UNIVERSITY OF SARGODHA
OFFICE OF THE REGISTRAR
(ACAD BRANCH)

NOTIFICATION

On the recommendations of Academic Council made in its 22nd (3/2024) meeting held on 30.09.2024, the Syndicate in its 69th (1/2025) meeting held on 17.01.2025 has approved the revised curricula of the following academic programs for implementation w.e.f Fall 2024:

1.	M.Phil in Botany	**(Annex-'A')**
2.	Ph.D in Botany	**(Annex-'B')**

(WAQAR AHMAD)
Additional Registrar (General)

No. SU/Acad/25/330

Dated: 13.03.2025

Distribution:

- Chairman Department of Botany
- Controller of Examinations
- Director Academics

C.C:

- Dean, Faculty of Sciences
- Director, QEC
- Additional Registrar (Affiliation & Registration)
- Secretary to the Vice-Chancellor
- PA to Registrar
- Notification File

SCHEME OF STUDIES

MASTER OF PHILOSOPHY

IN BOTANY

(2024 & onwards)

DEPARTMENT OF BOTANY

UNIVERSITY OF SARGODHA

SARGODHA

Department of Botany
Chairman
University of Sargodha

Master of Philosophy in Botany

The MPhil Botany program aims to provide advanced knowledge and research skills in various areas of botany.

1. **Program Learning Objectives:**
   a. Advanced Knowledge: To impart in-depth knowledge in core areas of botany, including recent advancements in plant sciences.
   b. Research Proficiency: To develop students' ability to design, execute, and analyze scientific research in botany.
   c. Analytical Skills: To enhance the ability to use advanced analytical tools and techniques in botany.
   d. Specialization: To provide opportunities for students to specialize in areas such as molecular biology, environmental toxicology, or phytoremediation.
   e. Scientific Communication: To train students in effective scientific writing and presentation skills.
   f. Problem-Solving: To develop critical thinking and problem-solving skills applicable to real-world challenges in botany.
2. **Program Learning Outcomes:**
   a. Mastery of Core Concepts: Graduates will have a comprehensive understanding of advanced concepts in botany, including recent trends and developments.
   b. Research Competence: Graduates will be capable of conducting independent research, including formulating research questions, employing appropriate methodologies and analyzing data.
   c. Technical Expertise: Graduates will be proficient in using advanced analytical and molecular biology techniques relevant to botany.
   d. Specialized Knowledge: Graduates will have specialized knowledge in elective areas, allowing them to contribute to specific fields within botany, such as phytoremediation or plant physiology.
   e. Effective Communication: Graduates will be able to write scientific papers, reports, and theses, as well as present their research findings clearly and effectively.
   f. Ethical and Environmental Awareness: Graduates will be aware of the ethical considerations and environmental impacts of their work, particularly in areas like environmental toxicology and biosafety.

3. **Program Structure:**

Admission Requirements	MSc/BS 4-Year or equivalent (16 years of Education) in the relevant field or equivalent degree from HEC recognized institution with at least second Division or CGPA 2.00 out of 4.00.
Duration	02 Year Program (04 Semesters)
Degree Completion Requirements	Total Credit Hours of Course Work: 24-33 Total Credit Hours of Thesis: 06 Total Credit Hours of Program: 30-39

4. **List of Deficiency Courses**

Course Code	Name of courses	Credit Hours
BOTN-5101	Cell Biology	3 (2-1)
BOTN-5102	Diversity of Plants	3 (2-1)
BOTN-5103	Fundamentals of Plant Taxonomy	3 (2-1)
BOTN-5105	Fundamental of Genetics & Evolution	3 (2-1)
BOTN-5108	Plant Anatomy & Embryology	3 (2-1)
BOTN-5110	Principles of Plant Ecology	3 (2-1)
BOTN-5111	Principles of Plant Biochemistry	3 (2-1)
BOTN-5112	Fundamentals of Plant Physiology	3 (2-1)

*Student can take minimum two and maximum three deficient courses (if needed) after the recommendation of departmental post graduate committee

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5. List of Compulsory Core Courses

Course Code	Name of courses	Credit Hours
BOTN-7101	Advanced Analytical Tools in Botany	3 (1-2)
BOTN-7102	Recent Trends in Botany	3 (3-0)
BOTN-7103	Research Methodology & Scientific Writing	3 (3-0)

6. List of Elective Core Courses

Course Code	Name of courses	Credit Hours
BOTN-7104	Advanced Techniques in Molecular Biology	3(2-1)
BOTN-7105	Advanced Plant Physiology and Biochemistry	3(2-1)
BOTN-7106	Advances in Physiology and Molecular Biology of Plants	3(2-1)
BOTN-7107	Environmental Toxicology and Impact Assessment	3(2-1)
BOTN-7108	Phytochemistry	3(2-1)
BOTN-7109	Plant Signal Transduction	3(2-1)
BOTN-7110	Phytoremediation	3(2-1)

7. List of Elective Courses

Course Code	Name of courses	Credit Hours
BOTN-7111	Biosystematics	3(2-1)
BOTN-7112	Proteomics and Genomics	3(2-1)
BOTN-7113	Modern Molecular Biology	3(2-1)
BOTN-7114	Biotechnology for Sustainable Development	3(2-1)
BOTN-7115	Radiation Biology	3(2-1)
BOTN-7116	Plant Developmental Processes	3(2-1)
BOTN-7117	Biohazards and Biosafety	3(2-1)
BOTN-7118	Food Industrial Waste Management	3(2-1)
BOTN-7119	Plant Nutrition Management	3(2-1)
BOTN-7120	Recombinant DNA Technology	3(2-1)

8. Thesis:

BOTN-7121	Thesis	06

*M.Phil student can opt for courses offered in PhD classes or from other disciplines/ departments (if needed) after recommendation of Graduate Program Committee. However, if a student has already taken a specific course during their PhD studies, they will not be allowed to take the same subject again in the M.Phil program.

Scheme of Studies
Master of Philosophy in Botany

Scheme of Studies / Semester-wise workload

S/No	Code	Course	Credits	Category
Semester I				
1.	BOTN-7101	Advanced Analytical Tools in Botany	3 (1-2)	Core
2.	BOTN-7102	Recent Trends in Botany	3 (3-0)	Core
3.	BOTN–XXXX	Elective – I	3(2-1)	Elective
4.	BOTN–XXXX	Elective – II	3(2-1)	Elective
	Total credit 12			
Semester II				
1.	BOTN-7103	Research Methodology & Scientific Writing	3 (3-0)	Core
2.	BOTN –XXXX	Elective – III	3 (2-1)	Core
3.	BOTN –XXXX	Elective – IV	3(2-1)	Elective
4.	BOTN –XXXX	Elective – V	3(2-1)	Elective
	Total credit 12			
Semester III & IV				
S/No	**Code**	**Course**	**Credits**	**Category**
1.	BOTN-7121	Thesis	6	Research

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BOTN-7101	Advanced Analytical Tools in Botany	3 (1-2)

Course Brief:

This course offers a deep dive into advanced analytical tools and techniques used in botanical research, with a strong focus on laboratory applications. Students will master state-of-the-art methods for analyzing plant tissues, metabolites, and genetic material through extensive hands-on lab work. The curriculum includes high-resolution microscopy, sophisticated chromatographic and spectroscopic methods, and advanced molecular analysis tools. Emphasis is placed on practical skills, data interpretation, and the integration of these tools to address complex research questions in plant science. By the end of the course, students will be well-equipped to use cutting-edge technologies to advance their botanical research.

Course Learning Objectives:

By the end of this course, students will master advanced microscopy and chromatography techniques for detailed plant analysis, as well as gain expertise in next-generation sequencing and gene editing tools like CRISPR/Cas9. They will also learn to integrate data from multiple analytical methods to solve complex botanical research problems and deepen their understanding of plant biology.

Course Content:

1. Advanced Microscopy Techniques, Utilization of confocal and super-resolution microscopy to examine plant cellular structures and dynamics at high resolution. , Introduction to Liquid chromatography (HPLC) and ultra-performance liquid chromatography (UPLC) for detailed metabolite analysis.
2. Application of mass spectrometry (MS), nuclear magnetic resonance (NMR), and Fourier-transform infrared spectroscopy (FTIR) to identify and quantify plant compounds.
3. Techniques for next-generation sequencing (NGS) to perform comprehensive genomic and transcriptomic analysis.
4. CRISPR/Cas9 for gene editing, and RNA-Seq and ChIP-Seq for studying gene expression and DNA-protein interactions.
5. Combining data from various analytical techniques to gain comprehensive insights into plant biology, Application of integrated data approaches to solve complex botanical research questions and enhance experimental outcomes.

