

UNIVERSITY OF THE PUNJAB

NOTIFICATION

It is hereby notified that on the recommendations of the Board of Faculty of Science, the Vice-Chancellor has, in anticipation of the approval of the other relevant bodies, approved revised Syllabi & Courses of Reading for M.Sc. (Botany) Part-I & II Examinations, w.e.f. the Academic Year 2004-2005.

The detail of the Syllabus of M.Sc. in (Botany) Part-I & II Examinations is available vide Appendix 'II'.

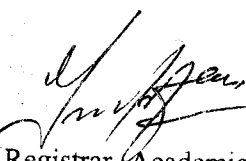
Col. (R) Masud-ul-Haq  
Registrar

Dated: 31-08- / 2004.

No. 2647 / Acad.

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

1. Dean,  
Faculty of Science.
2. Chairperson,  
Department of Botany.
3. Members of the Board of Studies.
4. Controller of Examinations.
5. Treasurer.
6. Deputy Controller (Examinations).
7. Deputy Controller (Computer).
8. Deputy Controller (Secrecy).
9. Deputy Controller (Conduct).
10. Assistant Registrar (Statutes).
11. Secretary to the Vice-Chancellor.
12. Secretary to the Registrar.

  
Deputy Registrar (Academic)  
for Registrar

*Swasti*  
31-8-04

**REVISED SYLLABUS  
M.Sc (BOTANY)**

**APPENDIX-I**

The revised syllabi and courses of reading for the M.Sc (Botany) Part-I and Part-II examinations of 2004 onwards. Recommended for approval by the Board of Studies in Botany in its meeting held on July 21, 2003.

**Outline of tests**

- i. Each course will be covered in 70±5 hours of theory lectures and atleast 22 practicals each of three hour duration.
- ii. Special optional papers should be offered only by teachers holding a Ph.D degree in his/her field of specialisation. Exceptions to the rules allowed where Ph.Ds are not available.
- iii. In courses where the subject matter includes distinct groups of plants as in Paper I, II, III and VIII, the question paper will be divided into 2 or 3 parts. The number of questions in each part of each paper will be decided by the Board of Studies and conveyed to the respective examiners.

**M.Sc Part-I and Part-II Examinations of 2004 onward**

**M.Sc Part-I:**

<u>Paper #</u>	<u>Title</u>	<u>Written</u>	<u>Practical</u>	<u>Total</u>
I :	Microbiology, Phycology and Bryology	60	30	90
II :	Mycology	60	30	90
III :	Evolutionary Biology of Vascular Plants	60	30	90
IV :	Cell Biology and Biostatistics	60	30	90
V :	Plant Biochemistry	60	30	90
VI :	Plant Ecology	60	30	90
VII :	Comprehensive viva-voce	--	--	60

**M.Sc Part-II:**

VIII :	Plant Anatomy and Taxonomy of Angiosperms	60	30	90
IX :	Plant Physiology	60	30	90
X :	Molecular Genetics	60	30	90
XI :	Environmental Biology	60	30	90
XII :	Comprehensive viva voce	--	--	40
*Optional (Special) Paper-I:		75	25	100
*Optional(Special) Paper II:		75	25	100

OR

03-08-2013

Research in lieu of two optional papers.

Total:-  
Grand Total:-

200  
600  
1200

Paper 1:

\*LIST OF OPTIONAL (SPECIAL) PAPERS

Optional Papers:	Title
(30) I :	Plant tissue culture and its agricultural applications
II :	Plant Biotechnology
III :	Gene Manipulation
IV :	Microbiology
(40) V :	Environmental Bacteriology
VI :	Applied Paleopalynology
(70) VII :	Advanced Plant Anatomy
VIII :	Biology of Imperfect Fungi
IX :	Mycorrhiza
X :	Fungal Plant Interactions
XI :	Physiology of Fungi
XII :	Wood Decay Fungi

MI

A)

- 1.
- 2.
- 3.
- 4.
- 5.
- 6.
- 7.

B)

- 1.
- 2.
- 3.

PHYCO

1. In (l cl
2. C w
- a. Ch
- b. Ch
- c. Xa
- d. Bac
- e. Pha
- f. Rho

3. Eco

BRYOLOG

1. Orig

## MICROBIOLOGY, PHYCOLOGY AND BRYOLOGY

### MICROBIOLOGY:

#### **A) BACTERIA:**

1. History and development of microbiology.
2. Characteristics of pro- and eukaryotic cells.
3. Characteristics of cyanobacteria.
4. Morphology, genetic recombination, locomotion and reproduction in bacteria.
5. Classification of bacteria.
6. Bacterial metabolism (respiration, fermentation and photosynthesis).
7. Economic importance of bacteria.

#### **B) VIRUSES:**

1. General features of viruses, viral architecture, classification, dissemination and replication.
2. Symptomatology of virus-infected plants: (External & Internal symptoms).
3. Metabolism of virus- infected plants.

### **PHYCOLOGY**

1. Introduction and general account, occurrence of algae in various environments (factors affecting their distribution). Characteristic criteria of classification, classification of the following phyla of Algae upto order level.
2. Cell structure, thallus organization, methods of reproduction, patterns of life- cycles with special reference to evolutionary trends of the following divisions.

a. Chlorophyta	Study of Chlorophyceae.
b. Charophyta	Study of Charophyceae.
c. Xanthophyta	Study of Xanthophyceae.
d. Bacillariophyta	Study of Bacillariophyceae.
e. Phaeophyta	Study of Phaeophyceae.
f. Rhodophyta	Study of Rhodophyceae.
3. Economic importance of Algae.

### **BRYOLOGY**

1. Origin of Bryophyta

- a. Nature of vegetative structure of primitive Bryophytic gametophyte and its evolution.
  - b. Origin and homologies of sex organs.
2. Distribution, habitats, general characters, reproduction, life cycles and classification of Bryophyta.
  3. Distinguishing characters and affinities of the following classes:
    - a. Hepaticopsida
    - b. Anthoceropsida
    - c. Bryopsida
  4. Nature of alternation of generations and origin of sporophyte

## PRACTICALS

### I. Bacteriology

1. Methods of sterilization of glassware & media.
2. Preparation of nutrient agar and inoculation.
3. Preparation of slides for the study of various forms, capsule/slime layer, spores, flagella and Gram-staining.
4. Growth of bacteria and pure – culture methods.

### II. PHYCOLOGY

1. Use of micrometer and camera lucida.
2. Macroscopic and microscopic study, description and identification of the following genera:  
*Gloeoecapsa, Microcystis, Oscillatoria, Lyngbya, Arthrospira, Tolypothrix, Stigonema, Spirulina, Nostoc, Anabaena, Gloeotrichia, Chlamydomonas, Pandorina, Eudorina, Hydrodictyon, Volvox, Pediastrum, Ulothrix, Stigeoclonium, Draparnaldia, Oedogonium, Bulbochaete, Cladophora, Pithophra, Rhizoclonium, Zygnema, Spirogyra, Mougeotia, Closterium, Ulva, Enteromorpha, Bryopsis, Caulerpa, Codium, Acetabularia, Chara, Nitella, Botrydium, Vaucheria, Navicula, Pinnularia, Ectocarpus, Dictyota, Cutleria, Laminaria, Sargassum, Fucus, Batrachospermum, Scinaia, Nemalion, Polysiphonia.*

### III. BRYOLOGY

1. Study of the following genera:  
*Riccia, Marchantia, Fimbriaria, Conocephalum, Pellia, Porella, Anthoceros, Sphagnum, Funaria, Polytrichum.*

- IV. Collection and identification of algae and bryophytes and their preservation.
- V. Visits to study algae and bryophytes in their natural habitats (field trips).

**BOOKS RECOMMENDED (latest edition):**

- 1. Ross F.C. Fundamentals of Microbiology. John Willey Co. New York.
- 2. Pelczar Jr.M.J. and Chan E.C.S. Elements of Microbiology. McGraw Hill Corp. London.
- 3. Smith, G M. Cryptogamic Botany (Vols. I & II). McGraw Hill, New York.
- 4. Bold H.C. and Wynne M.J. Introduction to the Algae. Structure and reproduction. Printice Hall Inc. Englewood Cliffs.
- 5. Lee R.E. Phycology. Cambridge University Press.
- 6. Schofield, W.B. Introduction to Bryology, MacMillan Publishing Company, London.

## PAPER II

### MYCOLOGY

#### INTRODUCTION:

- General introduction to fungi.
- Cells, hyphae and tissues.
- Sexual and a-sexual reproduction.
- Classification - Principles of taxonomy and nomenclature.

#### DIVISION MYCOTA:

##### SUB-DIVISION MASTIGOMYCOTINA:

- General introduction.
- Zoosporogenesis.
- Zoospore movement and structure.
- Zoospore discharge and germination.
- Classification.

Classes: Chytridiomycetes (wart diseases), Oomycetes (general characters of orders Saprolegniales (root rots) & Peronosporales. [Damping off, downy mildews, blights and white rusts].

##### SUB-DIVISION ZYGOMYCOTINA:

- General introduction.
- Class Zygomycetes.
- General characters of orders Mucorales [soft rots] and Glomales (VA mycorrhizae).
- Sporangial tendencies to evolve conidium.

##### SUB-DIVISION ASCOMYCOTINA:

- General introduction.
- Ascus, centrum and sexual reproduction.
- Non-sexual reproduction.
- Classification.
- Classes: Hemiascomycetes; general characters of orders: Endomycetales (yeasts), Tephriales (*Tephria* diseases), Plectomycetes, Pyrenomycetes; general characters of orders Erysiphales (powdery mildews), Xylariales [diseases of fruit and other trees], Clavicipitales [ergots, canker and rots] Discomycetes general characters of orders Pezizales (leaf spot diseases)

Helotiales and Loculoascomycetes; general characters of orders Pleosporales (scab diseases), Myriangiales (anthracnose diseases) and Hysteriales.

#### SUB-DIVISION BASIDIOMYCOTINA:

- General introduction.
- Mycelium, hyphae and hyphal system.
- Friesian system of classification and homoplasy.
- Basidium and sexual reproduction.
- Non-sexual reproduction.
- Classification.
- Classes Teliomycetes; general characters of orders Uredinales and Ustilaginales (rusts and smut diseases); Hymenomycetes; general characters of orders Agaricales and Aphyllophorales, [woody decay fungi Gasteromycetes; general characteristics and spore dispersal.

#### SUB-DIVISION DEUTEROMYCOTINA:

- General introduction.
- Concept of anamorphs and telomorphs.
- Spore types and morphology, conidial ontogeny, parasexual life cycle.
- Classification.
- Classes Form: Hyphomycetes; general characters of order Moniliales (*Cercospora*, *Alternaria* leaf spot diseases and *Fusarium* and *Verticillium* wilts) and Coelomycetes; general characters of orders Melanconiales (Anthracnose disease) and Sphaeropsidales (Ascochyta leaf spots and blights).

