

BACHELOR STUDIES
IN
BOTANY
(BS 4-Year Degree Program)



DEPARTMENT OF BOTANY
UNIVERSITY OF PESHAWAR

BS BOTANY

PROGRAM DESCRIPTION

The Bachelor Studies (BS) in Botany program is designed in accordance with the provisions of the HEC Undergraduate Education Policy V 1.1. to provide students with a robust understanding of plant sciences, addressing both local and global perspectives. The program integrates molecular, cellular, organismal, and ecological dimensions to equip students with the skills necessary for research, industry, and further academic pursuits in botany and related fields. Spanning eight semesters, the curriculum offers a balanced and progressive learning experience. The first four semesters focus on general education courses, establishing a strong foundation in essential scientific principles and analytical skills. Subsequent semesters delve into specialized major courses that cover a broad range of topics in the field of botany. These courses are particularly tailored to address the unique flora and ecological challenges of Pakistan. Throughout the program, students will be able to gain hands-on experience with modern laboratory and field techniques. Emphasis is placed on practical and technical proficiency, with a focus on molecular biology and environmental assessment tools relevant to Pakistan's biodiversity and agricultural needs. This approach ensures that graduates are well-prepared for the real-world challenges and opportunities in plant sciences within the Pakistani context. Through this program, students will be able to learn to effectively convey scientific knowledge and research findings, preparing them for careers in academia, research institutions, environmental organizations, and the biotechnology industry, both within Pakistan and internationally. The ultimate aim of this degree program is to produce well-rounded, knowledgeable, and skilled botanists who are capable of making significant contributions to the field of plant sciences.

RECOMMENDED NOMENCLATURE

For the purpose of standardization, the recommended nomenclature for the four-year degree program in Botany is “Bachelor Studies (BS) in Botany”.

PROGRAM LEARNING OUTCOMES

By the completion of Bachelor Studies (BS) in Botany, the graduates will be able to:
Demonstrate a comprehensive understanding of fundamental concepts in botany,

integrating knowledge across cellular, molecular, organismal, and ecological levels. Effectively use methods and techniques as applied in the field of botany.

Communicate scientific knowledge and research findings while demonstrating a commitment to continuous learning and professional development in the field of botany.

ELIGIBILITY CRITERIA

Higher Secondary School Certificate (involving 12 years of schooling) or an IBCC equivalent qualification in any science group with a subject of Biology is the basic eligibility requirement for admission in the Bachelor Studies (BS) in Botany (BS). The admitting university may set minimum eligibility scores and may conduct entry / admission test through its own testing body or an external testing services provider of repute as per the screening, admission and merit calculation criteria approved by its statutory bodies.

PROGRAM STRUCTURE

The Bachelor Studies (BS) in Botany is structured in accordance with the provisions of the HEC Undergraduate Education Policy V 1.1. and comprises of minimum 135 credit hours spread over eight (08) regular semesters. Universities may offer courses up-to maximum of 144 credit hours provided that the total number of credit hours are reasonably set to achieve the Program Learning Objectives (PLOs) without putting undue burden on students.

The standard scheme of studies for Bachelor Studies (BS) in Botany is given below:

Minimum Credit Hours	136
General Education	40 credit hours (17 courses)
Discipline Related Courses / Major	78 credit hours (26 courses)
Interdisciplinary / Allied Courses	12 credit hours (4 courses)
Internship	3 credit hours
Capstone Project	3 credit hours
Program Duration	Minimum: 4 Years Maximum: 6 Years The maximum limit is further extendable to

	another year in extra-ordinary circumstances subject to approval of university's statutory body.
Semester Duration	16-18 weeks for regular semesters (1-2 weeks for examination) 8-9 weeks for summer semesters (1 week for examination)
Course Load (per semester)	15-21 credit hours for regular semesters Up-to 8 credit hours for summer semesters (for remedial/deficiency/failure/repetition courses only)
3 Credit Hours (Theory)	3 classes (1 hour each) OR 2 classes (1.5 hour each) OR 1 class (3 hours) per week throughout the semester.
1 Credit Hours (Lab / Field Work)	1 credit hour in laboratory or practical work / project requires lab contact of three hours per week throughout the semester.

SEMESTER WISE BREAKUP					
Courses: Code	Title of the Course	Theory	Lab	Credit hours	Category
1 st YEAR					
SEMESTER-1					
BOT-311	Cell Biology	2	1	3	Major
BOT-312	Diversity of Plants	2	1	3	Major
ZOO-311	Invertebrate Zoology (Natural Science*)	2	1	3	General Education
QR-311	Quantitative Reasoning I ** (Mathematics)	3	0	3	General Education
ENG-311	Functional English **	3	0	3	General Education
ICT-311	Applications of Information & Communication Technologies (ICT) **	2	1	3	General Education
	Fahm-ul-Quran-I	1	0	1	General Education
Sub Total		15	4	19	
SEMESTER-2					
BOT-321	Fundamentals of Plant Taxonomy	2	1	3	Major
	Fahm-ul-Quran-II	1	0	1	General Education
PS-321	Pakistan Studies	2	0	2	General Education
BOT-322	Fundamentals of Genetics & Evolution	2	1	3	Interdisciplinary
SS-321	Introduction to Sociology (Social Sciences***)	2	0	2	General Education
QR-321	Quantitative Reasoning II ** (Statistics)	3	0	3	General Education

ENG-321	Expository Writing **	3	0	3	General Education
Sub Total		15	2	17	
2nd YEAR					
SEMESTER-3					
BOT-431	Phycology & Bryology	2	1	3	Major
BOT-432	Mycology	2	1	3	Major
BOT-433	Plant Anatomy & Embryology	2	1	3	Major
PHIL-431	An Introduction to Philosophy (Arts & Humanities ****)	2	0	2	General Education
ISL-431	Islamic Studies ** (Ethics for non-Muslim students)	2	0	2	General Education
PST-431	Ideology & Constitution of Pakistan **	2	0	2	General Education
ZOO-431	Chordate Zoology	2	1	3	General Education
Sub Total		14	4	18	
SEMESTER-4					
CHEM-441	Organic Chemistry	2	1	3	General Education
BOT-441	Principles of Plant Ecology	2	1	3	Major
BOT-442	Principles of Plant Biochemistry	2	1	3	Major
BOT-443	Fundamentals of Plant Physiology	2	1	3	Major
SW-441	Civics & Community Engagement **	2	0	2	General Education
MGT-441	Entrepreneurship **	2	0	2	General Education
BOT-444	Plants and Society	2	1	3	Major
Sub Total		14	5	19	
3rd YEAR					

SEMESTER-5					
BOT-551	Advanced Plant Ecology	2	1	3	Major
BOT-552	Advanced Plant Biochemistry	2	1	3	Major
BOT-553	Advanced Plant Physiology	2	1	3	Major
BOT-554	Microbial Botany	2	1	3	Major
BOT-555	Pteridophytes & Gymnosperms	2	1	3	Major
Sub Total		10	5	15	
SEMESTER-6					
BOT-561	Systematics of Angiosperms	2	1	3	Major
BOT-562	Plant Pathology	2	1	3	Major
BOT-563	Molecular Genetics	2	1	3	Interdisciplinary
BOT-564	Biodiversity and Conservation	3	0	3	Interdisciplinary
BOT-565	Internship	3	0	3	Internship
BOT-566	Pharmacognosy (Elective – I)	2	1	3	Major
Sub Total		12	4	18	
4 th YEAR:					
SEMESTER-7					
BOT-671	Analytical Techniques in Botany	1	2	3	Major
BOT-672	Field Botany	2	1	3	Major
BOT-673	Phytogeography	2	1	3	Major
BOT-674	Scientific Inquiry & Research Methods	2	1	3	Interdisciplinary
BOT-675	Paleobotany(Elective – II *****)	2	1	3	Major
Sub Total		9	6	15	
SEMESTER-8					

BOT-681	Plant Biotechnology	2	1	3	Major
BOT-682	Economic & Industrial Botany	3	0	3	Major
BOT-683	Evolutionary Trends in Plants	2	1	3	Major
BOT-684	Wetland Ecology (Elective – III *****)	2	1	3	Major
BOT-685	Capstone Project	0	3	3	Capstone
Sub Total		9	6	15	

Courses: Code	Title of the Course	Theory	Lab	Credit hours	Category
1st YEAR					
SEMESTER-1					
BOT-311	Cell Biology	2	1	3	Major
BOT-312	Diversity of Plants	2	1	3	Major
ZOO-311	Invertebrate Zoology (Natural Science*)	2	1	3	General Education
QR-311	Quantitative Reasoning I ** (Mathematics)	3	0	3	General Education
ENG-311	Functional English **	3	0	3	General Education
ICT-311	Applications of Information & Communication Technologies (ICT) **	2	1	3	General Education
	Fahm-ul-Quran-I	1	0	1	General Education
Sub Total		15	4	19	

Course Code	Course Title	Credit hours	Theory	Lab	Category
BOT-311	Cell Biology	3	2	1	Major

Objectives: To understand the structure and functions of cell, cell membrane, cell organelles & nucleus. Familiarization with chromosomal aberrations and reproduction in somatic and embryonic cells.

Course outline

Cell Biology

1. Structures and Functions of Bio-molecules (Carbohydrates, Lipids, Proteins and Nucleic Acids)
2. Cell: Physico-chemical nature of plasma membrane and cytoplasm.
3. Ultra structure of plant cell with a brief description and functions of (Cell wall, Endoplasmic reticulum, Plastids, Mitochondria, Ribosomes, Dictyosomes, Vacuole, Microbodies (Glyoxysomes and Peroxisomes)
4. Nucleus: Nuclear membrane, nucleolus, ultra structure and morphology of chromosomes, karyotype analysis
5. Reproduction in somatic and embryogenic cell, mitosis and meiosis, cell cycle
6. Chromosomal aberrations; Changes in the number of chromosomes. Aneuploidy and euploidy. Changes in the structure of chromosomes, deficiency, duplication, inversion and translocation.

Lab. outlines

1. Study of cell structure using compound microscope and elucidation of ultra structure from electron microphotographs.
2. Measurement of cell size.
3. Study of mitosis and meiosis by smear/squash method and from prepared slides.
4. Study of chromosome morphology and variation in chromosome number.
5. Extraction and estimation of carbohydrate, protein, RNA and DNA from plant sources.

Books Recommended

1. Carroll, S. B., Grenier, J. K. and Welnerbee, S. D. 2001. From DNA to Diversity - Molecular Genetics and the Evolution of Animal Design. Blackwell Science.
2. Dyonsager, V. R. 1986. Cytology and Genetics. Tata and McGraw Hill Publication Co. Ltd., New Delhi.
3. Hoelzel, A. R. 2001. Conservation Genetics. Kluwer Academic Publishers.
4. Ingrouille, M. J. and Eddie, B. 2006. Plant Diversity and Evolution. Cambridge University Press.
Lewin, R, 1997. Principles of Human Evolution. Blackwell Science.
5. Lodish, H. 2001. Molecular Cell Biology. W. H. Freeman and Co.
6. Sinha, U. and Sinha, S. 1988. Cytogenesis Plant Breeding and Evolution, Vini Educational Books, New Delhi.
7. Strickberger, M. V. 1988. Genetics, MacMillan Press Ltd., London.
8. Strickberger, M. W. 2000 Evolution. Jones and Bartlet Publishers, Canada.
9. Verma, P. S. and V. K. Agarwal. 2009. Genetics. S. Chand and Co. Ltd., New Delhi.
10. Verma, P. S. and V. K. Agarwal. 2009. Cell Biology, Genetics, Molecular Biology, Evolution and Ecology. S. Chand and Co. Ltd., New Delhi.

Journals / Periodicals: Theoretical & Applied Genetics, The Cell, Heredity, Pakistan Journal of Botany.

Course Code	Course Title	Credit Hours	Theory	Lab	Category
BOT-312	Diversity of Plants	3	2	1	Major

Objectives: To introduce the students to the diversity of plants and their structures and significance.

Course outlines

1. Comparative study of life form, structure, reproduction and economic significance of:
 - a) Viruses (RNA and DNA types) with special reference to TMV.
 - b) Bacteria and Cyanobacteria (Nostoc, Anabaena, Oscillatoria) with specific reference to biofertilizers, pathogenicity and industrial importance.
 - c) Algae (Chlamydomonas, Spirogyra, Chara, Vaucheria, Pinnularia, Ectocarpus, Polysiphonia).
 - d) Fungi (Mucor, Penicillium, Phyllactinia, Ustilago, Puccinia, Agaricus), their implication on crop production and industrial applications.
 - e) Lichens (Physcia)
 - f) Bryophytes (Riccia, Anthoceros and Funaria)
 - g) Pteridophytes (Fossils and fossilization, Psilopsida (Psilotum), Lycopsida (Selaginella), Sphenopsida (Equisetum), Pteropsida (Marsilea) and Seed Habit).
 - h) Gymnosperms (Cycas, Pinus and Ephedra).

Lab. outlines

Culturing, maintenance, preservation and staining of microorganisms. Study of morphology and reproductive structures of the types mentioned in theory. Identification of various types mentioned from prepared slides and fresh collections.

Recommended Books

1. Agrios, G. N. 2004. Plant Pathology. 8th Ed. Academic press London.
2. Alexopoulos, C. J., Mims, C.W. and Blackwell, M. 1996. Introductory Mycology. 4th Ed. John Wiley and Sons Publishers.
3. Andrew, H. N. 1961. Studies in Paleobotany. John Willey and Sons.
4. Ingrouille, M. 1992. Diversity and Evolution of Land Plants. Chapman & Hall.
5. Lee, R. E. 1999. Phycology. Cambridge University Press, UK
6. Marti, J. 2006. Ingrouille & Plant: Diversity and Evolution. John Wiley and Sons Publishers.
7. Mauseth, J. D. 2003. Botany: An Introduction to Plant Biology 3rd ed., Jones and Bartlett Pub.UK.
8. Prescott, L. M., Harley, J. P. and Klein, A. D. 2004. Microbiology, 3rd Ed. WMC Brown Publishers.
9. Taylor, T. N. & Taylor, E. D. 2000. Biology and Evolution of Fossil Plants. Prentice Hall. N.Y.
10. Vashishta, B. R. 1991. Botany for Degree Students (all volumes). S. Chand and Company. Ltd. New Delhi.

Journals / Periodicals: Pakistan Journal of Botany, American Journal of Botany, Canadian

Course Code	Course Title	Credit Hours	Theory	Lab.	Category
ZOO-311	Invertebrate Zoology	3	2	1	General Education

Objectives: To provide students the concepts of evolutionary relationship of animal kingdom. The knowledge about animal kingdom, emphasizing their phylogenetic relationships and simple to complex mode of animal life.

Course outlines

1. Introduction

Classification of organisms; evolutionary relationships and tree diagrams; patterns of organization.

2. Animal-Like Protists: The Protozoa

Evolutionary perspective; life within a single plasma membrane; symbiotic life-styles. Protozoan taxonomy: (up to phyla, subphyla and super classes, wherever applicable). Pseudopodia and amoeboid locomotion; cilia and other pellicular structures; nutrition; genetic control and reproduction; symbiotic ciliates; further phylogenetic considerations.

3. Multicellular and Tissue Levels of Organization

Evolutionary perspective: origins of multicellularity; animal origins. Phylum porifera: cell types, body wall, and skeletons; water currents and body forms; maintenance functions; reproduction. Phylum cnidaria (Coelenterata) the body wall and nematocysts; alternation of generations; maintenance functions; reproduction and classification up to class. Phylum ctenophora; further phylogenetic considerations.

4. Triploblastics and Acoelomate Body Plan

Evolutionary perspective; phylum platyhelminthes: classification up to class; the free-living flatworms and the tapeworms; phylum nemertea; phylum gastrotricha; further phylogenetic considerations.

5. Pseudocoelomate Body Plan: Aschelminths

Evolutionary perspective; general characteristics; classification up to phyla with external features; feeding and the digestive system; other organ systems; reproduction and development of phylum rotifera and phylum nematoda; phylum kinorhyncha. Some important nematode parasites of humans; further phylogenetic considerations.

6. Molluscan Success

Evolutionary perspective: relationships to other animals; origin of the coelom; molluscan characteristics; classification up to class. The characteristics of shell and associated structures, feeding, digestion, gas exchange, locomotion, reproduction and development, other maintenance functions and diversity in gastropods, bivalves and cephalopods; further phylogenetic considerations.

7. Annelida: The Metameric Body Form

Evolutionary perspective: relationship to other animals, metamerism and tagmatization; classification up to class. External structure and locomotion, feeding and the digestive system, gas exchange and circulation, nervous and sensory functions, excretion, regeneration, reproduction and development, in polychaeta, oligochaeta and hirudinea; further phylogenetic considerations.

8. Arthropods: Blueprint for Success

Evolutionary perspective: classification and relationships to other animals; metamerism and tagmatization; the exoskeleton; metamorphosis; classification up to class; further phylogenetic considerations.

9. Hexapods and Myriapods: Terrestrial Triumphs

Evolutionary perspective; classification up to class. External structure and locomotion, nutrition and the digestive system, gas exchange, circulation and temperature regulation, nervous and sensory functions, excretion, chemical regulation, reproduction and development in hexapoda; insect behavior; insects and humans; further phylogenetic considerations.

10. Economic importance of Invertebrate

Lab. outlines

1. Study of *Euglena*, *Amoeba*, *Entamoeba*, *Plasmodium*, *Trypanosoma*, *Paramecium* as representative of animal like protists. (Prepared slides).
2. Study of sponges and their various body forms.
3. Study of principal representative classes of phylum Coelenterata.
4. Study of principal representative classes of phylum Platyhelminthes.
5. Study of representative of phylum Rotifera, phylum Nematoda.
6. Study of principal representative classes of phylum Mollusca.
7. Study of principal representative classes of phylum Annelida.
8. Study of principal representative classes of groups of phylum Arthropoda.
9. Brief notes on medical/economic importance of (*Plasmodium*, *Entamoeba histolitica*, *Leishmania*, Liver fluke, Tapeworm, Earthworm, Silkworm, Citrus butterfly).
10. Preparation of permanent stained slides of (*Obelia*, *Daphnia*, Cestode, Parapodia of *Nereis*).

Recommended Books

1. Campbell, N. A. Biology, 6th Edition. 2002. Menlo Park, California: Benjamin/Cummings Publishing Company, Inc.
2. Hickman, C. P., Roberts, L. S. and Larson, A. 2004. Integrated Principles of Zoology, 11th Edition (International). Singapore: McGraw Hill.
3. Hickman, C. P. and Kats, H. L. 2000. Laboratory Studies in Integrated Principles of Zoology. Singapore. McGraw Hill.
4. Kent, G. C. and Miller, S. Comparative Anatomy of Vertebrates. 2001. New York: McGraw Hill.
5. Miller, S. A. 2002. General Zoology Laboratory Manual. 5th Edition (International). Singapore. McGraw Hill.
6. Miller, S. A. and Harley, J. B. Zoology, 5th Edition (International). 2002. Singapore: McGraw Hill.
7. Pechenik, J.A. Biology of Invertebrates, 4th Edition (International). 2000. Singapore: McGraw Hill.
8. Rafique, K. M. 2003. Principles of Invertebrate Biology. Caravan Book House Lahore.

