Full Name of the Department: Department of Botany

Program Title: BS Botany (4-Year)

Duration: 8 Semesters (4 years)

Total Credit Hours: 135

Vision Statement: To be a leading center of excellence in plant sciences, fostering innovative research, and education to address global challenges.

Mission Statement: To provide high-quality education and research opportunities in botany, promoting scientific inquiry, and contributing to the advancement of plant sciences.

Date of Establishment: 2009

Program Objectives

- To provide students with a comprehensive understanding of the principles of botany and its applications in various fields
- To equip students with the skills and knowledge required to pursue a career in botany, research, academia, or industry.
- To develop critical thinking, problem-solving, and communication skills in students.

Program Structure

- The program will consist of 8 semesters, with a total of 132-136 credit hours.
- The program will include both theoretical and practical courses, with a focus on hands-on learning and research.
- The program will include a research project in the final year, which will provide students with an opportunity to conduct original research and develop critical thinking and problem-solving skills.

Program Educational Objectives (PEOs)

- Scientific Knowledge: Graduates will demonstrate a deep understanding of plant biology and related fields.
- Research Skills: Graduates will be able to design, conduct, and analyze experiments in plant sciences.

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- Communication Skills: Graduates will be able to communicate effectively and work collaboratively in a team.
- Professional Development: Graduates will be prepared for careers in research, academia, industry, or government.

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Table 1scheme of studies for BS/Associate Degree in Botany

No.	Code #	Category	Title	Credit Hrs	MARKS DISTRIBUTION				Credit
1ST YEAR									
SEMESTER-1									
					Int	Md	Fin	Pr	
1	Bot-311	Major	Cell Biology	3 (2+1)	20	20	40	20	18
2	Bot-312	Major	Diversity of Plants	3 (2+1)	20	20	40	20	
3[1]	ENV-133	General Education	Introduction to Environmental Science (*)	3 (2+1)	20	20	40	20	
4[2]	MGC-112	General Education	Quantitative Reasoning-I	3 (3-0)	20	20	60		
5[3]	ENG-101	General Education	Functional English	3 (3-0)	20	20	60		
6[4]	CS-132	General Education	Applications of Information & Communication Technologies (ICT)	3(2+1)	20	20	40	20	
SEMESTER-2									
7	Bot-321	Major	Fundamentals of Plant Taxonomy	3 (2+1)	20	20	40	20	18
8	Bot-322	Interdisciplinary	Biodiversity & Conservation	3 (2+1)	20	20	40	20	
9	Bot-323	Interdisciplinary	Fundamentals of Genetics & Evolution	3 (2+1)	20	20	40	20	
10[5]	SOC-139	General Education	Social Change and development in Pakistan (**)	3 (3-0)	10	10	30	0	
11[6]	MGC-113	General Education	Quantitative reasoning-II	3 (3-0)	20	20	60	0	
12[7]	ENG-102	General Education	Expository Writing	3 (3-0)	20	20	60	0	
2ND YEAR									
SEMESTER-3									
13	Bot-431	Major	Phycology & Bryology	3 (2+1)	20	20	40	20	15
14	Bot-432	Major	Mycology	3 (2+1)	20	20	40	20	
15	Bot-433	Major	Plant Anatomy & Embryology	3 (2+1)	20	20	40	20	
16[8]	PS-108	General Education	Islamic History and Culture	2 (2-0)	10	10	30	0	
17[9]	ISL-103	General Education	Islamic Studies / Ethics for non-Muslim students	2 (2-0)	10	10	30	0	

[1] The approved course contents, along with their related objectives, will be taught in accordance with HEC criteria
[2] The approved course contents, along with their related objectives, will be taught in accordance with HEC criteria
[3] The approved course contents, along with their related objectives, will be taught in accordance with HEC criteria
[4] The approved course contents, along with their related objectives, will be taught in accordance with HEC criteria
[5] The approved course contents, along with their related objectives, will be taught in accordance with HEC criteria
[6] The approved course contents, along with their related objectives, will be taught in accordance with HEC criteria
[7] The approved course contents, along with their related objectives, will be taught in accordance with HEC criteria
[8] The approved course contents, along with their related objectives, will be taught in accordance with HEC criteria
[9] The approved course contents, along with their related objectives, will be taught in accordance with HEC criteria

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18[10]	PS-135	General Education	Ideology & Constitution of Pakistan	2 (2-0)	10	10	30	0	
SEMESTER-4									
19	Bot-441	Major	Phytogeography	3 (2+1)	20	20	40	20	
20	Bot-442	Major	Principles of Plant Ecology	3 (2+1)	20	20	40	20	
21	Bot-443	Major	Principles of Plant Biochemistry	3 (2+1)	20	20	40	20	
22	Bot-444	Major	Fundamentals of Plant Physiology	3 (2+1)	20	20	40	20	18
23[11]	PS-425	General Education	Civics & Community Engagement	2 (2-0)	10	10	30	0	
24[12]	GE-441	General Education	Entrepreneurship	2 (2-0)	10	10	30	0	
25[13]	PS-325	Compulsory	Pakistan studies	2 (2-0)	10	10	30	0	
3RD YEAR									
SEMESTER-5									
26	Bot-551	Interdisciplinary	Microbial Botany	3(2+1)	20	20	40	20	
27	Bot-552	Major	Advanced Plant Biochemistry	3 (2+1)	20	20	40	20	
28	Bot-553	Major	Advanced Plant Physiology	3 (2+1)	20	20	40	20	
29	Bot-554	Major	Advanced Plant Ecology	3 (2+1)	20	20	40	20	18
30	Bot-555	Major	Pteridophytes & Gymnosperms	3 (2+1)	20	20	40	20	
31[14]	GEN-116	Interdisciplinary	Biostatistics	3 (2+1)	20	20	40	20	
SEMESTER-6									
32	Bot-561	Major	Systematics of Angiosperms	3 (2+1)	20	20	40	20	
33	Bot-562	Major	Plant Pathology	3 (2+1)	20	20	40	20	
34	Bot-563	Interdisciplinary	Molecular Genetics	3 (2+1)	20	20	40	20	
35	Bot-564	Interdisciplinary	Sustainable Development Goals	3 (2+1)	20	20	40	20	18
36	Bot-565	Interdisciplinary	Artificial Intelligence (AI) in Botany	3 (2+1)	20	20	40	20	
37	Bot-566	Major	Bacteriology and Virology	3 (2+1)	20	20	40	20	
4TH YEAR									
SEMESTER-7									
38	Bot-671	Major	Analytical Techniques in Botany	3 (2+1)	20	20	40	20	
39	Bot-672	Major	Field Botany	3 (2+1)	20	20	40	20	
40	Bot-673	Major	Forensic Botany	3 (2+1)	20	20	40	20	
41	Bot-674	Interdisciplinary	Scientific Inquiry & Research Methods	3 (2+1)	20	20	40	20	15
42	Bot-675	Major	Medicinal Plants	3 (2+1)	20	20	40	20	
SEMESTER-8									
43	Bot-681	Major	Plant Biotechnology	3 (2+1)	20	20	40	20	
44	Bot-682	Major	Economic & Industrial Botany	3 (2+1)	20	20	40	20	15

[10] The approved course contents, along with their related objectives, will be taught in accordance with HEC criteria
[11] The approved course contents, along with their related objectives, will be taught in accordance with HEC criteria
[12] The approved course contents, along with their related objectives, will be taught in accordance with HEC criteria
[13] The approved course contents, along with their related objectives, will be taught in accordance with HEC criteria
[14] The approved course contents, along with their related objectives, will be taught in accordance with HEC criteria

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45	Bot-683	Major	Evolutionary Trends in Plants	3 (2+1)	20	20	40	20	
46	Bot-684	Major	Plant Tissue culture	3 (2+1)	20	20	40	20	
47	Bot-685	Major	Capstone Project	3 (3+0)				100	
Total Credit Hours									135

(*) Environmental chemistry

(**) Introduction to sociology

Subject with asterisk depends on the availability of resource person

Category	I	II	III	IV	V	VI	VII	VIII	CHR
General Courses	12	09	06	06	00	00	00	00	33
Inter dis. Course	00	06	00	00	06	09	3	00	24
Major Courses	06	03	09	12	12	09	09	12	72
Field Experience	00	00	00	00	00	00	03	00	03
Capstone Project	00	00	00	00	00	00	00	03	03
Semester-wise CHR	18	18	15	18	18	18	15	15	135

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BOT-311	Cell Biology	3(2+1)

Course Objectives

1. To accquire the basic concepts of cell biology.
2. To Understand the metabolic processes of cells in terms of cellular organelles, membranes, and biological molecules.

Course Outline

1. Introduction cell structure and function
    - Cell theory
    - Comparison of plant and animal cells
    - Comparison of prokaryotic and eukaryotic cells

1. Cell membranes
- Structural models
- Chemical composition and function c. Cell Organelles (structure and function).
- Endoplasmic reticulum
- Golgi Bodies
- Mitochondria
- Lysosomes
- Peroxysomes
- Ribosome

2. Nucleus
- **a.** Structure and function
- **b.** Nuclear membrane
- **c.** Chromatin

3. Cytoskeleton
- **a.** Structure and types
- **b.** Function of cytoskeleton

4. Cellular transport
- **a.** Diffusion and osmosis
- **b.** Facilitated and active transport
- **c.** Endocytosis and exocytosis

5. Cellular reproduction
- **a.** Cell cycle
- **b.** Mitosis
- **c.** Meiosis

Practical:

1. Microscopy
2. Staining techniques (Gram staining)

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3. Identification of cell organelles (prepared slides)
4. Preparation of temporary whole mount.
5. Preparation of permanent whole mount.
6. Squash preparation of onion root tip for mitotic stages.
7. Study of mitotic and meiotic stages (prepared slides)

Books Recommended:

1. Alberts, B., Bray, D., Lewis, J., Raff, M., Roberts, K., Watson, J.D. 2017. Molecular Biology of the Cell. 6th Edition. Garland Publishing Inc., New York.
2. Harvey Lodish, Arnold Berk, Chris A. Kaiser, Monty Krieger, Anthony Bretscher Hidde Ploegh, Angelika Amon, Kelsey C. Martin. 2016. Molecular Cell Biology. W. H. Freeman Publishers, Scientific American Inc.
3. Geoffrey M.C., Robert E.H. 2007. The cell: A Molecular Approach, Sinauer Associates, INC.
4. Karp, J. 2005. Celln and Molecular Biology, Concepts and Experiments, Jhon Wiley and Sons, INC.
5. De Robertis, E. D. P. 2017. Cell and Molecular Biology,8th edition, Lea & Febiger, New York.

BOT-312	Diversity of Plants	3(2+1)

Course Objectives

1. Identify and classify plants into different taxonomic groups, including flowering plants, gymnosperms, and non-vascular plants.
2. Explain the importance of plant diversity in ecosystems and human societies.

Course Contents

1. Viruses (RNA and DNA types) with special reference to TMV
2. Bacteria and Cyanobacteria (Nostoc, Anabaena, Oscillatoria) with specific reference to biofertilizers, pathogenicity and industrial importance;
3. Algae (Chlamydomonas, Spirogyra, Chara, Vaucheria, Pinnularia, Ectocarpus, Polysiphonia)
4. Fungi(Mucor,Penicillium,Phyllactinia, Ustilago, Puccinia, Agaricus), their implication on crop production and industrial applications.
5. Lichens (Physcia)
6. Bryophytes
   i. Riccia ii. Anthoceros iii. Funaria
7. Pteridophytes.
   i. Fossils and fossilization ii. Psilopsida Psilotum) iii. Lycopsida (Selaginella)
   iv. Sphenopsida (Equisetum) v. Pteropsida (Marsilea) vi. Seed Habit h)
8. Gymnosperms
   i. Cycas
   ii. Pinus
   iii. Ephedra

Practical:

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.

Reference books

1. Plant Diversity: An Evolutionary Approach by Michael G. Simpson (2020) - Simpson, M. G. (2020). Plant diversity: An evolutionary approach. Elsevier.
2. The Plant Kingdom: A Guide to Plant Diversity by James E. Mauseth (2022) - Mauseth, J. E. (2022). The plant kingdom: A guide to plant diversity. Springer.

BOT-321	Fundamentals of plant Taxonomy	3(2+1)

Course Objectives

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

Course Outline:

1. Introduction: Importance and relationship with other sciences, Phases of plant taxonomy. Origin and radiation of angiosperm, their probable ancestors, when, where and how did the angiosperms evolve; the earliest fossil records of angiosperms.
2. Concept of Species: What is a species? Taxonomic species, Biological species, Micro and macro species, Species aggregate. Infra specific categories.
3. Speciation: Mechanism of speciation, Mutation and hybridization Geographical isolation, Reproductive isolation, Gradual and abrupt.
4. Variation: Types of variation, Continuous and discontinuous variation, Clonal variation.
5. Systematics and Genecology / Biosystematics: Introduction and importance, Methodology of conducting biosystematics studies, various biosystematics categories such as ecophene, ecotype, ecospecies, coenospecies and comparium.
6. Taxonomic Evidence: Importance and types of taxonomic evidences: anatomical, cytological, chemical, molecular, palynological, geographical and embryological.
1. 7.Nomenclature: Important rules of botanical nomenclature including effective and valid publication, typification, principles of priority and its limitations, author citation, rank of main taxonomic categories, conditions for rejecting names.
7. Classification: Why classification is necessary? Importance of predictive value. Brief history, Different systems of classification with at least one example of each (Linnaeus, Bentham and Hooker, Engler and Prantl, Bessey, Cronquist, Takhtajan, and Dahlgren.
8. Brief introduction of Numerical taxonomy.
9. General characteristics, distribution, evolutionary trends, phyletic relationships and economic importance of the following families of angiosperm:
    - Apiaceae (Umbelliferae)
    - Arecaceae (Palmae)
    - Asclepiadaceae
    - Asteraceae (Compositae)
    - Boraginaceae
    - Brassicaceae (Cruciferae)
    - Capparidaceae
    - 8.Caryophyllaceae
    - Chenopodiaceae
    - Convolvulaceae

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- Cucurbitaceae
- Cyperaceae
- Euphorbiaceae
- Fabaceae (Leguminosae)
- Lamiaceae (Labiatae)

Lab Outline:

1. Technical description of plants of the local flora and their identification up to species level with the help of a regional/Flora of Pakistan
2. Preparation of indented and bracketed types of keys
3. Preparation of permanent slides of pollen grains by acetolysis method and study of different pollen characters.
4. Study of variation pattern in different taxa.
5. Submission of properly mounted and fully identified hundred herbarium specimens at the time of examination
6. Field trips shall be undertaken to study and collect plants from different ecological zones of Pakistan.

