

CURRICULUM OF BOTANY

(Revised 2005)



**HIGHER EDUCATION COMMISSION
ISLAMABAD**

CURRICULUM DIVISION, HEC

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Composed by Mr. Zulfiqar Ali, HEC Islamabad

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PREFACE

Curriculum of a subject is said to be the throbbing pulse of a nation. By looking at the curriculum one can judge the state of intellectual development and the state of progress of the nation. The world has turned into a global village; new ideas and information are pouring in like a stream. It is, therefore, imperative to update our curricula regularly by introducing the recent developments in the relevant fields of knowledge.

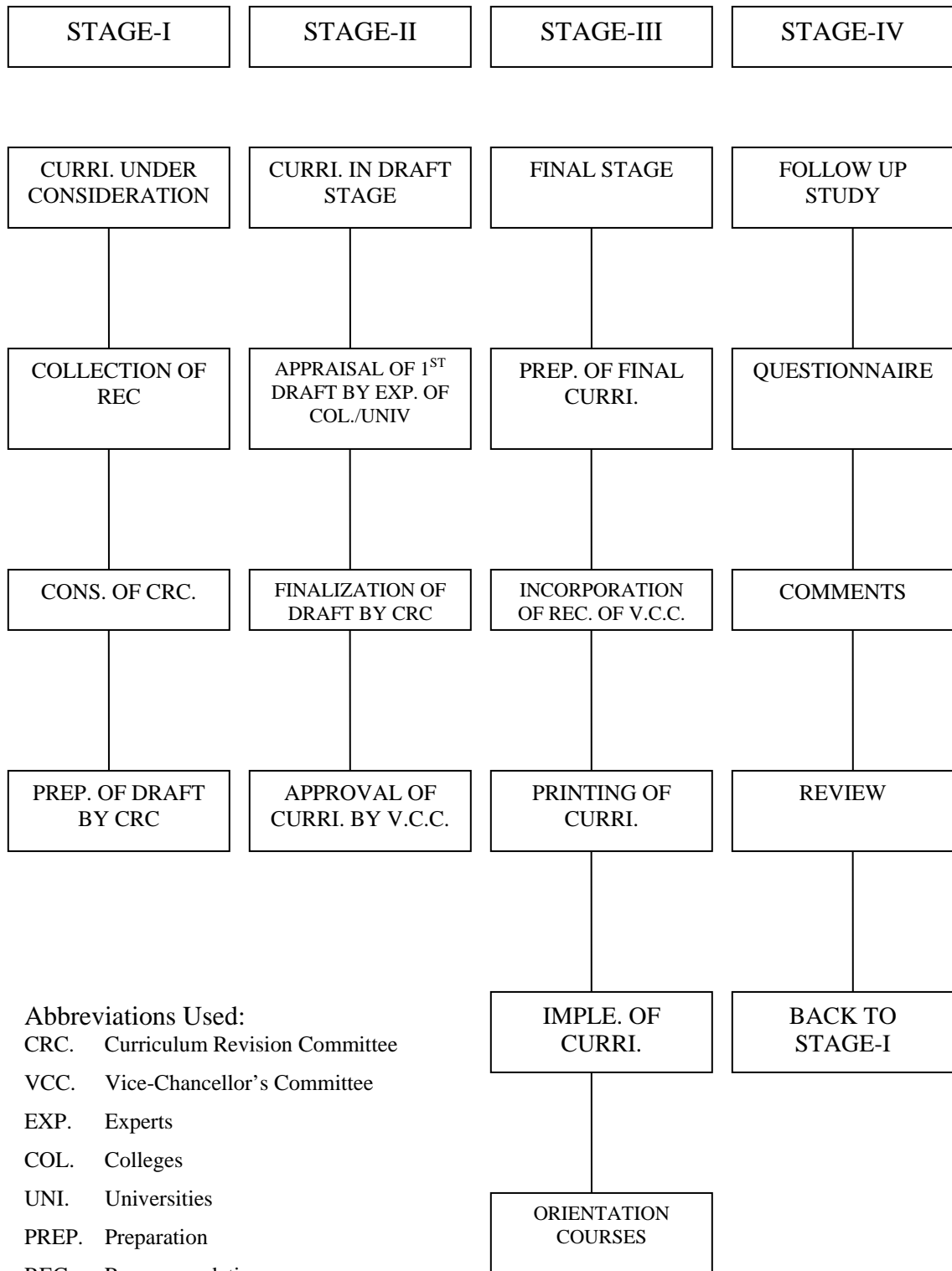
In exercise of the powers conferred by sub-section (1) of section 3 of the Federal Supervision of Curricula Textbooks and Maintenance of Standards of Education Act 1976, the Federal Government vide notification no. D773/76-JEA (Cur.), dated December 4, 1976, appointed University Grants Commission as the competent authority to look after the curriculum revision work beyond class XII at bachelor level and onwards to all degrees, certificates and diplomas awarded by degree colleges, universities and other institutions of higher education.

In pursuance of the above decisions and directives, the Higher Education Commission (HEC) is continually performing curriculum revision in collaboration with universities. According to the decision of the special meeting of Vice-Chancellors' Committee, curriculum of a subject must be reviewed after every 3 years. For the purpose, various committees are constituted at the national level comprising senior teachers nominated by universities. Teachers from local degree colleges and experts from user organizations, where required, are also included in these committees. The National Curriculum Revision Committee for Botany in its meeting held in May 9-11, 2005 at the HEC Regional Centre, Lahore revised the curriculum after due consideration of the comments and suggestions received from universities and colleges where the subject under consideration is taught. The final draft prepared by the National Curriculum Revision Committee duly approved by the Competent Authority is being circulated for implementation by architectural institutions.