#### GENERAL TOPICS:

- **Heterothalism.**
- **Fungi as symbionts:**
  - Classification.
  - Lichens.
  - Mycorrhizae.
  - Fungi as predators-Entomogenous fungi, nematode trapping fungi, medically important fungi.
- **Economically important fungi:**
  - Fungi in agriculture.
  - Fungi for food and food processing.
  - Industrially important fungi.
  - Poisonous fungi.
- **Fungi as recyclers (decomposers).**



## PRACTICALS

1. Basic mycological techniques.
2. Isolation of fungi from soil (direct and dilution plate methods).
3. Isolation of fungi from water (baiting with different plant materials like seed, leaves and twigs).
4. Isolation of fungi from air.
5. Isolation of pathogenic fungi from diseased tissues.
6. Field study of mushrooms, toadstools, rusts, smuts and other parasitic fungi.
7. Anatomical and microscopic study of lichens.
8. Anatomical study and hyphal systems of Polypores and Agarics.
9. Identification of various types of mycorrhizae, Processing and staining of roots for VA mycorrhizal assessment in roots of crop plants. Isolation and identification of endogonaceous fungi from soil by wet sieving and decanting techniques.
10. Study of interaction of fungi in culture, macroscopic and microscopic examination of common locally available types representing various taxonomic groups.
11. Collection, preservation and identification of at least 35 mycological specimens.

## BOOKS RECOMMENDED (Latest editions):

1. Webster, J. Introduction to the fungi. Cambridge University Press.
2. Alexopoulos, C.J. and Mims, C.W. Introductory Mycology. John Wiley and Sons.
3. Ahmad, S. Gasteromycetes of West Pakistan, Publication of Botany Department, P.U., Lahore.
4. Ahmad, S. Ascomycetes of Pakistan. Vol. I & II. Biological Society of Pakistan.
5. Ahmad, S. Basidiomycetes of Pakistan. Biological Society of Pakistan.
6. Ahmad, S. A contribution to the Agaricales of Pakistan. Bulletin of Mycology, 1: 35-90.
7. Harley, J.L. and Smith, S.E. Mycorrhizal Symbiosis, Academic Press.
8. Deacon, J. W. Introduction to modern Mycology. Blackwell Scientific Publication.

## PAPER III

### EVOLUTIONARY BIOLOGY OF VASCULAR PLANTS

#### EVOLUTION:

Definition, Convergent, Divergent and Homoplastic Evolution. Evolutionary Forces and Trends. Modern concept of Evolution.

#### FOSSILS

Definition, types of fossils and methods used for their study. Nomenclature. The geological time scale and major revolutions.

**Palynology:** Definition (Neopalynology and Palaeopalynology)

**Palaeopalynology:** Definition, different types of palynomorphs, role of Palaeopalynology in revealing and highlighting past vegetational history depicting plant evolution, role in Geology, Archaeology and other sciences.

**Stelar system:** Classification and evolution. Maturation pattern of xylem.

#### TRACHEOPHYTES (VASCULAR PLANTS)

##### Psilopsida

General characters, classification, (*Rhyniophyta*, *Zosterophyllophyta*, *Trimerophyllophyta*), affinities and phylogenetic importance.

##### Lycopsida

General characters, classification (*Drepanophycales*, *Protolepidodendrales*, *Lepidodendrales*, *Lycopodiales*, *Selaginellales*, *Pleuromiales*, *Isoetales*), affinities and phylogenetic importance.

##### Sphenopsida

General characters, classification (*Pseudoborniales*, *Sphenophyllales*, *Equisetales*), affinities and phylogenetic importance.

##### Pteropsida

1. **Ferns:** General characters, classification and phylogenetic importance of
  - a. Eusporangiate Ferns (*Ophioglossales*, *Marratiales*)
  - b. Leptosporangiate Ferns (*Filicales*, *Marseliales*, *Salviniales*)
2. **Origin and Evolution of Seed Habit**
3. **Seed Ferns:** General characters and phylogenetic importance of
  - a. *Calamopitales*

- b. *Lyginopterideles*
  - c. *Medullosales*
  - d. *Glossopterideles*
  - e. *Caytoniales*
4. **Gymnosperms:** Origin of Gymnosperms, Phylogeny and classification of *Bennettitales*, *Ginkgoales*, *Cycadales*, *Coniferales* and *Gnetales*. Distribution of gymnosperms in Pakistan.
  5. **Angiosperms:**
    - a. **Life cycle of Angiosperm**
    - b. **Inflorescence:** Definition, basic types and floral biology.
    - c. **Flower:** Definition, different parts of a generalized flower.
    - d. **Morphological Nature:** Morphological nature of flower, Different types of placentation and their inter-relationship.
    - e. **Origin of Angiosperms**
    - f. **Embryology:** Structure of stamen, microsporogenesis and structure of pollen. Structure of ovule, megasporogenesis. Different types of embryo sacs. Nature of endospermic tissue.

#### PRACTICALS:

1. Peel and ground sectioning techniques.
  2. Section cutting, staining and mounting of the following plants: *Adiantum*, *Asplenium*, *Dryopteris*, *Pteris*, *Marsilea*, *Equisetum*, twigs of *Pinus*, *Thuja*, *Cycas* and *Taxus*.
  3. Identification and study of stereoscopic sections of the woods of *Pinus*, *Cedrus*, *Abies*, *Cupressus*, *Juniperus* and *Thuja* (Prepared slides).
  4. Isolation of palynomorphs through maceration from the samples of Mesozoic and Paleozoic rocks of Pakistan.
  5. Morphological studies of the material and prepared slides of *Psilotum*, *Lycopodium*, *Equisetum*, *Pteris*, *Osmunda*, *Ophioglossum*, *Botrychium*, *Athyrium*, *Polysichum*, *Pinus*, *Cedrus*, *Abies* and *Picea*.
  6. Study of different types of placentation in different flowers.
  7. Examination of different types of Embryo sacs in Angiosperms through prepared slides.
  8. Examination of the fossilized plant material.
  9. Examination of the prepared microscopic slides of the following fossils : *Horneophyton*, *Sphenophyllum*, *Lepidocarpon*, *Calamites* and *Lyginopteris* and others.
- Candidates are required to study geological formations and collect Pteridophytes, Gymnosperms and rock samples from higher/Lesser Himalayas of Pakistan and to submit their collection in properly mounted and identified form at the time of practical examination. Students are also required to submit a Technical report covering all aspects of the fieldwork at the time of the Practical examination.

**BOOKS RECOMMENDED: (Latest Editions)**

1. D.W. Bierhorst. Morphology of Vascular plants. Macmillan, Inc. Insurance, New York.
2. Jeryme, A. C., T.A. Crabbe and B.A. Thomas. The phylogeny and classification of Ferns. Academic Press, London.
3. Paleobotany, Paleocology and Evolution. Kjnklas. Praeger Press, New York.
4. C.B. Beck. Origin and evolution of Gymnosperms. Columbia University Press, New York.
5. C.B. Beck. Origin and evolution of Angiosperms. Columbia University Press, New York.
6. Eanes, A.J. Morphology of Vascular Plants (Lower Groups). Meglaw Hill and Co.
7. Andrews, H.W. studies in Paleobotany. John Wiley and Sons.
8. Sporne, K.R. The morphology of Pteridophytes. Hutchinson University Library.
9. Sporne, K.R. The morphology of Gymnosperms. Hutchinson University Library.
10. Champalain, C.J. Gymnosperms structure and Evolution. Dover Publications Inc.

**PAPER-IV****CELL BIOLOGY AND BIOSTATISTICS****A: Cell Biology**

1. Introduction
2. Prokaryotes & eukaryotic cell.
3. Structure of plant cell.
  - a. Cell wall: Physico-chemical nature, ultrastructure.
  - b. Cell membrane: Molecular organization and molecular models of cell membrane, cell permeability - passive permeability, passive ionic diffusion, active transport, transport proteins.
  - c. Cytoskeleton, Ultra structure and function of cell organelles.
4. Chromosomes  
Morphology and molecular structure of prokaryotic and eukaryotic chromosome, significance of histones and high mobility proteins in packing of chromosome and gene expression.
5. Cell cycle:  
Synchronizing analysis of the control and models of control of cell cycle. Importance for growth and development of multicellular organisms. The G<sub>1</sub>, S and G<sub>2</sub> phases. DNA replication. Mitosis and cell division - emphasis on molecular organization and functional role on mitotic apparatus. Meiosis and replication - genetic consequences of meiosis and types of meiosis, DNA metabolism in meiosis.

**B: Biostatistics**

1. Introduction and scope:  
Definition; characteristics, importance and limitations, population and samples.
2. Frequency distribution and probabilities:  
Formation of frequency table from raw data, histograms. Applications of probabilities to simple events.
3. Measures of central tendencies and dispersion:  
Arithmetic mean, median, mode, range, variance and standard deviation, standard error of the mean, mean deviation, semi interquartiles range.

4. Standard distribution  
Binomial, poisson and normal distributions, properties and application.  
Normality.
5. Test of significance:  
Introduction:  
A) t-test: Basic idea, confidence limits of means, significant difference of means.  
B)  $\chi^2$ -test: Basic idea, testing goodness of fit to a ratio, testing association (contingency table).  
C) F-test: Introduction and application in analysis of variance.  
D) L.S.D. test, Duncan new multiple range test (for comparison of individual means), Bonferroni test.
6. Design of experiment  
Concept of design, principles of experiment, planning of an experiment, replication and randomization, field plot technique, layout and analysis of completely randomized design, randomized complete block design, Latin square, factorial design, treatment comparison.
7. Brief account of correlation and regression.

### **Practical**

#### **A. Cell Biology:**

1. Cell structure in the staminal hair of *Tradescantia*.
2. Microchemical detection of following in the structure of the plant cell. Protein, carbohydrate, cellulose, cutin, pectin.
3. Plastids in various plants: *Spirogyra*, *Hydrilla*, *Tradescantia*, *Daucus carota*, *Arisaema*, *Solanum tuberosum* and *Lycopersicon esculentum*, citrus.
4. Mitosis: Smear/squash preparation of onion roots.
5. Meiosis: Smear/squash preparation from anthers of plants such as oat, onion, wheat, maize etc.
6. Germination of pollen grains of various vascular plants.

#### **B. Biostatistics:**

8. Probability of simple events.
9. Data collection, arrangement of data in frequency table.
10. Calculation of mean from group and ungrouped data.
11. Calculation of variance and standard deviation from grouped and ungrouped data.
12. Binomial distribution.
13. T-test.
14. Poisson distribution.

15.  $\chi^2$ -test.
16. Analysis of variance-one factor design
17. Analysis of variance-two way analysis
18. Analysis of variance-for Latin square
19. Analysis of variance-for factorial design.
20. Correlation.
21. Linear Regression.

### **Books Recommended**

1. Alberts, B., Bray, D. Lewis, J., Raff, M., Roberts, K and Watson, J.D. (1994), *Molecular Biology of the Cell*, Garland Publishing Inc. New York.
2. Bailey, N.T.J. (1994). *Statistical Methods in Biology*, Cambridge University Press.
3. Darnell, Jr. J. Lodish, H. and Baltimore, D. (1990). *Molecular Biology of the Cells*, scientific American Inc. N.Y.
4. De. Robertis, F.P. and De. Robertis. E.M.F. *Cell and Molecular Biology*, 8<sup>th</sup> Edition, (2001), Holt Lea and Fbiger, New York.
5. Lodish, H. Baltimore, D. Berk. A. Zipursky, S.L. Matsudaira, P. Darnell, J. (2001). *Molecular Biology of the cell*. Scientific American Books, W.H. Freeman and Company, New York.
6. Quinn, G. (2002). *Experimental Design and Data Analysis for Biologists*. Cambridge University Press.
7. Steel, R.G.D. and Torrie, J.H.(1981). *Principles and procedures of Statistics: A Biometrical approach*, McGrew – Hill International Book company.
8. Swanson, C.P., Merz, T. and Young, W.J. 1990 (second edition) *Cytogenetics: The chromosome in division, inheritance and evolution*. Prentice – Hall Inc.
9. Wonnacott, T.H. and Wonnacott, R.J. (1990). *Introductory Statistics*, John Wiley and Sons.
10. Gerald Karp. *Cell and Molecular Biology – Concept and experiments*. Third edition. 2002. John Wiley and Sons. U.S.A.
11. Geoffrey M. Cooper. *The Cell – A Molecular approach*. 2000. ASM Press. Washington. D.C. U.S.A.