Lab Outline:

1. Preparing and imaging samples to study 3D structures of plant tissues at high resolution, including advanced techniques like fluorescence resonance energy transfer (FRET) for studying
2. Applying techniques such as STORM (Stochastic Optical Reconstruction Microscopy) or PALM (Photoactivated Localization Microscopy) to resolve structures at the nanoscale level.
3. Performing quantitative image analysis to measure cellular and subcellular structures.
4. Using live-cell imaging to monitor dynamic processes such as cell division, intracellular trafficking, and organelle function.
5. HPLC and UPLC (Ultra-Performance Liquid Chromatography): Separating complex mixtures of plant metabolites with high resolution and sensitivity.
6. GC-MS (Gas Chromatography-Mass Spectrometry): Identifying and quantifying volatile compounds in plant samples.
7. NMR Spectroscopy: Using 1D and 2D NMR techniques for detailed structural characterization of plant metabolites and proteins.
8. Mass Spectrometry: Employing high-resolution MS and MS/MS (Tandem Mass Spectrometry) for comprehensive analysis of plant metabolomes and proteomes.
9. Performing whole-genome, transcriptome, or exome sequencing to analyze plant genetic variations and gene expression profiles.
10. Using bioinformatics tools for data analysis, including sequence alignment, variant calling, and functional annotation.
11. CRISPR/Cas9 Gene Editing: Designing and conducting experiments to introduce specific genetic modifications and study their phenotypic effects.
12. RNA-Seq and ChIP-Seq: Analyzing gene expression and DNA-protein interactions using RNA sequencing and Chromatin Immunoprecipitation Sequencing.

Recommended Texts:

1. Barrangou, R. (2015). CRISPR-Cas Systems: RNA-mediated Adaptive Immunity in Bacteria and Archaea. *Science*, 348(6230), 36-41. doi:10.1126/science.aad5140.
2. Balachandran, V., & Pennell, C. M. (Eds.). (2016). *Plant Systems Biology*. CRC Press.

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BOTN-7102	Recent Trends in botany	3 (3-0)

Course Brief:

This course offers an in-depth exploration of recent trends in botany, focusing on cutting-edge developments and innovations in the field. Students will investigate advancements in plant genetics, molecular biology, and ecological research, with a particular emphasis on emerging technologies and their applications. The course will cover topics such as plant genomics, synthetic biology, plant-microbe interactions, climate change impacts, and novel agricultural practices. Through lectures, case studies, and practical exercises, students will gain a comprehensive understanding of how contemporary research is shaping the future of botany and plant science.

Course Learning Objectives:

By completing this course, students will gain expertise in advanced plant genomics, gene editing techniques, and multi-omics strategies for exploring plant function and adaptation. They will delve into plant-microbe interactions, develop climate-resilient crops, and apply AI and precision agriculture for sustainable farming. This course provides students with state-of-the-art skills in plant science and biotechnology.

Course Content:

1. Advanced Plant Genomics and Systems Biology: Explore next-generation sequencing (NGS) and high-throughput genomics to integrate genomic, transcriptomic, and proteomic data, and develop multi-omics strategies for understanding plant functions and adaptations.
2. Innovations in Synthetic Biology and Genetic Engineering: Examine cutting-edge CRISPR/Cas9 and other gene editing technologies, design synthetic gene circuits and pathways, and advance metabolic engineering to create novel plant products.
3. Plant-Microbe Interactions and Metagenomics: Investigate the role of plant-associated microbiomes in health and productivity using metagenomics and high-throughput sequencing, and develop biotechnological solutions to enhance plant-microbe interactions.
4. Climate Change Adaptation and Resilience Engineering: Focus on genomic and phenotypic selection for climate-resilient crops, conduct high-throughput phenotyping and stress response analysis, and apply precision agriculture and remote sensing for climate adaptation.
5. Next-Generation Agricultural Technologies and Sustainability: Integrate artificial intelligence (AI) and machine learning into plant science and agriculture, innovate in crop modeling, precision irrigation, and nutrient management. and explore sustainable farming practices for resource-efficient agriculture.

Recommended Texts :

1. Lipper, L., McCarthy, N., Zougmore, R., & Cramer, L. (Eds.). (2018). *Climate smart agriculture: Building resilience to climate change*.
2. Silvestri, L. (Ed.). (2021). *Artificial Intelligence in Agriculture*. Springer.

Suggested Readings :

1. Edwards, D. (Ed.). (2017). *Plant genomics and systems biology*. CRC Press.

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BOTN-7103	Research Methodology & Scientific Writing	3 (3-0)

Course Brief:

This course provides an in-depth understanding of scientific research methodology, guiding students through the entire research process from problem formulation to report writing. Students will learn the definition and methods of scientific research, starting with the creation of a well-written research proposal that addresses ethical considerations. The course covers the execution of research, including data collection, processing, analysis, and presentation, culminating in the preparation of a comprehensive and publishable research report. This course is designed to equip students, particularly those writing their thesis or entering scientific fields, with the skills necessary to conduct rigorous research and understand the scientific discoveries that impact our lives.

Course Learning Objectives :

By the end of this course, students will master the essential steps of scientific research, from formulating research problems to designing studies and analyzing data. They will develop skills in ethical research practices, effective proposal writing, and clear presentation of research findings. Additionally, students will learn to produce publishable research reports.

Course Content:

1. Definition of Scientific Research, Types and Methods of Scientific Research, Steps and Criteria of Scientific Research, Ethics in Scientific Research
2. Preparing for Your Research Project, Formulating the Research Problem, Designing the Research, Selecting Appropriate Samples, Writing a Convincing Research Proposal
3. Conducting and Reporting Research. Data Collection Techniques, Data Processing and Analysis, Presenting Research Findings, Writing a Publishable Research Report

Recommended Texts:

1. Leedy, P. & Ormrod, J.A., (2019). Practical research: planning and design (12th Ed.). New York: Pearson Publishers.
2. Creswell, J. & Creswell, D., (2018). Research design: qualitative, quantitative, and mixed methods approach (5th Ed.). New York: SAGE Publishers.

Suggested Readings:

1. Merriam, S. & Tisdell, E., (2015). Qualitative research: a guide to design and implementation (4th Ed.). New Jersey: John Wiley & Sons Incorporation.
2. Booth, W., Colomb, G., Williams, J. Bizup, J. & Gerald, W.F., (2016). The Crafts of Research (4th Ed.). Chicago: University of Chicago Press.
3. Flick, U., (2017). Introducing research methodology: a beginner's guide to doing a research project (1st Ed.). New York: SAGE Publishers.

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BOTN-7104	Advanced Techniques in Molecular Biology	3(2-1)

Course Brief:

This course introduces students to recombination of genetic material at molecular levels with emphasis on recombinant DNA technology, genomics; cloning strategies nucleic acid hybridization transgenic proteins, organisms and gene therapies. It will provide an insight into analysis of gene structure and expression in prokaryotes and eukaryotes, human genome project. gene identification, databases, sequence analysis, gene annotation, detecting open reading frames, software programs for finding genes, using homology to finding genes, phylogenetic trees and genome evaluation. It covers the applications of recombinant DNA technology which include production of transgenic proteins, transgenic organisms and gene therapies and genetic markers such as random amplified polymorphic DNA (RAPD), microsatellite /SSR, restriction fragment length polymorphism (RFLP), amplified fragment length polymorphism (AFLP).Students will be able to know about molecular basis of gene genetic and physical mapping of gene, deactivating the function of specific genes in prokaryotes (E. coli), eukaryotes (Arabidopsis thaliana and yeast).

Course Learning Objectives:

By the end of this course, students will have a comprehensive understanding of the molecular mechanisms underlying genetic recombination and the applications of recombinant DNA technology. They will gain practical skills in gene analysis, including identification, annotation, and expression profiling in both prokaryotes and eukaryotes, with a focus on model organisms such as *E. coli* and *Arabidopsis thaliana*. Additionally, students will be proficient in using bioinformatics tools for genome evaluation, constructing phylogenetic trees, and applying various genetic markers like RAPD, SSR, RFLP, and AFLP. They will also explore the production and application of transgenic proteins and organisms, as well as gene therapies, equipping them with the knowledge to deactivate specific genes and map genetic and physical gene locations.

Course Content:

1. Introduction, prokaryotic, eukaryotic and organellar genomes, genome sizes, introns and exons, methods of preparing genomic DNA.
2. Outline of DNA cloning methods, cloning vectors including plasmids, bacteriophages, cosmids and expression vectors, gene splicing, chromosome walking, development of gene libraries, gene sequencing, potentials of recombinant DNA technology
3. Introduction to DNA amplification and polymerase chain reaction (PCR). Gel electrophoresis of DNA, pulse-field agarose gel electrophoresis, southern blotting, northern and western blotting, in situ hybridization, DNA microarray.
4. Molecular definition of a gene, Analysis of gene structure and expression, genetic and physical mapping of gene, deactivating the function of specific genes in eukaryotes, prokaryotes (E. coli), eukaryotes (Arabidopsis thaliana and yeast) and Human genome project. Gene identification, databases, sequence analysis, gene annotation, detecting open reading frames, software programs for finding genes, using homology to finding genes, human genome project, genome evaluation.
5. Transgenic Proteins, Organisms and Gene Therapies.
6. Production of transgenic proteins, transgenic organisms and gene therapies, random amplified polymorphic DNA (RAPD), microsatellite /SSR, restriction fragment length polymorphism (RFLP), amplified fragment length polymorphism (AFLP).