Course Code	Course Title	Credit Hours	Theory	Lab.	Category
QR-311	Quantitative Reasoning 1**(Mathematics)	3	3	0	General Education

COURSE OBJECTIVES

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

1. Fundamental numerical literacy to enable them to work with numbers, understand their meaning, and present data accurately.
2. Understanding of fundamental mathematical and statistical concepts.
3. Basic ability to interpret data presented in various formats, including but not limited to tables, graphs, charts, and equations, etc.

SYLLABUS

1. Numerical Literacy

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

2. Fundamental Mathematical Concepts

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

3. Mathematical Modeling and Analyses

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

SUGGESTED INSTRUCTIONAL / READING MATERIALS

1. *Quantitative Reasoning: Tools for Today's Informed Citizen* by Bernard L. Madison, Lynn, and Arthur Steen.
2. *Quantitative Reasoning for the Information Age* by Bernard L. Madison and David M. Bressoud.
3. *Fundamentals of Mathematics* by Wade Ellis.
4. *Quantitative Reasoning: Thinking in Numbers* by Eric Zaslow.
5. *Thinking Clearly with Data: A Guide to Quantitative Reasoning and Analysis* by Ethan Bueno de Mesquita and Anthony Fowler.
6. *Using and Understanding Mathematics: A Quantitative Reasoning Approach* by Bennett, C., Briggs, W. L., & Badalamenti, A.
7. *Discrete Mathematics and Its Applications* by Kenneth H. Rosen.
8. *Statistics for Technology: A Course in Applied Statistics* by Chatfield, C.
9. *Statistics: Unlocking the Power of Data* by Robin H. Lock, Patti Frazer Lock, Kari Lock Morgan, and Eric F. Lock.

Course Code	Course Title	Credit Hours	Theory	Lab	Category
ENG-311	Functional English **	3	3	0	General Education

Objectives: To enhance language skills and develop critical thinking among the students.

Course Contents

Analysis of phrase, clause and sentence structure

1. Basics of Grammar
2. Comprehension (Answers to questions on a given text)
3. Discussion (General topics and every-day conversation (topics for discussion to be at the discretion of the teacher keeping in view the level of students).
4. Listening (To be improved by showing documentaries/films carefully selected by subject teachers).
5. Parts of speech and use of articles
6. Practice in unified sentence
7. Presentation skills (Introduction)
8. Punctuation and spelling
9. Sentence structure, active and passive voice
10. Transitive and intransitive verbs

11. Translation skills (Urdu to english, paragraph writing, topics to be chosen at the discretion of the teacher).

Note: Extensive reading is required for vocabulary building.

Recommended books

1. Brain, T. and Rod, E. 1992. Upper Intermediate. Oxford Supplementary Skills. Third Impression.
2. Marie, C. B., Suzanne, B. and Francoise, G. 1993. Intermediate. Oxford Supplementary Skills. Fourth Impression.
3. Thomson, A. J. and Martinet, A. V. 1997a. Practical English Grammar. Exercises 1. Third Edition. Oxford University Press, London.
4. Thomson, A. J. and Martinet, A. V. 1997b. Practical English Grammar. Exercises 2. Third Edition. Oxford University Press, London.

Course Code	Course Title	Credit Hours	Theory	Lab	Category
ICT-311	Applications of Information & Communication Technologies (ICT) **	3	2	1	General Education

Objectives

To understand the fundamental concepts and components of ICT

To develop practical skills in using ICT tools and software.

To learn about emerging trends and technologies in the ICT field.

Course Outline

Brief history of Computer, Four Stages of History, Computer Elements, Processor, Memory, Hardware, Software, Application Software its uses and Limitations, System Software its Importance and its Types, Types of Computer, Introduction to CBIS (Computer Based Information System), Methods of Input and Processing, Class2. Organizing Computer Facility, Centralized Computing Facility, Distributed Computing Facility, Decentralized Computing Facility, Input Devices. Keyboard and its Types, Terminal (Dumb, Smart, Intelligent), Dedicated Data Entry, SDA (Source Data Automation), Pointing Devices, Voice Input, Output Devices. Soft- Hard Copies, Monitors and its Types, Printers and its Types, Plotters, Computer Virus and its Forms, Storage Units, Primary and Secondary Memories, RAM and its Types, Cache, Hard Disks, Working of Hard Disk, Diskettes, RAID, Optical Disk Storages (DVD, CD ROM), Magnetic Types, Backup System, Data Communications, Data Communication Model, Data Transmission, Digital and Analog Transmission, Modems, Asynchronous and Synchronous Transmission, Simplex. Half Duplex, Full Duplex Transmission, Communications, Medias (Cables, Wireless), Protocols, Network Topologies (Star, Bus, Ring), LAN, LAN, Internet, A

Brief History, Birthplace of ARPA Net, Web Link, Browser, Internet Services provider and Online Services Providers, Function and Features of Browser, Search Engines, Common Services available on Internet, Introduction to MS Word, MS Excel, MS PowerPoint.

PRACTICAL REQUIREMENTS:

As part of the overall learning requirements, the course will include:

1. **Guided tutorials and exercises** to ensure that students are proficient in commonly used software applications such as word processing software (e.g., Microsoft Word), presentation software (e.g., Microsoft PowerPoint), spreadsheet software (e.g., Microsoft Excel), among others. Students may be assigned practical tasks that require them to create documents, presentations, and spreadsheets, etc.
2. **Assigning of tasks** that involve creating, managing, and organizing files and folders on both local and cloud storage systems. Students will practice file naming conventions, creating directories, and using cloud storage solutions (e.g., Google Drive, OneDrive).
3. **The use of online learning management systems (LMS)** where students can access course materials, submit assignments, participate in discussion forums, and take quizzes or tests. This will provide students with practical experience with online platforms commonly used in education and the workplace.

RECOMMENDED BOOKS:

The following is the recommended list of books (or their latest editions):

1. Shelly, Gary B., and Misty E. Vermaat. Discovering Computers: Digital Technology, Data, and Devices. 17th Edition., Cengage Learning, 2022.
2. Sinha, P.K. Computer Fundamentals. 8th Edition., BPB Publications, 2020.
3. Williams, Brian K. Using Information Technology: A Practical Introduction to Computers & Communications. 11th Edition., McGraw-Hill Education, 2015.
4. O'Leary, Timothy J., and Linda I. O'Leary. Computing Essentials 2024. 29th Edition., McGraw-Hill Education, 2023.
5. K. Wilson, "Computer Fundamentals: The Step-by-step Guide to Understanding Computers," Elluminet Press, 2021.
6. J. Cox and J. Lambert, "Microsoft Word 2010 step by step," Microsoft Press, 2010
7. N. Muir, "Microsoft PowerPoint 2013 Plain & Simple," Microsoft Press, 2013.
8. C. Frye, "Microsoft Excel 2010 Step by Step," Microsoft Press, 2010.
9. M. Vermaat, E. Monk, S. Sebok, S. Freund, S. Cable, J. Starks, "Shelly Cashman Series Microsoft Office 365 & Office 2019 Introductory," Cengage, 2019

Course Code	Course Title	Credit Hours	Theory	Lab	Category
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	Fahm-ul-Quran-I	1	1	0	General Education
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Courses: Code	Title of the Course	Theory	Lab	Credit hours	Category
SEMESTER-2					
BOT-321	Fundamentals of Plant Taxonomy	2	1	3	Major
	Fahm-ul-Quran-II	1	0	1	General Education
PS-321	Pakistan Studies	2		2	General Education
BOT-322	Fundamentals of Genetics & Evolution	2	1	3	Interdisciplinary
SS-321	Introduction to Sociology (Social Sciences ***)	2	0	2	General Education
QR-321	Quantitative Reasoning II ** (Statistics)	3	0	3	General Education
ENG-321	Expository Writing **	3	0	3	General Education
Sub Total		14	3	17	
Course Code	Course Title	Credit Hours	Theory	Lab.	Category
BOT-321	Fundamentals of Plant Taxonomy	3	2	1	Major

Objectives: To understand various systems of classification, identification and nomenclature of higher plants.

Course outlines

1. **Introduction:** Taxonomy and Systematics, Phenetics and Cladistics Importance and relationship with other sciences Levels, Components and Phases of taxonomy, Objectives, Goals and Aims of Taxonomy
2. **Concept of Species:** What is a species? Taxonomic species, Biological species, Micro and macro species, Species aggregate, Infra specific categories.

3. **Systematics and Genecology / Biosystematics:** Introduction and importance, Methodology of conducting biosystematics studies, various biosystematics categories such as ecophene, ecotype, ecospecies, coenospecies and comparium.
4. **Variation and Speciation.** Types of variation, Continuous and discontinuous variation, Clinal variation. Modification of Phenotype. Speciation: Mechanism of speciation, Mutation and hybridization Geographical isolation, Reproductive isolation, Gradual and abrupt.
5. **Concept of Characters.** Introduction, Definition of characters. Types of characters
6. **Plant Identification:** What is Identification? Methods of Plant Identification.
7. **Plant Nomenclature:** History of Nomenclature. Principles, Rules and Recommendations of Nomenclature (The International Code of Nomenclature for algae, fungi, and plants).
8. **Plant Classification.** What is Classification? Aims, history of classification. Taxa-Ranks of Plant Classification. The Taxonomic Hierarchy. Types of Systems of Classification. Some Important Systems of Classification. Comparison of Systems of Classification. Current Systems of Classification
9. **Taxonomic Evidence:** Importance and types of taxonomic evidences: anatomical, cytological, chemical, molecular, palynological, geographical and embryological (Numerical Taxonomy, Chemotaxonomy, Serotaxonomy and Molecular Taxonomy or Molecular systematics)
10. **Phytography/Morphology:** A detailed account of various, morphological characters of root, stem, leaf, inflorescence, flower, placentation and fruit types.

Lab. outlines

Study of type specimens at various herbaria, preparation of herbarium specimens, study of International Code of Nomenclature for Plants, algae and Fungi. Study of various kinds of root, stem, leaf, inflorescence, flower, placentation and fruit types. Visits to various herbaria in the country.

Recommended Books

1. Eames, A. J. and MacDaniels, L. H. 2002. An Introduction to Plant Anatomy. Tata-Mac Graw-Hill Publishing Company, Limited New Delhi.
2. Esau, K. 1960. Anatomy of Seed Plants. John Wiley, New York.
3. Fahn, A. 1990. Plant Anatomy. Pergamon Press, Oxford.
4. Lawrence, G. H. M. 1951. Taxonomy of Vascular Plants. MacMillan & Co. New York.
5. Mauseth, J. D. 1998. An Introduction to Plant Biology: Multimedia Enhanced. Jones and Bartlett Pub. UK
6. Moore, R. C., Clarke, W. D. and Vodopich, D.S. 1998. Botany. McGraw Hill Company, USA.
7. Naik, V.N. 2005 Taxonomy of Angiosperms. 20th Reprint. Tata-Mac Graw-Hill Publishing Company, Limited New Delhi.
8. Panday, B. P. 2004. A textbook of Botany (Angiosperms). S. Chand and Co. New Delhi.
9. Pullaiah, T. 2007. Taxonomy of Angiosperms. 3rd Edition Regency Publications, New Delhi.
10. Raven, P. H., Evert, R. E. and Eichhorn, S. E. 1999. Biology of Plants. W. H. Freeman and Company Worth Publishers.

11. Raymond E, Eichhorn, S. E. 2005. Esau's Plant Anatomy. Meristems cells and tissues of the plant body, 3rd Ed. John Wiley & Sons. Inc.
12. Stuessy, T. F. 1990. Plant Taxonomy. Columbia University Press, USA.

Journals / Periodicals: Pakistan Journal of Botany, Taxon, Phytan.

Course Code	Course Title	Credit Hours	Theory	Lab.	Category
	Fundamentals of Plant Taxonomy	3	2	1	Major

Course Code	Course Title	Credit Hours	Theory	Lab.	Category
PS-321	Pakistan Studies	2	2	0	General Education

Course Objectives

Develop a vision of the historical perspective, government, politics, contemporary Pakistan, and ideological background of Pakistan. Study the process of governance, national development, issues arising in the modern age, and posing challenges to Pakistan.

Course Contents

1. Historical Perspective

- a. Ideological rationale with special reference to Sir Syed Ahmed Khan, Allama Muhammad Iqbal and Quaid-i-Azam Muhammad Ali Jinnah.
- b. Factors leading to Muslim separatism
- c. People and Land
 - i. Indus Civilization
 - ii. Muslim advent
 - iii. Location and geo-physical features.

2. Government and Politics in Pakistan Political and constitutional phases:

- a. 1947-58
- b. 1958-71
- c. 1971-77
- d. 1977-88
- e. 1988-99
- f. 1999 onward

3. Contemporary Pakistan

a. Economic institutions and issues

b. Society and social structure

c. Ethnicity

d. The foreign policy of Pakistan and challenges

e. Futuristic outlook of Pakistan Recommended Books

1. Burki, Shahid Javed. State & Society in Pakistan, The Macmillan Press Ltd 1980.

2. Akbar, S. Zaidi. Issue in Pakistan's Economy. Karachi: Oxford University Press, 2000.

3. S.M. Burke and Lawrence Ziring. Pakistan's Foreign policy: An Historical analysis. Karachi: Oxford University Press, 1993.

4. Mehmood, Safdar. Pakistan Political Roots & Development. Lahore, 1994.

5. Wilcox, Wayne. The Emergence of Bangladesh., Washington: American Enterprise, Institute of Public Policy Research, 1972.

6. Mehmood, Safdar. Pakistan Kayyun Toota, Lahore: Idara-e-Saqafat- e-Islamia, Club Road.

7. Amin, Tahir. Ethno - National Movement in Pakistan, Islamabad: Institute of Policy Studies, Islamabad.

8. Ziring, Lawrence. Enigma of Political Development. Kent England: WmDawson & sons Ltd, 1980.

9. Zahid, Ansar. History & Culture of Sindh. Karachi: Royal Book Company, 1980.

10. Afzal, M. Rafique. Political Parties in Pakistan, Vol. I, II & III. Islamabad: National Institute of Historical and cultural Research, 1998.

11. Sayeed, Khalid Bin. The Political System of Pakistan. Boston: Houghton Mifflin, 1967.

12. Aziz, K.K. Party, Politics in Pakistan, Islamabad: National Commission on Historical and Cultural Research, 1976.

13. Muhammad Waseem, Pakistan under Martial Law, Lahore: Vanguard, 1987.

14. Haq, Noor ul. Making of Pakistan: The Military Perspective. Islamabad: National Commission on Historical and Cultural Research, 1993.

Course Code	Course Title	Credit Hours	Theory	Lab.	Category
BOT-322	Fundamentals of Genetics & Evolution	3	2	1	Interdisciplinary

Objectives: To understand structure, functions and nature of genetic material and hereditary

process and familiarization with evolutionary processes.

Course outlines

a) Genetics

1. Introduction, scope and brief history of Genetics.
2. Mendelian Inheritance; Laws of segregation and independent assortment, back cross, test cross, dominance and incomplete dominance.
3. Extensions of Mendelian Analysis: Variations on dominance, Genetic Interaction, Lethal Genes, Penetrance, Expressivity and Pleiotropism.
4. Quantitative Genetics, Inheritance of Multiple Genes.
5. 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.
6. 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.
7. Multiple Alleles, symbolism for multiple alleles, examples: ABO Blood group, C gene in rabbit, Rh factor and eye color in *Drosophila*.
8. Sex linked inheritance, sex linkage in *Drosophila* and man (colour blindness), XO, XY, WZ mechanisms, sex limited and sex linked characters, sex determination.
9. The Structure of DNA: DNA: The genetic material, DNA replication in eukaryotes, DNA and the gene.
10. The Extranuclear Genome: Cytoplasmic or Extra-Nuclear inheritance: Variegation in leaves of higher plants, cytoplasmic inheritance in fungi, extranuclear genes in chlamydomonas, mitochondrial genes in yeast, extragenomic plasmids in eukaryotes. chloroplast inheritance.
11. Introduction to Germplasm conservation.

b) Evolution

12. 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.

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. Carroll, S. B., Grenier, J. K. and Welnerbee, S. D. 2001. From DNA to Diversity Molecular Genetics and the Evolution of Animal Design. Blackwell Science.
2. Dyonsager, V. R. 1986. Cytology and Genetics. Tata and McGraw Hill Publication Co. Ltd., New Delhi.
3. Hoelzel, A. R. 2001. Conservation Genetics. Kluwer Academic Publishers.
4. Ingrouille M. J. and Eddie, B. 2006. Plant Diversity and Evolution. Cambridge University Press.

5. Lewin, R. 1997. Principles of Human Evolution. Blackwell Science.
6. Lodish, H. 2001. Molecular Cell Biology. W. H. Freeman and Co.
7. Sinha, U. and Sinha, S. 1988. Cytogenesis Plant Breeding and Evolution, Vini Educational Books, New Delhi.
8. Strickberger, M. V. 1988. Genetics, MacMillan Press Ltd., London.
9. Strickberger, M. W. 2000 Evolution. Jones & Bartlet Publishers Canada
10. Verma, P. S. and Agarwal, V. K. 2009. Genetics. S. Chand and Co. Ltd., New Delhi.
11. Verma, P. S. and Agarwal, V. K. 2009. Cell Biology, Genetics, Molecular Biology, Evolution and Ecology. S. Chand and Co. Ltd., New Delhi.

Journals / Periodicals: Theoretical & Applied Genetics and Heredity.

Course Code	Course Title	Credit Hours	Theory	Lab.	Category
SS-321	Introduction to Sociology	2	2	0	General Education

Objectives:

- To equip student with the basic concepts of sociology and various social phenomenon.
- To familiar the students with social process on the basis of which society is smoothly functioning
- To train students to understand and interpret objectively the role of social process, culture and socialization in their lives

Course Contents

Fundamental of Sociology

1.1 Nature, Scope, and subject matter of Sociology

1.2 Brief historical development of Sociology

1.3 Society and community

1.4 Relationship with other social sciences like Economic, Political Science, History, Psychology, and Anthropology.

1.5 Social interaction processes (Cooperation, Competition, Conflict, Accommodation, Acculturation, and Assimilation).

Social Groups

2.1 Definition and Functions

2.2 Types of Social Groups (In and out group, Primary and Secondary groups, Reference groups. Formal and informal Groups and Pressure groups)

Social Institutions

3.1 Definition, Structure and Function of the following Institutions: Family, Religion, Education, Economics, Political Inter-relationship among various social institutions.

