UNIVERSITY OF SARGODHA

Office of the Registrar

No SU/CE 4268

Dated 07/12/20

Ref: SU/Acad/1054
December/07/2020

Notification

The Academic Council in its meeting held on 18.06.2020 has approved the following recommendations made by the Board of Faculty of Sciences in its meeting held on 03.06.2020. The Syndicate in its meeting held on 27.07.2020 has also endorsed the decision of Academic Council:

1. Revised scheme of studies of BS Botany under Semester / Term System from session 2020 (Annex-'A')
2. Revised scheme of studies of MSc Botany under Semester / Term System from session 2020 (Annex-'B')
3. Revised scheme of studies of MPhil Botany from session 2020 (Annex-'C')
4. Revised scheme of studies of PhD Botany from session 2020 (Annex-'D')
5. Revised Scheme of Studies of MSc Botany under the Annual System from session 2020 (Annex-'E')

Muhammad Farooq
Deputy Registrar (Acad)

07/12/2020

Distribution:

- Chairman, Department of Botany
- Director, Sub-Campus Bhakkar
- Controller of Examinations
- Principals of all affiliated colleges (concerned)
- Web-Developer *(for uploading on university web-site)*

C.C:

- Focal Person, Faculty of Sciences
- Deputy Registrar (Affiliation)
- Deputy Registrar (Registration)
- Secretary to the Vice-Chancellor
- P.A to Registrar

For action pl.

07/12/20

07/12

DCE(S)

DCE(SS)

REVISED SCHEME OF STUDIES & CURRICULUM
MSc BOTANY TWO YEARS PROGRAMME
(Annual System)
(2020)

DEPARTMENT OF BOTANY

UNIVERSITY OF SARGODHA

SARGODHA - PAKISTAN

SCHEME OF STUDIES -MSc BOTANY 2 YEARS ANNUAL SYSTEM PROGRAM FOR AFFILIATED (Pvt.) COLLEGES
(2020)

MSc-Two Years ***Botany*** program comprises of two parts with 12 courses in total. Six courses have to be studied in Part I and Six courses have to be studied in Part II. Outline of the courses is as under.

Duration of the Program:

The duration of MSc Botany is two years (Part I & Part II)

Main Features of MSc Botany Program/Credit Requirements

Major Subject: Botany

Duration: 02 years (Part I & Part II)

Degree Requirements: All 12 courses have to be cleared both in theory and practical separately. Each course will have a separate paper of theory (75 marks) and a respective separate paper for practical (25 marks).

Candidate has to pass each subject separately both in theory and practical.

MSc 2 YEARS (ANNUAL) PROGRAM IN BOTANY FOR AFFILIATED COLLEGES (2020)

Annexure-A

Part-1

Paper	Course Title	Marks	Theory	Practical
Paper I	Phycology and Bryology	100	75	25
Paper II	Mycology and Plant pathology	100	75	25
Paper III	Plant Biochemistry	100	75	25
Paper IV	Morphology and Anatomy of Vascular Plants	100	75	25
Paper V	Bacteriology and Virology	100	75	25
Paper VI	Cell and Molecular Biology	100	75	25

Part-2

Paper VII	Genetics	100	75	25
Paper VIII	Plant Ecology	100	75	25
Paper IX	Plant Physiology	100	75	25
Paper X	Plant Systematics and Taxonomy	100	75	25
Paper XI	Biostatistics and Mathematics	100	75	25
Paper XII*	Optional Paper-I/Thesis	100	75	25
Paper XIII*	Optional Paper-II/Thesis	100	75	25

Total Marks: 1300

Elective courses will be offered from the list attached depending upon resources of the department and thesis would be of 200 marks in place of paper XII and XIII.

Note: Each theory will carry 75 marks, whereas each practical paper will carry 25 marks, whenever applicable.

Annexure-B

List of Optional Papers

Optional	Environmental and Conservation Biology	100	75	25
Optional	Plant Cell Tissue and Organ Culture	100	75	25
Optional	Recombinant DNA Technology	100	75	25
Optional	Trends in Molecular Genetics	100	75	25
Optional	The Biochemistry of the Nucleic Acids	100	75	25
Optional	Biodegradation and Bioremediation	100	75	25
Optional	Plant Biotechnology- I	100	75	25
Optional	Plant Biotechnology- II	100	75	25
Optional	Research Methodology	100	75	25
Optional	Plant Conservation Management	100	75	25

Paper I **Phycology and Bryology** **Marks: 100 (75+25)**

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: Chlorophyta, 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 work

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
1. 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.

Paper II **Mycology and Plant Pathology** **Marks: 100 (75+25)**

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

1. Mycology: Introduction: General characters of fungi, Thallus, cell structure and ultra structure of fungi. Reproduction: Asexual and sexual reproduction and reproduction structures, life cycle, haploid, heterokaryotic and diploid states.
2. 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.
3. Symbiotic relationships of fungi with other organisms (lichens and mycorrhiza) and their significance.
4. Importance of fungi in human affairs with special reference to Industry and Agriculture.
5. Pathology: Introduction and classification of plant diseases. Symptoms, causes and development of plant diseases.
6. Loss assessment and disease control
7. Epidemiology and disease forecast
8. Important diseases of crop plants and fruit trees in Pakistan caused by fungi, e.g. damping off, mildews, rusts, smuts, dieback, red rot of sugarcane etc.
9. Systemic resistance: Induced systematic resistance (ISR), Acquired Systematic resistance (ASR).