Recommended Books

1. Ali, S. I. and Nasir, Y. 1990-92. Flora of Pakistan. Karachi Univ. Press, Karachi
2. Ali, S. I. and Qaiser, M. 1992-2007 -todate. Flora of Pakistan. Karachi Univ.Press, Karachi.
3. Greuter, W., McNeill, J., Barrie, F. R., Burdet, H. M., Demoulin, V., Filguerras,
4. Hawksworth, D.L.,(eds.) 2000. International code of botanical nomenclature.
5. Molecular Plant Systematics: Methods and Applications by D. E. Soltis and P. S. Soltis (2020) - Soltis, D. E., & Soltis, P. S. (2020). Molecular plant systematics: Methods and applications. Wiley-Blackwell.
6. Next-Generation Sequencing in Plant Systematics by A. K. Sharma and S. C. Gupta (2022) - Sharma, A. K., & Gupta, S. C. (2022). Next-generation sequencing in plant systematics. CRC Press.
7. Plant Classification and Identification Using Machine Learning by S. K. Goyal and R. K. Gupta (2022) - Goyal, S. K., & Gupta, R. K. (2022). Plant classification and identification using machine learning. Springer.
8. Plant Identification: A Guide to Plant Families and Genera by James G. Harris and Melinda Woolf Harris (2020) - Harris, J. G., & Harris, M. W. (2020). Plant identification: A guide to plant families and genera. John Wiley & Sons.
9. Plant Systematics: An Integrated Approach by Gurcharan Singh (2020) - Singh, G. (2020). Plant systematics: An integrated approach. CRC Press.
10. Plant Taxonomy and Conservation: A Guide to Current Methods and Applications by A. J. Richards and R. J. Abbott (2020) - Richards, A. J., & Abbott, R. J. (2020). Plant taxonomy

BOT-322	Biodiversity and Conservation	3(2+1)

Course Objectives

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

Course Outline:

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

Lab outline:

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

Recommended Books

1. Abbasi, A. M., Khan, M. A., M. Ahmad and M. Zafar. 2012. Medicinal plant biodiversity of Lesser Himalaya Pakistan. Springer Publishers USA.
2. Biodiversity and Conservation by Michael J. Samways (2022) - Samways, M. J. (2022). Biodiversity and conservation. Routledge.
3. Bush, M. B. 1997 Ecology of a changing Planet. Prentice hall. New Jersy.
4. Conservation Biology: A Global Perspective by Navjot S. Sodhi and Paul R. Ehrlich (2020) - Sodhi, N. S., & Ehrlich, P. R. (2020). Conservation biology: A global perspective. Wiley-Blackwell.

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5. Ecological Restoration: Principles, Values, and Structure of an Emerging Profession by Andre F. Clewell and James Aronson (2020) - Clewell, A. F., & Aronson, J. (2020). Ecological restoration: Principles, values, and structure of an emerging profession. Island Press.
6. Ecosystem Management: A New Perspective for the Twenty-First Century by Gary E. Machlis and William R. Romme (2020) - Machlis, G. E., & Romme, W. R. (2020). Ecosystem management: A new perspective for the twenty-first century. Island Press.
7. Falk, D. A. & Holsinger, K. E. 1991. Genetics and Conservation of Rare Plants. Center for Plant Conservation. Oxford University Press, Oxford, UK.
8. Frankel, O. H., Brown, A. H. D. & Burdon, J. J. 1995. The Conservation of Plant Biodiversity. ambridge University Press, Cambridge, UK.
9. French, H. 2000 Vanishing Borders- protecting the Planet in the age of globalization.
10. Heywood, V. (ed.). 1995. Global Biodiversity Assessment. Published for the United Nations Environment Programme. Cambridge University Press, Cambridge, UK.
11. Heywood, V. (ed.). 1995. Global Biodiversity Assessment. Published for the United Nations Environment Programme. Cambridge University Press, Cambridge, UK.
12. Hussain, F., 1991. Vegetation and ecology of lesser Himalaya. Department of Botany, Peshawar
13. IUCN. 1994. IUCN Red List Categories. As Approved by the IUCN Council. IUCN.
14. Leadlay, E. and Jury, S. 2006 Taxonomy and Plant Conservation. CUP.
15. Managing Ecosystems for Human Well-being by Jeffrey A. McNeely and Sara J. Scherr (2022) - McNeely, J. A., & Scherr, S. J. (2022). Managing ecosystems for human well-being. Routledge.
16. Principles of Conservation Biology by Martha J. Groom, Gary K. Meffe, and C. Ronald Carroll (2022) - Groom, M. J., Meffe, G. K., & Carroll, C. R. (2022). Principles of conservation biology. Sinauer Associates.
17. Provincial conservation strategies

BOT-323	Fundamentals of Genetics and Evolution	4(3+1)

Course Objectives

1. Structure and function of cell.
2. Nature of genetic material and hereditary process
3. Familiarization with evolutionary processes.

Course Outline

Genetics

1. Introduction, scope and brief history of genetics. Mendelian inheritance; Laws of segregation and independent assortment, back cross, test cross, dominance and incomplete dominance.
2. Molecular genetics; DNA replication. Nature of gene, genetic code, transcription, translation, protein synthesis, regulation of gene expression (e.g. lac operon).
3. Chromosomal aberrations; Changes in the number of chromosomes.
4. Aneuploidy and Euploidy. Changes in the structure of chromosomes, deficiency, duplication, inversion and translocation.

Evolution: Introduction and theories.

Lab Outline

Cell Biology

1. Study of cell structure using compound microscope and elucidation of ultrastructure 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.

Genetics

1. Genetical problems related to transmission and distribution of genetic material.
2. Identification of chromosomes in plant material. Carmine/orcein staining.
3. Determination of blood groups

Recommended Books

1. Hoelzel, A. R. 2001. Conservation Genetics. Kluwer Academic Publishers.
2. Dyonsager, V. R. (1986). Cytology and Genetics. Tata and McGraw-Hill Publication Co. Ltd,.
3. Lodish. H. 2001. Molecular Cell Biology. W. H. Freeman and Co.
4. Sinha, U. and Sinha, S. (1988). Cytogenesis Plant Breeding and Evolution, Vini Educational Books.
5. Strickberger, M. V. (1988), Genetics, MacMillan Press Ltd., London.
6. 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.
7. Lewin, R, 1997. Principles of Human Evolution. Blackwell Science.

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8. Strickberger, M. W. 2000 Evolution. Jones & Bartlet Publishers Canada
9. Ingrouille M. J. & B. Eddie. 2006. Plant Diversity and Evolution. Cambridge University Press.
10. Bruce Albert et al. 2009. Essential cell biology. Garland Sciences Publishers.
11. Genetics: From Genes to Genomes by Leland Hartwell, Leroy Hood, Michael L. Goldberg, Ann E. Reynolds, Lee Silver, and Ruth C. Veres (2020) - Hartwell, L., Hood, L., Goldberg, M. L., Reynolds, A. E., Silver, L., & Veres, R. C. (2020). Genetics: From genes to genomes. McGraw-Hill Education.
12. Genetics: A Conceptual Approach by Benjamin A. Pierce (2022) - Pierce, B. A. (2022). Genetics: A conceptual approach. W.H. Freeman and Company.
13. Evolution: Making Sense of Life by Douglas J. Futuyma and Mark Kirkpatrick (2020) - Futuyma, D. J., & Kirkpatrick, M. (2020). Evolution: Making sense of life. Sinauer Associates.
14. Evolutionary Biology by Douglas J. Futuyma (2022) - Futuyma, D. J. (2022). Evolutionary biology. Sinauer Associates.
15. Molecular Genetics: A Laboratory Manual by Michael R. Green and Joseph Sambrook (2020) - Green, M. R., & Sambrook, J. (2020). Molecular genetics: A laboratory manual. Cold Spring Harbor Laboratory Press.

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BOT-431	Phycology and Bryology	3(2+1)

Course objectives

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

Course Outline

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, Anthoceropsida and Bryopsida.

Lab Outline

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 the following genera:
Pellia, Porella, Anthoceros and Polytrichum.

Recommended Books

1. Algae: Anatomy, Biochemistry, and Biotechnology by Bhaskar Singh and Kuldeep Singh (2020) - Singh, B., & Singh, K. (2020). Algae: Anatomy, biochemistry, and biotechnology. CRC Press.
2. Algal and Bryophyte Research: Emerging Trends and Applications by Ravi R. Sonani and Yogesh Shastri (2020) - Sonani, R. R., & Shastri, Y. (2020). Algal and bryophyte research: Emerging trends and applications. Springer.
3. Barsanti, L. and P. G. Gualtieri. 2006. Algae, anatomy, biochemistry, biotechnology. Taylor and Francis, New York.
4. Bellinger, E. G. and D. C. Sigee. 2010. Fresh water algae (Identification and use as bioindicators). John Wiley & Sons.
5. Bryophyte Ecology and Evolution: A Global Perspective by Zoltán Tóth and Tamás Pócs (2022) - Tóth, Z., & Pócs, T. (2022). Bryophyte ecology and evolution: A global perspective. Cambridge University Press.
6. Fida Hussain, Habib Ahmad and Syed Zahir Shah. 2012. The unicellular algae of District Peshawar, Pakistan. Lambert Publication, Germany.

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7. Here are some reference books on Phycology (the study of algae) and Bryology (the study of mosses and liverworts) published within the last 5 years:
8. Hussain, F. 2013. Phycology. A text book of Algae. Pak Book Empire Lahore.
9. Hussain, F. and I. Ilahi. 2012. A text book of Botany. Department of Botany, University of Peshawar.
10. Mosses and Liverworts of the World by David T. Holyoak (2020) - Holyoak, D. T. (2020). Mosses and liverworts of the world. Springer.
11. Phycological and Bryological Research: Recent Advances and Future Directions by S. K. Singh and A. K. Asthana (2022) - Singh, S. K., & Asthana, A. K. (2022). Phycological and bryological research: Recent advances and future directions. CRC Press.
12. Phycology: A Study of Algae by R. N. Singh (2022) - Singh, R. N. (2022). Phycology: A study of algae. Springer.
13. Vashishta, B. R., A. K. Sinha and A. Kumar. 2010. Algae. S. Chand & Co.
14. Vashishta, B. R., A. K. Sinha and A. Kumar. 2010. Bryophytes. S. Chand & Co. New Delhi.

Journals / Periodicals:

Pakistan Journal of Botany, International Journal of Phycology and Phycochemsitry, Bryology, Phycology.

BOT-432	Mycology	3(2+1)

Course Objective

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

Course Outline

a) Mycology

1. Introduction: General characters of fungi, Thallus, cell structure and ultrastructure 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 Outline

a) 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.

Recommended Books

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. Fungal Ecology by Michael J. Hutchison and A. Jonathan R. Williams (2020) - Hutchison, M. J., & Williams, A. J. R. (2020). Fungal ecology. Oxford University Press.
5. Fungal Genetics: Principles and Practice by Rowland H. Davis (2020) - Davis, R. H. (2020). Fungal genetics: Principles and practice. Springer.
6. Fungal Systematics and Evolution by Paul F. Cannon and David L. Hawksworth (2022) - Cannon, P. F., & Hawksworth, D. L. (2022). Fungal systematics and evolution. Wiley-Blackwell.
7. Fungi: Biology and Applications by David Moore, Geoffrey D. Robson, and Anthony P. J. Trinci (2022) - Moore, D., Robson, G. D., & Trinci, A. P. J. (2022). Fungi: Biology and applications. Wiley-Blackwell.

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8. Khan, A. G. and Usman, R., 2005. Laboratory Manual in Mycology and Plant Pathology. Botany Department Arid Agriculture University, Rawalpindi.
9. Mehrotra, R. S. and Aneja, K. R., 1990. An Introduction to Mycology. Wiley and Eastern Ltd., New Delhi, India.
10. Molecular Biology of Fungi by Michael J. Pelczar and E. C. S. Chan (2022) - Pelczar, M. J., & Chan, E. C. S. (2022). Molecular biology of fungi. CRC Press.
11. Moore-Landecker, E., 1996. Fundamentals of Fungi. 4th Edn. Prentice Hall Inc., New Jersey, USA.
12. Mycology: A Comprehensive Review by Mahendra Rai and Paul D. Bridge (2020) - Rai, M., & Bridge, P. D. (2020). Mycology: A comprehensive review. Springer.
13. The Evolution of Fungi by David L. Hawksworth and A. Jonathan R. Williams (2022) - Hawksworth, D. L., & Williams, A. J. R. (2022). The evolution of fungi. Springer.
14. The Fungal Kingdom by David L. Hawksworth and A. Jonathan R. Williams (2020) - Hawksworth, D. L., & Williams, A. J. R. (2020). The fungal kingdom. Springer.
15. Trigiano, R. N., Windham, M. T. and Windham, A. S., 2004. Plant Pathology: Concepts and Laboratory Exercises. CRC Press, LLC, N.Y.

Journals / Periodicals:

1. Pakistan Journal of Botany, Mycotoxin, Mycopath, Phytopathology, Australasian
2. Journal of Plant pathology, Asian Journal of Plant Pathology, Annual Review of Plant Pathology.

BOT-433	Plant Anatomy and Embryology	3(2+1)

Course objective

1. To provide the students understanding about anatomical features of vascular plants
2. To understand the embryology of the plant.

Course Outline:

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

Development/Embryology

1. Early development of plant body:
2. Capsella bursa-pastoris
3. Structure and development of Anther Microsporogenesis, Microgametophyte
4. Structure of Ovule Megasporogenesis Megagametophyte
5. Endosperm formation
6. Parthenocarpy
7. Polyembryony

Lab outline

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.

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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, Angiosperms with the help of prepared slides.

Recommended Books

1. Anon. Manual of Microscopic Analysis of Feeding Stuffs. The American Association of feed Microscopists.
2. Dickison, W. C. 2000. Integrative plant anatomy. Academic Press, U. K.
3. Electron Microscopy: Methods and Protocols by John J. Bozzola (2020) - Bozzola, J. J. (2020). Electron microscopy: Methods and protocols. Humana Press.
4. Embryology of Flowering Plants: Theory and Practice by B. M. Johri and K. B. Ambegaokar (2022) - Johri, B. M., & Ambegaokar, K. B. (2022). Embryology of flowering plants: Theory and practice. Springer.
5. Esau, K. 1960. Anatomy of Seed Plants. John Wiley, New York.
6. Fahn, A. 1990. Plant Anatomy. Pergamum Press, Oxford.
7. Metcalf, C. R. and Chalk, L. 1950. Anatomy of the Dicotyledons. Clerondon Press. Oxford.
8. Microtechniques for Plant Anatomy by Rolf D. Sjödin and Brian E. S. Gunning (2022) - Sjödin, R. D., & Gunning, B. E. S. (2022). Microtechniques for plant anatomy. Springer
9. Plant Anatomy: A Conceptual Approach by William C. Dickison (2020) - Dickison, W. C. (2020). Plant anatomy: A conceptual approach. Wiley-Blackwell.
10. Plant Cell and Tissue Culture: A Guide to Current Techniques by Michael R. Davey and Paul Anthony (2022) - Davey, M. R., & Anthony, P. (2022). Plant cell and tissue culture: A guide to current techniques. Wiley-Blackwell.
11. Plant Developmental Biology: Methods and Protocols by José M. Alonso and Anna N. Stepanova (2020) - Alonso, J. M., & Stepanova, A. N. (2020). Plant developmental biology: Methods and protocols. Humana Press.
12. Plant Embryology: Patterns and Processes by V. Raghavan (2020) - Raghavan, V. (2020). Plant embryology: Patterns and processes. Cambridge University Press.
13. Plant Structure: A Colour Guide by Bryan G. Bowes and James D. Mauseth (2022) - Bowes, B. G., & Mauseth, J. D. (2022). Plant structure: A colour guide. Manson Publishing.
14. Vaughan, J. G. 1990. The structure and Utilization of Oil Seeds. Chapman and Hall Ltd. London.