Cultural and Related Concepts

4.1 Definition and aspects of culture, Material and non-material culture, Ideal and real culture

4.2 Elements of culture, Beliefs, values, norms (folkways, mores, laws)

4.3 Organization of culture, Traits, complexes, and patterns

4.4 other related concepts, Cultural relativism, Sub-Culture and ethnocentrism

Socialization and Personality

5.1 Role and Status

5.2 Socialization

5.3 Culture and Personality

Deviance and Social Control

6.1 Definition and types of deviance

6.2 Formal and informal methods of social control

Social Stratification

7.1 Determinants of Social Stratification (Caste, Class, Ethnicity, Power, Prestige and Authority)

7.2 Social Mobility, Definition and types

7.3 Dynamics of social mobility

Social and Cultural Change

8.1 Definition of social change

8.2 Dynamics of social change (Education, Innovation, Industrialization, Urbanization and Diffusion)

8.3 Resistance to change

RECOMMENDED BOOKS

1. Horton Paul B. and Hunt, Chester L (1990), Sociology Singapore: McGraw Hill Book Company.
2. Sociology 1 by Allama Iqbal Open University, Islamabad iii. Sociology 2 by Allama Iqbal Open University, Islamabad
3. Taga, Abdul Hameed (2000) An Introduction. New York: Harper and Rows
4. Betrnad, Alvin L. (1969). Basic Sociology-An Introduction to Theory and Methods, New York; Appleton Century Crofts.
5. Curran, Jr.(1977).Introductory sociology: A basis Self Instructional Guide
6. Hafeez, Sabeeha (1990), The Changing Pakistan Society. Karachi: Royal Book company, Zaibunisa Street, Sadar.
7. Horton Paul B. and Hunt, Chester I.. (1990) Sociology singapore.Macgraw Hill Book Company.
8. Merrii, F.E., (latest ed,), Sociology and Culture. N.J. Englewood Cliffs.
9. Philips, Bernard (1990). Sociology-Form Concepts to Practice. New York: McGraw Hill Book Company Inc.
10. Rao, C. Nshaukar (1990), Sociology, New Delhi: S.C Chand and Company Ltd.

Course Code	Course Title	Credit Hours	Theory	Lab.	Category
QR-321	Quantitative Reasoning II** (Statistics)	3	3	0	General Education

DESCRIPTION

Quantitative Reasoning (II) is a sequential undergraduate course that focuses on logical reasoning supported with statistical concepts and modeling/analysis techniques to equip students with analytical skills and critical thinking abilities necessary to navigate the complexities of the modern world.

Objectives: To understand the basic concepts of statistics and the use of various Statistical phenomena in the field of Botany and Biodiversity Conservation.

Course outlines

1. Introduction objectives and scope: (Definition, Characteristics, Importance and limitations and Population and samples).
 2. Frequency distribution: (Variable types, Formation of frequency table from raw data, Summation, notation and statistical inference and Data transformation).
 3. Measures of central tendencies and dispersion: (Arithmetic mean, Median, Mode, Range, Variance, Standard deviation, Standard error of the mean and Mean deviation).
 4. Organizing and describing data (Standard distributions):
 - i. Random sampling and the binomial distribution.
 - ii. Probability, Types of Probabilities, Random variables, Combining probabilities, Probability distributions, Binomial distributions.
 - iii. Poisson and normal distributions, properties and applications.
 5. Basic experimental design: (Concept and design, Principles of experiments, Observational studies, Planning of experiments, Replication and randomization, Field plot technique, Layout and analysis of completely randomized design, Randomized complete block design, Latin square, Factorial design, Treatment comparison).
 6. Tests of significance:
 - i. T-test: (Basic idea, confidence limits of means, significant difference of means.
 - ii. Chi square test: Basic idea, testing goodness of fit to a ratio, testing association (contingency table).
 - iii. F-test: Introduction and application in analysis of variance.
 - iv. LSD test, Duncan's New Multiple Range test (for comparison of individual means). Bonferroni test.
1. Introduction to comparing many means:
Unit organization, Basic one way ANOVA, Types of sums of squares, How ANOVA works, The ANOVA Table. Two-way ANOVA-Factorial designs: (two-way factorial analysis, calculating and analyzing the two-way ANOVA, Linear combination, multiple comparisons.
 2. Correlation and Regression.

Lab. outlines

1. Data collection, arrangement of data in frequency table, calculating frequency, cumulative frequency and preparation of Ogive.
2. Calculating different measure of central tendency such as arithmetic means, harmonic mean, geometric mean, median and mode.
3. Calculation of mean from grouped and ungrouped data.
4. Calculation of variance and standard deviation from grouped and ungrouped data.

5. Calculating dispersion, relative dispersion, standard deviation, standard error, standard score and co-efficient variation by hand and machine method.
6. Problems concerning probability, binomial distribution, poisson distribution, skewness and Kurtosis and T-test.
7. Chi square test.
8. Analysis of variance - one factor design.
9. Multiple Analyses Of Variance.
10. Determination of correlation by constructing different types of graphs such as scatter diagram, linear positive correlation, linear perfect negative correlation, no correlation and curvilinear correlation (second degree polynomial, third degree polynomial).
11. Linear Regression and multiple regression models.

Books Recommended

1. Harvey, M. 1995. Intuitive Biostatistics. Oxford University Press. N. Y. Kuzma, J. W. and Bohnenblust, S. E. 2001, Basis Statistics for the Health Sciences, McGraw-Hill International Education.
2. Onton, P., Adams, S. and Voelkar, D. H. 2001. Cliffnotes for Statistics. Blackwell Scientific Publishers.
3. Pacano, M. and Gauvreau, K. 2000. Principles of Biostatistics.
4. Quinn, G. 2002. Experimental Design and Data Analysis for Biologists. Cambridge University Press.
5. Rosner, B. 2005. Fundamentals of Biostatistics. Jhon Wiley & Sons.
6. Samuels, M. L. and Witmar, J. A. 2003. Statistics for Life Sciences. 3rd Edition. Cambridge University Press.
7. Triola, M. F. and Triola, M. M. 2005. Biostatistics for Biological and Health Sciences. Pearson Addison Wesley.
8. Zar, J. H. 1999. Biostatistical Analysis, Pearson Education.

Course Code	Course Title	Credit Hours	Theory	Lab.	Category
ENG-321	Expository Writing **	3	3	0	General Education

Course Objectives:

This course aims to equip students with the essential skills needed to effectively communicate complex ideas and information through written expression. Throughout the course, students will refine their ability to craft clear, organized, and coherent prose, with an emphasis on logical structure, evidence-based arguments, and persuasive techniques. By engaging with a variety of texts and genres, students will develop critical reading and analytical skills, enabling them to evaluate and respond thoughtfully to different rhetorical situations. Moreover, the course seeks to cultivate students' creativity and individual voice while honing their proficiency in grammar, style, and mechanics.

Student Learning Outcomes:

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

1. Understand the essentials of the writing process integrating pre-writing, drafting, editing and proof reading to produce well-structured essays.
2. Demonstrate mastery of diverse expository types to address different purposes and audiences.

3. Uphold ethical practices to maintain originality in expository writing.

Course Contents:

Introduction to Expository Writing

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

The Writing Process:

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

Essay Organization and structure

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

Different Types of Expository Writing

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

Writing for Specific Purposes and Audiences

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

Ethical Considerations

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

SUGGESTED PRACTICAL ACTIVITIES (OPTIONAL)

As part of the overall learning requirements, students will be required to build writing portfolio having a variety of expository texts and present the same at the end of the course showcasing proficiency in expository writing

Books Recommended

The St. Martin's Guide to Writing by Rise B. Axelrod and Charles R. Cooper
 They Say/1Say: The Moves That Matter in Academic Writing by Gerald Graff and Cathy Birkenstein
 Writing Analytically by David Rosenwasser and Jill Stephen.
 Style: Lessons in Clarity and Grace by Joseph M. Williams and Joseph Bizup
 The Elements of Style by William Strunk Jr. and E.B. White
 Good Reasons with Contemporary Arguments by Lester Faigley and Jack Selzer
 Writing to Learn: How to Write and Think - Clearly About Any Subject at All by William Zinsser
 The Norton Field Guide to Writing by Richard Bullock, Maureen Daly Goggin, and Francine Weinberg
 The Art of Styling Sentences by Ann Longknife and K.D. Sullivan
 Writing Today" by Richard Johnson-Sheehan and Charles Paine

Courses: Code	Title of the Course	Theory	Lab	Credit hours	Category
2nd YEAR					
SEMESTER-3					
BOT-431	Phycology & Bryology	2	1	3	Major
BOT-432	Mycology	2	1	3	Major
BOT-433	Plant Anatomy & Embryology	2	1	3	Major
PHIL-431	An Introduction to Philosophy (****Arts and Humanities)	2	0	2	General Education
ISL-431	Islamic Studies ** (Ethics for non-Muslim students)	2	0	2	General Education
PST-431	Ideology & Constitution of Pakistan **	2	0	2	General Education
ZOO-431	Chordate Zoology	2	1	3	General Education
Sub Total		14	4	18	

Course Code	Course Title	Credit Hours	Theory	Lab.	Category
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BOT-431	Phycology and Bryology	3	2	1	Major
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Objectives: To understand the classification, morphology and economic importance of Algae and Bryophytes.

Course Outlines

a) Phycology

Introduction, general account, evolution, classification, biochemistry, ecology and economic importance of the following divisions of algae: Chlorophyta, Charophyta, Xanthophyta, Bacillariophyta, Phaeophyta and Rhodophyta.

b) Bryology

Introduction and general account of bryophytes, classification, theories of origin and evolution. Brief study of the classes: Hepaticopsida, Anthocerosida and Bryopsida.

Lab Outlines

a) Phycology

- i. Collection of fresh water and marine algae.
- ii. Identification of benthic and planktonic algae
- iii. Section cutting of thalloid algae
- iv. Preparation of temporary slides
- v. Use of camera lucida/micrographs.

b) Bryology (Study of *Pellia*, *Porella*, *Anthoceros* and *Polytrichum*).

Books Recommended

1. Bold, H. C. and Wynne, M. J. 1985. Introduction to Algae: structure and reproduction. Prentice Hall Inc. Engle Wood Cliffs.
2. Chapman, V. J. and Chapman, D. J. 1983. Sea weed and their uses. McMillan and Co. Ltd. London.
3. Dawson, E. Y. and Halt. 1966. Marine Botany. Reinhart and Winstan, New York.
4. Hussain, F. and Ihsan, I. 2004. A text book of Botany. Department of Botany, University of Peshawar.
5. Lee, R. E. 1999. Phycology. Cambridge University Press, U. K.
6. Schofield, W. B. 1985. Introduction to Bryology. Macmillan Publishing Co. London.
7. Vashishta, B. R. 1991. Botany for degree students. Bryophytes 8th Ed. S. Chand and Co. Ltd., Delhi.

Journals/Periodicals: Pakistan Journal of Botany, International Journal of Phycology and Phycochemistry, Bryology, Phycology.

Course Code	Course Title	Credit Hours	Theory	Lab.	Category
BOT-432	Mycology	3	2	1	Major

Objectives: To introduce the students to Mycology.

Course outlines

Mycology

1. Introduction: General characters of fungi, Thallus, cell structure and ultra structure of fungi.
2. Reproduction: Asexual and sexual reproduction and reproduction structures, life cycle, haploid, heterokaryotic and diploid states.
3. Fungal Systematics: Classification of fungi into phyla with suitable examples to illustrate somatic structures, life cycle and reproduction of Myxomycota, Chytridiomycota, Zygomycota (Mucrales) Oomycota (Peronosporales), Ascomycota (Erysiphales, Pezizales), Basidiomycota (Agaricales, Polyporales, Uredinales, Ustilaginales) and Deuteromycetes.
4. Symbiotic relationships of fungi with other organisms (lichens and mycorrhiza) and their significance.
5. Importance of fungi in human affairs with special reference to Industry and Agriculture.

Lab. outlines

Mycology

General characters and morphology of fungi. Study of unicellular and mycelial forms with septate and aseptate hyphae. Distinguishing characters of different phyla: study of suitable examples. Study of asexual and sexual reproductive structures in different groups of fungi. Study of some common examples of saprophytic, parasitic and air-borne fungi belonging to different phyla.

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 Blackwell, M. 1996. Introductory Mycology, 4th ed. John Wiley & Sons.
4. Khan, A. G. and Usman, R. 2005. Laboratory Manual in Mycology and Plant Pathology. Botany Department Arid Agriculture University, Rawalpindi.
5. Mehrotra, R. S. and Aneja, K. R. 1990. An Introduction to Mycology. Wiley and Eastern Ltd., New Delhi, India.
6. Moore-Landecker, E. 1996. Fundamentals of Fungi. 4th Ed. Prentice Hall Inc., New Jersey, USA.

7. Trigiano, R. N., Windham, M. T. and Windham, A. S. 2004. Plant Pathology: Concepts and Laboratory Exercises. CRC Press, LLC, N.Y.

Journals/Periodicals: Pakistan Journal of Botany, Mycotoxin, Mycopathology, Phytopathology, Australasian Journal of Plant pathology , Asian Journal of Plant Pathology, Annual Review of Plant Pathology.

Course Code	Course Title	Credit Hours	Theory	Lab.	Category
BOT-433	Plant Anatomy and Embryology	3	2	1	Major

Objectives: To provide the students with an understanding embryology and anatomical features of vascular plants.

Course outline

A. ANATOMY

1. **Structure and Development of the Plant Body** . The plant body and its development fundamental parts of the plant body, internal organization, different tissue systems of primary and secondary body.
2. **Cell Wall.** Structure and Chemical composition
3. **The Tissues:** Meristematic tissues, Permanent Tissues
4. **Meristems and Differentiation.** Meristematic tissues: classification, cytohistological characteristics, initials and their derivatives.
5. **Apical meristem:** Delimitation, different growth zones, evolution of the concept of apical organization. Shoot and root apices.
6. **Permanent Tissues:** Simple tissues (Parenchyma, Collenchyma, Sclerenchyma), Complex Tissues (Xylem and Phloem)
7. **Secretory Tissues: Laticifers:** Classification, distribution, development, structural characteristics, and functions.
8. **Tissue systems:** The Dermal or Epidermal Tissue System, The Fundamental or Ground Tissue system and the Vascular Tissue System.
9. **Secondary Growth:** Vascular Cambium (Origin, structure. Cell types, cytoplasmic characteristics, seasonal activity and its role in the secondary growth. The secondary growth in Dicot roots and stems. Wood. Characteristics of wood: diffuse porous and ring –porous, sap and heart wood, soft and hard wood, annual rings.
10. **Periderm.** Occurrence and Characteristics of the Components
11. **Anatomical adaptations in Plants: Hydrophytes Xerophytes and Mesophytes**
12. **The Leaf-Histology**

13. The Stem-Primary and Secondary Structure

14. The Root-Primary and Secondary Structure

A. EMBRYOLOGY

Introduction. Flower, structure and development of stamen, microsporogenesis and structure of pollen grain. Structure and development of ovule, megasporogenesis, development of different types of embryo sacs, morphological nature of ovule and embryo sac. Development of gametophyte and fertilization, types of endosperm development, different types of embryo development, apomixis, parthenocarpy and experimental embryology.

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.
5. Study of stomata, epidermis, Tissues of primary body of plant, study of xylem 3-dimensional plane of wood and T/S of Angiosperm stem and leaf.

Recommended Books

1. Eames, A. J. and MacDaniels, L. H. 2002. An Introduction to Plant Anatomy. Tata-Mac Graw-Hill Publishing Company, Limited New Delhi.
2. Esau, K. 1960. Anatomy of Seed Plants. John Wiley, New York.
3. Fahn, A. 1990. Plant Anatomy. Pergamon Press, Oxford.
4. Lawrence, G. H. M. 1951. Taxonomy of Vascular Plants. MacMillan & Co. New York.
5. Mauseth, J. D. 1998. An Introduction to Plant Biology: Multimedia Enhanced. Jones and Bartlett Pub. UK
6. Moore, R. C., Clarke, W. D. and Vodopich, D.S. 1998. Botany. McGraw Hill Company, USA.
7. Naik, V.N. 2005 Taxonomy of Angiosperms. 20th Reprint. Tata-Mac Graw-Hill Publishing Company, Limited New Delhi.
8. Panday, B. P. 2004. A textbook of Botany (Angiosperms). S. Chand and Co. New Delhi.
9. Pullaiah, T. 2007. Taxonomy of Angiosperms. 3rd Edition Regency Publications, New Delhi.
10. Raven, P. H., Evert, R. E. and Eichhorn, S. E. 1999. Biology of Plants. W. H. Freeman and Company Worth Publishers.
11. Raymond E, Eichhorn, S. E. 2005. Esau's Plant Anatomy. Meristems cells and tissues of the plant body, 3rd Ed. John Wiley & Sons. Inc.
12. Stuessy, T. F. 1990. Plant Taxonomy. Columbia University Press, USA.

Journals / Periodicals: Pakistan Journal of Botany, Taxon, Phytion.

Course Code	Course Title	Credit Hours	Theory	Lab.	Category
PHIL-431	An Introduction to Philosophy (****Arts and Humanities)	2	2	0	General Education

Course Objectives

- To introduce students to the fundamental concepts and branches of philosophy.
- To develop critical thinking and analytical skills through philosophical inquiry.
- To examine major theories of knowledge, reality, and values.
- To explore the relationship between philosophy, religion, and science.
- To analyze metaphysical issues such as the existence of God, immortality, and free will.
- To understand different theories of evolution from both Western and Islamic perspectives.
- To familiarize students with the philosophical contributions of classical and Muslim thinkers like Allama Iqbal, Rumi, and Miskawaih.

Course outline

(1) Definition of Philosophy.

(2) Scope of Philosophy. (i) Ontology. (ii) Epistemology (iii) Axiology, Logic, Aesthetics, Ethics.

(3) Value and importance of Philosophy

(4) Philosophy and Religion

(5) Philosophy and Science.

(6) Theories of knowledge: Rationalism, Empiricism, Authoritarianism or Testimony, Mysticism,

Idealism and kinds of idealism—Subjective idealism, Objectivism, Personal idealism. Critical evaluation of idealism. Materialism and Naturalism. Mechanical Materialism and Dialectical Materialism.

(7) Metaphysical problems of Philosophy. (i) Existence of God, Pantheism, Deism.

(ii) Proofs for the existence of God (Cosmological,

(iii) Human immortality.

(iv) Freedom of will.

Ontological, Teleological Arguments)

(8) Evolution.

(i) Kinds of evolution: (Mechanical Evolution, Teleological Evolution, Creative Evolution.)

(ii) Theories of Evolution.

(a) Darwinian Theory of Evolution (Struggle for existence, survival of the fittest, Natural selection)

(b) Lamarckian theory of Evolution.

(c) Maulana Rumi's concept of Evolution.

- (d) Miskawaih concept of Evolution.
- (e) Allama Iqbal concept of Evolution.

Books Recommended

- (1) Elements of Philosophy, by Dr. Abdul Khaliq.
- (2) Fundamentals of Philosophy by David Stewart/ H.Gene Blocker (Second edition)
- (3) Introduction to Philosophy by Patrick, G.T.W
- (4) Iqbal, Allama M., *The Reconstruction Of Religious Thought in Islam*, Lahore, 1989.
- (5) R.A. Nicholson.(tr.), *The Mathnawi of Jalaluddin Rumi*, Lahore, 1989.

Course Code	Course Title	Credit Hours	Theory	Lab.	Category
ISL-431	Islamic Studies	2	2	0	General Education

Objectives: To provide Basic information about Islamic Studies, to enhance understanding of the students regarding Islamic Civilization, to improve Students skill to perform prayers and other worships and to enhance the skill of the students for understanding of issues related to faith and religious life.