- C) Components of protein synthesis. Genetic code, protein synthesis: initiation, elongation and termination.

#### **Alkaloids:**

Occurrence, physiological effects, chemical nature with special reference to solanine, nicotine, morphine, theine and caffeine. Allatoxins, their nature and role.

#### **Terpenoids:**

Classification: monoterpenes, sesquiterpenes, diterpenes, triterpenes, tetraterpenes, polyterpenes and their chemical constitution and biosynthesis.

#### **Vitamins:**

General properties and role in metabolism.

#### **Practical**

1. Solutions, acids and bases. Electrolytes, non-electrolytes, buffers, pH, Chemical bonds.
2. To determine the R<sub>f</sub> value of monosaccharides on a paper Chromatogram.
3. To estimate the amount of reducing and non-reducing sugars in plant material titrimetrically/spectrophotometrically.
4. To estimate the amount of vitamin C in a plant organ (orange, apple juice).
5. To determine the saponification number of fats.
6. To extract and estimate oil from plant material using soxhlet apparatus.
7. Analysis of various lipids by TLC methods.
8. To estimate soluble proteins by Biuret or Lowry or Dye-binding method.
9. To estimate the amount of total Nitrogen in plant material by Kjeldahl's method.
10. To determine the R<sub>f</sub> value of amino acids on a paper chromatogram.
11. Extraction of Nucleic acids from plant material and their estimation by UV absorption, or colour reactions.
12. To estimate the catalytic property of enzyme catalase or peroxidase extracted from a plant source.
13. To determine the P<sub>Ka</sub> and isoelectric point of an amino acid.
14. Separation of soluble proteins by polyacrylamide gel (PAGE) electrophoresis.
15. Separation of nucleic acids by gel electrophoresis.

#### **Books Recommended (Latest Edition):**

1. Eric E. Conn and P.K. Stumpf, 2002. Outlines of Biochemistry, John Wiley & Sons Inc. New York.
2. Albert L. Lehninger, 1996. Principles of Biochemistry. Worth Publishers Inc.
3. D. Voet, J.G. Voet and C.W. Pratt, 1998, Fundamentals of Biochemistry, John Wiley & Sons, New York.



**PAPER V:****PLANT BIOCHEMISTRY****Carbohydrates:**

Occurrence, classification. Optical activity, structure and molecular configuration, mutarotation and important reactions. A general account of ribose, deoxyribose, xylulose, xylose, D-glucose, D-galactose, D-mannose, cellobiose, sucrose, maltose, pentosans, fructosans, starch, cellulose, hemicellulose, amino sugars, derived acids and alcohols, glucosides, mucilages, pectins and lignins.

**Lipids:**

Occurrence, classification. Structure and chemical properties of fatty acids, triglycerides, phospholipids, glycolipids, sulpholipids, waxes, sterols.

**Proteins:**

Amino acids and their structure. Electro chemical properties and reactions of amino acids. Classification of proteins. Primary, secondary, tertiary and quaternary structure of proteins. Biological role,

**Nucleic Acids:**

General introduction. Purine and pyrimidine bases, nucleosides, nucleotides. Structure and properties of DNA and RNA. Types and functions of RNA. Chemical synthesis of oligonucleotides and DNA sequencing.

**Enzymes:**

Nature and functions, I.U.E. classification with examples of typical groups. Specificity. Factors affecting enzyme activity, co-factors. Kinetics. Nature of active site and mode of action. Isozymes. Allosteric enzymes and feedback mechanism.

**Bioenergetics:**

Energy, laws about energy changes. 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.
- B) Replication of DNA. Reverse transcription. Biosynthesis of DNA and RNA.

4. Dey, P.M. and J.B. Harborne, 1997. Plant Biochemistry. Harcourt Asia PTE L.d. Singapore.
5. Emil. L. Smith; Robert L. Hill; Robert I. Lehman; Robert J. Lefkowitz Handler and Abraham. Principles of Biochemistry: (General Aspects). White. International Student Edition. McGraw Hill International Book Company.
6. G. Zubay. Biochemistry, MacMillan Publishing Co., New York.
7. J.M Chesworth,, T. Strichbury and J. R, Scaife. 1998. An introduction to agricultural biochemistry. Chapman and Hall, London,
6. Mckee, T. and J.R. Mckee, 1999. Biochemistry ~ An Introduction. WCB/McGraw-Hill, New York, Boston, USA.
9. P.J. Lea,. and R.C. Leegood. 1993. Plant Biochemistry and Molecular Biology. Wiley & Sons, New York.
10. R.H.Ables, P.A. Frey and W.P. Jencks Biochemistry, Jones & Bartlet, London.
11. T.W.Goodwin and E.I. Mercer, 1997. Biochemistry, Pergamon Press, Oxford.

**PAPER-VI****PLANT ECOLOGY****Introduction:**

Background and basic concept. History, development and current trends in ecology.

**Physiological ecology:****i. Soil**

Distinction between edaphology and pedology. Physical and chemical characteristics of the soil. Soil formation (detailed). Texture, structure and porosity. Inorganic and organic components, Living inhabitants of the soil. pH and conductivity,

**ii. Water**

1. The Soil-Plant- atmosphere system:  
Atmospheric moisture. Forms of precipitation and ecological effects. Role of water in the diversity of plants. Soil water relationships.
2. Environment and Adaptations:  
Water balance of plants. Adaptation based on water availability. Role of water in the diversity of plants. Plant water relationships.

**iii. Light and Temperature:**

Physical properties of light. Effect of shade, altitude. Latitude high or low pressure systems on the characteristics of light and temperature. Ecological response to warm, Chilling and freezing temperatures,

**a. Ecophysiological responses**

1. Photoperiodism
2. Themoperiodism
3. Dormancy
  - i) Bud dormancy
    - a) Reproductive
    - b) Vegetative
  - ii). Seed dormancy
4. Stratification
5. Vernalization
6. Summerization

**b. Role of temperature in diversity of plant****iv) Wind and fire as ecological factors.****Population Ecology:**

1. Ecological species
2. Plant population Structure: space and time
3. Plant population dynamics: Growth models and life tables.
4. Resource allocation and life history patterns: Seed dispersal. Seed bank. Recruitment. Mortality. Establishment. Competition. Reproduction and demography.

### **Community Ecology**

1. The Plant Community: discrete and continuum concepts with modern synthesis.
2. Community attributes: leaf spectra, life form, distribution pattern, periodicity, phenology, species maturity, age class etc.
3. Species diversity concepts.
4. Plant community structure.
5. Plant community dynamics (succession).
6. Method of sampling of plant community: quadrat, line intercept, closest individual, nearest neighbor, random pairs, point centered quarter methods.
7. Quantitative community description: Gradients, ordination & classification.
8. Productivity, measurement, energy flow and efficiency.

### **Vegetation of Pakistan**

#### **Ecosystem ecology:**

1. Concepts
2. Trophic levels and energy flow.
3. Biogeochemistry- Major nutrient cycles & influencing factors.

#### **Major Formations of world.**

#### **Practical**

1. Measurement of plant biomass and net primary productivity
2. Transplant experiment for ecotypic differentiation
3. Measurement of water relation components: conductance, osmotic potential, water potential, pressure potential, xylem pressure potential and pressure volume curve.
4. Measurement of radiation, temperature, humidity and wind velocity.
5. Soil texture & structure, soil water status, and soil water potential
6. Seed dispersal, seed bank, germination, recruitment, and reproductive allocations.
7. Community attributes
8. Reconnaissance survey of different local communities
9. Detailed sampling of local vegetation including gradient, ordination, and classification
10. Study of local ecosystem

### Book Recommended

1. Barbour, M. G., J. H. Burke and W.D. Pitts. 1999. Terrestrial Plant Ecology. The Benjamin, Gunning Publishing Co. Palo Alto, California, USA.
2. Chapman, J.L. and Reiss. M.J. 1999, Ecology: Principles and Applications. Cambridge University Press, UK,
3. Hussain F. 1989. Field -and Laboratory Manual of Plan Ecology. National Academy of Higher Education, Islamabad.
4. Krebs, C. J. 1997. Ecology. Harper and Row Publishers.
5. Moore. P. D. and S. B. Chapman. 1986. Methods in plant Ecology. Blackwell Scientific Publication, Oxford.
6. Ricklefs, R.E. 2000. Ecology. W.H. Freeman & Co., UK.
7. Ricklefs, R-E. 2001. The Economy of Nature. W.H. Freeman & Co., UK.
8. SHvertown, J.W- and Lovett-Doust, J. 1993. Introduction to plant population biology. Blackwell Scientific Pub.
9. Smith, R, L. 1996. Elements of Ecology. Harper & Row Publishers, New York.
10. Townsend, C.R., Harper, J.L. and Begon, M-E. 2000. Essentials of Ecology. Blackwell Scientific Publications. UK.

## PAPER VIII

### PLANT ANATOMY AND TAXONOMY OF ANGIOSPERMS Comparative Anatomy of Gymnosperms and Angiosperms

#### Anatomy

1. The plant body and its development, fundamental parts of the plant body, internal organization, different tissue systems of primary and secondary body, periderm.
2. Meristematic tissues: classification, initials and derivatives.
3. Apical meristem: Cytological characteristics, evolution of apical organization, shoot and root apices.
4. Leaf: Types, origin, internal organization, venation, bundle-sheaths and bundle-sheath extensions, enlargement of epidermal cells vis-a-vis different layers.
5. Vascular Cambium: origin, structure, storied and non-storied types of divisions, additive and multiplicative divisions, cell types, cytoplasmic characteristics, seasonal activity and its role in the secondary growth.
6. Origin, structure, development, functional and evolutionary specialization of the following tissues: Epidermis and epidermal emergences, parenchyma, collenchyma, sclerenchyma, phloem and xylem, with special emphasis on different types of wood. Abnormal secondary growth.
7. Secretory tissues: Laticifers, Classification, distribution, development, structural characteristics, functions and Resin Canals.
8. Primary structure of root and stem of angiosperms

#### TAXONOMY OF ANGIOSPERMS

##### Classification

Aims: History of classification, impact of evolutionary theory, units of classification and taxonomic hierarchy, detailed study of the more recent systems of classification. Linnaeus, Bentham and Hooker, Engler and Prantl, Bessey, Hutchinson and Takhtajan.

##### Origin of Angiosperms:

Different theories i.e., Cycadian, Benettitallian and Pteridosperm.

##### Nomenclature

Aims, history, rules of nomenclature which include criteria for effective and valid publication, and problems in nomenclature, conservation and rejection of names.

##### New Concepts in Plant Taxonomy - Biosystematics

Species (taxonomic and biological), types of variations, microspecies, macrospecies and other infra-specific categories, population study, ecophene ecotypes, ecospecies, coenospecies and similar other categories.

##### Introduction to the Methodology

Methodology of biochemical systematics and numerical taxonomy.

##### Taxonomic Evidences

Taxonomic evidence from different disciplines of botany and part played by them in solving problematic groups i.e., role of anatomy, palynology, embryology and palaeobotany in taxonomy.