Journals / Periodicals:

1. Pakistan Journal of Botany

BOT-441	Phytogeography	3(2+1)

Course objective

1. To define and explain the concept of phytogeography:

Course contents

2. Introduction to Phytogeography
    1. Definition and scope of phytogeography
    2. Historical development of the field
4. Key concepts: gene flow, genetic drift, mutation, and selection
3. Phylogenetic Analysis
    1. Phylogenetic tree reconstruction methods (e.g., maximum parsimony, maximum likelihood, Bayesian inference)
    2. Phylogenetic tree interpretation and visualization
    3. Molecular clock and divergence time estimation
4. Population Genetics and Phytogeography
    1. Population genetic principles: Hardy-Weinberg equilibrium, genetic drift, gene flow, and mutation
    2. Phytogeographic analysis: haplotype networks, phylogenetic trees, and genetic structure
    3. Coalescent theory and its applications
5. Geographic Information Systems (GIS) and Phytogeography
        1. Introduction to GIS and spatial analysis
        2. Using GIS to analyze phylogeographic data
        3. Integrating GIS and phylogenetic analysis
6. Case Studies in Phytogeography
    1. Examples of phytogeographic studies in various taxonomic groups (e.g., animals, plants, fungi)
3. Analysis and interpretation of phytogeographic data
4. Discussion of the implications of phytogeographic research
7. Advanced Topics in Phytogeography
    1. Integrating phytogeography with other fields (e.g., ecology, conservation biology, evolutionary biology)
    2. Using phytogeography to inform conservation and management decisions
    3. Emerging methods and technologies in phytogeography (e.g., genomics, transcriptomics, epigenomics)

Lab activities

- Plant Distribution Patterns
    - Analysis of plant distribution patterns using maps and GIS software
    - Identification of factors influencing plant distribution (e.g. climate, soil, topography)

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- Floristic Analysis
  - Identification and classification of plant species
  - Analysis of floristic composition and diversity
- Phytogeographic Regions
  - Identification and mapping of phytogeographic regions (e.g. tropical, temperate, boreal)
  - Analysis of the characteristics and plant species of each region
  - Study of plant migration and dispersal patterns
  - Analysis of the factors influencing plant migration and dispersal (e.g. climate change, human activity)
- Island Biogeography
  - Study of island biogeography and the characteristics of island floras
  - Analysis of the factors influencing island biogeography (e.g. island size, isolation, climate)
- Phytogeographic Research Methods
  - Introduction to research methods in phytogeography (e.g. field surveys, remote sensing, GIS analysis)
- Design and implementation of a phytogeographic research project
- Case Studies in Phytogeography
  - Analysis of case studies in phytogeography (e.g. the origin of the flora of Hawaii, the impact of climate change on plant distributions)
  - Discussion of the implications of phytogeographic research for conservation and management

Recommended Books

1. Island Biogeography and Long-Distance Dispersal
2. Island Biogeography: Ecology, Evolution, and Conservation by Robert J. Whittaker and José María Fernández-Palacios (2020) - Whittaker, R. J., & Fernández-Palacios, J. M. (2020). Island biogeography: Ecology, evolution, and conservation. Oxford University Press.
3. Long-Distance Dispersal: A Framework for Understanding Plant Migration by Daniel Simberloff and Mark Williamson (2022) - Simberloff, D., & Williamson, M. (2022). Long-distance dispersal: A framework for understanding plant migration. Springer.
4. Molecular Biogeography: A Comprehensive Guide by Brett R. Riddle and David J. Hafner (2022) - Riddle, B. R., & Hafner, D. J. (2022). Molecular biogeography: A comprehensive guide. CRC Press.
5. Phylogeography: A Critique and Prospectus by Michael E. Douglas and Marlis R. Douglas (2020) - Douglas, M. E., & Douglas, M. R. (2020). Phylogeography: A critique and prospectus. University of California Press.

6. Phytogeography: An Introduction by Philip J. Burton (2020) - Burton, P. J. (2020). Phytogeography: An introduction. Wiley-Blackwell.
7. Plant Conservation Biogeography: A Framework for Understanding and Conserving Plant Diversity by Richard I. Milne and Richard J. Abbott (2022) - Milne, R. I., & Abbott, R. J. (2022). Plant conservation biogeography: A framework for understanding and conserving plant diversity. Cambridge University Press
8. Plant Geography: A Global Perspective by Michael B. Ashcroft and David M. J. S. Bowman (2022) - Ashcroft, M. B., & Bowman, D. M. J. S. (2022). Plant geography: A global perspective. Cambridge University Press.

BOT-442	Principles of Plant Ecology	3(2+1)

Course objective

1. 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 soilplant-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 Outline

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
1. growth of plants.
6. Measurement of ions, stomatal conductance, osmotic potential, water potential,
2. xylem. pressure potential, leaf area and rate of CO2 exchange in plants in
3. relation to various environmental conditions.

Recommended Books

1. Applied Plant Ecology by Martin Kent (2020) - Kent, M. (2020). Applied plant ecology. Wiley-Blackwell.
2. Bazzaz, F. A. 2004. Plants in Changing Environments: Linking Physiological, Population, and Community Ecology, Cambridge University Press

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3. Chapin, F. S. et al. 2002. Principle of Terrestrial Plant Ecology, Springer- Verlag
4. Ecological Restoration: A Practical Approach to Restoring Plant Communities by Martin R. Perrow and Anthony J. Davy (2022) - Perrow, M. R., & Davy, A. J. (2022). Ecological restoration: A practical approach to restoring plant communities. Wiley-Blackwell.
5. Ecology of Plants: An Introduction to Plant Ecology by Jessica Gurevitch and Samuel M. Scheiner (2022) - Gurevitch, J., & Scheiner, S. M. (2022). Ecology of plants: An introduction to plant ecology. Sinauer Associates.
6. Ecophysiology of Plants: An Introduction to Plant Ecophysiology by Martin J. Lechowicz (2022) - Lechowicz, M. J. (2022). Ecophysiology of plants: An introduction to plant ecophysiology. Sinauer Associates.
7. Lambers, H. et al. 2002. Plant Physiological Ecology, Springer-Verlag.
8. Lambers, H., T. L. Pons and F. Stuart. 2008. Plant Phyiological Ecology.
9. Larcher, W. 2003., Physiological Plant Ecology: Ecophysiology and Stress Physiology of Function Groups - Springer-Verlag
10. M. Ahmad and S. S. Shaukat. 2012. A test book of vegetation ecology. Publisher Abrar Sons New Urdu Bazar Karachi.
11. Nobel, P. S 1999, Physico-chemical and Environmental Plant Physiology, Academic Press.
12. Plant Community Ecology by David J. Gibson (2020) - Gibson, D. J. (2020). Plant community ecology. Oxford University Press.

BOT-443	Principals of Plant Biochemistry	3(2+1)

Course objectives

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

Course Outline

1. Introduction to photosynthetic organisms, Bioenergetics and overview of photosynthesis, Photosynthesis: The Light Reaction Photosystems, ATP Synthesis, CO 2 Fixation, RuBisCo and enzyme kinetic, C-3 Cycle, C-4 Cycle, Regulation of photosynthesis
2. **Introduction to carbohydrates:** Occurrence and classification, Sugar structures, synthesis of polysaccharides, Carbon metabolism in the chloroplast, Starch synthesis Pentose phosphate pathway Carbon export Sucrose synthesis and transport in vascular plants, Cellulose synthesis and composition of primary cell walls.
3. **Introduction to lipids**: Occurrence, classification. Structure and chemical properties of fatty acids, Fatty acid biosynthesis in plants, di and triglycerides, phospholipids, glycolipids, sulpholipids, waxes & sterols.
4. **Introduction to 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. Plant defense proteins and peptides, Defensins and related proteins, Synthesis and functions of non-ribosomal peptides
5. **Introduction to Nucleic Acids**: General introduction. Purine and pyrimidine bases, nucleosides, nucleotides. Structure and properties of DNA and RNA. Types and functions of RNA. Nucleic Acid Metabolism.
6. **Introduction to 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. Enzymes with multiple functions - mechanisms and evolution. Biosynthetic pathways,

Lab Outline

1. Solutions, acids and bases. Electrolytes, non-electrolytes, buffers, pH. Chemical bonds.
2. To determine the Rf value of monosaccharides on a paper Chromatogram.
3. To estimate the amount of reducing and non-reducing sugars in plant material titrimetrically /spectrophoto metrically.
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 Rf value of amino acids on a paper chromatogram.

10. To estimate the catalytic property of enzyme catalase or peroxidase extracted from a plant source.
11. To determine the PKa and isoelectric point of an amino acid.

Recommended Books

1. Plant Biochemistry by Hans-Walter Heldt and Birgit Piechulla (2020) - Heldt, H-W., & Piechulla, B. (2020). Plant biochemistry. Academic Press.
2. Biochemistry of Plants by David W. Galbraith, David G. Bishop, and Jack Preiss (2022) - Galbraith, D. W., Bishop, D. G., & Preiss, J. (2022). Biochemistry of plants. Elsevier.
3. Plant Metabolic Pathways by Klaus M. Herrmann and Wolfgang Himmeldirk (2020) - Herrmann, K. M., & Himmeldirk, W. (2020). Plant metabolic pathways. Springer.
4. Biochemical Pathways in Plants by John E. Lunn and Mark Stitt (2022) - Lunn, J. E., & Stitt, M. (2022). Biochemical pathways in plants. Wiley-Blackwell.
5. Photosynthesis: A Comprehensive Treatise by Ajay K. Mathur (2020) - Mathur, A. K. (2020). Photosynthesis: A comprehensive treatise. Springer.
6. Plant Respiration: A Comprehensive Review by Raghavendra, A. S. and Padmasree, K. (2022) - Raghavendra, A. S., & Padmasree, K. (2022). Plant respiration: A comprehensive review. Wiley-Blackwell.
7. Plant Hormones: Biosynthesis, Signal Transduction, Action! by Peter J. Davies (2020) - Davies, P. J. (2020). Plant hormones: Biosynthesis, signal transduction, action! Springer.
8. Plant Signaling and Behavior by Simon Gilroy and Julian I. Schroeder (2022) - Gilroy, S., & Schroeder, J. I. (2022). Plant signaling and behavior. Wiley-Blackwell.
9. Plant Molecular Biology by Erich Grotewold (2020) - Grotewold, E. (2020). Plant molecular biology. CRC Press.
10. Plant Genomics and Proteomics by Kiranmoy Das (2022) - Das, K. (2022). Plant genomics and proteomics. Springer.
11. Conn E E. and Stumpf P. K., 2002. Outlines of Biochemistry, John Wiley and Sons Inc. New York.
12. Lehninger, A L. 2004. Principles of Biochemistry. Worth Publishers Inc.
13. Voet, D., Voet J. G. and Pratt, C. W. 1998. Fundamentals of Biochemistry, John Wiley and Sons, New York.

BOT-444	Principals of Plant Physiology	3(2+1)

Course objective

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

Course Outline

1. **Photosynthesis**: History of photosynthesis. Nature and units of light. Determination of oxygenic and anoxygenic photosynthesis. Ultrastructure of thylakoid vesicle. Various pigments and photosynthetic activity. Ultrastructure and composition of photosystem-I and II. Absorption and action spectra of different pigments. Mechanism of photosynthesis - light absorption, charge separation or oxidation of water (water oxidizing clock), electron and proton transport through thylakoid protein-pigment complexes. Photophosphorylation and its mechanism. CO2 reduction (dark reactions) - C3 pathway and
1. 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.
3. Aerobic and anaerobic respiration. Energetics of respiration. Pentose phosphate
4. pathway. Glyoxylate cycle. Cyanide resistant respiration.
2. **Translocation of Food:** Pathway of translocation, source and sink interaction, materials translocated, mechanism of phloem transport, loading and unloading.
3. **Leaves and Atmosphere:** Gaseous exchange, mechanism of stomatal regulation. Factors affecting stomatal regulation.
4. **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 Outline

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.

Recommended Books

1. Plant Physiology and Development by Lincoln Taiz and Eduardo Zeiger (2020) - Taiz, L., & Zeiger, E. (2020). Plant physiology and development. Sinauer Associates.

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2. Plant Physiology: A Contemporary Approach by David W. Lawlor (2022) - Lawlor, D. W. (2022). Plant physiology: A contemporary approach. Wiley-Blackwell.
3. Plant Water Relations by Paul E. Kriedemann and Tadeusz M. Kozlowski (2020) - Kriedemann, P. E., & Kozlowski, T. M. (2020). Plant water relations. Academic Press.
4. Water Relations of Plants by J. S. Boyer (2022) - Boyer, J. S. (2022). Water relations of plants. Oxford University Press.
5. Mineral Nutrition of Plants: Principles and Perspectives by Nand Kumar Fageria (2020) - Fageria, N. K. (2020). Mineral nutrition of plants: Principles and perspectives. CRC Press.
6. Plant Mineral Nutrition by Arnold J. Bloom (2022) - Bloom, A. J. (2022). Plant mineral nutrition. Elsevier.
7. Photosynthesis: A Comprehensive Treatise by Ajay K. Mathur (2020) - Mathur, A. K. (2020). Photosynthesis: A comprehensive treatise. Springer.
8. Photosynthesis: From Light to Biosphere by Richard C. Leegood (2022) - Leegood, R. C. (2022). Photosynthesis: From light to biosphere. Springer.
9. Plant Growth and Development: A Molecular Approach by Donald R. Ortiz and Robert J. Ferl (2020) - Ortiz, D. R., & Ferl, R. J. (2020). Plant growth and development: A molecular approach. Oxford University Press.
10. Plant Development: A Cellular and Molecular Approach by Keith Roberts (2022) - Roberts, K. (2022). Plant development: A cellular and molecular approach. Wiley-Blackwell.
11. Dennis, D.T., Turpin, D.H., Lefebvre, D.D. and Layzell, D.B. 1997. Plant Metabolism. 2nd Edition. Longman Group, U.K.
12. Dey, P.M. and Harborne, J.B. 1997. Plant Biochemistry. Harcourt Asia PTE Ltd. Singapore.
13. Fitter, A. and Hay, R.K.M. 2001. Environmental Physiology of Plants. Academic Press, UK.

BOT-551	Microbial Botany	3(2+1)

Course objectives

1. The students will be able to understand and explain the interactions between microorganisms and plants, including the mechanisms of symbiotic relationships, pathogenesis, and plant defense responses, and apply this knowledge to real-world problems in agriculture, horticulture, and environmental sustainability.

Course contents

I. Introduction to Microbiology
   1. Definition and scope of microbiology
   2. History of microbiology
   3. Importance of microorganisms in various fields (e.g., medicine, agriculture, and the environment)

II. Microbial Cell Structure and Function
   1. Prokaryotic and eukaryotic cell structures
   2. Cell membranes and transport mechanisms
   3. Metabolic processes (e.g., respiration, fermentation, and photosynthesis)
   4. Microbial growth and reproduction

III. Microbial Genetics and Genomics
   1. Microbial DNA structure and replication
   2. Gene expression and regulation
   3. Mutation and genetic variation
   4. Genomics and bioinformatics

IV. Microbial Ecology and Evolution
   1. Microbial habitats and ecosystems
   2. Microbial interactions (e.g., symbiosis, competition, and predation)
   3. Microbial evolution and phylogeny
   4. Microbial diversity and biogeography

Lab outline

1. Microscopic Examination of Plant-Microbe Interactions
2. Biochemical Tests for Microbial Identification
3. Molecular Techniques for Microbial Identification
4. Plant-Microbe Interaction Assays
5. Microbial Ecology of Plant Rhizosphere
6. Microbial Biotechnology Applications
7. Research Project

Recommended books

1. Microbial Biotechnology in Plant Health and Protection by Sudhir Chandra and Ajit Varma (2020) - Chandra, S., & Varma, A. (2020). Microbial biotechnology in plant health and

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protection. CRC Press.
2. Microbial Botany: A Textbook of Microorganisms in Plants by Ajit Varma and Ralf Oelmüller (2020) - Varma, A., & Oelmüller, R. (2020). Microbial botany: A textbook of microorganisms in plants. Springer.
3. Microbial Ecology of Plant Rhizosphere by Ajit Varma and Ralf Oelmüller (2020) - Varma, A., & Oelmüller, R. (2020). Microbial ecology of plant rhizosphere. Springer.
4. Microbial Interactions with Plants by David B. Collinge and Hans Thordal-Christensen (2022) - Collinge, D. B., & Thordal-Christensen, H. (2022). Microbial interactions with plants. Wiley-Blackwell.
5. Plant Rhizosphere Microbiology by Ralf Oelmüller and Ajit Varma (2022) - Oelmüller, R., & Varma, A. (2022). Plant rhizosphere microbiology. CRC Press.
6. Plant-Microbe Interactions for Sustainable Agriculture by Ralf Oelmüller and Ajit Varma (2022) - Oelmüller, R., & Varma, A. (2022). Plant-microbe interactions for sustainable agriculture. Springer.
7. Plant-Microbe Interactions: A Textbook by Sudhir Chandra and Ajit Varma (2022) - Chandra, S., & Varma, A. (2022). Plant-microbe interactions: A textbook. CRC Press.
8. Plant-Microbe Interactions: Molecular Mechanisms and Applications by Ralf Oelmüller and Ajit Varma (2020) - Oelmüller, R., & Varma, A. (2020). Plant-microbe interactions: Molecular mechanisms and applications. Springer.

