UNIVERSITY OF THE PUNJAB

NOTIFICATION

It is hereby notified that the Vice-Chancellor has, in exercise of the powers vested in him under Section 15(3) of the University of the Punjab Act, 1973 and in anticipation of approval of the Syndicate, approved the recommendations of the Director, Institute of Botany duly forwarded by the Board of Faculty of Life Sciences at its meeting dated 19-03-2017 ragarding approval of BS 5th to 8th Semester Syllabus (in replacement of M.Sc. Botany) in the subject of Botany for Affiliated Colleges with effect from the Academic Session, 2021.

The Syllabus of BS 5th to 8th Semester in Botany is attached herewith, vide Annexure 'A'.

Sd/-
Muhammad Rauf Nawaz
Registrar

Admin. Block,
Quaid-i-Azam Campus,
Lahore.

No. D/ 77 /Acad. **Dated: 06-01-2022.**

Copy of the above is forwarded to the following for information and further necessary action: -

1. Pro-Chancellor/The Minister of Education, Govt. of the Punjab, Lahore.
2. Members of the Syndicate
3. Dean, Faculty of Life Sciences
4. Director, Institute of Botany
5. Principals of Affiliated Colleges
6. Controller of Examinations
7. Director. Quality Enhancement Cell
8. Director, IT (for Uploding on website)
9. Deputy Registrar (Affiliation)
10. Deputy Registrar (General)
11. Secretary to the Vice-Chancellor
12. Secretary to the Pro-Vice-Chancellor
13. PS to the Registrar
14. Admin Officer Syndicate (with file)
15. Assistant Syllabus

Assistant Registrar (Academic)
for Registrar

ITEM NO. 6

Recommendations of the Board of Studies in Botany and Board of Faculty of Life Sciences made at their meetings held on 19-03-2017 and 03-05-2018 regarding revised Curriculum of BS Botany (4-years) program under Semester System.

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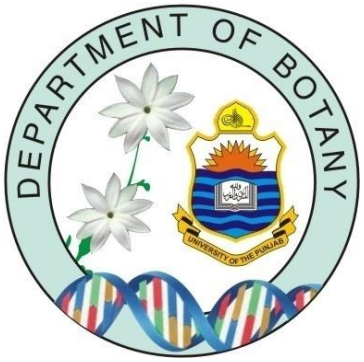
(Curriculum available from Page No. 2 to 167)

CURRICULUM

OF

BOTANY
BS (4 Years) Program



Revised 2018

DEPARTMENT OF BOTANY
UNIVERSITY OF THE PUNJAB
LAHORE (PAKISTAN)

FRAME WORK FOR BS BOTANY 4 YEARS PROGRAM

- **Total numbers of Credit Hours** **138**
- **Duration** **4 Years**
- **Semester duration** **16-18 weeks**
- **Semesters** **08**
- **Course Load per Semester** **15-18 Cr. Hr.**
- **Number of Course per Semester** **4-6 (not more than 3 Lab / Practical course)**

Compulsory requirements (the students have no choice)		**General Course to be chosen from other departments**		**Discipline Specific foundation Course**	
Subject	**Cr. Hr.**	**Subject**	**Cr. Hr.**	**Subject**	**Cr. Hr.**
1.English-I (Functional English)	3	1. General Course-I ***	3	1. Plant Diversity	4
2.English-II (Communication Skills)	3	2. General Course-II***	3	2. Plant Taxonomy, Anatomy and Development	4
3.English-III (Technical Report Writing & presentation skills)	3	3. General Course-III ***	3		
4. English-VI*	3	4. General Course-IV ***	3	3. Cell Biology, Genetics and Evolution	4
5. Pakistan Studies	2	5. General Course-V ***	3	4. Plant Physiology & Ecology	4
6. Islamic Studies / Ethics	2	6. General Course-VI ***	3	5. Biodiversity and Conservation	4
7. Mathematics	3	7. General Course-VII ***	3	6. Bacteriology and Virology	3
8. Biostatistics	3	8. General Course-VIII***	3	7. Diversity of Vascular Plants	3
9. Introduction to computer	3			8. Plant Anatomy	3
				9. Evolutionary trends among Vascular Cryptogams	3
				10.Evolutionary trends among spermatophytes	3
	25		**24**		**35**

Major courses including research projects/internship		**Elective Courses within the major**	
Subject	**Cr. Hr.**	**Subject**	**Cr. Hr.**
1. Phycology and Bryology	3	1. Elective-I Research Project / Internship/ *Optional	3
2. Lower Fungi	3		3
3. Higher Fungi	3	2. Elective-II University Option	3
4. Plant Pathology	3	3. Elective-III Research Project / Internship/ *Optional	3
5. Plant Systematics	3		
6. Principles of Genetics	3	4. Elective-IV University Option	
7. Plant Biochemistry (Structure and Catalysis)	3		
	3		
8. Fundamentals of Plant Physiology	3		
9. Molecular Biology	3		
10. Plant Biochemistry (Bioenergetics and Metabolism)	3		
	3		
11. Synecology and Ecosystems	3		
12. Advances in Plant Physiology	3		
13. Molecular Genetics			
14. Environmental Biology			
	42		**12**

* University has the option to recommend any other course in lieu of English IV

** University may recommend any other course in lieu of Mathematics

*** To be chosen from list of General Courses

Department of Botany

(BS 4 Years Program)

Semester – V		
Course Code	**Subjects**	**Credit Hours**
Bot-301 & 302	Bacteriology & Virology	2 + 1
Bot-303 & 304	Plant Systematics	2 + 1
Bot-305 & 306	Autecology	2 + 1
Bot-307 & 308	Evolutionary Trends among Vascular Cryptogams	2 + 1
Bot-309 & 310	Plant Biochemistry (Structure and Catalysis)	2 + 1
Bot-311 & 312	Lower Fungi	2 + 1
Semester Credit Hours		**18**
Semester – VI		
Course Code	**Subjects**	**Credit Hours**
Bot-313 & 314	Phycology and Bryology	2 + 1
Bot-315 & 316	Anatomy of Vascular Plants	2 + 1
Bot-317 & 318	Synecology & Ecosystems	2 + 1
Bot-319 & 320	Evolutionary Trends among Spermatophytes	2 + 1
Bot-321 & 322	Plant Biochemistry (Bioenergetics and Metabolism)	2 + 1
Bot-323 & 324	Higher Fungi	2 + 1
Bot-325	Lab Techniques	1 + 0
Semester Credit Hours		**19**
Semester – VII		
Course Code	**Subjects**	**Credit Hours**
Bot-401 & 402	Principles of Genetics	2 + 1
Bot-403 & 404	Plant Physiology and Development	2 + 1
Bot-405 & 406	Environmental Biology	2 + 1
Bot-407	Research Methods	2 + 0
Bot-408	Elective Paper/Research	2 + 1
		3 + 0
Bot-409	Seminar	1 + 0
Semester Credit Hours		**15**
Semester – VIII		
Course Code	**Subjects**	**Credit Hours**
Bot-410 & 411	Molecular Genetics	2 + 1
Bot-412 & 413	Plant Pathology	2 + 1
Bot-414 & 415	Plant Nutrition and Soil Fertility	2 + 1
Bot-416 & 417	Advances in Plant Physiology	2 + 1
Bot-418	Elective Paper/Research	2 + 1
		3 + 0
Semester Credit Hours		**15**

BS 5th Semester

Semester – V		
Course Code	**Subjects**	**Credit Hours**
Bot-301 & 302	Bacteriology & Virology	2 + 1
Bot-303 & 304	Plant Systematics	2 + 1
Bot-305 & 306	Autecology	2 + 1
Bot-307 & 308	Evolutionary Trends among Vascular Cryptogams	2 + 1
Bot-309 & 310	Plant Biochemistry (Structure and Catalysis)	2 + 1
Bot-311 & 312	Lower Fungi	2 + 1
Semester Credit Hours		**18**

Bot-301 & 302 BACTERIOLOGY AND VIROLOGY Credit Hours: 3 (2+1)

Theory:

Introduction of the Course:

The course is organized to provide basic knowledge of viruses and bacteria along with their importance. This is aimed to solve the problems of plant virus and bacteria associated with crops to evaluate the plant-microbes interaction and demonstrate diagnosis of viral and bacterial diseases in plants.

Course Objectives:

The course is designed:

1. To provide an adequate knowledge about morphological/anatomical characteristics of bacteria and viruses.
2. To give an insight into bacteria and viruses with an emphasis on their Biochemistry, Genetics and Evolution.

Contents:

1. Viruses

1.1 General features of viruses, viral architecture, biology, taxonomy, classification and replication of viruses.
1.2 Virus transmission and dissemination
1.3 Molecular biology of plant virus transmission.
1.4 Symptomatology of virus-infected plants.
1.5 Metabolism of virus-infected plants.
1.6 Resistance to viral infection.
1.7 Methods in molecular virology.

2. Bacteria

1.1 History, characteristics, taxonomy, Genetic and classification.
1.2 Evolutionary tendencies in Monera (Bacteria, Actinomycetes and Cyanobacteria)
1.3 Morphology, locomotion and reproduction in bacteria
1.4 Bacterial metabolism (Respiration, Fermentation, Photosynthesis and Nitrogen fixation)
1.5 Importance of bacteria with special reference to application in agriculture e.g Plant microbe interaction and biotechnology.
1.6 Symptoms and control of major bacterial diseases on plants of Pakistan.

Practicals:

1. Viruses

1. Observation of symptoms of some viral infected plant specimens.

2. Bacteria, Actinomycetes and Cyanobacteria

1. Methods of sterilization of glassware and media preparation.
2. Growth of bacteria, subculturing and identification of bacteria on morphological and biochemical basis (using available techniques).
3. Microscopic observation of bacteria. Different types of staining like simple and Differential (capsule, spores, and Gram-staining).
4. Microscopic study of Actinomycetes and Cyanobacteria.

Teaching-learning Strategies

1. Lectures
2. Group Discussion
3. Laboratory work
4. Seminar/ Workshop

Learning Outcomes:

1. Students will learn about the morphological and systematic knowledge about different microorganisms.
2. They will be able to describe, apply and integrate the basic concepts of Microbiology including Genetics and Evolution, Biochemistry, Physiology as well as Structure and Functions of different Bacteria and Viruses.
3. The obtained knowledge shall also enable the students to enter into various entrepreneurial activities involving general Microbiology, Plant Pathology.

Assessment Strategies:

1. Lecture Based Examination (Objective and Subjective)
2. Assignments
3. Class discussion
4. Quiz
5. Tests

Recommended Readings:

1. Agrios, G.N. (2004). *Plant Pathology*. 6th Edition, Elsevier.
2. Arora, D. R. (2004). *Textbook of Microbiology*. CBS Publishers and Distributors, New Delhi.
3. *Bergey' Manual of systematic Bacteriology*.
4. Black, J. G. (2005). *Microbiology - Principles and Exploration*. John Wiley and Sons, Inc.
5. Bouarab, K., Brisson, N. & Daayf, F. (2009). *Molecular Plant-Microbe Interactions.* MPG Books Group, Bodmin, UK.
6. Hull, R. (2009). *Comparative Plant Virology*. Academic Press.
7. Khan, J. A. & Dijkstra J. (2009). *Plant Viruses as Molecular Pathogens.* The Haworth Press, Inc.
8. Prescott, L. M., Harley, J. P. & Klein, D. A. (2005). *Microbiology*. McGraw-Hill Companies, Inc.
9. Ross F. C. (1995). Fundamentals of Microbiology. John Willey & Sons, New York.
10. Stacey, G. & Keen, N.T. (2011). *Plant-Microbe Interactions.* Springer London.
11. Tortora, G.J., Funke, B. R. & Case C. L. (2004). *Microbiology*. Pearson Education.

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Bot-303 & 304 PLANT SYSTEMATICS Credit Hours: 3(2+1)

THEORY:

Introduction of the Course:

The course is organized to study the taxonomy and nomenclature of plants from different families of Angiosperms and their phylogenetic relationships and basis of classification of these plants under various systems of classification. This course also focusses on study of variations and its types, concept of species and speciation.

Course Objectives:

The course is designed:

1. To provide an adequate knowledge about basic concepts of different plant groups and their morphological/anatomical characteristics.
2. To give an insight into plant cell structure with an emphasis on their Biochemistry, Genetics and Evolution.

Contents:

1. Introduction: Importance and relationship of Plant systematics with other sciences, Phases of plant taxonomy.
2. Concept of Species, Speciation: Mechanism of speciation.
3. Variation: Types of variation, Continuous and discontinuous variation, Clinal variation.
4. Biosystematics: Introduction and importance, Methodology of conducting biosystematics studies, various biosystematics categories such as ecophene, ecotype, ecospecies, coenospecies and comparium.
5. Taxonomic Evidence: Importance and types of taxonomic evidences: anatomical, cytological, chemical, molecular, palynological, geographical and embryological.
6. Nomenclature: Principles and important rules of botanical nomenclature.
7. Classification: Why classification is necessary? Importance of predictive value. Brief history, Different systems of classification with at least one example of each (Linnaeus, Bentham and Hooker, Engler and Prantl, Bessey, Cronquist, Takhtajan and Dahlgren.
8. Brief introduction of Numerical taxonomy.

Practicals:

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. Submission of properly mounted and fully identified hundred herbarium specimens at the time of examination.
4. Field trips shall be undertaken to study and collect plants from different ecological zones of Pakistan.
5. Description of important families of angiosperms: Apiaceae (Umbelliferae), Arecaceae (Palmae), Asclepiadaceae, Asteraceae (Compositae), Boraginaceae, Brassicaceae (Cruciferae), Cannaceae, Capparidaceae, Caryophyllaceae, Casuarinaceae, Chenopodiaceae, Convolvulaceae, Cucurbitaceae, Cyperaceae, Euphorbiaceae, Fabaceae (Leguminosae), Juncaceae, Lamiaceae (Labiatae), Liliaceae, Magnoliaceae, Malvaceae, Myrtaceae, Orchidaceae, Papaveraceae, Poaceae (Graminae), Ranunculaceae, Rosaceae, Salicaceae, Scrophulariaceae, Solanaceae, Trochodendraceae, Winteraceae.

Teaching-learning Strategies

1. Lectures

2. Group Discussion
3. Laboratory work
4. Seminar/ Workshop

Learning Outcome:

1. Students are expected to get familiarized with the morphological and systematic knowledge about different plant groups.

2. They will be able to learn about the history of Plant Systematics and its role in classification.

3. The obtained knowledge shall also enable the students to make use of this knowledge for the identification and grouping of different plants based on the anatomy.

Assessment Strategies:

1. Lecture Based Examination (Objective and Subjective)
2. Assignments
3. Class discussion
4. Quiz
5. Tests

Recommended Readings:

1. Ali, S. I. and Nasir, Y. (1995-to date). *Flora of Pakistan*. Karachi Univ. Press, Karachi.
2. Davis, P.H. and Heywood, V. H. (1963). *Principles of Angiosperm Taxonomy*. Oliver & Boyd, London.
3. Greuter, W., McNeill, J. Barrie, F.R., Burdet, H. M., Demoulin, V., Filguerras, T.S., Niclson, D.H., Silva, P.C., Skog, J.E., Trehane, P., Turland, N. J. and Hawksworth, D. L. (2000). *International code of botanical nomenclature (Saint Louis Code) adopted by the Sixteenth International botanical congress St. Louis Missouri, July –August 1999*. Koeltz, Konigstein. (Regnum Veg.138.)
4. Judd, W.S., Campbell, C.S., Kellogg, E.A., Stevens, P.F. and Donoghue, M. J. (2015). *Plant Systematics*; A phylogenetic Approach, Sinauer, USA.
5. Levine, D. A. (2000). *The Origin, Expansion and Demise of Plant Species*. Oxford University Press.
6. Naik, V. N. (1988). *Taxonomy of Angiosperms*. Tata McGraw Hill Publishing Company, New Delhi.
7. Simpson, M. G. (2018). *Plant Systematics* (3rd edition). Elsevier Academic Press, UK.
8. Singh, G. (2016). *Plant Systematics*; An Integrated Approach (3rd edition), University of Dehli, India.
9. Stace, C. (1992). *Plant Taxonomy and Biosystematics*, Edward Arnold.
10. Takhtajan, A. (1986). *Flowering Plant: Origin and Dispersal*, Oliver and Boyd, Edinburgh.

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Bot-305 & 306 **AUTECOLOGY** **Credit Hours: 3(2+1)**

THEORY:

Introduction of the Course:

The course is organized to provide information about main concept of ecology and its major divisions. It focuses on study of different environmental factors and environmental complex. Macroclimatic and microclimatic factors, dynamic and complex nature of organisms and environment are also discussed.

Course Objectives:

The course is designed:

1. To give an insight to understand the nature of environmental influences on individual organisms, their populations, and communities.
2. To prepare graduates to study and resolve the ecological consequences of environmental problems.

Course Detail:

1. **Introduction and concept of Autecology**. The seven major autecological factors and their detail. Adaptations in plants in response to autecological factors.
2. **The Soil Factor:** Definition and importance of soil: Concept of texture and structure; Physical and chemical properties of soil; Soil formation and parent materials; Soil porosity; Organic and inorganic components; Living inhabitants of soil; Water-logging and salinity of soil; causes and reclamation methods; Soil Erosion.
3. **The Water Factor:** Importance of water to plants; Forms of atmospheric moisture; Forms of precipitation and their ecological effects. Soil water relationships; Soil moisture constants; Role of water in plant diversity; Plant water relationships.
4. **Light and Temperature Factors:** Introduction; Comparison of tropical, temperate and polar regions; Temporal and spatial variations in light and temperature; Role of light and temperature in plant distribution and diversity; Responses and adaptations of plants to light and temperature; Differences in Heliophytes and Sciophytes; Ecological response of plants to warm, chilling and freezing temperatures. Hardening; Ecophysiological responses in plants: Photoperiodism; Thermoperiodism; Cardinal temperatures; Light compensation point; Dormancy; Stratification; Vernalization.
5. **The Wind Factor:** Formation of wind; Influences of wind on plants; Cushion plants; Shelterbelts.
6. **The Fire Factor:** Kinds of fire; Plant adaptations related to fire. Indirect effects fire; Modification of habitat after crown fire; Fire climax; Practical value of vegetation burning.
7. **The Biotic Factor:** Biotic influences; Grazing and Browsing by animals; Impacts of herbivorous animals on vegetation, pollination and dissemination.

Practicals:

1. Determination of soil texture, water stable aggregates and soil organic matter.
2. Soil moisture constants: Determination of soil water holding capacity.
3. Determination of infiltration, permeability and capillary rise of water in soil.
4. Determination of physico-chemical properties of soil and water.
5. Measurement of humidity, light and temperature under various ecological conditions.
6. Study of adaptations in Hydrophytes, Xerophytes and Cacti.
7. Study of Heliophytes and Sciophytes
8. Study of impact of wind on plants- Cushion plants

Teaching-learning Strategies

1. Lectures
2. Group Discussion
3. Lab work
4. Seminars/ Workshop
5. Assignments

Learning Outcome:

1. Students will be able to describe and debate various global and regional environmental concerns that affect various forms of life.
2. They will be able to determine impact of human activities on the life forms and the environment.
3. The students will acquire knowledge about the hazardous effects of different environmental pollutants and relative measures for their control/prevention.

Assessment Strategies:

1. Lecture Based Examination (Objective and Subjective)
2. Assignments
3. Classroom discussion
4. Quizzes and Tests
5. Self-assessments

Recommended Readings:

1. Begon, M., Howarth, R. W. and Townsend C. R. (2014). Essentials of Ecology.4th Edition .Wiley. 480 pp
2. Chapman, J. L. and Reiss, M.J. (1999). *Ecology: Principles & Applications.* Cambridge University Press. London. 330 pp.
3. Hussain, F. (1989). *Field and Laboratory Manual of Plant Ecology*. National Academy of Higher Education, Islamabad.
4. Lambers, H., Chapin III, F. S. and Pons, T. L. (2008). *Physiological Plant Ecology*. Second Edition. Springer. 545 pp.
5. Schulze, E. D., Beck, E. and Müller-Hohenstein, K. (2005). *Ecology.* Springer. 207 pp.
6. Smith, T. M. and Smith, R. L. (2006). *Elements of Ecology.* Pearson Canada. 645 pp.

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Bot-307 & 308 EVOLUTIONARY TRENDS AMONG VASCULAR CRYPTOGAMS

Credit Hours 3(2+1)

Theory

Introduction to the course:

The course aims to present the major groups of vascular cryptogamic plants to explore their morphology and evolution.

Course Objectives:

The aim of the course is to provide an adequate knowledge of tracheophytes and their evolutionary importance with special emphasis on vegetative and reproductive biology including morphology of lower vascular Land plants.

Contents:

1. **Evolution:** Definition. Convergent, Divergent and Homoplastic evolution. Evolutionary Forces and Trends. Modern concept of Evolution.
2. **Plant fossils:** Types, Preservation, Nomenclature.
3. **Palynology:** Neopalynology and Palaeopalynology; Definition, Palynomorph Categories, Applications, Durability, Significance of Evolution in Palynology, Palynomorphs as markers of Evolution.
4. **Steller system:** Classification and Evolution. Maturation pattern of xylem.
5. **Vascular cryptogams:**
    - **5.1. Psilopsida:** General Characters, Classification (*Rhyniophyta, Zosterophyllophyta, Trimerophyllophyta*), Affinities and Phylogenetic importance. Selected palynomorph genera representing above mentioned Divisions of Psilopsida and their morphographic description.
    - 5.2. **Lycopsida:** General Characters, Classification (*Drepanophycales, Protolepidodendrales, Lepidodendrales, Lycopodiales, Selaginellaes, Pleuromiales, Isoetales*), Affinities and Phylogenetic importance. Selected palynomorph genera representing above mentioned Lycopsid orders and their morphographic description.
    - 5.3. Sphenopsida: General Characters, Classification (*Pseudoborniales, Sphenophyllales, quisetales*), Affinities and Phylogenetic importance. Selected palynomorph genera representing above mentioned Sphenopsid orders and their morphographic description.
    - 5.4. Pteropsida

    Ferns: General Characters, Classification and Phylogenetic importance of

    a. Eusporangeate Ferns (*Ophioglossales, Marratiales*)

    b. Leptosponargiate Ferns (*Filicales, Marseliales, Salviniales*)

6. Selected palynomorph genera representing above mentioned Pteropsid orders and their morpho graphic description.

Practicals:

1. Study of Different types of rocks (Igneous, Sedimentary, Metamorphic).
2. Different techniques involved in studying fossils and age determination.
3. Examination of representative plants mentioned in the syllabus through live and preserved specimens (including prepared slides).
4. Study of Geological Time Scale – major and minor revolutions.
5. Field Study Tour (mandatory) to the Lesser / Higher Himalayas to collect and identify Vascular Cryptogams as given in the syllabus. Rock samples from various stratigraphically measured geological Formations shall be collected to isolate

Palynomorphs of Vascular Cryptogams mentioned in the theory section. Detailed Field Report will be submitted by each pupil at the time of practical examination carrying separate marks apart from Practical Note Book.

6. Free hand drawings (or Camera Lucida) of isolated and properly identified palynomorphs of Vascular Cryptogams along with the brief morphological description.

Teaching-learning Strategies

1. Lectures
2. Group Discussion
3. Laboratory work
4. Seminar/ Workshop

Learning Outcome:

Students will be able to:

1. Develop better understanding of the concept of evolution and modern evolutionary trends.
2. Know about the evolutionary architecture of early vascular land plants, Lycophytes, Sphenophytes and Ferns.

Assessment Strategies:

1. Lecture Based Examination (Objective and Subjective)
2. Assignments
3. Class discussion
4. Quiz
5. Tests

Recommended Readings:

1. Andrews, H.W. (Latest Edition). Studies in Paleobotany. John Wiley and Sons.
2. Bierhorst, D.W. (Latest Edition). Morphology of Vascular Plants. Macmillan, Inc. Insurance, New York.
3. Eames, A.J. (Latest Edition). Morphology of Vascular Plants (Lower Groups). McGraw Hill and Co.
4. Foster and Gifford, (Latest Edition). Comparative Morphology of Vascular Plants, W.H. Freeman, New York.
5. Jeryme, A.C., Ciabbe, T. A. and Thomas, B. A. (Latest Edition). The phylogeny and classification of Ferns, Academic Press, London.
6. Lithostratigraphic Units of the Kohat, - Potwar Province, Indus Basin Pakistan, 1980. Memoir Volume No.10. Geological Survey of Pakistan.
7. Niklas, K. J. (2016). Plant Evolution: an introduction to the history of life. Chicago; London: The University of Chicago Press, 2016. 566 pp.
8. Niklas, K. J. (1981). Paleobotany, Paleoecology and Evolution. Praeger Press, New York.
9. Sporne, K.R. (Latest Edition). The morphology of Pteridophytes. Hutchinson University Library.
10. Taylor, E. L., Taylor T. N. and Krings, M. (2009). Biology and Evolution of Fossil plants. Princeten Hall, New York. 1252 pp.
11. Traverse, A. (2007). Paleopalynology. Unwin Hyman Ltd. 813 pp.

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Bot-309 & 310 PLANT BIOCHEMISTRY Credit Hours 3(2+1)
(STRUCTURE AND CATALYSIS)

THEORY

Course Outline:

Introduction to Biochemistry, Structure and Catalysis; Carbohydrates; Lipids; Proteins; Nucleic Acids; Enzymes.