### **PRACTICALS:**

#### Anatomy:

- Study of stomata, epidermis, epidermal emergences, apical meristem, collenchyma, sclereids, intrusive growth in fibers, vascular cambium.
- Study of phloem, xylem i.e. tracheids and vessels. Study of 3-dimensional plane of wood, components of wood by maceration.
- T.S. of gymnosperm and angiosperm leaf.
- Study of laticifers and resin ducts.

#### Taxonomy:

- To study 41 families of angiosperms in nature. Familiarity with local flora is expected. Candidates should be able to describe shoot inflorescence, parts of flowers - Calyx, corolla, androecium and Gynoecium, Cohesion and adnation of floral whorls, floral diagram and floral formula.
- To describe the specimens in technical terms with floral diagram and floral formula.
- To key out the specimen upto family level.

#### Families:

- |                     |                      |
|---------------------|----------------------|
| 1. Magnoliaceae     | 2. Caesalpinaceae    |
| 3. Ranunculaceae    | 4. Mimosaceae        |
| 5. Papaveraceae     | 6. Euphorbiaceae     |
| 7. Moraceae         | 8. Rutaceae          |
| 9. Casuarinaceae    | 10. Solanaceae       |
| 11. Cactaceae       | 12. Boraginaceae     |
| 13. Caryophyllaceae | 14. Apocynaceae      |
| 15. Chenopodiaceae  | 16. Apiaceae         |
| 17. Amaranthaceae   | 18. Asclepiadaceae   |
| 19. Malvaceae       | 20. Convolvulaceae   |
| 21. Cucurbitaceae   | 22. Myrtaceae        |
| 23. Salicaceae      | 24. Lamiaceae        |
| 25. Capparidaceae   | 26. Scrophulariaceae |
| 27. Brassicaceae    | 28. Acanthaceae      |
| 29. Rosaceae        | 30. Asteraceae       |
| 31. Papilionaceae   | 32. Liliaceae        |
| 33. Palmae          | 34. Muscaceae        |
| 35. Araceae         | 36. Zingiberaceae    |
| 37. Juncaceae       | 38. Cannaceae        |
| 39. Cyperaceae      | 40. Orchidaceae      |
| 41. Poaceae         |                      |

### **BOOKS RECOMMENDED (Latest editions):**

1. Foster, A.S. and Gifford, E.M. Jr. Comparative Morphology of Vascular plants, W.J.Freeman & Co.
2. Esau, K. Plant Anatomy, John, Wiley and sons, Inc. New York, London.
3. Fahn, A. Plant Anatomy. Pergamon Press, Oxford.

4. Cutlers, D.F., Applied Plant Anatomy. Longman Press, London.
5. Eames E.J. An Introduction to Plant Anatomy. McGraw Hill, New York.
6. Ahmed, S. The Identification of Angiosperms (Parts I & II), Govt. College, Lahore.
7. Cronquist, A. An Integrated System of Classification of flowering plants, Columbia University Press, New York.
8. Davis, P.H. & Heywood, V.H. Principles of Angiosperm Taxonomy, D Van Nostrand, Princeton, New York.
9. Jalri, S.M.H. Flora of Karachi. Oxford Univ. Press Karachi.
10. Kashyap, S.R. Lahore District flora, Punjab University, Lahore.
11. Nasir, E. & Ali, S.I. Flora of Pakistan. Oxford Univ. Press, Karachi.
12. Radford, A.E. Vascular Plant Systematics, Harper & Row Publishers, New York.
13. Stebbins, C.A. Variation and Evolution in plants. Columbia University, New York.
14. Stace, C.A. Plant taxonomy and Biosystematics, Edward Arnold, London.
15. Takhtajan, A. Flowering Plant: Origin and Dispersal. Oliver and Boyd, Edinburgh.
16. Sokal, R. & Sneath, P.H. Principles of Numerical taxonomy, W.H. Freeman & Company, San-Francisco, U.S.A.
17. Jafferey, C. An Introduction to Plant taxonomy. Cambridge University Press, London.
18. Rajput, M.T., Syeda S.T. and Khan K.M. Plant Taxonomy. Nasim Book Depot, Funjdani Road, Hyderabad.
19. Soka R. and Greath P.H. Principles of numerical taxonomy W.H. Freeman & Company, USA.
20. Jaffery C. An introduction to Plant Taxonomy Cambridge University, Press London.
21. Rajput M.T. Syeda S.T. and Khan K.M. Plant Taxonomy. Nasim Book Depot Funjdani Road, Hyderabad.



**PAPER-IX:****PLANT PHYSIOLOGY****1. Water Relations**

The soil -plant -atmosphere continuum - an overview. Structure of water, Physico-chemical properties of water. Water in the soil and its potentials. Water in cell components. Absorption of water in plants (Aquaporins, pathways and driving forces). Cell water relations terminology- Hoffer diagram - analysis of change in turgor, water and osmotic potential with changes in cell volume. Modulus of elasticity coefficient; Hydraulic conductivity. Methods for measurement of water , osmotic and turgor potentials- Pressure chamber, psychrometry, pressure probe, pressure volume curve.

**2. Plant Mineral Nutrition**

Inorganic composition of plant and soil. Absorption of mineral nutrients - roots, mycorrhizae. Ion traffic into root. The nature of membrane carriers, channels and electrogenic pumps . Passive and active (primary and secondary) transports and their energetics. Essential and beneficial elements - their functions and deficiency symptoms in plants. Fertilizers and their significance in Agriculture.

**3. Translocation of Food**

Pathway of translocation, source and sink interaction, materials translocated, mechanism of phloem transport, loading and unloading.

**4. Leaves and Atmosphere**

Gaseous exchange, mechanism of stomatal movement (photoactive opening; scotoactive closing and scotoactive opening). Factors affecting stomatal movement,

**5. Photosynthesis**

History of photosynthesis. Nature and units of light. Determination of oxygenic and anoxygenic photosynthesis. Ultrastructure of thylakoid vesicle. Various pigments and photosynthetic activity. Ultrastructure and composition of photosystem-I and II. Absorption and action spectra of different pigments. Mechanism of photosynthesis - light absorption, charge separation or oxidation of water (water oxidizing clock), electron and proton transport through thylakoid protein-pigment complexes. Photophosphorylation and its mechanism.  $\text{CO}_2$  reduction (dark reactions) -  $\text{C}_3$  pathway and Photorespiration.  $\text{C}_4$  pathway and its different forms, CAM pathway. Methods of measurement of photosynthesis.

## 6. **Respiration**

Respiratory substrates. Respiratory Quotient. Synthesis of hexose sugars from reserve carbohydrates. Mechanism of respiration- Glycolysis, Oxidative decarboxylation, Krebs cycle, Electron transport and oxidative phosphorylation. Aerobic and anaerobic respiration. Energetics of respiration, Pentose phosphate pathway- Glyoxylate cycle. Control of respiration. Factors affecting respiration. Cyanide resistant respiration,

## 7. **Assimilation of Nitrogen, Sulphur and Phosphorus**

The nitrogen cycle. Nitrogen fixation. Pathways of assimilation of nitrate and ammonium ions. Assimilation of sulphur and phosphorus.

## 8. **Plant Growth Regulators**

Major natural hormones and their synthetic analogues. Bioassay, structure, biosynthesis, receptors and mechanism of action, transport, physiological effects and gene action of Auxins, Gibberellins, Cytokinins, Abscissic acid, Ethylene, Polyamines, Brassinosteroids, Jasmonates, and Salicylic acid.

## 9. **Phytochromes**

Discovery of phytochromes. Physical and chemical properties of phytochromes. Distribution of phytochromes among species, cells and tissues and their role in biological processes.

## 10. **Control of Flowering**

Autonomous versus environmental regulation. Circadian rhythms. Classification of plants according to photoperiodic reaction,- photoperiodic induction, locus of photoperiodic reaction and dark periods in photoperiodism. Role of photoperiodism in flowering. Vernalization and its effect on flowering. Floral meristem and floral organ development. Floral organ identity genes and the ABC model.

## 11. **Gene Regulation and Signal Transduction**

Genome size and organization. Gene regulation in prokaryotes and eukaryotes. Signal transduction in prokaryotes and eukaryotes.

## **Practical**

1. To investigate the preferential absorption of ions by corn seedlings and potato slices.
2. To determine osmotic potential of massive tissue by freezing point depression method or by an osmometer.

3. To investigate water potential of a plant tissue by dye method and water potential apparatus.
4. To determine the volume of CO<sub>2</sub> evolved during respiration by plant material,
5. To determine the amount of O<sub>2</sub> used by respiring water plant by Winkler Method.
6. Separation of chloroplast pigments on column chromatogram and their quantification by spectrophotometer.
7. To extract and separate anthocyanins and other phenolic pigments from plant material and study their light absorption properties.
8. To categorize C<sub>3</sub> and C<sub>4</sub> plants through their anatomical and physiological characters.
9. To regulate stomatal opening by light of different colours and pH.
10. Determination of K<sup>+</sup> uptake by excised roots,
11. Measurement of stomatal index and conductance.
12. Qualitative determination of K content in Guard cells by Sodium cobalt nitrite method.

#### BOOKS RECOMMENDED

1. Dennis, D.T, Turpin, D.H., Lefebvre, D.D. and Layzei), D.B. 1997. Plant Metabolism. 2nd Edition, Longman Group, U.K.
2. Dey, P.M. and Harborne, J.B. 1997. Plant Biochemistry. Harcourt Asia PTE Ltd. Singapore,
3. Fitter, A. and Hay, F.K.M. 2001. Environmental Physiology of Plants. Academic Press, UK.
4. Heldt, H-W- 1997. Plant Biochemistry and Molecular Biology. Oxford University Press, Oxford, U.K.
5. Ihsan Illani, 1991. Plant Growth, UGC Press, Islamabad.
6. Ihsan Illani, 1995. Plant Physiology, Biochemical Processes in Plants, UGC Press.
7. Nobel, P.S. 1999. Physicochemical and Environmental Plant Physiology. Academic Press, UK.
8. Press, M.C, Barker, M.G., and Scholes, J.D. 2000. Physiological Plant Ecology, British Ecological Society Symposium, Volume 39, Blackwell Science, UK.
9. Salisbury F.B. and Ross C.B. 1999 Plant Physiology. 5th Edition. Wadsworth Publishing Co. Belmont CA.
10. Taiz, L and Zeiger, E. 2002. Plant Physiology. 2nd Ed. Sinauauers Publ. Co. Inc. Calif.
11. W.B. Hopkins. 1999. Introduction to Plant Physiology. 2<sup>nd</sup> Ed, John Wiley & Sons. New York.

(X)✓  
PAPER-VIII

## MOLECULAR GENETICS

### 1. Extensions of Mendelian Analysis

Variations on dominance, multiple alleles, lethal alleles, several genes affecting the same character, penetrance and expressivity.

### 2. Linkage I: Basic Eukaryotic Chromosome Mapping

The discovery of linkage, recombination, linkage symbolism, linkage of genes on the X chromosome, linkage maps, three-point testcross, interference, linkage mapping by recombination in humans.

### 3. Linkage II: Special Eukaryotic Chromosome Mapping Techniques

Accurate calculation of large map distances, analysis of single meioses, mitotic segregation and recombination, mapping human chromosomes.

### 4. Gene Mutation

Somatic versus germinal mutation, mutant types, the occurrence of mutations, mutation and cancer, mutagens in genetic disorder, mutation breeding. Evolutionary significance of mutation.

### 5. Recombination in Bacteria and their Viruses

Bacterial chromosome, bacterial conjugation, bacterial recombination and mapping the *E. coli* chromosome, bacterial transformation, bacteriophage genetics, transduction, mapping of bacterial chromosomes, bacterial gene transfer.