Lab work

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* (1sted.). 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

Paper III **Plant Biochemistry** **Marks: 100 (75+25)**

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

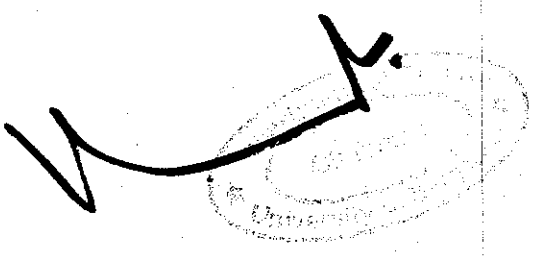
chemical science - it explores the chemistry of living organisms and the molecular basis for the changes occurring in living cells. It uses the methods of chemistry, "Biochemistry has become the foundation for understanding all biological processes. The course aims to provide an advanced understanding 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. Carbohydrates: Occurrence and classification: A general account of ribose, deoxyribose, xylulose, xylose, D-glucose, D-galactose, D-mannose, cellobiose, sucrose, maltose, trehalose, pentosans, fructosans, starch, cellulose, pectins and lignins.
2. Lipids: Occurrence and classification: Structure and chemical properties of fatty acids, triglycerides, phospholipids, glycolipids, sulpholipids, waxes and sterols.
3. Proteins: Amino acids 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.
4. Nucleic Acids: General introduction: Purine and pyrimidine bases, nucleosides, nucleotides. Structure and properties of DNA and RNA. Types and functions of RNA. Chemical synthesis of oligonucleotides and DNA sequencing. DNA restriction enzymes, properties of DNA polymerase.
5. 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.
6. Metabolism: Biosynthesis, degradation and regulation of sucrose and starch. Biosynthesis of fats, breakdown of fats with special reference to beta-oxidation and its energy balance. Replication of DNA. Reverse transcription. Biosynthesis of DNA and RNA. Components of protein synthesis. Genetic code, protein synthesis: initiation, elongation and termination.
7. Alkaloids: Occurrence, physiological effects, chemical nature with special reference to solanine, nicotine, morphine, theine and caffeine. Aflatoxins their nature and role.
8. Terpenoids: Classification monoterpenes, sesquiterpenes, diterpenes, triterpenes, tetraterpenes, polyterpenes and their chemical constitution and biosynthesis.
9. Vitamins: General properties and role in metabolism.

Lab work

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

Paper IV **Morphology and Anatomy of Vascular Plants** **Marks: 100 (75+25)**

The aim of the course is to provide the students understanding about morphological and 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. This course gives information about 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. Identify the anatomy and morphology (cells, tissues, and tissue systems) of a given plant root. 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. 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 *Azolla/Marsilea*).
2. Gymnosperms: Geological history, origin, distribution, morphology, classification and affinities of Cycadofillicales, Bennettitales, Ginkgoales, Cycadales, and Gnetales. Origin and Evolution of seed habit. Distribution of gymnosperms in Pakistan. Economic importance of gymnosperms. An introduction of Gondwana flora of world.
3. Palynology: An introduction to Neopalynology and Paleopalynology, its applications in botany, geology, archaeology, criminology, medicines, honey and oil and gas exploration. Basic information about the nomenclature, morphology and classification of living and fossil pollen and spores.
4. Angiosperms: Origin of angiosperms, Evolution of fruit habit
5. Anatomy: plant body and its development: fundamental parts of the plant body, internal organization, different tissue systems of primary and secondary body.
6. Meristematic tissues: classification, cytohistological characteristics, initials and their derivatives.
6. Apical meristem: Delimitation, different growth zones, evolution of the concept of apical organization, Shoot and root apices.

7. 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.
8. 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 stem. Abnormal secondary growth.
9. 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.
10. Secretory tissues: Laticifers (classification, distribution, development, structural characteristics, functions) and resin Canals.
11. Anatomy of reproductive parts: Flower, Seed, Fruit
12. Economic aspects of applied plant anatomy
13. Anatomical adaptations
14. Molecular markers in tree species used for wood identification.

Lab work

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 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.
4. Study of abnormal/unusual secondary growth.
5. Peel and ground sectioning and maceration of fossil material.
6. 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.* USA: Springer.
2. Koelling, C. (2016). *Plant Anatomy, Morphology and Physiology.* USA: Syrawood Publishing House.
3. Cutler, D.F., Botha, T., & Stevenson, D. (2008). *Plant Anatomy: An Applied Approach.* USA: John Wiley & Sons.

Suggested Readings

1. Pandey, B.P. (2001). *Plant Anatomy.* India: S. Chand Publisher.
2. Dickison, W.C. (2000). *Integrative Plant Anatomy.* USA: Academic Press.
3. Esau, K. (2006). *Esau's Plant Anatomy* (3rd ed.). USA: John Wiley & Sons, Inc.

Paper V **Virology and Bacteriology** **Marks: 100 (75+25)**

The aim of the course is 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 are 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

9. History, characteristics and classification.
10. Evolutionary tendencies in Monera (bacteria, actinomycetes and cyanobacteria)
11. Morphology, genetic recombination, locomotion and reproduction in bacteria
12. Bacterial metabolism (respiration, fermentation, photosynthesis and nitrogen fixation)
13. Importance of bacteria with special reference to application in variousmodern Sciencesspecially agriculture, biotechnology and genetic engineering.
14. Symptoms and control of major bacterial diseases in Pakistan
15. Plant microbe interaction

Lab work

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.
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.