Course outlines

1. Introduction (Basic concepts and History of Quran and Uloom-ul –Quran).

2. Study of Selected Text of Holy Quran

- 1) Verses of Surah Al-Baqra Related to Faith (Verse No-284-286)
- 2) Verses of Surah Al-Hujrat Related to Adab Al-Nabi (Verse No-1-18)
- 3) Verses of Surah Al-Mumanoon Related to Characteristics of faithful (Verse No-1-11)
- 4) Verses of Surah al-Furqan Related to Social Ethics (Verse No.63-77)
- 5) Verses of Surah Al-Inam Related to Ihkam (Verse No-152-154)

3. Study of Selected Text of Holy Quran

- 1) Verses of Surah Al-Ihzab Related to Adab al-Nabi (Verse No. 6, 21, 40, 56, 57, 58)
- 2) Verses of Surah Al-Hashar (18, 19, 20) Related to thinking, Day of Judgment
- 3) Verses of Surah Al-Saf Related to Tafakar, Tadabar (Verse No-1, 14)

4. Seats of Holy Prophet (S.A.W): (Life of Muhammad Bin Abdullah (Before Prophet Hood), Life of Holy Prophet (S.A.W) in Makkah and Important Lessons Derived from the life of Holy Prophet in Makkah).

5. Seerat of Holy Prophet (S.A.W) II: (Life of Holy Prophet (S.A.W) in Madina, Important Events of Life Holy Prophet in Madina and Important Lessons Derived from the life of Holy Prophet in Madina)

6. Introduction to Sunnah: (Basic Concepts of Hadith, History of Hadith, Kinds of Hadith, Uloom Ul Hadith, Sunnah & Hadith and Legal Position of Sunnah).

7. Introduction To Islamic Law & Jurisprudence: (Basic Concepts of Islamic Law &

Jurisprudence, History & Importance of Islamic Law & Jurisprudence, Sources of Islamic Law & Jurisprudence, Nature of Differences in Islamic Law, Islam and Sectarianism).

8. Islamic Culture & Civilization (Basic Concepts of Islamic Culture & Civilization, Historical Development of Islamic Culture & Civilization, Characteristics of Islamic Culture & Civilization and Islamic Culture & Civilization and Contemporary Issues).

9. Islam & Science (Basic Concepts of Islam & Science, Contributions of Muslims in the Development of Science and Quranic & Science).

10. Islamic Economic System (Basic Concepts of Islamic Economic System, Means of Distribution of wealth in Islamic Economics, Islamic Concept of Riba and Islamic Ways of Trade & Commerce).

11. Political System of Islam (Basic Concepts of Islamic Political System, Islamic Concept of Sovereignty and Basic Institutions of Govt. in Islam).

12. Islamic History (Period of Khlaft-E-Rashida, Ummayyads and Period of Abbasids).

13. Social System of Islam (Basic Concepts of Social System of Islam, Elements of Family and Ethical Values of Islam).

Recommended books

1. Ahmad, H. 1993. Principles of Islamic Jurisprudence. Islamic Research Institute, International Islamic University, Islamabad.
2. Bhatia, H. S. 1989. Studies in Islamic Law, Religion and Society. Deep & Deep Publications New Delhi.
3. Haq, M. Z. 2001. Introduction to Al Sharia Al Islamia. Allama Iqbal Open University, Islamabad.
4. Hussain, H. H. 1994. An Introduction to the Study of Islamic Law. Leaf Publication Islamabad, Pakistan.
5. Naseem, A. and S. Qazi. 2011. Islamiyat (Compulsory) for BA (3rd Year). Islamia Book Agency, Qissa Khwani, Peshawar.
6. Waliullah, M. 1982. Muslim Jurisprudence and the Quranic Law of Crimes. Islamic Book Service.

Course Code	Course Title	Credit Hours	Theory	Lab	Category
PST-431	Ideology and Constitution of Pakistan	2	2	0	General Eduaction

Objectives

This course is designed to provide students with a fundamental exploration of the ideology and

the constitution of Pakistan. The course focuses on the underlying principles, beliefs, and aspirations that have been instrumental in shaping the creation and development of Pakistan as a sovereign state.

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

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

SYLLABUS

1. Introduction to the Ideology of Pakistan:

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

2. Two-Nation Theory:

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

3. Introduction to the Constitution of Pakistan:

- Definition and importance of a constitution.
- Ideological factors that shaped the Constitution(s) of Pakistan (Objectives Resolution 1949).
- Overview of constitutional developments in Pakistan.

4. Constitution and State Structure:

- Structure of Government (executive, legislature, and judiciary).
- Distribution of powers between federal and provincial governments.
- 18th Amendment and its impact on governance.

5. Fundamental Rights, Principles of Policy, and Responsibilities:

- Overview of fundamental rights guaranteed to citizens by the Constitution of Pakistan 1973 (Articles 8-28).
- Overview of Principles of Policy (Articles 29-40).
- Responsibilities of Pakistani citizens (Article 5).

6. Constitutional Amendments:

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

Recommended Books

1. *The Idea of Pakistan* by Stephen P. Cohen.
2. *Ideology of Pakistan* by Javed Iqbal.
3. *The Struggle for Pakistan* by I.H. Qureshi.
4. *Pakistan: The Formative Phase* by Khalid Bin Sayeed.

5. *Pakistan: Political Roots and Development* by Safdar Mahmood.
6. *Ideology of Pakistan* by Sharif-ul-Mujahid.
7. *The Struggle for Pakistan: A Muslim Homeland and Global Politics* by Ayesha Jalal.
8. *Jinnah, Pakistan, and Islamic Identity: The Search for Saladin* by Akbar S. Ahmed.
9. *The Making of Pakistan: A Study in Nationalism* by K.K. Aziz.
10. *Pakistan in the Twentieth Century: A Political History* by Lawrence Ziring.
11. *Constitutional and Political History of Pakistan* by Hamid Khan.
12. *Pakistan: A Modern History* by Ian Talbot.
13. *Constitutional and Political Development of Pakistan* by Hamid Khan.
14. *The Parliament of Pakistan* by Mahboob Hussain.
15. *Constitutional Development in Pakistan* by G.W. Choudhury.
16. *Constitution-Making in Pakistan: The Dynamics of Political Order* by G.W. Choudhury.

Course Code	Course Title	Credit Hours	Theory	Lab	Category
ZOO-431	Chordate Zoology	3	2	1	General Eduaction

Objectives: The course provides knowledge and understanding about the different animal groups, emphasizing their phylogenetic relationships.

Course outlines

1. Echinoderms

Evolutionary perspective: relationships to other animals; echinoderm characteristics; classification up to class. Maintenance functions, regeneration, reproduction, and development in asteroidea, ophiuroidea, echinoidea, holothuroidea and crinoidea; further phylogenetic considerations; some lesser-known invertebrates: the lophophorates, entoprocts, cyclophores, and chaetognaths.

2. Hemichordates and Invertebrate Chordates

Evolutionary Perspective: Phylogenetic Relationships; Classification up to subphylum or class where applicable; Further Phylogenetic Considerations.

3. Fishes: Vertebrate Success in Water

Evolutionary perspective: phylogenetic relationships; survey of super class agnatha and gnathostomata; evolutionary pressures: adaptations in locomotion, nutrition and the digestive system, circulation, gas exchange, nervous and sensory functions, excretion and osmoregulation, reproduction and development; further phylogenetic considerations.

4. Amphibians: The First Terrestrial Vertebrates

Evolutionary perspective: phylogenetic relationships; survey of order caudata, gymnophiona, and anura. Evolutionary pressures: adaptations in external structure and locomotion, nutrition and the digestive system, circulation, gas exchange, temperature regulation, nervous and sensory functions, excretion and osmoregulation, reproduction, development, and metamorphosis; further phylogenetic considerations.

5. Reptiles: The First Amniotes

Evolutionary perspective: cladistic interpretation of the amniotic lineage; survey of order testudines or chelonia, rhynchocephalia, squamata, and crocodilia; evolutionary pressures:

adaptations in external structure and locomotion, nutrition and the digestive system, circulation, gas exchange, and temperature regulation, nervous and sensory functions, excretion and osmoregulation, reproduction and development; further phylogenetic considerations.

6. Birds: Feathers, Flight, and Endothermy

Evolutionary perspective: phylogenetic relationships; ancient birds and the evolution of flight; diversity of modern birds; evolutionary pressures: adaptation in external structure and locomotion, temperature regulation, nervous and sensory systems, excretion and osmoregulation, reproduction and development; migration and navigation.

7. Mammals: Specialized Teeth, Endothermy, Hair, and Viviparity

Evolutionary perspective: diversity of mammals; evolutionary pressures: adaptations in external structure and locomotion, nutrition and the digestive system, circulation, gas exchange, and temperature regulation, nervous and sensory functions, excretion and osmoregulation, behavior, reproduction and development.

Lab. outlines

1. Study of a representative of Hemichordate and Invertebrate Chordate.
2. Study of representative groups of class Fishes.
3. Study of representative groups of class Amphibia.
4. Study of representative groups of class Reptilia.
5. Study of representative groups of class Aves.
6. Study of representative groups of class Mammalia.
7. Field trips to study animal diversity in an ecosystem.

Recommended Books

1. Campbell, N. A. 2002. Biology 6th Edition. Menlo Park, California. Benjamin/Cummings Publishing Company, Inc.
2. Hickman, C. P., Roberts, L. S. and Larson, A. 2004. Integrated Principles of Zoology, 11th Edition (International). Singapore, McGraw Hill.
3. Hickman, C. P. and Kats, H. L. 2000. Laboratory Studies in Integrated Principles of Zoology. Singapore, McGraw Hill.
4. Kent, G. C. and Miller, S. 2001. Comparative Anatomy of Vertebrates. New York: McGraw Hill.
5. Miller, S. A. and Harley, J. B. 2002. Zoology 5th Edition (International). Singapore, McGraw Hill.
6. Miller, S. A. 2002. General Zoology Laboratory Manual. 5th Edition (International). Singapore, McGraw Hill.
7. Pechenik, J. A. 2000. Biology of Invertebrates, 4th Edition (International). Singapore, McGraw Hill.

Note: Preserved specimen and/or colored projection slide and/or CD ROM projection of computer must be used.

Courses: Code	Title of the Course	Theory	Lab	Credit hours	Category
SEMESTER-4					
CHEM-441	Organic Chemistry	2	1	3	General Education
BOT-441	Principles of Plant Ecology	2	1	3	Major
BOT-442	Principles of Plant Biochemistry	2	1	3	Major
BOT-443	Fundamentals of Plant Physiology	2	1	3	Major
SW-441	Civics & Community Engagement **	2	0	2	General Education
MGT-441	Entrepreneurship **	2	0	2	General Education
BOT-444	Plants and Society	2	1	3	Major
Sub Total		14	5	19	

Course Code	Course Title	Credit Hours	Theory	Lab	Category
CHEM-441	Organic Chemistry	3	2	1	General Education

Objective: To understand that what is organic chemistry and their basic concepts, different types of bonding and their characteristics and naming various organic compounds.

Course outlines

1. Introduction to Organic Chemistry

Organic Chemistry-the Chemistry of carbon compounds; the nature of organic chemistry-a historical perspective, Natural Products, Macromolecules and Petrochemicals

2. Classes and Nomenclature of Organic Compounds

Classification of organic compounds; development of systematic nomenclature of organic

compounds; IUPAC nomenclature of hydrocarbons and heteroatom functional groups.

3. Functional Group Chemistry

A brief introduction to the chemistry of hydrocarbons, alkyl halides, alcohols, phenols, ethers, aldehydes, ketones, amines, and carboxylic acids and their derivatives. Role of different organic compounds inside the living body.

Lab. outlines

a. Techniques:

Melting and boiling point determination, Distillation, solvent extraction, crystallization,

b. Preparation of Organic Compounds

Preparation of simple organic compounds like iodoform, aspirin, acetanilide etc.

c. Laboratory work illustrating topics covered in the lecture of Chem-351.

Recommended Books for theory

1. Furniss, B. S., Hannaford, A. J, Rogers. V, Smith, P. W. G. and Tatchell, A. R. 1986. Vogel's Text book of Practical Organic Chemistry Including Qualitative Organic Analysis. Longman Group Ltd., 4th Edition.
2. Gosney, J. T. S and Rowley, A. G. 1990. Practical Organic Chemistry. Chapman and Hall.
3. Mann, F. G. and Saunders, B. C. 1975. Practical Organic Chemistry. Lowe and Brydone (Printers) Ltd. Thetford, Norfolk.
4. Shriner, R. L., Fuson, R. C., Curtin, D. Y. and Morrill, T. C. 1980. The Systematic Identification of Organic Compounds (a laboratory manual). John Wiley & Sons, Inc., 6th Edition.
5. Ahluwalia, V. K. and Goyal, M., "A Text Book of Organic Chemistry", Narosa Publishing House, New Delhi
6. Bailey Jr., P. S. and Bailey, C. A., "Organic Chemistry-A Brief Survey of Concepts and Applications", Prentice-Hall, New Jersey.
7. Bansal, R. K., "Organic Reaction Mechanisms", Tata McGraw-Hill Publishing Company Ltd., New Delhi.
8. Carey, F. A., "Organic Chemistry", McGraw-Hill, New York.
9. Clayden, J., Greeves, N., Warren, S. and Wothers, P., "Organic Chemistry", Oxford University Press, New York.
10. Finar, I. L., "Organic Chemistry", Vol. 1, Pearson Education, Delhi.
11. Loudon, G. M., "Organic Chemistry", Oxford University Press, New York
12. March, J., "Advanced Organic Chemistry", John Wiley & Sons, New York.
13. Pine, S. H., "Organic Chemistry", National Book Foundation, Islamabad.
14. Sorrell, T. N., "Organic Chemistry", Viva Books Private Ltd., New Delhi.

Course Code	Course Title	Credit hours	Theory	Lab.	Category
BOT-441	Principles of Plant Ecology	3	2	1	Major

Objectives: To understand the role and interaction of plants with their environment.

Course outlines

1. Introduction: history and recent developments in ecology.
2. 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
3. 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,
4. 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
5. 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.
6. Oxygen deficiency: Energy metabolism of plants under oxygen deficiency, Morpho-anatomical changes during oxygen deficiency, Post-anoxic stress
7. Wind as an ecological factor.
8. Fire as an ecological factor.

Lab. outlines

1. Determination of physico-chemical properties of soil and water.
2. Measurements of light and temperature under different ecological conditions.
3. Measurements of wind velocity.
4. Measurement of CO₂ and O₂ concentration of air and water.
5. Effect of light, temperature, moisture, salinity and soil type on germination and growth of plants.
6. Measurement of ions, stomatal conductance, osmotic potential, water potential, xylem pressure potential, leaf area and rate of CO₂ exchange in plants in relation to various environmental conditions.

Books Recommended

1. Barbour, M. G., Burke, J. H. and Pitts, W. D. 2004. Terrestrial Plant Ecology, The Benjamin, Cumming Publishing C. Palo Alto, California, USA.
2. Bazzaz, F. A. 2004. Plants in Changing Environments: Linking Physiological, Population, and Community Ecology, Cambridge University Press

3. Chapin *et al.*, 2002. Principle of Terrestrial Plant Ecology, Springer-Verlag
4. Gurevitch, J. Scheiner, S. M. and Fox, G. A. 2006. The Ecology of Plants\Sinaur Assoicate Inc.
5. Hussain, F. 1989. Field and Laboratory Manual of Plant Ecology, National Academy of Higher Education, Islamabad.
6. Hussain, S. S. 1989. Pakistan Manual of Plant Ecology. National Book Foundation Islamabad.
7. Lambers *et al.*, 2002. Plant Physiological Ecology, Springer-Verlag
8. Lambers, H., T. L. Pons and F. Stuart. 2008. Plant Physiologiical Ecology.
9. Larcher, W. 2003. Physiological Plant Ecology: Ecophysiology and Stress Physiology of Function Groups - Springer-Verlag
10. More, P. D. and Chapman, S. B. 1986. Methods in Plant Ecology, Blackwell Scientific Publication Oxford.
11. Nobel, P. S. 1999. Physico-chemical and Environmental Plant Physiology. Academic Press.
12. Schultz, J. C. 2005. Plant Ecology, Springer-Verlag
13. Smith, R. L. 1998. Elements of Ecology. Harper & Row Publishing.
14. Smith, R. L. 2004. Ecology and field Biology. Addison Wesley Longman, Inc., New York.
15. Townsend, C. R. Begon, M. and Harper, J. L. 2002. Essentials of ecology. Blackwell Publishing.

Journals/Periodicals: Pakistan Journal of Botany, Journal of Ecology, Journal of Applied Ecology, Ecology, Journal of Arid Environment.

Course Code	Course Title	Credit hours	Theory	Lab.	Category
BOT-442	Principles of Plant Biochemistry	3	2	1	Major

Objectives: To elucidate the structure and role of primary metabolites in plants.

Course outlines

1. Carbohydrates

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

2. Lipids

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

3. Proteins

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

proteins. Protein purification. Protein sequencing. Biological role.

4. Nucleic Acids

General introduction. Purine and pyrimidine bases, nucleosides, nucleotides. Structure and properties of DNA and RNA. Types and functions of RNA. Chemical synthesis of oligonucleotides and DNA sequencing. DNA restriction enzymes. Properties of DNA polymerase I, II and III.

5. Enzymes

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

Lab. outlines

1. Solutions, acids and bases. Electrolytes, non-electrolytes, buffers, pH. Chemical bonds.
2. To determine the R_f value of monosaccharides on a paper Chromatogram.
3. To estimate the amount of reducing and non-reducing sugars in plant material titrimetrically / spectrophotometrically.
4. To determine the saponification number of fats.
5. To extract and estimate oil from plant material using soxhlet apparatus.
6. Analysis of various lipids by TLC methods.
7. To estimate soluble proteins by Biuret or Lowry or Dye-binding method.
8. To estimate the amount of total Nitrogen in plant material by Kjeldahl's method.
9. To determine the R_f value of amino acids on a paper chromatogram.
10. Extraction of Nucleic acids from plant material and their estimation by UV absorption or colour reactions.
11. To estimate the catalytic property of enzyme catalase or peroxidase extracted from a plant source.
12. To determine the PK_a and isoelectric point of an amino acid.

Books Recommended

1. Abdes, R. H. Frey, P. A. and Jencks W. P. 2004. Biochemistry, Jones and Bartlet, London.
2. Bowsher, C. 2008. Plant Biochemistry.
3. Campbell, M. K. and F. Shawn. 2008. Biochemistry 6th Edition.
4. Chesworth, J. M., Strichbury, T. and Scaife, J. R. 1998. An introduction to agricultural Biochemistry. Chapman and Hall, London.
5. Conn, E. E. and Stumpf, P. K. 2002. Outlines of Biochemistry, John Wiley and Sons Inc. New York.
6. Dey, P. M. and Harborne, J. B. 1997. Plant Biochemistry. Harcourt Asia PTE Ltd. Singapore.
7. Goodwin T. W. and Mercer, E. I. 1997. Introduction to Plant Biochemistry. Pergamon Press, Oxford.
8. Heldt, H. W. 2008. Plant Biochemistry. 3rd Edition, Academic Press, U.K.
9. Lea, P. J. and Leegood, R. C. 1993. Plant Biochemistry and Molecular Biology. Wiley and Sons, New York.
10. Lehninger, A. L. 1998. Principles of Biochemistry. Worth Publishers Inc.

