UNIVERSITY OF SARGODHA
OFFICE OF THE REGISTRAR
(ACAD BRANCH)

NOTIFICATION

On the recommendations of Academic Council made in its 16th (1/2023) meeting held on 02.01.2023, the Syndicate in its 61st (1/2023) meeting held on 27.01.2023 has approved the scheme of studies / curriculum of BS Botany (5th Semester Intake) for implementation w.e.f. Spring 2023 & onward **(Annex-'A')**.

27/02/23.

(Asif Mehmood)
Deputy Registrar (Acad)

No. SU/Acad/161 Dated: 27.02.2023

Distribution:

- Chairman, Department of Botany
- Controller of Examinations

C.C:

- Director Academics
- Director, QEC
- Deputy Registrar (Affiliation)
- Deputy Registrar (Registration)
- Secretary to the Vice-Chancellor
- PA to Registrar
- Notification File

SCHEME OF STUDIES & CURRICULUM
BS BOTANY

(AFTER 14 YEARS EDUCATION)

(Semester /Term system)

(2023 & onward)

DEPARTMENT OF BOTANY
UNIVERSITY OF SARGODHA
SARGODHA

SCHEME OF STUDIES/CURRICULUM OF BS BOTANY (AFTER 14 YEARS EDUCATION) SEMESTER/ TERM SYSTEM PROGRAM (2023 and onward)

BS Botany (after 14 Years Education) program comprises of 4 semesters with 66 credit hours. Outline of the courses is as under.

Duration of the Program:

The duration of BS Botany (after 14 Years Education) is two years (04 SEMESTERS)

General courses	01 years (02 semesters)
Specialization	01 year (02 semesters)

Main Features of BS Botany (after 14 Years Education) Program/Credit Requirements

Major Subject:	Botany
Duration:	02 years (04 Semesters)

Eligibility: At least 45% marks in ADS/BSc/equivalent with Botany and Zoology (compulsory).

Total numbers of credit hours for BS Botany (after 14 Years Education) is 66

Note:

a). Each semester shall be of 16 to 18 weeks for teaching, number of courses per semester 4-6,one week for the conduct of examination and one week for the preparation of results;

b). A 02+01 Credit hour course means as course of 3 credit hours i.e. 02 credit hours of theory and 01 credit hour of practical.

Deficiency Courses:

The deficiency courses (if applicable) will be determined by the committee (consisting of Senior Professors) constituted for this purpose in Department of Botany.

UNIVERSITY OF SARGODHA

BS BOTANY (AFTER 14 YEARS EDUCATION) 2023 AND ONWARDS

SCHEME OF STUDY

I SEMESTER:

Course Code	Description	Credit hours
STAT-6321	Biostatistics	3(2+1)
BOTN-6301	Bacteriology and Virology	3(2+1)
BOTN-6302	Phycology and Bryology	3(2+1)
BOTN-6303	Mycology and Plant Pathology	3(2+1)
BOTN-6304	Diversity of Vascular Plants	3(2+1)
BOTN-6305	Plant Systematics	3(2+1)
Total Credit hours		**18**

II SEMESTER:

Course Code	Description	Credit hours
BOTN-6306	Plant Anatomy	3(2+1)
BOTN-6307	Genetics-I	3(2+1)
BOTN-6308	Plant Biochemistry-I	3(2+1)
BOTN-6309	Plant Ecology-I	3(2+1)
BOTN-6310	Plant Physiology-I	3(2+1)
BOTN-6311	Cell Biology	3(2+1)
Total Credit hours		**18**

III SEMESTER:

Course Code	Description	Credit hours
BOTN-6312	Molecular Biology	3(2+1)
BOTN-6313	Plant Biochemistry-II	3(2+1)
BOTN-6314	Plant Ecology-II	3(2+1)
BOTN-6315	Research Methodology	2(2+0)
URCC-5110	Citizenship Education and Community Engagement	0(0)
BOTN-6316	Seminar	1(1+0)
BOTN-XXXX	Optional paper	3(2+1)
Total Credit hours		**15**

IV SEMESTER:

Course Code	Description	Credit hours
BOTN-6317	Genetics-II	3(2+1)
BOTN-6318	Plant Physiology-II	3(2+1)
BOTN-6319	Environmental Biology	3(2+1)
BOTN-6320	Biodiversity and Conservation	3(2+1)
BOTN-XXXX	Optional paper	3(2+1)
Total Credit hours		**15**

Total number of Credit Hours: 66

Graduate

Elective subjects will be as per available expertise of the university.

List of Optional Papers

Course Code	Title	Credit Hours	Course Code	Title	Credit Hours
BOTN-6321	Plant Water Relations	3(2+1)	BOTN-6322	Plant Micro Techniques	3(2+1)
BOTN-6323	Plant Seed Physiology	3(2+1)	BOTN-6324	Palynology	3(2+1)
BOTN-6325	Plant Tissue Culture	3(2+1)	BOTN-6326	Plant Biotechnology	3(2+1)
BOTN-6327	Advanced Environmental Biology	3(2+1)	BOTN-6328	Plant Conservation Management	3(2+1)
BOTN-6329	Conservation Genetics	3(2+1)	BOTN-6330	Basic Ecological Genetics	3(2+1)
BOTN-6331	Medicinal Plants	3(2+1)	BOTN-6332	Ethnobotany	3(2+1)
BOTN-6333	Biodegradation and Bioremediation	3(2+1)	BOTN-6334	Water Pollution Management	3(2+1)
BOTN-6335	Air Pollution Management Strategies	3(2+1)	BOTN-6336	Conservation Ecology	3(2+1)
BOTN-6337	Plant Stress Physiology	3(2+1)	BOTN-6338	Advanced Plant Anatomy	3(2+1)
BOTN-6339	Seed Production Technology	3(2+1)	BOTN-6340	Seed Pathology	3(2+1)

BS BOTNANY (AFTER 14 YEARS EDUCATION)

1st Year

1st Semester

STAT-6321 **Biostatistics** **3(3+0)**

This course is designed for graduate programs of sciences. Biostatistics provides an introduction to selected important topics in biostatistical concepts and reasoning. This course represents an introduction to the field and provides a survey of data and data types. Specific topics include tools for describing central tendency and variability in data; methods for performing inference on population means and proportions via sample data; statistical hypothesis testing and its application to group comparisons; issues of power and sample size in study designs; and random sample and other study types. While there are some formulae and computational elements to the course, the emphasis is on interpretation and concepts. Some statistical software will also be part of this course to analyze biostatistical data and improve the analytical skills of the students

Contents

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

Recommenced Books

1. Zar, J. (2000). *Biostatistical analysis* (5th ed.). New York: John Wiley & Sons.
2. Shoukri, M.M. & Pause, C.C. (1998). *Statistical methods for health sciences* (2nd ed.). Florida: CRC press.

Suggested books

1. Daniel, W.W. (2010). *Biostatistics: A foundation for the health Sciences* (6th ed.). New York: John Wiley & Sons.
2. Diggle, J.P. Liang, Kung Y. & Zeger, S. L. (1996). *Analysis of longitudinnal data.* Clarendon press.
1. Dunn, G. & Everit, B. (1995). *Clinical biostatistics*. London: Edward Arnold.

BOTN-6301 **Bacteriology and Virology** **3(2+1)**

To understand the morphology, structure and economic importance of Viruses and Bacteria. Bacteriology and Virology is a three credit hour course for BS in Botany, which covers the basic principles of Bacteriology and Virology. The main objectives of the Microbiology course is to establish the basic knowledge on microbes, mostly bacteria and viruses, and their relationships with other organisms, mainly plants and animals. Also included are the biochemical and molecular techniques and strategies used to study, but also to control, these microorganisms. The course is divided into two main sections corresponding to the type of microorganism studied. The Bacteriology part includes: the historical accounts of microbiology, the bacterial structure, physiology and metabolism, the diversity and classification of bacteria, the various ways to control microorganisms, microbial ecology, food and industrial microbiology and finally an introduction to descriptive epidemiology. After this course the students will be able to understand various biological and molecular aspects of viruses.

Contents

Viruses

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

Bacteria

1. History, characteristics and classification.
2. Evolutionary tendencies in Monera (bacteria, actinomycetes and cyanobacteria)
3. Morphology, genetic recombination, locomotion and reproduction in bacteria
4. Bacterial metabolism (respiration, fermentation, photosynthesis and nitrogen fixation)
5. Importance of bacteria with special reference to application in variousmodern Sciencesspecially agriculture, biotechnology and genetic engineering.
6. Symptoms and control of major bacterial diseases in Pakistan
7. Plant microbe interaction

Lab outline

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

Recommended Texts

1. Black J. & Black, L. (2017). *Microbiology - Principles and Exploration* (10th ed.). Arlington: John Wiley and Sons, Inc.
2. Willey, J., Sherwood, L. & Woolverton, C. (2017). *Prescott's microbiology* (10th ed.). Kent State: McGraw-Hill Companies, Inc.

Suggested Readings

1. Mandahar,C. L., (2017). *Plant viruses: structure and replication* (1st ed.). Florida: CRC Press, Taylor & Francis Group Publishers.
2. Arora, A., (2017). *Textbook of microbiology* (5th ed.). India: CBS Publishers and Distributors.
3. Pommerville, J., (2018). *Fundamentals of microbiology* (11th ed.). Sudbury: Jones and Bartlet Publishers.
4. Gaur, R. K, Khurana, K. & Dorokhov, Y. (2018). *Plant viruses: diversity, interaction and management* (1st ed.). Florida: CRC Press, Taylor & Francis Group Publishers.

BOTN- 6302 **Phycology and Bryology** **3(2+1)**

This course aims to understand the classification, morphology and economic importance of Algae and Bryophytes. This course provide basic knowledge about the structure and reproduction of algal and bryophytes and their evolutionary tendencies and to introduce the students with different species of algae and bryophytes, their collection methods, mounting and specimen identification and to enable the students to visualize and understand microscopic differences between algae and bryophytes and their importance. An advanced level course encompassing all the details related to evolution, types, ecology and economic importance of algae. The second half of the course will provide detail information on Introduction and general account of bryophytes, classification, and brief study of Hepaticopsida, Anthoceropsida and Bryopsida. By the completion of the course, students will be able to understand the structural difference between algae and bryophytes and their evolutionary trends. Students will also collect, identify and prepared stain slides for different specimens of algae and bryophytes. Students make use of this knowledge for the detailed study of algae, bryophytes and their economic importance.

Contents

1. Phycology Introduction, general account, evolution, classification, biochemistry, ecology and economic importance of the following divisions of algae: vChlorophyta, Charophyta, Xanthophyta, Bacillariophyta, Phaeophyta and Rhodophyta.
2. Bryology: Introduction and general account of bryophytes, classification, theories of origin and evolution. Brief study of the classes: Hepaticopsida, Anthoceropsida and Bryopsida.

Lab Outline

Phycology:
1. Collection of fresh water and marine algae.
2. Identification of benthic and planktonic algae
3. Section cutting of thalloid algae
4. Preparation of temporary slides
5. Use of camera lucida/micrographs.

Bryology
6. Study of the following genera: *Pellia, Porella, Anthoceros and Polytrichum.*

Recommended Texts

1. Lee, R. E. (2019). *Phycology* (5th ed.). England: Cambridge University Press.

2. Bellinger, E., (2015). *Freshwater algae* (2nd ed.). New Jersey: John Wiley and Sons Ltd.

Suggested Readings

1. Barsanti, L. & Gualtieri, P. (2014). *Algae: anatomy, biochemistry, and biotechnology* (1st ed.). Florida: CRC Press, Taylor and Francis Group.
2. Hussain, F. (2016) *Phycology: A text book of algae* (1st ed.). Lahore: Pak Book Empire.

BOTN-6303 **Mycology and Plant Pathology** **3(2+1)**

The aim of the course is to introduce the students to Mycology and diseases caused by Fungi, to develop an understanding of the diversity of organisms in the Kingdom Fungi. This course will provide students with basic concepts and identification of fungi, plant pathogens and diseases caused to various important crops. Students will be able to: identify major fungal groups based on morphology (both in the field and in the lab); understand and explain the ecological roles and trophic modes of major fungal groups; use fungal biology resources to understand fungal nomenclature and systematic; demonstrate a broad knowledge of core concepts in Plant Pathology; disease diagnosis and management. Upon completion of the course the student will be able to: describe the concepts of what constitutes disease in plants. Identify major principles of plant pathology; recognize the etiological agents of disease. Employ methods to diagnose and manage a wide range of plant diseases; describe aspects of integrated pest management; explain the impact of plant disease on human affairs.

Contents

Mycology

1. Introduction: General characters of fungi, Thallus, cell structure and ultra structure of fungi.
2. Reproduction: Asexual and sexual reproduction and reproduction structures, life cycle, haploid, heterokaryotic and diploid states.
3. Fungal Systematics: Classification of fungi into phyla with suitable examples to illustrate somatic structures, life cycle and reproduction of Myxomycota, Chytridiomycota, Zygomycota (Mucorales) 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.

Pathology

6. Introduction and classification of plant diseases.
7. Symptoms, causes and development of plant diseases
8. Loss assessment and disease control
9. Epidemiology and disease forecast
10. 5.Important diseases of crop plants and fruit trees in Pakistan caused by fungi, e.g.
11. damping off, mildews, rusts, smuts, dieback, red rot of sugarcane etc.
12. Systemic resistance: Induced systematic resistance (ISR), Acquired Systematic resistance (ASR).

Lab Outline

1. 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.
2. Pathology: Identification of major plant pathogens under lab and field conditions, cultural studies of some important plant pathogenic fungi, application of Koch's postulates for confirmation of pathogencity. Demonstration of control measures through chemotherapeutants.

Recommended Texts

1. Piepenbring, M., (2015). *Introduction to mycology in the tropics* (2nd ed.). America: APS Press, The American Phytopathological Society.
2. Burchett, S., & Burchett, S. (2018). *Plant pathology* (1st ed.). New York: Garland Science Published.

Suggested Readings

1. Phillips, M., (2017). *Mycorrhizal planet: how symbiotic fungi work with roots to support plant health and build soil fertility* (1st ed.). United States: Chelsea Green Publishing Company.
2. Piepenbring, M., (2015). *Introduction to mycology in the tropics* (1st ed.). America: APS Press, The American Phytopathological Society
3.