### 6. The Structure of DNA

DNA: The genetic material, DNA replication in eukaryotes, DNA and the gene.

### 7. The Nature of the Gene

How genes work, gene-protein relationships, genetic observations explained by enzyme structure, genetic fine structure, mutational sites, complementation.

### 8. DNA Function

Transcription, translation, the genetic code, protein synthesis, universality of genetic information transfer, eukaryotic RNA.

## 9. Recombinant DNA

Restriction enzymes, the formation of recombinant DNA, recombinant DNA methodology, recombinant DNA and social responsibility.

## 10. Application of Recombinant DNA

Applications of recombinant DNA technology using prokaryotes, recombinant DNA technology in eukaryotes: An overview, transgenic yeast, transgenic plants, transgenic animals, screening for genetic diseases, identifying disease genes, DNA typing, gene therapy, genetically modified organisms and apprehensions.

## 11. 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.

## 12. Mechanisms of Genetic Change I: Gene Mutation

The molecular basis of gene mutations, spontaneous mutations, induced mutations, reversion analysis mutagens and carcinogens, biological repair mechanisms.

## 13. Mechanisms of Genetic Change II: Recombination

General homologous recombination, the holiday model, enzymatic mechanism of recombination, site-specific recombination, recombination and chromosomal rearrangements.

## 14. Mechanisms of Genetic Change III: Transposable Genetic Elements

Insertion sequences, transposons, rearrangements mediated by transposable elements, review of transposable elements in prokaryotes, controlling elements in maize.

## 15. The Extranuclear Genome

Variegation in leaves of higher plants, cytoplasmic inheritance in fungi, extranuclear genes in *Chlamydomonas*, mitochondrial genes in yeast, extragenomic plasmids in eukaryotes

## 16. Developmental Genetics:

Gene Regulation and Differentiation, Crown gall disease in plants, cancer as a developmental genetic disease.

## 17. Human Genome Project

Strategies and application, achievement and future prospects.

### 18. Plant Genome Projects.

*Arabidopsis*, achievement and future prospects. Other plant genome projects.

### 19. Population Genetics

Gene frequencies, conservation of gene frequencies, equilibrium, Hardy-Weinberg law, factors affecting gene equilibrium.

#### Practical

#### A. Numerical problems

1.
  - i. Arrangement of genetic material:
    - a. Linkage and recombination.
    - b. Gene mapping in diploid.
    - c. Recombination in Fungi.
    - d. Recombination in bacteria.
    - e. Recombination in viruses.
  - ii. Population Genetics:
    - a. Gene frequencies and equilibrium.
    - b. Changes in gene frequencies.
2. Blood group & Rh-factor.
3. *Drosophila*
  - a. Culture technique
  - b. Salivary gland chromosome
4. Fungal genetics
 

*Saccharomyces* culture techniques and study.
5. Studies on variation in maize ear size and colour variation.
6. Bacterial Genetics.
  - a. Bacterial cultural techniques, Gram staining (*E. coli*, *B. subtilis*)
  - b. Transformation.
  - c. Conjugation.

7. **Molecular Genetics: Isolation and separation of DNA on Gel electrophoresis.**

- a. Bacterial chromosome
- b. Plasmid DNA (minipreps)
- c. Plant DNA
- d. Protein analysis (bacterial)

**BOOKS RECOMMENDED**

1. Setlow, J.K. 2000. Genetic Engineering: Principles and Methods. Kluwer Academic Publishers.
2. Lewin B. 2003. Gene VIII. Oxford University Press, Oxford, UK.
3. Hartt, D. I., and Jones, E.V. 2000. Genetic Analysis of Gene and Genomes. Jones and Bartlett Publishers, Sudbury, USA
4. Gelvin, S.B. 2000. Plant Molecular Biology Manual. Kluwer Academic Publishers
5. Synder, L., and Champness, W. 2003. Molecular Genetics of Bacteria (2<sup>nd</sup> ed.). ASM Press, Washington D.C.
6. Klug, W.S. and Cummings, M.R. (1997). Concepts of Genetics, Prentice Hall International Inc.
7. Roth Well, N.V. (1997). Understanding Genetics, second edition, Oxford University Press Inc.
8. Mays, L.L., (1981). Genetics. A Molecular Approach, MacMillan Publishing, N.Y. Collier Macmillan Publishers, London.
9. Old, R.W. and Primrose, S.B., 1994. Principles of Gene Manipulation, an Introduction to Genetic Engineering, (4th edition), Blackwell Scientific Publications.
10. Gardner, E.J., (1984). Principles of Genetics, John Willey and Sons, New York.
11. Griffiths A.J.F. and Gelbert, W.M. 2002. Modern Genetic Analysis. Freeman and Company.
12. Taurin, R.H. 2002. Principles of Genetics (7<sup>th</sup> ed.) McGraw Hill.
13. Snustad, D.P. and Simmons, M.J. 2003. Principles of Genetics (3<sup>rd</sup> ed.). John Wiley and Sons Inc.
14. Primrose, S.B., Twyman, R.M. and Old, R.W. 2001. Principles of Gene Manipulation. Blackwell Science.

**PAPER-XI:****ENVIRONMENTAL BIOLOGY**

1. Environment: Introduction, scope, pressure
2. Pollution: definition and impact on habitats
  - a. Air pollution: Sources and effect of various pollutants (inorganic, organic) on plants, prevention, control, remediation. Photochemical smog. Smog. Acid rain: 1. Theory of acid rain, 2. Adverse effects of acid rains. Chlorofluorocarbons and its effects.
  - b. Water pollution: Major sources of water pollution and its impact on vegetation, prevention, control remediation, eutrophication.
  - c. Sediments pollution: fungicide, pesticides, herbicide, major sources of soil pollution and its impact. Prevention, control remediation. Heavy metal pollution. Tanneries. Medical waste. Treatments of sewage, sludge, and polluted waters.
  - d. Noise pollution
  - e. Radiation pollution (including nuclear): Measurement, classification and effects, Principle of radiation protection, waste disposal
3. Forest: importance, deforestation, desertification and conservation
4. Ozone layer:
  - a. Formation
  - b. Mechanism of depletion
  - c. Effects of ozone depletion
5. Greenhouse effect: causes, impacts.
6. Human population growth: impact on environment.
7. Hydroelectric dam: short and long term destructions
8. Impact assessment: Industrial urban, civil developments.
9. National conservation strategy: Brief review of major problems of Pakistan and their solutions.
10. Erosion: Definition, types, causes and control measures,
11. Sustainable Environmental management
12. Water logging and salinity: Impact on environment and vegetation.
13. Wetlands and sanctuaries protection: The pressures, problems and solutions.
14. Range management: Types of rangelands, potential threats, sustainable management.

**Practical**

1. Examination of industrial waste water and Municipal sewage and sludge for
  - i) Total dissolved solids.
  - ii) pH and EC.
  - iii) BOD/COD.
  - iv) Chlorides, carbonate, and Nitrates.
2. Examination of water samples from different sites for the presence and diversity of organisms.



3. Effect of air pollutants on plants.
4. Visits to environmentally compromised sites and evolution of remediation methods.

#### BOOKS RECOMMENDED

1. Newman, E.I. 2001, Applied Ecology. Blackwell Science, UK
2. Mooney, H.A. and Saugier, B. 2000. Terrestrial Global Productivity. Academic Press, UK.
3. Eugene, E.D. and Smith, B.F. 2000. Environmental Science: A study of interrelationships. McGraw Hill- USA.
4. France, H. 2000. Vanishing Borders: Protecting the planet in the age of globalization. W.W. Norton & Company, NY.
5. Hall, C.A.S. and Perez, C.L. 2000, Quantifying Sustainable Development. Academic Press, UK.
6. Bazzaz, F.A. 1996. Plants in changing environments: Linking physiological, population, and community ecology. Cambridge Univ, Press.
7. Bush, M.B. 1997. Ecology of a changing planet. Prentice Hall, UK.
8. Marsh, M.W. and Gossa Jr., J.M. 1996 Environmental geography: Science, land use, and earth systems. John Wiley & Sons.

**Opt. Paper-I:****PLANT TISSUE CULTURE AND ITS AGRICULTURAL APPLICATIONS****Theory:**

- i) Introduction, the tissue culture revolution.
- ii) Aseptic Techniques.
- iii) Nutritional components of Tissue Culture media.
- iv) Initiation and maintenance of callus.
- v) Organogenesis: Root and shoot development.
- vi) Somatic embryogenesis.
- vii) Micropropagation: Culture of shoot apex - plantlet formation.
- viii) Isolation, purification and culture of protoplasts.
- ix) Protoplast fusion and somatic hybridization.
- x) Anther and pollen cultures.
- xi) Production of secondary metabolites.
- xii) Germplasm conservation.

**PRACTICALS:**

Aseptic techniques, preparation of tissue culture media, Initiation and maintenance of callus, culture of diverse explants - leaf, node, shoot apex & root tip, Isolation, purification and culture of protoplasts.

**BOOKS RECOMMENDED (Latest editions):**

1. H.E. Street. Plant tissue & Cell cultures. Blackwell Scientific Publishers, Oxford.
2. J. Reinert & Y.P.S. Fajaj (Eds). Plant cell Tissue and organ culture. Springer verlag. Berlin - Heidelberg - New York.
3. S.S. Bhojwan., M.K. Razdan (Eds. Plant Tissue Culture - Theory and Practetice. Elsevier, New York.
4. J.H. Dodds & L.W. Roberts. Experiments in plant tissue culture. Cambridge University Press, London.

**Opt. Paper-II:****PLANT BIOTECHNOLOGY**

1. Introduction:
2. Crop Productivity:
  - i) Plant cell culture
  - ii) Clonal Multiplication, through shoot apical meristem and root tip cultures.
  - iii) Conservation of Germplasm
  - iv) Somatic embryogenesis
  - v) Somaclonal variations
  - vi) Regeneration of haploids
  - vii) Isolation, yield and regeneration of protoplasts
  - viii) Vector construction, transformation.
3. Crop protection:
  - i) Biopesticides for use in agriculture & health sector.
  - ii) Control of viral diseases through *in vitro* cultures.
  - iii) Microbial biotechnology for detoxification of industrial effluents and pesticides waste.
4. Bioconversion:
  - i) Lignocellulose biotechnology
  - ii) Recycling of cellulosic biotechnology
  - iii) Microbial protein production
  - iv) Fermentation

**PRACTICALS:**

Experiments pertaining to plant cell cultures, protoplast isolation, transformation - chemical and Agrobacterium mediated and some bioconversions.

**BOOKS RECOMMENDED (Latest editions):**

1. R.W. Old & S.B. Primrose. Principles of Gene manipulation. Blackwell Scientific Publication.
2. S.B. Gelvin & R.A. Schilperoot (Ed.). Plant Molecular Biology, Manual. Kluwer Academic Publication.
3. L.A. Withers & P.T. Alderson (Ed.). Plant Tissue Culture and its Agricultural applications. Butterworths.
4. J. Reinert & Y.P.S. Bajaj. Plant Cell Tissue and organ Culture. Springer Verlag.
5. N.S. Subra, Rao. C. Balagopalan, S.V. Ramakrishnes. (Ed.) New trends in Biotechnology. Oxford & IBH. Publishing Co.
6. Commercial Biotechnology, An International Analysis. Elsevier Science Publisher.