(PROF. DR. ALTAF ALI G. SHAIKH)
Adviser (Acad/R&I)

July 2005

CURRICULUM DEVELOPMENT



INTRODUCTION

A meeting of National Curriculum Revision Committee to finalize the draft curriculum of Botany prepared by NCRC in its preliminary meeting was held from May 09-11, 2005 at HEC, Regional Centre, Lahore. The following attended:

1. Prof. Dr. Ihsan Ilahi,
Kohat University of Science and Technology,
Banu Road, off Jarma, Kohat. Convener
2. Dr. G. Raza Bhatti,
Professor,
Department of Botany,
Shah Abdul Latif University,
Khairpur, Sindh. Member
3. Mr. Sultan Mahmood Wazir,
Lecturer, Department of Biotechnology,
University of Malakand, Chakdara. Member
4. Ms. Yasmin Anjum,
Associate Professor,
Jinnah University for Women,
5-C Nazimabad, Karachi Member
5. Mrs. Raashda Zafar,
Head, Department of Botany,
Lahore College for Women University,
Jail Road, Lahore. Member
6. Dr. Rukhsana Bajwa,
Professor/Chairperson,
Department of Mycology and Plant
Pathology,
University of the Punjab,
Lahore. Member
7. Prof Dr. A. G. Khan,
Foreign Faculty Member,
Department of Botany,
University of Arid Agriculture,
Rawalpindi. Member

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| 8. | Dr. Zaheer-u-Din Khan, Associate Professor of Botany, GC University, Katchery Road, Lahore. | Member |
| 9. | Dr. Muhammad Subhan, Professor of Botany, Department of Plant Breeding and Genetics, Faculty of Agriculture, Gomal University, D.I.. Khan. | Member |
| 10. | Dr. Muhammad Ashraf, Chairman, Department of Botany, University of Agriculture, Faisalabad. | Member |
| 11. | Dr. Muhammad Qadeer Butt, University College of Education for Science, Township, Lahore. | Member |
| 12. | Dr. Zahoor Ahmad, Principal Scientific Officer, National Agriculture Research Centre, Park Road, Islamabad. | Member |
| 13. | Professor Dr. M. Fayyaz Ch. Department of Biological Sciences, Quaid-i-Azam University, Islamabad. | Member |
| 14. | Dr. Muhammad Hanif, Associate Professor, Department of Botany, GC, University, Faisalabad. | Member |
| 15. | Prof. Bahir Ahmed Arrain, Department of Botany, University of Sindh, Jamshoro. | Member |
| 16. | Prof. Dr. Saeed Malik, Professor, Department of Botany, B.Z. University, Multan. | Member |

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| 17. | Dr. Muhammad Arshad, Deputy Director, Cholistan Institute of desert Studies, P.O. Box 146, Islamia University, Bahawalpur. | Member |
| 18. | Dr. M. Qaiser, Dean, Faculty of Sciences, Department Botany, University of Karachi, Karachi. | Member |
| 19. | Prof. Dr. K. M. Aslam, Department of Botany, University of AJK, Muzaffarabad. | Member |
| 201. | Ms. Kishwer Nazeer, Director General, Pakistan Museum of Natural History, Garden Avenue, Shakarparian, Islamabad. | Member |
| 21. | Prof. Dr. Farrukh Hussain, Chairman, Department of Botany, University of Peshawar, Peshawar. | Member |
| 22. | Mr. Sajjad Zafar Baig Islamia College, Civil Lines, Lahore. | Member |
| 23. | Dr. Ambreen Sagheir Associate Professor of Botany, Queen Mary College for Women, Durand Road, Lahore. | Member |
| 24. | Prof. Hamid Saeed Forman Christian College University, Ferozpur Road, Lahore. | Member |
| 25. | Mrs. Sameeha Mujahid Associate Professor in Botany, Kinnaird College for Women University, Lahore. | Member |

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| 26 | Mr. Tauzeem Akbar Cheema, Government College University, Lahore. | Member |
| 27. | Ms. Ayesha Zeb, Lecturer, Kinnaird College, Lahore | Member |
| 28. | Prof. Dr. Shahida Hasnain, Chairperson, Department of Botany, University of the Punjab, Lahore. | Member/Secretary |

Meeting started with recitation from holy Quran.

The Sub Committees:

1. Diversity of Non-Vascular Plants

Dr. Ghaffar
Yasmin Anjum
Dr. Rukhsana
Mr. Sajad Baig

2. Diversity of Non-Vascular Plants

Dr. Basir
Dr. Zaheer
Ms. Samiha Mujahid
Dr. Ambreen
Dr. Kishwar

3. Plant Systematic

Dr. Zaheer
Dr. Qadeer Butt
Dr. Qaisar
Ms. Rashida

4. Anatomy and Development

Dr. Basir
Dr. Zaheer
Dr. Hanif
Mr. Sultan Mahmood Wazir

5. **Cell Biology**
Dr. Shahida
Ms. Rashida
Dr. Hanif
Dr. Muhammad Subhan
Mr. Hamid Saeed

6. **Genetics**
Dr. Shahida
Dr. Subhan
Dr. Aslam
Tanzeem Akbar
Ms. Aisha Zeb
Dr. Zahoor

7. **Physiology**
Dr. Ahsan Alahi
Dr. Ashraf
Dr. Fyaz
Dr. Zahoor
Dr. Subhan
Mr. Hameed Saeed

8. **Ecology**
Dr. Furrukh
Dr. Saeed
Sultan
Mr. Hamid Saeed

FOUR YEARS BS PROGRAMME SCHEME OF STUDIES

SEMESTER-1

| Course # | Title | Credit Hours |
|----------|------------------------------------|--------------|
| | English-1 | 3(3+0) |
| | Islamiyat | 2(2+0) |
| | Science Subject other than Major-I | 4(3+1) |
| | Science Subject other than Major-I | 4(3+1) |
| Bot-301 | Diversity of Plants | 4(3+1) |
| | | 17 |

SEMESTER-2

| Course # | Title | Credit Hours |
|----------|--------------------------------------|--------------|
| | English-II | 3(3+0) |
| | Pakistan Studies | 2(2+0) |
| | Science Subject other than Major-II | 4(3+1) |
| | Science Subject other than Major-II | 4(3+1) |
| Bot-302 | Systematics, Anatomy and Development | 4(3+1) |
| | | 17 |

SEMESTER-3

| Course # | Title | Credit Hours |
|----------|--------------------------------------|--------------|
| | Computer Applications | 3(1+2) |
| | Science Subject other than Major-III | 4(3+1) |
| | Science Subject other than Major-III | 4(3+1) |
| Bot-401 | Cell Biology, Genetics and Evolution | 4(3+1) |
| | | 15 |

SEMESTER-4

| Course # | Title | Credit Hours |
|----------|-------------------------------------|--------------|
| | Mathematics | 3(3+0) |
| | Science Subject other than Major-IV | 4(3+1) |
| | Science Subject other than Major-IV | 4(3+1) |
| Bot-402 | Plant Physiology and Ecology | 4(3+1) |
| | | 15 |

Note: In addition to Botany students are desired to study 2 other science subjects of equal credit hours as desired by the university.