BOTN-6304 Diversity of Vascular Plants 3(2+1)

This course provides a comparative study of pteridophytes, gymnosperms and angiosperms, integrating form, function and ecology. This course is designed to introduce students to the major lineages of vascular plants, including the ferns, gymnosperms and flowering plants; to enable the students to understand and appreciate the biology and evolution of plant architecture; to examine the evolutionary origins of plants and the impacts humans have had on plant evolution and diversity; to explore the methods of fossilization and its importance in biology; to get a broad overview of Pteridophytes, Gymnosperms and Angiosperms; to have a good overview of the general morphology, sexual reproduction and diversity of the different divisions of vascular plants; to emphasize appropriate science skills, in lab, including experimental observation, and illustration in various groups of vascular plants. Students will be able to: recognize the major groups of vascular plants; differentiate them by their principal characters, and understand their phylogenetic relationships; utilize the knowledge in developing strategies for their higher studies conservation of the plants and sustainable utilization of these natural resources.

Contents

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

a) An introduction to Neopalynology and Paleopalynology, its applications in botany, geology, archaeology, criminology, medicines, honey, oil and gas exploration.
b) Basic information about the nomenclature, morphology and classification of living and fossil pollen and spores.

Lab Outline

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

Recommended Texts

1. Maarten J., Christenhusz, M., & Michael F., (2017). Chase, *plants of the world: an illustrated encyclopedia of vascular plants* (1st ed.). United States: Kew publishing.
2. Maarten J., Christenhusz, M., Michael F. & Byng, J.W. (2018). *The global flora: a practical flora to vascular plant species of the world* (1st ed.). Bradford: Plant Gateway Limited.

Suggested Readings

1. Hobohm, C., (2016). *Endomism in vascular plants* (1st ed.). New York : Columbia University Press.
2. Bowcutt, F. & Hamman, S., (2016). *Vascular plants of the south sound prairies* (1st ed.). Washington: Evergreen State College Greener Bookstore .

BOTN-6305 **Plant Systematics** **3(2+1)**

The aim of the course is to know floral composition/system of classification focusing on identification, classification, and description nomenclature and flora writings monographs. An introduction to the goals and methods of plant systematics, and a survey of the diversity of vascular plants, including ferns, conifers, flowering plants, and related groups. Plant systematics is the study of flowering plant diversity. Lectures cover the processes of plant reproduction and evolution, patterns of plant diversity and biogeography, and the methods used to analyze and interpret these patterns and processes. The laboratory presents a survey of the vascular plants with a focus on major plant families, emphasizing prominent groups in natural habitats and in cultivation. Through the lectures, laboratory exercises, walks and readings students will learn: how to describe and classify plant diversity; the major features and evolutionary origins of vascular plants. What causes selection on, and variation in, plant characteristics; A "Vocabulary" of plant description; identification of plants using dichotomous keys; recognition of important angiosperm families; gain some knowledge of the local spring flora Learn where your food plants come from.

Contents

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, Clinal variation.
5. Systematics and Gene ecology / 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.
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.
8. 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 Prantle, Bessey, Cronquist, Takhtajan and Dahlgren).
9. Brief introduction of Numerical taxonomy.
10. 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), Caryophyllaceae, Chenopodiaceous, Convolvulaceae, Cucurbitaceae, Cyperaceae, Euphorbiacea, Fabaceae (Leguminosae), Lamiaceae (Labiatae), Liliaceae, Magnoliaceae, Malvaceae, Myrtaceae, Orchidaceae, Papaveraceae, Ranunculaceae, Rosaceae, Salicaceae, Scrophulariaceae

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 Texts

1. Simpson, M., (2019). *Plant systematics* (3rd ed.). New York: Elsevier.
2. Novikov, A. & Barabasz-Krasny, B., (2015). *Modern plant systematic* (1st ed.). Ukrainian: Liga-Press.

Suggested Readings

1. Hoorn, C., Perrigo, A. & Antonelli, A., (2018). *Mountains, climate and biodiversity* (1st ed.). New Jersey: Wiley-Blackwell.
2. Shipunov, A., (2018). *Introduction to botany* (1st ed.). North Dakota: Minot State University Publications.

BS BOTNANY (AFTER 14 YEARS EDUCATION)

1st Year

2nd Semester

BOTN-6306 **Plant Anatomy** **3(2+1)**

The aim of the course is to provide the students understanding about anatomical features of vascular plants. To provide students with skills necessary to section and stain fresh plant material in preparation for study of plant anatomy. To train students in the proper use of the compound light microscope and to give them experience in interpreting images that they see through the microscope in terms of how plant structure is related to function. To provide students with skills in modern microscopic digital image capture, processing and analysis techniques useful in plant anatomical studies. To instill in students an appreciation for the complexity of tissue organization that exists within plant bodies that allow plants to develop and live as integrated organisms in diverse environments. Identify the parts of a leaf and distinguish between compound and simple leaves. Identify the anatomy and morphology (cells, tissues, and tissue systems) of a given plant leaf. Emphasis on flowering plants. Identify the anatomy and morphology (cells, tissues, and tissue systems) of a given plant root. Also, emphasis on flowering plants. Explain primary growth, initiation of lateral meristems, and secondary growth in roots using appropriate terminology. Explain how the structural features of leaves and roots and their components (such as wood and cork) confer qualities that are useful to people. Compare and Contrast the structure of stem and roots.

Contents

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. 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.
6. Secretory tissues: Laticifers (classification, distribution, development, structural characteristics, functions) and Resin Canals.
7. Anatomy o
8. f Reproductive parts: Flower, Seed, Fruit
9. Economic aspects of applied plant anatomy.
10. Anatomical adaptations.
11. Molecular markers in tree species used for wood identification.

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.
2. Study of abnormal/unusual secondary growth.
3. Peel and ground sectioning and maceration of fossil material.
4. Comparative study of wood structure of gymnosperms and angiosperms with the help of prepared slides.

Recommended Texts

1. Crang, R., Lyons-Sobaski, S. & Wise, R., (2018). *Plant anatomy: a concept-based approach to the structure of seed plants* (1st ed.). Switzerland: Springer.
2. Schweingruber, F. H. & Borner, A., (2018). *The plant stem: a microscopic aspect* (1st ed.). Switzerland: Springer.

Suggested Readings

1. Hacke, U. G., (2015). *Functional and ecological xylem anatomy* (2nd ed.). New York: Springer International Publishing.
2. Steeves, T.A. & Sawhney, V.K., (2018). *Essentials of developmental plant anatomy* (1st ed.). England: Oxford University Press.

BOTN-6307 **Genetics-I** **3(2+1)**

This course provides the basic biology to understand all of these issues better, tries to clarify some misconceptions, and tries to prepare students for future, more advanced coursework in Genetics. Genetics is the study of how genes bring about characteristics, or traits, in living things and how those characteristics are inherited. The aim of the course is to learn and apply concepts of modern transmission and molecular genetics. The objectives of the are: to identify and describe the process

and purposes of the cell cycle, meiosis, and mitosis, as well as predict the outcomes of these processes; to solve transmission genetics problems, make accurate predictions about inheritance of genetic traits, and map the locations of genes; to accurately diagram and describe the processes of replication, transcription, translation, as well as predict the outcomes of these processes. This course discusses the principles of genetics with application to the study of biological function at the level of molecules, cells, and multicellular organisms, including humans.

Contents

1. Extensions of Mendelian Analysis: Variations on dominance, multiple alleles, lethal alleles, several genes affecting the same character, penetrance and expressivity.
2. Linkage I:Basic eukaryotic chromosome mapping : The discovery of linkage, recombination, linkage symbolism, linkage of genes on the X chromosome, linkage maps, three-point testcross, interference, linkage mapping by recombination in humans,
3. Linkage II: Special eukaryotic chromosome mapping techniques: Accurate calculation of large map distances, analysis of single meiosis, mitotic segregation and recombination, mapping human chromosomes.
4. Recombination in Bacteria and their Viruses: Bacterial chromosome, bacterial conjugation, bacterial recombination and mapping the *E. Coli* chromosome, bacterial transformation, bacteriophage genetics, transduction, mapping of bacterial chromosomes, bacterial gene transfer.
5. The Structure of DNA: DNA: The genetic material, DNA replication in eukaryotes, DNA and the gene.
6. The Nature of Gene: How genes work, gene-protein relationships, genetic observations explained by enzyme structure, genetic fine structure, mutational sites, complementation.
7. DNA Function: Transcription, translation, the genetic code, protein synthesis, universality of genetic information transfer, eukaryotic RNA.
8. The Extranuclear Genome: Variegation in leaves of higher plants, cytoplasmic inheritance in fungi, extranuclear genes in chlamydomonas, mitochrondrialgenes in yeast, extragenomic plasmids in eukaryotes.
9. Developmental Genetics: Gene Regulation and Differentiation, Crown gall disease in plants, cancer as a developmental genetic disease.
10. Population Genetics: Gene frequencies, conservation of gene frequencies, equilibrium, Hardy-Weinberg law, factors affecting gene equilibrium.

Lab Outline

Arrangement of genetic material:

1. Linkage and recombination.
2. Gene mapping in diploid.
3. Recombination in Fungi.
4. Recombination in bacteria.
5. Recombination in viruses.

Population Genetics:

6. Gene frequencies and equilibrium.
7. Changes in gene frequencies,
8. Blood group and Rh-factor
9. Drosophila
10. Culture technique
11. Salivary gland chromosome
12. Fungal Genetics: *Saccharomyces* culture techniques and study.
13. Studies on variation in maize ear size and colour variation
14. Bacterial Genetics.
15. Bacterial cultural techniques, Gram staining (*E. coli, B. Subtilis*)
16. Transformation.
17. Conjugation.

Recommended Texts

1. Klug, W. S., Cummings, M. R. Spencer, C. A. Palladino, M. A. & Killian, D. (2018). *Concepts of genetics* (12th ed.). New York: Pearson Publishers.
2. Klug, W. S., Cummings, M. R., Spencer, C. A. & Palladino, M. A., (2016). *Concepts of genetics* (11th ed.). New York: Pearson Publishers.

Suggested Readings

1. Grotewold, E., Chappell, J. & Kellogg, E. A., (2015). *Plant genes, genomes and genetics* (1st ed.). New Jersey: Willey Blackwell.
2. Carey, N., (2016). *The epigenetics revolution* (2nd ed.). UK: Publisher Icon *Books* Ltd.

BOTN-6308 **Plant Biochemistry-I** **3(2+1)**

Biochemistry is the study of the chemical processes that drive biological systems. Because the field of biochemistry is continually evolving and touches many areas of cell biology, this course also includes an elementary introduction to the study of molecular biology. Biochemistry is both life science and a chemical science - it explores the chemistry of living organisms and the molecular basis for the changes occurring in living cells. It uses the methods of chemistry, "Biochemistry has become the foundation for understanding all biological processes. The course aims to provide an advanced understanding of the core principles and topics of Biochemistry and their experimental basis, and to enable students to acquire a specialized knowledge and understanding of selected aspects. Its aim is to understand the fundamental chemical principles that govern complex biological systems. At the end of the course students will be enable to understand; An understanding of fundamental biochemical principles, such as the structure/function of biomolecules. An understanding of metabolic pathways and the regulation of biological & biochemical processes.

Contents

1. Introduction to photosynthetic organisms, Bioenergetics and overview of photosynthesis, Photosynthesis: The Light Reaction Photo systems, ATP Synthesis, CO_2 Fixation, RuBisCo and enzyme kinetics, 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, lipids, waxes and sterols.
4. Introduction to Proteins: Amin oacids and their structure. Electrochemical 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. Isoprenoid metabolism, biosynthetic pathways, monoterpenes,

sesquiterpenes, phytosterols, diterpenes, Enzymes with multiple functions, mechanisms and evolution.

Lab Outline

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

Recommended Texts

1. Nelson, D. & Cox, M., (2017). *Lehninger: principles of biochemistry* (7th ed). New York: W.H. Freeman.
2. Heldt, H. & Piechulla, B., (2016). *Plant biochemistry* (1st ed.). London: Academic Press.

Suggested Readings

1. Voet, D., Voet, J. G. & Pratt, C.W., (2015). *Fundamentals of biochemistry* (5th ed.). New Jersey: John Wiley and Sons.
2. Mitra, G. N., (2015). *Plants: A biochemical and molecular approach* (1st ed.). India: Springer.
3. Buchanan, B.B., Gruissem, & W., Jones, R. L., (2015). *Biochemistry and molecular biology of plants*, (2nd ed.). New Jersey: Wiley.
4. Conn E. E. & Stump, P.K., (2017). *Outlines of biochemistry* (4th ed.). New Jersey: John Wiley and Sons Inc.

BOTN-6309 **Plant Ecology-I** **3(2+1)**

Plant Ecology is the study of organisms, populations, and communities as they relate to one another and interact in the ecosystems they comprise. In plant ecology, ecosystems are composed of organisms, the communities they comprise, and the non-living aspects of their environment. The four main levels of study in plant ecology are the organism, population, community, and ecosystem. Ecosystem processes are those that sustain and regulate the environment. Ecological areas of study include topics ranging from the interactions and adaptations of organisms within an ecosystem to the abiotic processes that drive the development of those ecosystems. The course covers plant ecology on advanced level. The course deals with plants life history and functional traits, demography, and interactions between plants, between plants and animals and between plants and the remaining ecosystem. The student can analyze the current theories, methods and interpretations within the field plant ecology, and work independently with practical and theoretical problem solving.

Contents

1. Introduction: History and recent developments in ecology.
2. Soil: Nature and properties of soil (physical and chemical), water in the soil-plant-atmosphere continuum, the ionic environment and plant ionic relations, nutrient cycling. Physiology and

ecology of N, S, P and K nutrition. Heavy metals (brief description), salt and drought stress and osmoregulation.
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 CO_2assimilation rates of plants in contrasting environments. Ecophysiological effects of changing atmospheric CO_2concentration. Functional significance of different pathways of CO_2 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, morph-anatomical changes during oxygen deficiency, post-anoxic stress
7. Wind as an ecological factor.
8. Fire as an ecological factor.
9. Carbon credit

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 CO_2 and O_2 concentration of air and water.
5. Effect of light, temperature, moisture, salinity and soil type on germination and growth of plants.
6. Measurement of ions, stomatal conductance, osmotic potential, water potential, xylem. pressure potential, leaf area and rate of CO_2 exchange in plants in relation to various environmental conditions.

Recommended Texts

1. Keddy, P. A., (2017). *Plant ecology origins, processes, consequences* (2nd ed.). England: Cambridge University Press.
2. Canadell, J. G., Diaz, S. Heldmaier, G., Jackson, R.B., Levia, D.F., Schulze, E.D., Sommer, U. & Wardle, D. A., (2019). *Ecological studies* (1st ed.). New York: Springer.