Introduction of the Course:

The course is organized to provide an adequate knowledge about selected cellular macromolecules and the underlying concepts in catalysis. It focuses not only on the individual molecules that form the backbone of these diverse molecules but also the structural role they play with particular reference to higher plants. In addition, the biological role of these macromolecules is also the focus of this course. Hierarchical levels of organization of certain complex macromolecules such as proteins and their myriad roles in structure and function of plant cells are discussed. Key concepts are included to understand the basis of catalysis.

Course Objectives:

The course is designed:

1. To provide an adequate knowledge of Carbohydrates, Lipids, Proteins, Nucleic Acids and Enzymes with reference to their role in higher plants.
2. To give an insight into various catalytic processes that are so very vital to sustain life.

Course Detail:

1. **Introduction to Biochemistry, Structure and Catalysis.**
2. **Carbohydrates:** Occurrence, Classification, Structure and Chemical properties, Mono, Di, Oligo and Polysaccharides, Glycoconjugates.
3. **Lipids:** Occurrence, Classification. Structure and chemical properties of Fatty acids, Triglycerides, Phospholipids, Glycolipids, Sulpholipids, Waxes, Carotenoids and Sterols.
4. **Proteins:** Amino acids, structure and classification, electro-chemical properties and reactions of amino acids. Classification of proteins. Primary, Secondary, Tertiary and Quaternary structure of proteins. Protein targeting, folding and unfolding, transport, storage, regulatory and receptor proteins. Protein purification and sequencing.
5. **Nucleic Acids:** Introduction. Purine and Pyrimidine bases, Nucleosides, Nucleotides. Structure and properties of DNA and RNA. Types and functions of RNA. DNA sequencing.
6. **Enzymes:** Nature and functions, Classification. Principles of enzyme action. Enzyme specificity. Transition state. Binding energy. Isozymes, ribozymes, Abzymes. Enzyme kinetics. Allosteric enzymes.

Practicals:

1. Determination of R_f value of Monosaccharides on a Paper Chromatogram.
2. Estimation of Reducing and Non-reducing sugars in plant material titrimetrically/spectrophotometrically.
3. Extraction and estimation of oil from plant material.
4. To determine Saponification number of fats.
5. Analysis of various lipids by TLC method.
6. Determination of R_f value of Amino Acids on a Paper Chromatogram.
7. To determine pKa and Isoelectric point of an amino acid.
8. Estimation of soluble proteins.

9. Extraction of Nucleic acids from plant material and their estimation by UV absorption or colour reactions.
10. Estimation of catalytic property of enzyme catalase or peroxidase extracted from a plant source.
11. Extraction of genomic DNA from plants by CTAB method.

Teaching-learning Strategies

1. Lectures
2. Group Discussion
3. Lab work
4. Seminars/ Workshop
5. Assignments

Learning Outcome:

1. Students are expected to get themselves familiarized with the molecular/macromolecular organization of plant cells in general.

2. They should be able to understand almost infinite possibilities of structural organization, molecular backbones and the myriad roles or functions they can take or perform.

3. How catalysis takes place? Students should be able to understand the basic concepts with regard to configurational as well as conformational changes in enzyme catalysis.

Assessment Strategies:

1. Lecture Based Examination (Objective and Subjective)
2. Assignments
3. Classroom discussion
4. Quizzes and Tests
5. Self-assessments

Recommended Readings:

1. Abdes, R. H., Frey, P. A. and Jencks W. P. (2004). Biochemistry, Jones and Bartlet, London.
2. Buchanan B. B, Gruissem W and Jones R. L. (2015). Biochemistry and Molecular Biology of Plants. John Wiley and Sons.
3. Bowsher, C., Steer, M., Tobin, A. (2008). Plant Biochemistry. - Garland Science, Taylor and Francis Group, New York.
4. Campbell, M. K. and F. Shawn. (2008). Biochemistry 6th Edition.
5. Chesworth, J. M., Strichbury T. and Scaife J. R. (1998). An introduction to agricultural biochemistry. Chapman and Hall, London.
6. Conn E. E. and Stumpf, P. K. (2009). Outlines of Biochemistry, John Wiley and Sons Inc. New York.
7. Dey, P. M. and Harborne, J. B. (1997). Plant Biochemistry. Harcourt Asia PTE Ltd. Singapore.
8. Goodwin T. W. and Mercer, E. I. (1997). Introduction to Plant Biochemistry. Pergamon Press, Oxford.
9. Heldt, H. W. (2008). Plant Biochemistry. 3rd Edition, Academic Press, U. K.
10. Lea, P. J. and Leegood, R. C. (1993). Plant Biochemistry and Molecular Biology. Wiley and Sons, New York.
11. Nelson, D. L and Cox M. M. (2017). Lehninger Principles of Biochemistry. 7th edition. W. H. Freeman and Company. New York.

12. Mckee, T. and Mckee, J. R. (1999). Biochemistry – An Introduction. WCB/McGraw-Hill, New York, Boston, USA.
13. Voet, D. Voet J. G. and Pratt, C. W. (2016). Fundamentals of Biochemistry: Life at the Molecular level, 5th Edition. John Wiley and Sons, New York.
14. Zubay G. (2003). Biochemistry, MacMillan Publishing Co., New York.

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Bot-311 & 312 LOWER FUNGI Credit Hours: 3(2+1)

THEORY:

Introduction of the Course:

The course is organized to provide an adequate knowledge about different fungal groups with their representatives along with their Taxonomy, Morphology, Anatomy and life cycle patterns. It is generally aimed to familiarize students with the morphological and systematic knowledge of different members of lower fungi, their structure and Economic importance.

Course Objectives:

The course is designed:

1. To provide an adequate knowledge about basic concepts of different fungal groups and their characteristics.
2. To give an insight into structure of lower fungi with an emphasis on their morphology, taxonomy and life cycle patterns.

Contents:

1. **General introduction to fungi**
   - 1.1. Cells, hyphae and tissues
   - 1.2. Economic importance
   - 1.3. Sexual and asexual reproduction
   - 1.4. Zoosporogenesis
   - 1.5. Classification-principles of taxonomy
   - 1.6. Nomenclature and kingdom systems
2. **Kingdom Straminopila:**
   - 2.1. Importance, morphology, biology, taxonomy and nomenclature of Hyphochytridiomycota, Labyrinthulomycota and Oomycota
   - 2.2. Important characters and classification of Oomycota up to orders and family's level
   - 2.3. Importance and life cycles of fungal spores in Saprolegniales, Peronosporales, Sclerosporales and Pythiales
3. **Kingdom Fungi:**
   - 3.1. General characters, importance and classification up to phyla
   - 3.2. Chytridiomycota: General Characteristics and classification up to orders level
   - 3.3. Biology of *Synchytrium* and *Olpidium* spp.
   - 3.4. Evolution of orders into new phyla
4. **Zygomycota:**
   - 4.1. General characters, various types of asexual reproductive structures; Zygosporogenesis
   - 4.2. Role of hormones in sexual reproduction
   - 4.3. Heterothallism and classification up to order level
   - 4.4. Classification of Mucorales, Endogonales and Entomophthorales up to families and characteristics of important genera
   - 4.5. Evolution of Glomeromycota and their role in agriculture.
   - 4.6. Arbuscular mycorrhiza.
   - 4.7. Entomophthorales, their use as bio-control of insects.

Practicals:

1. Basic mycological techniques.
2. Isolation of fungi from soil, water and air using different techniques.
3. Processing and staining of roots for Arbuscular mycorrhizal assessment in roots of crop plants.
4. Isolation and identification of endogonaceous fungi from soil by wet sieving and decanting techniques.
5. Collection, preservation, culturing and identification of mycological specimens with special reference to taxa of agricultural importance; use of keys for their identification.
6. Examination of prepared slides of selected taxa.

Teaching-learning Strategies

1. Lectures
2. Group Discussion
3. Laboratory work
4. Seminar/ Workshop

Learning Outcome:

1. Students are expected to get familiarized with the morphological and systematic knowledge about different members of lower fungi.
2. They will be able to describe the concepts of what constitutes disease in plants and identify major principles of plant pathology.
3. This will enable them to employ methods to diagnose and manage a wide range of plant diseases caused by fungi.

Assessment Strategies:

1. Lecture Based Examination (Objective and Subjective)
2. Assignments
3. Class discussion
4. Quiz
5. Tests

Recommended Readings:

1. Alexopoulos, C.J., Mims, C.W. and Blackwell, M. (1996). *Introductory Mycology*, 4th edition, John Wiley and Sons. Inc., New York, USA.
2. Kendrik, B. (2000). *The Fifth Kingdom*. 3rd edition. Focus Publishing, Newburyport, MA. ISBN:1-58510-022-6.
3. Kirk, P.M., Stalpers, J.A., Minter, D.W. and Cannon, P. F. (2008). *Dictionary of fungi*. 10th ed. CABI, UK.
4. Lemke, P.A. and Esser, K. (2001). *The Mycota*. Volume VII. Systematics and Evolution. Part A. Springer.
5. Mirza, J. H., Khan, S. M., Begum, S. and Shagufta, S. (1979). *Mucorales of Pakistan*, University of Agriculture, Faisalabad, Pakistan.
6. Petrini-Klieber, L.E. and Petrini, O. (2013). *Identifying Moulds: A Practical Guide.* Gebruder Borntraeger Verlagsbuchhandlung, Science Publishers.
7. Webster, J. and Weber, R. (2007). *Introduction to Fungi*. Cambridge University Press.

BS 6th Semester

Semester – VI		
Course Code	**Subjects**	**Credit Hours**
Bot-313 & 314	Phycology and Bryology	2 + 1
Bot-315 & 316	Anatomy of Vascular Plants	2 + 1
Bot-317 & 318	Synecology & Ecosystems	2 + 1
Bot-319 & 320	Evolutionary Trends among Spermatophytes	2 + 1
Bot-321 & 322	Plant Biochemistry (Bioenergetics and Metabolism)	2 + 1
Bot-323 & 324	Higher Fungi	2 + 1
Bot-325	Lab Techniques	1 + 0
Semester Credit Hours		**20**

Bot-313 & 314 PHYCOLOGY AND BRYOLOGY Credit Hours: 3 (2+1)

THEORY:

Introduction of the Course:

The course is organized to provide an adequate knowledge about different algae and bryophytes groups with their representatives along with their Taxonomy, Morphology, Anatomy, Reproduction and Economic Importance. It is generally aimed to familiarize students with the morphological and systematic knowledge of different algae and bryophytes, and their economic importance.

Course Objectives:

The course is designed:

1. To provide an adequate knowledge about basic concepts of different algae and bryophytes groups and their morphological/anatomical characteristics.
2. To give an insight into algae and bryophytes with an emphasis on their structure, reproduction and economic importance.

Contents:

1. Phycology

1.1. Introduction.

1.2. Historical account, Evolution, Zonation, tides, habitats, geographical distribution of economically important algae:

1.3. Criteria for algae classification based on Biochemistry, pigment pattern, plastids, flagellation, movement pattern, cell wall structure, storage products, reproduction and life cycle pattern

1.4. Introduction, general account, classification and economic importance of the following phyla of algae

i. Cyanophyta
ii. Chlorophyta
iii. Charophyta
iv. Xanthophyta
v. Bacillariophyta
vi. Phaeophyta
vii. Rhodophyta

2. Bryology

2.1 Introduction and general account of bryophytes, classification, theories of origin and evolution.
2.2 Ecological role in absorption and retention of moisture
2.3 Distribution of bryophytes in Pakistan
2.4 Brief study of the classes: Hepaticopsida, Anthocerotopsida and Bryopsida.

Practicals:

1. Collection and preservation of algae from various habitats.
2. Identification of algae.
3. Preparation of temporary slides.
4. Culturing of algae.
5. Evaluation of algae as fertilizer.
6. Determination of the chemical composition of algal biomass.
7. Nitrogen fixation and hydrogen production by blue green algae.
8. Study of various available genera of bryophytes. For example; *Pellia*, *Porella*, *Anthoceros* and *Polytrichum*

Learning Outcome:

1. Students are expected to understand the unique and general features of Algae and Bryophytes and familiarize it.
2. They will be able to identify the external morphology, internal structure and reproduction of different types of algae and bryophytes.
3. This will enable them to predict the economic and ecological significance of bryophytes.
4. The obtained knowledge shall also enable the students to Examine the possible applications in phycology and Bryology

Assessment Strategies:

1. Lecture Based Examination (Objective and Subjective)
2. Assignments
3. Class discussion
4. Quiz
5. Tests

Recommended Readings:

1. Bold, H. C. & Wynne, M. J. (1985). *Introduction to Algae: structure and reproduction*. Prentice Hall Inc. Engle Wood Cliffs
2. Barsanti, L. & Gualtieri, P. G. (2006). *Algae, anatomy, biochemistry, biotechnology*. Taylor and Francis, New York.
3. Bellinger, E. G. & Sigee, D. C. (2010). *Fresh water algae (Identification and use as bioindicators).* John Wiley & Sons.
4. Chapman, V. J. & D. J. Chapman. (1983). *Sea weed and their uses.* MacMillan and Co. Ltd. London.
5. Dawson, E. Y. & Halt. (1966). *Marine Botany*. Reinhart and Winstan, New York.
6. Hussain, F. (2013). *Phycology.* A text book of Algae. Pak Book Empire Lahore.
7. Hussain, F. & Ilahi, I. (2012). *A text book of Botany*. Department of Botany, University of Peshawar.
8. Hussain, F., Ahmad, H. & Shah, S, Z. (2012). *The unicellular algae of District Peshawar, Pakistan.* Lambert Publication, Germany.
9. Lee. R. E. (1999). *Phycology.* Cambridge University Press, U.K.

10. Schofield, W. B. (1985). *Introduction to Bryology*. MacMillan Publishing Co.London.
11. Vashishta. B. R. (1991). *Botany for degree students. Bryophytes.* 8th ed. S. Chand and Co. Ltd. Delhi.
12. Vashishta, B. R., Sinha, A. K. & Kumar, A. (2010). *Algae*. S. Chand & Co.
13. Vashishta, B. R., Sinha, A. K. & Kumar, A. (2010). *Bryophytes*. S. Chand & Co. New Delhi.

Journals / Periodicals:

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

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Bot-315 & 316 ANATOMY OF VASCULAR PLANTS Credit Hours: 3(2+1)

THEORY:

Introduction of the Course:

This course introduces the internal structure of vascular plants, including their cells, tissues, organs and systems. It emphasizes the variation in the appearance and description of plant parts based on developmental and functional aspects. The relationship of structures with their possible functions is also elucidated. The laboratory-based microscopic assays of the stained plant specimen sections are also included for understanding plant structures.

Course Objectives:

The course is designed:

1- To enable students, learn about basic structures of the plant tissues, organs and systems.
2- To describe in depth the basic cell types found in plants
3- To expand understanding of tissue types including the epidermis, xylem and phloem
4- To introduce about the basic structure of meristems found in shoots and roots
5- To be able to identify the structures associated with plant reproduction such as cones, flowers, fruits and seeds

Contents:

1. Introduction of plant Anatomy

1.1. The plant body and its development; fundamental parts of the plant body, internal organization, different tissue systems of primary and secondary body.

2. Types of Tissues

2.1.1. Types of Tissues: Meristematic, permanent, complex and special / glandular tissues

2.1.1.1. Meristematic Tissues: classification, cytohistological characteristics, initials and their derivatives. Apical meristem; Delimitation, different growth zones, evolution of the concept of apical organization.

2.1.1.2. Theories of Shoot and Root Apical Organization

2.1.2. Permanent Tissues

2.1.2.1. Types of permanent tissues: Parenchyma, Collenchyma, Sclerenchyma

2.1.3. Complex Tissues

2.1.3.1. Xylem Tissue

2.1.3.2. Phloem tissue

2.1.4. Special / Secretary Tissues

2.1.4.1. Secretory tissues; Laticifers (classification, distribution, development, structural characteristics, functions) and Resin Canals.

3. The Tissue System

3.1. **Types of Tissue Systems:**

3.1.1. **The Epidermal tissue system**

3.1.1.1. Origin, structure, development, functional and evolutionary specialization

3.1.2. **Ground or fundamental tissue system**

3.1.2.1. comparison between monocotyledons and dicotyledons with respect to cortex, pericycle and medulla or pith

3.1.3. **Vascular tissue system**

3.1.3.1. Types of vascular bundles

3.1.3.2. Stele

3.1.4. **Internal structure of stems, roots and leaves**

3.1.4.1. Internal structure of dicotyledonous and monocotyledonous Stem

3.1.4.1.1. Nodal anatomy

3.1.4.2. Internal structure of dicotyledonous and monocotyledonous Root

3.1.4.3. Root-Shoot transition

3.1.4.4. Internal structure of dicotyledonous and monocotyledonous Leaves with special reference to mesophyll, venation, bundle-sheaths and bundle-sheath extensions

4. **The Secondary Growth**
   4.1. Secondary growth in dicot Stem by Vascular cambium, Fusiform and Ray initials, Annual / growth Rings, porous and non-porous wood, heart wood and sap wood, tyloses.
   4.2. Secondary growth in dicot Stem by cork cambium, Phellogen, Phellem and Phelloderm, Bark, Lenticels
   4.3. Secondary growth in dicot Root by Vascular cambium and cork cambium
5. **Anomalous Secondary Growth in Stem**
6. **Secondary Growth in Monocotyledons**
7. **Anatomy of reproductive parts; Flower, Seed, Fruit**
8. **Economic aspects of applied plant anatomy. Anatomical adaptations. Molecular markers in tree species used for wood.**

Practicals:

1. Microscopy and interpretation of various parts of light microscope
2. Study of internal organization of various tissues of monocotyledonous and dicotyledonous stem, root and leaf by cutting of T.S and L.S sections
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.

Teaching-learning Strategies

1. Lectures
2. Field tours to contaminated sites and industrial areas
3. Group Discussion
4. Laboratory work
5. Seminar/ Workshop

Learning Outcome:

1. Students are expected to get familiarized with the internal organization of plant tissues.
2. They will be able to learn about role of different cells and tissues in plant development, as well as, its importance in various plant.
3. They will be able to learn basic and applied aspects of plant anatomy.
4. The students will be able to conceptually integrate organismal structure and function
5. They will be able to have acquaintance with the current developments in the field of plant anatomy.

Assessment Strategies:

1. Lecture Based Examination (Objective and Subjective)
2. Assignments
3. Class discussion
4. Quiz
5. Tests

Recommended Readings:

1. Anon. Manual of Microscopic Analysis of Feeding Stuffs. The American Association of feed Microscopists.
2. Cutler, D.F. (1969). *Anatomy of the Monocotyledons*. IV. Juncales. Clarendon Press, Oxford.
3. Dickison, W.C. (2000). Integrative plant anatomy. Academic Press, U.K.
4. Esau, K. (1960). Anatomy of Seed Plants. John Wiley, New York.
5. Fahn, A. (1990). Plant Anatomy. Pergamon Press, Oxford.
6. Metcalf, C.R. and Chalk, L. (1950). Anatomy of the Dicotyledons. Clerondon Press. Oxford.
7. Metcalfe, C.R. (1960). *Anatomy of the Monocotyledons. Gramineae*. Clerondon Press, Oxford.
8. Richard, C., Sheila, L., Robert, W. (2018). *Plant Anatomy*: A Concept-Based Approach to the Structure of Seed Plants, Springer Publisher

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Bot-317 & 318 SYNECOLOGY & ECOSYSTEM S Credit Hours 3(2+1)

THEORY:

Introduction of the Course:

This course introduces the general concepts of the Ecological Hierarchy, Population Ecology, Community Ecology and Population Ecology.

Course Objectives:

The course is designed:

1. To understand the nature of environmental influences on individual organisms, their populations, and communities, and ultimately at the level of the biosphere.
2. To provide an adequate knowledge about basic concepts of Community and Population Ecology and to distinguish between biotic assemblages and communities.
3. To give an insight about ecosystems and emergent properties associated with ecosystems.

Contents:

1. **Ecological Hierarchy;** Hierarchical concept starting in the individual. Concepts of species; various species concept.
2. **Population Ecology:** Plant population structure; Plant population dynamics; Density dependent & density independent growth models; Life tables & Plant demography; Seed dispersal, seed dormancy, seed bank, Recruitment & Resource allocation
3. **Community Ecology:** Community concepts and attributes; Analytic & synthetic characteristics; Plant community structure; Plant community dynamics; Types of changes, succession, its types and climax concept. Community relationships; Local vegetation; Vegetation of Pakistan; Major Biomes of the world. Methods of sampling of communities, recent trends.
4. **Ecosystem Ecology:** Concept, components, structure & function; Trophic levels and energy flow; Food chains & food webs; Biogeochemical cycles; types; Hydrologic cycle, C, N and P cycles.

Practicals:

1. Reconnaissance survey of different local communities.
2. Study of various community attributes like Floristic Composition, Vitality, Periodicity, Association, Population density, Frequency of occurrence, Cover etc.
3. Detailed sampling of local vegetation including gradient, ordination and classification.
4. Use of Ecological Softwares.
5. Study of local aquatic and terrestrial ecosystems.

Teaching-learning Strategies

1. Lectures
2. Field tours to contaminated sites and industrial areas
3. Group Discussion
4. Laboratory work
5. Seminar/ Workshop

Learning Outcome:

1. Students are expected to get familiarized with the knowledge of the interdependence between people and nature that is vital for food production, maintaining clean air and water, and sustaining biodiversity in a changing climate.
2. They will be able to learn about human impacts on ecosystems and how humans have tried to rehabilitate ecosystems.
3. They will be able to learn basic and applied aspects of plant ecology.

Assessment Strategies:

1. Lecture Based Examination (Objective and Subjective)
2. Assignments
3. Class discussion
4. Quiz
5. Tests

Recommended Readings:

1. Begon, M. Howarth R. W., Townsend C. R. (2014). *Essentials of Ecology.* 4th Edition Wiley. 480 pp.
2. Chapman, J.L. and Reiss, M.J. (1999). *Ecology: Principles & Applications.* Cambridge University Press. London. 330 pp.
3. Hussain, F. (1989). *Field and Laboratory Manual of Plant Ecology*. National Academy of Higher Education, Islamabad.
4. Schulze, E. D., Beck, E. K. and Müller-Hohenstein (2005). *Ecology. S*pringer. 207 pp.
5. Smith, T. M. and Smith R. L. (2006). *Elements of Ecology.* Pearson Canada. 645 pp.

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EVOLUTIONARY TRENDS AMONG SPERMATOPHYTES

Bot-319 & 320 Credit Hours 3(2+1)

THEORY

Introduction to the course:

The course aims to present the major groups of spermatophytes to explore their morphology, anatomy and evolution.

Course Objectives:

The main objective of the course is

1. To provide an adequate knowledge of spermatophytes and their evolutionary importance with special emphasis on vegetative and reproductive biology.

Course Detail:

1. **Origin and Evolution of Seed Habit including evidences from Palynology.**
2. **Seed Ferns**: General Characters and Phylogenetic importance of
   2.1.*Calamopitales*
   2.2.*Lyginopteridales*
   2.3.*Medullosales*
   2.4.*Glossopteridales*
   2.5.*Caytoniales*
   Selected Palynomorph genera representing above mentioned Seed Fern orders and their Morphographic description.
3. **Gymnosperms**: Origin of Gymnosperms, Phylogeny and Classification of
   3.1.*Bennettitales*
   3.2.*Ginkgoales*
   3.3.*Cycadales*
   3.4.*Coniferales*
   3.5.*Gnetales.*
   Selected Palynomorph genera representing above mentioned Gymnosperm orders and their Morphographic description.
4. **Angiosperms**:
   4.1.Life cycle of an Angiosperm
   4.2.Flower: Definition, different parts of a generalized flower.
   4.3.Morphological nature of flower, Different types of placentation and their inter-relationship.
   4.4.Origin of Angiosperms
   4.5.Embryology: Structure of stamen, microsporogenesis and structure of pollen. Structure of an ovule, megasporogenesis. Different types of embryo sacs. Nature of endospermic tissue.
   4.6.Selected palynomorphs genera representing above mentioned Lycopsida orders and their Morphographic description.

Practicals:

1. Section cutting, staining and permanent / temporary mounting of the representative specimens mentioned in the theory portion (Gymnosperms and Angiosperms).
2. Identification and study of some stereoscopic sections of woods of Gymnosperms and Angiosperms.
3. Isolation of palynomorphs through maceration from samples of Mesozoic and Paleozoic rocks of Pakistan.

4. Study of different types of Placentation in different flowers.
5. Study of different types of Embryo Sacs in Angiosperms.
6. Field Study Tour (mandatory) to the Lesser / Higher Himalayas to collect and identify Vascular Cryptogams as given in the syllabus. Rock samples from various stratigraphically measured geological Formations shall be collected to isolate Palynomorphs of Seed Ferns, Gymnosperms and Angiosperms mentioned in the theory section. Detailed Field Report will be submitted by each pupil at the time of practical examination carrying separate marks apart from Practical Note Book.
7. Free hand drawings (or Camera Lucida) of isolated and properly identified palynomorphs along with the brief morphological description.