**Opt. Paper-III:****GENE MANIPULATION****Theory:****Section A: Basic Techniques:**

1. Introduction, Agarose gel electrophoresis, Southern, Northern and Western blotting, Transformation of *E. coli*; Transformation of other organisms.
2. Cutting and joining DNA molecules.  
Cutting DNA molecules, Host-controlled restriction and modification, Nomenclature, Target sites, Mechanical shearing of DNA.  
Joining DNA molecules, DNA ligase, Double-linkers, Adapters, homopolymer tailing.

**Section B: Cloning *E. coli*:**

3. Plasmids as cloning vehicles.  
Basic properties of plasmids, Desirable properties of plasmid cloning vehicles, Usefulness of 'natural' plasmids as cloning vehicles, PSC101, PBR322, low copy number plasmid vectors
4. Bacteriophage and cosmid vectors for *E. coli*.  
Bacteriophage, cosmid vectors, DNA cloning with single stranded DNA vectors, filamentous phage vectors, M 13.
5. Site-directed mutagenesis.
6. Analysing DNA sequences.
7. Cloning strategies, Genomic DNA libraries, chromosome walking, cDNA cloning.
8. Recombinant selection and screening.  
Genetic methods, immunochemical methods, Nucleic acid hybridization methods.
9. Expression in *E. coli* of cloned DNA molecules. The effect of plasmid copy number, plasmid stability.
10. Applications of recombinant DNA technology.

**PRACTICALS:**

1. *E. coli* Culture and growth curve

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

**-BOOKS RECOMMENDED (Latest editions):**

1. R.W. Old and S.B. Primrose, Principles of Gene Manipulation. An Introduction to Genetic Engineering. Blackwell Scientific Publication.
2. K.G. Hardy, Plasmid, A Practical Approach. IRL Press at Oxford University Press.
3. D.M. Glover, DNA Cloning, A Practical Approach (Volume I, II, III). IRL Press.
4. J. Sambrook, E.F. Fritsch and T. Maniatis, Molecular Cloning, A Laboratory Manual. Cold Spring Harbor Laboratory Press.
5. T.A. Brown. Gene Cloning, An introduction. Chapman-Hall.
6. D.S.T. Nicholl. An Introduction to Genetic Engineering. Cambridge University Press.
7. E. Thro. Genetic Engineering, Shaping the Material of Life. Facts on File, New York.
8. R. Williamson. Genetic Engineering, (Vol I-IV), Academic Press.
9. Primrose, S.E., Twyman, R.M. and Old, R.W. 2001. Principles of Gene Manipulation. Blackwell Science.

**Opt. Paper-IV:****MICROBIOLOGY**

History of Microbiology; origin of micro-organisms; classification of bacteria; ultra structure of bacterial cell; reproduction in bacteria; natural distribution of micro-organisms. (bacteria) in soil, air, water, sewage, rumen, intestinal tract, Hot springs, cold environments; characteristics of psychrophilic, mesophilic, and thermophilic bacteria.

Isolation methods for obtaining pure cultures of bacteria; morphology of Bacteria; simple and differential stains; microscopic methods for the study of bacteria, light microscope, phase contrast, fluorescent, dark field and electron microscope.

Bacterial growth; growth curves; growth on solid media and liquid media, batch and continuous cultures; nutritional requirements of bacteria, such as carbon,  $N_2$ , vitamins, amino acids, purines and pyrimidines, etc.; effect of temperature, pH, oxygen, surface tension, osmotic pressure, nutrition; ultraviolet radiation on the growth of bacteria.

Metabolic pathways in bacteria, tricarboxylic acid cycle, pentose phosphate pathway, yeast alcohol fermentation; bacterial alcohol fermentation; catabolite repression and feed back inhibition.

Introduction to immunology; specific and non-specific immunity; immunization in the prevention and treatment of infection; allergy and other forms of sensitivity; serological tests such as agglutination, haemagglutination, neutralization, complement fixation etc. Microbiology of water, foods, milk and dairy products; air and soil.

Some important bacterial genera and diseases, mycobacterium (TB), brucella (brucellosis), shigella (Shigellosis), salmonella (salmonellosis), streptococci (septic sore throat), staphylococci (mylitis), pasteurella (pasteurellosis), vibrio (vibriosis) Industrial application of bacteria.

General characteristics of viruses, multiplication and chemical composition of viruses; techniques for the cultivation of viruses, viral diseases such as polio, rabies, influenza, mumps, measles; bacteriophages.

**PRACTICALS:**

1. Preparation and sterilization of culture media, solid media, semi-solid media, liquid media.
2. Inoculation techniques for bacterial isolation.
3. Gram staining; acid fast staining; capsule and spore staining.
4. Isolation of bacteria from throat, faeces, pus, urine.
5. Enumeration of the number of bacteria from water, air, soil, foods.
6. Growth of bacteria in batch cultures.

7. Influence of temperature, pH, carbon source on the growth of bacteria in batch cultures.
8. Growth in continuous culture.
9. Slide and tube agglutination tests.
10. Bacteriophage isolation.

**BOOKS RECOMMENDED (Latest editions):**

1. Burdons and Williams. Microbiology. MacMillan Company.
2. Frobisher, Hindsdell, Crabtree, Goodheart. Fundamental of Microbiology. Topan Company, Tokyo, Japan.
3. Anderson and Sobieski. Introduction to Microbiology. C.V. Mosby Company. St. Louis, Toronto, London.
4. Paul Edmunds. Microbiology. MacMillan Publishing Company, New York.
5. Alice Lorrane Smith. Microbes and Pathology. C.V. Mosby Company, London.
6. A.J. Salle. Laboratory Manual of Fundamental Principles of Bacteriology. McGraw-Hill Book Co.
7. Koneman, Allen, Sommers; J.B. Color Atlas and Text Book of Diagnostic Microbiology. Lippincott Company.
8. Bailey and Scott. Diagnostic Microbiology. C.V. Mosby Company.
9. Wilson and Miles. Topleys and Wilson's Principles of Bacteriology, Virology and immunology. Butler and Toner Ltd.
10. William & Wilkins. Bergeys Manual of Bacteriology. Naverly Co. Baltimore.

**Opt. Paper-V:****ENVIRONMENTAL BACTERIOLOGY**

1. Introduction.
2. Methods of Microbiology.  
Pure culture technique, sterilization, culture media, selective media, light microscopy, phase contrast microscopy, fluorescent microscopy, electron microscopy.
3. Bacterial morphology, cell structure and reproduction.
4. Bacterial growth.
5. Basis of classification and major groups of bacteria.
6. Effect of environmental factors on bacterial growth.
7. The environment and pollution: Introduction, environmental laws.
8. Molecular approaches to environmental management.
9. Sources and forms of potentially toxic metals in soil plant system.
10. Microbial resistances to heavy metals.
11. Bacterial transformations of heavy metals.
12. Effects of heavy metals from sewage sludge on soil microbes in agricultural ecosystem.
13. Environmental hazards from the genetic toxicity of metal ion.
14. The importance of genetic exchange in degradation of xenobiotic compounds.
15. Bioremediation technologies.

**PRACTICALS:**

1. Preparation and sterilization of culture media, solid media, semi solid media, liquid media, agar slopes, streak plates, pour plates.
2. Staining techniques: Simple staining, negative staining, gram staining, spore staining, capsule staining.
3. Cultural techniques: Culture transfer techniques, isolation of pure cultures, serial dilution, agar plating procedures to quantify viable cells.
4. Cultivation of bacteria: Nutritional requirements, routine and selective media, Effect of temperature and pH on the growth of bacteria, bacterial growth curves.
5. Biochemical activities of bacteria: Starch hydrolysis, Oxidase, Indole production test, Methyl red test, Urease test, Nitrate reduction test, Oxidation fermentation test.
6. Bioremediation from culture by metal resistant bacteria.
7. Effect of bacteria in stimulating plant growth under metal ion stress.
8. Biodegradation of hydrocarbon (Benzene or xylene) by spray plate technique.

**BOOKS RECOMMENDED (Latest editions):**

1. R. Mitchell, Environmental Microbiology, Wiley Liss, A. John Wiley & Sons, Inc publication.



3. W.A. Volk. Basic Microbiology. Harper Collins Publishers.
4. M.J. Pelezar, E.C.S., Chan, N.R. Krieg. Microbiology. MeeGraw Hill.
5. C. Edwards, Microbiology of extreme environments (Environmental Bacteriology), MeeGraw Hill.
6. R. Mitchell. New concepts in Environmental Microbiology, Alan R. Liss.
7. K.J., Irgolic and Martell, A.E. Environmental Inorganic Chemistry. VCH Publishers, Inc. Deerfield Beach, Florida.
8. G.S. Sayler, Fox, R., Blackburn. J.W. Environmental Biotechnology for waste treatments, Plenum publishers. Co.
9. R.K. Poole and G.M. Gadd. Metal-Microbe Interaction, IRL Press.
10. S. McEldowney, D.J. Hardmen, S. Waite. Pollution: Ecology and Biotreatment, Longman Scientific Technical.
11. M.Alexander. Biodegradation and Bioremediation, Academic Press, Inc.
12. S.M. Ross. Toxic metals in Soil Plant Systems. John Wiley & Sons.
13. T.R. Johason and C.L. Case. Laboratory Experiments in Microbiology. The Benjamin/Cummings Publishing Company Inc.
14. J.G. Cappuccino and N. Sherman. Microbiology, A Laboratory Mannual. The Benjamin/Cummings Publishing Company Inc.
15. J.G. Holt, N.R. Krieg, P.H.A., Sneath, J.T. Staley and S.T.Williams. Bergeay's manual of Determinative Bacteriology. Williams and Wikins.
16. Gerhardt, R.G.E. Murray, W.A. Wood and Krieg, N.R. Methods for General and Molecular Bacteriology. American Society for Microbiology, Washington, D.C.

**Opt. Paper-VI:****APPLIED PALEOPALYNOLOGY**

1. Introduction - Scope and Importance.
2. Geological Time Scale. Rock types. Palaeozoic and Mesozoic sedimentary outcrops of the higher and Lesser Himalayas.
3. Palynomorphs in oil and gas exploration and in Stratigraphic Correlation. Geochronology.
4. Palynomorphs as sedimentary particles. Preservability in sediment. Vegetational analysis from pollen analytical data. "Stratigraphic leak" and Reworking. Post Depositional alteration of palynomorphs. Marginal paleopalynology. Shell Code, Ultra structure of Exine.
5. Coal, Formation and Classification.
6. Gondwanaland Palynofloristics - Formation and sequence of breakup of Gondwanaland and its affect on the flora.
7. Principles of Stratigraphy: Principles of Stratigraphic classification. Introduction to various Stratigraphic Units. Biostratigraphy. Fossils as a basis for Stratigraphic subdivision. Concept of Stage and Zone. Biostratigraphic Units, principal categories of Zones. Importance of palynostratigraphy in Geochronology Correlation. Index palynomorphs.

**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. Preparations of strew mount and single grain slides.
7. Polaroid/Cross Nickol Microscopy.
8. Preservation and cataloguing of palynoflora.

Candidates shall be required to submit a "Technical Report" at the time of Practical examination covering all aspects of fieldwork accomplished.

**BOOKS RECOMMENDED (Latest editions):**

1. A. Traverse. Paleopalynology. Unwin Hyman Ltd.
2. Stratigraphic Memoirs of Geological Survey of Pakistan. Vol.12.
3. D.N. Wadia. 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, N.Y.