Suggested Readings

1. Fath, B., (2018). *Encyclopedia of ecology* (2nd ed.). New York: Elsevier.
2. Keddy, P. A., (2018). *Wetland ecology: principles and conservation*, (2nd ed.). England: Cambridge University Press.

BOTN-6310 **Plant Physiology-I** **3(2+1)**

This course provides an introduction to basic principles of plant functions including physical processes occurring in plants, Photosynthesis, Respiration, Pathway of translocation, Gaseous exchange, Mechanism of stomatal regulation and growth and development. This course aims to develop understanding of the relationship of complementary metabolic pathways such as photosynthesis and respiration in energy acquistion and use during plant development and to develop understanding of the environmental influences upon carbon metabolism in plants (e.g. with respect to alternative fixation pathways, photoinhibition, and photorespiration). Plant physiology deals with all the internal activities of plants. The subject here to describe plant physiology-I comprises on harvesting of light by plants and its conversion into a chemical energy, mechanism of oxygen evolution by plants, cyclic and non-cyclic electron transport chain. This also gives information about

dark reaction, C3, C4 cycle, mechanisms of photosynthesis in CAM plants and phloem transport.

Contents

1. Photosynthesis: History of photosynthesis, nature and units of light, determination of oxygenic and an oxygenic photosynthesis, various pigments and photosynthetic activity, ultra structure and composition of photo system-I and II, absorption and action spectra of different pigments, mechanism of photosynthesis - light absorption, charge separation or oxidation of water (water oxidizing clock), electron and proton transport through thylakoid protein-pigment complexes. Photophosphorylation and its mechanism, CO_2 reduction(dark reactions) - C_3 pathway and photorespiration, regulation of C_3 pathway, C_4 pathway and its different forms, C_3-C_4 intermediates, CAM pathway.
2. Respiration: Synthesis of hexose sugars from reserve carbohydrates, mechanism of respiration-glycolysis, differences between cytosolic and chloroplastidic glycolysis, oxidative decarboxylation, Krebs cycle, regulation of glycolysis and Krebs cycle, Electron transport and oxidative phosphorylation, aerobic and anaerobic respiration. Energetics of respiration, pentose phosphate pathway, glyoxylate cycle, cyanide resistant respiration.
3. Translocation of Food: Pathway of translocation, source and sink interaction, materials translocated, mechanism of phloem transport, loading and unloading.
4. Leaves and Atmosphere: Gaseous exchange, mechanism of stomata regulation, factors affecting stomatal regulation.
5. Assimilation of Nitrogen, Sulphur and Phosphorus: The nitrogen cycle, nitrogen fixation, pathways of assimilation of nitrate and ammonium ions, assimilation of Sulphur and phosphorus.

Lab Outline

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

Recommended Texts

1. Taiz, L. & Zeiger, E., (2019). *Plant physiology* (7th ed.). England: Sinnauers Publ. Co. Inc.
2. Dennis, D. T., Turpin, D. H., Lefebvre, D. D. & Layzell, D. B., (2016). *Plant metabolism* (6th ed.). London: Longman Group.

Suggested Readings

1. Mitra, G. N., (2015). *Plants: a biochemical and molecular approach* (1st ed.). India: Springer.
2. Buchanan, B., Gruissem, W. & Russell, L., (2015). *Biochemistry and molecular biology of Plants* (2nd ed.). New Jersey: John Wiley & Sons.

BOTN-6311 Cell Biology 3(2+1)

This course aims to understand the structures and purposes of basic components of prokaryotic and eukaryotic cells, especially macromolecules, membranes, and organelles. These can include responses to environmental or physiological changes, or alterations of cell function brought about by mutation. To know about the cell division; how and when it takes place. To know about the cancer, causes types and possible preventive measures. Cell biology is the study of cell structure and function, and it revolves around the concept that the cell is the fundamental unit of life. Focusing on the cell permits a detailed understanding of the tissues and organisms that cells compose. It is the study of cell with respect to its anatomy and physiology. It provide understanding of about cell which act as fundamental unit of life. It focusing on cell combine form tissues, organ and organism. Research

in cell biology is interconnected to other fields such as genetics, molecular genetics, biochemistry, molecular biology, medical microbiology, immunology, and cytochemistry.

Contents

1. Introduction of prokaryotes and eukaryote cell, Animal and Plant cell structure.
2. Brief description of ultra-structure and functions of plant cell organelles.
3. End membranous systems.
4. Cell cycle and cell division; meiosis in sexual reproduction in plants.
5. Cellular metabolism and enzymes.
6. Cellular respiration and photosynthesis.
7. Biological information flow; transcription and translation.
8. Informational molecules; carbohydrates proteins and nucleic acids.
9. Cytoskeleton in cell cycle and mitosis.
10. Extra cellular matrix; various types of extra cellular matrix proteins; elastic fibronectin, glycoprotein, collagen, dynein and motor proteins.
11. Vesicular trafficking, cell migration, cell adhesion, cancer growth factors, disorders in cell cycle, apoptosis and gap junction.

Lab Outline

1. Study of mitosis and meiosis in onion root tip and pollen grains
2. Study of cell organelles in plant cell by compound microscope
3. Measurement of cell size
4. Separation of different sized DNA fragments on agarose gel.
5. Study of chromosomes morphology and variation in chromosomes number.
6. Counting of prokaryotic cells (bacteria) and blood cells by using haemocytometer.
7. Extraction and estimation of carbohydrates, proteins and DNA from plant sources.

Recommended Texts

1. Verma, P. S. & Agarwal, V.K., (2016). *Cell biology (cytology, biomolecules and molecular biology)* (1st ed.). India: S. Chand Publishing .
2. Milo, R. & Phillips, R., (2015). *Cell biology by the numbers (*1st ed.). London: Taylor and Francis publications.

Suggested Readings

1. Templeton, N. S., (2015). *Gene and cell therapy* (4th ed.). London: Taylor and Francis publications.
2. Sybille, M. & Maria, S., (2015). *Tumor cell metabolism* (1st ed.). New York: Springer Publications.
3. Bradshaw, R. & Stahl, P., (2015). *Encyclopedia of cell biology* (1st ed.). New York: Elsevier publications.

BS BOTNANY (AFTER 14 YEARS EDUCATION)
2nd YEAR
3rd Semester

BOTN-6312 **Molecular Biology** **3(2+1)**

Molecular biology is a specialized branch, 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. As a result, molecular biology techniques are at the forefront of most cutting edge scientific research. In this project you will investigate a number of commonly used molecular biology techniques involving DNA. The molecules which form the basis of life provide

scientists with a more predictable and mechanistic tool for scientists to study. Working with whole organisms (or even just whole cells) can be unpredictable, with the outcome of experiments relying on the interaction of thousands of molecular pathways and external factors. Molecular biology provides scientists with a toolkit with which they may "tinker" with the way life works. They may use them to determine the function of single genes or proteins, and find out what would happen if that gene or protein was absent or faulty. Molecular biology is used to examine when and why certain genes are switched "on" or "off".

Contents

1. Nucleic Acids: DNA-circular and super helical 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 Genomics: 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

Following techniques will be used for the isolation and analysis of different components:

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 Texts

1. Nelson, D., & Cox, M., (2017). *Lehninger: principles of biochemistry* (7th ed.). London: W.H. Freeman-Macmillan Learning.
2. Lodish, H., Berk, A., Kaiser, C., Krieger, M. & Bretscher, A., (2016). *Molecular cell biology* (8th ed.). London: W.H. Freeman-Macmillan Learning.

Suggested Readings

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

BOTN-6313 **Plant Biochemistry-II** **3(2+1)**

This course provides an advanced introduction to the fundamental processes of plant metabolism. Topics will include protein structure and function, mechanisms and control of enzyme action, the biochemistry of carbohydrate, fat and protein metabolism, energy generation and ruminant specific biochemistry. Explain how protein structure and function is derived from the constituent amino acids, and compare the features of structural and globular proteins. Describe the basic principles governing the rate of enzyme catalysed reactions and the forms of inhibition of enzyme-catalysed reactions. Describe the major pathways of carbohydrate, lipid and amino metabolism and demonstrate how energy is stored and released through them. Demonstrate familiarity and competence with the practical skills and techniques used in biochemical research and analysis. This will include

experimental planning, the preparation of reagents and use of basic instrumentation (spectrophotometers, centrifuges, chromatographic apparatus etc), the collection of biochemical data and its presentation, and most importantly, the analysis and interpretation of the outcomes of biochemical investigations.

Contents

1. Bioenergetics: Energy, laws about energy changes, oxidation and reduction in living systems.
2. Metabolism: Biosynthesis, degradation and regulation of sucrose and starch. Breakdown of fats with special reference to beta-oxidation and its energy balance, biosynthesis of fats. Replication of DNA, reverse transcription, biosynthesis of DNA and RNA. Components of protein synthesis, genetic code, protein synthesis: initiation, elongation and termination.
3. Alkaloids: Occurrence, physiological effects, chemical nature with special reference to solanine, nicotine, morphine, theine and caffeine. Aflatoxins, their nature and role.
4. Terpenoids: Classification monoterpenes, sesquiterpenes, diterpenes, triterpenes, tetraterpenes, polyterpenes and their chemical constitution and biosynthesis.
5. Vitamins: General properties and role in metabolism.

Lab 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 Texts

1. Nelson, D., & Cox, M. , (2017). *Lehninger: principles of biochemistry* (7th ed.). London:W.H. Freeman.
2. Heldt, H., & Piechulla, B., (2016). *Plant Biochemistry*. London: Academic Press.

Suggested Readings

1. Voet, D., Voet, J. G. & Pratt, C. W. (2015). *Fundamentals of biochemistry* (1st ed.). New Jersey: John Wiley and Sons.
2. Heldt, H. W., (2015). *Plant biochemistry* (5th ed.). Cambridge: Academic Press.
3. Buchanan, B. B, Gruissem, W. &. Jones, R.L., (2015). *Biochemistry and molecular biology of plants* (2nd ed.). New Jersey: Wiley.
4. Conn, E.E. & P.K. (2017). Stump, o*utlines of biochemistry* (1st ed.). New Jersey: John Wiley and Sons Inc.

BOTN-6314 **Plant Ecology-II** **3(2+1)**

The course aims to provide comprehensive knowledge of population, community, ecosystem ecology and its relevance to mankind. The course covers plant ecology on advanced level. The course deals with plants life history and functional traits, demography, and interactions between plants, between plants and animals and between plants and the remaining ecosystem. The main objectives for this course in plant ecology are to provide a broad overview of the field of plant ecology, gives students a fundamental appreciation of the local boreal forest and tundra floras and ecosystems, provide an overview of the Earth's major biomes. Plant ecology course deals with the study of the main environmental factors affecting the Earth's major vegetation types: tropical forests, tropical savannas, arid regions (deserts), Mediterranean ecosystems, temperate forest ecosystems, temperate grasslands, coniferous forests, tundra. Also give brief account about plant adaptations. The student can analyze the current theories, methods and interpretations within the field plant ecology, and work independently with practical and theoretical problem solving with respect to plant responses in terms of functional traits, life history, demography and ecosystem interactions in different ecosystems.

Contents

1. Population Ecology
   a. Population structure and plant demography: Seed dispersal, seed bank, seed dormancy, recruitment and demography
   b. Life history pattern and resource allocation: Density dependent and density independent factors, resource allocation, reproductive effort, seed size versus seed weight, population genetics and evolution
2. Community Ecology: Historical development of community ecology, community concepts and attributes, methods of sampling of plant communities, ecological succession, community soil-relationship, local vegetation, vegetation of Pakistan and major formation types of the world
3. Ecosystem Ecology: Ecological concepts of ecosystem, boundaries of ecosystem. Compartmentalization and system concepts, energy flow in ecosystem, biogeochemical cycles: water carbon and nitrogen case studies.

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. Sampling of vegetation including Quadrat, plotless, transect and Braun-Blanqut.
5. Field trip to study different communities located in different ecological regions of Pakistan.
6. Slide show of the vegetation of Pakistan.
7. Slide show of the major formations of the world.
8. Soil physical and chemical properties
9. Correlation of soil properties with vegetation type

Recommended Texts

1. West, P. W., (2015). *Tree and forest measurement* (1st ed.). Switzerland: Springer International Publishing AG.
2. Osborne, P. L., (2017). *Tropical ecosystems and ecological concepts* (2nd ed.). England: Cambridge University Press.

Suggested Readings

1. Perera, A. H., Peterson, U., Pastur, G.M. & Iverson, L. R., (2018). *Ecosystem services from forest landscapes: broadscale considerations* (1st ed.). New York: Springer International Publishing AG.
2. Mabberly, D. J. (2017). *Mabberly's, plant book: a portable dictionary of plants their uses and classification* (1st ed.). England: Cambridge University Press.
3. Osaki, M. & Tsuji, N., (2016). *Tropical peat land ecosystems* (1st ed.). Berlin: Springer Verlag.

BOTN-6315 **Research Methodology** **2(2+0)**

This course aims to know about research methods, research process, research design, development of skills for writing the research paper and knowledge about the major theoretical and philosophical underpinnings of research. The primary objective of this course is to develop a research orientation among the scholars and to acquaint them with fundamentals of research methods. Specifically, the course aims at introducing them to the basic concepts used in research and to scientific social research methods and their approach. This course will provide an opportunity for participants to establish or advance their understanding of research through critical exploration of research language, ethics, and approaches. The course introduces the language of research, ethical principles and challenges, and the elements of the research process within quantitative, qualitative, and mixed methods approaches. Participants will use these theoretical underpinnings to begin to critically review literature relevant to their field or interests and determine how research findings are useful in forming their understanding of their work, social, local and global environment.

Contents

1. Research Methods: Planning research, various methods, analyzing results, giving reports etc
2. Research Process: Formulating research questions; sampling (probability and no probability.
3. Measurements: Surveys, scaling, qualitative, unobtrusive.
4. Research Design; Experimental and quasi-experimental, data analysis
5. Writing the Research Paper, the major theoretical and philosophical underpinnings of research including; the idea of validity in research, reliability of measures; and ethics.

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 approaches* (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.