Teaching-learning Strategies

1. Lectures
2. Group Discussion
3. Laboratory work
4. Seminar/ Workshop

Learning Outcome:

Students will be able to:

1. Explain when seed plants first appeared and when gymnosperms became the dominant plant group
2. Describe the two major innovations that allowed seed plants to reproduce in the absence of water
3. Describe the significance of angiosperms bearing both flowers and fruit

Assessment Strategies:

1. Lecture Based Examination (Objective and Subjective)
2. Assignments
3. Class discussion
4. Quiz
6. Tests

Recommended Readings:

1. Beck. C.B. Origin and Evolution of Gymnosperms. Columbia University Press, New York.
2. Beck. C.B. Origin and Evolution of Angiosperms. Columbia University Press, New York
3. Chamberlain, C.J. (Latest Edition). Gymnosperms structure and Evolution. Dover Publications Inc. 480 pp.
4. Foster, S. and Gifford, E.M. (1971). Comparative Morphology of Vascular Plants, W.H. Freeman, New York. 751 pp.
5. Niklas, K. J. (2016). Plant Evolution: an introduction to the history of life. Chicago; London: The University of Chicago Press, 2016. 566 pp.
6. Sporne, K.R. (Latest Edition). The morphology of Gymnosperms. Hutchinson University Library.
7. Taylor, E. L., Taylor T. N. and Krings, M. (2009). Biology and Evolution of Fossil plants. Princeten Hall, New York. 1252 pp.
8. Traverse (2007). Paleopalynology. Unwin Hyman Ltd. 813 pp.

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Bot-321 & 322 PLANT BIOCHEMISTRY Credit Hours 3(2+1)
(BIOENERGETICS AND METABOLISM)

THEORY

Introduction of the Course:

This course is focused on Bioenergetics and Metabolism with a focus on energy relationships between catabolic and anabolic processes. How do the catabolic pathways deliver chemical energy? How are energy carrier molecules used in anabolic pathways? These are some of the questions that are answered making use of our knowledge of fatty acid catabolism, biosynthesis of nucleotides etc. An introduction to Alkaloids, Terpenoids and Vitamins is also presented with a focus on their general properties or role in metabolism.

Course Objectives:

The course is designed:

1. To provide an adequate knowledge of the underlying principles of Bioenergetics and Metabolism.
2. To investigate metabolism keeping in view various molecules and macromolecules like, Carbohydrates, Lipids, DNA/RNA, Proteins etc.
3. To understand the general properties and role of Alkaloids, Terpenoids and Vitamins in metabolism.

Course Detail:

Bioenergetics

a. Energy, laws about energy changes.
b. Oxidation and Reduction in living systems.

Metabolism

a. Biosynthesis, degradation and regulation of sucrose and starch. Breakdown of fats with special reference to beta-oxidation and its energy balance. Biosynthesis of fats/ fatty acids.
b. DNA replication and repair. Reverse transcription. Biosynthesis of DNA and RNA.
c. Components of protein synthesis. Genetic code. Protein synthesis: Initiation, elongation and termination.

Alkaloids

a. Occurrence, physiological effects, chemical nature with special reference to Solanine, Nicotine, Morphine, Theine and Caffeine.
b. Aflatoxins, their nature and role.

Terpenoids:

Classification: Monoterpenes, Sesquiterpenes, Diterpenes, Triterpenes, Tetraterpenes, Polyterpenes, their chemical constitution and biosynthesis.

Vitamins: General properties and role in metabolism.

Practicals:

1. Separation of soluble proteins by Polyacrylamide Gel Electrophoresis (PAGE)
2. Separation of Nucleic acids by gel electrophoresis.
3. Estimation of vitamin C (orange, apple juice).
4. Determination of potential Alkaloids in plants.
5. Estimation of Terpenoids in plants.

Teaching-learning Strategies

1. Lectures

2. Group Discussion
3. Lab work
4. Seminars/ Workshop
5. Assignments

Learning Outcome:

1. Students are expected to get themselves familiarized with the basic concepts of Bioenergetics and Metabolism.
2. They should be able to figure out the use of various biochemical reactions and to assess as to where do these individual chemical reactions fit in an overall metabolic process.
3. The students are expected to critically analyze the various biochemical pathways and their interaction with each other.
4. Students should be able to highlight the significance of Alkaloids, Terpenoids and Vitamins and the role they might play in a living system.

Assessment Strategies:

1. Lecture Based Examination (Objective and Subjective)
2. Assignments
3. Classroom discussion
4. Quizzes and Tests
5. Self-assessments

Recommended Readings:

1. Conn E. E. and Stumpf, P. K. 2009. Outlines of Biochemistry, John Wiley and Sons Inc. New York.
2. Buchanan B. B, Gruissem W and Jones R. L. 2015. Biochemistry and Molecular Biology of Plants. John Wiley and Sons.
3. Nelson, D. L and Cox M. M. 2017. Lehninger Principles of Biochemistry. 7th edition. W. H. Freeman and Company. New York.
4. Voet, D. Voet J. G. and Pratt, C. W. 2016. Fundamentals of Biochemistry: Life at the Molecular level, 5th Edition. John Wiley and Sons, New York.
5. Dey, P. M. and Harborne, J. B. 1997. Plant Biochemistry. Harcourt Asia PTE Ltd. Singapore.
6. Smith, E L., Hill, R. L., Lehman, R. I., Lefkowits, R J. and Abraham. H. Principles of Biochemistry, (General Aspects). White. International Student Edition. McGraw Hill International Book Company.
7. Zubay. G. 2003, Biochemistry, MacMillan Publishing Co., New York.
8. Chesworth,. J. M., Strichbury T. and Scaife, J. R. 1998. An introduction to Agricultural Biochemistry. Chapman and Hall, London.
9. Mckee, T. and Mckee, J. R. 1999. Biochemistry – An Introduction. WCB / McGraw-Hill, New York, Boston, USA.
10. Taiz, L. and Zeiger, E. MØller, I M and Murphy A. 2014. Plant Physiology and Development. 6th Edition. Sinauer Associates, Inc.

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Bot-323 & 324 HIGHER FUNGI Credit Hours: 3(2+1)

THEORY:

Introduction of the Course:

The course is organized to provide an adequate knowledge about different fungal groups with their representatives along with taxonomy and nomenclature of various fungal groups placed in higher fungi and their importance especially with reference to plants.

Course Objectives:

The course is designed:

1. To provide an adequate knowledge about basic concepts of different fungal groups and their characteristics.
2. To give an insight into structure of Higher fungi with an emphasis on their morphology, taxonomy and life cycle patterns.

Contents:

1. **Ascomycota:** Morphology, reproduction, life cycle patterns, sexual compatibility and parasexuality; Types of asci, centra and ascocarps; Ascosporogenesis and conidiogenesis; Principles and systems of classification of Ascomycota and mitosporic fungi; classification; Concept of anamorphs and telomorphs
   - 1.1. Classes of conidial fungi: Hemiascomycetes; general characters of orders: Endomycetales (yeasts), Taphrinales etc.
   - 1.2. Plectomycetes, Pyrenomycetes; general characters of orders Erysiphales (powdery mildew), Xylariales. Clavicipitales (ergots)
   - 1.3. Discomycetes: general characters of orders Pezizales and Helotiales
   - 1.4. Loculoascomycetes; general characters of orders Pleosporales, Myriangiales and Hysteriales
   - 1.5. Ascolichens, general characters, anatomy and distribution in Pakistan.
2. **Basidiomycota:** Introduction to Basidiomycetes: Somatic structure, reproduction, basidiocarp developmental patterns, types of basidia and basidiospores; Principles and systems of classification; Life cycle.
   - 2.1. Class Homobasidiomycetes
   - 2.2. Heterobasidiomycetes
   - 2.3. Urediniomycetes
   - 2.4. Ustilaginomycetes
   - 2.5. Cladistic classification of Homobasidiomycetes.
   - 2.6. Gasteromycetes; their placement in different clades, general characteristics and spore dispersal
   - 2.7. Basidiolichens and their taxonomy.
3. **Mycorrhizae:** Ectotrophic mycorrhizae
4. **Fungi as re-cyclers**
5. **Poisonous fungi**
6. **Anamorphic fungi** (nematophagy and aquatic fungi).

Practicals:

1. Field study of Ascomycetous macrofungi, mushrooms, toadstools, rusts, smuts and other pathogenic fungi.
2. Isolation of pathogenic fungi from diseased tissues.
3. Anatomical and microscopic study of lichens. Anatomical study and hyphal systems of Polypores and Agarics.

4. Identification of various types of Ectomycorrhizae.
5. Study of interaction of fungi in culture, macroscopic and microscopic examination of common locally available types representing various taxonomic groups.
6. Collection, preservation, culturing and identification of mycological specimens with special reference to taxa of agricultural importance; use of keys for their identification.

Teaching-learning Strategies

1. Lectures
2. Group Discussion
3. Laboratory work
4. Seminar/ Workshop

Learning Outcome:

1. Students are expected to get familiarized with the morphological and systematic knowledge about different fungal groups.
2. They will be able to describe the concepts of what constitutes disease in plants and identify major principles of fungal plant pathology.
3. This will enable them to employ methods to diagnose and manage a wide range of plant diseases caused by fungi.

Assessment Strategies:

1. Lecture Based Examination (Objective and Subjective)
2. Assignments
3. Class discussion
4. Quiz
5. Tests

Recommended Readings:

1. Ahmad, S. (1978). *Ascomycetes of Pakistan*, Vol.1 and II. Biological Society of Pakistan, Lahore, Pakistan.
2. Alexopoulos, C.J., Mims, C.W. and Blackwell, M. (1996). *Introductory Mycology*. 4th edition, John Wiley and Sons. Inc., New York, USA.
3. Barnett, H. L. and Hunter, B.B. (1996). *Illustrated Genera of Imperfect Fungi*, 4th edition, American Phytopathological Society Press, St. Paul, Minnesota, USA.
4. Cole, G.T. and Kendrick, B. (1981). *Biology of Conidial Fungi*, Vol-II. Academic Press, New York, USA.
5. Cummins, E.A. (1971). *The Rust Fungi of Cereals, Grasses and Bamboo*. Springer-Verlag. Berlin, Germany.
6. Cummins, G.B. and Hiratsuka, Y. (2003). *Illustrated Genera of Rust Fungi*, 3rd Ed. APS Press, St. Paul Minnesota. 240 pp.
7. Hanlin, R.T. (1990). *Illustrated Genera of Ascomycetes.* Vol. 1. APS Press, St. Paul. Minnesota. 263 pp.
8. Hanlin, R.T. (1998). *Illustrated Genera of Ascomycetes.* Vol. 2. APS Press, St. Paul Minnesota. 258 pp.
9. Kendrick, B. (2000). *The Fifth Kingdom*. (3rd ed.). Focus Publishing/R. Pullins Company, Incorporated.373 pp.
10. Kirk, P.M., Stalpers, J. A., Minter, D.W. and Cannon, P. F. (2008). *Dictionary of Fungi*. 10th ed. CABI, UK.
11. Lemke, P.A. and Esser, K. (2001). *The Mycota*. Volume VII. Systematics and Evolution. Part A. Springer.

12. Petrini-Klieber, L.E. and Petrini, O. (2013). *Identifying Moulds: A Practical Guide.* Gebruder Borntraeger Verlagsbuchhandlung, Science Publishers.
13. Vánky, K. (2012). *Smut Fungi of the World*. APS Press, St. Paul Minnesota. 1480 pp.
14. Vánky, K. (2002). *Illustrated Genera of Smut Fungi*. 3rd Ed. APS Press, St. Paul Minnesota. 280 pp.
15. Webster, J. and Weber, R. (2007). *Introduction to Fungi*. Cambridge University Press.
16. White J.F. (2003). Claviciptalean fungi, Evolution, Biology, Chemistry, Bio and Cultural Control.

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Bot-325 LAB TECHNIQUES Credit Hours 1 (0+1)

Course Outline: The aim of this course is to acquaint the student with the working of various Instruments and Techniques used in different laboratories.

Course Details: Students shall be required to visit all Research Laboratories in the Department on a regular basis to learn advanced techniques. They will submit Report about each Laboratory at the end of the Semester, which should elaborate and highlight details of all Advanced Techniques/Instrumentation in the written form. Each student will appear for Viva Voce Examination pertaining to that report during which time he/she shall be asked various questions pertaining to the said techniques. Total marks for this course would be divided into two parts: Written Repot and Viva Voce Examination. Students shall consult Books available in the library for each the discipline as directed by the respective Teacher/Faculty Member.

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BS 7th Semester

Semester – VII		
Course Code	**Subjects**	**Credit Hours**
Bot-401 & 402	Principles of Genetics	2 + 1
Bot-403 & 404	Plant Physiology and Development	2 + 1
Bot-405 & 406	Environmental Biology	2 + 1
Bot-407	Research Methods	2 + 0
Bot-408	Elective Paper/Research	2 + 1
		3 + 0
Bot-409	Seminar	1 + 0
Semester Credit Hours		**15**

Bot-401 & 402 PRINCIPLES OF GENETICS Credit Hours: 3(2+1)

THEORY:

Introduction of the Course:

This course includes concepts regarding inheritance patterns, recombination in bacteria, linkage and mapping, extranuclear inheritance, developmental and population genetics.

Course Objectives:

1. To enable the students to understand the structural and functional basis of genes and proteins and their mutual interactions
2. To enable the students to understand various DNA manipulations at the molecular level

Contents:

1. **Study of Inheritance Patterns:** Mendel's laws of inheritance**,** extensions of mendelian analysis, dominant and recessive alleles, multiple alleles, lethal alleles, several genes affecting the same character, penetrance and expressivity, quantitative inheritance.
2. **Linkage and Mapping**: 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, accurate calculation of large map distances, mapping human chromosomes.
3. **Gene Mutation**: Somatic versus germinal mutation, mutant types, the occurrence of mutations, mutation and cancer, mutagens and genetic disorders, evolutionary significance of mutation.
4. **Recombination in Bacteria and Viruses**: Bacterial chromosome, bacterial conjugation, bacterial recombination, bacterial transformation, transduction, mapping of bacterial chromosomes, bacteriophage genetics, bacterial gene transfer.
5. **The Structure of DNA**: DNA-The genetic material, DNA replication in eukaryotes.
6. **The Nature of the Gene**: How genes work, gene- protein relationships, genetic fine structure, complementation.
7. **DNA Function**: Transcription, translation, the genetic code, protein synthesis.
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, proto-oncogenes and oncogenes, cancer as a developmental genetic disease.
10. **Population Genetics**: Gene frequencies, conservation of gene frequencies, equilibrium, Hardy-Weinberg law, factors affecting gene equilibrium.

Practicals:

Numerical problems with reference to:

- Arrangement of genetic material
- Linkage and recombination
- Gene mapping in diploids
- Recombination in Fungi
- Recombination in bacteria
- Recombination in viruses.
- Population Genetics: Gene frequencies and equilibrium, Changes in gene frequencies,
- Blood group and Rh-factor.
- Drosophila: Culture technique, Salivary gland chromosome
- Fungal genetics: Sacchromyces culture techniques and study.
- Studies on variation in maize ear size and colour variation.
- Bacterial Genetics. Bacterial cultural techniques, Gram staining (*E. coli*, *B. subtilis*), Transformation, Conjugation.

Recommended Readings:

1. S. B. Gelvin. (2000). *Plant Molecular Biology Manual*. Kluwer Academic Publishers.
2. B. A. Pierca. (2005) *Genetics*. A conceptual approach, W. H. Freeman and Company, New York.
3. L. Synder and W. Champness. (2004) *Molecular Genetics of Bacteria*. ASM Press, Washington D.C.
4. W. S. Klug and M. R. Cummings (1997) *Concepts of Genetics*, Prentice Hall International Inc.
5. N. V. Roth Well (1997) *UnderstandingGenetics*, second edition, Oxford University Press Inc.
6. E. J. Gardner (2004) *PrinciplesofGenetics*, John Willey and Sons, New York.
7. J. Ringo (2004) *FundamentalGenetics*, Cambridge University Press.
8. A. J. F. Griffiths, S. R. Wessler, R. C. Lewontin, W. M. Gelbart, D. T. Suzuki, and J. H. Miller (2010) *IntroductiontoGeneticAnalysis*, W.H. Freeman and Company. 11thed.
9. L. Snyder and W. Champness (2003) *MolecularGeneticsofBacteria*, ASM Press.
10. D. L. Hartl, and E. W. Jones (2005) *Genetics -AnalysisofGenesandGenomes*, Jones and Bartlett Publishers. Sudbary, USA.
11. P. W. Hedrick (2005) *GeneticsofPopulation*. Jones and Bartlett Publisher, Sudbury, USA.

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Bot-403 & 404 PLANT PHYSIOLOGY AND DEVELOPMENT Credit Hours: 3(2+1)

THEORY:

Course Outline:

The Course Content Includes an elaborate account of Photosynthesis, Respiration, Assimilation of Nutrients, Translocation of Food, and Light Mediated Stomatal Movements.

Course Detail:

Photosynthesis: General Concepts, organization of the photosynthetic apparatus and light absorbing antenna system, Ultrastructure and composition of photosystem-I and II. Absorption and action spectra of different pigments. Mechanism of photosynthesis; light absorption, charge separation or oxidation of water (water oxidizing clock), electron and proton transport through thylakoid protein-pigment complexes. Photophosphorylation and its mechanism.CO_2 fixation mechanisms (C3, C4, CAM pathway).

Respiration: Overview of respiration; Mechanism of respiration- Glycolysis, Oxidative pentose phosphate pathway, The Citric Acid Cycle, Regulation of glycolysis and Krebs cycle, Mitochondrial Electron transport and ATP synthesis. Aerobic and anaerobic respiration. Energetics of respiration. Glyoxylate cycle.

Translocation of photosynthetic: Pathway of Translocation; mechanism of phloem transport;materials translocated; Phloem loading and unloading; Photosynthate allocation and partitioning. **Assimilation of inorganic Nutrients (N, S, P):** The nitrogen cycle; Nitrogen fixation; Pathways of assimilation of nitrate and ammonium ions. Sulphur Assimilation; Phosphorous Acquisition. **Stomatal biology:** Light dependent stomatal opening; photoreception of blue light by zeaxanthin and phototropins; Factors affecting stomatal movement.

Practicals:

1. Extraction and quantitative measurement of chlorophyll extracted from the leaves by spectrophotometer.
2. Estimation of Oxygen utilized by a Respiring Plant by Winkler's method.
3. Measurement of Carbon Dioxide Evolution during Respiration of Germinating Seeds by the Titration Method.
4. To Categorize C3 and C4 plants through their anatomical and physiological characters.
5. To regulate stomatal opening by light of different colors and pH

Recommended Readings:

1. L.Taiz, E.Zeiger, I.M. Møller, A. Murphy (2015).*Plant Physiology and Development,* 6th Edition. Sinauer Associates Inc., Sunderland MA. ISBN: 0-87893-831-1,700pp
2. R. L. Jones, H. Ougham, H. Thomas, S. Waaland (2012). *The Molecular Life of Plants***.** Wiley Blackwell**.** ISBN: 978-0-470-87011-2012 766pp
3. B. B. Buchanan (Editor), W. Gruissem (Editor), R. L. Jones (Editor) 2nd Edition (2015). *Biochemistry and Molecular Biology of Plants.*Wiley-Blackwell. ISBN: 978-0-470- 71421-8 1280pp
4. E. Grotewold, J. Chappell, E. A. Kellogg (2015).*Plant Genes, Genomes, and Genetics.* Wiley-Blackwell ISBN: 978-1-119-99888
5. Plant Physiology and Development (http://6e.plantphys.net/)
6. The Arabidopsis Book (https://aspb.org/publications/other-aspb-publications/the-arabidopsis-book/).
7. Plant Physiology (http://www.plantphysiol.org/).
8. Annual Review of Plant Biology (http://www.annualreviews.org/journal/arplant).

9. The Plant Cell (http://www.plantcell.org/site/teachingtools/).
10. Teaching tools in Plant Biology (http://www.plantcell.org/content/teaching-tools-plant-biology).
11. Basic Biology Concepts Khan Academy (http://lej4learning.com.pk/category/basic-sciences/biology).
12. Current protocols in Plant Biology (http://www.currentprotocols.com/WileyCDA/Section/id-810246.html).

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Bot-405 & 406 ENVIRONMENTAL BIOLOGY Credit Hours: 3(2+1)

THEORY

Introduction of the Course:

This course provides an introduction to the basic principles of environmental biology, ecology, and the relationship between humans and the natural world. This course will provide students with a broad survey of environmental science with emphasis on current events, global and international issues.

Course Objectives:

The course is designed to:

1. include different aspects of environmental pollution in order to understand its nature and impact on the living organisms
2. Analyze current environmental issues and evaluate potential solutions
3. Relate the features of human populations to different types of environmental degradation
4. Recognize the impact of globalization on the environment

Course Details:

5. **Introduction:** Aim and scope. An interdisciplinary field.
6. **Natural Resources:**
   - **2.1.** Nature, Importance and conservation of the following, Energy, Water, Land, Minerals, Agriculture, Forestry, Range Land, Wild-Life and Aquaculture

3. Air Pollution:

- **3.1.** Sources, Nature and impact of primary and secondary air pollution
- **3.2.** Effect of major and minor phytotoxic air pollutions on plants
- **3.3.** Prevention and Control (vehicles pollution and Industrial chimney wastes)

4. Water Pollution:

- **4.1.** Introduction, sources of water pollution, nature of water pollution
- **4.2.** Ground water and marine pollution impacts of water pollution
- **4.3.** Prevention and control measures.

5. Radiation Pollution:

- **5.1.** Nuclear concepts and terminology, sources, types
- **5.2.** Comparative radiation sensitivity of organisms, Radiation, Effects at cell organisms and ecosystem levels
- **5.3.** Fate of Radio-nuclides in the environment
- **5.4.** The Fall out Problem
- **5.5.** Nuclear waste disposal

6. Solid Waste, Noise and thermal pollution:

- **6.1.** Nature sources, impacts and control

7. Pesticides and Agro-Chemicals:

- **7.1.** Herlucides, Insecticides and Fungicides as plant poisons, characteristics, Environmental concerns and impact of pesticides Ecosystem.

8. Environmental Crisis:

- **8.1.** Nature origin, Impact and control of Ozone hole
- **8.2.** Green house effects
- **8.3.** Global Warming
- **8.4.** Acid rays chemical and Biological warfare

Practicals:

1. Examination of Industrial Waste Water and Municipal Sewage for some physical characteristic and

i. Total Dissolved Solids (TDS)
ii. pH and EC
iii. BOD and COD , DO
iv. Chlorides, Carbonates, Bicarbonates and Nitrates

2. Examination of Water Samples from different sites for the Presence and Diversity of Organisms.
3. Field observation on the Sources and Impacts of various Air Pollutants.
4. Examination of the Effects of Automobile Exhaust on the Adjacent Vegetation.

i) Chlorophyll Content
ii) Symptoms / Soot and Particulate matter

5. A visit to EPA to study the Instruments used for Monitoring Pollution.
6. A visit to the Industrial Organizations to examine their Effluent Treatment System.
2. A visit to the municipal Organization to study their Sewage Treatment System.
8. Irradiation of seeds / Effects of seed irradiation on seed germination and early seedling grow

Teaching-learning Strategies

1. Lectures
2. Group Discussion
3. Laboratory work
4. Seminar/ Workshop

Learning Outcome:

1. Describe and debate various global and regional environmental concerns that affect various forms of life.
2. Appreciate the impact of human activities on other life and the environment.
3. Investigate specific cases of environmental pollution or natural challenges, and their impacts.
4. Apply chemistry, biology, molecular biology and microbiology skills to environment issues.
5. Reflect on the scientific concerns, including ethical and social issues, to the environment associated with the applications of new technologies.

Assessment Strategies:

1. Lecture Based Examination (Objective and Subjective)
2. Assignments
3. Class discussion
4. Quiz
5. Tests

Recommended Readings:

1. Berry, W.K. (2017). *Water Pollution* CBS Publisher and Distributer Pvt. Ltd.
2. Goel, P. K. (2016). *Water Pollution: Causes, Effects and Control* (Revised 2nd edition) new AGE International Ltd Publisher.
3. Ghafoor, A., Murtaza, G. M., Rehman, Z., Sabir, M. Ahmad, H. R. and Saifullah. (2012). *Environmental Pollution*: *Types, Sources & Management*. Allied Book Centre, Urdu Bazar, Lahore.
4. Treshow, M. (Latest Edition) *Environment and Plant Response*. Mcgraw-Hill NY.

5. Koziol, M.J., Whatley, F. R. (Latest Edition) *Gaseous Air Pollution and Plant Metabolism.* Butterworths.
6. Agrawal, K. C. (Latest Edition) *Environmental Biology* Agro Botanical Publishers, India.
7. Johnson, C. E. (Latest Edition) *Eco-crisis* John Wiley & Sons. Inc., New York, London. Toronto.
8. Mansfield, T. A. (Latest Edition) *Effects of Air Pollutants on Plants* Cambridge University Press, London, New York, Melbourne.

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BS 8th Semester

Semester – VIII		
Course Code	**Subjects**	**Credit Hours**
Bot-411 & 412	Molecular Genetics	2 + 1
Bot-413 & 414	Plant Pathology	2 + 1
Bot-415 & 416	Plant Nutrition and Soil Fertility	2 + 1
Bot-417 & 418	Advances in Plant Physiology	2 + 1
Bot-419	Elective Paper/Research	2 + 1
		3 + 0
Semester Credit Hours		**15**

Bot-411 & 412 MOLECULAR GENETICS Credit Hours:3(2+1)

THEORY

Introduction of the Course:

This course includes concepts regarding Recombinant DNA and its applications, gene expression, mechanisms of genetic changes including mutation, recombination and transposable elements, genome projects.

Course Objectives:

1. To enable the students to understand the structural and functional basis of genes and gene expression, DNA and genetic changes including mutation, recombination and transposable elements.
2. To enable the students to understand various DNA manipulations at the molecular level.