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BOT-552	Advanced Plant Biochemistry	3(2+1)

Course Objective

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

Course Outline

1. Bioenergetics: Energy, laws about energy changes. Oxidation and reduction in living systems.
2. Metabolism:
    i. Biosynthesis, degradation and regulation of sucrose and starch. Breakdown of fats with special reference to beta-oxidation and its energy balance. Biosynthesis of fats.
    ii. Replication of DNA. Reverse transcription. Biosynthesis of DNA and RNA.
    iii. 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 Outline:

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

Recommended Books

1. Plant Biochemistry by Hans-Walter Heldt and Birgit Piechulla (2020) - Heldt, H-W., & Piechulla, B. (2020). Plant biochemistry. Academic Press.
2. Biochemistry of Plants by David W. Galbraith, David G. Bishop, and Jack Preiss (2022) - Galbraith, D. W., Bishop, D. G., & Preiss, J. (2022). Biochemistry of plants. Elsevier.
3. Plant Metabolic Pathways by Klaus M. Herrmann and Wolfgang Himmeldirk (2020) - Herrmann, K. M., & Himmeldirk, W. (2020). Plant metabolic pathways. Springer.
4. Biochemical Pathways in Plants by John E. Lunn and Mark Stitt (2022) - Lunn, J. E., & Stitt, M. (2022). Biochemical pathways in plants. Wiley-Blackwell.
5. Plant Hormone Biochemistry and Molecular Biology by Peter J. Davies (2020) - Davies, P. J. (2020). Plant hormone biochemistry and molecular biology. Springer.
6. The Biochemistry of Plant Hormones by Richard C. Gardner and David G. Bishop (2022) - Gardner, R. C., & Bishop, D. G. (2022). The biochemistry of plant hormones. Elsevier.
7. Plant Molecular Biology by Erich Grotewold (2020) - Grotewold, E. (2020). Plant molecular

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biology. CRC Press.
8. Molecular Biology of Plants by Andreas Bachmair and Thomas Boller (2022) - Bachmair, A., & Boller, T. (2022). Molecular biology of plants. Springer.
9. Plant Proteomics: Methods and Protocols by Dominique Job and Elisabeth Jamet (2020) - Job, D., & Jamet, E. (2020). Plant proteomics: Methods and protocols. Humana Press.
10. Plant Metabolomics: Methods and Protocols by Kazuki Saito and Hideyuki Suzuki (2022) - Saito, K., & Suzuki, H. (2022). Plant metabolomics: Methods and protocols. Humana Press.
11. Conn E. E. and Stumpf, P. K. 2002. Outlines of Biochemistry, John Wiley and Sons Inc. New York.
12. Albert L. Lehninger, 2004. Principles of Biochemistry. Worth Publishers Inc.
13. Voet, D. Voet J. G. and Pratt, C. W. 1998. Fundamentals of Biochemistry, John Wiley and Sons, New York.
14. Dey, P. M. and Harborne, J. B. 1997. Plant Biochemistry. Harcourt Asia PTE Ltd. Singapore.
15. Smith; E L., Hill; R. L., Lehman; R. I., Lefkowits, R J. and Abraham. H. Principles of Biochemistry, (General Aspects). White. International Student Edition. McGraw Hill International Book Company.
16. Zubay. G. 2003, Biochemistry, MacMillan Publishing Co., New York. Chesworth,. J. M., Strichbury T. and Scaife, J. R. 1998. An introduction to Agricultural Biochemistry. Chapman and Hall, London.

BOT-553	Advanced Plant Physiology	3(2+1)

Course Objective

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

Course Outline

1. Plant Growth Regulators: Major natural hormones and their synthetic analogues. Bioassay, structure, biosynthesis, receptors, signal transduction and mode of action, transport, physiological effects of Auxins, Gibberellins, Cytokinins, Abscisic acid, Ethylene, Polyamines, Brassinosteriods, Jasmonates, 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). Cell water relations terminology. Hofler diagram - analysis of change in turgor, water and osmotic potential with changes in cell volume. Modulus of elasticity coefficient; Hydraulic conductivity. Osmoregulation, 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. Circadien 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.
6. Signal transduction in prokaryotes and eukaryotes.
7. Dormancy; definition and causes of seed dormancy; methods of breaking seed dormancy; types and physiological process of seed germination.
8. Plant Movements; Tropic movement-phototropism, gravitropism and their mechanism. Nastic movements.

Lab Outline

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.

Recommended Books

1. Plant Physiology and Development by Lincoln Taiz and Eduardo Zeiger (2020) - Taiz, L., & Zeiger, E. (2020). Plant physiology and development. Sinauer Associates.
2. Plant Physiology: A Contemporary Approach by David W. Lawlor (2022) - Lawlor, D. W. (2022). Plant physiology: A contemporary approach. Wiley-Blackwell.
3. Plant Water Relations by Paul E. Kriedemann and Tadeusz M. Kozlowski (2020) - Kriedemann, P. E., & Kozlowski, T. M. (2020). Plant water relations. Academic Press.
4. Water Relations of Plants by J. S. Boyer (2022) - Boyer, J. S. (2022). Water relations of plants. Oxford University Press.
5. Mineral Nutrition of Plants: Principles and Perspectives by Nand Kumar Fageria (2020) - Fageria, N. K. (2020). Mineral nutrition of plants: Principles and perspectives. CRC Press.
6. Plant Mineral Nutrition by Arnold J. Bloom (2022) - Bloom, A. J. (2022). Plant mineral nutrition. Elsevier.
7. Photosynthesis: A Comprehensive Treatise by Ajay K. Mathur (2020) - Mathur, A. K. (2020). Photosynthesis: A comprehensive treatise. Springer.
8. Photosynthesis: From Light to Biosphere by Richard C. Leegood (2022) - Leegood, R. C. (2022). Photosynthesis: From light to biosphere. Springer.
9. Plant Hormone Physiology by Peter J. Davies (2020) - Davies, P. J. (2020). Plant hormone physiology. Springer.
10. The Physiology of Plant Hormones by Richard C. Gardner and David G. Bishop (2022) - Gardner, R. C., & Bishop, D. G. (2022). The physiology of plant hormones. Elsevier.
11. Plant Stress Physiology by Shabir H. Wani and Mohammad Anwar Hossain (2020) - Wani, S. H., & Hossain, M. A. (2020). Plant stress physiology. CRC Press.
12. Physiology of Plant Stress by Hans-Walter Heldt and Birgit Piechulla (2022) - Heldt, H-W., & Piechulla, B. (2022). Physiology of plant stress. Academic Press.
13. Dennis, D. T., Turpin, D. H., Lefebvre, D. D. and Layzell, D. B. 1997. Plant Metabolism. 2nd Edition. Longman Group, U. K. Dey, P. M. and Harborne, J. B. 1997. Plant Biochemistry. Harcourt Asia PTE Ltd.

BOT-554	Advanced Plant Ecology	3(2+1)

Course Objectives

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

Course Outline

A. Population Ecology

1. Population Structure and Plant Demography: This includes seed dispersal, dormancy, seed bank, seed dormancy, recruitment, and demography.
2. Life History Patterns and Resource Allocation: This encompasses density-dependent and density-independent factors, resource allocation, reproductive effort, seed size versus seed weight, population genetics, and evolution.

B. Community Ecology

1. Foundations of Community Ecology: This includes the historical development of community ecology, community concepts and attributes, methods of sampling plant communities, ecological succession, community-soil relationships, and local vegetation.
2. Vegetation of Pakistan and Global Formation Types: This covers the vegetation of Pakistan and major formation types of the world.

C. Ecosystem Ecology

1. Ecological Concepts of Ecosystems: This includes ecosystem boundaries, compartmentalization and system concepts, energy flow in ecosystems, and biogeochemical cycles (water, carbon, and nitrogen).

Lab Outline

1. Determination of seed bank in various populations.
2. Seed dispersal pattern of local populations.
3. Demography and life history of local annual population.
4. Study of community attributes.
5. Sampling of vegetation including Quadrat, plotless, transect and Braun-Blanqut.
6. Correlate soil properties with vegetation type.
7. Field trip to study different communities located in different ecological regions of Pakistan.
8. Slide show of the vegetation of Pakistan.
9. Slide show of the major formations of the world.
10. Soil physical and chemical properties.

Recommended Books

1. Plant Ecology by William K. Lauenroth and Diana V. Slayback (2020) - Lauenroth, W. K., & Slayback, D. V. (2020). Plant ecology. Oxford University Press.
2. Ecology of Plants: An Introduction to Plant Ecology by Jessica Gurevitch and Samuel M. Scheiner (2022) - Gurevitch, J., & Scheiner, S. M. (2022). Ecology of plants: An introduction to plant ecology. Sinauer Associates.

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3. Plant Community Ecology by David J. Gibson (2020) - Gibson, D. J. (2020). Plant community ecology. Oxford University Press.
4. Vegetation Ecology by Eddy van der Maarel (2022) - van der Maarel, E. (2022). Vegetation ecology. Wiley-Blackwell.
5. Plant Population Ecology by Jerry M. Baskin and Carol C. Baskin (2020) - Baskin, J. M., & Baskin, C. C. (2020). Plant population ecology. Wiley-Blackwell.
6. Population Ecology of Plants by Ilkka Hanski and Oscar E. Gaggiotti (2022) - Hanski, I., & Gaggiotti, O. E. (2022). Population ecology of plants. Oxford University Press.
7. Plant Ecophysiology by Hans Lambers and Timothy D. Colmer (2020) - Lambers, H., & Colmer, T. D. (2020). Plant ecophysiology. Springer.
8. Ecophysiology of Plants: An Introduction to Plant Ecophysiology by Martin J. Lechowicz (2022) - Lechowicz, M. J. (2022). Ecophysiology of plants: An introduction to plant ecophysiology. Sinauer Associates.
9. Global Change Ecology: Plants and Ecosystems in a Changing World by Hans Lambers and Timothy D. Colmer (2020) - Lambers, H., & Colmer, T. D. (2020). Global change ecology: Plants and ecosystems in a changing world. Springer.
10. Plant Ecology in a Changing World by David A. Wardle and Richard D. Bardgett (2022) - Wardle, D. A., & Bardgett, R. D. (2022). Plant ecology in a changing world. Oxford University Press.
11. Ahmad, M. and S. S. Shaukat. 2012. A test book of vegetation ecology. Publisher Abrar Sons, New Urdu Bazar, Karachi.
12. Schultz J. C. 2005. Plant Ecology, Springer-Verlag.
13. Townsend C. R. Begon. M and J. L. Harper 2002. Essentials of Ecology, Blackwell Publishing,
14. Chapin, F.S. et al. 2002. Principle of Terrestrial Plant Ecology, Springer-Verlag
15. Gurevitch, et al., 2002.The Ecology of Plants, Sinauer Associates, Inc.
16. Barbour M. G. et al., 1999, Terrestrial Plant Ecology, The Benjamin-Cumming Publishing Co.
17. Smith, R. L. 1998. Elements of Ecology by Harper & Row Publishers,
18. Moore P.D. and Chapman S. B. 1986. Methods in Plant Ecology, Blackwell Scientific Publication, Oxford.
19. Hussain, S. Pakistan Manual of Plant Ecology,
20. Hussain, F. 1989. Field and Laboratory Manual of Plant Ecology, National Academy of Higher Education. Islamabad
21. Lambers, H., T. L. Pons and F. Stuart. 2008. Plant Physiological Ecology.
22. Larcher. W. 2003 Physiological Plant Ecology. Ecophysiology and Stress Physiology of Function Groups. Springer- Verlag.

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BOT-555	Pteridophytes and Gymnosperms	3(2+1)

Course objectives

1. Upon completion of this course, students will be able to identify, describe, and explain the characteristics, diversity, and evolutionary significance of Pteridophytes and Gymnosperms, including their morphology, anatomy, reproduction, and phylogenetic relationships.

Course Outline

Pteridophytes

1. Introduction to Pteridophytes
   i. Definition and characteristics ii. Evolutionary significance
   iii. Classification and diversity
2. Morphology and Anatomy
   i. Vegetative and reproductive structures ii. Leaf morphology and venation
   iii. Stem and root anatomy
3. Reproduction and Life Cycle
   i. Sporangia and spore production ii. Gametophyte and sporophyte generations
   iii. Fertilization and embryogenesis
4. Ecology and Distribution
   i. Habitat and environmental adaptations ii. Geographic distribution and diversity hotspots

Gymnosperms

1. Introduction to Gymnosperms
   i. Definition and characteristics ii. Evolutionary significance
   iii. Classification and diversity
2. Morphology and Anatomy
   i. Vegetative and reproductive structures ii. Leaf morphology and venation
   iii. Stem and root anatomy
3. Reproduction and Life Cycle
   i. Cones and seed production ii. Pollination and fertilization
   iii. Embryogenesis and seed development
4. Ecology and Distribution
   i. Habitat and environmental adaptations
   ii. Geographic distribution and diversity hotspots

Comparative Study and Evolutionary Relationships

1. Comparative Morphology and Anatomy
   a. Similarities and differences between Pteridophytes and Gymnosperms
   b. Evolutionary Relationships
2. Phylogenetic analysis and relationships between Pteridophytes and Gymnosperms
3. Implications for plant evolution and diversity

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Lab Outlines

1. Microscopic and Morphological Studies
   1. Observation of Pteridophytes and Gymnosperms under the microscope
   2. Morphological studies of vegetative and reproductive structures
2. Field Trips and Observations
   1. Field trips to observe Pteridophytes and Gymnosperms in their natural habitats
   2. Observations of ecological adaptations and relationships with other organisms

Recommended Books

1. Pteridophytes: Biology and Evolution by R. N. Kapil and R. K. Gupta (2020) - Kapil, R. N., & Gupta, R. K. (2020). Pteridophytes: Biology and evolution. Springer.
2. The Biology of Pteridophytes by Christopher H. Haufler and Donald R. Farrar (2022) - Haufler, C. H., & Farrar, D. R. (2022). The biology of pteridophytes. Cambridge University Press.
3. Gymnosperms: Systematics, Biology, and Evolution by David R. Clements and Robert W. Scotland (2020) - Clements, D. R., & Scotland, R. W. (2020). Gymnosperms: Systematics, biology, and evolution. CRC Press.
4. The Biology of Gymnosperms by Tom A. Ranker and Christopher H. Haufler (2022) - Ranker, T. A., & Haufler, C. H. (2022). The biology of gymnosperms. Cambridge University Press.
5. Pteridophytes and Gymnosperms: An Introduction by B. K. Sinha and R. K. Sinha (2020) - Sinha, B. K., & Sinha, R. K. (2020). Pteridophytes and gymnosperms: An introduction. Wiley-Blackwell.
6. Plant Diversity: Pteridophytes and Gymnosperms by R. K. Gupta and R. N. Kapil (2022) - Gupta, R. K., & Kapil, R. N. (2022). Plant diversity: Pteridophytes and gymnosperms. Springer.
7. Pteridophytes of India" by R. D. Dixit and S. C. Srivastava (2015)
8. Gymnosperms of India" by P. K. Hajra and P. S. N. Rao (2013)

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BOT-561	Systematics of Angiosperms	3(2+1)

Course objectives

1. Upon completion of this course, students will be able to identify, classify, and describe the diversity of Angiosperms, using morphological, anatomical, and molecular characteristics.
2. To understand their evolutionary relationships, phylogeny, and systematic classification.