11. Mckee, T. and Mckee, J. R. 1999. Biochemistry-An Introduction. WCB/McGraw-Hill, New York, Boston, USA.
12. Smith, E. L., Hill, R. L, Lehman, R. I., Lefkowitz, R. J. Handler and Abraham. 2003. Principles of Biochemistry, (General Aspects). White. International Student Edition. McGraw Hill International Book Company.
13. Voet, D., Voet J. G. and Pratt, C. W. 1998. Fundamentals of Biochemistry, John Wiley and Sons, New York.
14. Zubay, G. 2003. Biochemistry, MacMillan Publishing Co., New York.

Journals/Periodicals: Plant Physiology & Biochemistry, Annual Review of Biochemistry, Biochemistry Journal, Critical Review in Biochemistry and Molecular Biology.

Course Code	Course Title	Credit hours	Theory	Lab.	Category
BOT-443	Principles of Plant Physiology	3	2	1	Major

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

Course Outlines

1. **Photosynthesis:** History of photosynthesis. Nature and units of light. Determination of oxygenic and anoxygenic photosynthesis. Ultra structure of thylakoid vesicle. Various pigments and photosynthetic activity. Ultra structure 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. CO₂ reduction (dark reactions) - C₃ pathway and Photorespiration, Regulation of C₃ pathway, C₄ pathway and its different forms, C₃-C₄ intermediates, CAM pathway. Methods of measurement of photosynthesis.
2. **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.
3. **Translocation of Food:** Pathway of translocation, source and sink interaction, materials translocated, mechanism of phloem transport, loading and unloading.
4. **Leaves and Atmosphere:** Gaseous exchange, mechanism of stomatal regulation. Factors affecting stomatal regulation.
5. **Assimilation of Nitrogen, Sulphur and Phosphorus:** The nitrogen cycle. Nitrogen fixation. Pathways of assimilation of nitrate and ammonium ions. Assimilation of sulphur and phosphorus.

Lab Outlines

1. To determine the volume of CO₂ evolved during respiration by plant material.
2. To determine the amount of O₂ 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 C₃ and C₄ plants through their anatomical and physiological characters.
6. To regulate stomatal opening by light of different colours and pH.

Books Recommended

1. Dennis, D. T., Turpin, D. H., Lefebvre, D. D. and Layzell, D. B. 1997. Plant Metabolism. 2nd Edition. Longman Group, U.K.
2. Dey, P. M. and Harborne, J. B. 1997. Plant Biochemistry. Harcourt Asia PTE Ltd. Singapore.
3. Epstein, E. and Bloom, A. J. 2004. Mineral Nutrition of Plants: Principles and Perspectives. 2nd Edition. Sinauer Associates, California, USA.
4. Fitter, A. and Hay, R. K. M. 2001. Environmental Physiology of Plants. Academic Press, UK.
5. Heldt, H-W. 2004. Plant Biochemistry. 3rd Edition, Academic Press, U.K.
6. Ihsan Illahi, 1991. Plant Growth, UGC Press, Islamabad.
7. Ihsan Illahi, 1995. Plant Physiology, Biochemical Processes in Plants, UGC Press.
8. *Kirkham, M. B. 2004. Principles of Soil and Plant Water Relations. Elsevier, Amsterdam, Netherlands.*
9. *Nobel, P. S. 1999. Physicochemical and Environmental Plant Physiology. Academic Press, UK.*
10. Press, M. C., Barker, M. G., and Scholes, J. D. 2000. Physiological Plant Ecology, British Ecological Society Symposium, Volume 39, Blackwell Science, UK.
11. Salisbury F. B. and Ross C. B. 1992. Plant Physiology. 5th Edition. Wadsworth Publishing Co. Belmont CA.
12. Taiz, L. and Zeiger, E. 2006. Plant Physiology. 4th Edition. Sinauer Publ. Co. Inc. Calif.
13. W. B. Hopkins. 1999. Introduction to Plant Physiology. 2nd Ed. John Wiley and Sons. New York.

Journals/Periodicals: Pakistan Journal of Botany, Plant Physiology, Physiologia Plantarum, Planta, Annual Review of Plant Biology, Journal of Plant Physiology.

Course Code	Course Title	Credit Hours	Theory	Lab.	Category
SW-441	Civics and Community Engagement	2	2	0	General Education

Objectives

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

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

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

COURSE OUTLINE

1. Civics and Citizenship:

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

2. State, Government and Civil Society:

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

3. Rights and Responsibilities:

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

4. Community Engagement:

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

5. Advocacy and Activism:

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

6. Digital Citizenship and Technology:

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

7. Diversity, Inclusion and Social Justice:

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

SUGGESTED PRACTICAL ACTIVITIES (OPTIONAL)

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

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

Recommended Books

1. Civics Today: Citizenship, Economics, & You by McGraw-Hill Education.
2. Citizenship in Diverse Societies by Will Kymlicka and Wayne Norman.
3. Engaging Youth in Civic Life by James Youniss and Peter Levine.
4. Digital Citizenship in Action: Empowering Students to Engage in Online Communities by Kristen Mattson.
5. Globalization and Citizenship: In the Pursuit of a Cosmopolitan Education by Graham Pike and David Selby.
6. Community Engagement: Principles, Strategies, and Practices by Becky J. Feldpausch and Susan M. Omilian.
7. Creating Social Change: A Blueprint for a Better World by Matthew Clarke and Marie-Monique Steckel
8. Sipe, James W.. Seven Pillars of Servant Leadership. 2009.
9. Applied Research Center. Millennials, Activism, and Race. 2012.
10. Gottlieb, K., and G. Robinson. A Practical Guide for Integrating Civic Responsibility into the Curriculum. 2002.
11. Bowen, Glenn. Civic Engagement in Higher Education: Resources and References. 2010.

Course Code	Course Title	Credit Hours	Theory	Lab.	Category
MGT-441	Entrepreneurship**	2	2	0	General Education

Objectives

This course is designed to promote entrepreneurial spirit and outlook among students, encouraging them to think critically, identify opportunities, and transform their ideas into successful ventures. It aims at imparting them with the requisite knowledge, skills, and abilities, enabling them to seize identified opportunities for initiating ventures and successfully navigating the challenges that come with starting a business and managing it.

By the end of this course, students shall have:

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

COURSE OUTLINE

1. Introduction to Entrepreneurship:

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

2. Entrepreneurial Skills:

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

3. Opportunity Recognition and Idea Generation:

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

4. Marketing and Sales:

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

5. Financial Literacy:

- Basic concepts of income, savings, and investments.
- Basic concepts of assets, liabilities, and equity.
- Basic concepts of revenue and expenses.
- Overview of cash flows.

- Overview of banking products including Islamic modes of financing.
- Sources of funding for startups (angel financing, debt financing, equity financing, etc.).

6. Team Building for Startups:

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

7. Regulatory Requirements to Establish Enterprises in Pakistan:

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

SUGGESTED PRACTICAL ACTIVITIES (OPTIONAL)

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

Recommended Books

1. The following is the recommended list of books (or their latest editions):
2. Hisrich, Robert D., Michael P. Peters, and Dean A. Shepherd. Entrepreneurship. 9th Edition, McGraw-Hill/Irwin, 2012.
3. Greene, Christopher L. Entrepreneurship: Ideas in Action. 5th Edition, South-Western Educational Pub, 2011.
4. Bygrave, William D., and Andrew Zacharakis. Entrepreneurship. 2nd Edition, Wiley, 2010.
5. Kuratko, Donald F. Entrepreneurship: Theory, Process, and Practice. 8th Edition, South-Western College Pub, 2008.
6. Barringer, Bruce R., and R. Duane Ireland. Entrepreneurship: Successfully Launching New Ventures. 4th Edition, Prentice Hall, 2011.
7. Entrepreneurship: Successfully Launching New Ventures by Bruce R. Barringer and R. Duane Ireland.
8. Entrepreneurship: Theory, Process, and Practice by Donald F. Kuratko.
9. New Venture Creation: Entrepreneurship for the 21st Century by Jeffry A. Timmons, Stephen Spinelli Jr., and Rob Adams.
10. Entrepreneurship: A Real-World Approach by Rhonda Abrams.
11. The Lean Startup: How Today's Entrepreneurs Use Continuous Innovation to Create Radically Successful Businesses by Eric Ries.
12. Effectual Entrepreneurship by Stuart Read, Saras Sarasvathy, Nick Dew, Robert Wiltbank, and Anne-Valérie Ohlsson

Course Code	Course Title	Credit Hours	Theory	Lab.	Category
BOT-444	Plants and Society	3	2	1	Major

Objectives: To understand the relationship between plants and people, and to expose students to society's historical connection to plants. To realize the importance of developing medicinal products from native plants and to encourage ethnobotanical endeavors and to understand and support the efforts to feed the growing populations of the world.

Course outlines

1. Plants in our lives, plants and human societies, fundamental properties of life.
2. Introduction to plant life (The plant cell, plant body, plant physiology, plant life cycle, fruits and seeds, genetics, plant systematic and evolution and diversity of plant life).
3. Plants as a source of food (Human nutrition, origin of agriculture, the grasses, legumes, starchy staples, feeding a hungry world).
4. Commercial products derived from plants (Stimulating beverages, herbs and spices, clothes, paper and wood).
5. Plants and human health (medicinal plants, psychoactive plants, poisonous and allergy plants).
6. The impact of algae and fungi on human affairs (The algae, fungi in the natural environment, beverages and food from fungi and fungi that affect human health).
7. Plants and the environment (ecological niche, biological magnification, species shift, the green world, harvesting trees).

Lab. outlines

1. Study tour to various museums and herbaria to observe human and plants relationship.
2. Study of various plant cells, plant body, plant life cycles, various fruits and seeds.
3. Determination of nutrition value of various grasses, legumes and staples.
4. Visits to various industries to observe and understand the use of plants in various products.
5. Methods of extraction from various plants for antifungal, antibacterial and other activities.
6. Collection and identification of economically important species of algae and fungi.

Books Recommended

1. Ali, S. I. 2011. Medicinal Plant Collection and Taxonomic Identification. Pak. J. Bot., 43 (SI): 11-13.
2. Bennett, B. C. 1992. Plants and people of the Amazonian Rain Forests. BioScience, 42(8); 599-607.
3. Epstein, P. 2000. Is Global Warming Harmful to Health? Scientific American, 283 (2): 50-57.
4. Hansen, J. 2004. Defusing the Global Warming Time Bomb. Scientific American, 290(3):68-77.
5. Jensen, M. N. 2004. Climate Warming Shapes Up species. Bioscience, 54 (8): 722-729.
6. Kaiser, J. 2003. An Intimate Knowledge of Trees. Science 300(5629): 566-567.
7. Levetin, E. and McMahon, K. 2006. Plants and Society. McGraw Higher Education, R. R. Donnelley, OH, USA.

8. Plotkin, M. 1990. The Healing Forest: The Search for New Jungle Medicines. The Futurist, 24(1):9-14.
9. Plotkin, M. and Famolore, L. 1992. Sustainable Harvest and Marketing of Rain Forest Products. Island Press, Washington, DC.
10. Shanley, P. and Luz, L. 2003. The Impacts of Forest Degradation on Medicinal Plant Use and Implications for Health Care in Eastern Amazonia. BioScience, 53(6): 573-584.
11. Shinwari, Z. K. and Khan, M. A. 1998. Ethnobotany of Margalla Hills, National Park of Islamabad. Published by Department of Biological Sciences, Quaid-e-Azam, University Islamabad Pakistan.
12. Shinwari, Z. K. 2010. Medicinal plants research in Pakistan. Journal of Medicinal Plants Research 4 (3): 161-176.
13. Shinwari, Z. K., Rehman, M., Watanabe, T. and Yoshikawa, T. 2006. A Pictorial Guide to Medicinal Plants of Pakistan. Al-Aziz Communications, Peshawar, Pakistan.
14. Spurr, S. 1979. Silviculture. Scientific American, 240 (20):76-91.
15. Stijhoorn, E. 1996-97. New timber forest products and Ethnobotany, concepts for management and research Department of Environment and Plant Biology, Ohio University, author, Ohio/ LATIE, Turrialba. 32.
16. Thomas, A. Y. and Shengji, P. 2003. Applied Ethnobotany a case study from the Himalayan Region. People and plants working paper. 2-13.
17. Weart, S. R. 2003. Discovery of Global Warming. Harvard University Press, Cambridge, MA.

Courses: Code	Title of the Course	Theory	Lab	Credit hours	Category
3rd YEAR					
SEMESTER-5					
BOT-551	Advanced Plant Ecology	2	1	3	Major
BOT-552	Advanced Plant Biochemistry	2	1	3	Major
BOT-553	Advanced Plant Physiology	2	1	3	Major
BOT-554	Microbial Botany	2	1	3	Major
BOT-555	Pteridophytes & Gymnosperms	2	1	3	Major
Sub Total		10	5	15	

Course	Course Title	Credit	Theory	Lab.	Category
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Code		Hours			
BOT-551	Advanced Plant Ecology	3	2	1	Major

Objectives: To provide comprehensive knowledge of population, community, ecosystem ecology and its relevance to mankind.

Course outlines

A. Population Ecology

1. Population structure and plant demography: Seed dispersal, Dormancy, Seed Bank, Seed dormancy, Recruitment, Demography
2. Life history pattern and resource allocation: Density dependent and density independent factors, Resource allocation, Reproductive effort, Seed size vs seed weight, Population genetics, Evolution

B. Community Ecology: Historical development of community ecology, Community concepts and attributes, Methods of sampling of plant communities, Ecological succession, Community soil-relationship, Local Vegetation, Vegetation of Pakistan, Major formation types of the world

C. Ecosystem Ecology: Ecological concepts of ecosystem, Boundaries of ecosystem? Compartmentalization and system concepts, Energy flow in ecosystem, Biogeochemical cycles: water carbon and nitrogen Case studies: any example

Lab. outlines

Determination of seed bank in various populations. Seed dispersal pattern of local populations. Demography and life history of local annual population. Study of community attributes. Sampling of vegetation including Quadrat, plot less, transect and Braun-Blanquet. Correlate soil properties with vegetation type. Field trip to study different communities located in different ecological regions of Pakistan. Slide show of the vegetation of Pakistan. Slide show of the major formations of the world. Soil physical and chemical properties

Books Recommended

1. Barbour *et al.*, 1999, Terrestrial Plant Ecology, The Benjamin-Cumming Publishing Co.
2. Chapin, F. S. *et al.*, 2002. Principle of Terrestrial Plant Ecology, Springer-Verlag
3. Gurevitch *et al.*, 2002. The Ecology of Plants, Sinauer Associates, Inc.
4. Hussain, F. 1989. Field and Laboratory Manual of Plant Ecology, National Academy of Higher Education. Islamabad
5. Hussain, S. 1998. Pakistan Manual of Plant Ecology. National Book Foundation.
6. Lambers, H., T. L. Pons and F. Stuart. 2008. Plant Physiological Ecology.
7. Larcher, W. 2003 Physiological Plant Ecology. Ecophysiology and Stress Physiology of Function Groups. Springer- Verlag.
8. Moore, P. D. and Chapman S. B. 1986. Methods in Plant Ecology, Blackwell Scientific Publication, Oxford.
9. Schultz, J. C. 2005. Plant Ecology, Springer-Verlag .
10. Smith, R. L. 1998. Elements of Ecology by Harper & Row Publishers,

11. Townsend, C. R. Begon, M and J. L. Harper. 2002. Essentials of Ecology, Blackwell Publishing.

Journals/Periodicals: Ecology, Journal of Ecology, Journal of Applied Ecology.

Course Code	Course Title	Credit Hours	Theory	Lab.	Category
BOT-552	Advanced Plant Biochemistry	3	2	1	Major

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

Course outlines

1. Bioenergetics: Energy, laws about energy changes. Oxidation and reduction in living systems.

2. Metabolism

- Biosynthesis, degradation and regulation of sucrose and starch. Breakdown of fats with special reference to beta-oxidation and its energy balance. Biosynthesis of fats.
- Replication of DNA. Reverse transcription. Biosynthesis of DNA and RNA.
- Components of protein synthesis. Genetic code, protein synthesis: initiation, elongation and termination.

3. Alkaloids: Occurrence, physiological effects, chemical nature with special reference to solanine, nicotine, morphine, theine and caffeine. Aflatoxins, their nature and role.

4. Terpenoids: Classification: monoterpenes, sesquiterpenes, diterpenes, triterpenes, tetraterpenes, polyterpenes and their chemical constitution and biosynthesis.

5. Vitamins: General properties and role in metabolism.

Lab. outlines

- Separation of soluble proteins by polyacrylamide gel (PAGE) electrophoresis.
- Separation of nucleic acids by gel electrophoresis.
- To estimate the amount of vitamin C in a plant organ (orange, apple juice).
- To determine potential alkaloids in plants.
- To estimate terpenoids in plants.

Books Recommended

- Abides, R. H., Frey P. A. and Jencks, W. P. 1992. Biochemistry, Jones and Bartlet, London.
- Albert L. Lehninger, 1998. Principles of Biochemistry. Worth Publishers Inc.
- Campbell, M. K. and F. Shawn. 2008. Biochemistry 6th Edition.

4. Chesworth, J. M., Strichbury T. and Scaife, J. R. 1998. An introduction to agricultural biochemistry. Chapman and Hall, London.
5. Conn E. E. and Stumpf, P. K. 2002. Outlines of Biochemistry, John Wiley and Sons Inc. New York.
6. Dey, P. M. and Harborne, J. B. 1997. Plant Biochemistry. Harcourt Asia PTE Ltd. Singapore.
7. Goodwin, T. W. and Mercer, E. I. 1997. Introduction to Plant Biochemistry. Pergamon Press, Oxford.
8. Heldt, H. W. 2008. Plant Biochemistry. 3rd Edition, Academic Press, U.K.
9. Lea, P. J. and Leegood, R. C. 1993. Plant Biochemistry and Molecular Biology. Wiley and Sons, New York.
10. Mckee, T. and Mckee, J. R. 1999. Biochemistry – An Introduction. WCB / McGraw-Hill, New York, Boston, USA.
11. Voet, D., Voet J. G. and Pratt, C.W. 1998. Fundamentals of Biochemistry, John Wiley and Sons, New York.
12. Zubay, G. 2003, Biochemistry, MacMillan Publishing Co., New York.

Journals/Periodicals: Plant Physiology & Biochemistry, Annual Review of Biochemistry, Biochemistry Journal, Critical Review in Biochemistry and Molecular Biology.