Lab Outline:

1. Centrifugation techniques, Plasmid DNA isolation from bacterial cells
2. Isolation of genomic DNA from plant tissues, DNA amplification (PCR), agarose gel electrophoresis of isolated DNA, Restriction enzyme digestion of plasmid DNA

Recommended Texts:

1. David, N. & Cox, M. (2017). Lehninger: principles of biochemistry. New York: W.H. Freeman Macmillan Learning.
2. Lodish, H., Berk, A., Kaiser, C., Krieger, M. & Bretscher, A. (2016).Molecular cell biology. (8th Ed.).New York: W.H. Freeman-Macmillan Learning.

Suggested Readings:

1. Venkat, B., Sahijram, R. & Murthy, K. (2015).Plant biology and biotechnology. Berlin: SpringerVerlag.
2. Clark, D., Pazdernik, N. & McGehee, M. (2019).Molecular biology. Amsterdam: Elsevier.

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BOTN-7105	Advanced Plant Physiology and Biochemistry	3(2-1)

Course Brief:
Plants are immobile in nature; they want to fulfill all their requirements of their life without moving from one place to another place. This course examines life process of plants such as signal transduction; different types of hormones their synthesis, mode of action and beneficial effects. It also gives information about mechanisms and different forces involve in uptake of water, role of water potential, minerals nutrition, their physiological role and deficiency symptoms in plants. Students will study photoperiodism, vernalization and assimilation of nutrients. The course elucidates the structure and role of primary and secondary metabolites in plants. Students will have insight into stress physiology, plant responses and stress tolerance mechanisms towards extreme conditions such as water deficit and drought, salinity, metal toxicity, freezing and heat stress and oxidative stress.

Course Learning Objectives:
This course explores the intricate life processes of plants, focusing on their ability to meet all their needs without mobility. Students will delve into signal transduction pathways and the synthesis, mode of action, and effects of various plant hormones. The course also covers essential mechanisms such as water uptake, the role of water potential, mineral nutrition, and their physiological roles and deficiency symptoms. Additionally, students will study photoperiodism, vernalization, and nutrient assimilation. The course provides insights into the structure and function of primary and secondary metabolites, as well as plant stress physiology, examining how plants respond to and tolerate extreme conditions like drought, salinity, metal toxicity, and temperature extremes.

Course Content:

1. Plant Metabolism: Amino Acid Metabolism: Amino acid biosynthesis, shikimic acid pathway, degradation of amino acids.
2. Regulation of carbohydrate metabolism. Regulatory enzymes and metabolites in different pathways like respiration.
3. Metabolism of secondary metabolites of plants, their biosynthesis, distribution and functions 4. Coumarins and lignins: Structure and chemistry, distribution and function.
4. Signal transduction: specific signaling mechanisms, e.g. two-component sensor-regulator system in bacteria and plants, sucrose-sensing mechanism.
5. Stress physiology: Plant responses to biotic and abiotic stress, mechanisms of biotic and abiotic stress tolerance, HR and SAR, water deficit and drought resistance, salinity stress, metal toxicity, freezing and heat stress, oxidative stress.
6. Cell Walls Structure, Biogenesis and Expansion: The cell wall polysaccharides: Structure and biosynthesis. Biosynthesis of non-starch storage polysaccharides. 8. Plant Growth Regulators – A brief idea about discovery, role and possible mechanism of action of Triacontanol, Brassins, Salicylic acid, Jasmonates and Polyamines.

Lab Outline :

1. Separation of Photosynthetic pigments using paper and column chromatography
2. Estimation of chlorophyll by OMSO Method, Calculation of iodine number. acid value, saponification value, Estimation of total carotene and xanthophylls.
3. Separation of Anthocyanin pigment by paper and thin layer chromatography.
4. Estimation of total nitrogen by kjeldahl Method, Separation of different phenolic compounds
5. Effect of A A on elongation growth of maize coleoptile.

Recommended Texts:

1. Taiz, L. & Zeiger, E. (2019).Plant physiology. 7th Edition. Sunderland Massachusetts: Sinnauers Publ. Co. Inc.
2. Taiz, L. & Zeiger, E. (2018). Fundamental of Plant Physiology. Sunderland Massachusetts: Sinnauers Publ. Co. Inc.

Suggested Readings:

1. Nelson D. & Cox, M. (2017). Lehningers principle of Biochemistry. (7th Ed.). New York: W.H Freeman.
2. Dennis, D.T., Turpin, D.H., Lefebvre, D.D. & Layzell, D.B. (2016). Plant metabolism. (6th Ed.). London: Longman Group.

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BOTN-7106	Advances in Physiology and Molecular Biology of Plants	3(2-1)

Course Brief:

Plants are immobile in nature; they want to fulfill all their requirements of their life without moving from one place to another place. This course examines life process of plants such as signal transduction; different types of hormones their synthesis, mode of action and beneficial effects. It also gives information about mechanism and different forces involve in uptake of water, role of water potential, minerals nutrition, their physiological role and deficiency symptoms in plants. Students will study photoperiodism, vernalization and assimilation of nutrients. The course elucidates the structure and role of primary and secondary metabolites in plants. Students will have insight into stress physiology, plant responses and stress tolerance mechanisms towards extreme conditions such as water deficit and drought, salinity, metal toxicity, freezing and heat stress and oxidative stress.

Course Learning Objectives:

This course explores key aspects of plant metabolism and stress physiology, covering amino acid and carbohydrate metabolism, secondary metabolites, and signaling mechanisms. Students will examine plant responses to biotic and abiotic stress, focusing on tolerance strategies and growth regulators like salicylic acid and jasmonates. The structure and biosynthesis of cell wall polysaccharides will also be studied. Overall, the course provides insights into how plants regulate metabolic processes and adapt to environmental challenges.

Course Content:

1. Plant Metabolism: Amino Acid Metabolism: Amino acid biosynthesis, shikimic acid pathway, degradation of amino acids.
2. Regulation of carbohydrate metabolism. Regulatory enzymes and metabolites in different pathways like respiration.
3. Metabolism of secondary metabolites of plants, their biosynthesis, distribution and functions Coumarins and lignins: Structure and chemistry, distribution and function.
4. Signal transduction: specific signaling mechanisms, e.g. two-component sensor-regulator system in bacteria and plants, sucrose-sensing mechanism.
5. Stress physiology: Plant responses to biotic and abiotic stress, mechanisms of biotic and abiotic stress tolerance, HR and SAR, water deficit and drought resistance, salinity stress, metal toxicity, freezing and heat stress, oxidative stress.
6. Cell Walls Structure, Biogenesis and Expansion: The cell wall polysaccharides: Structure and biosynthesis. Biosynthesis of non-starch storage polysaccharides. 8. Plant Growth Regulators – A brief idea about discovery, role and possible mechanism of action of Triacontanol, Brassins, Salicylic acid, Jasmonates and Polyamines

Lab Outline :

1. Separation of Photosynthetic pigments using paper and column chromatography
2. Estimation of chlorophyll by OMSO Method, Calculation of iodine number, acid value, saponification value, Estimation of total carotene and xanthophylls.
3. Separation of Anthocyanin pigment by paper and thin layer chromatography.
4. Estimation of total nitrogen by kjeldahl Method, Separation of different phenolic compounds
5. Effect of A A on elongation growth of maize coleoptile.

Recommended Texts:

1. Taiz, L. & Zeiger, E. (2019).Plant physiology.7th Edition. Sunderland Massachusetts: Sinnauers Publ. Co. Inc.
2. Taiz, L. & Zeiger, E. (2018). Fundamental of Plant Physiology. Sunderland Massachusetts: Sinnauers Publ. Co. Inc.

Suggested Readings:

1. Nelson D. & Cox, M. (2017). Lehningers principle of Biochemisry. (7th Ed.). New York: W.H Freeman.
2. Dennis, D.T., Turpin, D.H., Lefebvre, D.D. & Layzell, D.B. (2016). Plant metabolism. (6th Ed.). London: Longman Group.

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BOTN-7107	Environmental Toxicology and Impact Assessment	3(2-1)

Course Brief:

This course provide updated information on introduction and history of environmental toxicology, types of environmental toxicology and effects of toxins to environment, ecological risk assessment and sustainable environmental management by utilization of algae and plants, treatment technologies which include traditional and modern microbial techniques especially biodegradation and phytoremediation. Students will come to know how plants become helpful to remove toxic contaminants from polluted soils by using their organs, plant roots absorb the contaminants along with other nutrients and water. This method is used primarily for wastes containing metals, the metals are stored in the plants aerial shoots, which are harvested or disposed of as a hazardous waste. Rhizofiltration is similar to phytoextraction, plants used for cleanup are raised in greenhouses with their roots in water, and roots saturated with contaminants are harvested and disposed of. This course also covers toxic effects of metals and other toxins on health of human and plants. Comprehensive study will make students to apply skills to control toxicology through the use algae, plants and transgenic plants and organisms.

