N., Srivastava, M., Pandey, H., Mishra, P. K., & Ramteke, P. W. (Eds.). (2018). Green nanotechnology for biofuel production (Vol. 5). Springer.
8. Love, J., & Bryant, J. A. (Eds.). (2017). Biofuels and bioenergy. John Wiley & Sons.
9. Luque, R., & Clark, J. (Eds.). (2016). Handbook of biofuels production: Processes and technologies. Elsevier.
10. Hakeem, K. R., Jawaid, M., & Rashid, U. (2016). Biomass and bioenergy. Springer International Pu.