SEMESTER-5

| Course # | Title | Credit Hours |
|----------|------------------------------|--------------|
| Bot-501 | Biostatistics | 3(3+0) |
| Bot-502 | Bacteriology and Virology | 3(2+1) |
| Bot-503 | Phycology and Bryology | 3(2+1) |
| Bot-504 | Mycology and Plant Pathology | 3(2+1) |
| Bot-505 | Diversity of Vascular Plants | 3(2+1) |
| Bot-506 | Plant Systematics | 3(2+1) |
| | | 18 |

SEMESTER-6

| Course # | Title | Credit Hours |
|----------|----------------------------|--------------|
| Bot-507 | Plant Anatomy | 3(2+1) |
| Bot-508 | Genetics-I | 3(2+1) |
| Bot-509 | Plant Bio-chemistry-I | 3(2+1) |
| Bot-5010 | Plant Ecology-I | 3(2+1) |
| Bot-5011 | Plant Physiology-I | 3(2+1) |
| Bot-5012 | Research Methodology | 1(1+0) |
| | Humanities/Social Sciences | 2(2+0) |
| | | 18 |

SEMESTER-7

| Course # | Title | Credit Hours |
|----------|-------------------------------|--------------|
| Bot-601 | Molecular Biology | 3(2+1) |
| Bot-602 | Plant Bio-chemistry-II | 3(2+1) |
| Bot-603 | Plant Ecology-II | 3(2+1) |
| Bot-604 | Plant Physiology-II | 3(2+1) |
| Bot-605 | Biodiversity and Conservation | 3(2+1) |
| Bot-606 | Genetics-II | 3(2+1) |
| | | 18 |

SEMESTER-8

| Course # | Title | Credit Hours |
|----------|-----------------------|--------------|
| Bot-607 | Environmental Biology | 3(2+1) |
| Bot-608 | Special Paper-I* | 4(3+1) |
| Bot-609 | Special Paper-II* | 4(3+1) |
| | Research | 4(0+4) |
| | | 15 |

Total credit hours: 133

- Special papers will be according to the expertise of the university.

Detail of Courses

1st Year

1st Semester

Bot-301

Plant Diversity

4(3+1)

Theory

Comparative study of life form, structure, reproduction and economic significance of:

- a) Viruses (RNA and DNA types) with special reference to TMV;
- b) Bacteria and Cyanobacteria (Nostoc, Anabaena, Oscillatoria) with specific reference to biofertilizers, pathogenicity and industrial importance;
- c) Algae (Chlamydomonas, Spirogyra, Chara, Vaucheria, Pinnularia, Ectocarpus, Polysiphonia)
- d) Fungi (Mucor, Penicillium, Phyllactinia, Ustilago, Puccinia, Agaricus), their implication on crop production and industrial applications.
- e) Lichens (Phycia)
- f) Bryophytes
 - i. Riccia
 - ii. Anthoceros
 - iii. Funaria
- f). Pteridophytes.
 - i. Fossils and fossilization
 - ii. Psilopsida (Psilotum)
 - iii. Lycopsida (Selaginella)
 - iv. Sphenopsida (Equisetum)
 - v. Pteropsida (Marsilea)
 - vi. Seed Habit
- g). Gymnosperms Cycas, Pinus, Ephedra.

Practical

Culturing, maintenance, preservation and staining of microorganisms. Study of morphology and reproductive structures of the types mentioned in theory. Identification of various types mentioned from prepared slides and fresh collections.

Books recommended:

1. Lee, R.E. 1999. Phycology. Cambridge University Press, UK
2. Prescott, L.M., Harley, J.P. and Klein, A.D. 2004. Microbiology, 3rd ed. WM. C. Brown Publishers.
3. Alexopoulos, C.J., Mims, C.W. and Blackwell, M. 1996. Introductory Mycology. 4th ed. John Wiley and Sons Publishers.
4. Agrios, G.N. 2004. Plant pathology. 8th ed. Academic press London.
5. Vashishta, B.R. 1991. Botany for degree students (all volumes). S. Chand and Company. Ltd. New Delhi.
6. Andrew, H. N. 1961. Studies in Paleobotany. John Willey and Sons.
7. Ingrouille , M. 1992. Diversity and Evolution of Land Plants. Chapman & Hall .
8. Mauseth, J.D. 2003. Botany: An Introduction to Plant Biology 3rd ed., Jones and Bartlett Pub. UK

2nd Semester

Bot-302 PLANT SYSTEMATICS, ANATOMY AND DEVELOPMENT 4(3+1)

a) Plant Systematics

1. Introduction to Plant Systematics: aims, objectives and importance.
2. Classification: brief history of various systems of classification with emphasis on Takhtajan.
3. Brief introduction to nomenclature, importance of Latin names and binomial system with an introduction to International Code of Botanical Nomenclature (ICBN). St. Luis code.
4. Morphology: a detailed account of various, morphological characters root, stem, leaf, inflorescence, flower, placentation and fruit types.
5. Diagnostic characters, economic importance and distribution pattern of the following families:
 - i) Ranunculaceae
 - ii) Brassicaceae (Cruciferae)
 - iii) Fabaceae (Leguminosae)
 - iv) Rosaceae
 - v) Euphorbiaceae
 - vi) Cucurbitaceae

- vii) Solanaceae
- viii) Lamiaceae (Labiatae)
- ix) Apiaceae (Umbelliferae)
- x) Asteraceae (Compositae)
- xi) Liliaceae (Sen. Lato)
- xii) Poaceae (Graminae)

b) Anatomy

1. Cell wall: structure and chemical composition
2. Concept, structure and function of various tissues like:
 - i. Parenchyma
 - ii. Collenchyma
 - iii. Sclerenchyma
 - iv. Epidermis (including stomata and trichomes)
 - v. Xylem
 - vi. Phloem
3. Meristem: types, stem and root apices
4. Vascular cambium
5. Structure and development of root, stem and leaf. Primary and secondary growth of dicot stem, periderm
6. Characteristics of wood: diffuse porous and ring –porous, sap and heart wood, soft and hard wood, annual rings.

c) Development / Embryology.

1. Early development of plant body: *Capsella bursa-pastoris*
2. Structure and development of Anther
Microsporogenesis
Microgametophyte
3. Structure of Ovule
Megasporogenesis
Megagametophyte
4. Endosperm formation
5. Parthenocarpy
6. Polyembryony

Practicals

Anatomy

1. Study of stomata, epidermis,
2. Tissues of primary body of plant
3. Study of xylem 3-dimensional plane of wood,.
4. T.S of angiosperm stem and leaf .

Taxonomy

1. Identification of families given in syllabus with the help of keys.
2. Technical description of common flowering plants belonging to families mentioned in theory syllabus.
3. Field trips shall be undertaken to study and collect local plants. Students shall submit 40 fully identified herbarium specimens.