URCC-5110 **Citizenship Education and Community Engagement** **3(3+0)**

In recent years, community engagement has become a central dimension of governance as well as policy development and service delivery. However, efforts to directly involve citizens in policy processes have been bedeviled by crude understandings of the issues involved, and by poor selection of techniques for engaging citizens. This course will provide a critical interrogation of the central conceptual issues as well as an examination of how to design a program of effective community engagement. This course begins by asking: Why involve citizens in planning and policymaking? This leads to an examination of the politics of planning, conceptualizations of "community" and, to the tension between local and professional knowledge in policy making. This course will also analyze different types of citizen engagement and examine how to design a program of public participation for policy making. Approaches to evaluating community engagement programs will also be a component of the course. Moreover, in order to secure the future of a society, citizens must train younger generations in civic engagement and participation. Citizenship education is education that provides the background knowledge necessary to create an ongoing stream of new citizens participating and engaging with the creation of a civilized society.

Contents

1 Introduction to Citizenship Education and Community Engagement: Orientation
2 Introduction to Active Citizenship: Overview of the ideas, Concepts, Philosophy and Skills
3 Identity, Culture and Social Harmony: Concepts and Development of Identity
4 Components of Culture and Social Harmony, Cultural & Religious Diversity
5 Multi-cultural society and inter-cultural dialogue: bridging the differences, promoting harmony
6 Significance of diversity and its impact, Importance and domains of inter-cultural harmony
7 Active Citizen: Locally active, Globally connected
8 Importance of active citizenship at national and global level
9 Understanding community, Identification of resources (human, natural and others)
10 Human rights, Constitutionalism and citizens' responsibilities: Introduction to human rights
11 Universalism vs relativism, Human rights in constitution of Pakistan
12 Public duties and responsibilities
13 Social Issues in Pakistan: Introduction to the concept of social problem, Causes and solutions
14 Social Issues in Pakistan (Poverty, Equal and Equitable access of resources, unemployment)
15 Social Issues in Pakistan (Agricultural problems, terrorism & militancy, governance issues)
16 Social action and project: Introduction and planning of social action project
17 Identification of problem, Ethical considerations related to project
18 Assessment of existing resources

Recommended Books

1 Kennedy, J. K., & Brunold, A. (2016). *Regional context and citizenship education in Asia and Europe*. New York: Routledge Falmer.
2 Macionis, J. J., & Gerber, M. L. (2010). *Sociology*. New York: Pearson Education

Suggested Books

1 British Council. (2017). *Active citizen's social action projects guide.* Scotland: British Council
2 Larsen, K. A., Sewpaul, V., & Hole, G. O. (Eds.). (2013). *Participation in community work: International perspectives.* New York: Routledge

BS BOTNANY (AFTER 14 YEARS EDUCATION)
2nd YEAR
4th Semester

BOTN-6317 **Genetics-II** **3(2+1)**

Recombinant DNA technology has revolutionized our ability to investigate the genomes of diverse species and has led to the modern revolution in genomics. Modern genetic techniques are playing an emerging role in agriculture, health, medicine, foods, disease diagnosis and therapy. Genetic technology is developing faster than the policies, laws, and conventions that govern its use. The course aims to develop students' problem solving skills and to introduce them recombination of genetic material at molecular levels with emphasis on introduction to biotechnology and genomics. It also provides information to extend their knowledge about different Mechanisms of Genetic Change and to help them thinking in an analytical way. The objectives of learning of this course includes: to introduce recombinant DNA technology and to elaborate application of recombinant DNA.

Contents

1. Recombinant DNA: Recombinant DNA Technology Introduction, basic techniques, PCR and Rt PCR, Restriction enzymes, Plasmids, Bacteriophages as tools, the formation of recombinant DNA, recombinant DNA technology, site directed mutagenesis, DNA sequencing.
2. Application of Recombinant DNA: Applications of recombinant DNA technology using prokaryotes, recombinant DNA technology in eukaryotes: An overview, transgenic yeast, transgenic plants, transgenic animals, screening for genetic diseases, identifying disease genes, DNA typing, gene therapy, genetically modified organisms and apprehensions.
3. Mechanisms of Genetic Change I: Gene Mutation: The molecular basis of gene mutations, spontaneous mutations, induced mutations, reversion analysis mutagens and carcinogens, biological repair mechanisms.
4. Mechanisms of Genetic Change II: Recombination: General homologous recombination, the Holiday model, enzymatic mechanism of recombination, site-specific recombination, recombination and chromosomal rearrangements.
5. Mechanisms of Genetic Change III: Transposable Genetic Elements: Insertion sequences, transposons, rearrangements mediated by transposable elements, review of transposable elements in prokaryotes, controlling elements in maize.
6. Human Genome Project: Strategies and application, achievement and future prospects.
7. Plant Genome Projects: Arabidopsis, achievement and future prospects. Other plant genome projects
8. Bioinformatics: Application of computational tests to the analysis of genome and their gene products
9. Bioethics: Moral, religious and ethical concerns

Lab Outline

Problems relating to the theory

1. Isolation and separation of DNA and protein on gel electrophoresis: Bacterial chromosome, Plasmid DNA(mini-preps), Plant DNA, Protein.
2. DNA Amplification by PCR

Recommended Texts

1. Stevens, T. & Newman, S., (2019). *Biotech juggernaut: hope, hype, and hidden agendas of entrepreneurial bioscience* (1st ed.). Philadelphia: Routledge.
2. Shukla, P., (2018). *Applied microbiology and engineering: an interdisciplinary approach* (1st ed.). London: Academic Press.

Suggested Readings

1. Se-Kwon, K., (2015). *Handbook of marine biotechnology* (1st ed.). New York: Springer Publications.
2. Venkat, B., Sahijramand, R. & Murthy, K., (2015). *Plant biology and biotechnology* (2nd ed.). New York: Springer Publications.
3. Watson, J., Berry, A. & Davies, K., (2017). *DNA: the story of the genetic revolution* (1st ed.). New York: Knopf Double day Publishing Group.

BOTN-6318 **Plant Physiology-II** **3(2+1)**

The aim of the course is to give comprehensive and advance knowledge about growth regulators, mechanism of water uptake and role of essential nutrients in plant metabolism. Plants are immobile in nature, they want to fulfill all their requirements of their life without moving from one place to another place. Plant physiology helps to study a wide range of processes and functions that plants use to live and survive, including respiration, metabolism, transpiration, plant hormones, environmental response and transport processes. It is also very important to know the functions of a living organism or any of its parts. They also have help in agriculture fields, medicine, food production and textiles. This course examines life process of plants such as signal transduction, different types of hormones (old group of hormones and newly discovered 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. This course also introduces photoperiodism, vernalization and assimilation of nutrients.

Contents

1. Plant Growth Regulators: Major natural hormones and their synthetic analogues. Bioassay, structure, biosynthesis, receptors, signal transduction and mode of action and transport. Physiological effects of auxin, gibberellins, cytokinins, abscisicacid, 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, aqua porins, their structure and types).Cell water relations terminology. Hoflerdiagram - 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 and pressure volume curve
3. Plant Mineral Nutrition: Inorganic composition of plant and soil. Absorption of mineral nutrients through roots, mycorrhizae. Effect of soil pH on nutrient availability. Ion traffic into root. The nature of membrane carriers, channels and electrogenic pumps. Passive and active (primary and secondary) transports and their energetics. Essential and beneficial elements, their functions and deficiency symptoms in plants. Fertilizers and their significance in agriculture.
4. Phytochromes: Discovery of phytochromes and cryptochromes, physical and chemical properties of phytochromes, distribution of phytochromes among species, cells and tissues and their role in biological processes. Phytochromes and gene expression.
5. Control of Flowering: Autonomous versus environmental regulation. Circadian rhythms. Classification of plants according to photoperiodic reaction, photoperiodic induction, locus of photoperiodic reaction and dark periods in photoperiodism. Role of photoperiodism in flowering, biochemical signaling involved in flowering, vernalization and its effect on flowering. Floral meristem and floral organ development, floral organ identity genes and the ABC model.
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 Texts

1. Taiz, L. & Zeiger, E., (2019). *Plant* physiology (7th ed.). England: Sinnauers Publ. Co. Inc.
2. Dennis, D. T., Turpin, D. H., Lefebvre, D. D. & Layzell, D. B., (2016). *Plant Metabolism* (6th ed.). London: Longman Group.

Suggested Readings

1. Mitra, G.N., (2015). *Plants: a biochemical and molecular approach* (1st ed.). India: Springer.
2. Buchanan, B., Wilhelm, G. & Russell, L., (2015). *Biochemistry and molecular biology of plants* (1st ed.). New Jersey : John Wiley & Sons.
3. Hopkins. W.B., (2017). *Introduction to plant physiology* (5th ed.). New Jersey: John Wiley and Sons.

BOTN-6319 **Environmental Biology** **3(2+1)**

The aim of the course is to provide updated knowledge of environmental problems and sustainable environmental management. Environmental Biology encompasses varied themes such as energy flow biosphere & biomes, carbon trading and other biogeochemical cycling, greenhouse gas emissions, water resource management, land degradation and rehabilitation, flora and fauna, habitat destruction, deforestation, energy and mineral depletion, air and water pollution, soil erosion, and groundwater contamination. This course provides insight into of the basic science of environmental biology and ecological theory. Environmental Biology helps in recognition of environmental problems such as climate change, global warming, ozone layer depletion, acid rains as well. This course enables students to develop strong expertise in contemporaneous themes in ecological research, develop critical thinking and to discuss about advanced topics in population, community and ecosystem ecology as well as in biodiversity research.

Contents

1. Environment: Introduction, scope and pressure.
2. Pollution: Definition, classification and impact on habitats.
3. Air pollution: Sources and effect of various pollutants (inorganic, organic).on plants, prevention, control and remediation. Smog, photochemical smog. Acid rain: Theory of acid rain, adverse effects of acid rains. Chlorofluorocarbons and its effects.
4. Water pollution: Major sources of water pollution and its impact on vegetation, prevention, control, remediation, eutrophication and thermal pollution.
5. Sediments pollution: Fungicide, pesticides, herbicide, major sources of soil pollution and its impact. Prevention, control, remediation, heavy metal pollution. tanneries, hospital waste. Treatments of sewage, sludge, and polluted waters.
6. Noise pollution.
7. Radiation pollution (including nuclear radiation): Measurement, classification and effects, principle of radiation protection, waste disposal
8. Forest: Importance, deforestation, desertification and conservation.
9. Ozone layer: Formation, Mechanism of depletion, Effects of ozone depletion
10. Greenhouse effect and global warming: Causes and impacts.
11. Human population explosion: Impact on environment.
12. Environment impact assessment: Industrial urban, civil developments.
13. National conservation strategy: Brief review of major environmental problems of Pakistan and their solutions.
14. Sustainable environmental management.
15. Wetlands and sanctuaries protection: The pressures, problems and solutions.
16. Range management: Types of rangelands, potential threats, sustainable management.
17. Aerobiology: Pollen allergy and dust allergy.

Lab Outline

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

Recommended Texts

1. Ren, H. & Zhang, X., (2019). *High-risk pollutants in wastewater* (1st ed.). Amsterdam: Elsevier Publishing Company.
2. Nriagu, J., (2019). *Encyclopedia of environmental health* (2nd ed.). Amsterdam: Elsevier Publishing Company.

Suggested Readings

1. Sivasubramanian, V., (2016). *Environmental sustainability using green technologies* (1st ed.). Florida: CRC Press Taylor and Francis Group.
2. Fisher, M., (2018). *Environmental biology* (1st ed.). Medford: Open Oregon Press Book Publishing Company.

BOTN-6320 **Biodiversity and Conservation** **3(2+1)**

Over the years, the depletion of biodiversity has been quite active. This is happening as a result of habitat loss, excessive exploitation of resources, climatic changes, diseases, pollution, poaching of animals etc. In order to correct this scenario, biodiversity conservation has been majorly stressed by governments and social organizations. It must be understood that human beings cherish almost all benefits from the biodiversity. Hence, they should focus on taking proper care associated with the preservation of biodiversity in different forms. It is important because there must be something left for the future generation to look at. We as human beings should curb the degradation as well as the destruction of the habitats, upholding the biodiversity at its prime level. Biodiversity conservation is basically aimed at protection, enhancement and scientific management of the biodiversity. To be precise, manage it at its threshold level and acquire sustainable benefits both for the present and future population. Biodiversity and conservation maintain crucial ecological processes as well as life support systems. It preserves the variety of species and make sustainable exploitation of ecosystems and species.

Contents

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. Inventory of plant biodiversity in various habitats.

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

Recommended Texts

1. Walker, T., (2015). *Plant Conservation: Why it Matters and How it Works*. Timber Press.
2. Pellens, P. and P. Grandcolas, (2016). *Biodiversity Conservation and Phylogenetic Systematics*. SIP AG Swetzerland.
3. Blackmore, S. and S. Oldfield, (2017). *Plant Conservation Science and Practice: The Role of Botanic Gardens*. Cambridge University Press.

Suggested Readings

1. Boenigk, A., S., Wodniok and E. Glucksman. (2015). *Biodiversity and Earth history*. Berlin: Springer.
2. Scherson, R.A, (2018). *Phylogenetic Diversity*. Berlin: Springer.

Optional Courses

BOTN-6321 **Plant Water Relations** **3(2+1)**

The aim of the course is to overview comprehensively the soil-plant-atmosphere continuum for the maintenance of vital physiological functions and mechanisms in plants and to upgrade the concept about source sink relationships in translocation of solutes in plants. To familiarize graduate students with some of the tools necessary to measure plant water relations parameters in the field. Emphasis will be on water potential measurements with Scholander pressure chambers, leaf gas exchange measurements with potometers and infrared gas analysers, and xylem sap flux measurements with heat dissipation probes. Water is the major component of living cells and constitutes more than 90% of protoplasm by volume and weight. Mechanisms of water and nutrient movement in soils and plants, and their relationships with plant growth are discussed. The term "Cell water relations" describes plant water status in a cell, individual organ (leaf, internode, flower) or whole plant level, furthering our understanding of basic plant growth and development, and plant response to the environment. After completion of this course, the students will be able to understand water and nutrient movement in soil and plant and adaptation of plants to adverse soil water conditions. This course will focus on instruments and techniques used to quantify water balance and status in plants in the field.

Contents

1. The soil-plant-atmosphere continuum - an overview.
2. 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).
3. Cell water relations terminology. Hoflerdiagram - analysis of change in turgor, water and osmotic potential with changes in cell volume.
4. Modulus of elasticity coefficient; Hydraulic conductivity.
5. Osmoregulation, methods for measurement of water, osmotic and turgor potentials- pressure chamber, psychrometry, pressure probe and pressure volume curve, stomatal physiology, transpiration flux, anti-transpirants.
6. Source sink relationships in translocation of solutes. Mineral nutrition: Hydroponics prospects and problems,
7. Nutrient solutions, chelating agents. Mineral ion uptake passive and active uptake and transport
8. Nernst equation, Donnan's potential, role of H^+ ATPase as a carrier, co transport.