Course Learning Objectives :

By the end of this course, students will understand the principles of environmental toxicology, including the impact of chemical toxins and metals on the environment and health. They will gain skills in assessing ecological risks, utilizing bioremediation techniques, and applying bioanalytical methods for environmental risk assessment. Students will also explore the role of transgenic organisms in bioremediation and strategies for phytoremediation and toxicology control.

Course Content:

1. Introduction and history of environmental toxicology.
2. Types and effects of chemical toxins to environment (PCDDs, PCDFs, TEFs and related compounds).
3. Toxic effects of metals.
4. Ecological risk assessment.
5. Biotechnology and bioremediation, possible mechanisms.
6. Role of transgenic plants/ organisms in the bioremediation.
7. Contaminants in the environment.
8. Utilization of algae and plants assay for ecotoxicological assessment of environmental samples.
9. Biodegradation of toxic and environmental pollutants.
10. Bioanalytical techniques used in environmental risk assessment.
11. Environmental toxicology effects on plant and human health.
12. Chelate assisted phytoremediation.
13. Enhanced phytoextraction and rhizofiltration,
14. Control of toxicology.

Lab Outline :

1. Field survey:
2. Hydroponics systems for heavy metal studies, water sampling techniques, soil sampling, heavy metal estimation methods, sample preparation and digestion.
3. Principle of atomic absorption, spectrophotometer

Recommended Textss

1. Dong, M.H. (2018). An introduction to environmental toxicology. (4th Ed.).Carolina: Create Space Independent Publishing Platform.
2. Laws, E.A. (2013). Environmental toxicology. Switzerland: Springer.

Suggested Readings :

1. Sing, A. & Ward, O.P. (2004). Applied bioremediation and phytoremediation. Switzerland: Springer.
2. Rattner, B.A., Burton, G.A. & Cairns, J. (2002). Handbook of ecotoxicology. Florida: CRC Press.

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BOTN-7108	Phytochemistry	3(2-1)

Course Brief:
Phytochemistry is the study of phytochemicals, which are chemicals derived from plants. Those studying phytochemistry strive to describe the structures of the large number of secondary metabolic compounds found in plants, the functions of these compounds in human and plant biology, and the biosynthesis of these compounds. Plants synthesize phytochemicals for many reasons, including to protect themselves against insect attacks and plant diseases. Phytochemicals in food plants are often active in human biology, and in many cases have health benefits The compounds found in plants are of many kinds, but most are in four major biochemical classes, the alkaloids, glycosides, polyphenols, and terpenes. Phytochemistry can be considered a sub-field of botany or chemistry. Activities can be led in botanical gardens or in the wild with the aid of ethnobotany. The applications of the discipline can be for pharmacognosy or the discovery of new drugs, or as an aid for plant physiology studies. This course is designed to elucidate the structure and role of secondary metabolites in plants and familiarize students with developments of natural plant products as potential new drugs like antibiotics, anticancer and cardiovascular drugs.

Course Learning Objectives :
The objective of this course is to provide students with a thorough understanding of phytochemistry and its role in herbal medicine. Students will gain insights into various secondary metabolites and their biological and pharmacological activities, as well as the chemical nature of plant pigments, latex, and mucilages. The course aims to explore the discovery and development of natural products as potential new drugs, including the selection and optimization of lead compounds with applications in CNS, and the development of antibiotics, anticancer agents, and cardiovascular drugs.

Course Content:
1. Introduction, Phytochemistry, role of phytochemistry in herbal medicine.
2. Secondary metabolites, Alkaloids, steroids, phenols, flavonoids, terpenoids, tannins, saponins, glycosidases etc. Micronutrients and macronutrients, antioxidants, phytohormones, carbohydrates, protiens and lipids, enzymes and vitamins.
3. Plant pigments, chemical nature of plant based latex and mucilages.
4. Saponins with biological and pharmacological activity: Saponins, steroids, alkaloids and diterpene from Euphorabiaceae. Mono,di- and sesquiterpenes with pharmacological and therapeutic activity
5. Natural products leads to new drugs: Approaches to discovery and developments of natural products as potential new drugs
6. Selection and optimization of lead compounds for further development with suitable examples from CNS
7. Antibiotics, anticancer and cardiovascular drugs

Lab Outline:
1. Separation of photosynthetic pigments using paper and column chromatography
2. Estimation of total carotene and xanthophylls
3. Separation of anthocyanin pigment by paper and thin layer chromatography
4. Separation of different Phenolic compounds
5. Determination potential alkaloids in plants.
6. Estimation of terpenoids in plants.

Recommended Texts

1. Sarker, S. & Nahar, L. (2018).Computational phytochemistry. (1st Ed.). Amsterdam: Elsevier Science Publishing Company.
2. Schmidt, B.M., Diana, M. & Cheng, K. Ethnobotany: a phytochemical perspective. Hoboken, New Jersey: Wiley.

Suggested Readings

1. Akhtar, M.S. (2019). Natural Bio-active compounds: production and applications. Singapore: Springer Verlag.
2. Egbuna, C., Chinenye, J., Kumar, S. and Sharif, N. (2018). Phytochemistry. (1st Ed.). Cambridge: Apple Academic Press.

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BOTN-7109	Plant Signal Transduction	3(2-1)

Course Brief:

This course explores the molecular and physiological roles of plant hormones in growth, development, and responses to environmental stimuli. It covers the biosynthesis, transport, perception, and signal transduction mechanisms of key plant hormones, including auxins, gibberellins, cytokinins, abscisic acid, ethylene, brassinosteroids, jasmonates, and salicylic acid. Students will gain insights into the interactions between hormonal pathways and how they regulate plant stress responses, development, and adaptation to changing environments.

Course Learning Objectives:

Upon completion of this course, students will understand the fundamental mechanisms of plant hormone biosynthesis, transport, and signaling. They will be able to analyze how different hormones interact and coordinate plant growth, development, and stress responses. Students will also develop practical skills in experimental techniques for studying hormone action, such as reporter gene assays and hormone quantification. Additionally, they will be equipped to apply knowledge of hormone signaling in agricultural biotechnology and crop improvement.

Course Content:

1 Introduction to Plant Hormones, History, discovery, and classification of plant hormones.
2 Auxin Biology, Biosynthesis, polar transport, signaling pathways, and roles in development.
3 Gibberellins and Growth Regulation, GA biosynthesis, signaling, and effects on seed germination and stem elongation.
4 Cytokinins and Cell Division, Regulation of shoot and root development, delayed senescence, and cytokinin signaling.
5 Abscisic Acid and Stress Responses. Role in drought tolerance, stomatal regulation, and seed dormancy.
6 Ethylene and Plant Responses, Biosynthesis, ethylene perception, and roles in fruit ripening, stress signaling, and senescence.
7 Brassinosteroids and Growth Regulation, Hormonal crosstalk, BR signaling pathways, and roles in cell elongation.
8 Jasmonates and Salicylic Acid, Role in plant defense mechanisms, pathogen response, and secondary metabolite production.
9 Hormonal Crosstalk and Signal Integration, How different hormones interact and regulate development and stress responses.
10 Applications in Agriculture and Biotechnology Hormonal manipulation in crop improvement, plant tissue culture, and stress resistance.

Lab work:

1 Technique like ELISA, GC-MS, and HPLC for plant hormone analysis.
2 Use of qPCR and RNA sequencing to study hormone-regulated genes.
3 Use of GUS, GFP, and luciferase reporters to analyze hormone responses.
4 Study of hormone-deficient and hormone-overproducing mutants.
5 Effect of auxins and cytokinins on callus formation and organogenesis.
6 Investigating ABA and ethylene responses under drought and salt stress.

Recommended Texts:

1 Plant Hormones under Challenging Environmental Factors, 2016 · by Golam Jalal Ahammed & Jing-Quan Yu (Eds.)
2 Plant Ionomics: Sensing, Signaling and Regulation, 2023 · by Vijay Pratap Singh & Manzer H. Siddiqui

Suggested Readings :

1 Plant Hormones: Methods and Protocols, 2017 · by Jürgen Kleine-Vehn & Michael Sauer (Eds.)

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BOTN-7110	Phytoremediation	3(2-1)

Course Brief:

Phytoremediation is a bioremediation process that involves use of plants to remove, transfer, stabilize, or destroy contaminants in the soil and groundwater. There are several different types of phytoremediation. These are: rhizosphere biodegradation, in this process, the plant releases natural substances through its roots, supplying nutrients to microorganisms in the soil. The microorganisms enhance biological degradation while in Phyto-stabilization process, chemical compounds produced by the plant immobilize contaminants. Phyto-accumulation process, plant roots absorb the contaminants along with other nutrients and water. This method is used primarily for wastes containing metals, the metals are stored in the plants aerial shoots, which are harvested or are disposed of as a hazardous waste, readily bioavailable metals for plant uptake include cadmium, nickel, zinc, arsenic, selenium, and copper. Moderately bioavailable metals are cobalt, manganese, and iron. Lead, chromium, and uranium are not very bioavailable. Lead can be made much more bioavailable by the addition of chelating agents to soils.