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.

Paper VI **Cell and Molecular Biology** **Marks: 100 (75+25)**

Cell and 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. Structural organization of cell
2. Structure and function of biomolecules: Carbohydrates, Proteins, lipids and Nucleic acids
3. Molecular organization of cell membrane and cell wall
4. The cytoskeleton and cell mobility
5. Ultrastructure and function of cell organelles: Endoplasmic reticulum, Dictyosomes, Mitochondria, Plastids, Ribosomes, Peroxisomes, Glyoxisomes and Lysosomes.
6. Nucleus, Nucleolus and ultrastructure and morphology of chromosomes. Karyotype analysis.
7. Reproduction: Cell cycle, Mitosis and Meiosis
8. Chromosomal aberrations: Change in chromosome number, aneuploidy and Euploidy, Changes in chromosome structure: Deficiency, duplication, inversion and translocation
9. Gene regulation in Eukaryotes
10. The genetic code and genetic engineering

Lab work

1. Study of cell structure using compound microscope
2. Measurement of cell size
3. Study of mitosis and meiosis by smear/squash preparation and from prepare slides
4. Biochemical tests for starch, protein, cutin, carbohydrates from plant material
5. Study of different types of plastids
6. Study of streaming of movement in staminal hair of Trades cantia
7. Extraction and estimation of carbohydrates, proteins, DNA and RNA from plant sources

Recommended Texts

1. Verma P.S. & Agarwal, V.K. (2016). *Cell Biology (Cytology, Biomolecules and Molecular Biology)*. India: S. Chand Publishing.
2. Lodish, H. Berk, A., Kaiser, C., Krieger, M. & Bretscher, A. (2016). *Molecular Cell Biology* (8th ed.). USA: W.H. Freeman-Macmillan Learning.
3. Clark, D., Pazdernik, N. & McGehee, M. (2019). *Molecular Biology*. Amsterdam: Elsevier Inc.

Suggested Readings

1. Templeton, N.S. (2015). *Gene and Cell Therapy* (4th ed.). Florida: Taylor and Francis publications.
2. Sybille, M. & Shoshan, M. (2015). *Tumor Cell Metabolism*. USA: Springer publications.

Paper VII **Genetics** **Marks: 100 (75+25)**

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 the 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, universitality of genetic information transfer, eukaryotic RNA.
8. The Extranuclear Genome: Variegation in leaves of higher plants, cytoplasmic inheritance in fungi, extranuclear genes in *Chlamydomonas*, mitochrondrial genes 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.
11. Gene Mutation: Somatic versus germinal mutation. Mutant types, the occurrence of mutations. Mutation and cancer. Mutagens in genetic disorder, mutation breeding, evolutionary significance of mutation.
12. 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.
13. Mechanisms of Genetic Change II: Recombination: General homologous recombination, the holiday model, enzymatic mechanism of recombination, site-specific recombination, recombination and chromosomal rearrangements.

14. 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.
15. 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 methodology, Site directed Mutagenesis, DNA sequencing.
16. Plant Genome Projects: Arabidopsis, achievement and future prospects. Other plant genome projects
17. Bioinformatics: Application of computational tests to the analysis of genome and their gene products.
18. Bioethics: Moral, religious and ethical concerns

Lab work

Numerical Problems

1. Arrangement of genetic material: Linkage and recombination, Gene mapping in diploid, Recombination in fungi, Recombination in bacteria, Recombination in viruses
2. Population genetics: Gene frequencies and equilibrium, Changes in gene frequencies,
3. Blood group and Rh-factor
4. Drosophila: Culture technique, Salivary gland chromosome
5. Fungal Genetics; Saccharomyces culture techniques and study.
6. Studies on variation in maize ear size and colour variation
7. Bacterial Genetics: Bacterial cultural techniques, Gram staining (*E. coli* and *B. subtilis*), Transformation, 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.

Paper VIII **Plant Ecology** **Marks: 100 (75+25)**

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. Eco physiological effects of changing atmospheric CO_2concentration.
5. Functional significance of different pathways ofCO_2 fixation. Productivity: response of photosynthesis to environmental factors, C and N balance.
6. 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.
7. Oxygen deficiency: Energy metabolism of plants under oxygen deficiency, morph-anatomical changes during oxygen deficiency, post-anoxic stress.
8. Wind as an ecological factor.
9. Fire as an ecological factor.
10. Carbon credit
11. Population Ecology: Population structure and plant demography: Seed dispersal, dormancy, seed bank, seed dormancy, recruitment, demography. Life history pattern and resource allocation: Density dependent and density independent factors, resource allocation, reproductive effort, seed size vs. seed weight, population genetics and evolution.
12. Community Ecology:
13. Historical development of community ecology, community concepts and attributes, methods of sampling of plant communities, ecological succession, community soil-relationship, local vegetation, vegetation of Pakistan, major formation types of the world.
14. Ecosystem Ecology:
15. Ecological concepts of ecosystem, boundaries of ecosystem. Compartmentalization and system concepts. Energy flow in ecosystem. Biogeochemical cycles: Water carbon and nitrogen. Case studies, any example.