Course Code	Course Title	Credit Hours	Theory	Lab.	Category
BOT-553	Advanced Plant Physiology	3	2	1	Major

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

Course Outlines

- 1. Plant Growth Regulators:** Major natural hormones and their synthetic analogues. Bioassay, structure, biosynthesis, receptors, signal trasduction and mode of action, transport, physiological effects of Auxins, Gibberellins, Cytokinins, Absciscic and Salicylic acid.
- 2. Water Relations:** The soil -plant -atmosphere continuum - an overview. Structure of water. Physico-chemical properties of water. Water in the soil and its potentials. Water in cell components. Absorption of water in plants (pathways and driving forces, Aquaporins,-their structure and types). Methods for measurement of water, osmotic and turgor potentials- Pressure chamber, psychrometry, pressure probe, pressure volume curve.
- 3. 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.

4. **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.
5. **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. Floral organ identity genes and the ABC model.

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. Dennis, D. T., Turpin, D. H., Lefebvre, D. D. and Layzell, D. B. 1997. Plant Metabolism. 2nd Edition. Longman Group, U.K.
2. Dey, P. M. and Harborne, J. B. 1997. Plant Biochemistry. Harcourt Asia PTE Ltd. Singapore.
3. Epstein, E. and Bloom, A. J. 2004. Mineral Nutrition of Plants: Principles and Perspectives. 2nd Edition. Sinauer Associates, California, USA.
4. Fitter, A. and Hay, R.K.M. 2001. Environmental Physiology of Plants. Academic Press, UK.
5. Heldt, H. W. 2004. Plant Biochemistry. 3rd Edition, Academic Press, U.K.
6. Ihsan Illahi. 1991. Plant Growth, UGC Press, Islamabad.
7. Ihsan Illahi. 1995. Plant Physiology, Biochemical Processes in Plants, UGC Press.
8. Nobel, P.S. 1999. Physicochemical and Environmental Plant Physiology. Academic Press, UK.
9. Press, M.C., Barker, M.G., and Scholes, J.D. 2000. Physiological Plant Ecology, British Ecological Society Symposium, Volume 39, Blackwell Science, UK.
10. Salisbury, F. B. and Ross, C.B. 1992. Plant Physiology. 5th Edition. Wadsworth Publishing Co. Belmont CA.
11. Taiz, L. and Zeiger, E. 2002. Plant Physiology. 3rd Edition. Sinauer Publ. Co. Inc. Calif.
12. W. B. Hopkins. 1999. Introduction to Plant Physiology. 2nd Ed. John Wiley and Sons. New York.
13. Taiz, L. and Zeiger, E. 2006. Plant Physiology. 4th Edition. Sinauer Publ. Co. Inc. Calif.

Journals/Periodicals: Pakistan Journal of Botany, Plant Physiology, Physiologia Plantarum, Planta, Annual Review of Plant Biology, Journal of Plant Physiology.

Course Code	Course Title	Credit Hours	Theory	Lab.	Category
BOT-554	Microbial Botany	3	2	1	Major

Objectives: To understand the morphology, structure and economic importance of Viruses and Bacteria.

Course outlines

a) Viruses

1. General features of viruses, viral architecture, classification, dissemination and replication of single and double – stranded DNA/RNA viruses.
2. Plant viral taxonomy, Virus biology and virus transmission.
4. Molecular biology of plant virus transmission.
5. Symptomatology of virus-infected plants: (External and Internal symptoms).
6. Metabolism of virus-infected plants, Resistance to viral infection and Methods in molecular virology.

b) Bacteria

1. History, characteristics and classification.
2. Evolutionary tendencies in Monera (Bacteria, actinomycetes and Cyanobacteria).
3. Morphology, genetic recombination, locomotion and reproduction in bacteria
4. Bacterial metabolism (respiration, fermentation, photosynthesis and nitrogen fixation)
5. Importance of bacteria with special reference to application in various modern sciences specially agriculture, biotechnology and genetic engineering.

Lab. outlines

a) Viruses (Observation of symptoms of some viral infected plant specimens).

b) Bacteria, Actinomycetes and Cyanobacteria

1. Methods of sterilization of glassware and media etc.
2. Preparation of nutrient medium and inoculation.
3. Preparation of slides for the study of various forms, capsule/slime layer, spores, flagella and Gram-staining.
4. Growth of bacteria, sub culturing and identification of bacteria on morphological and biochemical basis (using available techniques).
5. Microscopic study of representative genera of Actinomycetes and Cyanobacteria from fresh collections and prepared slides.

Books Recommended

1. Arora, D. R. 2004. Textbook of Microbiology, CBS Publishers and Distributors, New Delhi.
2. Black, J. G. 2005 Microbiology - Principles and Exploration, John Wiley and Sons, Inc.
3. Khan, J. A. and Dijkstra, J. 2004. Plant Viruses as Molecular Pathogens. The Haworth Press, Inc. Hull R. Matthews, Academic Press.
4. Prescott, L. M., Harley, J. P. and Klein, D. A. 2005. Microbiology McGraw Hill Companies, Inc.
5. Ross, F. C. 1995. Fundamentals of Microbiology. John Willey Co. New York.
6. Tortora, G. J., Funke, B. R. and Case C. L. 2004. Microbiology. Pearson Education.

Journals/Periodicals: World Journal of Microbiology & Biotechnology, Current Microbiology, Journal of Industrial Microbiology and Biotechnology, Journal of General Virology, Journal of Virology.

Course Code	Course Title	Credit Hours	Theory	Lab.	Category
BOT-555	Pteridophytes and Gymnosperms	3	2	1	Major

Objectives: To enable the students to understand the biology and evolution of vascular plants architecture.

Course Outlines

a) 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 phyla: Psilopsida (Psilotum), Lycopsidea (Lycopodium, Selaginella), Sphenopsida (Equisetum), Pteropsida (Ophioglossum, Dryopteris and Azolla and Marsilea).

b) Origin and Evolution of seed habit.

c) Gymnosperms

Geological history, origin, distribution, morphology, anatomy, classification and affinities of Cycadofilicales, Bennettitales, Ginkgoales, Cycadales and Gnetales. Distribution of gymnosperms in Pakistan. Treats to the forests of Pakistan. Economic importance of gymnosperms. An introduction to the Gondwana flora of world.

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.

Books Recommended

1. Beck, C. B. 1992. Origin and Evolution of Gymnosperms. Vol-1&II, Columbia University Press, New York,
2. Foster, A. S. and Gifford, E. M. 1998. Comparative Morphology of Vascular Plants. W. H. Freeman and Co.
3. Jones, D. 1983. Cycadales of the World, Washington, DC.
4. Mauseth, J. D. 1998. An Introduction to Plant Biology, Multimedia Enhanced, Jones and Bartlett Pub. UK.
5. Moore, R. C., Clarke, W. D. and Vodopich, D. S. 1998. Botany McGraw Hill Company, USA
6. Raven, P. H. Evert, R. E. and Eichhorn, S. E. 1999. Biology of Plants, W.H. Freeman and Company Worth Publishers.
7. Ray, P. M., Steeves, T. A. and Fultz, T. A. 1998. Botany Saunders College Publishing, USA.

Journals / Periodicals: Pakistan Journal of Botany, New Phytologist, Review of Paleobotany & Palynology, Palaeontographica, Palaeobotanist.

Courses: Code	Title of the Course	Theory	Lab	Credit hours	Category
SEMESTER-6					
BOT-561	Systematics of Angiosperms	2	1	3	Major
BOT-562	Plant Pathology	2	1	3	Major
BOT-563	Molecular Genetics	2	1	3	Interdisciplinary
BOT-564	Biodiversity and Conservation	3	0	3	Interdisciplinary
BOT-565	Internship	3	0	3	Internship
BOT-566	Pharmacognosy (Elective – I)	2	1	3	Major
Sub Total		14	4	18	

Course Code	Course Title	Credit Hours	Theory	Lab .	Category
BOT-561	Systematics of Angiosperms	3	2	1	Major

Objectives: To know and understand the taxonomy and phylogeny of flowering plants.

Course outlines

1. **Evolution of Flowering plants.** Phylogeny and Apomorphies of Angiosperms. Origin and radiation of angiosperms, their probable ancestors, when, where and how did the angiosperms evolve; Lines of evolution in angiosperms.
2. **Diversity and Classification of Flowering Plants:** Introduction, Angiosperm Phylogeny Group, Major Angiosperms Clades
3. **ANA Grade:** Characteristics and Phylogeny of Amborellales, Nymphaeales, Austrobaileyales. General characteristics, distribution, evolutionary trends, phyletic relationships and economic importance of the following families.
 1. Amborellaceae
 2. Nymphaeaceae
 3. Illiciaceae
4. **Chloranthales.** Characteristics and Phylogeny.
5. **Magnoliid Complex.** Apomorphies of Magnoliids (Canellales, Piperales, Laurales and Magnoliales). General characteristics, distribution, evolutionary trends, phyletic relationships and economic importance of the following families.
 1. Lauraceae
 2. Annonaceae
 3. Myristicaceae
 4. Magnoliaceae
 5. Piperaceae
 6. Winteraceae
6. **Monocots:** Apomorphies and Classification. General characteristics, distribution, evolutionary trends, phyletic relationships and economic importance of the following families.
 1. Arecaceae (Palmae)
 2. Amaryllidaceae
 3. Bromeliaceae
 4. Iridaceae
 5. Cannaceae
 6. Cyperaceae
 7. Juncaceae
 8. Liliaceae
 9. Orchidaceae
 10. Poaceae
 11. Zingiberaceae
7. **Ceratophyllales:** Characteristics and Phylogeny.
8. **Eudicots:** Apomorphies and classification. General characteristics, distribution, evolutionary trends, phyletic relationships and economic importance of the following families of angiosperm:

1. Apiaceae (Umbelliferae)
2. Asclepiadaceae
3. Asteraceae (Compositae)
4. Boraginaceae
5. Brassicaceae (Cruciferae)
6. Capparidaceae
7. Caryophyllaceae
8. Chenopodiaceae
9. Convolvulaceae
10. Cucurbitaceae
11. Euphorbiaceae
12. Fabaceae (Leguminosae)
13. Lamiaceae (Labiatae)
14. Malvaceae
15. Papaveraceae
16. Ranunculaceae
17. Rosaceae
18. Salicaceae
19. Scrophulariaceae
20. Solanaceae
21. Trochodendraceae

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
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. Ali, S. I. and Nasir, Y. 1990-92. Flora of Pakistan. Karachi Univ. Press, Karachi
2. Ali, S. I. and Qaiser, M. 1992-2012. Flora of Pakistan. Karachi Univ. Press, Karachi.
3. Davis, P.H. & Heywood, V. H. 1963. Principles of Angiosperm Taxonomy. Oliver & Boyd, London
4. Greuter, W., McNeill, J., Barrie, F. R., Burdet, H. M., Demoulin, V., Filguerras, T. S., Nicolson, D. H. Silva, P. C., Skog, J. E., Trehane, P., Turland, N. J. & Hawksworth, D. L., (Eds.) 2000. International code of botanical nomenclature (Saint Louis Code) adopted by the Sixteenth International botanical congress St. Louis Missouri, July –August 1999. Koeltz, Konigstein. (Regnum Veg.138.)
5. Heywood, V. H. 1978. Flowering Plants of the World. Oxford University Press.
6. Ingrouille, M. 1992. Diversity and Evolution of Land Plants, Chapman & Hall. London

7. Jeffrey, C. 1980. An Introduction to Plant Taxonomy. Cambridge University Press.UK
8. Jones, S. B. and Luchsinger, A. E. 1987. Plant Systematics. McGraw Hill, Inc. New York.
9. Leadlay, E. and Stephen. 2006. Taxonomy and Plant Conservation.
10. Levin, D. A. 2000. The Origin, Expansion and Demise of Plant Species. Oxford University Press.
11. Naik, V. N. 2005. Taxonomy of Angiosperms. Tata McGraw Hill Publishing Company, New Delhi.
12. Nasir, E. & Ali, S. I. 1970-89. Flora of Pakistan. Karachi Univ. Press, Karachi.
13. Pullaiah, T. 2007 Taxonomy of Angiosperms 3rd Ed. Regency Publication, New Delhi.
14. Radford, A. E., Dickison, W. C. Massey, J. R. and Bell, C. R. 1998 Vascular Plant Systematic. Harper and Row, New York.
15. Rajput, M. T., S. Saliha and K. M. Khan. 1996. Plant Taxonomy. Nasim Book Depot Hyderabad.
16. Simpson, M. G. 2006. Plant Systematics. Elsevier Academic Press.
17. Sivarajan, V. V and Robson, N. K. P. 1991. Introduction to the Principles of Plant Taxonomy.
18. Soltis, D. E., Soltis, P. S., Endress, P. K. and Chase, M. W. 2005. Phylogeny & evolution of angiosperms. Sinauers associates, Inc. Publishers.
19. Stace, C. 1992. Plant Taxonomy and Biosystematics, Edward Arnold.
20. Stussy, T. F. 1990. Plant Taxonomy, Columbia University Press, USA.
21. Takhtajan, A. 1986. Flowering Plant: Origin and Dispersal, Oliver and Boyd, Edinburgh.

Journals/Periodicals: Pakistan Journal Botany, Flora of Pakistan, Taxon, Botanical Journal of the Linnaean Society.

Course Code	Course Title	Credit Hours	Theory	Lab .	Category
BOT-562	Plant Pathology	3	2	1	Major

Objectives: To familiarize the students with various diseases caused by Fungi.

Course outlines

Pathology

1. Introduction and classification of plant diseases.
2. Symptoms, causes and development of plant diseases
3. Loss assessment and disease control
4. Epidemiology and disease forecast

5. Important diseases of crop plants and fruit trees in Pakistan caused by fungi, e.g. damping off, mildews, rusts, smuts, shisham dieback etc.

Lab. outlines

Pathology

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.

Books Recommended

8. Agrios, G. N. 2005. Plant Pathology, Academic Press, London.
9. Ahmad, I. and Bhutta, A. R. 2004. Textbook of Introductory Plant Pathology. Book Foundation, Pakistan.
10. Alexopoulos, C. J., Mims, C. W. and Blackwell, M. 1996. Introductory Mycology, 4th ed. John Wiley & Sons.
11. Khan, A. G. and Usman, R. 2005. Laboratory Manual in Mycology and Plant Pathology. Botany Department Arid Agriculture University, Rawalpindi.
12. Mehrotra, R. S. and Aneja, K. R. 1990. An Introduction to Mycology. Wiley and Eastern Ltd., New Delhi, India.
13. Moore-Landecker, E. 1996. Fundamentals of Fungi. 4th Ed. Prentice Hall Inc., New Jersey, USA.
14. Trigiano, R. N., Windham, M. T. and Windham, A. S. 2004. Plant Pathology: Concepts and Laboratory Exercises. CRC Press, LLC, N.Y.

Journals/Periodicals: Pakistan Journal of Botany, Mycotoxin, Mycopathology, Phytopathology, Australasian Journal of Plant pathology, Asian Journal of Plant Pathology, Annual Review of Plant Pathology.

Course Code	Course Title	Credit Hours	Theory	Lab	Category
BOT-563	Molecular Genetics	3	2	1	Interdisciplinary

Objectives: To understand the nature and function of genetic material.

Course outlines

1. Introduction, Historical background, Material and methods in molecular genetics.
2. Identification of the Genetic Materials, Direct evidence of DNA as the genetic materials, Indirect evidence of DNA as the genetic materials; evidences for RNA as the genetic material of some viruses.
3. Chemical nature of genetic materials (*i.e.*, DNA and RNA),
4. Replication of DNA: Watson and Crick's model of DNA replication, experimental evidence for semi-conservative DNA replication in *E.coli* and eukaryotes, enzymes of

- DNA replication, roles of RNA primers in DNA replication, mechanism of DNA replication in prokaryotes, DNA replication in eukaryotes, models of DNA replication.
5. Genetic Code: Basis of cryptoanalysis; codon assignment (cracking the code or deciphering the code), the *in vitro* codon assignment, the *in vivo* codon assignment, characteristics of genetic code, wobble hypothesis.
 6. Biosynthesis of Protein: DNA Function: Transcription, translation, protein synthesis.
 7. Regulation of Gene Action: Regulation of gene action in prokaryotes- transcriptional control mechanisms; negative control, inducible operons, repressible system, positive control, lac operon, translational control, post-translation control (feedback inhibition); regulation of gene action in eukaryotes.
 8. Genetic Engineering: Principles of genetic engineering / biotechnology; Basic genetic engineering techniques. Application of genetics in plant improvement.
 9. Mutations: Gene Mutation: Somatic versus germinal mutation, mutant types, the occurrence of mutations, mutation and cancer, mutagens in genetic disorder, mutation breeding. Evolutionary significance of mutation.
 10. Genetic Recombination and Gene Transfer: Recombination in Bacteria and their Viruses: Bacterial chromosome, bacterial conjugation, bacterial recombination and mapping the *E. coli* chromosome, bacterial transformation, bacteriophage genetics, transduction, mapping of bacterial chromosomes, bacterial gene transfer.
 11. Developmental Genetics: Gene Regulation and Differentiation, Crown gall disease in plants, cancer as a developmental genetic disease.
 12. Population Genetics: Gene frequencies, conservation of gene frequencies, equilibrium, Hardy-Weinberg law, factors affecting gene equilibrium.

Lab. outlines

1. **Numerical problems**
 - a) Arrangement of genetic material:
 - i. Linkage and recombination.
 - ii. Gene mapping in diploid.
 - iii. Recombination in Fungi.
 - iv. Recombination in bacteria.
 - v. Recombination in viruses.
 - b) Population Genetics:
 - i. Gene frequencies and equilibrium.
 - ii. Changes in gene frequencies,
2. **Blood group and Rh-factor**
3. **Drosophila**
 - i. Culture technique
 - ii. Salivary gland chromosome
4. **Fungal genetics**

Sacchromyces culture techniques and study.

5. **Studies on variation in maize ear size and colour variation**
6. **Bacterial Genetics.**
 - i. Bacterial cultural techniques, Gram staining (E. coli, B. subtilis)
 - ii. Transformation
 - iii. Conjugation.

Books Recommended

1. Gardner, E. J. 2004. Principles of Genetics, John Wiley and Sons, New York.
2. Gelvin, S. B. 2000. Plant Molecular Biology Manual. Kluwer Academic Publishers.
3. Griffiths A. J. F., Wessler, S. R., Lewontin, R. C., Gelbart, W. M., Suzuki, D. T. and Miller, J. H. 2005. Introduction to Genetic Analysis, W.H. Freeman and Company.
4. Hartl, D. L. and Jones, E.W. 2005. Genetics - Analysis of Genes and Genomes, Jones and Bartlett Publishers. Sudbury, USA.
5. Hedrick, P. W. 2005. Genetics of Population. Jones and Bartlett Publisher, Sudbury, USA.
6. Klug, W. S. and Cummings, M. R. 1997. Concepts of Genetics, Prentice Hall International Inc.
7. Pierca, B. A. 2005. Genetics. A conceptual approach, W. H. Freeman and Company, New York.
8. Ringo, J. 2004. Fundamental Genetics, Cambridge University Press.
9. Rothwell, N. V. 1997. Understanding Genetics, second edition, Oxford University Press Inc.
10. Snyder, L. and Champness, W. 2003. Molecular Genetics of Bacteria, ASM Press.
11. Synder, L. and Champness, W. 2004. Molecular Genetics of Bacteria. ASM Press, Washington DC.
12. Verma, P. S. and Agarwal, V. K. 2009. Genetics. S. Chand and Co. Ltd, New Delhi.
13. Verma, P. S. and Agarwal, V. K. 2009. Cell Biology, Genetics, Molecular Biology, Evolution and Ecology. S. Chand and Co. Ltd, New Delhi.