Contents:

1. **Recombinant DNA:** Recombinant DNA Technology – Introduction, Basic Techniques, PCR, Restriction enzymes, DNA sequencing, plasmids and bacteriophages as tools, the formation of recombinant DNA, Restriction and modification system, recombinant DNA and social responsibility, Site directed mutagenesis.
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, gene therapy, genetically modified organisms and apprehensions.
3. **Control of Gene Expression**: Discovery of the *lac* system: negative control, catabolite repression of the *lac* operon: positive control, transcription: gene regulation in eukaryotes - an overview.
4. **RNA Processing**: Exons & introns, splicing, Self-splicing introns, RNA editing, Trans-splicing, RNA interference, siRNAs, miRNAs, ncRNAs.
5. **Genetic Change-Gene Mutation**: The molecular basis of gene mutations, spontaneous mutations, induced mutations, mutagens and carcinogens, biological repair mechanisms.
6. **Genetic Change-Recombination**: General homologous recombination, the holiday model, enzymatic mechanism of recombination, site-specific recombination, recombination and chromosomal rearrangements.

7. **Genetic Change - Transposable Genetic Elements**: Insertion sequences, transposons, review of transposable elements in prokaryotes, controlling elements in maize.
8. **Human Genome Project**: Strategies and application, achievement and future prospects.
9. **Plant Genome Projects**: Arabidopsis, achievement and future prospects.
10. **Bioinformatics:** Application of computational tests to the analysis of genome and their gene products.
11. **Bioethics**: Moral, Religious and ethical concerns

Practicals:

1. Problems related to the theory, Isolation and separation of DNA and protein on Gel electrophoresis.
2. Quantitative separation of macromolecules (Plasmid DNA, plant DNA, Protein) using electrophoresis.
3. DNA Amplification by PCR

Teaching-learning Strategies

1. Lectures
2. Group Discussion
3. Laboratory work
4. Seminar/ Workshop

Learning Outcome:

1. Students are expected to get themselves familiarized with the molecular/macromolecular organization of plant cells and DNA in general.
2. They should be able to understand almost infinite possibilities of structural organization, molecular backbones and the myriad roles or functions they can take or perform.
4. Students should be able to understand the basic concepts with regard to DNA Amplification by PCR.

Recommended Readings:

1. Brown, T. A. (2002). *Genomes*, Bios Scientific Publishers Ltd.
2. Gelvin, S. B. (2000). *Plant Molecular Biology Manual*. Kluwer Academic Publishers.
3. Griffiths, A. J. F., Wessler, S. R., Lewontin, R. C., Gelbart, W. M., Suzuki, D. T. and Miller, J. H. (2010). *Introduction to Genetic Analysis*, W.H. Freeman and Company. (11^{th} Edition)
4. Hartt, D. L. and Jones, E. W. (2005). *Genetics, Analysis of Gene and Genomes*. Jones and Bartlett Publishers, Sudbury, USA
5. Ignacimuthu, S. (2005) *Basic Bioinformatics*, Narosa Publishing House, India.
6. Lwein, B. (2004). *Gene VIII*, Pearson Education Int.
7. Miglani (2003) Advanced *Genetics*, Narosa Publishing House, India.
8. Primrose, S. B., Twyman, R. M. and Old, R. W. (2004). *Principles of Gene Manipulation*, an Introduction to Genetic Engineering, Blackwell Scientific Publications.
9. Snyder, L. and Champness, W. (2003). *Molecular Genetics of Bacteria*, ASM Press.
10. Trun, N. and Trempy, J. (2004). Fundamental *Bacterial Genetics*, Blackwell Publishing House.
11. Wilson, J. and Hunt, T. (2004). *Molecular Biology of the cell* – the problems book, Garland publishing Inc.
12. Winnacker, E. L. (2003). *From Gene to Clones – Introduction to Gene Technology*, Panima Publishing Corporation, New Delhi.

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Bot-413 & 414 PLANT PATHOLOGY Credit Hours: 3(2+1)

THEORY

Introduction of the Course:

The course is designed to provide an adequate knowledge about basic concepts of important plant pathogens and pathogenic diseases, pattern of disease development and disease cycle. It is generally aimed to familiarize students about the identification of major plant pathogens such as bacteria, fungi, nematodes, viruses and other microbes that cause huge economic losses to the farmers.

Course Objectives:

The course is designed:

1. To provide an adequate knowledge about basic concepts of different plant pathogens and their morphological/anatomical characteristics.
2. To acquaint students with basic vocabulary and recent trends in Plant Pathology and to familiarize them with the plant disease management.

Contents:

1. **Introduction**:
   - 1.1.History and classification of plant pathogens and pathogenic diseases.
   - 1.2.Symptoms, causes and patterns of their development.
   - 1.3.Loss assessment and plant pathogen control and systemic resistance.
   - 1.4.Epidemiology and disease forecast.
   - 1.5.The effect of environmental factors on disease development.
2. **Taxonomy:**
   - 2.1.Taxonomic position and classification of economically important plant pathogens.
3. **Viruses**:
   - 3.1.Important Pathogenic diseases of crop plants and fruit trees caused by Viruses.
   - 3.2.Sugarcane mosaic virus disease.
   - 3.3.Cotton leaf curl disease.
   - 3.4.Tobacco Mosaic virus disease.
   - 3.5.Potato virus Y disease.
4. **Fungi**:
   - 4.1.Important Pathogenic diseases of crop plants and fruit trees caused by fungi including Apple scabs etc.
   - 4.2.Rusts (*Puccinia, Phragmidium, Uromyces* etc.).
   - 4.3.Smuts (*Ustilago, Urocystis, Thekaphora* etc.).
   - 4.4.Powdery Mildews (*Erysiphe, Phyllactinia, Microsphaera, Podosphaera* etc).
   - 4.5.Downy Mildews
5. **Bacteria**:
   - 5.1.Blight of cereals and grasses
   - 5.2.ring rot of Potato
   - 5.3.Crown Gall disease
6. **Nematodes**:
   - 6.1.Root Knot Disease of Vegetables
   - 6.2.Potato Cyst disease
7. **Economic importance of plant diseases**
8. **Introduction to molecular techniques and their application in Plant pathology**

Practicals:

1. Collection, preservation and identification of infected plant specimens based on symptoms
2. Study of important taxonomic characteristics of various plant pathogens
3. Basic pathological cultural techniques for isolation and inoculation. Preparation of media and isolation of different plant pathogens
4. Macroscopic and Microscopic examination of diseased specimens of the type studied
5. Field trips for collection of different plant samples infected with fungal, viral and bacterial pathogens

Teaching-learning Strategies

1. Lectures
1. Group Discussion
2. Laboratory work
3. Seminar/ Workshop

Learning Outcome:

1. Students are expected to get familiarized with the morphological and systematic knowledge about different plant pathogens.
2. They will be able to describe the concepts of what constitutes disease in plants and identify major principles of plant pathology.
3. This will enable them to employ methods to diagnose and manage a wide range of plant diseases.
4. The obtained knowledge shall also enable the students to describe aspects of integrated pest management and to explain the impact of plant diseases on human affairs.

Assessment Strategies:

1. Lecture Based Examination (Objective and Subjective)
2. Assignments
3. Class discussion
4. Quiz
5. Tests

Recommended Readings:

1. Agrios, G. N. (2011). *Plant Pathology*, 6th edition. Academic Press, New York, USA.
2. Ahmad, I. and Bhutta, A. R. (2005). *Textbook of introductory Plant Pathology*. Published by National Book Foundation, Islamabad.
3. Ahmad, S., Iqbal, S. H. and Khalid, A. N. (1997). *Fungi of Pakistan*. Sultan Ahmad Mycological Society Pakistan, Department of Botany, University of Punjab, Lahore, Pakistan.
4. Braun, U. and Cook, R. T. A. (2012). *Taxonomic Manual of the Erysiphales (Powdery Mildews)*. ISBN: 978-90-70351-89-2.
5. Cummins, G.B. and Hiratsuka, Y. (2003). *Illustrated Genera of Rust Fungi*. Third ed. The American Phytopathological Society. APS Press, St. Paul, MN.
6. Hafiz, A. (1986). *Plant Diseases*. Pakistan Agricultural Research Council, Islamabad, Pakistan.
7. Mathew, J. D. (2003). *Molecular Plant Pathology*. Bios Scientific Publishers Ltd. UK.
8. Mehrotra, R. S. and Agarwal, A. (2003). *Plant Pathology*. 2nd Edition. TATA McGraw-Hill. Pub. Company Ltd. New Delhi.
9. Sambamurty, A. V. S. S. (2006). *A Text Book of Plant Pathology*. I.K. International Pvt. Ltd.

10. Schumann, G. L. and D'Arcy, C. J. (2010). *Essential Plant Pathology*. APS Press. 369 PP.
11. Strange, R. N. (2003). *Introduction to Plant Pathology*. John Willey & Sons, New York.
12. Ravichandra, N. G. (2013). *Fundamentals of Plant Pathology*. Prentice Hall of India Pvt. Ltd.
13. Prell, H. H. and Day, P. (2001). *Plant – Fungal Pathogen Interaction – A Classical and Milecular View*. Springer Verlage.
14. Vánky, K. (2011["2012"]). *Smut fungi of the World*. APS Press, St. Paul, Minnesota, USA.
15. Vánky, K. (2013). *Illustrated Genera of Smut Fungi*, 3rdedn. St. Paul, MN, USA, APS Press.

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Bot-415 & 416 PLANT NUTRITION AND SOIL FERTILITY Credit Hours: 3(2+1)
THEORY

Introduction of the Course:

The course is organized to provide an adequate knowledge about plant nutrition and soil fertility. Soil fertility is the ability or the quality of a soil that enables it to provide chemical elements in quantities and proportions for plant growth. Soil fertility and plant nutrition, therefore, cannot be divorced from each other. Plant nutrition involves the study of chemical elements necessary for plant growth.

Course Objectives:

The course is designed:

1. To provide an adequate knowledge about basic concepts of plant nutrition and soil fertility.
2. To provide the knowledge about different mineral plant nutrition, their requirements, and deficiency symptoms in plants. It also explains the soil fertility evaluation methods for soil and plants.

Contents:

1. **Mineral Plant Nutrition:**
   1.1 Introduction
   1.2 Scope and history of mineral plant nutrition
2. **Macronutrient and Micronutrient Elements:**
   2.1 Introduction
   2.2 Inorganic components of plants
   2.3 Essential and other mineral elements
   2.4 Macronutrient and micronutrient elements requirements of higher plants
   2.5 Deficiency symptoms of individual elements
3. **Media of Plant Nutrition:**
   3.1 The variety of nutrient media
   3.2 Soil
   3.3 Solution culture
   3.4 Chemical composition of nutrient solutions
   3.5 Modified solution culture
   3.6 Culture solutions compared with soil solutions
4. **Soil Fertility:**
   4.1 Introduction
   4.2 Soil fertility evaluation
5. **Soil and Fertilizer:**
   5.1 Introduction
   5.2 Soil and fertilizer N.P.K. Ca, Mg, S, Fe and trace elements
   5.3 Liming and use of Gypsum; Fertilizers and efficient use of water

Practicals:

1. Preparation of standard acid, alkali and indicator solutions
2. Preparation of fertilizer mixtures.
3. Study of deficiency symptoms of macro and micro nutrient elements.
4. Phenotypic adaptations of plants to nutrients, deficiency and methods of growth analysis.
5. Determination of macro and micro nutrient elements of Plant tissues.

6. Determination of macro and micro nutrient elements of soil.
7. Determination of total water requirement of a crop by using climatic data (Blaney & Criddle formula will be used).

Teaching-learning Strategies:

1. Lectures
2. Group Discussion
3. Laboratory work
4. Seminar/ Workshop

Learning Outcome:

1. Students are expected to get familiarized with the morphological and systematic knowledge about different plant groups.
2. They will be able to describe, apply and integrate the basic concepts of Cell Biology including Genetics and Evolution, Biochemistry, Physiology as well as Structure and Functions of different Organelles.
3. This will enable them qualify for basic to moderate level jobs involving knowledge of plants and their environment.
4. The obtained knowledge shall also enable the students to enter into various entrepreneurial activities involving general introduction to Botany.

Assessment Strategies:

1. Lecture Based Examination (Objective and Subjective)
2. Assignments
3. Class discussion
4. Quiz
5. Tests

Recommended Readings:

1. Epstein, F., Mineral Nutrition of plants: Principles and perspectives. 1972. John Wiley & sons, Inc. 1971.
2. Treshow, M. Environment and plant response McGraw Hill, 1970.
3. Wallace, T., The diagnosis of mineral deficiencies in plants. Her Majesty's Stationery Office London, 1961.
4. Tisdale, S. and W. Nelson, Soil Fertility and Fertilizers. 3rd ed. Mchillans, 1975.

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Bot-417 & 418 ADVANCES IN PLANT PHYSIOLOGY Credit Hours: 3(2+1)

THEORY:

Introduction of the Course:

The course is organized to provide an adequate knowledge about advances in plant physiology. Physiology studies about these internal processes and their functional aspects. Plant physiology is a study of vital phenomena in plant. It is the science concerned with Processes and functions, the responses of plants to environment and the growth and development that results from the responses.

Course Objectives:

The course is designed:

1. To provide an adequate knowledge about basic concepts of plants according to syllabus.
2. To a give detailed account of water and solute transport, plant growth regulators, phytochromes and control of floral development.

Contents:

1. **Plant Growth Regulators**:
   - 1.1 Major natural hormones (Auxins, Gibberellins, Cytokinins, Abscisic acid, Ethylene)
   - 1.2 Structure, biosynthesis, receptors, signal transduction, mode of action, transport, and physiological effects.
2. **Water Relations**:
   - 2.1 The soil plant atmosphere continuum an overview
   - 2.2 Structure of water
   - 2.3 Physico-chemical properties of water
   - 2.4 Water in the soil and its potentials
   - 2.5 Water in cell components
   - 2.6 Absorption of water in plants
   - 2.7 Pathways and driving forces
   - 2.8 Aquaporins,-their structure and types
   - 2.9 Cell water relations terminology
   - 2.10 Modulus of elasticity coefficient
   - 2.11 Hydraulic conductivity
3. **Solute Transport:**
   - 3.1 The nature of membrane carriers
   - 3.2 channels and electro genic pumps
   - 3.3 Passive and active (primary and secondary) transports and their energetics
   - 3.4 Membrane transport proteins Ion traffic into root
4. **Phytochromes**:
   - 4.1 Discovery of phytochromes
   - 4.2 Physical and chemical properties of phytochromes
   - 4.3 Role of phytochromes in biological processes
   - 4.4 Phytochromes signaling pathways
5. **Control of Flowering**:
   - 5.1 Floral meristem and floral organ development
   - 5.2 Floral organ identity genes and the ABC model
   - 5.3 Circadian rhythms
   - 5.4 Photoperiodism
   - 5.5 Vernalization

Practical:

1. To determine osmotic potential of massive tissue by freezing point depression method or by an osmometer.
2. To investigate water potential of a plant tissue by dye method and water potential apparatus.
3. Measurements of stomata index and conductance, Determination of K uptake by excised roots.
4. To investigate the preferential absorption of ions by corn seedlings and potato slices.

Teaching-learning Strategies:

1. Lectures
2. Group Discussion
3. Laboratory work
4. Seminar/ Workshop

Learning Outcome:

1. Students are expected to get familiarized with the morphological and systematic knowledge about different plant groups.
2. They will be able to describe, apply and integrate the basic concepts of Cell Biology including Genetics and Evolution, Biochemistry, Physiology as well as Structure and Functions of different Organelles.
3. This will enable them qualify for basic to moderate level jobs involving knowledge of plants and their environment.
4. The obtained knowledge shall also enable the students to enter into various entrepreneurial activities involving general introduction to Botany.

Assessment Strategies:

1. Lecture Based Examination (Objective and Subjective)
2. Assignments
3. Class discussion
4. Quiz
5. Tests

Recommended Readings:

1. Taiz, L., Zeiger, E. Møller I.M. and Murphy, A. (2015). *Plant Physiology and Development,* 6th Edition. Sinauer Associates Inc., Sunderland MA. ISBN: 0-87893-831-1,700pp
2. Jones, R. L., Ougham, H. H. Thomas, S. and Waaland. (2012). *The Molecular Life of Plants***.** Wiley Blackwell**.** ISBN: 978-0-470-87011-2012 766pp
3. Buchanan, B. B., Gruissem, W., Jones, R. L. (2015). *Biochemistry and Molecular Biology of Plants*. Wiley-Blackwell. 2nd Edition, ISBN: 978-0-470- 71421-8, 1280pp.
4. Grotewold, E., Chappell, J. and Kellogg, E. A. (2015). *Plant Genes, Genomes, and Genetics.* Wiley-Blackwell ISBN: 978-1-119-99888.
5. Plant Physiology and Development (http://6e.plantphys.net/).
6. The Arabidopsis Book (https://aspb.org/publications/other-aspb-publications/the-arabidopsis-book/).
7. Plant Physiology (http://www.plantphysiol.org/).
8. Annual Review of Plant Biology (http://www.annualreviews.org/journal/arplant).
9. The Plant Cell (http://www.plantcell.org/site/teachingtools/).
10. Teaching tools in Plant Biology (http://www.plantcell.org/content/teaching-tools-plant-biology).

11. Basic Biology Concepts Khan Academy (http://lej4learning.com.pk/category/basic-sciences/biology).
12. Current protocols in Plant Biology (http://www.currentprotocols.com/WileyCDA/Section/id-810246.html).

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LIST OF SPECIAL PAPERS:

Bot.Sp-01	Applied Paleopalynology	3(2+1)
Bot.Sp-02	Bioremediation	3(2+1)
Bot.Sp-03	Recombinant DNA Technology	3(2+1)
Bot.Sp-04	Plant Breeding and Horticulture	3(2+1)
Bot.Sp-05	Fungal Diseases of Cereal Crops	3(2+1)
Bot.Sp-06	Biochemistry of Nucleic Acids	3(2+1)
Bot.Sp-07	Soil And Agricultural Microbiology	3(2+1)
Bot.Sp-08	Water logging and Salinity	3(2+1)
Bot.Sp-09	Computational Biology	3(2+1)
Bot.Sp-10	Environmental Impact Assessment	3(2+1)
Bot.Sp-11	Biostratigraphy	3(2+1)
Bot.Sp-12	Cultivation of Edible Fungi	3(2+1)
Bot.Sp-13	In vitro Technologies and Industrial Applications	3(2+1)
Bot.Sp-14	Agriculture and Environmental Pollution	3(2+1)
Bot.Sp-15	Advances in Molecular Genetics	3(2+1)
Bot.Sp-16	Biohazards, Biosafety, Bioethics	3(2+1)
Bot.Sp-17	Mycorrhizae in Agriculture	3(2+1)
Bot.Sp-18	Plant Physiology and Climate Change	3(2+1)
Bot.Sp-19	Archaeopalynology	3(2+1)
Bot.Sp-20	Plant Architecture-Innovations Through Time and Space	3(2+1)
Bot.Sp-21	Aero palynology and Pollen Borne Diseases	3(2+1)
Bot.Sp-22	Environmental Bacteriology	3(2+1)
Bot.Sp-23	Gene Cloning	3(2+1)
Bot.Sp-24	Genomics and Proteomics	3(2+1)
Bot. Sp-25	Contemporary concepts and methods in cell biology	3(2+1)

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Bot.Sp-01 APPLIED PALEOPALYNOLOGY Credit Hours: 3(2+1)

THEORY:

Introduction to the course:

The primary mission of this course is to provide with a set of practical skills that will allow you to date a rock sample and reconstruct the climate at the time of deposition, based on constituent palynomorphs.

Course Objectives:

The aim of the course is:

1) Explore the function and morphology of pollen and spores, using modern specimens as the primary examples.

2) Examine the organic evolution of plants, from the Cambrian colonization of the land to the Cretaceous rise of flowering plants, as recorded by fossil pollen and spores.

3) Understand the relationships between temperature, precipitation and vegetation cover.

Course Detail:

1. Introduction
   1.1. Scope and Importance.
2. Geological Time Scale.
3. Rock types.
4. Palaeozoic and Mesozoic sedimentary outcrops.
5. Palynomorphs in oil and gas exploration and in Stratigraphic Correlation.
6. Palynomorphs as sedimentary particles.
7. Preservability in sediments.Vegetational analysis from pollen analytical data.
8. "Stratigraphic leak" and Reworking. Post Depositional alteration of palynomorphs.
9. Marginal paleopalynology. Shell Code, Ultra structure of Exine.
10. Coal, formation and Classification.
11. Gondwanaland Palynofloristics
    11.1. Formation and sequence of breakup of Gondwanaland and its effect on the flora.

Practicals:

1. Map reading, use of clinometer and other instruments in the field.
2. Field survey of Mesozoic and Palaeozoic sedimentary outcrops of the higher / Lesser Himalayas.
3. Various techniques employed in identification and sampling of sedimentary rocks including section measurement.
4. Lithological description of sedimentary rock samples.
5. Observation, identification, technical and systematic description of the palynomorphs through Bulk and Powder maceration.
6. Preparation of strew mount and single grain slides.
7. Polaroid / Cross Nickol Microscopy.
8. Preservation and 51aleopalyno of palynoflora. Candidates shall be required to submit a Technical Report" at the time of Practical examination covering all aspects of fieldwork accomplished.

Teaching-learning Strategies

1. Lectures
2. Group Discussion
3. Laboratory work
4. Seminar/ Workshop

Learning Outcome:

Students will be able to:

1. Compare and contrast the function and morphology of pollen and spores
2. Describe and illustrate modern and fossil spores and pollen grains
3. Date any palynomorph-bearing sample to the correct geologic period
4. Reconstruct vegetation and paleoclimate based on palynomorph assemblages

Assessment Strategies:

1. Lecture Based Examination (Objective and Subjective)
2. Assignments
3. Class discussion
4. Quiz
5. Tests

Recommended Readings:

1. Traverse, A. *Paleopalynology*. Unwin Hyman Ltd.
2. Stratigraphic Memoirs of Geological Survey of Pakistan. Vol. 12.
3. Wadia, D.N. *Geology of India*. Tata Mcgraw Hill Publishing Co., New Delhi, India.
4. Andrews, H.N. Ancient plants and the World They Live in Comstock, Ithaca, New York.

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Bot-Sp-02 BIOREMEDIATION Credit Hours: 3 (2+1)

THEORY:

Introduction of the Course:

The course is about application of various living organisms viz. plants, microbes, etc. for remediation of contaminants and pollutants from different environmental spheres viz. lithosphere, hydrosphere, atmosphere. The living organisms individually or in combinations can degrade, detoxify, immobilize or minimize risk of contaminants to the environment of other living organisms, especially human. The course comprises an overview of the bioremediation process, its major types, strategies, factors and case studies as success stories at large scale.

Course Objectives:

The course is designed:

1. To understand basic importance and nature of bioremediation
2. To have concept of contaminants and pollutants in terms of its remediation through application of organisms
3. To have in depth idea of bioremediation technology, its level of advancement and existing challenges
4. To elucidate real world application of bioremediation for abatement of environmental pollution

Contents:

1. Basic concepts: environment, contaminant and pollutant

1.1 Definition and concept of environment

1.2 Concept of contaminant and pollutant

1.3 Types of pollutions and pollutants

1.3.1 Organic pollutants

1.3.2 Inorganic pollutants

1.3.3 Xenobiotics

2. Traditional approaches to pollution remediation

2.1 Traditional approaches for remediation of soil

2.1.1 *In situ* physico-chemical remediation approaches for soil, sediment, sludge, bedrock

2.1.1.1 Soil flushing and Vitrification

2.1.1.2 Encapsulation of contaminant areas with impermeable layers

2.1.1.3 Electrokinesis

2.1.2 *Ex situ* physico-chemical remediation approaches for soil, sediment, sludge bedrock

2.1.2.1 Landfarming

2.1.2.2 Soil washing

2.1.2.3 Chemical reduction / oxidation

2.1.2.4 Chemical extraction

2.3 Traditional approaches for remediation of water and air

3. Introduction to bioremediation

3.1 Bio treatment technologies for pollution control

3.2 Bioavailability: Sequestering and complexing

4. Bioremediation of soil, sediment, sludge, water and air

a. Bioremediation of polluted and contaminated soils, sediment and sludge, water and air

5. Microbial remediation

b. Molecular biological aspects of microbial remediation
   i. Biocatalyst selection and genetic modification
   ii. Enrichment and screening strategies.
   iii. Design of enrichment strategies relating to the environmental source

c. Microbial technologies for remediation of pollution
   i. Microbial acclimation, detoxification, Microbial activation and Microbial sorption
   ii. Cometabolism

d. Bacterial remediation

e. Mycoremediation

f. Phycoremediation

6. Phytoremediation

6.1. Non-assisted phytoremediation

6.1.1. Phytostabilization, Phytodegradation, Phytovolatilization, Phytoextraction

6.2. Assisted phytoremediation

6.2.1. Fungal-assisted phytoremediation

6.2.2. Bacterial assisted phytoremediation

6.2.3. Chemical assisted phytoremediation

6.2.4. Inorganic / organic chemical-assisted phytoremediation

6.2.5. Organic amendment-assisted phytoremediation

6.2.5.1. Compost-assisted phytoremediation

6.2.5.2. Biochar-assisted phytoremediation

7. Soil remediation through lower animals

6.1 Role of lower animals in pollutant detoxification

6.2 Role of earthworm in redistribution of heavy metals in soils

8. Case studies: Success stories of bioremediation at applied scale

6.1 Local case studies of Pakistan: Bioremediation success stories

6.2 International case studies: Bioremediation success stories at global scale

Practicals:

1. Sampling from contaminated sites and its characterization
2. Quantification of metals in the contaminated soil, water and biomass samples
3. Isolation of bacteria and fungi from indigenous non-polluted sources
4. Isolation of bacteria and fungi from polluted sources such as, oil wastes, polluted water from industries and sewage
5. Spray plate technique for testing the degradation ability of bacteria for different aromatic hydrocarbons
6. Bioremediation assays: Heavy metal resistant bacteria isolation through culturing method
7. Enrichment and isolation of pesticide degrading bacteria

Teaching-learning Strategies

1. Lectures
2. Field tours to contaminated sites and industrial areas
3. Group Discussion
4. Laboratory work
5. Seminar/ Workshop

Learning Outcome:

1. Students are expected to get familiarized with the current and upcoming challenges of environmental pollution in Pakistan.
2. They will be able to learn basic and applied aspects of bioremediation as one of the possible indigenously adaptable technology for pollution abatement.
3. The students will be able think in an innovative way to apply bioremediation technologies in solution-oriented way.
4. They will be able to have acquaintance with the current developments in the field of bioremediation at national and international level.