Lab outline

1. Preparation of solutions of specific normality of acids/bases, salts, sugars, molal and molar solutions and their standardization.
2. Determination of uptake of water by swelling seeds when placed in sodium chloride solution of different concentrations.
3. Measurement of leaf water potential by the dye method.
4. Determination of the temperature at which beet root cells lose their permeability.

5. Determination of the effects of environmental factors on the rate of transpiration of a leafy shoot by means of a potometer/cobalt chloride paper method.
6. To regulate stomatal opening by light of different colors and pH.

Recommended Texts

1. Taiz, L. & Zeiger, E., (2019). *Plant physiology* (7th ed.). England: Sinnauers Publ. Co. Inc.
2. Dennis, D. T., Turpin, D. H., Lefebvre, D. D. & Layzell, D. B., (2016). *Plant metabolism* (6th ed.). London: Longman Group.

Suggested Readings

1. Mitra, G. N., (2015). *Plants: a biochemical and molecular approach* (1st ed.). India: Springer.
2. Buchanan, B., Wilhelm, G. &Russell, L. (2015). *Biochemistry and molecular biology of plants* (1st ed.). New Jersey: John Wiley & Sons .
3. Willey, N., (2016). *Environmental plant physiology* (1st ed.). New York: Garland Science.
4. Taiz, L. & Zeiger, E., (2018). *Fundamental of Plant Physiology* (1st ed.). England: Sinnauers Publ. Co. Inc.

BOTN-6322 **Plant Micro Techniques** **3(2+1)**

The aim of the course is to elucidate the importance of light microscopy and other special techniques maceration and staining to study plant sections, and to make students able to use microtome and camera Lucida. Microtechnique an important experimental science that has led and continues to lead a great service for each branch of the life sciences: microbiology, genetics, embryology, morphology and science, also plays an important role in the development of medical studies of human anatomy. This includes knowledge of the preparations microscopic plant sample. This course provides information for managing the techniques of microscopic slides making, microscopic measurements and methods of identification of some organic compounds in plant cells. Microteaching is a highly individualized training device. Microteaching is an experiment in the field of teacher education which has been incorporated in the practice teaching schedule. Microteaching is micro in the sense that it scale down the complexities of real teaching. Microteaching advocates the choice and practice of one skill at a time. After finishing this course, students should be able to make temporary microscopic slides, using different cutting techniques and permanent microscopic slides using paraffin method.

Contents

1. Light microscopy–optical principle, resolution, magnification, aberration. Phase contrast microscopy Dark field illumination.
2. Electron microscope (TEM & SEM), principle and preparation techniques. Special techniques maceration; squashes, smears, whole mount and clearing techniques.
3. Micro technique steps fixation and fixatives, dehydration, clearing, infiltration, embedding, block making and sectioning.
4. Microtome's types, principles and operating mechanisms, stainsand staining techniques, Camera Lucida types, principles and their uses.
5. Micrometry

Lab outline

1. Preparation of hand sections, maceration and clearing
2. Temporary and permanent mounting of whole specimens and Sections using different types of mountants.
3. Calibration of microscope and micrometry
4. Microtomy and microtome sectioning
5. Examination of different cell and tissue types with help of techniques
6. Study of structure of (primary and or secondary) leaf, root, stem and floral parts (including fruit).
7. Examination of vascular cambium and study of its activity.

8. Examination of structure and identification of Wood of some common trees such as *Dalbergia sissoo, Acacia arabica.* etc

Recommended Texts

1. Yeung, E. C. T., Stasolla, C., Sumner, M. J.&Huang, B. Q., (2015). *Plant microtechniques and protocols* (1st ed.). New York: Springer.
2. Richard, C., Sobaski, L., Wise, S.& Robert, S., (2018). *Plant anatomy* (1st ed.). New York: Springer.

Suggested Readings

1. Back, C. B., (2010). *An introduction to plant structure and development: plant anatomy for the twenty-first century* (2nd ed.). England: Cambridge University Press.
2. Maiti, R., (2012). *Crop plant anatomy* (15th ed.). England: CABI.
3. Steeves, T. A. & Sawhney, K. V., (2017). *Essentials of developmental plant anatomy* (1st ed.). England: Oxford University Press.

BOTN-6323 Plant Seed Physiology 3(2+1)

This course comprehensively provides the details of physiology of seed development and maturation. It is science and technology that is applied in the seed industry and includes biotech, crop improvement, as well as courses in seed production and conditioning. This course provides students with core graduate level management and leadership skills enabling them to better serve seed and agricultural biotechnology businesses and regulatory agencies in an increasingly complex industry. This program emphasizes seed production, handling, and use; seed physiology and technology; plant breeding, and plant biotechnology. This course is designed to help students integrate and better understand crop growth, development and yield from a perspective of whole plant physiology. In this course, students will gain an overview of plant seeds physiological processes that are necessary to understand how plants operate, and interact with their environment. The course is useful to understand and interpret agronomic phenomena contributing to crop yield. It also offers an opportunity to survey contemporary aspects of crop physiology with emphasis on recent research progress in related fields.

Contents

1. Physiology of seed development and maturation; chemical composition, synthesis and accumulation of seed reserves, induction of desiccation tolerance, hormonal regulation of seed development.
2. Seed germination Types of germination, factors affecting germination; role of embryonic axis; growth hormones and enzyme activities, effect of age, size and position of seed on germination. Physiological processes during seed germination; seed respiration, breakdown of stored reserves in seeds, mobilization and interconversion pathways.
3. Seed dormancy- types, significance, mechanism, endogenous and exogenous factors regulating dormancy, role of phytochrome and PGR, genetic control of dormancy.
4. Seed viability and longevity, pre-and post-harvest factors affecting seed viability; seed ageing; physiology of seed deterioration; lipid peroxidation and other viability theories; means to prolong seed viability; mechanism of desiccation sensitivity and recalcitrance with respect to seed longevity.
5. Seed vigour and its concept, vigour test methods, factors affecting seed vigor, physiological basis of seed vigour in relation to crop performance and yield. Seed, invigoration and its physiological and molecular control.

Lab outline

1. Proximate analysis of chemical composition of seed;
2. Different types of seed germination and evaluation,

3. Methods for breaking seed dormancy
4. Seed vigor test
5. Accelerated aging test
6. Priming and invigoration treatment for improving germination and vigor

Recommended Texts

1. Agrawal, P. K. & Sherry, R. J., (2018).*Techniques in seed science and technology* (3rd ed.). New Delhi: Brillion Publishing.
2. Baskin, C. C., & Baskin, J. M., (2014). *Seeds: ecology, biogeography and evolution of dormancy and germination* (1st ed.). Cambridge: Academic Press.

Suggested Readings

1. Taiz, L. & Zeiger, E., (2019). *Plant physiology* (7th ed.). England: Sinnauers Publ. Co. Inc.
2. Dennis, D.T., Turpin, D.H., Lefebvre, D.D. & Layzell, D.B., (2016). *Plant metabolism* (6th ed.). London: Longman Group.
3. Arnold, R. B. & Sanchez, R., (2004). *Handbook of Seed Physiology* (3rd ed.). New York: The Haworth Press, Inc.

BOTN-6324 **Palynology** **3(2+1)**

This course aims to introduce students to neopalynology and paleopalynology and its applications in botany, geology, archaeology, criminology, medicines, honey, oil and gas exploration. It also provide the students information about the nomenclature, morphology and classification of living and fossil pollen, and spores. The objective of the course is to disseminate information on palynology samples and preparation techniques that avoid the use of acids. Palynology is a particular study within the realm of ecology that deals with the pollen and spores of plant species. Specifically, palynologists look at such factors as abundance of pollen and its occurrence in preserved samples. In the research of plants and their origins, palynologists have an important foothold in the study of past environmental systems, or paleoenvironments. The course teaches the practical procedures used and will be taught through instruction within a laboratory environment. This course gives information about spores and pollens of preserved species samples, which in turn can reveal many details about different ecosystems, especially marine environments. With palynology, one can determine such environmental characteristics as water depth, temperature, and salinity. This is important in learning more about past wildlife and how it has evolved.

Contents

1. An introduction to Neopalynology and Paleopalynology, its applications in botany, geology, archaeology, criminology, medicines, honey, oil and gas exploration.
2. Basic information about the nomenclature, morphology and classification of living and fossil pollen, and spores; Morphology and functional significance of spores and pollen,
3. Palynomorphs of the Paleozoic, Palynomorphs of the Mesozoic, mega and microspores.
4. Gymnosperm pollen-major types through time, diagnostic features of angiosperm pollen and the early fossil record,
5. Anita group and Magnolid pollen, monocot pollen, lower Eudicot pollen types, selected Rosid pollen types, selected Asterid pollen types.
6. Applications: forensics, honey, paleo environment, case histories. Fagales, geometrically bizarre and fun pollen types.

Lab outline

1. Microscopic Study of Spores and Pollen, Herbarium sheets.
2. Acetolysis.
3. Slide preparation, temporary and permanent slides of spores and pollen
4. Photomicrography, HF safety training, maceration and dissolution, gravity separation, counting techniques.

Recommended Texts

1. Slam, H., (2016). *Aerobiology: the toxicology of airborne pathogens and toxins* (1st ed.). London: Royal Society of Chemistry.
2. Burge, H. & Muilenberg, M., (2018). *Aerobiology* (1st ed.). Florida: CRC Press.

Suggested Readings

1. Bhattacharya, K., (2015). *A text book of palynology* (1st ed.). New Delhi: New Century Publication.
2. Beaudoin, A.B. & Head, M.J., (2017).*The palynology and micropalaeontology of boundaries* (1st ed.). London: Geological Society.
3. Alfred, T., (2018). *Paleopalynology* (2nd ed.). New York: Springer.

BOTN-6325 **Plant Tissue Culture** **3(2+1)**

The aim of the course is to know about concept of cellular totipotency, differentiation and de-differentiation and various tissue culture methods / techniques for the production pathogen-free plants and explicit the role of plant tissue culture in crop improvement. Plant tissue culture broadly refers to the an *in vitro* cultivation of plants, seeds and various parts of the plants (organs, embryos, tissues, single cells, protoplasts). With the advances made in the tissue culture technology, it is now possible to regenerate species of any plant in the laboratory. In this process the growth medium or culture solution is very important as, it is used for growing plant tissue because it contains various plant nutrients in the form of 'jelly' known as agar and plant hormones which are necessary for the growth of plant. Plant tissue culture is used widely in the plant sciences, forestry, and in horticulture. Applications include: The commercial production of plants used as potting, landscape, and florist subjects, which uses meristem and shoot culture to produce large numbers of identical individuals.

Contents

1. Plant Tissue Culture-An introduction
2. Cellular totipotency, differentiation and de-differentiation
3. Selection of a suitable explant material in different plant groups
4. Initiation and maintenance of callus cultures
5. Organogenesis
6. Somatic embryogenesis
7. Micropropagation
8. Role of somaclonal variation in crop improvement
9. Cell suspension cultures
10. Isolation, purification and culture of plant protoplasts
11. Role of plant protoplasts in crop improvement
12. Production of pathogen-free plants using tissue culture techniques.

Lab outline

1. An introduction to a Plant Tissue Culture lab.
2. Laboratory facilities and their use.
3. Aseptic techniques.
4. Preparation and use of Stock solutions.
5. Media composition and preparation protocols.
6. Preparation of selected media, pouring and sterilization.
7. Procurement, preparation and sterilization of explants.

8. Initiation and maintenance of callus cultures and regeneration studies in selected species.
9. Culture initiation and maintenance for Micropropagation of selected species.

Recommended Texts

1. Umesha, S., (2019). *Plant biotechnology* (1st ed.). Philadelphia: Francis and Taylor Group.
2. Dixon, R.A. & Gonzalcs, F.A., (2017). *Plant Cell Cultures. A Practical Approach* (2nd ed.). England: Oxford University Press.

Suggested Readings

1. Loyola-Vargas, V.M. & Ochoa-Alejo, N., (2016). *Somatic embryogenesis: fundamental aspects and applications* (1st ed.). Switzerland: Springer International Publishing.
2. Kumar, S., Mishra, S. & Mishra, A.P., (2016). *Plant tissue culture: theory and techniques* (2nd ed.). England: Scientific Publishers.

BOTN-6326 **Plant Biotechnology** **3(2+1)**

The aim of the course is to introduce students to genetic engineering, cloning strategies, PCR and genetic markers and applications of plant biotechnology, to provide updated knowledge of environmental problems and sustainable environmental management through treatment technologies such as phytoremediation. The objective of the course is to give students new knowledge and widening of the knowledge acquired in other course by handling of classical and modern plant biotechnology processes, including breeding of healthy plants, plants with improved characteristics and plants for biomolecule production. This course enhances the ability of explanation of concepts, principles and usage of the acquired knowledge in biotechnological, pharmaceutical, medical and agricultural applications. This course explores the use of biotechnology to both generate genetic variation in plants and to understand how factors at the cellular level contribute to the expression of genotypes and hence to phenotypic variation. There is an emphasis on the molecular mechanisms directing plant gene expression under diverse environmental and developmental stimuli.

Contents

1. Biotechnology: Definition, history, scope and significance. Principles and applications of genetic recombinant technology in medicine, agriculture, veterinary and food industry. Production of biotechnological products – food SCP(algae, yeast, mushroom).
2. Biofertilizers, biofuel, biopesticides, biogas production, waste and sewage management, effective microorganisms.
3. Enzyme biotechnology: Sources and production of commercially important enzymes. cellulase, amylase, pectinases, proteinases. Immobilization of enzymes and its applications.
4. Amplification of genes by PCR, cDNA and construction of cDNA libraries.
5. Blotting techniques (Southern, northern and western blotting) nonradioactive probe DNA diagnostics (RFLP, AFLP and RAPD). DNA sequencing.
6. Recombinant DNA technology-gene transfer in plants. Vectors – types, plasmids (PBR 322, PBR 327), cosmid insertion vectors, replacement vectors, shuttle vectors and high expression vectors.
7. Strategies for development of transgenic plants, specific and non-specific methods of gene transfer, organization of Ti plasmid in Agrobacterium tumifaciens-Ti plasmid mediated gene transfer. DNA transfer by particle bombardment, micro and macro injection methods – lipofection-electroporation. Gene cloning in E. *coli*. isolation of DNA – insertion of DNA – use of linkers and adapters, transformation, uptake of DNA by host cell, selection of clones, identification of recombinants, insertional inactivation.
8. Plant tissue culture: Concept of totipotency-organization of tissue culture laboratory. Sterilization methods-callus induction, subculture and maintenance. Organogenesis, anther culture and production of haploids, somatic embryogenesis-isolation, culture and fusion of protoplasts-cybrids, micro-propagation, encapsulated seeds.