- 5 Dunbar, C.O. Historical Geology. Wiley, New York.
- 6 Seward, Hafner & Co. Plant life through ages.
- 7 Stratigraphic Code of Pakistan. Memoir's of the Geological Survey of Pakistan. Vol. IV, Part.I.
- 8 Qasim Jan and A.A. Kazmi. Geotectonics of Pakistan.

Opt. Paper-VII:

ADVANCED PLANT ANATOMY

Theory:

1. The Cell Wall: Gross microscopic structure, chemical composition of walls, microscopic and submicroscopic structure, properties of walls, formation of walls, formation of intercellular spaces.
2. Apical meristems: Vegetative shoot apex, shoot apex of vascular cryptogams, gymnosperms and angiosperms, reproductive shoot apex, origin of branches.
3. The epidermis: Study of epidermis with special reference to trichomes and stomata.
4. Xylem: The vessel element, morphological specialization in vessel element, organographic and ontogenetic specialization of vessel. Secondary Xylem, growth rings, imperforate tracheary elements, vessels, vascular rays, axial parenchyma. Xylem phylogeny.
5. Phloem: The Primitive sieve elements. Evolution in sieve tube elements. Evolution in phloem as a tissue.
6. Secretory structures: External secretory structures, secretory cells and spaces.
7. The Periderm: Concept, occurrence, characteristics of the components, place of origin of phellogen, initiation and activity of phellogen, time of origin of phellogen, physiologic aspects of periderm formation, morphology of periderm and rhytidome, protective tissue in monocotyledons, lenticels.
8. The Stem: Concept, origin of stem, external morphology of the shoot, tissue systems, primary vascular system, the concept of the stele, delimitation of the vascular region, primary vascular differentiation, secondary growth of the vascular system, types of stem, anomalous secondary growth.
9. The Leaf: Concept, morphology of the foliage leaf, histology of angiosperm leaf, histology of gymnosperm leaf, development of leaf, abscission of leaves, venation pattern, bundle sheath and bundle extension from an ecological point of view.
10. The Root: Concept, origin, morphology, primary structure, development, structure in relation to function, comparative structure of shoot and root, vascular connection between shoot and root, concept of the transition region, structure of the transition region, morphologic significance of the transition region.

11. The Flower: Concept, structure, origin and development, abscission.
12. The Fruit: Definition and classification, fruit wall and pericarp, histology of the fruit wall, abscission.
13. The Seed: Seed in relation to ovule embryo, storage tissue, seed coat, nutritional aspects in seed development.
14. Economic aspects of applied plant anatomy.
15. Ecological anatomy.

#### PRACTICALS:

1. Examination of staminal hairs of *Tradescantia* for the study of primary cell wall, cytoplasm, nucleus, cytoplasmic streaming and vacuole. Leaf mesophyll cells and cortical cells of carrot for the study of plastids.
2. Important staining reactions for the identification of different wall layers, study of simple pits, bordered pits and half bordered pits.
3. Apical meristems: Stained preparations of the stem apex of *Ricinus*, *Nigella*, *Ficus*, *Pelargonium*, *Clerodendron*, *Salvia*, *Eugenia* and *Cucurbita* for the study of different growth zones. Stained preparation of root apices of bean, mustard, maize and *Eichhornia* for the study of root apex.
4. Study of epidermis with special reference to stomata and epidermal appendages. Study of *Ficus*, *Hydrilla*, *Nerium*, *Pyrus*, *Prunus* and *Tradescantia* leaves.
5. Xylem: Study of primary xylem and secondary xylem in knema, rose, maize, *Cucurbita*, *Ranunculus*, sunflower. Study of wood of shisham, *Pinus* and Mango. Study of macerated materials of common woods.
6. Phloem: Study of primary and secondary phloem in *Cucurbita*, *Pinus*, shisham and *Eugenia*.
7. Study of the transverse sections of root, stem and leaf of commonly available plants.
8. Study of venation patterns of leaves of different plants from stained and cleared material.
9. Study of stamens of *Hibiscus*, *Ricinus*, *Nymphaea*, *Brassica*, buttercup, *Datura* and *Cassia* from cleared as well as sectioned material.
10. Study of placentation of *Brassica*, Rose, *Silene*, *Asphodelus*, *Nymphaea* and sunflower.

#### BOOKS RECOMMENDED (Latest editions):

1. Bailey, I.W. Contribution to plant anatomy. Waltham, Mass., U.S.A.
2. Carlquist, S. Comparative plant anatomy. Holt Rinehart & Winston, New York.
3. Cutler, D.F. Anatomy of the monocotyledons. IV. Juncaceae Clarendon Press Oxford.
4. Cutler, D.F. Applied plant anatomy. Longman, London.
5. Eames, A.J. Morphology of the angiosperms. McGraw Hill, New York.

6. Eames, A.J. and MacDaniels, L.H. An introduction to plant anatomy. McGraw Hill, New York.
7. Esau K. Plant anatomy. Wiley, New York.
8. Fahn A. Plant anatomy. Pergamon press, Oxford.
9. Foster, A.S. Practical plant anatomy. Van Nostrand, New York.
10. Jerey, E.C. The anatomy of woods plants. Univ. Chicago Press, Chicago.
11. Metcalfe, C.R. Anatomy of the Monocotyledons. I. Gramineae. Clarendon press, Oxford.
12. Metcalfe, C.R. Anatomy of the monocotyledons V. Cyperaceae. Clarendon press, Oxford.
13. Metcalfe, C.R. and L. Chalk. Anatomy of the dicotyledons. Vol. I. & II. Clarendon press, Oxford.
14. Tomlinson, P.B. Anatomy of the monocotyledon. III. Clarendon press, Oxford.
16. Zahur, M.S. Comparative study of the secondary phloem of 423 species of woody dicotyledons belonging to 85 families. Cornell University Press, Ithica - New York.

Opt. Paper-VIII:

**BIOLOGY OF IMPERFECT FUNGI**

**Lectures 75+5**

1. Introduction, concepts about taxonomy and morphology, classification.
2. Perfect/Imperfect states (Anamorph-Teleomorph Relationships).
3. Concept of form genera.
4. Convergent and Divergent Evolution.
5. Patterns of Conidial Development.
6. Conidial Morphology in relation to habitat.
  - Significance of Tetraradiate/Sigmoid shapes.
7. Aquatic Fungi Imperfecti.
  - Aquatic habitats.
  - Role in aquatic ecosystem.
  - Interactions with invertebrates.
  - Hyphomycetes as intermediaries in energy flow.
  - Biodiversity of aquatic hyphomycetes.
  - Effects of substrate availability, seasonal variation and physicochemical characteristics of water on growth and sporulation of aquatic hyphomycetes.
  - Ecological techniques for trapping aquatic hyphomycetes, merits/demerits of each.
  - Colonization patterns on leaves/wood and concept of early and late colonizers.
  - Communities of aquatic hyphomycetes in different ecological environments.
  - Erection of an Association Table from raw data.
  - Effect of environmental factors on the constitution of aquatic hyphomycete communities.
8. Aero-aquatic Fungi Imperfecti.
  - Biodiversity of aero-aquatic fungi imperfecti.
  - Colonization and ecology of aero-aquatic fungi imperfecti.
9. Predaceous Fungi Imperfecti.
  - Nematophagous fungi, biological control.
10. Plant pathogenic fungi imperfecti.

Important diseases caused by imperfect fungi with reference to the following groups:

- a. Seed borne Fungi Imperfecti.
  - Seed borne dematiaceous hyphomycetes.
  - Seed borne coelomycetes.
- b. Soil borne fungi imperfecti.

#### **PRACTICALS:**

1. Study of aquatic hyphomycete species in a stream (temperate) and a canal (semi-tropical) ecosystem with details of their taxonomic characters.
2. Study of different techniques to trap aquatic hyphomycetes with calculation of frequencies and RIV (relative importance values) of various species.
  - Water filtration.
  - Leaf Baits
  - Woody Baits
  - Foam
3. Study of the effect of aeration and pH on the sporulation of aquatic hyphomycetes.
4. Study of aero-aquatic fungi imperfecti and the details of their taxonomic characters.
5. Culturing of aquatic and aero-aquatic fungi imperfecti using different techniques.
6. Study of nematophagous fungi imperfecti.
7. Culture studies of various soil and seed borne fungi imperfecti with details of their taxonomic characters.
8. Culture studies of various seed borne fungi imperfecti with detail of their taxonomic characters.

#### **BOOKS RECOMMENDED: (Latest Editions)**

1. J. Webster. Introduction to Fungi. Cambridge University Press New York.
2. G.T. Cole and B. Kendrick. Biology of Conidial Fungi. Academic Press, London.
3. G.C. Carroll and D.T. Wicklow. The Fungal Community. Marcel Dekker, New York
4. F. Barlocher. The Ecology of Aquatic Hyphomycetes. Springer Verlag, New York.
5. N.J. Dix and J. Webster. Fungal Ecology. Chapman & Hall, London.
6. G.N. Agrios. Plant Pathology, Academic Press, New York.



**Opt. Paper-IX:****MYCORRHIZA**

Mycorrhizal symbiosis, nature, classification.

**Section 1: Vesicular arbuscular mycorrhizas**

1. The symbionts forming VA mycorrhizas
2. Colonization of roots and anatomy of VA mycorrhizas
3. Genetic, cellular and molecular interactions in the establishment of VA mycorrhizas
4. Growth and carbon economy of VA mycorrhizal plants
5. Mineral nutrition, heavy metal accumulation and water relation of VA mycorrhizal plants

**Section 2: Ectomycorrhizas**

1. Structure and development of ectomycorrhizal roots
2. Growth and carbon economy in ectomycorrhizal plants
3. Nitrogen nutrition of ectomycorrhizal plants
4. Phosphorus nutrition of ectomycorrhizal plants
5. Ectomycorrhizas-features of infection

**Section 3: Mycorrhizas in the ericales**

1. Arbutoid and monotropoid mycorrhizas-Symbionts and features of infection
2. Ericoid mycorrhizas-Symbionts and features of infection

**Section 4: Orchid mycorrhizas-Symbionts and features of infection****Section 5: General themes**

1. uptake translocation and transfer of nutrients in mycorrhizal symbioses
2. The roles of mycorrhizas in ecosystems
3. Vesicular arbuscular mycorrhizas in agriculture and horticulture
4. Mycorrhizas in managed environments: forest production, interactions with other microorganisms and pollutants
5. Mycorrhizas as mycobio indicators.

**PRACTICALS:**

1. Basic techniques for studying VA mycorrhizal and ectomycorrhizal associations.

2. Processing and staining of plant materials (roots and portions other than roots) for study of intramatrical VA mycorrhizal structures.
3. Sample storage, storage of processed and stained plant materials.
4. Extraction of spores of Glomalean fungi from soil and their identification following synoptic keys.
5. Slide preparation of stained plant-materials and spores.
6. Microscopic studies of mycorrhizal organs and method to estimate hyphal length, extent of colonization and frequency of mycorrhizal infections.
7. Interaction studies with root infecting fungi and bacteria.
8. Isolation, culture and anatomical studies of ectomycorrhizas
9. Inoculation and synthesis of ectomycorrhizas on tree seedling and cuttings.
10. Field and pot experiments using variable inocula to study plant growth responses to mycorrhizas.
11. A field survey of VA mycorrhizal plants in acidic, alkaline and saline areas.