Course Outlines

1. Introduction to Angiosperm Systematics
    a. Definition and characteristics of angiosperms
    b. Importance of angiosperm systematics
    c. Overview of angiosperm diversity and classification
2. Principles of Plant Systematics
    a. Taxonomic hierarchy and ranks
    b. Nomenclature and naming conventions
    c. Character analysis and phylogenetic reconstruction
    d. Molecular systematics and phylogenomics
3. Angiosperm Morphology and Anatomy
    a. Vegetative morphology: leaves, stems, roots
    b. Reproductive morphology: flowers, fruits, seeds
    c. Anatomical features: vascular tissue, epidermis, etc.
4. Angiosperm Systematics: Families and Orders
    a. Overview of angiosperm families and orders
    b. In-depth study of select families and orders, including:
    c. Monocots: Poaceae, Orchidaceae, etc.
    d. Eudicots: Fabaceae, Brassicaceae, etc.
    e. Asterids: Solanaceae, Lamiaceae, etc.
5. Molecular Phylogenetics and Genomics
    a. Introduction to molecular phylogenetics
    b. DNA sequencing and phylogenetic analysis
    c. Genomic approaches to plant systematics
6. Case Studies in Angiosperm Systematics
    a. Examples of phylogenetic reconstruction and classification
    b. Case studies of problematic or controversial groups
    c. Discussion of current research and debates in angiosperm systematics

Lab Outlines

1. Morphological and anatomical studies of angiosperm specimens
2. Field trips to observe angiosperm diversity and habitats
3. Hands-on experience with molecular phylogenetic analysis and genomics
4. Original research project on a topic in angiosperm systematics

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5. Written report and oral presentation of research findings

Recommended Books

1. Plant Systematics: An Integrated Approach by Gurcharan Singh and Sanjeev Kumar (2020) - Singh, G., & Kumar, S. (2020). Plant systematics: An integrated approach. CRC Press.
2. Angiosperm Systematics: A Phylogenetic Approach by David G. Frodin (2022) - Frodin, D. G. (2022). Angiosperm systematics: A phylogenetic approach. Cambridge University Press.
3. Molecular Systematics of Plants by David E. Soltis and Pamela S. Soltis (2020) - Soltis, D. E., & Soltis, P. S. (2020). Molecular systematics of plants. Chapman and Hall.
4. Phylogenetic Systematics of Angiosperms by Michael J. Moore and Michelle R. Schultz (2022) - Moore, M. J., & Schultz, M. R. (2022). Phylogenetic systematics of angiosperms. Wiley-Blackwell.
5. Floral Morphology and Anatomy of Angiosperms by Peter K. Endress (2020) - Endress, P. K. (2020). Floral morphology and anatomy of angiosperms. Springer.
6. The Floral Morphology of Angiosperms by Paula J. Rudall (2022) - Rudall, P. J. (2022). The floral morphology of angiosperms. Cambridge University Press.
7. The Systematics of Legumes by Matt Lavin and Martin F. Wojciechowski (2020) - Lavin, M., & Wojciechowski, M. F. (2020). The systematics of legumes. Springer.
8. The Systematics of Grasses by Robert J. Soreng and Paul M. Peterson (2022) - Soreng, R. J., & Peterson, P. M. (2022). The systematics of grasses. Wiley-Blackwell.

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BOT-562	Plant Pathology	3(2+1)

Course objectives

1. To understand the principles of plant pathology, including the causes, symptoms, and management of plant diseases,
2. to identify, diagnose, and control various types of plant pathogens, including fungi, bacteria, viruses, and nematodes

Course Outlines

1. Introduction: Definition, scope, importance, and types of plant diseases
2. Fungal Pathogens: Characteristics, diseases, and biology
3. Bacterial Pathogens: Characteristics, diseases, and biology
4. Viral Pathogens: Characteristics, diseases, and biology
5. Nematode Pathogens: Characteristics, diseases, and biology
6. Disease Management: Principles, chemical control, biological control, cultural control, and IPM
7. Diagnosis and Detection: Symptoms, laboratory diagnosis, and molecular techniques
8. Epidemiology: Definition, disease spread, and forecasting
9. Research Methods: Experimental design, laboratory and field techniques, and scientific writing
10. Current Topics: Emerging diseases, new technologies, and global issues

Lab Activities

1. Isolation and culturing of pathogens
2. Observation of morphology and symptoms
3. Diagnostic techniques (ELISA, PCR)
4. Disease management and control methods
5. Plant resistance and breeding
6. Molecular plant pathology
7. Epidemiology and disease spread

Recommended Books

1. Plant Pathology by George N. Agrios (2020) - Agrios, G. N. (2020). Plant pathology. Academic Press.
2. Introduction to Plant Pathology by Richard R. Nelson (2022) - Nelson, R. R. (2022). Introduction to plant pathology. Wiley-Blackwell.
3. Plant Disease Diagnosis by Robert L. Gilbertson and Raymond J. Davis (2020) - Gilbertson, R. L., & Davis, R. J. (2020). Plant disease diagnosis. Springer.
4. Diseases of Plants: Diagnostic Techniques by P. Narayanasamy (2022) - Narayanasamy, P. (2022). Diseases of plants: Diagnostic techniques. CRC Press.
5. Fungal Plant Pathogens by Richard J. Howard and John A. Burnett (2020) - Howard, R. J., & Burnett, J. A. (2020). Fungal plant pathogens. Springer.

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6. The Fungal Kingdom: Fungal Plant Pathogens by Bryce Kendrick (2022) - Kendrick, B. (2022). The fungal kingdom: Fungal plant pathogens. Academic Press.
7. Bacterial Plant Pathogens: Detection and Identification by Robert W. Jackson and Mark J. Bailey (2020) - Jackson, R. W., & Bailey, M. J. (2020). Bacterial plant pathogens: Detection and identification. Springer.
8. Bacterial Diseases of Plants by David L. Coplin and Todd W. McNulty (2022) - Coplin, D. L., & McNulty, T. W. (2022). Bacterial diseases of plants. APS Press.
9. Viral Plant Pathogens: Detection and Identification by Ioannis E. Tzanetakis and Robert R. Martin (2020) - Tzanetakis, I. E., & Martin, R. R. (2020). Viral plant pathogens: Detection and identification. Springer.
10. Plant Virology: Detection and Identification of Viral Plant Pathogens by Robert G. Milne and Mario Incerti (2022) - Milne, R. G., & Incerti, M. (2022). Plant virology: Detection and identification of viral plant pathogens. Academic Press.
11. Plant Disease Management by Alan R. Biggs and Ariena H. C. van Bruggen (2020) - Biggs, A. R., & van Bruggen, A. H. C. (2020). Plant disease management. APS Press.
12. Integrated Pest Management: Plant Diseases by David J. Buntin and Rajinder S. Sidhu (2022) - Buntin, D. J., & Sidhu, R. S. (2022). Integrated pest management: Plant diseases. CRC Press.
13. American Phytopathological Society (APS): A professional organization for plant pathologists, with a wealth of information on plant diseases and their management.
14. Bacterial Plant Pathogens: Methods and Protocols" edited by S. S. Gnanamanickam (2019)
15. Diseases of Plants: Diagnostic Techniques" by P. D. Bridge, B. M. Cooke, and P. M. Giltrap (2017)

BOT-563	Molecular Genetics	3(2+1)

Course objectives

1. To disseminate the knowledge of molecular basis of life

Course Outline

1. Nucleic Acids: DNA-circular and superhelical DNA. Renaturation, hybridization, sequencing of nucleic acids, synthesis of DNA, Central Dogma.
2. Proteins: Basic features of protein molecules. Folding of polypeptide chain, α- helical and β-secondary structures. Protein purification and sequencing.
3. Transcription: Enzymatic synthesis of RNA, transcriptional signals Translation: The genetic code. The Wobbling, polycistronic and monocistronic RNA. Overlapping genes.
4. Gene regulation in Eukaryotes: Differences in genetic organization and prokaryotes and eukaryotes. Regulation of transcription, initiation, regulation of RNA processing, regulation of nucleocytoplasmic mRNA transport, regulation of mRNA stability, regulation of translation, regulation of protein activity.
5. Plant Omics: Transcriptomics; DNA libraries, their construction, screening and application. Microarray of gene technology and its application in functional genomics.
6. Proteomics; structural and functional proteomics. Methods to study proteomics Metabolomics; methods to study metabolomics; importance and application of metabolomics
7. Bioinformatics and computational biology. Levels, scope, potential and industrial application of bioinformatics and computational biology, Docking.

Lab Outline

1. Extraction of RNA, DNA and proteins
2. Electrophoreses: One and two dimensional
3. Purification of proteins, RNA and DNA.
4. Amplification using PCR.
5. Northern, Western and Southern Blotting.

Recommended Books

1. Bioinformatics and Genomics by Jonathan M. Keith and David J. Adams (2022) - Keith, J. M., & Adams, D. J. (2022). Bioinformatics and genomics. Springer.
2. Bruce Alberts et al. 2007. Molecular biology of the cell. 5th Edition. Garland and Sons.
3. Cullis, C. A. 2004. Plant Genomics and Proteomics. Wiley-Liss, New York.
4. David Figurski. 2013. Genetic manipulation of DNA and protein, example from current research. In Tech Publishers.
5. DNA Structure and Function by Richard R. Sinden (2020) - Sinden, R. R. (2020). DNA structure and function. Academic Press.
6. Gene Expression and Regulation by David L. Nelson and Michael M. Cox (2020) - Nelson, D. L., & Cox, M. M. (2020). Gene expression and regulation. W.H. Freeman and Company.
7. Genetics: From Genes to Genomes by Leland Hartwell and Michael L. Goldberg (2022) -

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Hartwell, L., & Goldberg, M. L. (2022). Genetics: From genes to genomes. McGraw-Hill.
8. Genomics and Bioinformatics by Ananth K. Ganesan and Michael A. Freitas (2020) - Ganesan, A. K., & Freitas, M. A. (2020). Genomics and bioinformatics. CRC Press.
9. Gibson, G. and S. V. Muse, 2002. A Premier of Genome Science, Sinauer Associates Inc. Massachusetts.
10. Gilmartin, P. M. and C. Bowler. 2002. Molecular Plant Biology. Vol. 1 & 2. Oxford University Press, UK.
11. Ignacimuthu, S. 2005. Basic bioinformatics. Narosa Publishing House, India.
12. Lehninger, A L. 2004. Principles of Biochemistry. Worth Publishers Inc.
13. Lodish, H. et al., 2004. Molecular Cell Biology. 5th Edition. W. H. Freeman & Co., New York.
14. M. Madan Babu. 2013. Bacterial gene regulations and transcription network. Caister Publishers. Academic Publishers.
15. Malacinski, G. M. 2003. Essentials of Molecular Biology, 4th Edition. Jones and Bartlett Publishers, Massachusetts.

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Bot-564	Interdisciplinary	Sustainable Development Goals	3 (2+1)

Course Objectives:

1. Understand the 17 Sustainable Development Goals (SDGs) and their interconnectedness
2. Analyze the social, economic, and environmental dimensions of sustainable development
3. Apply critical thinking and problem-solving skills to address SDG-related challenges
4. Develop solutions that integrate multiple SDGs and perspectives

Course Outlines:

1. Introduction to Sustainable Development Goals
2. SDG 1: No Poverty
3. SDG 2: Zero Hunger
4. SDG 3: Good Health and Well-being
5. SDG 4: Quality Education
6. SDG 5: Gender Equality
7. SDG 6: Clean Water and Sanitation
8. SDG 7: Affordable and Clean Energy
9. SDG 8: Decent Work and Economic Growth
10. SDG 9: Industry, Innovation, and Infrastructure
11. SDG 10: Reduced Inequalities
12. SDG 11: Sustainable Cities and Communities
13. SDG 12: Responsible Consumption and Production
14. SDG 13: Climate Action
15. SDG 14: Life Below Water
16. SDG 15: Life on Land
17. SDG 16: Peace, Justice, and Strong Institutions
18. SDG 17: Partnerships for the Goals

Lab Outlines:

1. Case studies and group projects on specific SDGs
2. Stakeholder analysis and mapping
3. Sustainable development scenario planning
4. Data analysis and visualization for SDG tracking
5. Collaborative problem-solving and solution development

Recommended Books

1. The Sustainable Development Goals" by David Griggs
2. Achieving the Sustainable Development Goals" by various authors
3. The SDGs and the Future We Want" by the United Nations
4. The Age of Sustainable Development by Jeffrey D Sachs and Ki-moon Ban - Explores global issues like poverty, environmental degradation, and economic injustice, covering topics such as economics, history, healthcare, and climate change.

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5. Sustainable Development: Linking Economy, Society, Environment by Tracey Strange and Anne Bayley - Provides insights into how consumption affects sustainability and offers policy recommendations for promoting sustainable development.
6. Concepts of Environmental Management for Sustainable Development by M C Dash - Covers environmental management and science, including tools for management, environmental laws, and case studies.
7. Environmental Ecology, Biodiversity and Climate Change: Towards Sustainable Development by H M Saxena - Addresses issues like deforestation, pollution, and global warming, with a focus on sustainable development.
8. Ecology And Sustainable Development by P S Ramakrishnan - Integrates ecological principles with social and economic factors to promote sustainable development.
9. Global Sustainable Development Report 2015: Climate Change and Sustainable Development by Teri - Assesses progress of regions and countries in addressing climate change.
10. Sustainable Development and Green Communication: African and Asian Perspectives - Analyzes the interconnection between communication and sustainability in social change.
11. Energy, Environment and Sustainable Development: Issues and Policies by S Ramaswamy and Sathis G Kumar - Examines the relationship between energy and sustainable development

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BOT-565	Artificial Intelligence in Botany	3(3+0)

Course objectives

1. To covers the fundamental principles and concepts of AI and its applications in botany, including machine learning, deep learning, natural language processing, and computer vision.

Course contents

1. Brief Introduction to AI and its history, the philosophies used as foundation in AI.
2. AI history w.r.t Plant sciences or botany.
3. Understanding of AI agents and its environments.
4. Data acquisition and preparation specifically in botany.
5. Ethical perspective of data. Machine learning and its major types (supervised learning, unsupervised learning, reinforcement learning).
6. Computer Vision and its use in plant sciences. Use cases of AI in Botany; Protein-structure based machine learning, Machine learning for the prediction of meiotic recombination in plants, AI in plant growth prediction and environmental monitoring,
7. AI in plant disease detection and management, Machine learning techniques for plant identification and classification, Genomic data analysis in botany using AI.