Lab outline

1. Extraction and estimation of plant DNA.
2. Basic biotechnology techniques
3. Preparation of different types of standard tissue culture media.
4. Establishment of aseptic cultures following appropriate sterilization procedures using seeds.
5. Preparation of culture medium (MS, N & N, SH, B5), sterilization and inoculation.
6. Demonstration of Agarose gel electrophoresis.
7. Encapsulation of seeds/embryos in calcium alginate.
8. Visits of Biotechnology labs at NIBGI, Faisalabad, AARI, Faisalabad and School of Biological Sciences Lahore, Center of Excellence in Molecular Biology, Lahore: National institute for Genomics and Advance Biotechnology (NIGAB)

Recommended Texts

1. Abdin, M.Z., Kiran, U. Kamaluddinand, A. & Ali, M.A.(2017). *Plant biotechnology: principles and applications* (1st ed.). New York: Springer.
2. Kumar, S., Kumar, R., & Pandey, A. (2019). *Current developments in biotechnology and bioengineering: waste treatment processes for energy generation* (1st ed.). Amsterdam: Elsevier .
3. Gahlawat, S. K., Salar, R.K., Siwach, P.,Duhan, J. S.,Kumar, S., & Kaur, P. (2017). *Plant biotechnology: recent advancements and developments* (1st ed.). New York: Springer.

Suggested Readings

1. Smith, R. H., (2013). *Plant tissue culture: techniques and experiments* (3rd ed.). Cambridge: Academic Press.
2. Stewart, N., (2017). *Plant biotechnology and genetics: Principles, Techniques, and Applications* (2nd ed.). New Jersey: Wiley Online Liberar.

BOTN-6327 **Advanced Environmental Biology** **3(2+1)**

The aim of the course is to provide updated knowledge of environmental problems and sustainable environmental management, to familiarize the students with national conservation strategy and role of natural resources in conservation diversity of nature and importance of biodiversity for survival and proper functioning of ecosystems. This course introduces the student to the fundamentals of environmental biology: the structure and biota of several aquatic and terrestrial ecosystems, including Vermont ecosystems. It includes spatial and temporal changes in ecosystems and species; critical observation and interpretation of landscapes; and communication skills, critical thinking, and teamwork. The student investigates why species occupy specific habitats. Environmental Biology is the study of living organisms in relation to their environment. It is emerged from the fields of natural history and medicine during the Enlightenment. Today it provides an integrated, quantitative, and interdisciplinary approach to the study of environmental systems. Environmental biology incorporates more of the pure sciences for understanding human relationships, perceptions and policies towards the environment.

Contents

1. Environmental problems, their causes, and sustainability & Environmental history.
2. Science Systems, Matter and Energy, Energy Conversions, Thermodynamics, Basic Chemistry (acids, bases, salts), Niches, Interactions, Succession
3. Biogeography: Weather, Climate, Biomes & Biodiversity

4. Population Dynamics, Carrying Capacity, and Conservation Biology and Evolution of a Species
5. The Human Population: Growth, Demography
6. Global Problems, Energy Resources, Human Health
7. Air, Water soil and their pollution
8. Food Resources, Pesticides and Pest Control,
9. Land Management and Diversity
10. Economics, Politics, and Ethics

Lab work

1. Water Characterization, Alkalinity and Buffering Capacity of Water,
2. Examination of industrial waste water and Municipal sewage and sludge for: Total dissolved solids, pH and EC, BOD/COD, Chlorides, carbonate, and Nitrates,
3. Visits to environmentally compromised sites, disturbed ecosystems, different sanctuaries
4. Survey of different important species for conservation.

Recommended Texts

1. Fisher, M., (2018). *Environmental biology* (1st ed.). Medford: Open Oregon Press Book Publishing Company.
2. Ren, H. & Zhang, X., (2019). *High-risk pollutants in wastewater* (1st ed.). Amsterdam: Elsevier Publishing Company.

Suggested Readings

1. Sivasubramanian, V., (2016). *Environmental sustainability using green technologies* (1st ed.). Florida: CRC Press Taylor and Francis Group.
2. Calver, M., Lymbery, A. McComband, J. & Bamford, M. (2018). *Environmental biology* (1st ed.). England: Cambridge University Press.
3. Nriagu, J., (2019). *Encyclopedia of environmental health* (2nd ed.). Amsterdam: Elsevier Publishing Company.

BOTN-6328 **Plant Conservation Management** **3(2+1)**

The aim of the course is to provide updated knowledge of plant conservation, conservation in practice and conservation techniques for sustainable ecosystem management, to familiarize the students with threats to plant communities and its impact on population dynamics and economic development. Plants are the base for virtually all other life on Earth however humans appropriate approximately 1/3 to 1/2 of all plant productivity. The course provides a thorough introduction to the essential aspects of plant conservation including an overview of threats to the world's plant diversity, conservation genetics, conservation assessments and ways to minimize biodiversity loss. It includes an introduction to international legislations, politics and humans' role, both as threats and conservers of plant diversity. The course has a tropical focus and requires basic knowledge in plant biology at university level. This class will review the causes of plant species decline, the biological factors associated with small populations at both the ecological and genetic level, the current practices of population monitoring and management for conservation in both in-situ and ex-situ environments and the possibility of reintroduction.

Contents

1. Plant Conservation: Introduction, philosophy, origin, scope, objectives. Definitions
2. Understanding of Conservation: Biodiversity (types). Species (number), advantages of conservation (food, drugs and medicine
3. Extinction of Plant Species: Natural causes of Extinction. Anthropogenic (man-made) extinction, habitat destruction, Invasive species. Pollution, over harvesting, commercial products and life specimen, introduced species, predator and pest control, threats to species, over exploitation, introduced species, genetic problems in small population, risks reviews and dynamics of small population
4. Threats to Communities: Chains of extinctions, emergence of new species from old. Functional integrity in relation to fragment size
5. Conservation in Practice: Endangered species management and biodiversity protection, categorization of plant species, endangered species law. Bunting and fishing laws, the endangered species act, recovery plans, captive breeding and management plans, types of conservation (Ex-situ conservation), protected areas, conservation towards restoration of ecology, healthy approach to save biodiversity, saving rare species in the wild, habitat protection, private land and land critical habitat. Reauthorizing the endangered species.
6. Conservation Techniques: Parks and natural preserves, trouble in our parks and management. New parks establishment. Wildlife in parks, wilderness areas, wildlife refuges, refuge management, world conservation strategy.
7. Conservation and Economic Development: Indigenous communities and biosphere reserves, International wildlife preserves. Transboundary peace parks, preserving functional ecosystem and landscapes, landscape dynamics, size and design of nature preserves, wetland conservation.

Lab outline

1. Visit to Botanical garden. Governor House, Lahore
2. Visit to Bagh-e-Jinnah Lahore
3. Visit to Soon Valley, Pakistan
4. Visit to Botanical Garden, University of Agriculture. Faisalabad

Recommended Texts

1. Ortega-Rubio, A., (2018). *Mexican natural resources management and biodiversity conservation* (1st ed.). New York: Springer publication.
2. Blackmore, S., (2018). *Best plant conservation practices to support species survival in the wild* (3rd ed.). Amsterdam: Center for Plant Conservation.

Suggested Readings

1. Walker, T., (2015). *Plant conservation: why it matters and how it works* (5th ed.). Portland: Timber Press.
2. Blackmore, S. & Oldfield, S. (2017). *Plant conservation science and practice: the role of botanic gardens* (1st ed.). England: Cambridge University Press.

BOTN-6329 **Conservation Genetics** **3(2+1)**

The aim of the course is to provide updated knowledge of conservation genetics, scope of conservation genetics, values of biodiversity and loss of biodiversity, to familiarize the students with *conservation techniques and* genetic tools, genetic markers for assessing biodiversity. This course will introduce the principles and applications of conservation genetics, from assessing the genetic health of individuals and whole populations to deciding on species and sub-species divisions. The key genetic analyses employed in conservation genetics studies will be described and their technical and theoretical limitations discussed, as will their considerable power to inform key conservation decisions. It is becoming increasingly apparent that measures of genetic diversity should be included in our assessment of species health and future viability, to make the best decisions for their protection and management. As genetic techniques become more sophisticated and reliable, our use of them to support species conservation has similarly increased.

Contents

1. Introduction to plant conservation genetics, scope of conservation genetics, values of biodiversity and loss of biodiversity, Hardy-Weinberg principle, genetic drift, effective population size, population subdivision, quantitative genetics, molecular phylogenetics.
2. Genetic tools for conservation, genetic markers, inbreeding coefficients, conservation issue, met population and fragmentation, evolutionary significant units, conservation breeding.
3. Types of conservation: Forest conservation, wild plant conservation, invasive species study and control, medicinal plant conservation,
4. Conservation methods/techniques/management.
5. Natural and human-caused factors that cause plant species to be rare or imperiled and the genetic and ecological implications of rarity in plant species, conservation strategy for a rare or imperiled plant species, and applications of ecological and population genetics principles to evaluate the long-term viability of such a plant species with and without conservation measures.

Lab outline

1. Extraction of DNA from plant material by using CTAB method.
2. Molecular markers: SSR, Intron-polymorphisms, CAPS, AFLP, RAPD etc.
3. Analysis of morphological and molecular diversity in different cultivars/varieties of a crop plant.
4. QTL mapping (Theoretical using available data)
5. Field trips to the location of rare or threatened plant populations.

Recommended Texts

1. Ortega-Rubio, A., (2018). *Mexican natural resources management and biodiversity conservation* (1st ed.). New York: Springer publication.
2. Blackmore, S., (2018). *Best plant conservation practices to support species survival in the wild* (3rd ed.). Amsterdam: Center for Plant Conservation.

Suggested Readings

1. Walker, T., (2015). *Plant conservation: why it matters and how it works* (5th ed.). Portland: Timber Press.
2. Blackmore, S. & Oldfield, S. (2017). *Plant conservation science and practice: the role of botanic gardens* (1st ed.). England: Cambridge University Press.

BOTN-6330 **Basic Ecological Genetics** **3(2+1)**

This course elucidates the role of genetic techniques, genetic markers to assess the genetic diversity within and among the population. This course also provides an insight into gene flow and mating system and importance of biological and environmental factors on gene flow. The aim of this course is to provide the basics of the genetic component in functioning, development and sustainability of ecosystems with the main focus on forests and the associated communities. Sustainable development and biodiversity as well as increased impact of biotechnology became important present-day challenges and the basics of interaction between genetics and environment are needed to solve these problems. After completing the course students should obtain the basics of ecological genetics on one hand and breeding and biotechnology on another hand. This knowledge will allow the students to efficiently cope with the ecological problems connected with genetics to proceed with well-balanced approach to simultaneously maintain the ecological stability and economical benefit.

Contents

1. Ecological genetics What is ecological genetics? Why study ecological genetics.
2. Markers and sampling in ecological genetics Introduction, methods of data generation, principles of sampling within and among population.
3. Genetic diversity and differentiation. Introduction, factors influencing diversity and differentiation, The Hardy Weinberg Equilibrium, genetic diversity, genetic differentiation, genetic distance, statistical approaches, use of genetic diversity statistics.
4. Gene flow and mating system. Introduction, Factors governing gene flow. Considerations for measuring gene flow, measuring gene flow -indirect estimates, measuring gene flow -direct estimates. The importance of biological and environmental factors on gene flow.
5. Intraspecific phylogenies and phylogeography. Introduction, homology, gene trees and species trees, tree form and building, tree interpretation, organelles versus nuclear intraspecific phylogenies.
6. Speciation and hybridization. Introduction, species, speciation, hybridization, analysis of speciation and hybridization

Lab outline

1. Extraction of DNA from plant material.
2. Separation of DNA by gel electrophoreses.
3. Gene amplification through PCR
4. Graphical representation of speciation and hybridization data by UPGMA
5. DNA sequencing.

Recommended Texts

1. Daniel, L., & Cochrane, H. B. (2017). *Genetics: analysis of genes and genomes 9th Edition.* USA: Jones & Bartlett Learning.
2. Turnpenny, P. D., & Ellard, S. (2016). *Emery's elements of medical genetics.* Amsterdam: Elsevier.

Suggested Readings

1. Pierce, B.A. (2017). *Genetics: a conceptual approach.* 6th Edition. USA: W. H. Freeman.
2. Klug, W. S., Michael, R. Cummings, R. Spencer, C. A. Palladino, M. A. & Killian, D. (2018). *Concepts of genetics.* UK: Pearson.
3. Lewis, R., (2017). *Human genetics.* 12th Edition. USA: McGraw Hill Publication.

BOTN-6331 **Medicinal Plants** **3(2+1)**

The overall objective of this course is to improve students understanding of the uses and effects of medicinal plants, including herbal supplements, on people and their cultures or societies. The course topics will be taught from the perspective of how different cultures utilize medicinal plants. Students will learn how different cultures perceive diseases and then utilize plants to treat them. Currently medicinal plant usage is quite common, but how that use of medicinal plants is perceived depends on the society where they are used. The latter part of the course focuses on how societies in developed countries perceive, use and regulate plant medicines or herbal supplements. Finally, because all plants with bioactive compounds can't always be regulated, throughout the course students will learn how to evaluate claims made of specific plants and herbal supplements and will learn where to find reliable information about those plants and products. Use of plants for medicinal and other purposes; poisonous plants, cross-cultural aspects, chemistry and biological significance of natural products, and natural products from higher plants in modern medicine are discussed. This will focus on natural products extraction (hydrodistillation, solvent extraction, and quality control), assessment of dried botanicals, and quality assessment and sensory analysis of essential oils.

Contents

1. History of Medicinal plants. Traditional Medicinal systems: Ayurvedha, Siddha, Unani and Naturopathy. Cultivation, therapeutically and pharmaceutical uses of selected medicinal plants of Sargodha region. Historical account of medicinal plants in Pakistan. Establishment of medicinal plant gardens.
2. Definition of Drug-Classification of natural drugs: alphabetical, morphological, pharmacological and chemical .traditional and folklore medicine-native medicine drugs from leaves, flower, fruits and seeds, roots, bark (Cinchona) and wood (Ephedra)
3. Pharmacognosy-Definition and scope, drug adulteration, drug evaluation, chemical evaluation and biological evaluation of drugs, phytochemical investigations-quality control of herbal drugs.