Journals/Periodicals: J. Genetics, Theoretical and Applied Genetics, Cytologia, Chromosoma, Genome.

Course Code	Course Title	Credit Hours	Theory	Lab	Category
BOT-564	Biodiversity & Conservation	3	3	0	Interdisciplinary

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

Course outlines

1. Definition of biodiversity as defined in the convention of biological diversity (CBD).
2. Introduction of species on each other for their survival.
3. Extent of known and estimated biodiversity of earth.
4. Measuring biodiversity: Alpha, Beta, and Gamma diversity, Systematic diversity, functional diversity, taxic diversity.

5. Ecological services, indirect value of ecosystem by virtue of their ecological functions, direct value of ecosystem (i.e. Utility of living resources).
6. Sustainable and unsustainable use of ecosystem resources, consequences of unsustainable use, ecosystem degradation, extinct species, desertification and deforestation.
7. Biodiversity Hot spots of the world.
8. International treaties/agreements regarding Biodiversity and conservation; CBD, CITES, Ramsar.
9. IUCN categorised protected areas in Pakistan.
10. Environmental Impact Assessment.
11. Use of herbarium and Botanical Garden in biodiversity and conservation.

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. Bush, M. B. 1997 Ecology of a changing Planet. Prentice Hall. New Jersey.
2. Falk, D. A. and Holsinger, K. E. 1991. Genetics and Conservation of Rare Plants. Center for Plant Conservation. Oxford University Press, Oxford, UK.
3. Frankel, O. H., Brown, A. H. D. and Burdon, J. J. 1995. *The Conservation of Plant Biodiversity*. Cambridge University Press, Cambridge, UK.
4. French, H. 2000 Vanishing Borders- protecting the Planet in the age of globalization. W.W. Norton and Co.
5. Heywood, V. 1995. Global Biodiversity Assessment. Published for the United Nations Environment Programme. Cambridge University Press, Cambridge, UK.
6. IUCN. 1994. *IUCN Red List Categories*. As Approved by the IUCN Council. IUCN.
7. Leadlay, E. and Jury, S. 2006 Taxonomy and Plant Conservation. CUP.
8. Swanson, T. 2005 Global Action for Biodiversity. Earth Scan Publication Ltd.
9. Taylor, P. 2005. Beyond Conservation. Earth Scan Publication Ltd.

Journals /Periodicals: Systematics and Biodiversity Conservation.

Course Code	Course Title	Credit Hours	Theory	Lab	Category
BOT-565	Internship	3	3	0	Internship

Objectives

To expose students to do practical work in a real world situation to bridge the gap between theory and practice by writing a report independently. Learn communication skills by presenting it in a seminar.

Course outlines

The proposal to introduce a mandatory internship of 06-08 weeks (3 credit hours) during the 6th or 7th semester (summer break can also be utilized) was approved and the following key decisions were made.

- Internships will be arranged in collaboration with botanical gardens, herbaria, research institutes, universities and relevant industries.
- No financial liability will be borne by the department or university.
- Students will manage their own expenses and arrangements.
- Internship will be graded by a faculty member in collaboration with the supervisor.

Course Code	Course Title	Credit Hours	Theory	Lab	Category
BOT-566	Pharmacognosy	3	2	1	Major

Objectives: To understand the identification of drugs, its origin, morphology and microscopic studies, to determine the quality of the drug, its chemical compositions and therapeutic effects. To identify and introduce Medicinal Plants as alternative crops for commercial purposes to the general public.

Course outlines

1. Definition, history, scope and development of Pharmacognosy.
2. Source and classification of drugs, important medicinal plant families, cultivation, collection, processing and storage of crude drugs. Factors influencing cultivation of medicinal plants.
3. Quality control of crude drugs, systematic pharmacognostic studies of various products including Carbohydrates and derived products and Lipids.
4. Studies of drugs containing Resin and Volatile oils. Phytochemical screening, pharmaceutical aids, study of fibres and tannins. Utilization of aromatic plants and desired products and their role in national economy.
5. Study of Biological sources, cultivation, collection, commercial varieties, chemical constituents, substitutes, adulterants, uses, microscopic and macroscopic features and chemical tests of alkaloids, glycosides, plant bitters, sweeteners and other chemicals. Biological sources, preparation, identification tests and uses of enzymes diastase, papain, penicillinase, hyaluronidase and streptokinase.
6. Utilization and production of phytoconstituents and studies of traditional drugs. Brief introduction and principals of Ayurvedic, Unani, Siddha and Homeopathic systems of medicines and herbal Pharmacopoeia.
7. Worldwide trade of Aromatic and High Valued Medicinal Plants. Introduction, classification and study of different chromatographic methods and its application in evaluation of herbal drugs. Application of Plant Tissue Culture in pharmacognosy.

Lab. outlines

1. Collection, identification and pressing of 50 Aromatic and High Valued Medicinal Plants.
2. Powder drug study of various selected Aromatic and High Valued Medicinal Plants
3. Microscopic study of Resin, Volatile oils, fibres and tannins.
4. Visits to various pharmaceutical industries to observe and understand the use of Aromatic and High Valued Medicinal Plants.

5. Microscopic and macroscopic features and chemical tests of alkaloids, glycosides, plant bitters, sweeteners and other chemicals in various plant groups.
6. Use of different chromatographic methods and its application in evaluation of herbal drugs.

Books Recommended

1. Anonymous. 1986. Ayurvedic Pharmacopoeia. Ministry of Health and Family Welfare, Govt. of India, New Delhi.
2. Atal, C. K. and Kapoor, B. M. 1982. Cultivation and Utilization of Medicinal Plants. Regional Research Laboratory (CSIR), Jammu-Tawi.
3. Bhattacharjee, S. K. 2001. Hand Book of Medicinal Plants. Pointer Publishers, Jaipur India.
4. Brain, K. R. and Turner, T. D. 1975. The Practical Evaluation of Phytopharmaceuticals. Wright-Scientifica, Bristol.
5. Evan, W. C., Trease and Evans. 2002. Pharmacognosy. W.B. Saunders, London.
6. Harborne, J. B. 1998. Phytochemical methods: A guide to the modern techniques of Plant analysis, 3rd edition. Champion and Hall, London.
7. Jarald, E. E. and S. E. Jarald. 2009. Pharmacognosy and Phytochemistry. CBS Publishers and Distributors, New Delhi, India.
8. Trease, G. E. and W. C. Evans. 1985. Pharmacognosy. 12th Ed. English Language Soc. Baillere Tindall.
9. Wallis, T. E. 1981. A Text Book of Pharmacognosy. J & A Churchill Ltd. Gloucester Palace, W. I. London.
10. Youngkin, H. W. 1950. A Text Book of Pharmacognosy. The Blackistan Co. Toronto Philadelphia.

Courses: Code	Title of the Course	Theory	Lab	Credit hours	Category
4th YEAR:					
SEMESTER-7					
BOT-671	Analytical Techniques in Botany	1	2	3	Major
BOT-672	Field Botany	2	1	3	Major
BOT-673	Phytogeography	2	1	3	Major
BOT-674	Scientific Inquiry & Research Methods	2	1	3	Interdisciplinary
BOT-675	Paleobotany(Elective – II *****)	2	1	3	Major
Sub Total		9	6	15	

Course Code	Course Title	Credit Hours	Theory	Lab	Category
BOT-671	Analytical Techniques in Botany	3	2	1	Major

Objectives

1. To familiarize students with modern and classical analytical techniques used in botanical research.
2. To provide an understanding of the principles, applications, and limitations of analytical instruments in plant sciences.
3. To develop the ability to analyze plant metabolites, biomolecules, and ecological samples.
4. To explore the role of analytical techniques in taxonomy, physiology, ecology, and phytochemistry.

COURSE OUTLINE

1. Introduction to Analytical Techniques in Botany

- Importance of analytical methods in modern botanical research.
- Scope and applications in taxonomy, phytochemistry, physiology, and molecular biology.
- Overview of qualitative and quantitative analysis.

2. Sample Preparation and Handling

- Principles of sample collection, preservation, and preparation.
- Methods for drying, grinding, and extracting plant materials.
- Importance of avoiding contamination during sample preparation.

3. Spectroscopic Techniques

- ✓ **UV-Visible Spectroscopy:**
 - Principles of light absorption and Beer-Lambert law.
 - Applications in analyzing pigments, secondary metabolites, and enzyme activity.
- ✓ **Infrared (IR) Spectroscopy:**
 - Functional group identification in phytochemicals.
 - Basics of FTIR instrumentation and sample preparation.
- ✓ **Fluorescence Spectroscopy:**
 - Detection of fluorescent compounds in plant extracts.
 - Application in chlorophyll and secondary metabolite analysis.
- ✓ **NMR Spectroscopy:**
 - Principles of nuclear spin and chemical shifts.
 - Applications in structural analysis of plant-derived compounds.
- ✓ **Mass Spectrometry (MS):**
 - Introduction to ionization techniques (EI, ESI, MALDI).
 - Use in identifying and quantifying plant metabolites.

4. Chromatographic Techniques

- ✓ **Paper Chromatography:**
 - Separation of plant pigments and identification of primary metabolites.
- ✓ **Thin-Layer Chromatography (TLC):**
 - Principles, stationary phases, and visualization techniques.
 - Use in screening secondary metabolites.
- ✓ **High-Performance Liquid Chromatography (HPLC):**

- Overview of stationary phases, mobile phases, and detectors.
- Applications in quantifying phenolics, flavonoids, and alkaloids.
- ✓ **Gas Chromatography (GC):**
 - Instrumentation, types of detectors (FID, MS), and applications.
 - Analysis of volatile compounds and essential oils.

5. *Molecular Biology Techniques*

- ✓ **Nucleic Acid Extraction:**
 - Principles of DNA and RNA isolation from plants.
 - Use of organic and column-based methods.
- ✓ **Polymerase Chain Reaction (PCR):**
 - Principles, types (e.g., real-time PCR, RT-PCR), and applications.
 - Use in genetic identification and phylogenetic studies.
- ✓ **Electrophoresis:**
 - Agarose gel electrophoresis for DNA/RNA.
 - SDS-PAGE for protein separation and profiling.

6. *Elemental and Nutritional Analysis*

- ✓ **Atomic Absorption Spectroscopy (AAS):**
 - Principles and applications in macro and micronutrient analysis.
- ✓ **Inductively Coupled Plasma Mass Spectrometry (ICP-MS):**
 - Analysis of trace elements in plants.
- ✓ **Flame Photometry:**
 - Quantification of alkali and alkaline earth metals.

7. *Phytochemical Analysis*

- ✓ **Extraction Techniques:**
 - Solvent-based extractions (maceration, Soxhlet, ultrasonic-assisted extraction).
 - Green extraction techniques (supercritical fluid extraction).
- ✓ **Qualitative Tests:**
 - Detection of alkaloids, saponins, tannins, flavonoids, and terpenoids.
- ✓ **Quantitative Assays:**
 - Total phenolic content (Folin-Ciocalteu method).
 - Total flavonoid content (Aluminum chloride method).
 - Antioxidant activity (DPPH, ABTS, FRAP assays).

8. *Microscopy and Imaging Techniques*

- ✓ **Light Microscopy:**
 - Basics of microscopy and sample preparation.
 - Observation of plant tissues, stomata, and trichomes.
- ✓ **Fluorescence Microscopy:**
 - Detection of plant pigments and fluorescence probes.
- ✓ **Electron Microscopy:**
 - Scanning Electron Microscopy (SEM) for surface morphology.
 - Transmission Electron Microscopy (TEM) for ultrastructure analysis.

9. Plant Physiology and Stress Marker Analysis

- Measurement of photosynthetic pigments (chlorophyll, carotenoids).
- Analysis of osmolytes (e.g., proline) and stress markers (MDA, ROS).
- Enzyme assays for catalase, peroxidase, and superoxide dismutase activities.

10. Bioinformatics and Data Analysis

- Introduction to bioinformatics tools for genomics and metabolomics.
- Statistical methods for analyzing experimental data.
- Use of software (SPSS, R, GraphPad Prism) for data visualization.

LAB OUTLINE

1. Sample Preparation and Extraction

- Preparation of plant samples for spectroscopic and chromatographic analysis.
- Solvent extraction of primary and secondary metabolites.

2. Spectroscopic Experiments

- Estimation of chlorophyll and carotenoids using UV-Vis spectrophotometry.
- FTIR analysis of plant extracts for functional group identification.
- Fluorescence analysis of chlorophyll and secondary metabolites.

3. Chromatographic Experiments

- Separation of pigments using paper chromatography.
- TLC for qualitative analysis of secondary metabolites.
- HPLC for quantification of phenolics and flavonoids.
- GC for volatile organic compound analysis.

4. Molecular Biology Techniques

- DNA and RNA extraction from plant tissues.
- Visualization of DNA using agarose gel electrophoresis.
- PCR amplification of plant DNA for phylogenetic analysis.

5. Elemental Analysis

- Estimation of sodium and potassium using flame photometry.
- Macro and micronutrient analysis using AAS.

6. Phytochemical Analysis

- Qualitative analysis of tannins, alkaloids, and saponins.
- Quantitative estimation of total phenolics and flavonoids.
- Antioxidant activity assays (DPPH and ABTS).

7. Microscopy Techniques

- Preparation of slides for light microscopy.
- Observation of cellular details using fluorescence microscopy.
- SEM and TEM for studying plant structures.

8. Enzyme Assays

- Measurement of catalase, peroxidase, and superoxide dismutase activities.
- Quantification of stress markers such as proline and MDA.

9. Data Recording and Report Preparation

- Compiling experimental results.
- Statistical analysis and presentation of data using scientific software.
- Preparation of lab reports and presentations.

Recommended Books

1. **"Principles and Techniques of Biochemistry and Molecular Biology"** by Keith Wilson and John Walker.
2. **"Phytochemical Methods: A Guide to Modern Techniques of Plant Analysis"** by Jeffrey B. Harborne.
3. **"Introduction to Spectroscopy"** by Donald L. Pavia, Gary M. Lampman, and George S. Kriz.
4. **"Chromatographic Techniques"** by Rosemary Alves De Azevedo.
5. **"Plant Physiology and Development"** by Lincoln Taiz and Eduardo Zeiger.
6. **"Practical Manual for Plant Molecular Biology"** by Promila Pathak and R.C. Gupta.
7. **"Analytical Techniques in Plant Sciences"** by S. K. Pande and H. Panda.
8. **"Mass Spectrometry for Biotechnology"** by Gary Siuzdak.
9. **"Bioinformatics: Sequence and Genome Analysis"** by David W. Mount.
10. **"The Handbook of Phytochemical Techniques"** by R. A. Dixon.

Course Code	Course Title	Credit Hours	Theory	Lab	Category
BOT-672	Field Botany	3	2	1	Major

Objectives

1. To introduce students to the principles of field botany, including plant identification, taxonomy, and ecological interactions.
2. To familiarize students with the diversity and distribution of plant species in natural habitats.
3. To provide knowledge on the methods of plant collection, preservation, and herbarium techniques.
4. To understand the relationship between plants and their environment, including adaptations and ecological roles.
5. To train students in the use of floras, field guides, and dichotomous keys for plant identification.

Course Contents (Theory)

1. Introduction to Field Botany

- Definition, scope, and importance of field botany in biodiversity conservation.
- Historical perspective and contributions of notable field botanists.
- Applications of field botany in taxonomy, ecology, and environmental science.

2. Plant Morphology and Taxonomy

- Basic morphological features of angiosperms, gymnosperms, pteridophytes, bryophytes, and lichens.
- Principles of taxonomy and nomenclature (ICN guidelines).
- Introduction to key plant families and their diagnostic characteristics.
- Role of morphological, anatomical, and molecular data in taxonomy.

3. Vegetation Types and Habitats

- Overview of vegetation types: forests (tropical, temperate), grasslands, deserts, wetlands, and alpine ecosystems.
- Factors influencing vegetation distribution (climatic, edaphic, and biotic).
- Endemism, invasive species, and indicator species of different ecosystems.

4. Field Techniques in Botany

- Methods of plant collection, labeling, and preservation.
- Use of field tools: GPS devices, compasses, altimeters, and field notebooks.
- Role and preparation of herbarium sheets, herbarium management, and digitization.

5. Plant Adaptations

- Adaptations to terrestrial habitats: xerophytes, mesophytes, and hydrophytes.
- Anatomical and physiological adaptations to specific environmental conditions (e.g., drought, salinity, temperature extremes).

6. Biodiversity Assessment

- Biodiversity concepts: species richness, evenness, and diversity indices.
- Sampling techniques: quadrats, transects, and plotless methods.
- Recording and analyzing biodiversity data.

7. Conservation Biology

- Principles of plant conservation and its importance.
- In situ and ex situ conservation strategies.
- Role of botanical gardens, seed banks, and herbaria in conservation.

8. Ethnobotany

- Importance of traditional knowledge and its documentation.
- Ethnobotanical surveys: methodologies and ethical considerations.
- Case studies of culturally significant plants and their uses.

9. Introduction to Field Guides and Plant Identification

- Using floras, field guides, and dichotomous keys.
- Introduction to mobile applications and software for plant identification.
- Regional flora and their use in identifying native plants.

10. Plant Ecology

- Plant community structure: composition, dominance, and stratification.
- Ecological interactions: mutualism, competition, and parasitism.
- Ecological succession and its stages.

LAB OUTLINE

1. Plant Collection and Preservation

- Practical demonstration of plant collection techniques in different habitats.
- Methods for pressing, drying, and mounting plants for herbarium specimens.
- Labeling protocols: scientific name, family, habitat, collector, and date.

2. Herbarium Techniques

- Step-by-step process of herbarium specimen preparation.
- Study of herbarium organization and database systems.
- Practical application of herbarium specimen digitization.

3. Field Visits

- Visits to local ecosystems such as forests, wetlands, or grasslands.
- Observation of plant diversity and ecological interactions.
- Hands-on experience with field tools: GPS, soil testing kits, and compasses.

4. Vegetation Sampling and Analysis

- Quadrat sampling for species frequency, density, and dominance.
- Transect methods to analyze vegetation gradients.
- Recording and interpreting data for diversity indices.

5. Plant Morphology and Identification

- Detailed observation of plant morphological features: roots, stems, leaves, flowers, and fruits.
- Comparative identification of major plant families using field guides.

6. Ethnobotanical Survey Techniques

- Conducting surveys to document the uses of plants by local communities.
- Collection and recording of ethnobotanical data: tools, methods, and challenges.
- Case studies of economically and medicinally important plants.

7. Data Recording and Reporting

- Maintaining field notebooks with observations and sketches.
- Preparation of field reports and data sheets for analysis.

- Use of software tools (e.g., MS Excel, R, or GIS tools) for data organization.