Assessment Strategies:

1. Lecture Based Examination (Objective and Subjective)
2. Assignments
3. Class discussion
4. Quiz
5. Tests

Recommended Readings:

1. Bhat, R.A., Hakeem, R., Qadri, H. (2020). Bioremediation and Biotechnology: Sustainable Approaches to Pollution Degradation. Springer Publishers. ISBN: 978-3-030-35691-0.
2. Hasanuzzaman, M., Prasad, M.N.V. (2020). Handbook of Bioremediation (1st Ed.). Academic Press. ISBN: 9780128193822.
3. Koul, B., Taak, P. (2018). Soil Remediation Through Algae, Plants and Animals. Springer Publishers. ISBN: 978-981-13-2420-8.
4. Kumar, V., Prasad, R., Kumar, M. (2021). Rhizobiont in Bioremediation of Hazardous Waste. Springer Publishers. ISBN: 978-981-16-0602-1.
5. Pandey, V.C., Singh, V. (2020). Bioremediation of Pollutants: From Genetic Engineering to Genome Engineering. Elsevier Publishers. ISBN: 978012819258.
6. Saxena, G., Kumar, V., Shah, M. (2020). Bioremediation for Environmental Sustainability (1st Ed.). Elsevier Publishers. ISBN: 9780128205242.

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Bot.Sp-03 RECOMBINANT DNA TECHNOLOGY Credit Hours: 3(2+1)

Introduction of the Course

This course is designed to provide essential knowledge about basic techniques of Recombinant DNA Technology. It also includes detailed study about DNA Structure and Regions, Study of various Vectors used in the development of recombinant DNA, their types and uses for expression of desired gene. This course will also make students familiar with the knowledge about Genetically Modified Plant, Transgenic Crop and their Importance. Concept based knowledge of breeding and production of new varieties of plant for future benefits.

Course Objectives

1. To enable the students to understand the concept of recombinant DNA synthesis
2. To make the students learn the application of recombinant DNA technology in various fields such as agriculture and medicine for the benefit of mankind

Contents

Unit I: Basic Techniques

- Agarose gel electrophoresis
- Southern (Northern and Western blotting)
- Transformation of *E.coli:* Transformation of other organisms.
- 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, Adapters, Homopolymer tailing.

Unit II: Plasmids as cloning vehicles

- Basic properties of plasmids
- Desirable properties of plasmid cloning vehicles, pBR322, low copy number plasmid vectors.
- Bacteriophage, cosmid vectors, filamentous phage vectors M13.

Unit III: Genetic methods

- Analysing DNA sequences
- Genomic DNA libraries
- Chromosome walking
- Complementary DNA cDNA
- Site directed mutagenesis
- Recombinant selection and screening
- 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.

Practicals:

- *E.coli* culture and growth curve
- Transformation of plasmid DNA to *E.coli.*
- Conjugation
- Extraction of plasmid DNA.
- Gel electrophoresis
- Polyacrylamide gel electrophoresis.

- Detection of bacterial proteins.

Teaching-learning Strategies

1. Lectures
2. Group Discussion
3. Laboratory Work
4. Seminar/ Workshop

Assessment and Examinations:

As per University Rules

Recommended Readings

1. Brown, T.A. (2020). *Gene Cloning*, an introduction. 8th Ed. Chapman Hall.
2. Burke, M. T. (2018). *Nanotechnology: the business*. CRC Press.
3. Eckert, C. (2018). Genome Editing and Engineering. In *SIMB Annual Meeting 2018*. SIMB.
4. Gardner, E.J. 2004 *Principles of Genetics,* John Willey and Sons,.
5. Glover, D.M. (2005). *DNA Cloning, a Practical Approach* (volume I and II). IRL Press.
6. Hardy K.G. (1993) *Plasmid, practicalapproach.* IRL Oxford University Press.
7. Hardy, K.G. (2003). *Plasmid, A Practical Approach.* IRL Press at Oxford University Press.
8. Hunter, V., & Strickland, F. (2018). *Applications of Recombinant DNA Technology*. Scientific e-Resources.
9. Ijaz, S., & Haq, I. U. (2019). *Recombinant DNA Technology*. Cambridge Scholars Publishing.
10. Manahan, S. (2017). *Environmental chemistry*. CRC press.
11. Nicholl, D.S.T. (2002). *An Introduction to Genetic Engineering*. (3rd Ed.) Cambridge University Press.
12. Nicholl, D.S.T. (2008). *An introduction to Genetic Engineering*. Cambridge University Press.
13. Old, R. W. and Primrose, S. B. (2003) *Principles of Gene Manipulation*, an introduction to genetic engineering, Blackwell Scientific Publications.
14. Pierce, B.A. (2013). *Genetics*; *A Conceptual Approach.* 5th Ed. W. H. Freeman and Company, New York.
15. Primrose, S.B., and Twyman, R. M. (2006). *Principles of Gene Manipulation and Genomics.* (7th Ed.) Wiley- Blackwell Scientific Publications.
16. Sambrook, J., Fritsch, E.F. and Maniatis, T. (2006). Molecular Cloning, A Laboratory Manual (2nd Ed.). Cold Spring Harbor Laboratory Press.
17. Sambrook, J., Fritsch, E.F. and Maniatis T. (2012). *Molecular Cloning, A Laboratory Manual*. Cold Spring Harbor Laboratory Press.
18. Snustad, D.P. and Simmons, M.J., (2011). *Principles of Genetics,* (6th Ed.), John-Wiley and Son Inc. New York. Shen, C. H. (2019). *Diagnostic molecular biology*. Academic Press.
19. Synder, D. C. and Champness, W. (2020). *Molecular Genetics of Bacteria.* (5th Ed.) ASM Press, Washington
20. Thro, E. (1993) *Genetic Engineering, Shaping the Material of Life*. Facts on file, New York.
21. Thro, E. (2003). *Genetic Engineering, Shaping the Material of Life.* Facts on file, New York.

22. Yi, D. (2015). *The recombinant university: Genetic Engineering and the Emergence of Biotechnology at Stanford*, University of Chicago Press.
23. Williamson, R. (1983) *GeneticEngineering* (Volume I-V), Academic Press.
24. Wilson, J. and Hunt, T. (2004). *Molecular Biology of the Cell – The Problems Book*, Garland Publishing
25. Wu, R. (2014). *Recombinant DNA Methodology II*. Academic press. (1st Ed.)

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Bot.Sp-04 PLANT BREEDING AND HORTICULTURE Credit Hours: 3(2+1)

THEORY

Introduction of the Course

This course is designed to provide essential knowledge about Plant Breeding. Different strategies used in breeding for plant selection with desired characteristics are also discussed. It also includes detailed study about application of horticulture techniques used in green house and in landscaping.

Course Objectives

1. To enable the students to understand the concept of Plant Breeding and different strategies used in breeding for plant selection with desired characteristics.
2. To make the students learn the application of horticulture techniques used in green house and in landscaping.

Contents

1. **Plant Breeding:** Introduction and History of Plant breeding, Basic Principles and Aims of Plant Breeding, Mendelian Genetics: Checker's Board and factors leading to deviation from Mendelian genetics, Breeding Methods for Both self-crop: Selection in (Single Plant Selection, Mass Selection, Pedigree Selection, Bulk Population Selection, and Backcross Breeding), Selection in cross pollinated (Single Plant Selection, Mass Selection, Recurrent Selection, Backcross Breeding). Hybrid Vigour, Hybrid Breeding.
2. **Horticulture:** An Introduction, Plant Science, Plant Propagation, Greenhouse Management and Crops, Integrated Pest Management (IPM), Container-Grown Plants, Using Plants in the Landscape, Lawn and Turf Grass Establishment and Maintenance, The Vegetable Garden, The Small Fruit Garden. Complete Production technology of one fruit, one vegetable and one ornamental plant.

Practicals:

1. Techniques of Plant Breeding (Emasculation in Wheat, Rice, Maize, Cotton and Tomato)
2. Pollination and fertilization in self and out Breeding Plants, their Implications and Consequences
3. Grafting, and Budding techniques
4. Nursery Development (Growing fruits/vegetables seeds and reporting germination percentage)
5. Gene Action, Hybrid Vigor Numerical Problems
6. Extraction of proteins from plant tissue and their quantitative (Bradford's) and qualitative (SDS, PAGE gel) analysis.

Teaching-learning Strategies

1. Lectures
2. Group Discussion
3. Laboratory work
4. Seminar/ Workshop

Learning Outcome:

1. Students are expected to get themselves familiarized with the molecular/macromolecular organization of plant cells and DNA in general.

2. They should be able to understand the concept of Plant Breeding and different strategies used in breeding for plant selection with desired characteristics.

Recommended Readings:

1. Acquaach, G. (2012). *Principles of Plant Genetics and Breeding*. Blackwell and Synergy Publishers.
2. Acquaach, G. (2002). *Horticulture Principles and Practices.* (2nd Ed.), Prentice Hall of India Private Limited, New Delhi.
3. Brown, J. and Caligare, P. (2008). *An Introduction to Plant Breeding*. Blackwell Synergy Publishers.
4. Carpenter, P.L. and Walker, I. (2004). *Plants in Landscape.* (2nd Ed.), New York Freeman.
5. Clevelard, D.A. (2002). Farmers, Scientists and Plant Breeding Integrating Knowledge and Practice.
6. Crockett, J.V. (1999). Landscape Gardening. New York Time – Life.
7. Gupta, S.K. (2000). *Plant Breeding Theory and Techniques.* Narosa Publishers.
8. Kang, M.S. (2002). *Quantitative Genetics. Genomics and Plant Breeding.*
9. Kumar, N. (2006). *Breeding of Horticulture Crops: Principles and Practices.* New Indian Publishers.
10. Peter, K.V. (2009). *Basics of Horticulture*. New India Publishers.

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Bot.Sp-05 FUNGAL DISEASES OF CEREAL CROPS Credit Hours: 3(2+1)

THEORY

Introduction of the Course:

The course is organized to provide basic concepts of Fungal Diseases of cereal crops and identification of different plant pathogens, their comparative study, disease cycle, Economic Importance of different fungal pathogens and control measures.

Course Objectives:

The course is designed:

1. To provide an adequate knowledge about basic concepts and identification of plant pathogens
2. To give an insight into important fungal diseases of cereal crops and their management.

Contents:

1. **Introduction**:
   - 1.1. Comparative study of the different Fungal pathogen groups with representative examples, including Rusts, Smuts, Powdery Mildews, Downy Mildews, Soil Born and Air Born Fungal pathogens, Spots, Blights, Wilts, Damping off and Rots etc.
   - 1.2. Importance and symptoms of various cereal crop diseases;
   - 1.3. disease cycle
   - 1.4. Plant-Fungal Interactions
2. **Cereal crop pathogens**
   - 2.1. The Oomycetes, Downy mildews
   - 2.2. Chytrid & Zygomycota pathogens
   - 2.3. Ascomycota pathogens, Structures & Functions, Sexual and asexual ascomycetes, conidial structures and identification, Powdery Mildews
   - 2.4. Basidiomycota: Rusts, Smuts; Taxonomy, Biology, Host Range, Life Cycle and Ecology, Basidiomycetes pathogens, Structures & functions
3. **Fungi in the Air:**
   - 3.1. Airborne pathogens
   - 3.2. Foliar diseases
4. **Soil borne Fungal Pathogens**
5. **Economic Importance**:
   - 5.1. Fungal pathogens of cereal crops (Wheat, Maize, Oat, Barley etc.)
6. **Adaptations for Pathogenicity:**
   - 6.1. Obligate vs. opportunistic pathogens,
   - 6.2. Fungal Pathogens in Row Crops & Perennial Crops,
7. **Control of Fungal Diseases:**
   - 7.1. Mycotoxins
   - 7.2. Whetzel's principles of plant disease control
   - 7.3. Cultural controls
   - 7.4. Chemical Control of Fungal Diseases

Practicals:

1. Maintenance and preservation of cultures of pathogenic fungi
2. Identification of various types mentioned in the syllabus form fresh specimens, preserved specimens and prepared slides
3. Study of morphology and reproductive structures of the types mentioned in theory (Specimens/prepared slides)
4. Recognition of disease symptoms and keys for pathogen identification

5. Isolation of pathogens and their Characterization
6. Field trips for collection of different plant samples infected with fungal pathogen.

Teaching-learning Strategies

1. Lectures
2. Group Discussion
3. Laboratory work
4. Seminar/ Workshop

Learning Outcome:

1. Students are expected to get familiarized with the morphological and systematic knowledge of different plant pathogens.
2. They will be able to describe the concepts of what constitutes disease in cereal crops and identify major principles of fungal plant pathology.
3. This will also enable them to employ methods to diagnose and manage a wide range of fungal diseases of cereal crops.
4. The obtained knowledge shall also enable the students to describe aspects of integrated pest management and to explain the impact of plant diseases on human affairs.

Assessment Strategies:

1. Lecture Based Examination (Objective and Subjective)
2. Assignments
3. Class discussion
4. Quiz
5. Tests

Recommended Readings:

1. Ahmad, S., Iqbal, S.H. and Khalid, A.N. (1997). *Fungi of Pakistan*. Sultan Ahmad Mycological Society Pakistan, Department of Botany, University of Punjab, Lahore, Pakistan.
2. Agrios, G. N. (2011). *Plant Pathology*, 6th edition. Academic Press, New York, USA.
3. Alexopoulos, C.J., Mims, C.W. and Blackwell, M. (1996). *Introductory Mycology* (4thed.). John Wiley & Sons, Inc. ISBN0-471-52229-5
4. Braun, U. and Cook, R.T.A. (2012). *Taxonomic Manual of the Erysiphales (Powdery Mildews)*. ISBN: 978-90-70351-89-2.
5. Cummins, G.B. and Hiratsuka, Y. (2003). *Illustrated Genera of Rust Fungi*. Third ed. The American Phytopathological Society. APS Press, St. Paul, MN.
6. Schumann, G.L. and D'Arcy, C.J. (2010). *Essential Plant Pathology*. APS Press. 369 PP.
7. Vánky, K. (2011["2012"]). *Smut fungi of the World*. APS Press, St. Paul, Minnesota, USA.
8. Vánky, K. (2013). *Illustrated Genera of Smut Fungi*, 3rdedn. St. Paul, MN, USA, APS Press.
9. Webster, J. and Weber, R.W.S. (2007). *Introduction to Fungi* (3rded.). Cambridge University Press. ISBN: 0-521-01483-2.

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Bot. Sp-06 BIOCHEMISTRY OF NUCLEIC ACIDS Credit Hours 3(2+1)

THEORY

Introduction of the Course:

The course is organized to provide knowledge of how nucleotides are synthesized and degraded in cells. An understanding of structure-function relationships for nucleic acids and chromatin. Knowledge of the enzymatic basis of replication of and error correction in the genome. An understanding of how genes are read and how the transcribed RNA is processed, and how genes are regulated through a coordinated collaboration between proteins and nucleic acid sequences.

Course Objectives:

The course is designed:

1. To enable the students to understand the different composition and roles of nucleic acids in the cell and their interactions with each other and with agents that cause DNA damage.
2. To enable the students to describe in detail the protein components of the nucleosome and key modifications to nucleosome components and understand the interactions between the DNA double helix and the nucleosome.
3. The students will be able to describe how gene expression is regulated at the transcriptional and post-transcriptional level.
4. To Learn about the structure of RNA, the flow of genetic information, and the transcription of DNA to form RNA.

Course Contents:

1. Nucleic Acids

1.1. DNA as a carrier of genetic information.
1.2. Double-helical structure of DNA.
1.3. Forces stabilizing nucleic acid structures and super-coiled DNA.
1.4. Nucleic acid fractionation, sequencing.
1.5. Chemical synthesis of oligonucleotides.
1.6. DNA polymerases, DNA replication-general aspects and enzymes involved and mechanism of replication.
1.7. DNA repair and methylation.

2. Transcription and Translation

2.1 RNAs and their role in protein synthesis.
2.2 RNA polymerases and transcription.
2.3 Regulation of transcription in prokaryotes and post transcriptional processing.
2.4 The genetic code and its properties.
2.5 Structure of transfer RNA.
2.6 Ribosomes, its type and role in translational process.
2.7 Protein synthesis inhibitors and control of eukaryotic translation.
2.8 Post translational modifications and protein degradation.
2.9 Non-ribosomal polypeptide synthesis, structure and genomic organization.
2.10 Regulation of eukaryotic gene expression.
2.11 Cell differentiation, oncogenes and cancer.

3. Regulation of Gene Activity in Prokaryotes and Eukaryotes:

4.1 Principles of gene regulation.
4.2 The *E. coli* Lactose system and the Operon model, the Tryptophan Operon.
4.3 A biosynthetic system autoregulation.
4.4 Feedback inhibition.

4.5 Gene families, gene dosage and gene amplification.
4.6 Regulation of transcription; regulation of processing.
4.7 Hypersensitive sites and upstream regulatory sites.
4.8 Translational control; multiple proteins from a single segment of DNA.
4.9 Gene rearrangement: joining coding sequences in the immune system.

4. Recombinant DNA and Genetic Engineering:

4.1. An outline of DNA cloning experiment.
4.2. Cloning vectors including Plasmids, Bacteriophages, Cosmids, YAC, Shuttle and Expression vectors.
4.3. Gene splicing in Eukaryotes and Prokaryotes.
4.4. Genomic libraries and screening methods for gene libraries.
4.5. DNA cloning methods, tumor inducing (TI) plasmids.
4.6. Southern and Northern blotting; Chromosome walking; Site specific mutagenesis.
4.7. Potentials of recombinant DNA technology.
4.8. PCR and production of proteins.
4.9. Tissue culture techniques; transgenic organisms and gene therapies.
4.10. Restriction fragment length polymorphism and disease detection e.g., cystic fibrosis.
4.11. Human genome project and social considerations.

Practicals:

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

Teaching-Learning Strategies

1. Lectures
2. Group Discussion
3. Laboratory work
4. Seminar/ Workshop

Learning Outcome:

1. This course can help the students to identify major structural feature that distinguish DNA and RNA.
2. After completion of this course, students will be able to describe nucleic acid structure, its function in detail.
3. The students can describe easily how the genetic information is transferred from DNA to synthesis of protein.
4. They are expected to use this information for further advancement in recombinant DNA Technology.

Assessment Strategies:

1. Lecture Based Examination (Objective and Subjective)
2. Assignments
3. Class discussion
4. Quiz
5. Tests

Recommended Readings.

1. Abdes, R. H., Frey, P. A. and Jencks W. P. (2004). *Biochemistry*, Jones and Bartlet, London.
2. Buchanan B. B, Gruissem W and Jones R. L. (2015). *Biochemistry and Molecular Biology of Plants*. John Wiley and Sons.
3. Bowsher, C., Steer, M., Tobin, A. (2008). *Plant Biochemistry*. - Garland Science, Taylor and Francis Group, New York.
4. Campbell, M. K. and F. Shawn. (2008). *Biochemistry* 6th Edition.
5. Chesworth, J. M., Strichbury T. and Scaife J. R. (1998). *An introduction to agricultural biochemistry*. Chapman and Hall, London.
6. Conn E. E. and Stumpf, P. K. (2009). *Outlines of Biochemistry*, John Wiley and Sons Inc. New York.
7. Dey, P. M. and Harborne, J. B. (1997). *Plant Biochemistry*. Harcourt Asia PTE Ltd. Singapore.
8. Goodwin T. W. and Mercer, E. I. (1997). *Introduction to Plant Biochemistry*. Pergamon Press, Oxford.
9. Heldt, H. W. 2008. *Plant Biochemistry*. 3rd Edition, Academic Press, U. K.
10. Lea, P. J. and Leegood, R. C. (1993). *Plant Biochemistry and Molecular Biology*. Wiley and Sons, New York.
11. Nelson, D. L and Cox M. M. (2017). *Lehninger Principles of Biochemistry*. 7th edition. W. H. Freeman and Company. New York.
12. Mckee, T. and Mckee, J. R. (1999). *Biochemistry – An Introduction*. WCB/McGraw-Hill, New York, Boston, USA.
13. Voet, D. Voet J. G. and Pratt, C. W. (2016). *Fundamentals of Biochemistry*: Life at the Molecular level, 5th Edition. John Wiley and Sons, New York.
14. Zubay G. 2003. Biochemistry, MacMillan Publishing Co., New York.

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Bot.Sp-07 SOIL AND AGRICULTURAL MICROBIOLOGY Credit Hours 3(2+1)

Introduction of the Course

This course is designed to provide essential knowledge about soil structure and composition and learning about soil biodiversity with reference to the bacterial community present in the soil. It will help the students to have knowledge about Soil Microflora and its effects on Soil Composition and Information about Agriculture Soils in Pakistan.

Course Objectives

1. To enable the students to understand the mutual interaction of soil microflora and its types.
2. To enable the students to learn about the beneficial role played by the soil microflora in improving the soil fertility with respect to agricultural sector.

Contents

1. Elements of soil formation.
2. Soil microbial population and their advantages and disadvantages.
3. Role of microorganisms in mineral transformations with emphasis on carbon and nitrogen transformations.
4. Introduction to soil ecology
5. Plant microbe interactions and microbe-microbe interactions and their impact on soil fertility.
6. Problems of salinity and water logging and the methods of their reclamations. Microbial activities in saline soil.
7. Interaction between plants and their beneficial and harmful symbionts.

Practicals:

1. Study of role of microbes in soil structure and improvement.
2. Symbiotic and antagonistic effects of microbes soil/crop.
3. Improvement by microbes in the saline and water-logged soils.
4. Use of *Azospirillum* and *Azospirillum* as natural fertilizers.

Learning Outcome:

1. This course can help the students to identify Symbiotic and antagonistic effects of microbes.
2. After completion of this course, students will be able to describe role of microbes in soil structure and improvement.

Assessment Strategies:

1. Lecture Based Examination (Objective and Subjective)
2. Assignments
3. Class discussion
4. Quiz
5. Tests

Recommended Readings.

1. Berthelin, J., Bollag, J.M., Page, A.L., Huang, P.M., McGill, W.B. and Huang, P.M. (1995*). Environmental Impacts of Soil Component Interactions: Natural and Anthropogenic Organics.* Vol.1, Lewis Publishers.
2. Bottomley, P. J., Angle, J. S., & Weaver, R. W. (Eds.). (2018). *Methods of soil analysis, Part 2: Microbiological and biochemical properties* (Vol. 12). John Wiley & Sons.
3. Charles, J., Delecluse, A., Lerou, N. and Roux, C.N. (2000). *Entomopathogenic Bacteria: From Laboratory to Field Application* (1st Ed.), Kluwer Academic Publishers.
4. De Oliveira, A. (Ed.). (2018). *Sustainability of Agroecosystems*. BoD–Books on Demand.
5. Glick, B.R., Patten, C.L., Holguin, G. and Penrose, D.M. (1999). *Biochemical and Genetic Mechanisms Used by Plant Growth Promoting Bacteria.* Imperial College Press.
6. Newman, D. J., Cragg, G. M., & Grothaus, P. (Eds.). (2017). *Chemical Biology of Natural Products*. CRC Press.
7. Parray, J. A., Mahmoud, A. H. A. E., & Sayyed, R. (Eds.). (2021). *Soil Bioremediation: An Approach Towards Sustainable Technology*. John Wiley & Sons.
8. Rao, N.S.S. and Dommergues, Y.R. (2001). *Microbial Interactions in Agriculture and Forestry*. (2nd Ed.), Science Publishers
9. Soriano, M. C. H. (Ed.). (2014). *Environmental risk assessment of soil contamination*. BoD–Books on Demand.
10. Stirling, G., Hayden, H., Pattison, T., & Stirling, M. (2016). *Soil health, soil biology, soilborne diseases and sustainable agriculture: A guide*. Csiro Publishing.
11. Tate III, R. L. (2020). *Soil microbiology*. John Wiley & Sons.
12. Wang, K., Estrella, A.H. and Montagu, M.V. (2004): *Transformation of Plants and Soil Microorganisms (Plant and Microbial Biotechnology Research).* No.3, Cambridge University Press.

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Bot.Sp-08 WATERLOGGING AND SALINITY Credit Hours: 3(2+1)

THEORY

Introduction:

This course gives the awareness and to understand the student about the waterlogging and salinity problems in Pakistan.