Lab outline

1. Ethnomedicinal survey of various places
2. Preparation of herbarium sheets of ethnomedicinal plants.
3. Phytochemical analysis of ethnomedicinal plants.
4. HPLC of selected plant extracts

Recommended Texts

1. Akos, M. (2015). *Medicinal and Aromatic Plants of the World*: USA: Springer publishers.
2. Tránsito, M., L. Luengo and C. Máñez (2015). *Medicinal plants at home*: NYC: Skyhorse Publishers.

Suggested Readings

1. Krochmal, A., R.S. Walters and R.M. Doughty (2016). *A guide to medicinal plants of Appalachia*: NYC: Amazon publishers.
2. Kumar, A. (2016). *Handbook of medicinal plants*. NYC: Amazon publishers.
3. Da, H., J. Xiao, G. Pei and G. Xiao (2015). *Medicinal plants*. (1st ed.) Amsterdam: Elsevier Publsihers.

BOTN-6332 **Ethnobotany** **3(2+1)**

Ethnobotany is the scientific study of interactions between human cultures and plants/plant environments (the interrelationships between people and plants). This course examines many different levels and types of interactions between people and plants. The goal of this course is to introduce students to the fascinating world of the relationships between people and plants. The course offers a unique and multidisciplinary approach that includes plant structure and function, plant diversity, the origins of agriculture, and the uses of plants by peoples around the world. As plants are important to people, the course focuses on how plants affect human health, nutrition and well-being, interact with other organisms, and provide critical support to biodiversity. The course also offers important views on how people damage plants and their habitats, and how the reversion of this trend is important to secure the future of humankind. The course offers exciting insights into groups of economically important plants such as grasses, legumes, and staples, and how plants serve as a source of useful natural products. The course provides important examples on the economic importance of plants, and how the study of plants with a focus on medicine, health, and nutrition can shape the future careers of students.

Contents

1. Definition-Scope. History of ethnomedicinal plants. Traditional Medicinal systems:
2. Ayurvedha, Siddha, Unani and Naturopathy.
3. Definition of Drug-Classification of natural drugs, alphabetical, morphological, pharmacological, chemical and chemo taxonomical.
4. Traditional and Folklore medicines. Native medicine. Major tribes of the Sargodha region and their ethnobotanical and ethno-biological heritage.
5. Ethno Medicines. Ethnobotany and conservation of plants with special reference to Pakistan – mythology and conservation of ecosystems, conservation of selected plant species: sacred grove, forestry and unique ecosystems and their ethnobiological values, plants and animals in art, tradition and ethnography: Ethnobotanical field methods.
6. Pharmacognosy: Definition and scope,drug adulteration,drug evaluation;chemical evaluation, physical evaluation and biological evaluation.
7. Phytochemical investigations, standardization and quality control of herbal drugs.
8. Cultivation, collection and preparation of natural drugs. Macroscopic characters: physical and organoleptic characters, therapeutical and pharmaceutical uses of the local ethnomedicinal plans: Commercial value.

Lab outline

1. Ethnobotanical survey of various places
2. Preparation of herbarium sheets of ethnobotanical plants.
3. Phytochemical analysis of ethnobotanical plants.
4. HPLC of selected plant extracts.

Recommended Texts

1. Rafael, L., Casas, A., & Jose, B. (2016). *Ethnobotany of mexico*. USA: Springer publisher.
2. Albuquerque, A., Paulino, U., Alves, N., & Romeu, R. (2016). *Introduction to ethnobiology*. USA: Springer publishers.

Suggested Readings

1. Rainer, B. (2017). *Ethnobotany of the Caucasus*. USA: Springer Publisher.
2. Schmidt, B. M., Diana, M., & Cheng, K. (2017). *Ethnobotany: a phytochemical perspective*. New Jersey: Wiley publishers.
3. Pullaiah, T., Murthy K., & Bahadur, B. (2017). *Ethnobotany of India*. UK: Taylor and Francis Publishers.

BOTN-6333 **Biodegradation and Bioremediation** **3(2+1)**

This course will present the basic principles of chemical and biological degradation of toxic chemicals, and familiarize the students with the application of the remedial technologies in natural environments. Topics covered will include: 1) occurrence and ecological significance of toxic organic chemicals, 2) chemistry of contaminants, kinetics and mechanisms of degradation (chemical and biological), and 3) current technologies of bioremediation of contaminated soils and water. Bio/remediation as an option to treat contaminated soils and ground water. Advantages and disadvantages of bioremediation compared to non-biological processes. Biodegradation of specific contaminants (e.g. diesel fuel, polychlorinated biphenyls, dyestuffs, aromatic and poly-aromatic hydrocarbons) will be studied in detail. The investigation component of this course consists of learning how to do appropriate laboratory and field experiments to obtain data on microbial degradation of an organic pollutant to be able to calculate bioremediation design parameters such as mass and delivery rate requirements of electron acceptors and nutrients and degradation rates in reactor and non-reactor based systems; and to be aware of limitations of these calculations.

Contents

1. The environment and pollution: Introduction, environmental laws.
2. Treatment technologies: Traditional approaches to pollution control, Bio-treatment technologies for pollution control.
3. Biocatalyst selection and genetic modification: Enrichment and screening strategies, Design of enrichment strategies relating to the environmental source, Microbiological techniques for enrichment and selection, Genetic approach, The carbon cycle and xenobiotic compounds, Biodegradation and microbial technologies by microorganisms, Acclimation, Detoxification, Activation, Sorption, Bioavailability, Sequestering and complexing, co-metabolism, Environmental effects, Effects of metals and radionuclide on environment, Metal and radionuclide microbial treatment, Biotechnology for metal and radionuclide removal and recovery, Recalcitrant molecules

Lab outline

1. Isolation of bacteria from oil wastes, polluted water from industries and sewage.
2. Spray plate technique for testing the degradation ability of bacteria for different aromatic hydrocarbons.
3. Bioremediation from culture by metal resistant bacteria.

Recommended Texts

1. Kaushik, G. (2015). *Applied environmental biotechnology: present scenario and future trends*. Singapore: Springer Verlag.
2. Crawford, R.L. (2009). *Bioremediation principle and applications*. UK: Cambridge University Press.
3. Singh, H. (2006). *Mycoremediation: Fungal Bioremediation*. New Jersey: Wiley-Interscience.

Suggested Readings

1. Chang, W. (2017). *Biodegradation and bioremediation*. USA: Syrawood Publishing House.
2. Sangeetha, J., Thangadurai, D., Muniswamy D., & Abdullah, M.A. (2016). *Environmental biotechnology: biodegradation, bioremediation, and bioconversion of xenobiotics for sustainable development*. USA: Apple Academic Press.
4. Das, S. (2018). *Microbial biodegradation and bioremediation, reprint ed.* Amsterdam: Elsevier Science Publishing Co Inc.

BOTN-6334 **Water Pollution Management** **3(2+1)**

This course provides an overview of engineering approaches to protecting water quality with an emphasis on water treatment unit operations. It covers a wide range of topics, including water characterization parameters and designing systems to treat municipal and industrial wastewater, as well as the legislative framework. Water Pollution management and strategies is offered to students to let students know basic knowledge and control technologies of water pollution, so that they can solve problems on water treatment. An understanding of the physical, chemical and biological processes involved during contamination of water is essential if society is going to effectively monitor and control the effects of pollution using modern technology and engineering practices. A huge range of pollutants may be released into the aquatic environment during everyday domestic, leisure, industrial and commercial activities and many of these contaminants are potentially harmful to human health and the environment. In this course, we will focus on the origins, pathways and consequences of anthropogenic pollutants in the environment as well as discussing the various approaches to pollution control and remediation. At the end students will learn about the causes and harms of water pollution and their possible methods to remove the pollutants and contaminants.

Contents

1. Water pollution: Sources, types and their impacts; Pollution problems of groundwater resources, sources of contamination, management issues; Pollutants - sewage, pesticides, oils, metals, radioactive wastes, biomedical wastes, etc. Common transport processes of pollutants in the aquatic environment; dispersal of pollutants; Algal blooms and their management, Methods of pollution surveys; Waste disposal and water quality criteria used in different parts of world national and international standards; ISO-14000 (EMS), EIA, Management strategies'
2. Wastewaters - classification and characteristics of sewage and industrial effluents; treatment methods for water and waste water; Principles of aeration, chlorination, ozonation and U.V. irradiation; Waste recycling and utilization in aquaculture; Design and construction of water filtration devices; aerobic and anaerobic treatment of wastewater; Wastes from fish processing units and their treatment; solid waste management; removal of nitrogen and phosphorus from waste water; Role of aquatic macrophytes in treatment of waste water.

Lab outline

1. Determination of DO, BOD and COD of water.
2. Determination of total dissolved solids (TDS) of ground and surface water.
3. Estimation of amount of phosphate, sulphate, nitrate, nitrite, iron and magnesium and calcium in the ground and surface water.
4. Estimation of Ca, Mg, organic matter and phosphates in soil.
5. Collection and preservation of waste water samples; Physicochemical analysis of wastewater total dissolved and suspended solids, color, odor, DO, BOD, COD, H_2S, NH_3–N, NO_2-N, NO_3-N, PO_4-P, CH_4, heavy metals and pesticides.
6. Use of algae for organic waste treatment.
7. Visit to sewage treatment plants, fish processing units and other industries.

Recommended Texts

1. Chakraborty, D., & Mukhopadhyay, K. (2016). *Water pollution and abatement policy in india: a study from an economic perspective,*(1st ed.) USA: Springer.
2. McMillan, S. (2018). *Water pollution: types, causes and management strategies.* USA: Syrawood Publishing House.

Suggested Readings

1. Kneese, A.V. (2015). *Water pollution: economics aspects and research needs.* London, United Kingdom.
2. Rose, M., & Mendoza, O. (2016). *Water pollution and treatment.* Canada: Arcler Education Inc.
3. Humaira, Q., Bhat, R.A., Mehmood, M.A., & Dar, G.H. (2019). *Fresh water pollution dynamics and remediation,*(1st ed.) Berlin: Springer Verlag.

BOTN-6335 **Air Pollution Management Strategies** **3(2+1)**

In this course, students will learn effects of air pollutants on human beings, materials and the environment, what their sources are, and their physical and chemical behaviour in the atmosphere. This will introduce the nature of our atmosphere, its composition and meteorology, air pollutant emissions, air pollution chemistry and climate change / carbon management, together with the practical measures used to limit emissions from sources ranging from power stations to vehicles and the legislative and policy framework used by national and local authorities to enforce air quality objectives. Successful air quality management programs can reduce emissions that lead to air pollution while simultaneously providing other development benefits that accrue locally as well as globally. Benefits can include improved public health, energy savings, economic development, agricultural benefits and reduced emissions of greenhouse gases and other short-lived climate pollution. This course provides skills and information on how to monitor air pollution and increase public awareness, how to develop emission inventories and track progress, how to assess the benefits of air quality improvement, how to select control strategies that are most effective and will describe regulatory approaches that have been most effective elsewhere.

Contents

1. Nature and classification of pollutants, sources and effects of pollutants on plant growth viz; fluoride, Sulphur dioxide (SO_2), ozone, PAN + smog, ammonia, chlorine, ethylene, dusts etc., nature, causes, prevention and control of air pollution (vehicular pollution and industrial chimney wastes).
2. Air Pollution Sources: Origin, dispersion and impact on human, crops and forest of Particulates, Sulphur oxides, Nitrogen oxides & volatile organic compounds, carbon monoxide, carbon dioxide, Smog and PAN, MTBE (methyl tertiary butyl ether) and CFCs (chlorofluorocarbons),
3. Basic principles of air pollution management, ambient concentrations of air pollutants and trace gases, national environmental policies, implementation of policies and organization of management agencies, national air monitoring programme, effects of air pollution on human health, air quality criteria and case study, emergency preparedness, safety planning and management, vehicular pollution, monitoring and abatement technologies.
4. Air pollution control equipments, objectives and types of control equipments, efficiency of separating devices, control of particulate emission settlers, cyclones, filters, scrubbers and esps. Control of sulphur dioxide from lean and rich waste gases (recovery of sulphur and sulphuric acid).Control of NOx through absorption and other newer methods; control of vehicular emission (catalytic conversion devices); Indoor air pollution and its control.
5. Hazardous air pollutants and their management. Biological abatement of air pollution, scope of green belt development, economical aspect of air pollution abatement technologies.

Lab outline

1. Estimation of foliar dust deposition in samples collected from sites exposed to air pollution.
2. Determination of settled particulate matter in air.
3. Biomonitoring of heavy metals in the environment.
4. Mapping of vegetation of selected region by using Remote sensing data.
5. Field visits to industrial areas for on-spot biodiversity assessment and to prepare status report.

Recommended Texts

1. Vallero, D. A. (2014). *Fundamentals of air pollution*. Cambridge: Academic Press.
2. Vallero, D. A. (2019). *Air pollution calculations: quantifying pollutant formation, transport, transformation, fate and risks*. USA: Elsevier.

Suggested Readings

1. Guardia, M.D.L., & Sergio A. (2016). *The quality of air: Volume 73.* United Kingdom: Oxford Press.
2. Smedley, T. (2019). *Clearing the air: the beginning and the end of air pollution.* UK: Bloomsbury Sigma.
3. Tiwary, A., & Williams, I. (2018). *Air pollution: measurement, modelling and mitigation.* (4th ed.) USA: CRC Press.

BOTN-6336 Conservation Ecology 3(2+1)

This course will help the students to learn about the work of conservation biologists and study of ecosystems can help with conserving the world's biodiversity. Students will explore the impact of wind farms on populations of seabirds, and understand how the use of advanced techniques can be used to study different populations. It will also enable the students to know that how ecosystems are influenced by human activity and will explore the reasons behind the bee decline across the world, and examine fish species in tropical seas to see at first-hand how climate change damages coral reefs. Conservation ecology is the branch of ecology and evolutionary biology that deals with the preservation and management of biodiversity and natural resources. It is a discipline that is emerging rapidly as a result of the accelerating deterioration of natural systems and the worldwide epidemic of species extinctions. Its goal is to find ways to conserve species, habitats, landscapes, and ecosystems as quickly, as efficiently, and as economically as possible. Conservation, study of the loss of Earth's biological diversity and the ways this loss can be prevented. Biological diversity or biodiversity includes its ecosystems, species, populations, and genes.