Books Recommended

1. Mauseth, J.D. 1998. An Introduction to Plant Biology: Multimedia Enhanced. Jones and Bartlett Pub. UK
2. Moore, R.C., W.D. Clarke and Vodopich, D.S. 1998. Botany. McGraw Hill Company, U.S.A.
3. Raven, P.H., Evert, R.E. and Eichhorn, S.E. 1999. Biology of Plants. W.H. Freeman and Company Worth Publishers.
4. Stuessy, T.F. 1990. Plant Taxonomy. Columbia University Press, USA.
5. Lawrence, G.H.M. 1951 Taxonomy of Vascular Plants. MacMillan & Co. New York.
6. Panday, B.P. 2004. A textbook of Botany (Angiosperms). S. Chand and Co. New Delhi.
7. Raymond E, S. E. Eichhorn. 2005. Esau's Plant Anatomy. Meristems cells and tissues of the plant body, 3rd ed. John Wiley & Sons. Inc.
8. Fahn, A. 1990. Plant Anatomy. Pergamon Press, Oxford.
9. Esau, K. 1960. Anatomy of Seed Plants. John Wiley, New York.
10. Maheshwari, P.1971. Embryology of Angiosperms, McGraw Hill. New York.

2ND YEAR

3rd Semester

BOT-401 CELL BIOLOGY, GENETICS AND EVOLUTION 4(3+1)

a) Cell Biology

1. Structures and Functions of Bio-molecules
 - i. Carbohydrates
 - ii. Lipids
 - iii. Proteins
 - iv. Nucleic Acids
2. Cell: Physico-chemical nature of plasma membrane and cytoplasm.
3. Ultrastructure of plant cell with a brief description and functions of the following organelles

- i. Endoplasmic reticulum
 - ii. Plastids
 - iii. Mitochondria
 - iv. Ribosomes
 - v. Dictyosomes
 - vi. Vacuole
 - vii. Microbodies (Glyoxysomes and Peroxisomes)
- 4. Nucleus: Nuclear membrane, nucleolus, ultrastructure and morphology of chromosomes, karyotype analysis
- 5. Reproduction in somatic and embryogenic cell, mitosis and meiosis, cell cycle
- 6. Chromosomal aberrations; Changes in the number of chromosomes. Aneuploidy and euploidy. Changes in the structure of chromosomes, deficiency, duplication, inversion and translocation.

b) Genetics

- 1. Introduction, scope and brief history of genetics. Mendelian inheritance; Laws of segregation and independent assortment, back cross, test cross, dominance and incomplete dominance.
- 2. Sex linked inheritance, sex linkage in *Drosophila* and man (colour blindness), XO, XY, WZ mechanisms, sex limited and sex linked characters, sex determination.
- 3. Linkage and crossing over: definition, linkage groups, construction of linkage maps, detection of linkage.
- 4. Molecular genetics; DNA replication. Nature of gene, genetic code, transcription, translation, protein synthesis, regulation of gene expression (e.g. *lac* operon).
- 5. Transmission of genetic material in Bacteria: Conjugation and gene recombination in *E.coli*, transduction and transformation.
- 6. Principles of genetic engineering / biotechnology; Basic genetic engineering techniques.
- 7. Application of genetics in plant improvement: Induction of genetic variability (gene mutation, recombination), physical and chemical mutagens, selection, hybridization and plant breeding techniques. Development and release of new varieties.

8. Introduction to germplasm conservation
9. Evolution

Practicals

Cell Biology

1. Study of cell structure using compound microscope and elucidation of ultrastructure from electron microphotographs
2. Measurement of cell size.
3. Study of mitosis and meiosis by smear/squash method and from prepared slides.
4. Study of chromosome morphology and variation in chromosome number.
5. Extraction and estimation of carbohydrate, protein, RNA and DNA from plant sources.

Genetics

1. Genetical problems related to transmission and distribution of genetic material.
2. Identification of DNA in plant material. Carmine/orcein staining.
3. Study of salivary gland chromosomes of *Drosophila*.

Books Recommended

1. Hoelzel, A. R. 2001. Conservation Genetics. Kluwer Academic Publishers.
2. Dyonsager, V.R. (1986). Cytology and Genetics. Tata and McGraw Hill Publication Co. Ltd., New Delhi.
3. Lodish. H. 2001. Molecular Cell Biology. W. H. Freeman and Co.
4. Sinha, U. and Sinha, S. (1988). Cytogenesis Plant Breeding and Evolution, Vini Educational Books, New Delhi.
5. Strickberger, M.V. (1988), Genetics, MacMillan Press Ltd., London.
6. Carroll, S.B., Grenier, J.K. and Welnerbee, S.d. 2001. From DNA to Diversity - Molecular Genetics and the Evolution of Animal Design. Blackwell Science.
7. Lewin, R, 1997. Principles of Human Evolution. Blackwell Science.

4th Semester

Bot-402 PLANT PHYSIOLOGY and ECOLOGY 4(3+1)

A. Plant Physiology

1. Water relations (water potential, osmotic potential, pressure potential, matric potential). Absorption and translocation of water. Stomatal regulation.
2. Mineral nutrition: Soil as a source of minerals. Passive and active transport of nutrients. Essential mineral elements, role and deficiency symptoms of macronutrients.
3. Photosynthesis: Introduction, Oxygenic and non-oxygenic photosynthesis Mechanism: light reactions (electron transport and photophosphorylation) and dark reactions (Calvin cycle). Differences between C₃ and C₄ plants. Factors affecting this process, Products of photosynthesis.
4. Respiration: Definition and respiratory substrates. Mechanism- Glycolysis, Krebs cycle. Electron transport and oxidative phosphorylation. Anaerobic respiration. Energy balance in aerobic and anaerobic respiration, Respiratory quotients.
5. Growth: Definition; role of auxins, gibberellins, cytokinins, abscisic acid and ethylene in controlling growth. Introduction to plant tissue culture.
6. Photoperiodism: Definition, historical background, Classification of plants based on photoperiodic response, Role of phytochromes, and hormones and metabolites in photoperiodism,
7. Dormancy: Definition and causes of seed and bud dormancy; methods of breaking seed dormancy. Physiological processes during seed germination.
12. Plant Movements: Classification. Tropic movements-phototropism, gravitropism and their mechanisms. Nastic movements.