Course Learning Objectives:

Students will gain a thorough understanding of phytoremediation processes, including rhizosphere biodegradation, phyto-stabilization, and phyto-accumulation, and how these methods are used to remove or stabilize contaminants in soil and groundwater. They will learn to assess the bioavailability of various metals for plant uptake and the role of chelating agents in enhancing metal availability. Additionally, students will evaluate the effectiveness of different phytoremediation strategies and manage the disposal of contaminated plant biomass.

Course Content:

1. Introduction to phytoremediation types of contaminants, sources, risks, and the soil environment
2. The scope and applicability of phytoremediation
3. The various mechanisms that can be involved in phytoremediation, phytoextraction, Phyto stabilization etc.
4. Remediation Technologies: Physical - chemical and biological.
5. Bioremediation; Factors affecting bioremediation in soil systems, optimization of bio-remediation, biological enhancement in bioremediation.
6. Mechanisms of phytoremediation, phytoextraction, phytostabilization, phytovolatilization, phytodegradation, rhizofilteration and phytofilteration.
7. Organics that can be phytoremdiated, plants exudates in organic phytoremediation, uptake rates for organics in phytoremediation
8. soil environment, fate of metals in soils, phyto- availability and bioavailability of metal, methods to assess and measure bioavailability
9. The Genetics of Metal Tolerance: Phytovolatilization of metals, phytoextraction of metals, phytostabilization of metals, phytofilteration of metals.
10. The role of bacteria in the phytoremediation of heavy metals, use of bioactivation and bioaugmentation technologies for treating acidic metal rich drainage.

Lab Outline:

1. Comparison of two potential lead bioremediating plants.
2. Use of plants to remove pesticides from storm water runoff
3. Phytoremediation of lead using Brassica nigra or sunflower (Helianthus annuus)

Recommended Textss:

1. Ravishankar, G.A. & Ambati, R.R. (2019). Handbook of algal technologies and phytochemicals. Boca Raton, Florida: CRC Press
2. Terry, N. & Banuelos, G.S. (2019). Phytoremediation of contaminated soil and water. Florida: CRC Press.

Suggested Readings:

1. David, W.M. (2018). Recent advances towards improved phytoremediation of heavy metal pollution. Sharjah, UAE: Bentham Science Publishers.
2. Matichenkov, V. (2018). Phytoremediation: methods, management and assessment. Hauppauge, New York: Nova Science Publishers.

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BOTN-7111	Biosystematics	3(2-1)

Course Brief:

Plant biosystematics is a science that includes and encompasses traditional taxonomy; however, its primary goal is to reconstruct the evolutionary history of plant life. It divides plants into taxonomic groups, using morphological, anatomical, embryological, chromosomal and chemical data. However, the science differs from straight taxonomy in that it expects the plants to evolve, and documents that evolution. Determining phylogeny - the evolutionary history of a particular group - is the primary goal of systematics. Approaches to classifying plants include cladistics, phenetics, and phyletics. Cladistics relies on the evolutionary history behind a plant to classify it into a taxonomic group. Cladogramsare used to represent the evolutionary pattern of descent. The map will note a common ancestor in the past, and outline which species have developed from the common one over time. Phenetics does not use evolutionary data but rather an overall similarity to characterize plants. Physical characteristics or traits are relied upon, although the similar physicality can reflect evolutionary background as well. Phyletics is difficult to compare directly with the other two approaches, but it may be considered as the most natural approach, as it assumes new species arise gradually. Phyletics is closely linked to cladistics, though, as it does clarify ancestors and descendants. This course is aimed to know about the concept of biological systematics; phylogeny: the evolutionary history of plant life and study taxonomy, taxonomic hierarchy, taxonomic keys and their significance and use of taxonomic literature in taxonomic publications.

Course Learning Objectives :

The objective of this course is to provide students with a comprehensive understanding of biological systematics and plant taxonomy. Students will gain insights into the evolutionary history and diversity of plants, including nonvascular, vascular, seed, and flowering plants. The course aims to equip students with skills in plant description, identification, nomenclature, and classification, as well as character analysis and cladogram construction. Additionally, students will learn about international nomenclature rules, taxonomic hierarchy, and advanced analytical methods in systematics. Practical experience will be provided through field trips and the study of plant adaptations in diverse environments, enhancing their ability to apply theoretical knowledge in real-world settings.

Course Content:

1. Introduction to biological systematics; Phylogeny: The evolutionary history of life; Evolution and diversity of plants (nonvascular, vascular, seed and flowering plants).
2. Taxonomy: Description, identification, nomenclature and classification.
3. Character and character analysis; Cladograms construction, species and different types of species, speciation.
4. International rules of nomenclature; Historical and contemporary situation.
5. Taxonomic hierarchy. Taxonomic keys and their significance, use of taxonomic literature in taxonomy and taxonomic publications.
6. Advanced analytical methods in systematics.

Lab Outline

1. Field trips to different Eco-zones of Pakistan
2. Study of different adaptations in diverse environments (study of ecotypes)

Recommended Textss :

1. Singh, G. (2016). Plant systematics: an integrated approach. (3rd Ed.) Boca Raton, Florida: CRC Press
2. Williams, D., Schmitt, M., & Wheeler, Q. (2016). The future of phylogenetic systematics: the legacy of Willi Hennig. Cambridge, England: Cambridge University Press.

Suggested Readings

1. Briggs, D. & Walters, S.M. (2016). Plant variation and evolution. Cambridge UK: Cambridge University Press.
2. Pontarotti, P. (2018). Origin and Evolution of biodiversity. Switzerland: Springer.

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BOTN-7112	Proteomics and Genomics	3(2-1)

Course Brief:

Proteomics is a relatively recent field. Studying proteins generates insight into how they affect cell processes. The goal of proteomics is to analyze the varying proteomes of an organism at different times to highlight differences between them; more simply proteomics analyzes the structure and function of biological systems. A proteome is the entire set of proteins produced by a cell type. Proteomes can be studied using the knowledge of genomes because genes code for mRNAs and the mRNAs encode proteins, not all mRNAs are translated into proteins. Thus, the genome is constant, but the proteome varies as many proteins are modified after translation. There are also protein-protein interactions, which complicate the study of proteomes. Although the genome provides a blueprint, the final architecture depends on several factors that can change the progression of events that generate the proteome. This course will familiarize students with scope of proteomics and genomics, protein separation techniques, protein identification and sequencing, protein modifications, methods of preparing genomic DNA, sequence analysis of DNA, protein engineering and applications of proteomics and genomics.

Course Learning Objectives:

This course will introduce students to proteomics, a field focused on analyzing proteins to understand their roles in cellular processes. Students will learn how to study proteomes, the complete set of proteins produced by a cell, and how this varies from the static genome due to post-translational modifications and protein-protein interactions. The curriculum covers protein separation techniques, identification, and sequencing, as well as protein modifications, genomic DNA preparation, sequence analysis, and protein engineering, highlighting the interplay between proteomics and genomics in biological research.

Course Content:

1. Introduction and scope of proteomics; Protein separation techniques: ion exchange, size-exclusion and affinity chromatography techniques; Polyacrylamide gel electrophoresis; Isoelectric focusing (IEF); Two-dimensional PAGE for proteome analysis; Image analysis of 2D gels.
2. Introduction to mass spectrometry; Strategies for protein identification; Protein sequencing, protein modifications and proteomics.
3. Applications of proteome analysis to drug; Protein-protein interaction (two hybrid interaction screening).
4. Protein engineering; Protein chips and functional proteomics; Clinical and biomedical application of proteomics; Proteome database; Proteomics industry.
5. Methods of preparing genomic DNA; DNA sequence analysis methods: Sanger dideoxy method and Fluorescence method;
6. Gene variation and Single Nucleotide Polymorphisms (SNPs); Expressed sequenced tags (ESTs); Gene disease association.
7. Recombinant DNA technology: DNA cloning basics, Polymerase chain reaction, DNA fingerprinting, human genome project and the genetic map.

Lab Ouline :

1. Protein separation techniques
2. Polyacrylamide gel electrophoresis (PAGE) for protein analysis
3. Isolation of genomic DNA from plant tissues 4. DNA amplification (PCR), Agarose gel electrophoresis of isolated DNA

Recommended Texts :

1. Strachan, T. & Andrew, P. (2018).Human molecular genetics. New York: Garland Science.
2. Thangadurai, D. & Sangeetha, J. (2015).Genomics and proteomics: principles, technologies, and applications. Florida: CRC Press.