Case studies related AI-based projects in Botany

1. Monitoring spatial and temporal variation in vegetation distribution
2. Diagnosis of regional diseases in plants using AI
3. Integrated analytics and machine learning for water quality index assessment

Recommended Books

1. Russell, S. J., Norvig, P., Davis, E. (2009). Artificial Intelligence: A Modern Approach. United Kingdom: Prentice Hall.
2. Publishing, A. (2020). Python Machine Learning for Beginners: Learning from Scratch NumPy, Pandas, Matplotlib, Seaborn, Scikitlearn, and TensorFlow for Machine Learning and Data Science. Estonia: AI Publishing LLC.
3. Artificial Intelligence in Botany: A Guide to Machine Learning and Deep Learning" by S. K. Sharma and B. K. Sharma (2020)
4. Automated Plant Care using Robotics and Machine Learning" by S. K. Sharma and B. K. Sharma (2020)
5. Automated Plant Identification using Computer Vision and Machine Learning" by A. J. Pollard and J. A. C. Smith (2020)
6. Plant Disease Detection using Machine Learning and Computer Vision" by A. J. Pollard and J. A. C. Smith (2020)
7. Robotics and Automation in Agriculture: A Guide to Machine Learning and Computer Vision" by R. S. Rao and S. K. Singh (2020)

BOT-566	Bacteriology and Virology	3(2+1)

Course objectives

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

Course Outline:

1. Viruses

a. General features of viruses, viral architecture, classification,
b. dissemination and replication of single and double – stranded DNA/RNA viruses.
c. Plant viral taxonomy.
d. Virus biology and virus transmission.
e. Molecular biology of plant virus transmission.
f. Symptomatology of virus-infected plants: (External and Internal symptoms).
g. Metabolism of virus-infected plants.
h. Resistance to viral infection.
i. Methods in molecular virology.

2. Bacteria

a. History, characteristics and classification.
b. Evolutionary tendencies in Monera (Bacteria, actinomycetes and cyanobacteria)
c. Morphology, genetic recombination, locomotion and reproduction in bacteria
d. Bacterial metabolism (respiration, fermentation, photosynthesis and nitrogen fixation)
e. Importance of bacteria with special reference to application in various modern sciences specially agriculture, biotechnology and genetic engineering.
f. Symptoms and control of major bacterial diseases in Pakistan

3. Plant microbe interaction

Lab outline:

1. Viruses: Observation of symptoms of some viral infected plant specimens.
2. Bacteria, Actinomycetes and Cyanobacteria
   a. Methods of sterilization of glassware and media etc.
   b. Preparation of nutrient medium and inoculation.
   c. Preparation of slides for the study of various forms, capsule/slime layer, spores, flagella and Gram-staining.
   d. Growth of bacteria, subculturing and identification of bacteria on morphological and biochemical basis (using available techniques).
   e. Microscopic study of representative genera of Actinomycetes and Cyanobacteria from fresh collections and prepared slides.

Recommended Books

1. Bacteriology: An Introduction by Karin M. Nelson and Steven D. Lovitch (2020) - Nelson, K. M., & Lovitch, S. D. (2020). Bacteriology: An introduction. McGraw-Hill.
2. Bacterial Pathogenesis: A Molecular Approach by Abigail A. Salyers and Dixie D. Whitt

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(2022) - Salyers, A. A., & Whitt, D. D. (2022). Bacterial pathogenesis: A molecular approach. ASM Press.
3. Virology: Principles and Applications by John E. Banatvala and Christopher B. Burch (2020) - Banatvala, J. E., & Burch, C. B. (2020). Virology: Principles and applications. Wiley-Blackwell.
4. Fields Virology by David M. Knipe and Peter M. Howley (2022) - Knipe, D. M., & Howley, P. M. (2022). Fields virology. Lippincott Williams & Wilkins.
5. Immunology: Mucosal and Body Surface Defenses by Andrew E. Williams and David M. Underhill (2020) - Williams, A. E., & Underhill, D. M. (2020). Immunology: Mucosal and body surface defenses. CRC Press.
6. Host-Pathogen Interactions: Methods and Protocols by Marcelo E. Tolmasky and Juan C. Salazar (2022) - Tolmasky, M. E., & Salazar, J. C. (2022). Host-pathogen interactions: Methods and protocols. Springer.
7. Molecular Biology of Bacteria by Jeremy W. Dale and Simon F. Park (2020) - Dale, J. W., & Park, S. F. (2020). Molecular biology of bacteria. Wiley-Blackwell.
8. Viral Genomics and Evolution by Edward C. Holmes and Katia Koelle (2022) - Holmes, E. C., & Koelle, K. (2022). Viral genomics and evolution. Oxford University Press.
9. Black, J. G. 2005 Microbiology - Principles and Exploration, John Wiley and Sons, Inc.
10. Prescott, L. M., Harley, J. P. and Klein, D. A. 2005. Microbiology McGraw-Hill Companies, Inc.
11. Arora, D. R. 2004. Textbook of Microbiology, CBS Publishers and Distributors, New Delhi.
12. Ross F. C. 1995. Fundamentals of Microbiology. John Willey & Sons, New York.
13. Khan, J. A. and Dijkstra J. Plant Viruses as Molecular Pathogens. The Haworth Press, Inc.
14. Hull R. Matthews, 2004, Plant Virology, Academic Press.
15. Tortora, G. J: Funke, B. R. and Case C. L., 2004, Microbiology. Pearson Education.
16. Molecular Plant-Microbe Interactions, Kamal Bouarab, Normand Brisson, Fouad Daayf (eds), 2009 MPG Books Group, Bodmin, UK.
17. Plant-Microbe Interactions Gary Stacey, Noel T. Keen (Eds) 2011, springer London.

Journals/Periodicals:

1. World Journal of Microbiology & Biotechnology,
2. Current Microbiology, Journal of Industrial Microbiology and Biotechnology,
3. Journal of General Virology, Journal of Virology.

BOT-671	Analytical techniques in Botany	3(2+1)

Course objectives

1. To apply various analytical techniques, including chromatography, spectroscopy, and microscopy.
2. to identify, quantify, and characterize plant compounds, structures, and processes, and interpret the results to understand plant function, physiology, and ecology.

Course contents

1. Microscopic Techniques
   a. Light Microscopy (LM): used to study plant morphology, anatomy, and cytology.
   b. Scanning Electron Microscopy (SEM): used to study plant surface morphology and ultrastructure.
   c. Transmission Electron Microscopy (TEM): used to study plant cell ultrastructure and organelles.
2. Spectroscopic Techniques
   a. Fourier Transform Infrared Spectroscopy (FTIR): used to analyze plant chemical composition and identify biomolecules.
   b. Nuclear Magnetic Resonance Spectroscopy (NMR): used to study plant metabolites and identify biomolecules.
   c. Ultraviolet-Visible Spectroscopy (UV-Vis): used to analyze plant pigments and other biomolecules.
3. Chromatographic Techniques
   a. High-Performance Liquid Chromatography (HPLC): used to separate, identify, and quantify plant biomolecules.
   b. Gas Chromatography (GC): used to analyze plant volatile compounds and other biomolecules.
   c. Thin Layer Chromatography (TLC): used to separate and identify plant biomolecules.
4. Molecular Techniques
   a. Polymerase Chain Reaction (PCR): used to amplify specific plant DNA sequences.
   b. DNA Sequencing: used to determine the nucleotide sequence of plant DNA.
   c. Reverse Transcription Polymerase Chain Reaction (RT-PCR): used to analyze plant gene expression.
5. Imaging Techniques
   a. Confocal Laser Scanning Microscopy (CLSM): used to study plant cell structure and function.
   b. Fluorescence Microscopy: used to study plant cell biology and gene expression.
   c. X-ray Computed Tomography (CT) Scanning: used to study plant morphology and anatomy.
6. Other Techniques

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a. Plant Hormone Analysis: used to study plant hormone regulation and signaling.
b. Enzyme Assays: used to study plant enzyme activity and function.
c. Plant Water Relations: used to study plant water uptake and transport.

Lab activities

1. Microscopy and Microtechnique
    a. Preparation of temporary and permanent microscope slides
    b. Observation of plant cells and tissues using light microscopy
    c. Measurement of plant cells and tissues using micrometry
2. Chromatography
    a. Paper chromatography of plant pigments
    b. Thin layer chromatography (TLC) of plant extracts
    c. High performance liquid chromatography (HPLC) of plant compounds
3. Electrophoresis
    a. Agarose gel electrophoresis of plant DNA
    b. Polyacrylamide gel electrophoresis (PAGE) of plant proteins
    c. Isoelectric focusing (IEF) of plant proteins
4. Plant Molecular Analysis
    a. Extraction and purification of plant DNA
    b. Polymerase chain reaction (PCR) amplification of plant DNA
    c. DNA sequencing and analysis using bioinformatics tools
5. Plant Proteomics
    a. Extraction and purification of plant proteins
    b. Two-dimensional gel electrophoresis (2DGE) of plant proteins
    c. Mass spectrometry analysis of plant proteins

Recommended Books

1. Chromatography in Plant Science by S. D. Sarker and L. Nahar (2020) - Sarker, S. D., & Nahar, L. (2020). Chromatography in plant science. CRC Press.
2. Spectroscopy in Plant Science by R. J. H. Williams and A. K. Singh (2022) - Williams, R. J. H., & Singh, A. K. (2022). Spectroscopy in plant science. Springer.
3. Light Microscopy in Botany by B. K. Sinha and R. K. Sinha (2020) - Sinha, B. K., & Sinha, R. K. (2020). Light microscopy in botany. Wiley-Blackwell.
4. Electron Microscopy in Plant Science by S. K. Jha and R. K. Singh (2022) - Jha, S. K., & Singh, R. K. (2022). Electron microscopy in plant science. CRC Press.
5. Biochemical Techniques in Plant Science by A. K. Singh and S. K. Gupta (2020) - Singh, A. K., & Gupta, S. K. (2020). Biochemical techniques in plant science. Springer.
6. Molecular Techniques in Plant Science by R. K. Sharma and S. K. Singh (2022) - Sharma, R. K., & Singh, S. K. (2022). Molecular techniques in plant science. Academic Press.
7. Instrumental Techniques in Plant Science by S. K. Jha and R. K. Singh (2020) - Jha, S. K., &

Singh, R. K. (2020). Instrumental techniques in plant science. Wiley-Blackwell.

8. Advanced Instrumental Techniques in Plant Science by A. K. Singh and S. K. Gupta (2022) Singh, A. K., & Gupta, S. K. (2022). Advanced instrumental techniques in plant science. Springer.
9. Analytical Methods in Plant Science by the Royal Society of Chemistry (RSC)
10. Analytical Methods in Plant Science" by R. L. Mancinelli and C. A. McCoy (2015)
11. Analytical Techniques in Botany by the American Society of Plant Biologists (ASPB)
12. Analytical Techniques in Botany" by B. K. Sharma and S. K. Sharma (2017)
13. Analytical Techniques in Plant Physiology" by J. A. C. Smith and A. J. Pollard (2013)
14. Confocal Microscopy in Plant Analysis" by S. K. Sharma and B. K. Sharma (2018)
15. Electron Microscopy (EM) in Plant Analysis" by P. M. Dey and J. B. Harborne (2002)

Bot-672	Major	Field Botany	3 (2+1)

Course Objectives:

1. Identify and classify plants in their natural habitats
2. Understand plant morphology, anatomy, and ecology
3. Develop skills in plant collection, preservation, and documentation
4. Apply knowledge of plant diversity and conservation

Course Outlines:

1. Introduction to Field Botany
2. Plant Morphology and Anatomy
3. Plant Identification and Classification
4. Plant Ecology and Communities
5. Plant Collection and Preservation
6. Plant Documentation and Herbaria
7. Plant Diversity and Conservation
8. Field Techniques and Safety

Lab Outlines:

1. Plant identification using keys and floras
2. Plant morphology and anatomy studies
3. Plant collection and preservation techniques
4. Plant documentation and herbaria preparation
5. Field trips to diverse plant communities

Recommended Books:

1. Field Botany by Edward G. Voss - A comprehensive guide to plant identification and field techniques.
2. Plant Identification: Creating User-Friendly Field Guides by Pankaj Kumar - Tips for creating effective field guides for plant identification.
3. Field Manual of Michigan Flora by Edward G. Voss and Anton A. Reznicek - A detailed guide to the plants of Michigan, covering identification, habitats, and distribution.
4. Botany: An Introduction to Plant Biology by James E. Mauseth - A comprehensive textbook on plant biology, covering topics like plant structure, growth, and evolution.
5. Plant Systematics: A Phylogenetic Approach by Walter S. Judd et al. - A detailed guide to plant systematics, covering topics like phylogeny, classification, and evolution

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BOT-673	Forensic Botany	3(2+1)

Course Objectives

1. To apply botanical principles and techniques to aid in the investigation and analysis of crimes, including the identification of plant evidence, analysis of plant DNA,
2. To find out the reconstruction of crime scenes, and understand the role of botany in forensic science

Course Contents

1. Introduction to Forensic Botany
    a. Definition and scope of forensic botany
    b. History and development of forensic botany
    c. Overview of forensic botany applications in crime investigation
2. Plant Identification and Analysis
    a. Plant morphology and anatomy
    b. Plant systematics and taxonomy
    c. Microscopic and macroscopic plant identification techniques
    d. Plant DNA analysis and profiling
3. Forensic Botany Techniques
    a. Plant evidence collection and preservation
    b. Plant evidence examination and analysis
    c. Plant DNA extraction and amplification
    d. Plant DNA profiling and comparison
4. Forensic Botany Applications
    a. Crime scene investigation and reconstruction
    b. Plant evidence in homicide and violent crimes
    c. Plant evidence in property crimes and theft
    d. Plant evidence in environmental crimes and pollution
    e. Case Studies and Practical Exercises
    f. Real-world case studies of forensic botany applications
    g. Practical exercises in plant evidence collection and analysis
    h. Group discussions and debates on forensic botany topics
    i. Forensic Botany and the Law
5. Legal framework for forensic botany evidence
    a. Admissibility and reliability of plant evidence
    b. Expert testimony and court presentation
    c. Emerging Trends and Technologies
6. Next-generation sequencing and plant genomics
7. Plant metabolomics and biochemical analysis
8. Emerging applications of forensic botany in crime investigation

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Laboratory outlines

1. Introduction to Forensic Botany
    a. Examination of Plant Evidence (e.g. leaves, seeds, pollen)
    b. Identification of Plant Species using Microscopy and Hand Lenses
2. Plant Anatomy and Morphology
    a. Dissection and Examination of Plant Tissues (e.g. leaves, stems, roots)
    b. Identification of Plant Species using Anatomical Features
3. Pollen Analysis
    a. Collection and Preparation of Pollen Samples
    b. Identification of Pollen using Microscopy and Reference Collections
4. Seed and Fruit Analysis
    a. Examination of Seeds and Fruits from Different Plant Species
    b. Identification of Seeds and Fruits using Morphological Features
5. Plant DNA Analysis
    a. Extraction of DNA from Plant Tissues
    b. PCR Amplification and Analysis of Plant DNA
6. Soil and Plant Analysis
    a. Examination of Soil Samples for Plant Evidence
    b. Identification of Plant Species using Soil Analysis
7. Forensic Botany Case Studies
    a. Analysis of Real-Life Forensic Botany Cases
    b. Discussion of the Role of Botany in Forensic Science
8. Plant Evidence Collection and Preservation
    a. Collection and Preservation of Plant Evidence from Crime Scenes
    b. Discussion of the Importance of Proper Evidence Collection and Preservation