b) Ecology

1. Introduction, aims and applications of ecology.

2. Soil: Physical and Chemical properties of soil (soil formation, texture. pH,EC, organism and organic matter etc)and their relationships to plants.
3. Light and Temperature. Quality of light, diurnal and seasonal variations. Ecophysiological responses.
4. Water: Field capacity and soil water holding capacity. Characteristics of xerophytes and hydrophytes. Effect of precipitation on distribution of plants.
5. Wind: Wind as an ecological factor and its importance.
6. Population Ecology: Introduction. A brief description of seed dispersal, seed bank, demography, density effects and reproductive strategy.
7. Community Ecology
 - I. Ecological characteristics of plant community
 - II. Methods of sampling vegetation (Quadrat and line intercept)
 - III. Succession.
 - IV. Major vegetation types of the local area.
8. Ecosystem Ecology
 - I. Definition, types and components of ecosystem.
 - II. Food chain and Food web.
 - III. Biogeochemical cycles, definition, types with emphasis on nitrogen and Hydrological cycles.
9. Applied Ecology
 - I. Causes, effects and control of water logging and salinity with respect to Pakistan
 - II. Soil erosion: types, causes and effects (wind and water)
 - III. Brief concept of pollution types and effects (air, sediments and water pollution)
 - IV. Brief introduction to biodiversity and conservation with emphasis on Pakistan.

Practicals

A. Plant Physiology

1. Preparation of solutions of specific normality of acids/bases, salts, sugars, molal and molar solutions and their standardization.
2. Determination of uptake of water by swelling seeds when placed in sodium chloride solution of different concentrations.

3. Measurement of leaf water potential by the dye method.
4. Determination of the temperature at which beet root cells lose their permeability.
5. Determination of the effects of environmental factors on the rate of transpiration of a leafy shoot by means of a porometer/by cobalt chloride paper method.
6. Chemical tests for the following cell constituents:
 - i. Starch
 - ii. Cellulose
 - iii. Lignin
 - iv. Proteins
7. Extraction of chlorophyll from the leaves and separation of component pigments on a paper chromatogram. Study of absorption spectra using spectrophotometer.
8. Estimation of oxygen utilized by a respiring plant by Winkler's method.
9. Extraction of amylase from germinating wheat seeds and study of its effect on starch breakdown.
10. Measurement of carbon dioxide evolution during respiration of germinating seeds by the titration method.
11. Measurement of light and temperature.
12. Effect of light and temperature on seed germination.

b) Ecology

13. Determination of physical and Chemical characteristics of soil.
14. Measurements of various population variables
15. Measurement of vegetation by Quadrat and line intercept methods.
16. Field trips to ecologically diverse habitats.
17. Measurements of wind velocity.

Books Recommended

1. Ihsan Illahi (1995). Plant Physiology, Biochemical Processes in Plants, UGC Press.
2. Witham and Devlin. 1986 Exercises in Plant Physiology, AWS Publishers, Boston.
3. Taiz, L. and Zeiger, E. 2002. Plant Physiology. 3rd. Sinauers Publ. Co. Inc. Calif.
4. Salisbury F.B. and Ross C.B. 1992. Plant Physiology. 5th Edition. Wadsworth Publishing Co. Belmont CA.
5. Hopkins, W.B. 1999. Introduction to Plant Physiology. 2nd Ed. John Wiley and Sons. New York
6. Schultz et al. (2005). Plant Ecology. Springer-Verlag, Berlin.
7. Ricklefs, R.E. 2000. Ecology. W.H. Freeman and Co., UK.

8. Ricklefs, R.E. 2001. The Economy of Nature. W.H. Freeman and Co., UK.
9. Barbour, M. G., J. H. Burke and W.D. Pitts. 1999. Terrestrial Plant Ecology, The Benjamin, Cumming Publishing Co. Palo Alto, California, USA.
10. Chapman, J.L. and Reiss, M.J. 1995. Ecology: Principles and Applications. Cambridge University Press.
11. Hussain F. 1989. Field and Laboratory Manual of Plant Ecology. National Academy of Higher Education, Islamabad.
12. Krebs, C. J. 1997. Ecology. Harper and Row Publishers.
13. Smith, R. L. 1996. Ecology and Field Biology. Addison Wesley Longman, Inc., New York.
14. Smith, R. L. 1998. Elements of Ecology. Harper and Row Publishers, New York.
15. Subrahmanyam, N.S. and Sambamurthy, A.V.S.S. 2000. Ecology. Narosa Publishing House, New Delhi.
16. Townsend, C.R., Harper, J.L. and Begon, M.E. 2000. Essentials of Ecology. Blackwell Scientific Publications, UK.
17. Odum, E.P. 1985. Basic Ecology. W.B. Saunders.

3rd Year

5th Semester

Bot-501

BIOSTATISTICS

3(2+1)

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, standard deviation, standard error of the mean, mean deviation, semi interquartile range.
4. Standard distributions: Binomial, Poisson and normal distributions, properties and applications. Normality.
5. Tests of significance: Introduction:

- i) t-test: Basic idea, confidence limits of means, significant difference of means.
 - ii) Chi square test: Basic idea, testing goodness of fit to a ratio, testing association (contingency table).
 - iii) F-test: Introduction and application in analysis of variance.
 - iv) LSD test, Duncan's New Multiple Range test (for comparison of individual means). Bonferroni test.
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 linear regression.

PRACTICALS

1. Probability of simple events.
2. Data collection, arrangement of data in frequency table.
3. Calculation of mean from grouped and ungrouped data.
4. Calculation of variance and standard deviation from grouped and ungrouped data.
5. Binomial distribution.
6. T-test.
7. Poisson distribution,
8. Chi square test.
9. Analysis of variance - one factor design
10. Analysis of variance - two way analysis
11. Analysis of variance - for latin square
12. Analysis of variance - for factorial design.
13. Correlation.
14. Linear Regression.

Books Recommended

1. Quinn, G. 2002. Experimental Design and Data Analysis for Biologists. Cambridge University Press.
1. Bailey, N.T.J. 1994. Statistical Methods in Biology, Cambridge University Press.
2. Wonnacott, T.H, and Wonnacott. R.J. 1990, Introductory Statistics, John Wiley and Sons.
3. Fernholz L.T, Morgenhaler, S., Stahel, W. 2000. Statistics in Genetics and in Environmental Sciences, Birkhauser Verlag;.
4. Zar J.H. 1999. Biostatistical Analysis., Pearson Education,

5. Kuzma J.W. and Bohnenblust, S.E. 2001, Basis Statistics for the Health Sciences, McGraw-Hill International Education.

BOT-502

VIROLOGY AND BACTERIOLOGY

3(2+1)

a) Viruses

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

b) Bacteria

1. History, characteristics and classification.
2. Evolutionary tendencies in Monera (Bacteria, actinomycetes and cyanobacteria)
3. Morphology, genetic recombination, locomotion and reproduction in bacteria
4. Bacterial metabolism (respiration, fermentation, photosynthesis and nitrogen fixation)
5. Importance of bacteria with special reference to application in various modern sciences specially agriculture, biotechnology and genetic engineering.