Lab work

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.
7. Pressure potential, leaf area and rate of CO_2 exchange in plants in relation to various environmental conditions.
8. Determination of seed bank in various populations.
9. Seed dispersal pattern of local populations.
10. Demography and life history of local annual population.
11. Study of community attributes. Sampling of vegetation including Quadrat, plot less, transect and Braun-Blanqut.
12. Field trip to study different communities located in different ecological regions of Pakistan.
13. Slide show of the vegetation of Pakistan.
14. Slide show of the major formations of the world.
15. Soil physical and chemical properties.
16. Correlation of soil properties with vegetation type.

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

Paper IX **Plant Physiology** **Marks: 100 (75+25)**

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-1 and 11, absorption and action spectra of different pigments. Mechanism of photosynthesis - light absorption, charge separation or oxidation of water (Water Oxidizing Clock), electron and proton transport through thylakoid protein-pigment complexes. Photophosphorylation and its mechanism, CO_2 reduction (dark reactions) - C_3 pathway and Photorespiration, regulation of C_3 pathway, C_4 pathway and its different forms, C_3-C_4 intermediates, CAM pathway. Methods of measurement of photosynthesis.
2. Respiration: Synthesis of hexose sugars from reserve carbohydrates. Mechanism of respiration: Glycolysis, differences between cytosolic and chloroplastidic glycolysis, oxidative decarboxylation, Krebs cycle, regulation of glycolysis and Krebs cycle.Electron transport and oxidative phosphorylation. Aerobic and anaerobic respiration. Energetics of respiration. Pentose phosphate pathway. Glyoxylate cycle. Cyanide resistant respiration.
3. Translocation of Food: Pathway of translocation, source and sink interaction, materials translocated, mechanism of phloem transport, loading and unloading.
4. Leaves and Atmosphere: Gaseous exchange, mechanism of stomatal regulation. Factors affecting stomatal regulation.
5. Assimilation of Nitrogen, Sulphur and Phosphorus: The nitrogen cycle. Nitrogen fixation. Pathways of assimilation of nitrate and ammonium ions. Assimilation of sulphur and phosphorus.
6. Plant Growth Regulators: Major natural hormones and their synthetic Analogues. Bioassay, structure, biosynthesis, receptors, signal transduction and mode of action, transport, physiological effects of Auxin, Gibberellins, Cytokinins, Abscisic acid, Ethylene, Polyamines, Brassinosteriods, Jasmonates, and Salicylic acid.
7. Water Relations: The soil -plant -atmosphere continuum - an overview. Structure of water. Physico-chemical properties of water. Water in the soil and its potentials. Water in cell components.

Absorption of water in plants (pathways and driving forces, Aquaporins,-their structure and types). Cell water relations terminology. 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, pressure volume curve.

8. Plant Mineral Nutrition: Inorganic composition of plant and soil. Absorption of mineral nutrients - roots, mycorrhizae. Effect of soil pH on nutrient availability. Ion traffic into root. The nature of membrane carriers, channels and electrogenic pumps. Passive and active (primary and secondary) transports and their energetic. Essential and beneficial elements-their functions and deficiency symptoms in plants. Fertilizers and their significance in Agriculture.
9. 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.
10. 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.
11. Floral meristem and floral organ development. Floral organ identity genes and the ABC model.
12. Gene regulation and Signal transduction in prokaryotes and eukaryotes: Genome size and organization. Gene regulation in prokaryotes and eukaryotes.
13. Signal transduction in prokaryotes and eukaryotes.

Lab work

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.

Paper X **Plant Systematics and Taxonomy** **Marks: 100 (75+25)**

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 analyse 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; 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. 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), Capparidaceae, Caryophyllaceae, Chenopodiaceae, Convolvulaceae, Cucurbitaceae, Cyperaceae, Euphorbiacea, Fabaceae (Leguminosae), Lamiaceae (Labiatae), Liliaceae, Magnoliaceae, Malvaceae, Myrtaceae, Orchidaceae, Papaveraceae, Poaceae (Gramineae), Ranunculaceae, Rosaceae, Salicaceae, Scrophulariaceae, Solanaceae, Cannaceae, Juncaceae, Trochodendraceae, Winteraceae

Lab work

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.

Paper XI **Biostatistics and Mathematics** **Marks: 100 (75+25)**

To produce students, that has applicable knowledge about statistics, which they apply in different fields of study. Course aimed at providing students with a formal treatment of biological data. The course explores the basic concepts of Biostatistics and its applications. The goal is to provide students, to the community with high skills to play the major role in statistics by using the knowledge of biological variables and their analysis. The course is heavily oriented with tools for analyzing biological data through statistical methods with practical applications, and to prepare the students, not majoring in mathematics, with the essential tools of algebra to apply the concepts and the techniques in their respective disciplines. The purpose of the course is to give students an introduction to the discipline, an appreciation of a statistical perspective on information arising from the health arena and basic critical appraisal skills to assess the quality of research evidence.

Contents

Biostatistics
1. Definition of biostatistics, viz-a-viz the type of variables and observations in biological.
2. Health and medical sciences, uniqueness in terms of behavior of variables their domain, and units.
3. Categorical, numerical and censored data. Populations, target populations and samples.
4. Role of sampling in Biostatistics, size of samples of various types of studies, Proportions, rates and ratios; incidence, prevalence odds.
5. Distributional Behavior of biological variables (Binomial, Poisson and Normal), Role of transformation for analysis of biological variables.
6. Prob it and Log it transformation and their analysis, p values, its importance and role.
7. Confidence interval in simple and composite hypothesis testing.