8. Plant Photography and Documentation

- Basics of plant photography for documentation.
- Techniques for capturing clear images of plants in the field.
- Annotation of photographs for scientific records.

9. Use of Field Guides and Digital Tools

- Practicing plant identification with dichotomous keys.
- Demonstration of mobile and online tools (e.g., iNaturalist, PlantNet).
- Integrating technology into field research.

10. Plant Ecology in the Field

- Observing ecological interactions in natural habitats.
- Recording abiotic factors: temperature, humidity, soil pH, and light intensity.
- Study of seasonal variations in plant communities.

11. Preparation of Herbarium Report

- Compilation of collected specimens into a report.
- Herbarium specimen indexing and cataloging.
- Presentation of findings in the form of a practical manual.

Recommended Books

1. **"Field Botany: A Handbook"** by F.J. Rumsey and A. Briggs
2. **"Field Guide to the Wildflowers of North America"** by National Wildlife Federation
3. **"Plant Identification Terminology: An Illustrated Glossary"** by James G. Harris and Melinda Woolf Harris
4. **"The Herbarium Handbook"** by Leonard Forman and Diane Bridson
5. **"Manual of Field Botany"** by John Smith
6. **"Field Botany: A Beginner's Guide"** by Chris Thorogood
7. **"Flora of the World"** series (region-specific floras for reference)
8. **"Ethnobotany: Principles and Applications"** by Anthony Cunningham
9. **"Ecology: Concepts and Applications"** by Manuel C. Molles
10. **"New Flora of the British Isles"** by Clive Stace (for comprehensive species identification).

Course Code	Course Title	Credit Hours	Theory	Lab	Category
BOT-673	Phytogeography	3	2	1	Major

Objectives

- To study the geographic distribution of plants across the globe and comprehend the factors influencing their distribution.

- To explore the evolutionary and historical aspects that have shaped the current plant distributions.
- To understand the characteristics of major biomes and floristic regions worldwide.
- To analyze the impact of climate, soil, and topography on plant distribution.

Theory

1. Introduction to Phytogeography

- Definition and scope of biogeography.
- Definition and scope and branches of phytogeography.
- Relationship of phytogeography with ecology, taxonomy, systematics, and evolution.

2. Patterns of Biodiversity: Distribution of Plants

- Global patterns of species richness and endemism.
- Latitudinal gradients and biodiversity hotspots.
- Species-area relationships.
- Temporal dynamics of diversity
- Types of Distribution: Endemic, disjunct, cosmopolitan, and relict distributions. Examples of species for each type.
- Centers of origin and diversification of flora.
- Concept of refugia and their role in plant evolution.
- Role of plate tectonics, continental drift, and land bridges in shaping plant distributions (e.g., Gondwanan flora, Laurasian flora).
- Concept of vicariance and dispersal mechanisms.

3. Factors Affecting Plant Distribution

- Abiotic Factors:
 - Climate: temperature, light, precipitation, and wind.
 - Soil properties: texture, pH, nutrients, and salinity.
 - Topography: altitude, slope, and aspect.
- Biotic Factors:
 - Interspecific and intraspecific competition.
 - Mutualism, parasitism, and allelopathy.
 - Role of natural disturbances: fire, floods, and landslides.
- Human influences: agriculture, urbanization, deforestation, and habitat fragmentation.

4. Floristic Regions of the World (Takhtajan's Classification)

- Overview of Takhtajan's classification system and its principles.
- Major phytochoria (floristic kingdoms):
 - Holarctic Kingdom: Arctic, Boreal, Temperate, and Mediterranean floristic regions.
 - Paleotropical Kingdom: Tropical Asia, African, and Polynesian regions.
 - Neotropical Kingdom: South America and Central America regions.
 - Australian Kingdom: Flora of Australia and nearby islands.
 - South African (Capensis) Kingdom: Unique flora of the Cape region.
 - Antarctic Kingdom: Southern Hemisphere islands and their flora.

Comparative analysis of biodiversity among these regions.

Endemism and hotspot analysis in floristic kingdoms.

5. The Geography of Communities Global Biomes and Vegetation Types

- Classification of global vegetation:
- Tropical rainforests.
- Grasslands and savannas.
- Deserts and xerophytic vegetation.
- Temperate forests (deciduous and coniferous).
- Tundra and alpine vegetation.
- Climate-vegetation interactions in different biomes.
- Role of latitudinal and altitudinal gradients in vegetation patterns.

6. Phytogeographic Barriers and Corridors

- Role of geographic and ecological barriers in shaping distributions.
- Physical barriers: mountains, oceans, and deserts.
- Ecological corridors and their role in species migration.
- Impacts of climatic changes and glaciation on plant migration.

7. Conservation Phytogeography

- Biodiversity hotspots and their importance.
- Challenges to plant conservation: habitat loss, climate change, and invasive species.
- Protected areas: national parks, wildlife sanctuaries, and biosphere reserves.
- Role of phytogeography in designing conservation strategies.

8. Floristic and Phytogeographic Studies in Pakistan

- Overview of major phytogeographic regions of Pakistan.
- Endemic and economically significant plants of Pakistan.
- Conservation challenges and strategies specific to Pakistan.

Lab. outlines

- 1. Visits to various museums and herbaria of the country to observe animal and plant fossils and their importance in biogeography.
- 2. Visits to various ecological and phytogeographical regions of Pakistan.
- 3. Study of diverse ecosystems.
- 4. Collection of plant specimens from various phytogeographical regions of the country.

Recommended Books

Ali, S. I. and M. Qaiser. 1986. Phytogeographical analysis of the phanerogames of Pakistan and Kashmir. Proc. Royal Soc. Edin Burgh, 89 B: 89-101.

Cox, C. B. and P. D. Moore. 2010. Biogeography: An ecological and evolutionary approach. John Wiley & Sons, Inc., USA.

Humphries, C. J. and L. R. Paranti. 1986. Cladistic Biogeography. Oxford, Clarendon Press.

Huston, M. A. 1994. Biological Diversity. The coexistence of species on changing landscapes. Cambridge University Press.

Lomolino, M. V., D. F. Sax. and J. H. Brown. 2004. Foundations of biogeography. Sinauer Associates, Inc. Publishers, Sunderland, Massachusetts.

Lomolino, M. V., B. R. Riddle and J. H. Brown. 2006. Biogeography. Sinauer Associates, Inc. Publishers, Sunderland, Massachusetts.

Armen Takhtajan . 1986. "Floristic Regions of the World" by– Detailed account of floristic regions.

"Principles of Plant Geography" by Otto Nordenskjöld – Basics of plant distribution.

"The Geography of Plants" by Alexander von Humboldt and Aimé Bonpland – Foundational work in phytogeography.

Ronald Good . 1974. "Plant Geography" by– Excellent coverage of floristic patterns.

Course Code	Course Title	Credit Hours	Theory	Lab	Category
BOT-674	Scientific Inquiry & Research Methods	3	2	1	Interdisciplinary

Objectives:

- To familiarize the students about modern research
- To develop modern skills of research i.e., preparation, identification of problems, project designing, review of literature and enable students to write research proposal.
- To learn about ethical issues.

Course Contents:

Introduction to Research Methodology; Overview of research methodology. Differences between qualitative and quantitative research. Ethical considerations in research

Qualitative Research Methods; Introduction to qualitative research designs, Data collection methods: interviews, focus groups, and observations, Qualitative data analysis techniques: coding and thematic analysis

Quantitative Research Methods: Introduction to quantitative research designs; Survey research methods: questionnaire design and sampling techniques; Basic statistical analysis: descriptive statistics and inferential statistics

Mixed-Methods Research; Combining qualitative and quantitative research approaches; Designing mixed-methods research studies; Integrating data from different sources and analysis techniques

Data Collection Techniques; Conducting interviews and focus groups, Designing surveys and questionnaires; Ethical considerations in data collection

Data Analysis Techniques: Analyzing qualitative data: coding, thematic analysis, and content analysis; Analyzing quantitative data: descriptive statistics, correlation analysis, and regression analysis, Introduction to statistical software tools (e.g., SPSS, NVivo)

Reporting and Presenting Research Findings: Writing research reports: structure and formatting; creating effective visualizations: tables, charts, and graphs; Presenting research findings: oral presentations and posters

Research Project; Applying research methods to Botany-related topics; Conducting a research project from design to presentation; Final project presentations and peer feedback

Lab

Course Project (Assignment):

Students are required to complete individual and/or group assignments, presentations, or other course-related projects as directed by the instructor, in accordance with the rules and regulations of

the university and the current semester.

Recommended Books

1. Franklin, M. I. (2012). Understanding research: Coping with the quantitative-qualitative divide. Routledge.London.
2. Merriam, S. B. (2014). Qualitative Research: A Guide to Design and Implementation. John Wiley & Sons.
3. Leavy, P. (2022). Research Design: Quantitative, Qualitative, Mixed Methods, Arts-Based, And Community-Based Participatory Research Approaches, 2nd Edition. Guilford Press.London.
4. Merriam, S. B., & Tisdell, E. J. (2020). Qualitative research: A guide to design and implementation. 5th edition. John Wiley & Sons.
5. Alasuutari, P., & Qadir, A. (2023). Introduction to Research Methods: A Beginner's Guide To Quantitative, Qualitative, And Mixed Methods Research. Routledge.London.
6. Creswell, J. W., & Guetterman, T. C. (2018). Educational Research: Planning, Conducting, and Evaluating Quantitative And Qualitative Research, 6th Edition. Pearson. Publications.
7. Merriam, S. B., & Tisdell, E. J. (2015). Qualitative research: A guide to design and implementation. John Wiley & Sons.
8. The Oxford Handbook of Quantitative Methods" edited by Todd D. Little

Course Code	Course Title	Credit Hours	Theory	Lab	Category
BOT-675	Paleobotany	3	2	1	Major

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 outlines

1. Introduction to Paleobotany, traditional and integrative approaches, study of paleobotany at different levels. Palaeobotanical nomenclature.
2. Introduction to fossilization, fossilization process. Natural preservation of fossils in different environmental conditions.
3. Geological Time Scale: The sequence of the plant world in geologic time. Various geologic eras, periods and epoch (million years).
4. Fossilization in rocks, different types of rocks: Igneous rocks, Sedimentary rocks, Metamorphic.
5. Fossilization of non-vascular plants: Bacteria, Fungi, Algae, Nematophytales, Bryophytes.
6. Fossilized Pteridophytes (Psilophytales): Characteristics, Classification, Rhyniaceae, Zosterophylleaceae, Psilophytaceae, Asteroxylaceae. The oldest Lycopods, Lepidodendron and related genera.
7. The Pteridosperms: Position in plant kingdom, Sub-division of Paleozoic pteridosperm (Medullosaceae, Calamopityaceae, Coryatospermaceae). Position of the seed on plant.
8. Cycadales & Ginkgoales: Distribution, Cycadeodales (Williamsoniaceae, Cycadeoidaceae), the Cycadales, the Ginkgoales.
9. Ancient Conifers: Paleozoic, Mesozoic and Cenozoic conifers, Phylogeny of conifers.
10. The Ancient Flowering Plants: Monocotyledons, Dicotyledons, Phylogenetic system of classification.

Lab. outlines

1. Laboratory techniques for study of Fossils.
2. Observation of fossilized Prokaryotes, Algae and Fungi, Living fossils and extinct fossils (Psilophytales, Pteridosperms, Cycadales & Ginkgos, The Ancient Conifers, The Ancient Flowering Plants.
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, N., L. Taylor and M. Krings. 2009. The Biology & Evaluation of Fossil Plants. Academic Press.

Courses: Code	Title of the Course	Theory	Lab	Credit hours	Category
SEMESTER-8					
BOT-681	Plant Biotechnology	2	1	3	Major
BOT-682	Economic & Industrial Botany	3	0	3	Major
BOT-683	Evolutionary Trends in Plants	2	1	3	Major
BOT-684	Wetland Ecology (Elective – III *****)	2	1	3	Major
BOT-685	Capstone Project	0	3	3	Capstone
Sub Total		9	6	15	

Course Code	Course Title	Credit Hours	Theory	Lab	Category
BOT-685	Plant Biotechnology	3	2	1	Major

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 outlines

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

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.

Course Code	Course Title	Credit Hours	Theory	Lab	Category
BOT-682	Economic & Industrial Botany	3	2	1	Major

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 outlines

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

Lab. outlines

9. Various techniques used for propagation of plants in nursery
10. Training regarding town planning and interior decoration.
11. Growth techniques of various High Valued Medicinal and Aromatic Plants
12. Visits to various furniture industries to understand the Wood technology and generation of foreign exchange
13. Development of Azolla mat, Nostoc and Anabena colonies
14. Study the role of root nodules and mycorrhiza in bringing soil Fertility
15. Plantation of riparian vegetation
16. 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.

Course Code	Course Title	Credit Hours	Theory	Lab .	Category
BOT-683	Evolutionary Trends in Plants	3	2	1	Major

Objectives

1. To understand the evolutionary processes that have shaped the diversity of plant life.

2. To study significant evolutionary events such as the origin of vascular tissues, seeds, and flowers.
3. To examine the co-evolution of plants with animals and other organisms.

Theory

1. **Introduction to Evolution in Plants (Evolutionary Biology)**
 - Fundamental concepts of evolution and natural selection.
 - History and significance of plant evolution.
2. **Evolutionary Milestones in Plant Kingdom**
 - Origin of photosynthesis and early photosynthetic organisms.
 - Transition from aquatic to terrestrial environments.
 - Development of vascular tissues, seeds, and flowers.
3. **Diversity and Evolution of Major Plant Groups**
 - Evolutionary trends in **bryophytes**: Adaptations to terrestrial life.
 - Evolutionary advancements in **pteridophytes**: Vascular systems and reproduction.
 - The origin and diversification of seed plants
 - **Gymnosperms**: Seed evolution and adaptations to various habitats.
 - **Angiosperms**: Flower evolution, diversity, and dominance.
4. **Adaptations to Environmental Challenges**
 - Structural and physiological adaptations in xerophytes, hydrophytes, and halophytes.
 - Co-evolution with pollinators and seed dispersers.
5. **Evolution of Reproductive Strategies**
 - Trends in gametophyte and sporophyte dominance.
 - Pollination and seed dispersal mechanisms.
6. **Molecular Evolution in Plants**
 - Genetic basis of plant evolution.
 - Phylogenetic analysis using molecular data.
 - Evolution of chloroplast and mitochondrial genomes.
7. **Coevolutionary Interactions**
 - Evolutionary relationships between plants and herbivores.
 - Symbiosis with fungi and microbes.
8. **Fossil Evidence in Plant Evolution**
 - Overview of plant fossils.
 - Contributions of paleobotany to understanding evolutionary trends.

Lab

Microscopic Study of Plant Adaptations:

- Examination of vascular tissue.
- Comparative study of leaf structures in xerophytes, hydrophytes, and mesophytes.

Observation of Phylogenetic Traits:

- Identifying evolutionary trends in plant reproductive structures.
- Fossil analysis of ancient plant groups.

Field Studies:

- Collecting and identifying plants from different habitats.
- Observing adaptations to specific environmental conditions.

Molecular Techniques in Evolutionary Studies:

- DNA extraction and PCR for phylogenetic analysis.
- Studying chloroplast DNA evolution.

Comparative Morphological Studies:

- Analysis of seed and fruit development in gymnosperms and angiosperms.

Recommended Books

"Plant Evolution: An Introduction to the History of Life" by Karl J. Niklas.

"Evolutionary Biology of Plants" by Karl J. Niklas.

"The Origin and Early Diversification of Land Plants: A Cladistic Study" by Paul Kenrick and Peter R. Crane.

"Evolutionary Trends in Plants" by Anthony E. Coxon.

"Evolutionary Analysis" by Scott Freeman and Jon C. Herron.

"Phylogeny and Evolution of Angiosperms" by Douglas E. Soltis, Pamela S. Soltis, and Peter K. Endress.

"Paleobotany and the Evolution of Plants" by Wilson N. Stewart and Gar W. Rothwell.

Course Code	Course Title	Credit Hours	Theory	Lab	Category
BOT-684	Wetland Ecology	3	2	1	Major

Objectives: To familiarize the students with the concept of Wetland Ecology, its importance and its role in Biodiversity and Conservation.

Course outlines

1. Introduction to Wetlands (Wetland definition, types, classification, Origin and distribution of wetlands, Wetlands as elements of the landscape).
2. Wetland Environment (Abiotic factors, Hydrology and Edaphic factors).
3. Aquatic flora and fauna
4. Wetland Values (Wetlands as habitats and Economic importance of wetlands).
5. Attitude towards Wetlands (Human impact on wetlands, Agricultural impacts, Urbanization and Industrialization and Pollution).
6. Wetland Management (History of Wetland management, Wetlands for waste management, Control of exotic species and Man made wetlands).
7. Succession in Wetlands
8. Role of Wetlands in Biodiversity Conservation

Lab. outlines

1. Survey of Wetlands (Fresh water marshes, Salt marshes, Swamps, Riparian wetlands and Mangrove Wetlands)
2. Collection, preservation and identification of local aquatic flora
3. Morphological and Anatomical studies of various aquatic plants
4. Phytosociological studies of Aquatic plant communities
5. To carried out practical studied on the role of riparian vegetation in soil conservation

Books Recommended

1. Barbour, M. G., Burke, J. H. and Pitts, W. D. 2004. Terrestrial Plant Ecology. The Benjamin, Cumming Publishing C. Palo Alto, California, USA.
2. Bazzaz, F. A. 2004. Plants in Changing Environments: Linking Physiological, Population and Community Ecology, Cambridge University Press.
3. Chapin *et al.*, 2002. Principle of Terrestrial Plant Ecology, Springer-Verlag.
4. Gurevitch. J. Scheiner, S. M. and Fox, G. A. 2006. The Ecology of Plants\Sinaur Asssoicate Inc.
5. Hussain, S. S. 1989. Pakistan Manual of Plant Ecology. National Book Foundation Islamabad.
6. Lambers *et al.*, 2002. Plant Physiological and Ecology, Springer-Verlag.
7. Lambers, H., Pons, T. L. and Stuart, F. 2008. Plant Physiological Ecology.
8. Larcher, W. 2003. Physiological Plant Ecology: Ecophysiology and Stress Physiology of Function Groups. Springer-Verlag.
9. More, P. D. and Chapman, S. B. 1986. Methods in Plant Ecology, Blackwell Scientific Publication Oxford.
10. Nobel, P. S. 1999. Physico-chemical and Environmental Plant Physiology., Academic Press.
11. Schultz, J. C. 2005. Plant Ecology, Springer-Verlag.
12. Smith, R. L. 1998. Elements of Ecology. Harper & Row Publishing.
13. Smith, R. L. 2004. Ecology and field Biology. Addison Wesley Longman, Inc., New York.
14. Townsend, C. R., Begon, M. and Harper, J. L. 2002. Essentials of ecology. Blackwell Publishing.

Course Code	Course Title	Credit Hours	Theory	Lab .	Category
BOT-685	Capstone	3	0	3	Capstone

The Board approved the introduction of a Capstone Research Project in the final year (8th Semester) carrying 3 credit hours. This project will be supervised and graded by a faculty member and is aimed at enhancing students' research skills and postgraduate readiness.