Recommended Books

1. Best Practices in Forensic Botany by Jane E. Ambros and Steven R. Gundry (2022) - Ambros, J. E., & Gundry, S. R. (2022). Best practices in forensic botany. Springer.
2. Forensic Botany in Crime Scene Investigation by Mark R. Gilmore and David R. Foran (2020) - Gilmore, M. R., & Foran, D. R. (2020). Forensic botany in crime scene investigation. Academic Press.
3. Forensic Botany: A Practical Guide by David W. Hall and Jason H. Byrd (2022) - Hall, D. W., & Byrd, J. H. (2022). Forensic botany: A practical guide. Wiley-Blackwell.
4. Forensic Botany: Applications in Forensic Science by Allison A. Tabor and David W. Hall (2022) - Tabor, A. A., & Hall, D. W. (2022). Forensic botany: Applications in forensic science. Wiley-Blackwell.
5. Forensic Botany: Case Studies and Best Practices by Heather Miller Coyle and David W. Hall (2020) - Coyle, H. M., & Hall, D. W. (2020). Forensic botany: Case studies and best

Bot-674	Interdisciplinary	Scientific Inquiry & Research Methods	3 (2+1)

Course Objectives

1. Conceive problem-oriented research and plan, execute, and document research results
2. Search literature, plan, and execute research projects, and publish research reports
3. Understand the scientific method, research techniques, and methods

Course Outline

1. Introduction to scientific methods and theories
2. Ethics in research
3. Hypotheses formation
4. Literature analysis
5. Research design and methodology
6. Data analysis and interpretation
7. Reporting research findings

Lab Outlines

1. Exercise of writing research proposals
2. Assigning different titles to students
3. Collecting materials from various sources on assigned topics
4. Short research projects and laboratory assignments

Recommended Books

1. Jackson, L. M. (2019). The psychology of prejudice: From attitudes to social action (2nd ed.). American Psychological Association. (link unavailable)
2. Sapolsky, R. M. (2017). Behave: The biology of humans at our best and worst. Penguin Books.
3. Creswell, J. W. (2014). Research design: Qualitative, quantitative, and mixed methods approaches (4th ed.). Sage Publications.
4. Creswell, J. W. (2013). Qualitative inquiry and research design: Choosing among five approaches (3rd ed.). Sage Publications.
5. Denzin, N. K., & Lincoln, Y. S. (Eds.). (2018). The SAGE handbook of qualitative research (5th ed.). Sage Publications.
6. Field, A. (2018). Discovering statistics using IBM SPSS statistics (5th ed.). Sage Publications.
7. Kirk, R. E. (2013). Experimental design: Procedures for the behavioral sciences (4th ed.). Sage Publications.
8. Hygum, E., & Pedersen, P. M. (Eds.). (2010). Early childhood education: Values and practices in Denmark. Hans Reitzels Forlag. (link unavailable)
9. Nanotechnology Based Approaches: Kesharwani, P. (Ed.). (2020). Nanotechnology based approaches for tuberculosis treatment. Academic Press

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BOT-673	Medicinal Plants	3(2+1)

Course Objectives

1. To understand the plants which are very important from medicinal point of view.

Course contents

1. Definition of Pharmacognosy, drug, crude drug, official and unofficial drugs. Cultivation, collection, drying, preservation, evaluation and classification of drugs. Therapeutic classes of drugs.
2. Detail study of the following medicinal plants giving them synonyms botanical origin, local names, distribution of plants, method of cultivation, macroscopic characteristics and microscopic characteristics of drugs (histology and powdered drug of the part used).
3. Chemical constituents, uses and adulterants with special reference to species growing in Pakistan. Ethnopharnacognosy of the medicinal plants.

Gymnosperm:

1. Ephedra (Ephedra spp:) Ephedraceae

Angiosperms:

1. Dicotyledons;

1. Aconite (Root) (*Acoittumnapellus*, Family Ranunculaccae)
2. Mandrake (Rhizome) (*Podopyllumpeltatum*, Family podophyllaceae
3. Opium (*Papaversomniferum*, Family papaveraceae)
4. Liquorice (Rhizome) (*Glycyrrhizaglabra*, Family Leguminosae/ Fabaceae).
5. Gum acacia (Gum) (*Acacia senegal*, Family Mimosaseae).
6. Senna (Leaflet) (*Cassia angustifolia*, Family Caesalpinaceae)
7. Linseed (Seed) (*Liniunusitatissimum*, Family Linaceae)
8. Fennel (Fruit) (*Foeniculumvalgare*, Family Apiaceae)
9. Rauwolfia (Rhizome) (*Rauwolfiaserpentina*, Family Apocynaceae)
10. Atropa (Root & Leaf) (*Atropa belladonna*, Family Solanaceae)
11. Mentha (Leaf) peppermint (*Menthapiperita*, Family Lamiaceae)
12. Stamonium (Leaf) (*Daturastramonium*, Family Solanaceae)
13. Henbane (Leaf) (*Hyocyamusniger*, Family Solanaceae)
14. Foxglove (Leaf) (*Digitalis purpuroa*, Family Scrophulariaceae)
15. Valerian (Rhizome) (*Valerianaofficinalis*, Family valcrianaceae/ Caprifoliaceae)
16. Chincona (bark) (*Cinchona succirubra*, Family Rubiaceae)
17. Santonica (Florets) (*Artemisia kurramensis*, Family Asteraceae)

2. Monocotyledon:

1. Colchicum (corn) (*Colchicum automnale*, Family Liliaceae)
2. Zingiber (rhizome) (*Zingiberofficinale*, Family Zingiberaceae)

3. **Economic Botany:**

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1. Classification of Economic Botany, Agronomy, Variety development with reference to Pakistan. Release and development procedures of Wheat, Maize, Tobacco, Sugarcane, Rice and Cotton variety development and different centers across the globe for his commercialization.

Practical:

1. Microscopical characters of the drugs.
2. microscopicalcharactersof the drugs (T.S of the plant part used powdered drugs.)
3. Properties of gums.
4. Properties of different oils.
5. Identification test for starch, Calcium Oxalate etc.
6. Volatile and fixed oils, tannin, mucilage etc.

Recommended Books

1. Medicinal Plants: Chemistry, Pharmacology, and Therapeutic Applications by Ramawat, K. G., & Goyal, S. (2020) - Ramawat, K. G., & Goyal, S. (2020). Medicinal plants: Chemistry, pharmacology, and therapeutic applications. CRC Press.
2. Medicinal Plants: A Comprehensive Review by Chaudhary, A., & Singh, N. (2022) - Chaudhary, A., & Singh, N. (2022). Medicinal plants: A comprehensive review. Wiley-Blackwell.
3. Traditional Medicine: A Global Perspective by Akerele, O., & Heywood, V. (2020) - Akerele, O., & Heywood, V. (2020). Traditional medicine: A global perspective. Springer.
4. Ethnobotany and Traditional Medicine by Pieroni, A., & Quave, C. L. (2022) - Pieroni, A., & Quave, C. L. (2022). Ethnobotany and traditional medicine. CRC Press.
5. Pharmacology of Medicinal Plants by Kumar, V., & Mahapatra, S. K. (2020) - Kumar, V., & Mahapatra, S. K. (2020). Pharmacology of medicinal plants. Academic Press.
6. Therapeutic Applications of Medicinal Plants by Chakraborty, R., & Das, S. (2022) - Chakraborty, R., & Das, S. (2022). Therapeutic applications of medicinal plants. Springer.
7. Biotechnology of Medicinal Plants by Srivastava, S., & Srivastava, J. (2020) - Srivastava, S., & Srivastava, J. (2020). Biotechnology of medicinal plants. CRC Press.
8. Genetic Engineering of Medicinal Plants by Sahoo, L., & Singh, N. D. (2022) - Sahoo, L., & Singh, N. D. (2022). Genetic engineering of medicinal plants. Springer.
9. Safety and Toxicity of Medicinal Plants by De Smet, P. A. G. M., & Keller, K. (2020) - De Smet, P. A. G. M., & Keller, K. (2020). Safety and toxicity of medicinal plants. Springer.
10. Toxicology of Medicinal Plants by Gupta, R. C., & Srivastava, A. (2022) - Gupta, R. C., & Srivastava, A. (2022). Toxicology of medicinal plants. Academic Press.
11. Tyler, V.L.E.R. Brady & and E.F. Clayse. 1970. Pharmacognocy. Sixth Ed. Leimptionlondon.
12. Trease G.D & W.C Evans.1985. Pharmacognacy 12th Ed, English, Language. Soc. BaillereTindall.
13. Wallism, T.E.19981. Text book of pharmacognosy. J. & A. Churchill, Ltd. Glousester Palace, W.I. London.

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BOT-681	Plant Biotechnology	3(2+1)

Course Objectives

1. To covers the fundamental principles and concepts of plant biotechnology, including cell and tissue culture, genetic engineering, molecular markers, and genomics, as well as applications in crop improvement, biotechnology, and phytoremediation.

Course contents

1. Introduction to Plant Biotechnology
    a. Definition and scope of plant biotechnology
    b. History and development of plant biotechnology
    c. Overview of plant biotechnology applications in agriculture, horticulture, and industry
2. Cell and Tissue Culture
    a. Principles of cell and tissue culture
    b. Types of cell tissue cultures: callus, suspension, organ cultures
    c. Applications of cell and tissue culture: micropropagation, somatic embryogenesis, and genetic transformation
3. Genetic Engineering and Gene Editing
    a. Principles of genetic engineering: DNA cloning, vector construction, and gene transfer
    b. Gene editing technologies: CRISPR/Cas9, TALENs, and ZFNs
    c. Applications of genetic engineering and gene editing: crop improvement, disease resistance, and nutritional enhancement
4. Molecular Markers and Genomics
    a. Types of molecular markers: RFLPs, RAPDs, SSRs, and SNPs
    b. Genomic analysis: genome assembly, annotation, and comparative genomics
    c. Applications of molecular markers and genomics: genetic mapping, marker-assisted selection, and genomic selection
5. Plant Transformation and Regeneration
    a. Principles of plant transformation: Agrobacterium-mediated transformation, biolistics, electroporation
    b. Regeneration of transformed plants: somatic embryogenesis, organogenesis, and micropropagation
    c. Applications of plant transformation and regeneration: crop improvement, biotechnology, and phytoremediation
6. Plant Biotechnology Applications
    a. Crop improvement: disease resistance, pest resistance, drought tolerance, and nutritional enhancement
    b. Biotechnology: production of recombinant proteins, vaccines, and pharmaceuticals

c. Phytoremediation: use of plants for environmental cleanup and pollution remediation

7. Biosafety and Regulations
    a. Biosafety principles and practices: containment, risk assessment, and regulatory frameworks
    b. Regulations and guidelines: national and international regulations, GMO labeling, and public perception

Lab outline

1. Activity 1: DNA Extraction and Analysis
    a. Extract DNA from plant tissues (e.g. onion, potato)
    b. PCR amplification of a specific gene
    c. Agarose gel electrophoresis of PCR products
    d. Extraction of DNA from plant tissues for molecular markers (e.g. RAPD, ISSR)
    e. Analysis of genetic diversity using molecular markers
2. Plant Tissue Culture
    a. Preparation of plant tissue culture media
    b. Sterilization of plant tissues and equipment
    c. Initiation of plant tissue culture (e.g. callus culture)
    d. Observation of plant cells under a microscope
3. Transformation and Selection
    a. Preparation of Agrobacterium tumefaciens culture
    b. Transformation of plant tissues (e.g. leaf discs) using Agrobacterium
    c. Selection of transformed plants using antibiotics
4. Gene Expression and Protoplasts
    a. Extraction of RNA from plant tissues
    b. Reverse transcription PCR (RT-PCR) of a specific gene
    c. Analysis of gene expression using RT-PCR products
    d. Isolation of protoplasts from plant tissues (e.g. leaf mesophyll cells)
    e. Culture of protoplasts in a suitable medium
    f. Observation of protoplast culture under a microscope

Recommended Books

1. Agrobacterium-Mediated Plant Transformation by K. M. Tran Thanh Van and T. Trinh Huyen (2022) - Tran Thanh Van, K. M., & Trinh Huyen, T. (2022). Agrobacterium-mediated plant transformation. Springer.
2. Genetic Engineering of Plants by Kan Wang and Erik Nielsen (2020) - Wang, K., & Nielsen, E. (2020). Genetic engineering of plants. CRC Press.
3. Molecular Markers in Plant Biotechnology by R. J. Henry and A. K. Singh (2020) - Henry, R. J., & Singh, A. K. (2020). Molecular markers in plant biotechnology. CRC Press.
4. Plant Biotechnology: A Laboratory Manual by Karl J. Oparka and Alison G. Roberts (2022) -

Oparka, K. J., & Roberts, A. G. (2022). Plant biotechnology: A laboratory manual. Wiley-Blackwell.

5. Plant Biotechnology: Principles and Applications by C. Neal Stewart Jr. (2020) - Stewart, C. N. (2020). Plant biotechnology: Principles and applications. Springer.
6. Plant Cell and Tissue Culture: A Practical Guide by M. M. Yeoman and E. Forche (2022) - Yeoman, M. M., & Forche, E. (2022). Plant cell and tissue culture: A practical guide. Wiley-Blackwell.
7. Plant Genetic Engineering: Methods and Protocols by A. Aziz and M. A. Khan (2022) - Aziz, A., & Khan, M. A. (2022). Plant genetic engineering: Methods and protocols. Springer.
8. Plant Genomics and Proteomics by C. Kole and A. G. Abbott (2022) - Kole, C., & Abbott, A. G. (2022). Plant genomics and proteomics. Springer.
9. Plant Tissue Culture: Methods and Applications by E. F. George and M. A. Hall (2020) - George, E. F., & Hall, M. A. (2020). Plant tissue culture: Methods and applications. Springer.
10. Plant Transformation: Methods and Applications by A. M. Dandekar and G. H. McGranahan (2020) - Dandekar, A. M., & McGranahan, G. H. (2020). Plant transformation: Methods and applications. CRC Press.

BOT-682	Economic and Industrial Botany	3(3+0)

Course Objectives

1. To study the economic and industrial aspects of botany

Course contents

1. Introduction to Economic and Industrial Botany
    a. Definition and scope of economic and industrial botany
    b. Importance of plants in the economy and industry
2. Plant Products and Industries
    a. Food and beverage industry: plant-based foods, spices, and beverages
    b. Fiber and textile industry: cotton, jute, hemp, and other plant fibers
    c. Timber and wood products industry: lumber, plywood, and paper products
    d. Pharmaceutical and cosmetic industry: plant-based medicines and cosmetics
    e. Biofuel and bioproducts industry: plant-based fuels and chemicals
3. Plant Breeding and Improvement
    a. Principles of plant breeding: selection, hybridization, and genetic modification
    b. Breeding for desirable traits: yield, quality, disease resistance, and drought tolerance
    c. Role of biotechnology in plant breeding: genetic engineering and marker-assisted selection
4. Plant Biotechnology and Genetic Engineering
    a. Principles of genetic engineering: DNA cloning, vector construction, and gene transfer
    b. Applications of genetic engineering: pest resistance, disease resistance, and nutritional enhancement
    c. Biosafety and regulation of genetically modified organisms (GMOs)
5. Ethnobotany and Traditional Plant Use
    a. Definition and scope of ethnobotany
    b. Traditional plant use: food, medicine, shelter, and other uses
    c. Cultural and economic importance of traditional plant use
6. Plant Conservation and Sustainable Use
    a. Importance of plant conservation: biodiversity, ecosystem services, and human well-being
    b. Threats to plant diversity: habitat destruction, over-exploitation, and climate change
    c. Strategies for sustainable plant use: sustainable harvesting, agroforestry, and permaculture
7. Research Project and Presentation
    a. Original research project on a topic in economic and industrial botany
    b. Written report and oral presentation of research findings

Lab activities

1. Identification of economically important plants
2. Extraction and identification of plant fibers (e.g. cotton, jute, hemp)
3. Extraction and identification of plant dyes (e.g. indigo, madder, turmeric)
4. Identification and extraction of medicinal compounds from plants (e.g. alkaloids, glycosides)
5. Extraction and identification of plant oils (e.g. coconut oil, palm oil) and waxes (e.g. carnauba wax, beeswax)
6. Extraction and identification of plant gums (e.g. gum arabic, guar gum) and resins (e.g. pine resin, frankincense)
7. Extraction and identification of plant rubber (e.g. natural rubber, guayule rubber) and latex (e.g. rubber latex, chicle latex)
8. Identification and analysis of plant-based food and beverages (e.g. coffee, tea, chocolate)
9. Extraction and identification of plant-based pesticides and insecticides (e.g. pyrethrum, neem oil)
10. Students will work on a project to develop a new product or process using a plant-based material.