Mathematics
1. Real Numbers, Relations and Functions, Inequalities.
2. Quadratic Functions and Complex Numbers, Sequence and Series.
3. Trigonometric Functions, Trigonometric Applications,
4. Graph of Functions and Modelling, Limits and Continuity, Derivatives, Integration, Probability and Binomial Theorem.

Recommended Texts

1. Zar, J. (2000). *Bostatistical Analysis* (5th ed.). USA: John Wiley & Sons.
2. Gantert, A. X. (2009). *Algebra 2 and Trigonometry*. New York: AMCOS School Publication Inc.
3. Thomas G.B. & Finney A.R. (2002). *Calculus* (10th ed). USA: Addison-Wesley.

Suggested Readings

1. Dainel, W.W. (1996). Biostatistics: A Foundation for the Health Sciences (6th ed.). New York: John Wiley.
2. Diggle, J.P, Liang, Kung-Yee & Zegar, S.L. (1996). Analysis of Longitudinal Data (1st ed.). Oxford: Clarendon Press.

(Optional Papers)

Environmental and Conservation Biology **Marks: 100 (75+25)**

The aim of the course is to provide updated knowledge of environmental problems, its conservation 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.
18. Physical conditions and availability of resources: Introduction, environment conditions, effect of condition, animal responses, microorganisms, plant resources and animal resources.
19. Applied issues in conservation: Sustainability, forming of monoculture and pest control.
20. Role of natural resources in conservation: Types of resources (renewable and non-renewable), wild life management, species conservation, conservation of habitat, introduction of exotic species, natural parks, forest resources, soil and water resources, food and agriculture resources.

Lab work

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. Survey of different important species for conservation.
5. Visits to different sanctuaries.

Recommended Texts

1. Ren, H. & Zhang, X. (2019). *High-risk pollutants in wastewater* (1st ed.). USA: Elsevier Publishing Company.
2. Nriagu, J. (2019). *Encyclopedia of environmental health* (2nd ed.). Elsevier Publishing Company.
3. Fisher, M. (2018). *Environmental biology* (2nd ed.). Oregon: Open Oregon Press Book Publishing Company.

Suggested Readings

1. Sivasubramanian, V. (2016). *Environmental sustainability using green technologies* (1st ed.). USA: CRC Press Taylor and Francis Group.
2. Calver, M., Lymbery, A. McComband, J. & Bamford, M. (2017). *Environmental biology* (1st ed.). UK: Cambridge University Press.

Plant Cell Tissue and Organ Culture **Marks: 100 (75+25)**

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 work

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.

Recombinant DNA Technology **Marks: 100 (75+25)**

The aim of the course is to introduce students to recombinant DNA technologies like genetic engineering, cloning strategies, PCR and genetic markers and its applications on plant improvements, 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. Introduction: Agarose-gelelectrophoresis, southern, northern and western blotting, transformation of *E. coli.* And other organisms.
2. Cutting and joining DNA molecules: Cutting DNA molecules, host controlled restriction and modification. Nomenclature, target sites, mechanical shearing of DNA, joining DNA molecules, DNA ligase, double linkers, adopters, homopolymer tailing.
3. Cloning *E. coli.* Plasmids as cloning vehicles, basic properties of plasmids ,properties of plasmid cloning vehicles, copy number plasmid vectors. Bacteriophage and cosmid vectors for *E.coli.* Bacteriophage, cosmid vectors, DNA cloning with single stranded DNA vectors, filamentous phage vectors.
4. Site directed mutagenesis. Analyzing DNA sequences. Cloning strategies, Genomic DNA libraries, Chromosome walking, cDNA cloning. Recombinant selection and screening. Genetic methods, immunochemical methods. Nucleic acid hybridization methods. Expression in *E.coli* of cloned DNA molecules. The effect of plasmid copy number, plasmid stability. Applications of recombinant DNA technology.

Lab work

1. *E.coli* culture and growth curve.

2. Transformation of plasmid DNA to *E.coli.* Conjugation.
3. Extraction of plasmid DNA.
4. Gel electrophoresis. Detection of plasmid DNA on gel electrophoresis.
5. Polyacrylamide gel electrophoresis. Detection of bacterial proteins.

Recommended Texts

1. Abdin, M.Z., Kiran, U. Kamaluddinand, A. & Ali, M.A. (2017). *Plant biotechnology: principles and applications* (1st ed.). NYC: 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.). NYC: Springer.

Suggested Readings

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

Trends in Molecular Genetics **Marks: 100 (75+25)**

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. Autonomous Replicating Genetics Entities: Plasmid, Plasmid replication and maintenance. Plasmid replication, different mechanisms of regulation of plasmid replication, genes involved instable maintenance. Plasmid born functions. Transfer function, resistances to antibiotics and loxk ions, Bacteriocin and toxin production, plasmid involvement in host metabolism. Nomenclature of plasmids and plasmid born functions. Transposable Elements: Symbols and nomenclature, Transposable elements in Gram-negative bacteria, Structure of transposable elements: Class 1. Class II. Class III. Class IV and Class V, Genetic features associated with transposition, Transposition mechanisms, Role of mobile elements in evolution
2. Protection DNA Integrity. DNA Methylation and the Restriction: Modification, System, Restriction-modification phenomenon, Discovery, General features of DNA methylation, The host specificity of DNA (Hsd) systems, The methylated-adenine (Mar or Mrr) and methylated cytosine (Mcr)
3. Restriction system of E. *Coli*: Other modification and/or restriction system. The DNA adenine-methylation (Dam) and DNA cytosine-methylation (Dem)systems
4. Restriction-modification and evolution
5. DNA Repair: Classification of repairable lesions, Direct repair, Base excision repair, Nucleotide-excision repair, Recombination (or post replication) repair, Cross-link repair, Mismatch repair, Inducible repair