Practical

a) Viruses

Observation of symptoms of some viral infected plant specimens.

b) Bacteria, Actinomycetes and Cyanobacteria

1. Methods of sterilization of glassware and media etc.
2. Preparation of nutrient medium and inoculation.
3. Preparation of slides for the study of various forms, capsule/slime layer, spores, flagella and Gram-staining.

4. Growth of bacteria, subculturing and identification of bacteria on morphological and biochemical basis (using available techniques).
5. Microscopic study of representative genera of Actinomycetes and Cyanobacteria from fresh collections and prepared slides.

Books Recommended

1. Black, J.G. 2005 Microbiology - Principles and Exploration, John Wiley and Sons, Inc.
2. Prescott, L.M., Harley, J.P. and Klein, D.A. 2005. Microbiology McGraw Hill Companies, Inc.
3. Arora, D.R. 2004. Textbook of Microbiology, CBS Publishers and Distributors, New Delhi.
4. Ross F.C. 1995. Fundamentals of Microbiology. John Willey Co. New York.
5. Khan, J. A. and Dijkstra J. Plant Viruses as Molecular Pathogens, The Haworth Press, Inc.
6. Hull R. Matthews, 2004, Plant Virology, Academic Press.
7. Tortora, G.J. ; Funke, B.R. and Case C.L. , 2004, Microbiology. Pearson Education.

Bot- 503 PHYCOLOGY AND BRYOLOGY

3(2+1)

a) Phycology

Introduction, general account, evolution, classification, biochemistry, ecology and economic importance of the following divisions of algae: Chlorophyta, Charophyta, Xanthophyta, Bacillariophyta, Phaeophyta and Rhodophyta.

b) Bryology:

Introduction and general account of bryophytes, classification, theories of origin and evolution. Brief study of the classes: Hepaticopsida, Anthoceroopsida and Bryopsida.

Practical

a) Phycology:

- i. Collection of fresh water and marine algae.
- ii. Identification of benthic and planktonic algae
- iii. Section cutting of thalloid algae
- iv. Preparation of temporary slides
- v. Use of camera lucida/micrographs.

b) Bryology

Study of the following genera:

Pellia, *Porella*, *Anthoceros* and *Polytrichum*.

Books Recommended:

1. Bold, H. C. and M.J. Wynne 1985. Introduction to Algae: structure and reproduction. Prentice Hall Inc. Engle Wood Cliffs
2. Lee. R.E. 1999. Phycology. Cambridge University Press, U.K.
3. Dawson, E.Y., Halt. 1966. Marine Botany. Reinhart and Winstan, New York.
4. Chapman, V.J. and D.J. Chapman. 1983. Sea weed and their uses. McMillan and Co. Ltd. London.
5. Vashishta. B. R. 1991. Botany for degree students. Bryophytes 8th ed. S. Chand and Co. Ltd. Delhi.
6. Schofield, W.B. 1985. Introduction to Bryology. Macmillan Publishing Co. London.
7. Hussain, F. and I. Ilahi. 2004. A text book of Botany. Department of Botany, University of Peshawar.

Bot-504 Mycology and Plant Pathology

3(2+1)

Theory

a) Mycology

1. Introduction : General characters of fungi, Thallus, cell structure and ultrastructure of fungi
2. Reproduction: Asexual and sexual reproduction and reproduction structures, life cycle, haploid, heterokaryotic and diploid states.
3. Fungal Systematics: Classification of fungi into phyla with suitable examples to illustrate somatic structures, life cycle and reproduction of Myxomycota, Chytridiomycota, Zygomycota (Mucrales) Oomycota (Peronosporales), Ascomycota (Erysiphales, Pezizales), Basidiomycota (Agaricales, Polyporales, Uredinales, Ustilaginales) and Deuteromycetes.
4. Symbiotic relationships of fungi with other organisms (lichens and mycorrhiza) and their significance.
5. Importance of fungi in human affairs with special reference to Industry and Agriculture

b) Pathology

1. Introduction and classification of plant diseases.
2. Symptoms, causes and development of plant diseases
3. Loss assessment and disease control
4. Epidemiology and disease forecast
5. Important diseases of crop plants and fruit trees in Pakistan caused by fungi, e.g. damping off, mildews, rusts, smuts, shisham dieback etc.

Practical

a) Mycology

General characters and morphology of fungi. Study of unicellular and mycelial forms with septate and aseptate hyphae. Distinguishing characters of different phyla: study of suitable examples. Study of asexual and sexual reproductive structures in different groups of fungi. Study of some common examples of saprophytic, parasitic and air-borne fungi belonging to different phyla.

b) Pathology

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

Books Recommended

1. Agrios, G.N., 2002. Plant Pathology, 5th ed. Academic Press, London.
2. Ahmad, I. and Bhutta, A.R., 2004. Textbook of Introductory Plant Pathology. Book Foundation, Pakistan.
3. Alexopoulos, C.J., Mims, C.W. and Blackwell, M., 1996. Introductory Mycology, 4th ed. John Wiley & Sons.
4. Khan, A.G. and Usman, R., 2005. Laboratory Manual in Mycology and Plant Pathology. Botany Department Arid Agriculture University, Rawalpindi.
5. Mehrotra, R.S. and Aneja, K.R., 1990. An Introduction to Mycology. Wiley and Eastern Ltd., New Delhi, India.
6. Moore-Landecker, E., 1996. Fundamentals of Fungi. 4th edn. Prentice Hall Inc., New Jersey, USA.
7. Trigiano, R.N., Windham, M.T. and Windham, A.S., 2004. Plant Pathology: Concepts and Laboratory Exercises. CRC Press, LLC, N.Y.

a). Pteridophytes

Introduction, origin, history, features and a generalized life cycle.

Methods of fossilization, types of fossils, geological time scale and importance of paleobotany. First vascular plant - Rhyniophyta e.g. *Rhynia*.