Course Objectives:

The course is designed:

1. To provide an adequate knowledge about basic concepts of waterlogging, salinity and types of affected soils
2. To give an insight about principal responses and adaptations mechanisms of plants in response to salinity and waterlogging
3. To give an overview about various reclamation projects and practices to control waterlogging and salinity problems in Pakistan

Course Detail:

1. **Introduction; Land and Water resources of Pakistan.**
2. **Waterlogging:**
   - **2.1.** Causes and effects of the problem
   - **2.2.** Affects of waterlogging on soil and plant;
   - **2.3.** Quality and characteristics of irrigation water
   - **2.4.** Drainage water (characteristics & management).
3. **Salinity & Sodicity:**
   - **3.1.**Saline, sodic, and saline-sodic soils and their characteristics
   - **3.2.**Origin of salinity and sodicity
   - **3.3.** Extent of salinity and sodicity in Pakistan.
4. **Response of Salt-Affected Soils:**
   - **4.1.**Effect of solution composition on clay swelling and dispersion
   - **4.2.**Effects of electrolytes and hydraulic conductivity of sodic soils
   - **4.3.** Effect of exchangeable sodium percentage and electrolyte concentration on infiltration rate.
5. **Plant Response to Salt-Affected Soils:**
   - **5.1.**Principal responses of plants to salinity
   - **5.2.**Mechanism of responses.
6. **Reclamation & Management of Salt-Affected and Waterlogged Soils:**
   - **6.1.**Mechanical methods (Tube wells, Surface and Sub-surface drainage)
   - **6.2.**Chemical approaches (Use of soil amendments such as Gypsum, Sulfur, Farmyard Manure etc.)
   - **6.3.**Biological techniques (Use of Biotechnology, Saline Agriculture and Forestry)
   - **6.4.**Ecological options (development of Salt-affected and waterlogged areas as Rangelands and Pasturelands etc).
7. **Measures Taken in Pakistan to Combat Waterlogging and Salinty/Sodicity Hazards:**
   - **7.1.**Salinity control and reclamation projects
   - **7.2.** Irrigation system rehabilitation programme
   - **7.3.** Command water management programme
   - **7.4.** On-Farm water management programme
   - **7.5.** National drainage programme.

Practicals:

1. Sample collection, handling and sub-sampling
2. Determination of some 69aleop-chemical properties of soil and water
3. Determination of calcium, magnesium, sodium, potassium and chloride in plant material by wet digestion method.

Teaching-learning Strategies

1. Lectures
2. Group Discussion
3. Laboratory work
4. Seminar/ Workshop

Learning Outcome:

1. Students will be able to define Saline, Saline sodic and Sodic soils
2. They will be able to describe, apply and integrate the basic concepts of Electrical conductivity, pH, CEC and SAR.
3. This will enable them qualify for basic to moderate level jobs involving knowledge of plants and agriculture.
4. The obtained knowledge shall also enable the students to enter into various entrepreneurial activities.

Assessment Strategies:

1. Lecture Based Examination (Objective and Subjective)
2. Assignments
3. Class discussion
4. Quiz
5. Tests

Recommended Readings:

1. Abrol, I.P., J.S.P. Yadav and F.I. Masood. Salt-Affected Soils and their Management. Soil Bull. 390, FAO, Rome, Italy.
2. Ayers, R.S. And D.W. Westcot. Water Quality for Agriculture. Irrigation and Drainage Paper No. 29, FAO, Rome, Italy.
3. Ghafoor, A., M. Qadir and G. Murtaza. Salt-Affected Soils: Principles of Management. Allied Book Cetre, Urdu Bazar, Lahore.
4. IWASRI-UNDP. Manual of Salinity Research Methods. International Waterlogging and Salinity Research Institute, Lahore.
5. Khan, M.A. And I. A. Ungar (Ed). Biology of Salt Tolerant Plants. Book Crafters. Chelsca, Michigan, USA.
6. Nazir. A. Water Resources of Pakistan. Nazir Sons Pub. Gulberg, Lahore.
7. Tanji. K.K. (Ed). Agricultural Salinity Assessment and Management. ASCE. NY, USA.
8. Pessarakali, M. (Ed). Handbook of Plant and Crop Stress. Marcel-Dekker Inc., NY, USA.
9. Richards L.A. (Ed). Diagnosis and Improvement of Saline and Alkali Soils. USDA Handbook No. 60. US. Printing Office, Washington, DC.
10. Rhoades, J.D., A. Kandiah And A.M. Mashil. The Use of Saline Waters for Crop Production. Irrigation and Drainage Paper No. 48, FAO, Rome, Italy.
11. Scheunan And Watina. Managing Salinization- Institutional Analysis of Public Irrigation Systems. Springer Verlag, Berlin.
12. SSRI. Reclamation and Management of Waterlogged Saline Soils. Soil Salinity Research Institute, Kernal, India.

13. Sumner, M.E. And Naidu. R. Sodic Soils: Distribution, Properties, Management and Environmental Consequences. Oxford University Press.
14. Waisal. Y. Biology of Halophytes. Academic Press, NY, USA.

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Bot.Sp-09 COMPUTATIONAL BIOLOGY Credit Hours: 3 (2+1)

THEORY:

Introduction of the Course

The course contains methods and software tools related to the interdisciplinary field of biology, computer (database) sciences, mathematics and statistics. It comprises techniques about how to derive desired information out of large biological databases mainly stored in online repositories. The course helps in analysis and interpretation of biological data mainly through *in silico* (simulatory) means in response to certain biological queries.

Course Objectives:

The course is designed:

1. To make students well versed on the latest digital application of data sciences in biology for reaching out to solution of a bioinformatics problem over short span of time.
2. To make students learned about novel methods and tools to provide better understanding of biological systems.
3. To familiarize with computational tools related to biological systems.
4. To be able to conduct, analyze and interpret large dataset related to biological sciences.

Contents:

1. Introduction to computational biology and bioinformatics

1.1 Introduction to data and databases
1.2 Internet databases and resources
1.2 Databases – access, retrieval and submission

2. Genome databases (GDB) and software

2.1 Introduction to genome databases and software
2.2 Public repository of data on human genes, clones, STSs, polymorphisms and maps
2.3 Genomic database
2.4 GenBank – NIH genetic sequence database

3. Interpretation of Genomic Data

3.1 Sequence Similarity and sequence alignment
3.2 Software tools for pairwise and multiple sequence alignment
3.3 Phylogenetic analysis

4. Use of software related to structure of macromolecules

4.1 Software related to proteins, DNA, etc.
4.2 Introduction and use of FiberApp
4.3 Introduction and use of RasMol and OpenRasMol

PRACTICALS:

1. Purpose and use of major bioinformatics software
2. Practical demo of use of Database Search, NCBI BLAST
3. Practical demo of use of Pairwise sequence alignment
4. Practical demo of Multiple sequence alignment (Clustal W)
5. Performing phylogenetic analysis
6. Performing interpretation of Genomic Data
7. Use of different software for analysis of biomolecules etc.

Teaching Learning Strategies:

1. Lectures
2. Visits to different biotechnology laboratories
3. Laboratory work
4. Assignments / Seminars Workshops

Learning Outcomes:

1. The students would know about latest developments in the online databases related to biological sciences.

2. The students would be able to use the online database search engines for its application in biological sciences.

3. The students would have hands on practice on how to use major software related to computational biology.

4. The students would have essential skillset related to research in genetics, molecular biology and other relevant disciplines of biology.

Assessment Strategies:

1. **Lecture-based quiz (both objective and subjective)**
2. **Brief and detailed assignments**
3. **Class tests**
4. **Group activities**

Recommended Readings:

1. Buffalo, V. (2015). Bioinformatics Data Skills: Reproducible and Robust Research with Open Source Tools 1st Edition. O'Reilly Media, Inc. ISBN-13: 978-1449367374.
2. Edwards, D., Stajich, J.E. and Hansen, D. (2009) Bioinformatics Tools and Application. Springer Link Publishers. ISBN: 0387927379.
3. Information Resources Management Association, USA (Eds.). Bioinformatics: Concepts, Methodologies, Tools, and Applications (3 Volumes). IGI Global Publishers. ISBN13: 9781466636040.
4. Kelley, S.T., Didulo. D. (2018). Computational Biology: A Hypertextbook. Willey Publishers. ISBN: 978-1-683-67002-5.

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Bot.Sp-10 ENVIRONMENTAL IMPACT ASSESSMENT Credit Hours: 3(2+1)

Introduction to the course:

This course is designed to introduce students to environmental impact assessment and to provide theoretical and practical education in this field. The focus is on the rationale and methodology of integrated environmental impact assessment (EIA), including consideration of the relevant bio-physical, social, cultural, economic and human health aspects of development proposals, programs and policies.

Course Objectives:

The course is designed:

1. To identify, predict and evaluate the economic, environmental and social impact of development activities.
2. To provide information on the environmental consequences.
3. To promote environmentally sound and sustainable development through the identification of appropriate alternatives and mitigation measures.

Course Detail:

1. **Environment**:
   1.1. Definitions, Basic Concepts; Environmental Parameters.
2. **Environmental Assessment:**
   2.1. Historical perspective; The Need for Environmental Assessment
   2.2. Global and Cross-sectoral Issues in Environmental Review; Social and Cultural Issues in Environmental Review
3. **Environmental Assessment Process:**
   3.1. Introduction; Resources; Screening; Scoping; Prediction & Mitigation
   3.2. Management and Monitoring; Auditing; Managing Uncertainty
4. **Environmental Impact Assessment Techniques:**
   4.1. Baseline studies; The Checklists, Matrices; Network Diagrammes; Overlays, Mathematical Modelling; Expert Techniques; Economic Techniques, Impact Statement.
5. **Sectoral Environmental Impacts**:
   5.1. Impacts of Irrigation and Drainage Projects
   5.2. Impacts of Population and Growth; Impacts of Energy Development
   5.3. Impacts of Natural Environmental Hazards
   5.4. Human Environmental Disturbances.
6. **Guidelines for Preparation And Review Of Environmental Reports:**
   6.1. Drafting Style; Main Features of Environment Report; Distribution of Reports, and other Forms of Presentations
   6.2. Reviewing and Decision Making.
7. **Preparation of Terms of Reference.**
8. **Policies and Procedures for Filing, Review and Approval of Environmental Assessment:**
   8.1. International Policies
   8.2. Government of Pakistan Policies (Ordinances and Acts)
   8.3. Procedure for Filing, Review and Approval of Environmental Assessments
9. **Case Studies**.

Practicals:

- Initial Environmental Screening/Scoping of Selected Projects from Different Sectors (Group Tasks).

Teaching-learning Strategies

1. Lectures
2. Group Discussion
3. Seminar/ Workshop

Learning Outcome:

On successful completion of the course students will be able to:

1. To critically examine assumptions inherent in impact assessment.
2. To provide students with an understanding of the historical evolution of impact assessment in selected parts of the world.
3. To provide students with the knowledge and professional skills necessary to enable them to undertake environmental impact assessment.
4. To identify and explore impact assessment fields and approaches.
5. To familiarize students with a variety of professional tools used in predicting environmental impacts.
6. To enable students to develop skills in critical thinking and professional procedures through various forms of oral and written presentation and individual and group work.

Assessment Strategies:

1. Lecture Based Examination (Objective and Subjective)
2. Assignments
3. Class discussion
4. Quiz
5. Tests

Recommended Readings:

1. ADB. Environmental Guidelines for Selected Infrastructural Projects. Asian Development Bank, Manila, Philippines.
2. ADB. Environmental Guidelines for Selected Agricultural And Natural Resources Development Projects. Asian Development Bank, Manila, Philippines.
3. ADB. Environmental Assessment Requirements and Environmental Review Procedures. Asian Development Bank, Manila, Philippines.
4. Biswas, A. K. and S.B. C. Agarwal. Environmental Impact Assessment for Developing Countries. Butterworth-Heinemenn, Guidford, UK.
5. Dougherty, T. C. and Aw.Hall. Environmental Impact Assessment of Irrigation And Drainage Projects. Irrigation And Drainage Paper No. 53, FAO, Rome, Italy.
6. ERL. Environmental Assessment Procedures in the UN System. Environmental Resources Limited, London, UK.
7. Goodland, R. and H. Daly. Environmental Assessment and Sustainability in the World Bank. World Bank, Washington, DC, USA.
8. GOP. Pakistan Environmental Protection Act, Government of Pakistan, Islamabad.
9. OECF. Environmental Guidelines. Overseas Economic Cooperation Fund, Tokyo, Japan.
10. PEPA. Environmental Impact Assessment Guidelines. Pakistan Environmental Protection Agency, Islamabad.

11. PDC. Guidelines for Environmental Scooping and Screening of Drainage, Irrigation and Water Resources Development Projects. Pakistan Drainage Consultants, National Drainage Programme, Water and Power Development Authority, Lahore.
12. Wathern, P. (Ed). Environmental Impact Assessment: Theory and Practice. Routledge, London.
13. World Bank. Environmental Assessment Source Book, Vol. I, Policies, Procedures and Cross-Sectoral Issues. World Bank Technical Paper No.139. World Bank, Washington, USA
14. World Bank. Environmental Assessment Source Book, Vol. II, Sectoral Guidelines. World Bank Technical Paper No. 140. World Bank, Washington, USA.

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Bot.Sp-11 BIOSTRATIGRAPHY Credit Hours: 3(2+1)

THEORY:

Introduction to the course:

The course provides advanced knowledge on the contribution of Biostratigraphy to modern stratigraphic analyses.

Course Objectives:

The aim of the course is:

1. To understand the biostratigraphic concepts and methods.
2. To provide students with the practical skills for the reconstruction of the palaeoenvironment and palaeoclimate.

Course Contents:

1. Basic Principles:

1.1. Introduction to sedimentary and stratigraphical paleopalynology, paleopalynology as an important stratigraphical tool.

1.2. Classification of stratigraphic units.

1.3. Concept of Zone, stratigraphic ranges, overlapping ranges, time units, index fossils (Palynomorphs), index species, biogeographic province.

1.4. Introduction to the International code of stratigraphical nomenclature.

2. Biostratigraphic units:

2.1. Concept of Biozone and principal categories of zones viz., Interval Zone (Sub Zone), Taxon Range Zone, Concurrent Range Zone, Partial Range Zone, Lineage Zone, Assemblage Zone, Composite assemblage Zone, Oppel Zone, Acme Zone.

2.2. Ranking and naming biostratigraphic units.

3. Biocorrelation:

3.1. Correlation by Assemblage Zones, Abundance Zones, Biologic interval Zones, Taxon Range Zones, other interval Zones, Biogeographical Acme Zones.

3.2. Recent advances in the Salt Range Paleozoic and Mesozoic biostratigraphy.

Practicals:

1. Field study tour to the Salt and Murree Ranges to identify and classify major sedimentary rocks including lithological description.
2. Use of clinometer, Map reading.
3. Palynological biostratigraphy of some late Paleozoic and Mesozoic rocks of the Salt Range, Pakistan.
4. Extraction, identification and technical description of palynomorphs to identify Biostratigraphic Zone(s) across a particular geological strata.
5. Data Management in Biostratigraphy.

Teaching-learning Strategies

1. Lectures
2. Group Discussion
3. Laboratory work
4. Field visits/ Workshop

Learning Outcome:

Knowledge and understanding of:

1. Analysis of the geological framework, and identification of the problem to be solved
2. Selection of the best biostratigraphic tools with respect geological/stratigraphical framework
3. Selection of the more appropriate biostratigraphic method
4. Evaluation of the results

Assessment Strategies:

1. Lecture Based Examination (Objective and Subjective)
2. Assignments
3. Class discussion
4. Quiz
5. Tests

Recommended Readings:

1. Biostratigraphy of Fossil Plants. Edited by David L. Dilcher and Thomas N. Taylor, 1980.Dowden Hutchinson and Ross, Inc.
2. Stratigraphy of Pakistan. Memoir No.10, 1977.Geological Survey of Pakistan.
3. Earth's Earlier Biosphere, its origin and evolution, 1983. J.W. Schopf. Princeton University Press Princeton.New Jersey.
4. Fossils and Climate, 1984. P.J. Brenchley. Jhon Wiley and Sons Inc., New York.
5. Gondwana Geology, 1975. K.S.W. Campbell. AustralianNationalUniversity Press, Canberra.
6. Life and its Environment on the Early Earth, 1981. Nargulis, L., W.H. Freeman and Co., San Francisco.
7. Evolutionary Botany and Biostratigraphy, 1984. A.K. Sherma, G.C. Mitra and M. BanerJee. Today and Tomorrow's Printers and Publishers, New Delhi.
8. Palaeopalynology. Alfred. A. Traverse, 1988. Unwin Hymen N.Y.
9. Microfossils. M.D. Brasiev, 1985. London George Allen Unwin.
10. Essentials of Map Reading. Nazir Ahmad, 1978. Army Education Press, Rawalpindi.
11. Techniques of Extracting Palynomorphs from Sediments. Phipps D. and Palyford.G., 1984.Dep. of Mineralogy and Geology Sp. Pub.Univ. Queensland.Brisbane. Australia.

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Bot.Sp-12 CULTIVATION OF EDIBLE MUSHROOMS Credit Hours: 3(2+1)

THEORY:

Introduction of the Course:

This course is designed to provide information about occurrence of mushrooms and their diversity status in Pakistan. It will help the students to have knowledge about cultivation, and identification of edible and poisonous Mushrooms including *Agaricus*, *Volvierella*, *Pleurotos;* their Status and diseases of cultivated mushrooms.

Course Objectives:

The course is designed:

1. To provide an adequate knowledge about basic concepts of different mushrooms and their diversity status in Pakistan
2. To give an insight into mushroom cultivation and identification of edible and poisonous Mushrooms

Contents:

1. Introduction and History of Mushrooms and Mushroom Cultivation.
2. Ecological importance of Mushrooms.
3. Mushroom Science and Mushroom Cultivation Technology.
4. The Nutritional attributes of Edible Mushrooms.
5. Medicinal Values of Mushrooms. Poisonous and Edible Mushrooms.
6. World production of Edible Mushrooms.
7. Present status and Future Prospects of Mushroom Cultivation in Pakistan.
8. Methods of Preparation of Spawn and Compost. Factors suitable for Cultivation.
9. Compost and Methods of Composting, Spawn and Methods of Spawning, Casing, Cropping and Harvesting, Preservation.
10. Cultivation of white Button Mushroom (*Agaricus bisporus*).
11. Cultivation of white Paddy Straw Mushroom (*Volvariella* spp.).
12. Cultivation of Oyster Mushroom (*Pleurotus* spp.).
13. Diseases of Mushrooms.
14. Uses of Mushrooms.

Practicals:

1. Morpho-Anatomical study of *Agaricus*, *Volvariella* and *Pleurotus* species
2. Cultivation of *Agaricus* and *Pleurotus* species
3. Preparation of Compost using different Basic Materials
4. Preparation of Spawn (Grain Spawn and Brick Spawn)
5. Preparation of Casing, Cropping (Bags, Columns and Trays), Harvestings, Preservation

Teaching-learning Strategies

1. Lectures
2. Group Discussion
3. Laboratory work
4. Seminar/ Workshop

Learning Outcome:

1. Students are expected to get familiarized with the morphological and systematic knowledge about different edible and poisonous mushrooms.
2. They will be able to describe, apply and integrate the basic concepts of mushroom cultivation.

Assessment Strategies:

1. Lecture Based Examination (Objective and Subjective)
2. Assignments
3. Class discussion
4. Quiz
5. Tests

Recommended Readings:

1. Bahl, N. (1988). *Handbook on Mushrooms*. Oxford and IBH Pub. New Delhi.
2. Chang, S.T. and Miles, P.G. (2004). *Mushrooms, Cultivation, Nutritional Value, Medicinal Effect and Environmental Impact*. (2nd Ed.), CRC Press, New York, Washington, D.C.
3. Dickinson, C. and Lucas, J. (2003). *Encyclopedia of Mushrooms.* Orbis Pub. London.
4. Mahmood, S.K., Khatoon, A.Y. and Sarfraz, K.R. (1988). *Pakistan Men Khhumbi Ugane Ki Technology*. PARC Publications, Pakistan.
5. Rehman, T. and Shakir, A. (1997). *Mushroom Ki Kasht.* PARC Publications, Pakistan.
6. Singer, R. (1999). *The Agaricales in Modern Taxonomy*. J. Grammer, Lebre, Germany.
7. Svreck, M. (2010). *The Hamlyn Book of Mushrooms and Fungi.* Hamlyn, N.Y. London.

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IN VITRO TECHNOLOGIES AND INDUSTRIAL APPLICATIONS

Bot.Sp-13 **Credit Hours: 3(2+1)**

THEORY:

Introduction of the Course:

The course is organized to provide students with an overview of plants tissue culture techniques, their potential in the production of propagative material and interaction with industries. It also introduces students to principles, practices and applications of plant tissue culture and transformation. Further, to give students hand-on experience and training in plant tissue culture and genetic engineering techniques. Additionally, it exposes students to issues and challenges encountered in the area of plant biotechnology.

Course Objectives:

The course is designed:

1. To enable the students to understand plant tissue culture and its industrial application.
2. To enable students in understanding the method of plant germplasm conservation, maintenance of cell suspension cultures, secondary metabolite production and utilization and its industrial application.
3. To enable the students how to develop academia industry linkage.

Course Contents:

1. Micropropagation (via organogenesis and embryogenesis) of floricultural, agricultural and pharmaceutical crops: Orchids, Chrysanthemum, Gerbera, Carnation, Anthurium, Bamboos, *Spilanthes*, *Stevia, Psoralea,* Chickpea and elite tree species of nation importance.
2. Production of virus free plants through meristem culture in orchids and fruit trees.
3. Germplasm conservation under *in vitro* conditions.
4. Variations: Somaclonal and gametoclonal variations, spontaneous, genetic and epigenetic variations.
5. Culture systems: Differentiated, undifferentiated, physiological, biochemical and molecular role of minerals and growth regulators in understanding differentiation of organs under *in vitro* conditions.
6. Problems in Plant Tissue Culture: contamination, phenolics, recalcitrance.
7. Problems in establishment of regenerated plants in nature: hardening, association of mycorrhiza and rhizobia.
8. Factors responsible for *in vitro* and *ex vitro* hardening.
9. Use of bioreactors in secondary metabolite production and scale up automation of plant tissue culture.
10. Recent applications of tissue culture techniques and biotechnology in the introduction of economically important traits in horticultural, agricultural and medicinal plants.
11. Interactions, training and workshops in Biotech industries and placements.

Practicals:

1. Development of regeneration protocols employing direct and indirect organogenesis / somatic embryogenesis in economically important horticultural and/or medical plants.
2. Control of phenolics in recalcitrant tissue under culture conditions.
3. Study of various physico-chemical factors (pH, light, hormones, etc.) on *in vitro* growth and development of tissue or organs, rooting of regenerants, *in vitro* and *ex-vitro* hardening, potting and acclimatization in natural conditions.
4. Shoot-tip meristem culture for raising virus-free plants in tomato / tobacco.

5. *Agrobacterium rhizogenes* medicated development of hairy root cultures.
6. Isolation of bioactive compounds from medicinal plants using column chromatography and TLC.
7. Preparation of synthetic seeds for germplasm conservation using somatic embryos or other propagules.

Teaching-Learning Strategies

1. Lectures
2. Group Discussion
3. Laboratory work
4. Seminar/ Workshop

Learning Outcome:

1. The mentioned course fulfills all demands of plant propagation from basic to advance level.
2. They are expected to use this information for further advancement in Plant Tissue Culture.
3. The course is designed to educate students regarding various techniques of Tissue Culture and its application in various allied fields of sciences.
4. After completion of this course, students will be able to commercialize tissue culture products.
5. They can enhance the yield of several secondary metabolite by using tissue culture techniques.

Assessment Strategies:

1. Lecture Based Examination (Objective and Subjective)
2. Assignments
3. Class discussion
4. Quiz
5. Tests

Recommended Readings:

1. George, E.F., Hall, M.A and Geert-Jan De Klerk. (2008). *Plant Propagation by Tissue Culture* (3rd Edition), Springer, Netherlands.
2. Herman, E.B. (2008). *Media and Techniques for Growth, Regeneration and Storage* 2005-2008. Agritech Publications, New York, USA.
3. Neumann, K.H., Kumar, A. and Imani, J. (2020). *Plant Cell and Tissue Culture- A Tool in Biotechnology*. Springer Netherlands.
4. Pierik, R.L.M. (1999). *In vitro Culture of Higher Plants.* Kluwer Academic Publishers.
5. Prakash, J. and Pierik, R.L.M. (1991). *Horticulture – New technologies and Applications* (current Plant Science and Biotechnology in Agriculture). Kluwer Academic Publishers.

Recommended Journals:

In vitro Cellular and Developmental Biology-Plant, Plant Cell, Tissue and Organ Culture, Plant Growth Regulation, Plant Cell Reports.

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AGRICULTURE AND ENVIRONMENTAL POLLUTION

Bot.Sp-14 **Credit Hours: 3(2+1)**

THEORY

Introduction to the course:

This course provides the knowledge about different environmental pollution problems and their effects on agriculture soil and crop plants. It is generally aimed to familiarize students with agricultural pollution, its causes and effects.

Course Objectives:

The course is designed:

1. To provide an adequate knowledge about basic concepts of agricultural environmental pollution and types of agricultural environmental pollutants
2. To give an insight about behavior of environmental pollutants in the environment and their effects on crop plants.