6. Homologous Genetic Recombination-: The Rec. A pathway of *E. coli,* Mechanism of recombination, The recombination pathways in other organisms
7. Genetics with Transposons: Transposons-induced mutagenesis, Transposable elements arid the development of genetics in new species, *In vitro* gene fusion

Lab work

1. Transformation, Conjugation.
2. Mutagenesis.
3. Plasmid DNA preparation's (mini preps).
4. Agarose gel electrophoresis.

Recommended Texts

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

Suggested Readings

1. Carey, N. (2016). *The Epigenetics Revolution* (1st ed.). London: Icon Books Ltd.
2. Doudna, J., Samuel, H., & Sternberg, A. (2017). *A Crack in Creation* (1st ed.). USA: Houghton Mifflin Harcour.

The Biochemistry of the Nucleic Acids **Marks: 100 (75+25)**

Nucleic acids, deoxyribonucleic acid (DNA) and ribonucleic acid (RNA), carry genetic information which is read in cells to make the RNA and proteins by which living things function. The well-known structure of the DNA double helix allows this information to be copied and passed on to the next generation. This course elucidates the structural and functional role of nucleic acids in plants as carrier of genetic information and key players in protein synthesis. This course also provides an insight about regulation of gene activity in prokaryotes and eukaryotes through Lac. Operon model. Also includes valuable information on genetic engineering and its applications. Discusses nucleic acid structure, and also describes techniques for manipulating and analyzing nucleic acids, including gel electrophoresis, PCR, and DNA sequencing. Reviews methods used to synthesize nucleosides, nucleotides and oligonucleotides, and chemical reactions that lead to modifications of nucleic acids.

Contents

Nucleic Acids

1. Transcription and Translation: DNA as a carrier of genetic information, double-helical structure of DNA, forces stabilizing nucleic acid structures, supercoiled DNA, nucleic acid fractionation and sequencing, chemical synthesis of oligonucleotides, DNA polymerases, DNA replication-general aspects and enzymes involved, prokaryotic and eukaryotic replication mechanisms, repair of DNA.
   RNAs and their role in protein synthesis:
2. RNA polymerases and transcription, regulation of transcription in prokaryotes, post transcriptional processing, the genetic code, structure of transfer RNA, ribosome structure, translational process, protein synthesis inhibitors. Control of eukaryotic translation, post translational modification, protein degradation, non-ribosomal polypeptide synthesis, structure and genomic organization.
3. Regulation of eukaryotic gene expression, cell differentiation, oncogenes and cancer.

4. Regulation of Gene activity in Prokaryotes and Eukaryotes:
5. Principles of regulation; The *E.coli* Lactose system and the Operon model, the Tryptophan Operon - A biosynthetic system autoregulation, feedback inhibition, gene families, gene dosage and gene amplification, regulation of transcription, regulation of processing, hypersensitive sites and upstream regulatory sites, translational control, multiple proteins from a single segment of DNA, gene rearrangement, joining coding sequences in the immune system.
6. Recombinant DNA and Genetic Engineering: An outline of DNA cloning experiment, cloning vectors including plasmids, bacteriophages, cosmids, YAC vectors, shuttle and expression vectors, gene splicing, genomic libraries, screening methods for gene libraries. DNA cloning methods, tumor inducing (TI) plasmids, southern and northern blotting, chromosome walking, site specific mutagenesis. Potentials of recombinant DNA technology, PCR, production of proteins, tissue culture techniques, transgenic organisms and gene therapies, restriction fragment polymorphism and disease detection (e.g. cystic fibrosis). Human genome project, social considerations.

Lab work

1. Measurement of DNA and RNA in leaf (Perchloric acid methods). Extraction and estimation of RNA from seedling tissues (Phenol method. Extraction and estimation of DNA from leaf tissue (CDTA – NaCl method). Fractionation of nucleic acid by column chromatography. Estimation of soluble proteins by Lowry methods. Separation of seeds proteins by polyacrylamide gel electrophoresis.

Recommended Texts

1. Nelson, D & Cox, M. (2017). *Lehninger: Principles of Biochemistry* (5th ed.). USA: W.H. Freeman-Macmillan Learning.
2. Lodish, H., Berk, A., Kaiser, C., Krieger, M., & Bretscher, A. (2016). *Molecular Cell Biology* (8th ed.). USA: W.H. Freeman-Macmillan Learning.

Suggested Readings

1. Bahadur, V., Sahijram, R., & Murthy, K. (2015). *Plant Biology and Biotechnology* (1st ed.). Berlin: Springers-Verlag.
2. Clark, D., Pazdernik, N. & McGehee, M. (2019). *Molecular Biology* (2nd ed.). Amsterdam: Elsevier Inc.