#### **BOOKS RECOMMENDED:(Latest editions)**

1. Smith, S.E. and Read, D.J. Mycorrhizal Symbiosis, Academic Press, Hartcourt Brace & Company Publishers, New York.
2. Gianinazzi-Pearson and Gianinazzi, S. Physiological and Genetical Aspects of Mycorrhizae. CNRS, INRA, Dijon.
3. Varma, A. and Hock, B. Mycorrhiza, Structure, Function, Molecular Biology and Biotechnology. Springer-verlag, Berlin, Heidelberg, New York.
4. Allen, M.F. Mycorrhizal Functioning, Chapman and Hall, New York, London.
5. Norris, J.R., Read, D.J. and Varma, A.K. Techniques for the study of mycorrhiza. Microbiology, Volume 24. Academic Press, Hartcourt Brace & Company Publishers, New York.
6. Sanders, F.E., Mosse, B. and Tinker, P.B. (eds). Endomycorrhizas, Academic Press, Hartcourt Brace & Company Publishers, New York.
7. Cooke, R. The Biology of Symbiotic Fungi. John Wiley and sons, New York.
8. Marks, G.G. and Kozolowshi, T.T. Ectomycorrhizae: their ecology and physiology. Academic Press, hartcourt Brace & Company Publishers, New York.
9. Schenck, N.C. (ed.) Methods and Principles of mycorrhizal research. The American Phytopathological Society, St. Paul, Minnesota.
10. Allen M.E. The Ecology of Mycorrhizae. Cambridge University Press, Cambridge.

**Opt. Paper-X:**

## **FUNGAL PLANT INTERACTIONS**

**1. Fungal life styles:**

Introduction: vegetative growth and development, hyphal structures, cell wall: (components, extension, synthesis), dimorphism, colony and colony growth, duplication cycle, membrane transport processes, exploitation of nutrient resources, role of environmental factors, autolysis, reproduction, fungal strategies (saprotrophs, necrotrophs, biotrophs).

**2. Plants as an environment:**

Plant cells and tissues as an environment (stems, roots and leaves), plant surfaces, development of fungal communities and succession. Colonization and decomposition of leaves. Development of fungal communities on herbaceous stems and grasses. Colonization and decay of wood.

**3. Effect of fungi on plant health:**

Nutrition, Effect of environmental condition on plant health, plant responses to biotic/abiotic influences, disease symptoms, control of plant diseases.

**4. Fungal plant confrontation:**

Introduction, fungal invasion, mechanism of disease resistance. Prepenetration, penetration and post-penetration phenomenon.

**5. Effect of pathogenic fungal invasion on host plant physiology:**

Introduction, physiological changes in host plant tissues, effect of invasion on plant growth.

**6. Mutualistic symbioses:**

Introduction, Mycorrhizal symbiosis, lichens, endophytic symbioses.

**7. Role of biotechnology in the study of fungal plant interaction:**

Introduction, disease resistance through breeding, tissue culture and molecular biology. Biocontrol of fungal plant pathogens and weeds using other fungi.

**PRACTICALS:**

1. Study and isolation of commonly found plant pathogens.
2. Isolation and detailed culture studies, reinoculation experiments of plant pathogens involved in various economically important diseases.
3. Isolation of soil fungi and study of their interaction with other fungi.
4. Isolation of mycoparasites from soil and disease lesions.
5. Multiplication of mycoparasites on culture media and substrates and assessment of their efficiency in suppressing the disease incidence.
6. Field study of ecto-mycorrhizal association of plants.
7. Processing of roots, scale-leaves, decaying sheathing leaves for the assessment of VA mycorrhizae.
8. Synthesis of VA mycorrhizae in plants from spore and root inocula.
9. Study of inoculum potential of various types of inocula.
10. Assessment of plant growth response to mycorrhiza.
11. Morphological, microscopic, biochemical studies of some lichens collected from northern areas of Pakistan.

**BOOKS RECOMMENDED: (Latest editions)**

1. Vanderplank, J.E. Host-Pathogen Interactions in Plant Diseases. Academic Press, New York, London
2. Ghaffar, A. and Shahzad, S. Status of Plant Pathology in Pakistan. Department of Botany, University of Karachi, Pakistan.
3. Dix, N.J. and Webster, J. Fungal Ecology, Chapman and Hall Inc.
4. Varma, A. and Hock, B. Mycorrhiza, structure, function, molecular biology and biotechnology. Springer-Verlag, Berlin, Heidelberg, New York.
5. Cooke, R. The Biology of Symbiotic Fungi, John Wiley and Sons, London, New York.
6. Alexopoulos, C.J., Mims, C.W. and Blackwell, M. Introductory Mycology, John Wiley and sons, London, New York.
7. Smith, S.E. and Read, D.J. Mycorrhizal Symbiosis, Academic Press, Harcourt Brace and Company, Publishers, London, New York.

**Opt. Paper-XI:**

## **PHYSIOLOGY OF FUNGI**

**Cultivation and growth of fungi:** Growth forms and morphogenic patterns. Effect of environmental factors (biotic and abiotic) on fungal growth.

**Water relations:** Effect of soil substrate and atmospheric moisture contents on the colonization and growth of macro and micro fungi. Physiology of adaptation to growth at low water potentials and osmoregulation in fungi: Pseudothraust fungi, thermotolerant and psychrotolerant fungi, xerotolerant and osmotolerant fungi/Marine fungi.

**Enzymes:** Amylases, Proteases, Pectinases, lipases, Aspartyl proteases, penicillin acylases, lactases, cellulases, amyloglucosidases, Role of fungi in biodegradation and biodeterioration, cellulytic activity of fungi, economic importance of enzymes produced by fungi.

**Nutrition in fungi:** Carbon, Nitrogen and inorganic nutrients including essential macro and micro nutrients.

**Vitamins and growth factors:** Their requirement and effects on growth and reproduction.

**Physical factors affecting spore germination, growth and reproduction:** Effect of physical factors like temperature, light intensity and pH on spore germination, growth and reproduction in fungi.

**Carbon metabolism:** Carbon sources used by fungi and their utilization.

**Phosphate metabolism:** Sources of phosphorus used by fungi and their utilization.

**Respiration:** Energy production, glycolyses and fermentation pathways, Embden-Meyerhof Parnas pathway, hexose monophosphate pathway, Fermentation pathways.

**Physiology of reproduction:** Asexual and sexual reproduction, hormonal systems in fungi, heterothallicism, parasexual life cycle, dormancy.

**Fungal metabolism:** Commercially important fungal metabolites, Acetate pathway, shikimic acid pathway, lichen products, phytotoxins, aromatic metabolites.

**Fungal metabolism:** Commercially important fungal metabolites, Acetate pathway, shikimic acid pathway, lichen products, phytotoxins, aromatic metabolites.

**Medicinal and poisonous fungi.**

## **Physiology of symbiosis and parasitism.**

### **Applied fungal physiology**

#### **PRACTICALS:**

1. Cultivation of fungi on different media and substrates.
2. Growth of fungi on different carbon sources.
3. Growth of fungi on different nitrogen sources, both organic and inorganic.
4. Effect of pH on growth and spore production in fungi.
5. Effect of temperature on growth and spore production in fungi.
6. Effect of vitamins on growth of fungi.
7. Effect of other essential element (including trace elements) on the growth of fungi.
8. Effect of moisture and temperature on spore germination.
9. Study of some by products of fungi such as alcohol, organic acids and antibiotics.
10. Study of fungal interaction on culture media.

#### **BOOKS RECOMMENDED: (Latest editions)**

1. Gianinazzi-Pearson and Gianinazzi. S. Physiological and genetical aspects of mycorrhizae. CNRS, INRA, Dijon.
2. Cochrane, V.W. Physiology of fungi. John Wiley and Sons Inc. London, New York.
3. Allen, M.F. Mycorrhizal functioning, Chapman and Hall, New York, London.
4. Lilly, V.C. and Barnett, J. Physiology of fungi. Macmillan Company.
5. Dix, N.J. and Webster, J. Fungal Ecology. Chapman and Hall.
6. Woly, F.A. and Wolf, F.T. The fungi, Vol.II Academic Press, New York, London.
7. Tiaz, L. and Zeiger, E. Plant physiology. The Benjamin/Cummings Publishing Company, Inc. New York.

**Opt. Paper-XII:**

**WOOD DECAY FUNGI**

**Introduction:** Colonization and decay of wood; wood as a resource, colonization of woody tissue, types of wood rots, water relations, fungal biodeterioration and biodegradation, substrate-invader interactions.

**Fungi involved:** Macro and microfungi, Taxonomy and classification.

**Structure of fungal communities:** Introduction, development of fungal communities, Succession.

**Economic Importance:** Introduction, damages caused to timber/wood and related industries.

**Role in carbon cycle:** Introduction, fungi as recyclers and their role in major ecosystem types of Pakistan.

**Taxonomic description and characterization of important wood decay fungi:** Distinguishing features of specific families, key to families. Ecological and geography distribution, morphology and taxonomy of basidiocarp, hyphal analysis, hymenial configuration, taxonomy of spores, distinguishing features and description of genera and important species under each genus and key to genera and species.

**-Auriculariaceae:** Auricularia; Septobasidium; Helicobasidium and Uredinella.

**-Tremellaceae:** Tremella; Exidia; Tremellodendron; Phlogiotus and Psuedohydnum.

**-Dacrymycetaceae:** Dacrymyces; Cerinomyces; Calocera; Dacrymitra; and Femsjonina.

**-Thelephoraceae:** Exobasidium; Thelephora, Stereum; Corticium; and Peniophora;

**-Clavariaceae:** Clavaria; Clavulina; Pistilaria; Pterula and Ramaria.

**-Hydnaceae:** Hydnum; Hericium; Echinodontium; Astrodon and Phlebia.

**-Polyporaceae:** Polyporus; Lenzites; Tremates; Daedalea; Fomes and Irpex.

**-Agaricaceae:** Agaricus; Schizophyllum; Pleurotus; Armillaria; Volvaria; Marasmius; Paxillus; Pholiota and Clityocybe;

**PRACTICALS:**

1. Study of wood decaying fungi.
2. Study of successional patterns of common wood decay fungi in natural habitat.
3. Study of their growth and morphology.
4. Morphology of basidiocarp, hyphal analysis.
5. Taxonomy of hymenium, spores and preparation of spore prints.
6. Taxonomic studies and identification of some commonly occurring wood decay species fungi.
7. Collection and preservation of 25 specimens.

**BOOKS RECOMMENDED: (Latest editions)**

1. Dix, N.J. and Webster, J. Fungal Ecology, Chapman and Hall Inc., London, New York.
2. Alexopoulos, G.J., Mims, G.W. Introductory Mycology, John Wiley and sons, London, New York.
3. Khan, A.H. Pathology of Trees (vol. I & II). University of Agri. Fsd.
4. Ahmad, S. Fungi of West Pakistan. Biol. Soc. Pak. Monograph I: 63-78.
5. Ahmad, S. Fungi of West Pakistan. Biol. Soc. Pak. Monograph V: 39-46.
6. Ahmad, S. 1980. A contribution to the Agaricales of Pakistan. Bulletin of Mycology, 1: 35-90.
7. Moore - Landecker, E. Fundamentals of the Fungi. Prentice Hall Inc. N.J.
8. Surcek, M. The Hamlyn Book of Mushrooms and Fungi. Hamlyn. London, N.Y.
9. Dickinson, C. and J. Lucas. The Encyclopedia of Mushrooms. Orbis Pub. London.
10. Fergus, C.L. Illustrated Genera of Wood Decay Fungi, Burgess Publ. Co. Minneapolis.
11. Overenhts, L.O. The Polyporaceae of United States, Alaska and Canada. University Mich, Press. U.S.A.

*Handwritten signature:* R. H. H. H.