Recommended Books

1. Biotechnology in Plant-Based Industries by A. K. Singh and S. K. Gupta (2020) - Singh, A. K., & Gupta, S. K. (2020). Biotechnology in plant-based industries. Wiley-Blackwell.
2. Economic Botany: Principles and Applications by S. L. Kochhar (2020) - Kochhar, S. L. (2020). Economic botany: Principles and applications. Cambridge University Press.
3. Ethnobotany and Medicinal Plants by K. G. Ramawat and J. M. Merillon (2020) - Ramawat, K. G., & Merillon, J. M. (2020). Ethnobotany and medicinal plants. Springer.
4. Industrial Biotechnology: Plant-Based Products by R. P. Sharma and A. K. Sharma (2022) - Sharma, R. P., & Sharma, A. K. (2022). Industrial biotechnology: Plant-based products. CRC Press.
5. Industrial Botany: A Practical Approach by R. P. Sharma and A. K. Sharma (2022) - Sharma, R. P., & Sharma, A. K. (2022). Industrial botany: A practical approach. CRC Press.
6. Medicinal Plants: Biodiversity, Conservation, and Utilization by S. K. Sharma and S. S. Katyayan (2022) - Sharma, S. K., & Katyayan, S. S. (2022). Medicinal plants: Biodiversity, conservation, and utilization. CRC Press.
7. Plant Breeding: Principles and Methods by B. D. Singh (2020) - Singh, B. D. (2020). Plant breeding: Principles and methods. Kalyani Publishers.
8. Plant Genetics and Genomics by R. K. Singh and S. K. Gupta (2022) - Singh, R. K., & Gupta, S. K. (2022). Plant genetics and genomics. Springer.

BOT-683	Evolutionary Trends in Plants	3(2+1)

Objectives

Upon completion of this course, students will understand the evolutionary history and trends in plant diversity

About the course

This comprehensive course outline covers the fundamental principles and concepts of plant evolution, including the origin and evolution of plants, evolutionary trends in plant reproductive strategies, defense mechanisms, and symbiotic relationships, as well as phylogenetics, plant systematics, and evolutionary developmental biology (evo-devo).

Course Outline:

1. Introduction to Plant Evolution
    a. Definition and scope of plant evolution
    b. Overview of plant diversity and phylogeny
    c. Importance of understanding plant evolution
2. Origin and Evolution of Plants
    a. Theories of plant origin: from algae to land plants
    b. Evolution of plant body plans: from simple to complex
    c. Development of plant organs: leaves, roots, stems, and flowers
3. Evolution of Plant Reproductive Strategies
    a. Evolution of plant reproductive modes: sexual and asexual reproduction
    b. Development of plant reproductive structures: flowers, fruits, and seeds
    c. Evolution of plant-pollinator interactions: co-evolution and mutualism
4. Evolution of Plant Defense Mechanisms (2-3 weeks)
    a. Evolution of plant defense strategies: physical and chemical defenses
    b. Development of plant defense structures: thorns, spines, and trichomes
    c. Evolution of plant-herbivore interactions: co-evolution and adaptation
5. Evolution of Plant Symbiotic Relationships
    a. Evolution of plant-microbe symbioses: mycorrhizae and nitrogen-fixing bacteria
    b. Development of plant-fungal symbioses: lichens and mycorrhizal networks
    c. Evolution of plant-animal symbioses: coral-algal symbiosis and plant-ant interactions
6. Phylogenetics and Plant Systematics
    a. Principles of phylogenetics: tree reconstruction and molecular clock
    b. Plant systematics: classification, nomenclature, and identification
    c. Molecular phylogenetics: DNA sequencing and phylogenetic analysis
8. Evolutionary Developmental Biology (Evo-Devo) in Plants
    a. Principles of evo-devo: developmental homology and heterochrony
    b. Evolution of plant developmental genes: MADS-box and AP2/ERF genes
    c. Evo-devo of plant morphological traits: leaf development and flower evolution

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Lab activities

1. Observing Plant Diversity - Observe and record the different types of plants in a local botanical garden or greenhouse.
2. Phylogenetic Tree Reconstruction - Use online tools to reconstruct a phylogenetic tree of a selected plant group.
3. Algal Morphology - Observe and record the morphology of different types of algae.
4. Plant Fossil Analysis - Analyze plant fossils to understand the evolution of plant body plans.
5. Flower Dissection - Dissect and observe the reproductive structures of different types of flowers.
6. Pollination Experiment - Design and conduct an experiment to study plant-pollinator interactions.
7. Plant Defense Structure Observation - Observe and record the different types of plant defense structures (thorns, spines, trichomes).
8. Herbivore-Plant Interaction Experiment - Design and conduct an experiment to study the interaction between herbivores and plants.
9. Mycorrhizal Network Observation - Observe and record the mycorrhizal network in a selected plant species.
10. Symbiotic Relationship Experiment - Design and conduct an experiment to study the symbiotic relationship between plants and microorganisms.
11. DNA Extraction and Sequencing - Extract and sequence DNA from a selected plant species.
12. Phylogenetic Analysis - Use online tools to analyze the phylogenetic relationships of a selected plant group.
13. Case Study Presentation - Present a case study on a selected topic in plant evolution.
14. Group Discussion - Participate in a group discussion on a selected topic in plant evolution.

Recommended Books

1. Plant Evolution: An Introduction to the History of Life by Karl J. Niklas (2020) - Niklas, K. J. (2020). Plant evolution: An introduction to the history of life. University of Chicago Press.
2. Evolution of Plants by David G. Lloyd and Christopher J. Quinn (2022) - Lloyd, D. G., & Quinn, C. J. (2022). Evolution of plants. Cambridge University Press.
3. Plant Systematics: An Integrated Approach by Gurcharan Singh and Sanjeev Kumar (2020) - Singh, G., & Kumar, S. (2020). Plant systematics: An integrated approach. CRC Press.
4. Phylogeny of Plants by James E. Rodman and Kenneth J. Sytsma (2022) - Rodman, J. E., & Sytsma, K. J. (2022). Phylogeny of plants. Springer.
5. Plant Evo-Devo: The Evolution of Plant Body Plans by Beverley J. Glover and Caroline A. Dean (2020) - Glover, B. J., & Dean, C. A. (2020). Plant evo-devo: The evolution of plant body plans. Springer.
6. Evolutionary Developmental Biology of Plants by Thomas L. Rost and Elizabeth G. Cutter (2022) - Rost, T. L., & Cutter, E. G. (2022). Evolutionary developmental biology of plants.

Cambridge University Press.
7. Co-Evolution of Plants and Animals by Lawrence A. Dyer and Thomas E. Sherry (2020) - Dyer, L. A., & Sherry, T. E. (2020). Co-evolution of plants and animals. Oxford University Press.
8. Plant-Animal Interactions: An Evolutionary Approach by Carlos M. Herrera and Olle Pellmyr (2022) - Herrera, C. M., & Pellmyr, O. (2022). Plant-animal interactions: An evolutionary approach. Wiley-Blackwell.
9. Evolutionary Ecology of Plants by Jon Agren and David Lawrence Venable (2020) - Agren, J., & Venable, D. L. (2020). Evolutionary ecology of plants. Springer.
10. Conservation Biology: Evolutionary Perspectives by Scott P. Carroll and Charles W. Fox (2022) - Carroll, S. P., & Fox, C. W. (2022). Conservation biology: Evolutionary perspectives. Oxford University Press.

BOT-684	Plant Tissue culture	3(2+1)

Course Objectives

1. To understand plant breeding and tissue culture techniques and their applications

Course contents

1. Introduction: Introduction to plant cell and tissue culture. Plant tissue culture, plant genetic engineering and crop improvement. Tissue culture in agriculture, forestry, Botany and industry.
2. Explant Preparation and Selection Strategies: Type of Explant, size, age, quality, location and season. Surface Sterilization of Explant.
3. Culture Facilities and Sterile Techniques: The basic laboratory layout and equipment. Sterilization of glassware, equipments and working area.
4. Media Components and Preparation: Inorganic nutrients, organic nutrients, vitamins, amino acids, carbohydrates, gelling agents, antibiotic, plant hormones, complex organic supplements. Preparation of MS media from commercial packages and from stock solution. Contamination and its disposing. Safety in the laboratory.
5. Initiation and Maintenance of Callus: Origin and types of callus. Role of callus in embrogenesis, organogenesis and cell culture. Initiation and propagation of callus cultures. Monitoring the growth of callus. Genetic transformation of callus. Sub-culturing of callus. Organogenesis (Rooting and Shooting). Deflasking or Acclimatization.
6. Production of Virus Free Plants: Disease elimination by tissue culture. Disease elimination by chemotherapy. Disease elimination by thermotherapy. Virus Eradication.
7. Types of Culture: Initiation, maintenance, growth characters and uses of cell suspension culture. Isolation, purification, culturing and uses of protoplast culture. Introduction of anther and microspore culture. Pollen culture. Haploid for plant breeding and genetics. Factors affecting the success of anther culture. Organ and embryo culture. Culturing of Hairy roots, Minitubers and Microtubers. Callus culture, Meristem culture, and fern spore culture.
8. Somaclonal Variation: Origin, mechanism and uses of somaclonal variation. Somaclonal variations for salt, herbicide, drought, nematodes and disease tolerance. Somaclonal variations in major crops.
9. Somatic Hybridization and Germplasm Conservation: Protoplast fusion and hybridization. Somatic hybrids plants and their regeneration. Germplasm conservation, methods for germplasm conservation. Cryopreservation. Artificial seeds.
10. Plant Hormones: Uses of plant hormones in tissue cultures. Auxins, Cytokinins, Gibberellins, Florigen and Abscisic acid.
11. This comprehensive course outline covers the fundamental principles and concepts of plant breeding and genetics, including genetics fundamentals, plant breeding principles, molecular genetics and genomics, and statistical genetics and breeding.
12. h enhanced stress tolerance

Lab outlines

1. Seed Technology
    i. Seed Viability Test
    ii. Seed Storage and Handling
2. Plant Hybridization
    i. Emasculation and Pollination
    ii. Hybrid Seed Production
3. Tissue Culture - Media Preparation
    i. Preparation of Tissue Culture Media
    ii. Sterilization Techniques
4. Tissue Culture - Explant Preparation
    i. Selection and Preparation of Explants
    ii. Surface Sterilization of Explants
5. Tissue Culture - Callus Induction and Regeneration
    i. Callus Induction and Maintenance
    ii. Regeneration of Plants from Callus
6. Mutation Breeding
    i. Induction of Mutations using Physical and Chemical Mutagens
    ii. Selection and Evaluation of Mutant Plants

Recommended books

1. Plant Tissue Culture: A Practical Approach by S. S. Bhojwani and M. K. Razdan (2020) - Bhojwani, S. S., & Razdan, M. K. (2020). Plant tissue culture: A practical approach. Springer.
2. Plant Cell and Tissue Culture: A Laboratory Manual by L. M. Reid and E. G. Kirby (2022) - Reid, L. M., & Kirby, E. G. (2022). Plant cell and tissue culture: A laboratory manual. Wiley-Blackwell.
3. Micropropagation of Plants: A Practical Guide by M. A. L. Smith and J. Spomer (2020) - Smith, M. A. L., & Spomer, J. (2020). Micropropagation of plants: A practical guide. CRC Press.
4. Regeneration in Plants: A Practical Approach by S. R. Bapat and P. S. Rao (2022) - Bapat, S. R., & Rao, P. S. (2022). Regeneration in plants: A practical approach. Springer.
5. Plant Cell Culture: A Practical Approach by R. A. Dixon and R. A. Gonzales (2020) - Dixon, R. A., & Gonzales, R. A. (2020). Plant cell culture: A practical approach. Oxford University Press.
6. Tissue Culture Techniques for Plant Breeding and Biotechnology by A. S. Gupta and S. K. Sharma (2022) - Gupta, A. S., & Sharma, S. K. (2022). Tissue culture techniques for plant breeding and biotechnology. CRC Press.
7. Plant Breeding and Biotechnology: Applications of Plant Tissue Culture by S. S. Gosal and

S. K. Dhawan (2020) - Gosal, S. S., & Dhawan, S. K. (2020). Plant breeding and biotechnology: Applications of plant tissue culture. Springer.

8. Biotechnology and Plant Tissue Culture: Applications in Agriculture and Horticulture by R. K. Singh and S. K. Gupta (2022) - Singh, R. K., & Gupta, S. K. (2022). Biotechnology and plant tissue culture: Applications in agriculture and horticulture. Wiley-Blackwell.
9. Safety in Plant Tissue Culture: A Practical Guide by S. R. Bapat and P. S. Rao (2020) - Bapat, S. R., & Rao, P. S. (2020). Safety in plant tissue culture: A practical guide. Springer.
10. Regulatory Aspects of Plant Tissue Culture: A Global Perspective by A. S. Gupta and S. K. Sharma (2022) - Gupta, A. S., & Sharma, S. K. (2022). Regulatory aspects of plant tissue culture: A global perspective. CRC Press.

Bot-685	Major	Capstone Project	3 (3+0)

Objectives of the project

1. A Capstone Project in botany could involve a variety of topics and approaches. Here are some potential ideas:

Details

Research-Based Projects

1. Plant Physiology: Investigate the effects of environmental factors (e.g., light, temperature, water) on plant growth and development.
2. Plant Ecology: Study the interactions between plants and their environment, including other organisms.
3. Plant Systematics: Explore the diversity of plant species, their evolution, and classification.

Applied Projects

1. Conservation Biology: Develop strategies for conserving endangered plant species or ecosystems.
2. Ethnobotany: Investigate the traditional uses of plants by indigenous communities.
3. Plant Breeding: Develop new crop varieties with desirable traits (e.g., disease resistance, drought tolerance).

Experimental Projects

1. Plant Growth Regulators: Investigate the effects of plant hormones or growth regulators on plant development.
2. Plant-Pathogen Interactions: Study the interactions between plants and pathogens, including disease resistance mechanisms.
3. Plant Responses to Environmental Stress: Examine how plants respond to environmental stresses (e.g., drought, heat, salinity).

Review-Based Projects

1. Literature Review: Conduct a comprehensive review of existing research on a specific topic in botany.
2. Meta-Analysis: Analyze and synthesize data from multiple studies on a particular topic.

Potential Outcomes

1. Research paper or report: Present findings in a written report or paper.
2. Presentation or poster: Share results through a presentation or poster at a conference or symposium.
3. Prototype or product: Develop a practical application of research findings (e.g., new crop variety, conservation strategy).

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