Biodegradation and Bioremediation **Marks: 100 (75+25)**

Biodegradation or biological degradation is the phenomenon of biological transformation of organic compounds by living organisms; particularly the microorganisms. Biodegradation basically involves the conversion of complex organic molecules to simpler (and mostly non-toxic) ones. The term biotransformation is used for incomplete biodegradation of organic compounds involving one or a few reactions. Biotransformation is employed for the synthesis of commercially important products by microorganisms. Bioremediation refers to the process of using microorganisms to remove the environmental pollutants i.e. the toxic wastes found in soil, water, air etc. The microbes serve as scavengers in bioremediation. The removal of organic wastes by microbes for environmental clean-up is the essence of bioremediation. The other names used (by some authors) for bioremediation are bio-treatment, bio-reclamation and bio-restoration, o provide updated knowledge of environmental problems and sustainable environmental management through environmental laws, treatment technologies which include traditional and modern microbial techniques especially explicating the role of bacteria biodegradation and bioremediation.

Contents

1. The environment and pollution: Introduction, environmental laws.
2. Treatment technologies: Traditional approaches to pollution control, Biotreatment 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, Genetical approach.
4. The carbon cycle and xenobiotic compounds:
5. Biodegradation and microbial technologies by microorganisms: Acclimation, Detoxification, Activation, Sorption, Bioavailability: Sequestering and complexing, Co-metabolism, Environmental effects.
6. Effects of metals and radionuclide on environment:
7. Metal and radionuclide microbial treatment:
8. Biotechnology for metal and radionuclide removal and recovery
9. Recalcitrant molecules:

Lab work

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. Das, S. (2018). *Microbial Biodegradation and Bioremediation* (1st ed.). USA: Elsevier Science Publishing Co Inc.
2. Chang, W. (2017). *Biodegradation and Bioremediation* (1st ed.). USA: Syrawood Publishing House.

Suggested Readings

1. Crawford, R.L. (2009). *Bioremediation principle and applications* (1st ed.). Cambridge: Cambridge University Press.
2. Singh, H. (2006). *Mycoremediation: Fungal Bioremediation* (1sted.). USA: Wiley Interscience.

Plant Biotechnology-I

Marks: 100 (75+25)

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. Plant biotechnology has promptly developed into one of the most prolific, expanding and influential areas of the plant sciences. Applications of modern biotechnological tools have resulted in great advances for agriculture and society. Plant biotechnology is highly interdisciplinary and involves numerous plant sciences specialties, including cell biology, genetics, physiology, bioinformatics, biochemistry and tissue biology. This course covers the methods, applications, and implementation of plant biotechnology in agriculture. The topics covered include technical as well as regulatory and policy aspects of aspects of plant biotechnology. This course is designed to provide students with theoretical knowledge through lectures as well as critical discussion through the seminar abut current technological developments in research with trends in the aims and needs of today's biotechnology industries.

Contents

1. Genetic Engineering: Genetic engineering - Definition & explanation, restriction enzymes and restriction modification system. Cloning and expression vectors - Definition and explanation: plasmids, cosmids, phagemids, and transposons vectors.
2. Cloning in bacteria vs cloning in Eukaryotic cells. Preparation of molecular probes and their uses; labelling of probes, radioactive vs non-radioactive. Techniques used in probing DNA, RNA & Protein electrophoresis. Southern, Northern and Western blotting. Polymerase chain –reaction- Principles, techniques and modification, gene cloning vs. PCR, application and uses of PCR.
3. Chromosome walking, Chromosome jumping. Chromosome landing, map based cloning.
4. Compliment DNA, its cloning and cDNA library. RFLPs & RAPD and their applications. Gene sequencing.
5. Environmental Biotechnology
6. Ecosystem Stability: Concept (resistance and resilience), Ecological Perturbations (natural and anthropogenic) and Their Impacts on Plants and Ecosystems, Ecology of Plant Invasion, Environmental Impact Assessment (EIAJ, Ecosystem Restoration. Environment and energy, Energy resources- Renewable and Non- renewable. Natural resources, loss of diversity, causes and consequences, Environmental Auditing, Conservation of Biodiversity.
7. Ecological Management: Concepts-Sustainable Development, Remote Sensing and GISas Tools for Resource Management. Phytoremediation: - Prevention and Control, Methods of reducing environmental impacts of chemicals, Weedicides, Pesticides and Fertilizers. Biotechnological advances in pollution control through OEMs.

Lab work

1. Biodegradation of environmental pollutants by microorganisms.
2. Bacteriology of Drinking water, Microscopic studies of water specimens collected from various locations.
3. Field survey of polluted areas
4. Field study for pollution indicators (Plants, Microorganisms).
5. DNA and plasmid isolation and agarose gel electrophoresis, conjugation, transformation, route of mutagenic agents in mutation
6. Blotting techniques.

Recommended Texts

1. Abdin M.Z., Kiran, U., Kamaluddin, M. & Ali, A. (2017). *Plant Biotechnology: Principles and Applications* (3rd ed.). USA: 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.

Suggested Readings

1. Smith, R.H. (2013). *Plant Tissue Culture: Techniques and Experiments* (1st ed.).USA: Academic Press.
2. Stewart, N. (2007). *Plant Biotechnology and Genetics: Principles, Techniques, and Applications* (1st ed.). USA: Wiley Online Library.