Suggested Readings :

1. Darvas, F., Guttman, A. & Dormán, G. (2016).Chemical genomics and proteomics. Florida: CRC Press.
2. Smejkal, G.B. & Lazarev, A. (2019). Separation methods in proteomics.Florida: CRC Press

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BOTN-7113	Modern Molecular Biology	3(2-1)

Course Brief:

Molecular biology is the study of living things at the level of the molecules which control them and make them up. While traditional biology concentrated on studying whole living organisms and how they interact within populations (a —top down approach), molecular biology strives to understand living things by examining the components that make them up (a —bottom upl approach). Both approaches to biology are equally valid, although improvements to technology have permitted scientists to concentrate more on the molecules of life in recent years. Molecular biology is a specialized branch of biochemistry, the study of the chemistry of molecules which are specifically connected to living processes. Of particular importance to molecular biology are the nucleic acids (DNA and RNA) and the proteins which are constructed using the genetic instructions encoded in those molecules. Other biomolecules, such as carbohydrates and lipids may also be studied for the interactions they have with nucleic acids and proteins. Molecular biology is often separated from the field of cell biology, which concentrates on cellular structures (organelles and the like), molecular pathways within cells and cell life cycles.

Course Learning Objectives :

Molecular biology focuses on understanding living organisms at the molecular level; examining the components that control their functions rather than just the whole organisms. This "bottom-up" approach contrasts with traditional biology's "top-down" perspective, which studies organisms and their interactions. Molecular biology, a specialized branch of biochemistry, emphasizes nucleic acids (DNA and RNA) and proteins, as well as their interactions with other biomolecules like carbohydrates and lipids. Although it often intersects with cell biology, which examines cellular structures and processes, molecular biology centers on the molecular mechanisms underlying living systems.

Course Content:

1. Introduction and scope: Mutations, types of mutations, biochemical basis of mutagenesis, baseanalogue mutagens, chemical mutagens, intercalating agents, reversion.
2. Restriction and modification system, properties of restriction endonucleases, their occurrence and recognition sequences, assay procedures for restriction endonucleases and slab gel electrophoresis; In vitro genetic engineering; Cloning vehicles: plasmids, cosmids and phagemids, YAC and BAC etc.
3. Cloning strategies: Labeling methods of probes, construction of genomic libraries; Methods for screening the clones; PCR and its application in cloning; prokaryotes and eukaryotes expression systems; DNA sequencing; Genetic transformation system; Gene Knock down, knock out and knock in.
4. Organization and structure of genomes; genome sequencing genetic mapping (RFLP, microsatellite, SNP) high resolution physical mapping (STS, EST); comparative genomics and genome evolution, hierarchical and whole genome shotgun sequencing.
5. DNA sequencing strategies, manual and automated sequencing, different platforms used for next generation sequencing , sequence assembly, obstacles and solutions; estimating gene number over prediction and under prediction, homology searches, exon prediction programs, integrated gene finding software packages, structural variation in the genome and its applications, DNA microarray.

Lab Ouline:

1. Restriction digestion of DNA and preparation of restriction maps.
2. PCR, Blotting Techniques, RNA isolation and RT – PCR. 3. Gel Electrophoresis.

Recommended Textss

1. Nelson, D. & Cox, M. (2017). Lehninger: principles of biochemistry. New York: W.H. Freeman MacMillan Learning.
2. Lodish, H., Berk, A., Kaiser, C., Krieger, M. & Bretscher. A. (2016).Molecular cell biology. (8th Ed.). New York: W.H. Freeman-Macmillan Learning.

Suggested Readings :

1. Venkat, B., Sahijram, R. & Murthy, K. (2015).Plant biology and biotechnology. Singapore: Springer-Verlag.
2. Clark, D., Pazdernik, N. &McGehee, M. (2019). Molecular biology. Amsterdam: Elsevier Inc.

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BOTN-7114	Biotechnology for Sustainable Development	3(2-1)

Course Brief:

The major strength of biotechnology is its multidisciplinary nature and the extremely broad range of scientific approaches that it encompasses. Commercialization of biotechnology ranges from research to products and services. These are powerful technologies, supported by complementary bioprocess engineering, to help translate new discoveries of life-sciences into lab work products and services. One of the important aspects of biotechnology is its role in the sustainable development of various sectors. Sustainability is fast becoming the corner stone of economy of many countries, both developed and developing. Biotechnology has great potential for solving many problems pertaining to agriculture, industry, environment and health, which have direct relevance to sustainable development. These features and potentials of biotechnology have generated great interest among the developing countries. This course explicates role of microbes in industry for commercial production of organic acids, amino acids, vitamins, antibiotics and enzymes.

Course Learning Objectives :

Upon completing this course, students will gain a comprehensive understanding of biotechnology's multidisciplinary nature and its role in integrating various scientific approaches for commercialization. They will learn how bioprocess engineering techniques are applied to translate life sciences discoveries into practical products and services. Additionally, students will evaluate biotechnology's significant contributions to sustainable development across agriculture, industry, environment, and health. They will also acquire practical skills in using microbes for the industrial production of organic acids, amino acids, vitamins, antibiotics, and enzymes, understanding both their commercial applications and impact

Course Content:

1. Introduction; Crop Improvement: Clonal multiplication through, micropropagation, somatic embryogenesis, somaclonal variations, regeneration of haploids, isolation and yield of protoplast, regeneration of protoplast, somatic hybridization, vector construction, transformation
2. Crop Protection: Bio-pesticides for use in agriculture and health sector, viral disease control through tissue culture technique. Microbial biotechnology for detoxification of industrial effluents and pesticides waste.
3. Microbes: Single cell protein production, microbial fermentation, choice of substrate, microbes in organic acid production, enzyme production, antibiotic, ergotin, vitamin and glycerin production, microbes in medicine. Mutant selection of microbe strain for high yield.
4. Energy transformation from source to services; Energy sources, sun as the source of energy; Biological processes; Photosynthesis, food chains, classification of energy sources, quality and concentration of energy sources, fossil fuel reserves - estimates, duration.
5. Theory of renewability, renewable resources; Overview of global/ Pakistan's energy scenario.
6. Food Processing: Production of beer, wine, cheese, bread, citric acid and amino acids.
7. Enzyme Technology: Enzymes: Enzyme fermentors and medium, enzyme extraction and purification of oxidoreductases, oxidases, hydrolases, penicillin amidases, transferases and applications of enzymes in therapeutics, clinical analysis and pharma industry
8. Biomass fuels, market barriers of biomass fuels, biomass fuel standardization, biomass fuel life cycle, sustainability of biomass fuels, economics of biomass fuels, fuel stoichiometry and analysis:

Lab Outline:

1. Experiments pertaining to clonal plant propagation, protoplast isolation and regeneration, virus detection, enzymology, some food processing and bioconservations.

Recommended Textss :

1. Mukhopadhyay, K., Sachan, A. & Kumar, M. (Eds.). (2017). Applications of biotechnology for sustainable development. Singapore: Springer.
2. Smith, R.H. (2013). Plant tissue culture: techniques and experiments. Massachusetts: Academic Press.

Suggested Readings :

1. Venkat, B., Sahijram, R. & Murthy, K. Plant biology and biotechnology. (2015). Singapore: Springer-Verlag.
2. Clark, D., Pazdernik, N. & McGehee, M. (2019).Molecular biology. Amsterdam. Elsevier Inc

BOTN-7115	Radiation Biology	3 (2-1)

Course Brief:

The course provides basic knowledge on radiation biological effects and risks from cells to humans as well as in-depth knowledge of radiation protection of ionizing and non-ionizing radiation, introducing students to radiobiology, radioisotopes and types of radiations and sources, effects of radiations on living cells, exposure and dose-effect, molecular basis of cellular effects and cell radiation sensitivity, radiation therapy, radiation protection, safety measures, treatment of radiation injuries, aspects and relationship of imaging physics and radiobiology. The course also familiarizes the students with radiological technologies, labeling techniques, use of radioisotopes as diagnostic and therapeutic tools. Radiation sensitivity and tolerance is evaluated based on normal tissue architecture and kinetics. The mechanisms of radiobiological damage, radiation effects are elucidated. The impact of time, dose, and fractionation on tumor control and radiation effects are clarified and related to established and newer treatment modalities, including combination therapies and emerging technologies

Course Learning Objectives :

This course offers foundational knowledge on the biological effects and risks of radiation, covering both ionizing and non-ionizing types. Students will delve into radiobiology, the impacts of radiation on cells and tissues, and radiation protection practices, including safety measures and treatment of radiation injuries. The course also explores radiological technologies, radioisotope applications, and the relationship between imaging physics and radiobiology, with a focus on evaluating radiation sensitivity, damage mechanisms, and the impact of dose and treatment modalities on tumor control and radiation effects.