General characters, classification, affinities and comparative account of evolutionary trends of the following phyla: Psilophyta (*Psilotum*), Lycophyta (*Lycopodium*, *Selaginella*), Sphenophyta (*Equisetum*), Pterophyta (*Ophioglossum*, *Dryopteris* and *Azolla/Marsilea*).

b). Gymnosperms:

Geological history, origin, distribution, morphology, classification affinities and anatomy of Cycadofillicales, Bennettitales, Ginkgoales, Cycadales and Gnetales. Origin and Evolution of seed habit. Distribution of gymnosperms in Pakistan. Economic importance of gymnosperms. An introduction to the Gondwana flora of world.

c). Palynology:

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

d). Angiosperms:

1. Origin of angiosperms
2. Evolution of fruit habit.

Practicals

1. Morphological and reproductive features of available genera.
2. Study trips to different parts of Pakistan for the collection and identification of important pteridophytes and gymnosperms.

Books Recommended:

1. Beck, C.B. 1988. Origin and Evolution of Gymnosperms, Columbia University Press, New York,
2. Foster, A.S. and Gifford, E. M. Jr. 1998. Comparative Morphology of Vascular Plants. W. H. Freeman and Co.
3. Jones, D. 1983. Cycadales of the World, Washington, DC.
4. Mauseth, J.D. 1998. An Introduction to Plant Biology, Multimedia Enhanced, Jones and Bartlett Pub. UK.
5. Moore, R.c., W.d. Clarke and Vodopich, D.S. 1998. Botany McGraw Hill Company, USA
6. Raven, P.H. Evert, R.E. and Eichhorn, S.E. 1999. Biology of Plants, W.H. Freeman and Company Worth Publishers.
7. Ray, P.M. Steeves, T.A. and Fultz, T.A. 1998. Botany Saunders College Publishing, USA.
8. Taylor, T.N. and Taylor, E.D. 1987. The Biology and Evolution of Fossil Plants, Prentice Hall.
9. Erdtman, G. 1954. An Introduction to Pollen analysis. 2nd. Ed. Ronald Press, New York.
10. Sporne, K.R. 1967. The Morphology of Gymnosperms. Hutchinson Univ. Library.
11. Stewart, W. N. and Rothwell, G.W. 1993. Paleobotany and the Evolution of Plants, University Press, Cambridge.

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PLANT SYSTEMATICS

3(2+1)

1. Introduction: Importance and relationship with other sciences, Phases of plant taxonomy. Origin and radiation of angiosperm, their probable ancestors, when, where and how did the angiosperms evolve; the earliest fossil records of angiosperms.
2. Concept of Species : What is a species? Taxonomic species, Biological species, Micro and macro species, Species aggregate., Infra specific categories
3. Speciation: Mechanism of speciation, Mutation and hybridization Geographical isolation, Reproductive isolation, Gradual and abrupt
4. Variation : Types of variation, Continuous and discontinuous variation, Clinal variation
5. Systematics and Genecology / Biosystematics: Introduction and importance, Methodology of conducting biosystematics studies, Various biosystematics categories such as ecophene, ecotype, ecospecies, coenospecies and comparium.

6. Taxonomic Evidence: Importance and types of taxonomic evidences: anatomical, cytological, chemical, molecular, palynological, geographical and embryological.
7. Nomenclature : Important rules of botanical nomenclature including effective and valid publication, typification, principles of priority and its limitations, author citation, rank of main taxonomic categories, conditions for rejecting names.
8. Classification: Why classification is necessary? Importance of predictive value. Brief history, Different systems of classification with at least one example of each (Linnaeus, Bentham and Hooker, Engler and Prantl, Bessey, Cronquist, Takhtajan, and Dahlgren).
9. Brief introduction of Numerical taxonomy.
10. General characteristics, distribution, evolutionary trends, phyletic relationships and economic importance of the following families of angiosperm:
 1. Apiaceae (Umbelliferae)
 2. Arecaceae (Palmae)
 3. Asclepiadaceae
 4. Asteraceae (Compositae)
 5. Boraginaceae
 6. Brassicaceae (Cruciferae)
 7. Cannaceae
 8. Capparidaceae
 9. Caryophyllaceae
 10. Casuarinaceae
 11. Chenopodiaceae
 12. Convolvulaceae
 13. Cucurbitaceae
 14. Cyperaceae
 15. Euphorbiaceae
 16. Fabaceae (Leguminosae)
 17. Juncaceae
 18. Lamiaceae (Labiatae)
 19. Liliaceae
 20. Magnoliaceae
 21. Malvaceae
 22. Myrtaceae
 23. Orchidaceae
 24. Papaveraceae
 25. Poaceae (Graminae)
 26. Ranunculaceae

27. Rosaceae
28. Salicaceae
29. Scrophulariaceae
30. Solanaceae
31. Trochodendraceae
32. Winteraceae

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. Preparation of permanent slides of pollen grains by acetolysis method and study of different pollen characters.
4. Study of variation pattern in different taxa.
5. Submission of properly mounted and fully identified hundred herbarium specimens at the time of examination
6. Field trips shall be undertaken to study and collect plants from different ecological zones of Pakistan.

Books Recommended

1. Ali, S.I. and Nasir, Y. 1995. Flora of Pakistan. Karachi Univ. Press, Karachi
2. Ali, S.I. and Qaiser, M. 1995 -to date. Flora of Pakistan. Karachi Univ. Press, Karachi.
3. Greuter, W., McNeill, J., Barrie, F.R., Burdet, H. M., Demoulin, V., Filguerras, T.S., Nicolson, D.H. Silva, P.C., Skog, J.E., Trehane, P., Turland, N.J. & Hawksworth, D.L., (eds.) 2000. International code of botanical nomenclature (Saint Louis Code) adopted by the Sixteenth International botanical congress St. Louis Missouri, July –August 1999. Koeltz, Königstein. (Regnum Veg. 138.)
4. Davis, P.H. & Heywood, V.H. 1963. Principles of Angiosperm Taxonomy. Oliver & Boyd, London
5. Ingrouille, M. 1992. Diversity and Evolution of Land Plants, Chapman & Hall. London
6. Nasir, E. & Ali, S.I. 1994. Flora of Pakistan. Karachi Univ. Press, Karachi.
7. Stace, C. (1992). Plant Taxonomy and Biosystematics, Edward Arnold..
8. Takhtajan, A. (1986). Flowering Plant: Origin and Dispersal, Oliver and Boyd, Edinburgh
9. Jones, S. B. and Luchsinger, A.E. 1987. Plant Systematics. McGraw Hill, Inc. New York.
10. Naik, V.N. 1988. Taxonomy of Angiosperms. Tata McGraw Hill Publishing Company, New Delhi.
11. Stussy, T.F. 1990. Plant Taxonomy, Columbia University Press, USA.