Course Outline:

1. **Agriculture as a Global Polluter:**
   - 1.1. Polluting Gases (Methane, Nitrous Oxides and Ammonia), their Sources and Trends in the Atmosphere, the Products of Burning of Vegetation, Local and Global Impacts of Agricultural Pollution
2. **Air Pollution and Agriculture:**
   - 2.1. Introduction; Sources and causes of air pollution Methods of Assessing Air Pollution and its impact on Agriculture
   - 2.2. Ozone; Particulate matter; Mixtures of Pollutants and their effects on plants
3. **Acid Rain**:
   - 3.1. Introduction to acid rain; Trends of emission and pattern of acid deposition; Effects of acid rain on soil and agriculture.
4. **Pesticides**:
   - 4.1. Introduction; Use and Impacts on agriculture.
5. **Heavy Metals:**
   - 5.1. General and Specific Heavy Metals (Lead, Copper, Zinc and Cadmium),
   - 5.2. Sources; Distribution and Damage to Plants
6. **Water Pollution:**
   - 6.1. Introduction; Sources and causes of water pollution
   - 6.2. Impact of water pollution on Agriculture
7. **Sewage Pollution:**
   - 7.1. Introduction to sewage effluents and waste water; Sewage sludge; Constituents of sludge and their Effects on Plants

Practicals:

1. Sampling of agricultural soil.
2. Analysis of soil affected by water pollution for important Physical and Chemical Characteristics.
3. Study of various sources of air pollution
4. Study the symptoms of various Air Pollutants on Plants.
5. Study of Impact of Polluted Water on Germination and Seedling Growth.
6. Field Work: Visit to sites of Water Pollution and sewage effluents treatment plant.

Teaching-learning Strategies

1. Lectures
2. Group Discussion

3. Laboratory work
4. Seminar/ Workshop

Learning Outcome:

Students will be able to

1. Define agricultural environmental pollution.
2. Explain the types of agricultural environmental pollutants.
3. Explain the behavior of environmental pollutants in the environment.
4. Explain the modern agricultural practices
5. Evaluate and use the new knowledge in the field of agricultural pollution with a systematic approach.

Assessment Strategies:

1. Lecture Based Examination (Objective and Subjective)
2. Assignments
3. Class discussion
4. Quiz
5. Tests

Recommended Readings:

1. Agricultural Nonpoint Source Pollution: Watershed Management and Hydrology edited by William F. Ritter, Adel Shirmohammadi
2. Agricultural Pollution: Environmental Problems and Practical Solutions By Graham Merrington, Dr Linton Winder Nfa, R. Parkinson, Mark Redman, L. Winder
3. Assessment of Crop Loss From Air Pollutants Editors: Walter W. Heck, O. Clifton Taylor, David T. Tingey ISBN: 978-94-010-7109-3 (Print) 978-94-009-1367-7 (Online)
4. Biomass Burning and Global Change: Remote sensing, modeling and ..., Volume 1, edited by Joel S. Levine
5. Conway, G.R. and Pretty, J.N (2009). Unwelcome Harvest: Agriculture and Pollution. Earthscan Publications Ltd. London.
6. Dassler, H.G. and Bortitz, S. (2002). Air Pollution and its influence on vegetation. Dr. W. Junk Publishers, The Netherlands.
7. Nebel, B.R. and Edward, E.J. (2002). Environmental Science. Prentice-Hall. Inc. New Jersey.
8. Stiling, P.D. (1996). Ecology: Theories and Applications. (2nd Ed.), Prentice-Hall, Inc. London.
6. Unsworth, M.H. and Ormrod, D.P. (2006). Effects of Gaseous Air Pollution in Agriculture and Horticulture. Butterworth Scientific. London, Sydney, Toronto.
7. Treshow, M. (2003). Air Pollution and Plant Life. John Wiley and Sons. New York, Toronto. Brisbane.

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Bot.SP-15 ADVANCES IN MOLECULAR GENETICS Credit Hours: 3(2+1)

THEORY

Introduction of the Course

This course work is designed to highlight autonomous replicating entities, DNA Integrity, Protection and Repair and Homologous Genetic Recombination.

Course Objectives

1. To introduce advance genetic engineering techniques to the students
2. To enable the students to understand various DNA manipulations at the molecular level

Contents

1. **Autonomous Replicating Genetics Entities:** Plasmid Replication and Maintenance, Plasmid Replication, different Mechanisms of Regulation of Plasmid Replication, Genes involved in Stable Maintenance. Plasmid Born Functions, Transfer Function, Resistances to Antibiotics and Toxic Ions, Bacteriocin and Toxin Production, Plasmid Involvement in Host Metabolism. Nomenclature of Plasmids and Plasmid Born Functions.
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 Cystosine (Mcr) Restriction System of *E.Coli.*Other Modification and/or Restriction System. The DNA Adenine-Methylation (Dam) and DNA Cystosine-Methylation (Dcm) Systems. Restriction-Modification and Evolution.
3. **DNA Repair:** Classification of Repairable Lesions. Direct Repair. Base Excision Repair.Nucleotide-Excision Repair. Recombinational (or post replication) Repair. Cross-Link Repair. Mismatch Repair. Inducible Repair.

Practicals:

1. Transformation
2. Conjugation
3. Mutagenesis
4. Plasmid DNA Preparations (Mini Preps)
5. Agarose Gel Electrophoresis
6. Molecular Markers

Teaching-Learning Strategies

1. Lectures
2. Group Discussion
3. Laboratory work
4. Seminar/ Workshop

Learning Outcome:

1. Students are expected to get themselves familiarized with the molecular/macromolecular organization of plant cells and DNA in general.
2. They should be able to understand almost infinite possibilities of structural organization, molecular backbones and the myriad roles or functions they can take or perform.
3. Students should be able to understand the basic concepts with regard to DNA Amplification by PCR.

Assessment Strategies:

1. Lecture Based Examination (Objective and Subjective)
2. Assignments
3. Class discussion
4. Quiz
5. Tests

Recommended Readings:

1. Gardner, E.J. (2004). *Principles of Genetics,* John Willey and Sons, New York.
2. Glick, B.R. and Pasternak, J.J. (2003). *Molecular Biotechnology.* ASM Press Washington DC.
3. Pierca, B.A. (2005). *Genetics*; *A Conceptual Approach.* W. H. Freeman and Company, New York.
4. Primrose, S.B., and Twyman, R.M. (2006). *Principles of Gene Manipulation and Genomics.* Blackwell Scientific Publications.
5. Primrose, S.B., Twyman, R.M. and Old R.W. (2004). *Principles of Gene Manipulation, an Introduction to Genetic Engineering*. (6th Ed.), Blackwell Scientific Publications.
6. Snustad, D.P. and Simmons, M. J., (2005). *Principles of Genetics,*(4th Ed.). John-Wiley and Son Limited.
7. Synder, L, and Champness, W. (2004). *Molecular Genetics of Bacteria.* ASM Press, Washington D.C
8. Wilson, J. and Hunt, T. (2004). *Molecular Biology of the Cell* – The Problems Book. Garland Publishing Inc.

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Bot.Sp-16 BIOHAZARDS, BIOSAFETY, BIOETHICS Credit Hours: 3(2+1)

THEORY:

Introduction of the Course

This course will enable students to learn about recognized and unrecognized hazards related to organismic working specimens within laboratory that can cause serious physical harm or even death. Furthermore, it contains recommendations as well as descriptions of mandatory biosafety standards being followed at international and national level. It would also help students to learn about role international and national committees related to bioethics and biosafety.

Course Objectives:

The course is designed:

1. To learn about recognized and unrecognized hazards related to organismic working specimens within laboratory that can cause serious physical harm or even death.
2. To familiarize with the essential basics of biosafety while dealing with biohazardous specimens in the laboratories
3. To give essential insight about bioethics related to biotechnological interventions

Contents:

1. Introduction to Biohazards, Biosafety and Bioethics

- 1.1 Concept of hazard and risk
- 1.2 Definition and concepts of Biohazards
  - 1.2.1 Uses and abuses of genetic information and biohazards
  - 1.2.2 Hazardous group of organisms – Natural and those altered by human
    - 1.2.2.1 Hazardous microbes
    - 1.2.2.2 Hazardous plants
    - 1.2.2.3 Hazardous animals
  - 1.2.3 Possible solutions to various biohazards
- 1.3 Definition and concepts of Biosafety
- 1.4 Definition and concepts of bioethics

2. Genetically modified organisms (GMOs)

- 2.1 Definitions and concepts of GMOs
- 2.2 Risk assessment of GMOs manipulations
  - 2.2.1 Release of genetically modified organisms
- 2.3 Intellectual property rights (IPR) related to GMOs
  - 2.3.1 Patenting of GMOs
  - 2.3.2 Commercializing and benefit sharing

3. Bioethics

- 3.1 Introduction to bioethics
- 3.2 Ethical issues related to GMOs
- 3.3 Concept of euthanasia and its application for humanism purposes
- 3.4 Possible risks associated with reproductive and cloning technologies
- 3.5 Possible risks associated with transplants and eugenics
- 3.6 International bioethics norms
- 3.7 Role of national bioethics committees

4. Biosafety

4.1 Introduction to Occupational Safety and Health Administration (OSHA) Laboratory standard

4.1.1 Concept of PPEs and its significance

4.2 International rules and regulations for biosafety of GMOs

4.3National rules and regulations for biosafety in Pakistan

4.3.1 Biosafety steering committees and their roles in Academia and R&D Laboratories

4.4 Potential source of human health risks in the laboratory

4.3.1 Radiation – its use in laboratory and human health and safety concerns

4.3.2 Handling and disposal of radioactive materials in the laboratories

4.3.3 Use of effective PPEs for protection of workers and public

PRACTICAL:

1. Acquaintance with OSHA laboratory safety guidelines
2. Identification of hazards commonly found in microbiological laboratories
3. Microbiological procedures to explain potential hazards and biosafety measures
4. Safer disposal / release of biohazardous materials (microbes, plants, animals) from laboratories
5. Handling of pathogenic microbes (bacteria, fungi, viruses)

Teaching Learning Strategies:

1. Lectures
2. Visits to different biotechnology laboratories
3. Laboratory work
4. Assignments / Seminars Workshops

Learning Outcomes:

1. The students will be able to work in the research laboratories while following personal biosafety recommendations.

2. The students will know the biohazard and biosafety signs and will adopt use of PPEs accordingly.

3. During their professional life either at national or international level, the students will know the biosafety standards of laboratories such as, OSHA standards.

4. One of the key learning outcomes will be that it will ensure occupational health and safety both at personal and team level.

Assessment Strategies:

1. Lecture-based quiz (both objective and subjective)
2. Brief and detailed assignments
3. Class tests
4. Group activities

Recommended Readings:

1. Abdin, M.Z., Kiran, U., Ali, A., Kamaluddin. (2017). Plant Biotechnology: Principles and Applications. Springer Nature Singapore, ISBN: 978-981-10-2961-5 (eBook). DOI: 10.1007/978-981-10-2961-5.
2. Bayot, M.L., Limaiem, F. (2021). Biosafety Guidelines. StatPearls Publishing LLC. 8600 Rockville Pike, Bethesda MD, 20894 USA. Bookshelf ID: NBK430685.
3. Laboratory Biosafety Manual, 3rd Ed. (2004). World Health Organization (WHO), Geneva. ISBN: 92-4-154650-6.
4. OSHA Laboratory Safety Guidance (2011). OSHA 3404-11R 2011.
5. Sateesh, M.K. (2020). Bioethics and Biosafety. Distributed by: Willey. Dreamtech Press. ISBN: 978-93-89795-60-8.

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Bot.Sp-17 MYCORRHIZAE IN AGRICULTURE Credit Hours: 3(2+1)

THEORY:

Introduction of the Course:

This course provides concepts about Mycorrhizae in Plant Soil System. It also describes role of AM Fungi in Soil and their Conservation.

Course Objectives:

The course is designed:

1. To provide an adequate knowledge about basic concepts of different fungal groups and their relationships with plant roots.
2. To give an insight into Arbuscular mycorrhizae and soil microbial interaction.

Contents:

1. **Mycorrhizae and Crop Productivity:** The AM Plants and Cultural and environment Effects.
2. **Role of AM Fungi in Soil and their Conservation.**
3. **Arbuscular mycorrhizae and soil microbial interaction:**
   - **3.1.**Introduction.
   - **3.2.**The Mycorrhizosphere.
   - **3.3.**Microbial effects on VA Mycorrhiza Formation.
   - **3.4.**Biological Nitrogen Fixation.
   - **3.5.**Implications in Sustainable Agriculture.
4. **Arbuscular Mycorrhizae and Cultural Stresses:**
   - **4.1.**Cropping Sequence.
   - **4.2.**Crop Breeding.
   - **4.3.**Pesticides, Fertilizers, Tillage Effects.
   - **4.4.**Inoculation with AM fungi.
5. **Arbuscular Mycorrhizae and Environmental Stresses:**
   - **5.1.**Introduction.
   - **5.2.**Soil Nutrients.
   - **5.3.**Water and Aeration.
   - **5.4.**Soil Structure.
   - **5.5.**Hydrogen Ion Activity.
   - **5.6.**Salt (Osmotic) Stress.
   - **5.7.**Heavy Metals.
   - **5.8.**Biotic Factors.

Practicals:

1. Study of VA Mycorrhizal associations. Clearing and staining of Mycorrhizal roots, sample storage and slide preparation.
2. Estimation of root length and colonization by Mycorrhizal fungi.
3. Bioassay Measurements of Mycorrhizal inoculum in soil.
4. Isolation and identification of glomalean fungi from field and other soils.
5. Synthesis of Mycorrhiza from spore inoculum and from root inoculum.
6. Assessment of plant growth response to Mycorrhizal infection in some seasonal crops.

Teaching-learning Strategies

1. Lectures
2. Group Discussion
3. Laboratory work
4. Seminar/ Workshop

Learning Outcome:

1. Students are expected to get familiarized with the morphological and systematic knowledge about different fungal groups and their relationships with plant roots.
2. They will be able to describe, apply and integrate the basic concepts of Mycorrhizae and Crop Productivity.

Assessment Strategies:

1. Lecture Based Examination (Objective and Subjective)
2. Assignments
3. Class discussion
4. Quiz
5. Tests

Recommended Readings:

1. Khan, A. G. (2006). *Laboratory Manual of Mycology and Plant Pathology.* HEC Pakistan.
2. Podila, G. P. and Varma, A. (2005). *Basic Research and Application of Mycorrhizae.* K. International (Pvt) Ltd. New Delhi.
3. Sanders, F. E., Mosse, B. and Tinker, P.B. (2004). *Endomycorrhizae*. Academic Press, N.Y.
4. Smith, S. E. and Read, D. J. (2008). *Mycorrhizal Symbiosis.* Academic Press, London, N.Y.
5. Allen, M.F. (1992). *Mycorrhizal Functioning. An Integrative Plant Fungal Process*. Chapman and Hall Inc., New York, London.
6. Brundrett, M., Bougher, N., Dell, B., Grove, T. and Malajczuk, N. (1996). *Working with Mycorrhizas in Forestry and Agriculture.* ACIAR Monograph 32. Canberra, Australia.
7. Brundrett, M., Melville, L. and Peterson, L. (1994). *Practical Methods in Mycorrhiza Research.* Mycologue Publications.
8. Bethlenfalvay, G. J. and Linderman, R.G. (1992). *Mycorrhizae in Sustainable Agriculture.* ASA Special Publication No.54.
9. Powell, L.I. and Bagyaraj, D. J. (1984).*VA Mycorrhiza.* CCRC Press Inc.

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Bot-Sp-18 PLANT PHYSIOLOGY AND CLIMATE CHANGE Credit hours: 3 (2+1)
THEORY:

Introduction of the Course:

The course is organized to provide an adequate knowledge about plant physiology and climate change. Plant physiology is the study of plant function and behavior, encompassing all the dynamic processes of growth, metabolism, reproduction, defense, and communication that account for plants being alive. Climate change alters species interactions via direct effects on plant antagonists and mutualists and via changes in plant traits that influence the dynamics of these interactions. Global change is a topic of great concern today. Change includes increasing temperatures, decreasing rainfall, rising atmospheric carbon dioxide levels, degrading soils, excess of nutrients, salt, heavy metals or man-made chemicals. Change can mean altered presence of herbivores, pests and pathogens, or competition with aggressive weeds.

Course Objectives:

The course is designed:

1. To provide an adequate knowledge about basic concepts of plant physiology and climate change.
2. To give an insight knowledge of plant physiology and climate change, their evolutionary and ecological response

Contents:

1. **Plants and Global Change:**
   - 1.1 Effects of Rising Atmospheric Concentrations of Carbon Dioxide on Plants
   - 1.2 Potential impact of climate change on nutrient availability
   - 1.3 Ozone exposure response on Crop Productivity
2. **Physiological Traits for Improving Heat Tolerance in Crops:**
3. **Climate Change:**
   - 3.1 Resetting Plant-Insect Interactions
   - 3.2 Climate change and multitrophic level species interactions
   - 3.3 Waterproofing Crops
   - 3.4 Effective Flooding Survival Strategies
   - 3.5 Molecular and Physiological Analysis of Drought Stress in response to environmental change
   - 3.6 Evolutionary and ecological responses to anthropogenic climate change
   - 3.7 Microorganisms and ocean global change
   - 3.8 Prevalence of polyploidy in cold climates

Practicals:

1. To determine the activity of Antioxidant enzymes.
2. To investigate cold-induced physiological responses in plants.
3. To study heat induced physiological responses in plants.
4. To determine the Oxygen radical absorbance capacity of stressed tissues.
5. To determine Ferric reducing antioxidant power of stressed tissues.

Teaching-learning Strategies:

1. Lectures
2. Group Discussion
3. Laboratory work
4. Seminar/ Workshop

Learning Outcome:

1. Students are expected to get familiarized with the morphological and systematic knowledge about different plant groups.
2. They will be able to describe, apply and integrate the basic concepts of Cell Biology including Genetics and Evolution, Biochemistry, Physiology as well as Structure and Functions of different Organelles.
3. This will enable them qualify for basic to moderate level jobs involving knowledge of plants and their environment.
4. The obtained knowledge shall also enable the students to enter into various entrepreneurial activities involving general introduction to Botany.

Assessment Strategies:

1. Lecture Based Examination (Objective and Subjective)
2. Assignments
3. Class discussion
4. Quiz
5. Tests

Recommended Readings:

1. Baxter, B. (2014) Plant acclimation and adaptation to cold environments, in Temperature and Plant Development (eds K. a. Franklin and P. a. Wigge), John Wiley & Sons, Inc, Oxford. doi: 10.1002/9781118308240.ch2.
2. Morison, J. I. L. and Morecroft, M. D. (2008). *Plant Growth and Climate Change.*Wiley-Blackwell.232pp. ISBN: 978-1-405-13192-6
3. Redden, R., Yadav, S. S. Maxted, N., Dulloo, M. E., Guarino, L. and Smith, P. (2015). *Crop Wild Relatives and Climate Change*.John Wiley & Sons. 400pp.
4. Rozema, J., Aerts, R. and Hans Cornelissen (2007). *Plants and Climate Change.*Springer. ISBN 978-1-4020-4443-4.

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Bot.Sp-19 ARCHAEOPALYNOLOGY Credit Hours: 3(2+1)

THEORY

Introduction to the course:

The course gives the students an introduction to the fossil record of land plants and algae, their evolution, biology, and morphology. The primary goal is to explain the science of Archaeopalynology, to outline the main features of pollen and to show how these properties are used in various branches of science.

Course Objectives:

The aim of the course is:

1. To understand the structure pollen and spores.
2. To raise a level of identification for pollen analysis
3. To provide students with the practical skills to analyze pollen/spores and plant remains with microscopic techniques and the statistical modelling for the reconstruction of the palaeoenvironment and palaeoclimate.

Course Detail:

1. **Archaeopalynology**: Definition, Pollen Structure, Exine Stratification, Sporopollenin.
2. **Pollen Production**: Dispersal and deposition by Air (Anemophily), Water (Hydrophily), Animals (Zoophily) and other Agencies, Re-deposition and Recycling.
3. **The Archaeological Deposits**: Classification and Description (Allochthonous, Autochthonous, Regenerative Peat).
4. **Pollen as indicators of vegetation**: Flora, history of Climate, Domestication of Plants, the Human Impact, Cultivation Practices through ages; Cultural Landscape Development, examples from Indus Valley Civilization and other parts of the world.
5. **Pollen Analysis** for dating, Recent Pollen as Markers.
6. **Coprolite Palynology** to deduce human dietary habits, the climate and cooking abilities.
7. **Pollen Diagrams and Maps**

Practicals:

1. Various Pollen and Spores extraction techniques from soil samples collected from Archeological Sites through standard maceration techniques.
2. Study of pollen morphology e.g. structure and sculpturing, apertures, size etc in relation to its function.
3. Preparing reference collection of pollen or the pollen herbarium in form of permanent strew mount slides.
4. Identification of Palynomorphs other than pollen and spores in the strew mount slides e.g. Tissue fragments, Algae and Animal remains.
5. Pollen identification through standard keys.
6. Interpretation of palynological data in terms of pollen Diagrams and Maps.
7. Preparing Pollen for Phase Contrast and Electron Microscopy
8. Mandatory Field Study tour to the Archeological sites near Lahore to collect soil samples for palynomorphs extraction representing plants through standard maceration techniques. Students shall be required to prepare a field study tour report in addition to the Practical copy and produce it at the time of Practical Examination. Both practical copy and Field report shall carry separate marks. Any student not attending the field study tour shall loose those marks (Field report).

Teaching-learning Strategies

1. Lectures
2. Group Discussion
3. Laboratory work
4. Field visits/ Workshop

Learning Outcome:

Students will be able to:

1. How plants evolved as shown from the fossil record.
2. How to identify and classify palynomorphs.
3. How to use palynofacies to reconstruct sedimentary environments.
4. How to use plant fossils in palaeoclimate reconstructions.
5. How sedimentary transport and post-depositional processes control the plant fossil record.

Assessment Strategies:

1. Lecture Based Examination (Objective and Subjective)
2. Assignments
3. Class discussion
4. Quiz
5. Tests

Recommended Readings:

1. Dolores, R. Piperno (2006). Phytoliths: A Comprehensive Guide for Archaeologists and Paleoecologists. AltaMira Press (January 23, 2006). Pp. 304.
2. Faegri, K., Kaland, P.E, Krzywinski, K. (Latest Edition). Text book of Pollen Analysis,4th edn. Wiley, Chichester.
3. John, M. Marston (Editor),,Jade d'Alpoim Guedes (Editor) Christina Warinner (Editor). .Method and Theory in Paleoethnobotany – February 15, 2015
4. Kenoyer, J. M. (Latest Edition). Ancient Cities of the Indus Valley Civilization.Oxford University Press.
5. Pearsall, D.M. (2015). Paleoethnobotany. A handbook of procedures. Routledge; 3 edition (September 2, 2015). PP 513
6. Weber, S.A. (1991). Plants and Harappan Subsistence. Westview.
7. Weber, S.A. and Belcher, W.R. (2003). Indus Ethnobiology. Lexington Books.

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PLANT ARCHITECTURE-INNOVATIONS THROUGH TIME AND SPACE

Bot.Sp-20 **Credit Hours: 3(2+1)**

THEORY:

Introduction to the course:

The course gives the students an introduction to the plant architecture, their evolution, biology, and morphology. The primary goal is to explain the science of palynology, to outline the main features of pollen and to show how these properties are used in various branches of science.

Course Objectives:

The aim of the course is:

1. To understand the structure pollen and spores.
2. To raise a level of identification for pollen analysis
3. To provide students with the practical skills to analyze pollen/spores and plant remains with microscopic techniques.

Course Detail:

1. **Plant Architecture**; meaning and Interpretation. Evolution, forces of evolution; geological, environmental, biological extinction and subsequent birth of new species. Concept of species in plants.
2. **Early Silurian:** Amphibious plants, the Silurian Climate, Stresses and Strains, Vegetative and Reproductive instability verses short life span and water dependency, Rootless, branchless and leaveless bodies, problems of geometrical symmetry and overcoming gravitational forces and desiccation, Only sporophytic generation known e.g. *Cooksonia.*
3. **Late Silurian to Early Devonian:** Archetectureal triumph, Erect upright very small (17-20cm) sporophytic body divided into three zones i.e.; Photosynthetic, Conductive and Absorptive Zones, branching dichotomous, epidermis cutinized and stomatiferous, spore smooth thin walled, both gametophyte and sporophyte short lived and amphibious. Hydroid and leptoids for conduction, xylem and phloem also emerged later, rounded geometrical symmetry firmly established, homospory e.g., *Aglaophyton, Taenocardia, Hicklingia, Horneophyton*.
4. **Late Devonian – Early Carboniferous:** Birth of roots, leafy appendages, dichotomy cum trichotomy, abaxial sporangia, heterospory, Corm containing reserved food developed, Aquatic habit emerged, sporangia terminal and lateral, spores thich walled, e.g., *Zosterophyllum, Trimerophyta, Drepanophycus, Asteroxylon*.
5. **Mid to late Carboniferous:** witnessed another important breakthrough further strengthening the Plant architecture i.e., Arborescent habit, root or root like structures, Heterospory and seed Habit, Pseudo-Bitegmic Seed, Twiner stems, bifacial true leaves, e.g., *Protolepidodendron, Lepidodendron, Spbenophyllum*, Ferns, Seed Ferns.
6. **Early Permian to Early Triassic**:- Arborescent and Seed Habits more refined and well established, Hetrospory more pronounced, true Bitegmic Seeds evolved, Seed Ferns, Progymmnosperms and Gymnosperms dominated the terrestrial Ecosystems. End Permian great Mass Extinction Episode, 90% Land Flora diminished. Some plants recovered during early Triassic. Permian Glossopteris Flora replaced by Dicoridium Flora, e.g., *Verteberaria, Glossopteriss, Gangamopteris, Squamalia, Dicoridium*.
7. **Mid Triassic to Late Triassic**; Gymnosperms with Arborescent Habit dominated the terrestrial Ecosystem further strengthening the Arborescent Habit with pronounced secondary growth and deep tap root system along with Dicoridium Flora.

8. **Early Cretaceous to Palaeocene**: Emergence of Angiosperms with same fundamental archetectural layout as exhibited by all tracheophytes till late Jurassic, but with two important Evolutionary innovations apart from many others, i.e.; reduction of male gametophyte to one cell, not requiring water for its transportation to female gametophyte and development of flower with bitegmic ovule.