Contents

1. Introduction to conservation ecology, history, importance of edaphic factors in conservation. Importance of topographic factors, biotic factors.
2. Ecosystem: Physical conditions and availability of resources.
3. Applied issues in conservation: Role of natural resources in conservation ecology.
4. Types of natural resources (renewable m non-renewable), wildlife management, species preservation, conservation of habitat, introduction of exotic species, natural parks, forests resources, soil and water resources, food and agriculture resources.

Lab outline

1. Visits to different disturbed ecosystem
2. Survey of different important species for conservation
3. Visit to different sanctuaries

Recommended Texts

1. Schowalter T. D. (2016). *Plant Ecology: An Ecosystem Approach.* United States: Academic Press.
2. Ent, A., Repin, R., Sagau, J., & Wong, K. (2015). *Plant Diversity and Ecology of outcrops in Malaysia.* United States: Springer.

Suggested Readings

1. Real, L. (2017). Ecological genetics. United States: Princeton University Press.
2. Kobori, H., Dicikinson, L. D., Washintani, I., Sakurai, R., & Amano, T. (2016). *A new approach to plant ecology and conservation.* United States: Springer.
3. Baer, H., & Singer, M. (2016). *Global warming and the political ecology of plants health.* United Kingdom: Rautledge Publishers.

BOTN-6337 **Plant Stress Physiology** **3(2+1)**

This course will provide an understanding of the unique features of plant cells and a general grounding on plant physiology and growth. In addition it will provide a brief introduction to the various physiological, molecular, and biochemical mechanisms plants use to respond to environmental stresses like extreme temperature, drought, salt, and pathogens. Any external factor that negatively influences plant growth, productivity, reproductive capacity, or survival is considered as a stress. Plants have to face different type of stresses and develop possible mechanism to compensate the effect of stress. In this course the students are expected to; learn the major principles of plant physiology and the crucial processes behind it (e.g. water and nutrient transport, photosynthesis, key regulatory hormones); gain understanding on the interaction between plants and the environment, become familiar with basic methodologies employed in these fields and to develop the skills to read relevant literature, to follow research seminars in these fields and to critically assess the presented information. This course will also allow the students to learn about the molecular mechanism of the plant to overcome /minimize the plant stress which affects the plant basic processes.

Contents

1. The history of stress research, general theory of stress.
2. Stress at plants at sub-cellular, cellular, organ.
3. Stress factors, classification of biotic, abiotic factors, methods of measurement
4. Signal transduction, molecular biological foundations of anti-stress reaction
5. Stress proteins, antioxidants - anti-stress response mechanisms
6. Stress lack / excess of available water (mechanisms to avoid stress)
7. Stress of substrate salinity, osmotic stress
8. Stress caused by toxic and foreign substances
9. Stress caused by cold, frost
10. Thermal stress (heat effects of physical, chemical, molecular and biological)
11. Radiation stress (regularly, classification, mechanisms of formation, mechanisms for protection)
12. Acclimation / adaptation to stress in extreme environments (deep oceanic waters, submarine volcanic eruptions, oceanic coastal areas, an extremely toxic habitats, alpine and polar regions, and desert biomes, extra-terrestrial systems). Plant responses to stress at multiple levels of integration - from the molecule to the whole plant. Global issues related to environment and plant stresses. Use of the primary scientific literature as a basis for the in-depth study of plant responses to environmental stress

Lab outline

1. Determination of water potential by pressure chamber
2. Determination of osmotic potential by osmometer
3. Investigation of osmolytes from plants growing under stress conditions
4. Estimation of antioxidant activity in plants under stress conditions

Recommended Texts

1. Mitra, G.N. (2015). *Plants: A Biochemical and Molecular* Approach. India: Springer.
2. Jugulam, M. (2017). *Biology, physiology and molecular biology of weeds*. United States: CRC Press.

Suggested Readings

1. Taiz, L., & Zeiger, E. (2019). *Plant physiology* 7th Edition. Unites States: Sinnauers Publ. Co. Inc.
2. Taiz, L., & Zeiger, E. (2018). *Fundamental of plant physiology*. Unites States: Sinnauers Publ. Co. Inc.
3. Buchanan, B., Gruissem, W., & Russell, L. (2015). *Biochemistry and molecular biology of plants*. Jones. United States: John Wiley & Sons.
4. Dennis, D. T., Turpin, D. H., Lefebvre, D. D., & Layzell D. B. (2016). *Plant* metabolism. (6th ed.) England: Longman Group.

BOTN-6338 **Advanced Plant Anatomy** **3(2+1)**

Plant anatomy is the study of the internal structure of plants. It plays a key role in understanding how plants function and is an essential component of much research. This course focuses on plants and provides with comprehensive, updated information about the organization, development, structure and function of plant cells, tissues and organs. It will enable the students to learn about the internal organization of the tissues and their types and when or where these specific types of tissues arise and perform specific function. The following learning outcomes are expected to be achieved through the study of this course i.e. Understand basic concepts and terminology in plant anatomy and various structures of seed plants in relation to their development, function and evolution, Explain how knowledge of plant anatomy is connected to our everyday life and practices in agriculture and forestry etc. The Plant Anatomy course will combine theory and practical so that participants can develop a sound understanding of the structure and function of plants. This subject has a vital role and helps to understand the internal organization of the plant.

Contents

1. Different types of Meristems: Organization of shoot and root apical meristems; Differentiation of primary and secondary plant body: Epidermis, Stomatal ontogeny, Cuticle and epidermal appendages; Secretory structures, Reproductive plant anatomy: Floral vasculature.
2. Secondary Xylem: Axial and ray system, Growth layers. Reaction wood, Gymnosperm wood, Angiosperm wood, Differentiation in secondary xylem, Strength of wood in relation to structure
3. Dendrochronology (Sap wood, Heart wood, Tension wood, Grain and Knot in wood) Healing of wounds, Secondary thickening growth in Monocots. More about Dendrochronology.
4. Stem: Tissue systems, Leaf traces, Leaf gaps, Branch traces and branch gaps, Vascular bundles,Concept of stele delimitation of vascular region, Endodermis, Pericycle, Origin of vascular cambium, Common forms of secondary growth
5. Anomalous Secondary Growth: Secondary growth in monocots, Grafting and wound healing
6. Types of Stems: Conifer. Woody dicotyledons, Dicotyledonous vine, Herbaceous, Dicotyledons,Herbaceous monocotyledons Crowns anatomy
7. Leaf: Histology of angiosperm, Leaf, Mesophyll, Bulliform cell, Vascular system, Bundle sheaths, Supporting structure, Secretary structures, Petiole, Histology of gymnosperm leaf, Development of leaf, Growth of leaf lamina, Monocotyledonous leaf, Development of vascular tissues, Abscission of leaves. Anatomy of the node
8. Root: Concept, Origin, Morphology, Primary structure, Root cap, Vascular cylinder, Development of histogens, Primary and secondary growth, Development of lateral roots, Development of adventitious roots, Development of buds on roots, Structure in relation to function. Root-Shoot Transition: Secretary structures, Glands, Nectaries, Hydathodes, Internal secretary structures, Laticifers. Root Apex: Root Apex in lower vascular plants, Gymnosperms, Angiosperms; Dicots and monocots,Colcorbizae.
9. Theories of structural development and differentiation (Stem and Root)
10. Flower: Concept, Structure, Vascular system, Different parts, Sepals, Petals, Stamen, Carpel, Ovule, Organogenesis, Histogenesis, Abscission, Structure of peduncle Petiole and Pedicle Anatomy, Resin canal in Plants
11. Anatomy of Reproductive parts: Seed, Grain, Fruit
12. Applied plant anatomy: Brief idea on the application of anatomical studies in climatology, Pharmacognosy, Forensic science, Archaeology and taxonomy. Anatomical adaptations
13. Molecular markers in tree species used for wood identification

Lab outline

1. Study of Tissues from the Living and Preserved Material of Stems, Roots and leaves.
2. Study of trichomes, sclereids,, tracheids, vessels and sieve tube elements.
3. Study of laticifers, oil glands, resin canals, cystolith and crystals.
4. Study of different types of stomata (monocots and dicots).
5. Anatomy of bark and lenticels
6. Nodal anatomy: Study of unilacunar, trilacunar, multilacunar. 7. TS, TLS and RLS of woody

Recommended Texts

1. Clive, A., Stace, C.A., & Crawley, M. J. (2015). *Alien* plants. United States: Harper Collins

Publishers.
2. Hather, J.G. (2016). *Archaeological Parenchyma*. United Kingdom: Routledge Publishers.

Suggested Readings

1. Steeves, T. A., & Sawhney, V. K. (2017). *Essentials of developmental plant anatomy*. United Kingdom: Oxford University Press.
2. Spichiger, R.E. (2019). *Systematic Botany of flowering plants: A new phytogenetic approach of the angiosperms of the temperate and tropical regions*. United States: CRC Press.
3. Cleal, C. J., & Thomas, B. A. (2019). *Introduction to plant fossils*. United Kingdom: Cambridge University Press.
4. Richard, C., Wise, L. S., & Robert, W. (2018). *Plant anatomy*. Germany: Springer-Verlag.

BOTN-6339 **Seed Production Technology** **3(2+1)**

The course is designed to enhance the students' knowledge of seed production and the key roles of bees and other insect pollinators, how to manage seed crops from agronomic, quality control, and genetic integrity standpoints, and how to meet new challenges through seed production research. Seed is the product of fertilized ovule that consists of embryo, seed coat, and cotyledon (s). In terms of seed technology, any part of the plant body which is used for commercial multiplication of crop is called seed. To make the available good quality seeds to the farmers, seed certification is necessary, which is a scientifically designed process. In our country seed certification is linked with notification of kind/variety. Only those varieties are eligible for certification, which are released and notified under Seeds Act. Seed testing is required to achieve the objectives for minimizing the risks of planting low quality seeds and the primary aim of the seed testing is to obtain accurate and reproducible results regarding the quality status of the seed samples submitted to the seed testing laboratories. After analyzing seed from each aspect i.e. disease, productivity and germination it is produced in bulk amount and brought to the market.

Contents

1. Reproductive process in plants. Definition of seed and planting material. Anatomy and chemistry of seed. Introduction to seed industry of Pakistan. Variety development, registration and maintains system.
2. Modern concept of quality and seed management. Production of early generation seed. Seed generation system from pre-basic to basic and certified. Seed quality system, legislation under seed (Amendment). Act-2015, crop inspection, seed testing, seed processing and storage.
3. Production of true to type disease free fruit nursery plant, hybrid seed production, establishment, planning and management of seed business, seed marketing and prices network.
4. Comparative study of various seed management systems in the world.

Lab outline

1. Lay out of seed adaptability and demonstration plot.
2. Visit to seed production plot and seed testing Laboratory to know the physical and analytical purity of seed lot,
3. Variety purity identification by using electrophoresis and DNA fingure printing techniques.
4. Assessment of seed viability and planting value by using tetrazolium test and vigor test.
5. Visit to variety breeding institute, seed farm and seed processing plant and seed storage.
6. An assignment/Mini project to assess the profit and loss of seed production entrepreneur.

Recommended Texts

1. Bhutta, A. R. (2010). *Introduction seed pathology*. Pakistan: HSC.
2. Khare, D., & Shale, M. S. (2014). *Seed technology* (2nd ed.) USA: Scientific Publisher.
3. Singh, S. (2014). *Seed Testing*. Pakistan: Gene Tech Book.

Suggested Readings

1. Hussain, A., & Bhutta, A. R. (2016). *Seed industry in pakistan*. Islamabad: FSC & RD/PSF..
2. Shagufta, S. (2012). *Seed science & seed technology*. India: APH Publisher.
3. Chakarborty, S. (2013). *Plant Molecular Genetics*. USA: Scientific Publisher.

BOTN-6340 **Seed Pathology** **3(2+1)**

Seed pathology involves the study and management of diseases affecting seed production and utilization, as well as disease management practices applied to seeds. International seed trade has been affected significantly by changing phytosanitary regulations, not always based on science. This course deals with the History, economic importance, dynamic of transmission of plant pathogens, methodology and control measures of seed borne diseases. Seed pathology as a subdisipline of plant pathology is relatively new. Recent developments in the area of seed pathology technology allow for more ecofriendly seed treatments and more reliable seed health testing. Due to economics and new interest in environmental issues, research into the viability of biological seed treatments is becoming more common. The use of sophisticated DNA amplification technologies allows for the detection of seed borne pathogens that might go undetected using more conventional means. For the farmers seeds are not produced and collected in appropriate scientific technology rather these are the portions of grain cash crop harvested for their consumptions. However, the seed organizations in the country are still not so aware of the impact of unhealthy seeds which affect directly or indirectly the crop productivity and sustainable food security in the country.

Contents

1. Emergence of seed pathology as an independent discipline and its significance.
2. Morphological and anatomical studies of healthy and infected seed and planting material by using molecular techniques.
3. Effect of seed borne disease on seed viability and planting value. Histopathological study of infected seed, transmission of seed borne pathogens and their establishment in host and then to seed.
4. Mycotoxicological problems induce by seed borne pathogens and their health hazards. Identification of economical important seed borne disease and their post-harvest losses in agriculture and horticulture crops. Seed health technology and seed health certification system for production of disease free seed and inspection of seed consignments during export import and testing of germplasm material.
5. Concept of GMO in management of seed borne disease. Management of commercial scale production of disease free forest nursery and fruit plant certification. Seed and planting material national health standard under the seed (Amendment) Act-2015.Bioterrorism, SPS measures and international obligations.

Lab outline

1. Collection of seed samples as per ISTA rules,
2. Isolation of pathogen, identification and preservation of culture.
3. Histopathology of healthy and infected seed.
4. Effect of different chemicals and antagonistic microorganisms on seed borne pathogens and seed germination.
5. Field crop inspection for disease assessment.
6. Visit to seed health testing lab, seed processing plants and seed storage.

Recommended Texts

1. Bhutta, A. R. (2010). *Introductory seed pathology*. Pakistan: HEC.
2. Ahmed, S. (2009). *Plant Disease Management for Sustainable Agriculture*. India: Daya Publishing House.

Suggested Readings

1. Agarwal,V. K. (2014). *Management of Seed Borne Disease*. India: Agrobios.
2. Agrios, G. N. (2005). *Plant Pathology*. United States: Academic Press.
3. Sharma, R.C., & Sharma, J. N. (2011). *Integrated plant disease management*. United States: Scientific Publishers.