Course Content:

1. Introduction to radiobiology, radioisotopes and types of radiations and sources, effects of radiations on living cells, exposure and dose-effect, molecular basis of cellular effects and cell radiation sensitivity, radiation therapy, radiation protection, safety measures, treatment of radiation injuries, aspects and relationship of imaging physics and radiobiology, current regulation and recommendations in radiations in radiation biology.
2. Radiological technologies, labeling techniques, use of radioisotopes as diagnostic and therapeutic tools, computational approaches in molecular radiation biology, health risks due to radiation biology, diagnostic radiology.
3. Radiobiological damage, oxygenation, fractionation, and 4 R's of radiobiology, cell and tissue radio sensitivity.

Lab Outline:

1. Visit of different medical centers/hospitals for study of use of different types of radiation,
2. Visit to different stations/offices where any type of radio waves, electromagnetic waves etc. are in continuous use and collecting data.

Recommended Textss :

1. Eric, H. (2018). Handbook of evidence-based radiation oncology. Basel, Switzerland: Springer International Publishing AG.
2. Michael, C.J. (2018). Basic clinical radiobiology. Oxfordshire, UK: Taylor & Francis Ltd.

Suggested Readings:

1. Kieran, M. & Fergus, R. (2013). Interventional neuroradiology. London: Springer-Verlag London Ltd.
2. Abass, A., Ghassan, E., Marnix, G.E. &Stephen, S. (2019). Evolving role of pet in interventional radiology based procedures: an issue of pet clinics. Edinburgh: Elsevier - Health Sciences Division.

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BOTN-7116	Plant Developmental Processes	3(2-1)

Course Brief:

Plant developmental processes of flowering plants or angiosperms comprise the twin processes of growth and differentiation in vascular plants in general, focused on the clearly ordered process of growth whereby the structural and functional organization of the plant body, beginning with the single-celled fertilized egg or the zygote, became progressively established. This led to the thesis that the fundamental phenomena embodied in plant development are the production of specialized cells and their organization into tissues and organs of the adult plant. In this scenario, the study of meristems, most importantly of the shoot apical and root apical meristems-first organized during embryogenesis -became a matter of great importance. At the same time development of plants appeared to center on the coordination of the dynamic activities of the root, stem, leaves, and flowers and that some fine-tuning of their growth and development occurs as a result of the prevailing environmental conditions. This course will enable the students to understand plant development processes, central dogma of genetic analysis and general strategies of genetic analysis, embryogenesis, genetic analysis of embryogenesis and regulation of embryogenesis.

Course Learning Objectives:

This course will explore plant developmental processes in flowering plants, focusing on the growth and differentiation from a single-celled zygote to a fully organized adult plant. Students will examine the role of meristems, particularly shoot and root apical meristems, and their importance in plant development. The course will also cover the central dogma of genetic analysis, strategies for genetic analysis, and the regulation of embryogenesis, providing a comprehensive understanding of how plants coordinate growth and adapt to environmental conditions.

Course Content:

1. Introduction to plant development, central dogma of genetic analyses, general strategies of genetic analyses.
2. Plant cell division and its regulation, cell expansion, embryogenesis, genetic analysis of embryogenesis, regulation of embryogenesis.
3. Plant meristem, types, cell fate determination.
4. Root development: Models of root growth, genetic analysis of root development.
5. Stem development: Genetic analyses of stem development, regulation of stem development
6. Leaf development, role of cytoskeleton in leaf development, role of genetics in leaf development
7. Vascular development and secondary growth.
8. Vegetative to reproductive transition; Floral morphogenesis fertilization: Pollen pistil interaction, role of cytoskeleton in pollen tube growth.
9. Development of seed, development of fruit and its ripening, seed germination and development of seedling, central role of hormones in plant development.
10. Light perception and developmental responses to light. Epigenetic regulation of developmental responses.

Lab Outline:

1. Study of organization of shoot and root growth, different primary and secondary tissues from the living and preserved material in macerates and sections, hairs, glands, and other secondary structures.
2. Study of embryological stages. 3. Peel and ground sectioning and maceration of fossils material.

Recommended Textss :

1. Geitmann, A. (2019). Plant biomechanics from structure to function at multiple scales. Switzerland: Springer Nature.
2. Minelli, A. (2018).Plant evolutionary developmental biology. Cambridge, UK: Cambridge University Press.

Suggested Readings :

1. Hejatko, J. & Hakoshima, T. (2018). Plant structural biology: hormonal regulations. Basel, Switzerland: Springer International Publishing AG.
2. Bhatla, S.C. & Lal, M.A. (2018). Plant physiology, development and metabolism. Singapore: Springer.

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BOTN-7117	Biohazards and Biosafety	3(2-1)

Course Brief:

Biological agents pose a significant challenge to public health across the world. The emergence of pathogens which have developed resistance to antibiotics and their potential use in bioterrorism has prompted governments to manage the threats posed by these agents by adopting stringent bio risk management practices. This course has been designed and developed to introduce students to diverse biological agents, their classification into risk groups and the practices and procedures recommended by global organizations such as the World Health Organization (WHO). This course will discuss each of these aspects of bio risk management, through this course students will learn about bio risk management, basic knowledge of life sciences will benefit more from the course. However, the specific target of the course are bio-safety in labs, hospitals, public and public organizations with large number of staff, and sanitation officials in the municipal/ local governments. Designating labs based on biosafety, biosecurity and good microbiology techniques are also of significant importance in this regard.

Course Learning Objectives:

This course is designed to equip students with essential knowledge about biological agents and the challenges they pose to public health, including antibiotic-resistant pathogens and bioterrorism threats. It covers the classification of biological agents into risk groups and the bio risk management practices recommended by global organizations like the World Health Organization (WHO). Students will learn about biosafety and biosecurity measures applicable in labs, hospitals, public organizations, and sanitation departments, with a focus on implementing effective microbiological techniques and designating labs based on biosafety standards.

Course Content:

1. Detailed concept of Biohazards. Types and different levels of biohazards. Application to use biohazardous materials, Classification of pathogens by risk group. Biohazard events related to the World and Pakistan, their causes and effects. Impact of biohazards on the economy of a country. Enlist Biohazards responsible for Disasters in the World.
2. Designating labs based on biosafety and containment parameters. Biohazards associated with animal handling, Laboratory safety protocols, Safe handling of laboratory equipment, Reporting of accidents, Waste disposal, Laboratory Biosafety level criteria, Laboratory Biosafety level 1-4, Essential Biosafety measures for TB laboratories, Safety equipment, Personal protective equipment and clothing, Plans for emergency preparedness and response, Introduction to the transport of infectious materials, Biosafety and recombinant DNA technology.
3. Design Biosafety plan, Objectives of Laboratory biosafety, Laboratory Biosafety and risk of Bioterrorism, Laboratory Biosafety and International obligations, Pakistan Biosafety legislations and guidance.
4. Risk assessment, Overview of Biosafety risk assessment methodology, Evaluate the pathogens and toxins, Evaluate the potential Adversaries, Characterize the risk, Risk reduction.
5. . Risk management; Preventions, surveillance, monitoring committee.
6. Judicial Right/ Penalties, Policies and Practices. Concepts of biosafe environment: Terrestrial, marine, atmosphere.

Lab Outline:

1. Visit to relevant labs, observation and preparation of inventory of report on biosafety measures.
2. Visit to hospitals and other relevant units and preparation of report on biosafety measures

Recommended Textss :

1. Karen, B. (2016). Biosafety in microbiological and biomedical laboratory. USA: U.S. Department of human health.
2. Lytton, T.D. (2019). Outbreak: foodborne illness and the struggle for food safety. Chicago: University of Chicago.

Suggested Readings

1. Wooley, D.P. & Byers, K.B. (2017).Biological safety: principles and practices. Ohio, USA: ASM Press.
2. Rita, Y.M. (2015).Construction safety and waste management: an economic analysis. Basel, Switzerland: Springer International Publishing AG.

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BOTN-7118	Food Industrial Waste Management	3(2-1)

Course Brief:

Food service sector is one of the most significant areas of food waste, the simplest and the most preferable practice is prevention of waste at the source, for example better food management at restaurants and cafeterias will consequently reduce the amount of food wastes in this sector. Even though landfilling is the least preferable waste management option, yet food waste generated from leftovers, perished produce and spoiled food is the number one material taking up landfill space. Food waste is much more costly that is obviously seen, and its impact is much more serious. When food is wasted all of the natural resources that were expended in the supply chain are also lost, including the use of land, water and energy. Except for economic impact, the impact that food waste have on the environment and society is bitterer. Broad-scale effects of food wastage contribute to global environmental problems such as pollution and climate change. International Organization for Standardization (ISO) has developed a numerous number of international standards which help organizations to improve their management systems and optimize their processes related to quality. This course will enable the students to know about food industrial wastes, its types, source and characteristics, waste disposal, physical, chemical and biological treatments, bio processing of waste food for sustainable environmental management. This will familiarize the students with utilization of food industry wastes, recovery and utilization of effluents from meat processing industries.