Practicals:

1. Study of Architectural layout model of the major plant groups mentioned in the theory section through clay moulds.
2. Study through prepared slides the relevant anatomical and structural details of representative plants groups mentioned in the text.
3. Mandatory Field Study tour to the lesser Himalayas to collect rock samples from various formation (Permian to Palaeocene) to extract palynomorphs representing plants in the theory section through standard maceration techniques. Students shall be required to prepare a field study tour report in addition to the Practical copy and produce it at the time of Practical Examination. Both practical copy and Field report shall carry separate marks. Any student not attending the field study tour shall lose those marks (Field report).

Teaching-learning Strategies

1. Lectures
2. Group Discussion
3. Laboratory work
4. Field visits/ Workshop

Learning Outcome:

Students will be able to learn:

1. How plants evolved as shown from the fossil record.
2. How to identify and classify palynomorphs.
3. How to use palynofacies to reconstruct sedimentary environments.
4. How to use plant fossils in palaeoclimate reconstructions.
5. How sedimentary transport and post-depositional processes control the plant fossil record.

Assessment Strategies:

1. Lecture Based Examination (Objective and Subjective)
2. Assignments
3. Class discussion
4. Quiz
5. Tests

Recommended Readings:

1. Paleobotany, Paleoecology and Evolution. Kjniklas.Praeger Press, New York.
2. Jeryme, A.C., T.A. Ciabbe and B.A. Thomas. The phylogeny and classification of Ferns, Academic Press, London
3. Alfered Traverse 2007. Paleopalynology. Unwin Hyman Ltd.
4. Eames, A.J. Morphology of Vascular Plants (Lower Groups). McGraw Hill and Co.
5. Andrews, H.W. Studies in Paleobotany. John Wiley and Sons.
6. Sporne, K.R. The morphology of Pteridophytes. Hutchinson University Library.
7. Taylor and Taylor. Biology and Evolution of Fossil plants. Princeten Hall, New York.
8. Foster and Gifford. Comparative Morphology of Vascular Plants, W.H. Freeman, New York.
9. Lithostratigraphic Units of the Kohat, - Potwar Province, Indus Basin Pakistan, 1980. Memoir Volume No.10. Geological Survey of Pakistan.
10. Bierhorst, D.W. Morphology of Vascular plants. Macmillan, Inc. Insurance, New York.

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AERO PALYNOLOGY AND POLLEN BORNE DISEASES

Bot. Sp-21 **Credit Hours: 3(2+1)**

THEORY

Introduction to the course:

The course aims to explain the science of Aero Palynology, to outline the main features of pollen and to show how these properties are used in various branches of science. It also aims to study the various pollen borne diseases.

Course Objectives:

The aim of the course is:

1. To understand the airborne pollen and spores.
2. To raise a level of identification of pollen and spores which cause allergy on sensitive individuals.
3. To study the common airborne pollen allergens and diseases.

Course Detail:

1. **Aeropalynology:**
   1.1. Definition, the Ultrastructur and Morphology of Pollen and Spores.
2. **Pollination Biology**:
   2.1. Critical Analysis and Morphographic Comparison of the Anemophilous, Zoophilous and Hydrophilous pollen.
   2.2. Classification of Anemophilous pollen and their aerodynamic properties.
3. **The Atmosphere and its Stratification**.
4. **Pollen Production and Aerial travels of pollen**:
   4.1. Transport Distances, Precipitation and Pollen Dispersal, Deposition and Re-deposition
   4.2. Intercontinental and Intracontinental transport of pollen.
5. **Stratification of pollen of various categories in the atmosphere**:
   5.1. Meteorological factors affecting their distribution (Wind, Temperature, Pollen Structure, Size, Humidity etc.)
   5.2. Role of Pollen (upper atmosphere) in Cloud Formation and Precipitation.
6. **Seasonal Distribution of spores and pollen at different levels in the atmosphere**:
   6.1. Pollen rain.
7. **Pollen Deposition Traps**:
   7.1. By Direct Experiments
   7.2. Short Term Trapping (Artificial Traps)
   7.3. Long Term Trapping (Natural Or Manmade Traps)
   7.4. Daily Pollen Count Techniques.
8. **Pollen as Allergen Vector**:
   8.1. Causing Allergies and Asthma.
   8.2. Mode of Action and Preventive Measures.

Practicals:

1. Preparation of pollen strew mount temporary aquas and permanent slides from freshly collected (or from herbarium) anthers to study the detailed morphograhpic structure of pollen including size, shape, aperture, ornamentation pattern etc. of the exine through standard procedures.
2. To build up reference pollen herbarium through standard established preparatory methods in form of permanent Strew mount slides representing plants of all seasons.

3. Capture Air borne pollen from various levels in the Atmosphere by using standard pollen deposition traps.
4. To count pollen per day in the atmosphere reflecting quantitative frequencies of various pollen types responsible for causing allergies and asthmas through standard techniques.
5. Visit any hospital or Allergy Centre to demonstrate before the pupils carrying out a specific pollen allergy tests.

Teaching-learning Strategies

1. Lectures
2. Group Discussion
3. Laboratory work
4. Seminar/ Workshop

Learning Outcome:

Students will be able to:

1. Explain the outlines of the science of Palynology.
2. Explain the contributions of the science of Aero Palynology to the following sciences: plant systematic, medicine, pharmacology, apiculture, archology, criminology and geology.
3. Choose a profession in area of palynology in the future.

Assessment Strategies:

1. Lecture Based Examination (Objective and Subjective)
2. Assignments
3. Class discussion
4. Quiz
5. Tests

Recommended Readings:

1. K. Faegri, P.E. Kaland and K. Krzywinski, (Latest Edition). Text book of Pollen Analysis, 4th edn. Wiley, Chichester.
2. R.G. Stanley, (Latest Edition). Pollen. Biology – Biochemistry –Management; in Linskens HF (ed): Berlin, Springer
3. A. Menzel, Estrella N: Plant phonological changes; in Walther et al (ed): Fingerprints of Climate Change. New York, Kluwer Academic/ Plenum Publishers.
4. Blackley CH: Experimental Researches on the Causes and Nature of Catarrhus aestivus (Hayfever or Hay-Asthma). London, Dawson's of Pall Mall, 1959 (original publication: London, Baillière, Tindall& Cox.
5. Aas K, Aberg N, Bachert C, Bergmann K, Bergmann R, Bonini S, Bousquet J, de Weck A, Farkas I, Hejdenberg K: European Allergy White Paper: Allergic Diseases as a Public Health Problem. The UCB Institute of Allergy, Brussels
6. Olga Ukhanova and Evgenia Bogomolova. Airborne Allergens. Komarov Botanical Institute of the Russian Academy of Sciences, St. Petersburg, Russia
7. Behrendt H, Frierichs KH, Kainka-Stänicke E, Darsow U, Becker WM, Tomingas R: Allergens and pollutants in the air – a complex interaction; in Ring J, Prybilla B (eds): New Trends in Allergy III. Berlin, Springer, 1991, pp 467–478.
8. Stephen T Holgate, Martin K. Church, David H. Broide, Fernando D Martinez. Allergy. Elsevier Health Sciences.
9. Maureen E. Lacey andJonathan S. West.(latest edn.). The Air Spora: A manual for .catching and identifying airborne biological particles. Springer; 2007 edition

10. Maureen E. Lacey and Jonathan S. West. The Air Spora – A Manual for Catching and Identifying Airborne Biological Particles . Dordrecht, the Netherlands : Springer-Verlag Gmbh (http://www.springer.com) 2006 . 156pp.
11. Mikhail Sofiev and Karl-Christian Bergmann. (2013). Allergenic Pollen: A Review of the Production, Release, Distribution and Health Impacts. Springer; 2013 edition
12. Kainka-Stänicke E, Behrendt H, Friedrichs KH, Tomingas R: Surface alterations of pollen and spores by particulate air pollutants. J Hyg Environm Med 1989;188:516.
13. Knox RB: The pollen grain; in Johri BM (Latest ed): Embryology of Angiosperms. Berlin, Springer.
14. Linskens HF, Jorde W: Pollen as food and medicine – A review. Econ Bot 1997; 51:77– 78.

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Bot. Sp-22 ENVIRONMENTAL BACTERIOLOGY Credit Hours 3(2+1)

Introduction of the Course

The course is designed to enable the students to be familiar with the role played by the bacteria in the environment. Environmental bacteriology involves the study about the ecology of bacteria, their relationship with one another and with their environment, the beneficial and hazardous role of bacteria in the environment and how laws and biosafety guide lines should be implemented in order to maintain healthy environment. Bacteria play primary role in regulating biogeochemical systems on our planet including some of the most extreme regions, from frozen environments and acidic lakes, to hydrothermal vents at the bottom of deepest oceans, and some of the most familiar, such as the human small intestine. After studying the subject of Environmental Bacteriology, students will be able to define the beneficial and harmful effects of microorganisms on individual health, public health, food and water quality.

Course Objectives

1. To make the students aware of the role played by bacteria (both beneficial and harmful) in the environment
2. To understand the impact of various environmental factors on the growth of bacteria

Contents

Unit I: Introduction to Environmental Bacteriology
Unit-II: Effect of environmental factors on bacteria
Unit- III: Biogeochemical cycle involving Bacteria.
Unit- IV: Environmental laws and Biosafety guide lines.
Unit- V: Molecular approaches to the environmental management.
Unit- VI: Bacterial Biodegradation of xenobiotics.
Unit- VII: Microbial resistances, transformation and detoxification of pollutants.
Unit- VIII: Biofilms: introduction and applications.
Unit- IX: Environmental law and management.
Unit- X: Mineral leaching with bacteria

Practicals:

1. Study of effects of environmental factors on the bacterial growth.
2. Study of effect of pollutants on bacterial growth.
3. Determination of reduction potential of heavy metals by bacteria.
4. Antibiotic resistance of bacteria

Teaching-learning Strategies

1. Lectures
2. Group Discussion
3. Laboratory Work
4. Seminar/ Workshop

Assessment and Examinations:

As per University Rules

Recommended Readings

1. Alcamo, I. E. (2022). *Fundamentals of Microbiology.* (12th Ed.), Jones & Bartlett Publishers, USA.
2. Barnett, V. (2003). *Environmental Statistics: Methods and Applications*. John-Wiley and Son Limited.ss
3. Bertrand, J. C., Caumette, P., Lebaron, P., Matheron, R., Normand, P., & Ngando, T. S. (Eds.). (2015). *Environmental microbiology: fundamentals and applications* (pp. 3-7). Dordrecht: Springer.
4. Black, J.G. (2017). *Microbiology*: Principles & Explorations, (10th Ed.), Publisher McGraw Hill.
5. Borlak, J. (2005). *Handbook of Toxicogenomics: Strategies and Applications*. John-Wiley and Sons Limited.
6. Canter, L. (1996). *Environmental Impact Assessment*. McGraw-Hill Science. ISBN: 0070097674
7. Cunningham, W.P. and Cunningham, M.A. (2020). *Principles of Environmental Science Inquiry and Applications*. (9th Ed.) McGraw-Hill Science.
8. Grant, W. D., & Long, P. E. (2013). *Environmental microbiology*. Springer Science & Business Media.
9. Heikki, M., Hokkanen, T. and Hajek, A.E. (2004). *Environmental Impacts of Microbial Insecticide: Needs and Methods for Risk Assessment*, Science Publishers.
10. Ivanov, V. (2016). *Environmental microbiology for engineers*. CRC press.
11. Maier, M.R. Pepper, L.I., and Gerba, P.C. (2014). *Environmental Microbiology.* (3rd Ed.), Elsevier Inc, U.K.
12. Méndez-Vilas, A. (Ed.). (2014). *Industrial, medical and environmental applications of microorganisms: current status and trends*. Wageningen Academic Publishers.
13. Mitchell, R. (2010). *Environmental Microbiology*. John Wiley & Sons Carde.
14. Pepper, I. L., Gerba, C. P., Gentry, T. J., & Maier, R. M. (Eds.). (2011). *Environmental microbiology*. Academic press.
15. Rubin, E.S. (2001). *Introduction to Engineering and the Environment*. McGraw-Hill Science.
16. Schmidt, T. M. (Ed.). (2019). *Encyclopedia of Microbiology*. Academic Press.
17. Sunahara, G.I., Agnes Y., Renoux, A.Y., Thellen, C., Gaudet, C.L., and Pilon, A. (2002). *Environmental Analysis of Contaminated Sites.* John-Wiley and Son Limited.
18. Talaro, K.P. (2022). *Foundations in Microbiology:* Basic Principles. (11th Ed.) McGraw Hill. Publisher.
19. Tickner, J.A. (2002). *Precaution, Environmental Science, and Preventive Public Policy.* Island press.
20. Tortora, G.J., Christine L., Case, C.L., Funke, B.R., Funke, B. and Case, C. (2022). *Microbiology*: An Introduction. (13th Ed.), Pearson Education Publishers.

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Bot. Sp-23 **GENE CLONING** **Credit Hours: 3 (2+1)**

Introduction of the Course

This course work is designed to highlight importance of Gene Cloning in the field of research and Biotechnology including learning about the concept of cloning agents, their behavior, structure and manipulations. It will help the students to learn advance techniques regarding the synthesis of recombinant DNA and their manipulations for the production of beneficial products such as hormones and metabolites. It will also be helpful for students to learn applications of these techniques in various fields such as agriculture and medicine.

Course Objectives

1. To introduce advance genetic engineering techniques to the students
2. To enable the students to understand various DNA manipulations at the molecular level

Contents:

Unit –I: The Principles of Cloning DNA:
- 1.1. General Principles of Cloning
- 1.2. Strategies for gene cloning

Unit-II Vehicles: Plasmid and Bacteriophages:
- 2.1 Plasmids
  - i. Basic Features of Plasmids
  - ii. Size and Copy Number
  - iii. Conjugation and Compatibility
  - iv. Plasmid Classification
- 2.2. Bacteriophages:
  - i. Basic Features of Bacteriophages
  - ii. Lysogenic Phages
  - iii. Viruses as Cloning Vehicles

Unit-III: Purification of DNA:
- 3.1. Preparation of total Cell DNA
- 3.2. Preparation of Plasmid DNA
- 3.3. Preparation of Bacteriophage DNA

Unit-IV: Manipulation of Purified DNA:
- 4.1. The range of DNA Manipulative Enzymes
- 4.2. Enzymes for Cutting DNA- Restriction Endonucleases
- 4.3. Ligation- Joining DNA Molecule together

Unit-V: Introduction of DNA into Living Cells:
- 5.1. Transformation
- 5.2. Selection for Recombinants
- 5.3. Introduction of phage DNA into Bacterial Cells
- 5.4. Selection for Recombinant Phage

Unit-VI: The Applications of Cloning in Gene Analysis:
- 6.1. Cloning of Specific Gene
- 6.2. Studying Gene Location and Structure
- 6.3. Studying of Gene Expression

Unit-VII: Gene Cloning in Research and Biotechnology:
- 7.1. Production of Protein from Cloned Gene
- 7.2. Gene Cloning in Medicine
- 7.3. Gene Cloning in Agriculture

Practicals:

1. Problems related to gene cloning
2. Conjugation
3. Total cell lysate preparation
4. Plasmid DNA Isolation
5. Plasmid DNA detection on Gel Electrophoresis
6. Transformation of Plasmid DNA to *E. coli.*

Teaching-learning Strategies

1. Lectures
2. Group Discussion
3. Laboratory work
4. Seminar/ Workshop

Assignments Types:

1. Lecture Based Examination (Objective and Subjective)
2. Assignments
3. Class discussion
4. Quiz
5. Tests

Assessment and Examinations:

As per University Rules

Recommended Readings

1. Brown, T. A. (2020). *Gene cloning and DNA analysis: an introduction*. John Wiley & Sons. 8th ed.
2. Fowler, S., Roush, R., Wise, J., & Stronck, D. (2013). *Concepts of biology*. OpenStax College, Rice University.
3. Gardner, E.J. (2004). *Principles of Genetics.* John Willey and Sons, New York.
4. Glover, D.M. (2001). *Gene Cloning. The Mechanics of DNA Manipulation.* Chapman and Hall.
5. Glover, D. M. (2013). *Gene cloning: the mechanics of DNA manipulation*. Springer.
6. Pierca, B.A. (2005). *Genetics*; *A Conceptual Approach.* W. H. Freeman and Company, New York.
7. Primrose, S.B., Twyman, R.M. and Old, R.W. (2004). *Principles of Gene Manipulation, an Introduction to Genetic Engineering*. (6th Ed.), Blackwell Scientific Publications.
8. Primrose, S.B., and Twyman, R. M. (2006). *Principles of Gene Manipulation and Genomics.* Blackwell Scientific Publications.
9. Roy D. (2010). *Biotechnology.* Alpha Science, Technology & Engineering
10. Snustad, D.P. and Simmons, M. J., (2005). *Principles of Genetics,* (4th Ed.). John Wiley and Son, Inc. New York.
11. Stacey, J. (2010). *The cinematic life of the gene*. Duke University Press.
12. Synder, L. and Champness, W. (2004). *Molecular Genetics of Bacteria.* ASM Press, Washington D.C.
13. Wilson, J. and Hunt, T. (2004). *Molecular Biology of the Cell – The Problems book,* Garland Publishing Inc.

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Bot. Sp-24 GENOMICS AND PROTEOMICS Credit Hours: 3(2+1)

Introduction of the Course

This course involves the Study of Structural and Functional role of Macromolecules in Eukaryotic Genomic System. Genomics is the study of genomes which refers to the complete set of genetic material present in a cell or organism. Thus, genomics is the study of the genetic make-up of organisms while proteomics is the branch of molecular biology that involves the study of the structure and function of the proteins, their mutual interactions and coordinated expression in a living system. Thus, the current course will help the students to have conceptual knowledge about genes and proteins.

Course Objectives

1. To enable the students to understand the structural and functional basis of genes and proteins and their mutual interactions
2. To make the students familiar with the most advanced techniques in the fields of genomics and proteomics

Contents

Unit I: Genomics

- Genome sequencing strategies and programs, new technologies for high-throughput sequencing, methods for sequence alignment and gene annotation
- Approaches to analyze differential expression of genes – ESTs, SAGE, microarrays and their applications; gene tagging; gene and promoter trapping; knockout and knockout and knock-down mutants; dynamic modulation of protein structure and function; Comparative genomics of model plants and related crop special Recombination-based cloning techniques
- RNAi and gene silencing; genome imprinting, small RNAs and their biogenesis, role of small RNAs in heterochromatin formation and gene silencing
- Genomic tools to study methylome and histone modifications.

Unit II: Proteomics

- Analysis of proteins by different biochemical and biophysical procedures like CD (Circular Dichroism), NMR, UV/Visible and fluorescent spectroscopy
- Protein identification and analysis, other protein related databases, 1-D and 2-D gel electrophoresis for proteome analysis, Sample preparation, gel resolution and staining; Mass spectrometry based method for protein identification like PMF (protein mass fingerprinting) and LCMS; image analysis of 2D gels: Data acquisition, spot detection & quantitation, gel matching, data analysis, presentation, databases, conclusions; DIGE (Differential In Gel Electrophoresis), alternatives to 2-DE for protein expression analysis
- Analysis of post-translational modifications and protein-protein interactions; protein chips and arrays, future directions in proteomics, scope of functional proteomics.

Practicals:

1. DNA amplification through PCR
2. Real-time PCR
3. Northern and Western Blotting
4. 2D electrophoresis
5. Differential staining procedures

Teaching-learning Strategies

1. Lectures
2. Group Discussion
3. Laboratory Work
4. Seminar/ Workshop

Assessment and Examinations:

As per University Rules

Recommended Readings

1. Bernot, A. (2005). *Genome Transcriptome and Proteome Analysis.* John Wiley and Sons, Inc. New York.
2. Buchanan B, Gruissem G, and Jones R (2015) Biochemistry and Molecular Biology of Plants, American Society of Plant Physiologists, USA.
3. Cecconi, D. (2021). *Proteomics Data Analysis.* Springer (1st Ed.).
4. Colin, A. (2001). *DNA Sequencing Protocols.* Publishers John McGraw Hill.
5. Dziuda, D. M. (2010). *Data mining for Genomics and Proteomics: Analysis of Gene and Protein Expression Data* (Vol. 1). John Wiley & Sons.
6. Hammes, G.D. (2005) Spectroscopy for the Biological Sciences; Willey Inter science, USA.
7. Harlow and Lane, D. (Eds.) (1998) Antibodies _ A Laboratory Manual; Cold Spring Harbor Laboratory, USA.
8. Kahl, G. (2015). *The dictionary of genomics, Transcriptomics and Proteomics, 4 Volume set*. John Wiley & Sons.
9. Lesk, A. M. (2017). *Introduction to Genomics*. Oxford University Press.
10. Lieber, D.C. (2002) Introduction to Proteomics: Tools for New Biology; Humana Press, NJ.
11. Pennington SR, Dunn MJ (Eds.) (2002) Proteomics: From Protein Sequence to Function, BIOS Scientific Publishers, United Kingdom.
12. Pevsner, J. (2015). *Bioinformatics and Functional Genomics*. John Wiley & Sons.
13. Sambrook J and Russell DW (2001) Molecular Cloning – A Laboratory Manual, Vols I –III, Cold Spring Harbor Laboratory, USA.
14. Sensen, C.W. (2005). *Hand Book of Genome Research: Genomics, Proteomics, Metabolomics, Bioinformatics, Ethics and Legal Issues.* John Wiley and Sons, Inc. New York.
15. Singer M and Berg P (1991). Genes and Genomes: A Changing Perspective; University Science Books, CA, USA.
16. Thompson, J.D. (2010). *Functional Proteomics – Methods and Protocols.* (2nd ed.) Schacffli. Rciss, Christine; Ueffing, Marius Press. Springer.
17. Wink, M. (Ed.). (2013). *An introduction to molecular biotechnology: fundamentals, methods and applications*. John Wiley & Sons.

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CONTEMPORARY CONCEPTS AND METHODS IN CELL BIOLOGY

Bot.Sp-25 **Credit Hours 3(2+1)**

Theory:

Introduction of the Course:

This course focuses on the structure, molecular biology, and physiology of eukaryotic cells. It also provides knowledge about the structure and function of macromolecules DNA, RNA, proteins and modern approaches in genomics.

Course Objectives:

1. Students will understand the structures and purposes of basic components of prokaryotic and eukaryotic cells, especially macromolecules, membranes, and organelles.
2. Students will understand how these cellular components are used to generate and utilize energy in cells.
3. Students will apply their knowledge of cell biology to selected examples of changes or losses in cell function.

Course Detail:

1. **Infective particles and life forms:**
   - 1.1. Prions, viroids, origin and evolution of various life forms
   - 1.2.Cell theory vs. cell body concept
   - 1.3.Multicellularity vs. supracellularity.
2. **Cell Wall:**
   - 2.1.Temporal and spatial dynamism in structure, structural and functional roles
   - 2.2.In planta and explanta uses
   - 2.3.Cell wall biotechnology
3. **Biological membranes:**
   - 3.1.From PLP model to Dynamically Structured Mosaic Model
   - 3.2.Transport through membranes
   - 3.3. Membranes as sties and routes of intra- and inter-organism and environment interactions
4. **Cytoplasmic components:**
   - 4.1.Endomembranes
   - 4.2.rganellar architecture
   - 4.3.Protein sorting and vesicular traffic
5. **Biopolymers:**
   - 5.1.Structural and functional aspects of cytoskeleton and associated motore molecular, their role in cell organization and movement
   - 5.2. Interaction among cytoskeletal elements, genomics, proteomics and bioinformatics of plant cytoskeleton
   - 5.3.Cytoskeleton in agro-biotechnolgy
6. **Nucleus:**
   - 6.1.Detailed structure of nuclear pore complex and nuclear Lamina, nuclear transport
   - 6.2.Chromatin subunit structure: from DNA to metaphase chromosome, histone code, states of chromatin during replication and transcription heterochromatization as a method of gene regulation

7. **Cell turnover:**
   7.1. Cell division, cell cycle controls, breakdown of cell cycle control: cancer vs. Plant tumors, programmed cell death.
8. **Cells to tissues:**
   8.1. Cell polarity, cell fate determination, integration of plant cells in tissues.
9. **Introduction to methods in plant cell biology:**
   9.1. Optical and electron microscopy
   9.2. Fluorescent probes
   9.3. Flow cytometry
   9.4. Transient expression
   9.5. Microinjection and micromanipulation
   9.6. Electrophysiological methods
   9.7. Plant histology
   9.8. Immunocytochemistry
   9.9. In-situ hybridization
   9.10. Cell fractionation and organelle isolation

PRACTICALS:

1. Would be based on the above topics. These could be in real time if facilities are available or could be virtual experiments.

Teaching-learning Strategies

1. Lectures
2. Group Discussion
3. Laboratory work
4. Seminar/ Workshop

Learning Outcome:

Students will be able to:

1. Illustrate that fundamental structural units define the function of all living things.
2. Explain that the growth, development, and behavior of organisms are activated through the expression of genetic information.
3. Summarize those biological systems grow and change by processes based upon chemical transformation pathways.
4. Communicate biological concepts and understanding to members of a diverse scientific community as well as to the general public.

Assessment Strategies:

1. Lecture Based Examination (Objective and Subjective)
2. Assignments
3. Class discussion
4. Quiz
5. Tests

Recommended Readings:

1. Alberts B, Johnson A, Lewis J, Raff Marin, Roberts K and Walter P. (2007). Molecular Biology of the Cell. Garland Publ., New York.
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