Plant Biotechnology-II **Marks 100 (75+25)**

The aim of the course is to introduce students, role of microbes in industry for commercial production of organic acids, amino acids, vitamins, antibiotics and enzymes strategies PCR and genetic markers and applications of plant biotechnology, to provide updated knowledge about plant tissue culture for the production of genetically modified, disease resistant plants and other roles in crop improvement.

Plant Biotechnology gives information about the basic principles of the plant sciences and molecular biology, as well as the integration of these disciplines, to provide healthy plants in a safe environment for food, non-food, feed and health applications. It describes methods for obtaining and application of genetically modified plants. This course defines regulatory issues for genetically modified plant production and explains the application of plants as bioreactors for the production of vaccines and therapeutic proteins. This demonstrates critical knowledge in problem solving within an interdisciplinary context of biotechnological production of secondary metabolites and recombinant proteins using plant cell technology.

Contents

Microbial Biotechnology

1. Sources and characters of industrial microbes, their isolation and methods for induction of mutations; stabilization of mutants and their isolation. Fermentation technology, microbial growth, application of fermentation; batch, fed batch and their continuous cultures of microbes. Patent protection for biological inventions.
2. Bioreactors: Principles and their design. Microbial transformations with special reference to steroids and alkaloids, polysaccharides. Microbiology and up gradation of alcoholic beverages. Commercial production of organic acids like acetic, lactic, citric and gluconic acids.
3. Commercial production of important amino acids, insulin, steroids, vitamins and perfumes. Commercial production of antibiotics with special references to penicillin, streptomycin arid their derivatives.
4. Immobilization of microbial enzymes and whole cells and their applications in industries. Use of microbes in food, feed and dairy; Bioprocess engineering; Downstream processing, various steps for large-scale protein purification. Single cell proteins, physiological aspects, SCP from hydrocarbons. Waste materials and renewable resources. Improvement in SCP production.
5. Industrial sources of enzymes: Cellulases, Xylanases, Pedinases, Amylases, Lipases, and Proteases, their production and applications. Bioconversion of waste for fuel and energy. Petroleum Microbiology Commercial production of bio fertilizers and bio pesticides.

Plant Cell, Tissue and Organ Culture

6. Planning and organization of tissue culture laboratory. Basic techniques of plant tissue culture. Induction and maintenance of callus and cell suspension culture.
7. Study of differentiation through organogenesis and embryogenesis. Cell line selection through suspension culture for the production of stress resistant plants, their application in crop improvement.
8. Tissue culture techniques for haploid production and their application in agriculture. Meristem culture for mass and clonal propagation of ornamental plants, virus resistant plants and forests trees.
9. *In vitro* pollination, shotgun wedding, embryo rescue technique and embryo culture. Encapsulation of somatic embryos and shoot apices for artificial seeds. Cryopreservation techniques for germplasm conservation.
10. Protoplast isolation, culture and regeneration. Somatic hybridization and selection mechanism for hybrids and cybrids, with special reference to crop plants.
11. Delivery systems for gene transfer in plants through co-cultivation of explants and Agrobacterium, or through direct methods-electroporation, silicon carbide method.
12. Transgenic plants: Use of transgene for herbicides, insecticides, virus, drought, salinity and insect resistance; mate sterility and restoration system, molecular farming.
13. Industrial application of plant tissue culture for: Secondary metabolites for commercial purpose. Scale up and down stream processing for secondary metabolites.

Lab work

1. Isolation and screening of potential microbes from different environmental sources.
2. Lab scale production of bacterial enzymes, lab scale production of alcohol by yeast,
3. Use of microbes in bioleaching, use of microbes in microbial enhanced oil recovery.

4. Preparation of stock and working solutions, preparation of culture media (liquid) semi-liquid and semi-solid).
5. Explants preparation, callus culture and organogenesis.
6. Preparation and fusion of protoplasts.

Recommended Texts

1. Abdin M.Z., Kiran, U., Kamaluddin, M. & Ali, A. (2017). *Plant Biotechnology: Principles and Applications* (3rd ed.). USA: Springer.
2. Wittman, C., & James, C. (2016). *Industrial Biotechnology: Products and Processes* (1st ed.). USA: Wiley.
3. Gahlawat S.K., Salar, R.K., Siwach, P., Duhanandand, J.S., Kaur, P. (2017). *Plant Biotechnology: Recent Advancements and Developments* (2nd ed.). USA: Springer.

Suggested Readings

1. Smith, R.H. (2013). *Plant Tissue Culture: Techniques and Experiments* (1st ed.). USA: Academic Press.
2. Stewart, N. (2007). *Plant Biotechnology and Genetics: Principles, Techniques, and Applications* (1st ed.).USA: Wiley Online Liberary.

Research Methodology **Marks: 100 (75+25)**

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.). London: 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.

Plant Conservation Management **Marks: 100 (75+25)**

Over the years, plant conservation management has been ignored and 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, plant conservation management has been majorly stressed by governments and social organizations. It must be understood that human beings cherish almost all benefits from the plants. Hence, they should focus on taking proper care associated with the conservation of Plant 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. Plant conservation is basically aimed at protection, enhancement and scientific management of the plants. To be precise, manage it at its threshold level and acquire sustainable benefits both for the present and future population. Plant conservation maintains crucial ecological processes as well as life support systems. It preserves the variety of species and makes sustainable exploitation of ecosystems and species.

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, genetic problems in small population, risks reviews, 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 work

Visits to Botanical garden, Governor House, Lahore, Bagh-e-Jinnah Lahore, Soon Valley, 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.