Course Learning Objectives:

This course will provide students with a thorough understanding of food industry waste, including its types, sources, and characteristics. They will explore methods for waste disposal and treatment, including physical, chemical, and biological approaches, and learn about the bioprocessing of food waste for sustainable environmental management. Students will also gain insights into the recovery and utilization of effluents from meat processing industries, enhancing their ability to manage and mitigate food waste's economic, environmental, and societal impacts.

Course Content:

1. Food industrial wastes, types, source and characteristics of industrial wastes, waste disposal. Physical, chemical and biological treatments, BOD, COD.
2. Bio processing in food waste treatment, management of waste by products: Sugars, fruits, vegetables, meat, fish oil, and fat.
3. Diary and cereals recovery of the useful materials from effluents by different systems.
4. Utilization of food industry wastes, food waste management innovations in the foodservice industry, adsorption of organic pollutants from dairy wastewater on soil
5. Pollution problem and control, recovery and utilization of effluents from meat processing industries.

Lab Outline:

1. Visit to food industrial units
2. Visit to waste recycling plants

Recommended Textss:

1. Elina, N., Nina, M., Malla, M. & Anna, H. (2019). Food waste management: solving the wicked problem. Basel, Switzerland: Springer Nature Switzerland AG
2. Kalam had, A.S. & Dhamodharan, K. (2018). Advances in waste management: select proceedings of recycling. Singapore: Springer Verlag. .

Suggested Readings:

1. Ramesha, C. & Das, D.B. (2016). Solid waste management: principles and practice. Berlin: Springer-Verlag Berlin and Heidelberg GmbH & Co. KG.
2. Rita, Y.M. (2015). Construction safety and waste management: an economic analysis. Basel, Switzerland: Springer International Publishing AG.

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BOTN-7119	Plant Nutrition Management	3(2-1)

Course Brief:

This course explores sources of plant nutrition, micro and macronutrients, plant nutrient balance, inducible repressible nutrient transport. Photosynthesis, regulation of photosynthesis by sink activity. Students will get familiarize with methods of plant nutrition such as solution culture techniques, chelating agents, radiotracer techniques, role of rhizosphere bacteria to help plants to tolerate abiotic stress, ammonium and nitrate nutrition of plants and role of mineral nutrition in bioactive compounds, antioxidant phenolics, carotenoids, flavonoids in vegetables and fruits. This course also explains role of soil microorganisms in improving phosphorous nutrition of plants and interaction between plant nutrients, antagonism between potassium and magnesium and calcium. Students will successfully learn about management of different fertilizers in soil and hydroponic conditions for better growth and development of crops, they will also know about leaching substances of plants, biocher effect on nutrient leaching in plants.

Course Learning Objectives :

The objectives of this course are to provide students with a comprehensive understanding of plant nutrition, focusing on the sources, roles, and interactions of micro and macronutrients essential for plant growth. Students will learn about the mechanisms of nutrient transport, regulation of photosynthesis by sink activity, and various methods used to study plant nutrition, such as solution culture techniques and radiotracer methods. The course aims to equip students with knowledge about the role of rhizosphere bacteria in mitigating abiotic stress, the importance of ammonium and nitrate nutrition, and the influence of mineral nutrition on the synthesis of bioactive compounds. Additionally, students will explore the interactions between plant nutrients, the role of soil microorganisms in phosphorus uptake, and best practices for fertilizer management in both soil and hydroponic systems. The course also seeks to enhance students' understanding of the effects of leaching substances and the benefits of biochar in improving nutrient retention and overall plant health.

Course Content:

1. Plant nutrients, micro and macronutrients. Sources of plant nutrition and plant nutrient balance
2. Effect of mineral nutrition in bioactive compounds in vegetables and fruits (antioxidant phenolics, carotenoids, flavonoids).
3. Photosynthesis, regulation of photosynthesis by sink activity, mineral nutrition inducible repressible nutrient transport.
4. Methods of studying plant nutrition, solution culture techniques, chelating agents, radiotracer techniques,
5. Role of rhizosphere bacteria to help plants to tolerate abiotic stress, ammonium and nitrate nutrition of plants.
6. Leaching substances of plants, biocher effect on nutrient leaching. Nuclear techniques used in soil fertility and plant nutrition. Uptake of mineral nutrition and foliar absorption of mineral nutrients.
7. Role of soil micro-organism in improving phosphorous nutrition of plants, Interaction between plant nutrients, antagonism between potassium and magnesium and calcium

Lab Outline:

1. Experiments of plant growth under different nutrient supplies.

2. Experiments of plant growth with application of different fertilizers in soil and hydroponic conditions.

Recommended Texts

1. Naeem, M., Ansari, A.A. & Gill, S.S. (2017). Essential plant nutrients: uptake, use efficiency, and management. Switzerland: Springer.
2. Jones, J.B. (2012).Plant nutrition and soil fertility manual (2nd Ed.). Florida: CRC Press.

Suggested Readings

1. Hossain, M.A., Kamiya, T., Burritt, D., Tran, L.P. and Fujiwara, T. (2017). Plant macronutrient use efficiency: molecular and genomic perspectives in crop plants. Massachusetts: Academic Press.
2. Mitra, G.N. (2015).Regulation of nutrient uptake by plants: a biochemical and molecular approach. Switzerland: Springer.

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BOTN-7120	Recombinant DNA Technology	3(2-1)

Course Brief:

Recombinant DNA technology introduces students to recombination of genetic material at molecular levels with emphasis on recombinant DNA technology and genomics, cloning strategies and nucleic acid hybridization. Students will learn about DNA modifying enzymes and their uses in molecular biology, use of thermostable DNA polymerases in PCR, plasmids as cloning vehicles, basic properties of plasmid, desirable properties of plasmid cloning vehicles, usefulness of natural plasmids as cloning vehicles. There is special focus on DNA sequencing; principle of chemical and enzymatic methods, automated DNA sequencing, high through put pyrosequencing, next generation sequencing, deep sequencing. Site-directed mutagenesis and protein engineering will also be discussed along biotechnological applications of rDNA technology including synthesis and purification of proteins from cloned genes- native and fusion proteins, yeast expression system and production of enzymes. In this regards students will get familiar with therapeutic products of rDNA technology for use in human health care like insulin, growth hormones, TPA, alpha interferon, hepatitis B vaccine and factor VIII.

Course Learning Objectives:

The objective of this course is to provide students with a comprehensive understanding of molecular biology techniques, focusing on the use of DNA modifying enzymes, plasmids as cloning vehicles, and thermostable DNA polymerases in PCR. Students will gain insights into various cloning strategies, including the construction of genomic DNA libraries and cDNA cloning, and learn methods for recombinant DNA selection and screening. The course aims to equip students with knowledge of DNA sequencing techniques, including automated and next-generation sequencing methods, and explore advanced topics such as site-directed mutagenesis and protein engineering. Additionally, students will understand the applications of recombinant DNA technology in biotechnology, including the synthesis of proteins, enzyme production, and the development of therapeutic products for human health care.

Course Content:

1. Introduction: DNA modifying enzymes and their uses in molecular biology Thermostable DNA polymerases used in PCR. Plasmids as cloning vehicles, basic properties of plasmid, desirable properties of plasmid cloning vehicles, usefulness of natural plasmids as cloning vehicles,
2. Cloning strategies, genomic DNA libraries, chromosome walking, cDNA cloning.
3. Recombinant selection and screening: Genetic methods, immunochemical methods, nucleic acid hybridization methods. Expression in E. coli of cloned DNA molecules. The effect of plasmid copy number and plasmid stability.
4. Applications of recombinant DNA technology.
5. DNA sequencing; Principle of chemical and enzymatic methods, Automated DNA sequencing, high throughput. Pyrosequencing, next generation sequencing, deep sequencing.
6. Site-directed mutagenesis and protein engineering. DNA foot printing, chromosome jumping, chromosome walking.

7. Biotechnological applications of rDNA technology; Synthesis and purification of proteins from cloned genes- native and fusion proteins. Yeast expression system. Production of enzymes: Therapeutic products for use in human health care- insulin, growth hormones, TPA, alpha interferon, hepatitis B vaccine and factor VIII.

Lab Outline:

1. E coli culture and growth curve.
2. Conjugation
3. Gel electrophoresis for isolation of protein
4. Transformation of plasmid DNA to E. coli
5. Extraction of plasmid DNA

Recommended Texts:

1. Nelson, D. & Cox, M. (2017). Lehninger: principles of biochemistry. New York: W.H. Freeman MacMillan Learning.
2. Lodish, H., Berk, A., Kaiser,C., Krieger, M. & Bretscher, A. (2016).Molecular cell biology. (8th Ed.). New York: W.H. Freeman-Macmillan Learning.

Suggested Readings:

1. Venkat, B., Sahijram, R. & Murthy, K. (2015). Plant Biology and Biotechnology. Berlin: Springer Verlag.
2. Clark, D., Pazdernik, N. & McGehee, M. (2019). Molecular biology. Amsterdam: Elsevier Inc.

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