12. Jeffrey C. 1980. An Introduction to Plant Taxonomy. Cambridge University Press.UK
13. Levine, D.A. 2000. The Origin, Expansion and Demise of Plant Species. Oxford University Press.

6th Semester

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ANATOMY OF VASCULAR PLANTS

3(2+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. Meristematic tissues: classification, cytohistological characteristics, initials and their derivatives.
3. Apical meristem: Delimitation, different growth zones, evolution of the concept of apical organization. Shoot and root apices.
4. Leaf: types, origin, internal organization, development of different tissues with special reference to mesophyll, venation, bundle-sheaths and bundle-sheath extensions. Enlargement of epidermal cells.
5. Vascular cambium: Origin, structure, storied and non-storied cell types, types of divisions: additive and multiplicative; cytoplasmic characteristics, seasonal activity and its role in the secondary growth of root and stem. Abnormal secondary growth.
6. Origin, structure, development, functional and evolutionary specialization of the following tissues: Epidermis and epidermal emergences, Parenchyma, Collenchyma, Sclerenchyma, Xylem, Phloem with special emphasis on different types of woods, Periderm.
7. Secretory tissues: Laticifers (classification, distribution, development, structural characteristics, functions) and Resin Canals.
8. Anatomy of reproductive parts:
 - Flower
 - Seed
 - Fruit
9. Economic aspects of applied plant anatomy
10. Anatomical adaptations
11. Molecular markers in tree species used for wood.

Practical:

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

4. Comparative study of wood structure of Gymnosperms and Angiosperms with the help of prepared slides.

Books Recommended:

1. Dickison, W.C. 2000. Integrative plant anatomy. Academic Press, U.K.
2. Fahn, A. 1990. Plant Anatomy. Pergamon Press, Oxford.
3. Esau, K. 1960. Anatomy of Seed Plants. John Wiley, New York.
4. Metcalf, C.R. and Chalk, L. 1950. Anatomy of the Dicotyledons. Clarendon Press. Oxford.
5. Anon. Manual of Microscopic Analysis of Feeding Stuffs. The American Association of feed Microscopists.
6. Vaughan, J.G. 1990. The structure and Utilization of Oil Seeds. Chapman and Hall Ltd. London.
7. Metcalfe, C.R. 1960. Anatomy of the Monocotyledons. Gramineae. Clarendon Press, Oxford.
8. Metcalfe, C.R. 1971. Anatomy of the Monocotyledons.V. Cyperaceae. Clarendon Press, Oxford.
9. Cutler, D.F. 1969. Anatomy of the Monocotyledons. IV. Juncales. Clarendon Press, Oxford.
10. Cutler, D.F. 1978. Applied Plant Anatomy. Longman Group Ltd. England

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Genetics - I

3(2+1)

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. 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.
10. Developmental Genetics:Gene Regulation and Differentiation, Crown gall disease in plants, cancer as a developmental genetic disease.
11. Population Genetics : Gene frequencies, conservation of gene frequencies, equilibrium, Hardy-Weinberg law, factors affecting gene equilibrium.

Practical

A. Numerical problems

- 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 and Rh-factor.**
 3. **Drosophila**
 - a. Culture technique

- b. Salivary gland chromosome
- 4. **Fungal genetics**
Sacchromyces 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.

BOOKS RECOMMENDED

1. Gelvin, S.B. 2000. Plant Molecular Biology Manual. Kluwer Academic Publishers.
2. Pierca, B.A. 2005. Genetics. A conceptual approach, W. H. Freeman and Company, New York.
3. Synder, L, and Champness, W. 2004. Molecular Genetics of Bacteria. ASM Press, Washington D.C.
4. Klug, W.S. and Cummings, M.R. 1997. Concepts of Genetics, Prentice Hall International Inc.
5. Roth Well, N.V. 1997. Understanding Genetics, second edition, Oxford University Press Inc.
8. Gardner, E.J., 2004. Principles of Genetics, John Willey and Sons, New York.
6. Ringo J, 2004. Fundamental Genetics, Cambridge University Press.
7. Griffiths A.J.F: Wessler, S.R; Lewontin, R.C, Gelbart, W.M; Suzuki, D.T. and Miller, J.H., 2005, Introduction to Genetic Analysis, W.H. Freeman and Company.
8. Snyder, L and Champness W, 2003, Molecular Genetics of Bacteria, ASM Press.
- 10 Hartl, D.L. and Jones, E.W. 2005, Genetics - Analysis of Genes and Genomes, Jones and Bartlett Publishers. Sudbary, USA.
- 11 Hedrick, P.W. 2005. Genetics of Population. Jones and Bartlett Publisher, Sudbury, USA.

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PLANT BIOCHEMISTRY-I

3(2+1)

Carbohydrates: Occurrence and classification. A general account of ribose, deoxyribose, xylulose, xylose, D-glucose, D-galactose, D-mannose, cellobiose, sucrose, maltose, trehalose, pentosans, fructosans, starch, cellulose, hemicellulose, amino sugars, derived acids and alcohols, glycosides, mucilages, pectins and lignins.

Lipids: Occurrence, classification. Structure and chemical properties of fatty acids, triglycerides, phospholipids, glycolipids, sulpholipids, waxes and 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. Protein targeting. Protein folding and unfolding. Transport, storage, regulatory and receptor proteins. Protein purification. Protein sequencing. 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. DNA restriction enzymes. Properties of DNA polymerase I, II and III.

Enzymes: Nature and functions, I.U.E. classification with examples of typical groups. Isozymes, ribozymes, abzymes. Enzyme specificity. Enzyme kinetics. Nature of active site and mode of action. Allosteric enzymes and feedback mechanism.

Practicals

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

Books Recommended

1. Conn E E. and Stumpf P.K., 2002. Outlines of Biochemistry, John Wiley and Sons Inc. New York.
2. Lehninger, A L. 1998. Principles of Biochemistry. Worth Publishers Inc.

3. Voet, D., Voet J.G. and Pratt, C.W. 1998. Fundamentals of Biochemistry, John Wiley and Sons, New York.
4. Dey, P.M. and Harborne, J.B. 1997. Plant Biochemistry. Harcourt Asia PTE Ltd. Singapore.
5. Smith, E. L., Hill, R L, Lehman, R I., Lefkowitz, R J. Handler and Abraham. 2003, Principles of Biochemistry, (General Aspects). White. International Student Edition. McGraw Hill International Book Company.
6. Zubay G,..2003, Biochemistry, MacMillan Publishing Co., New York.
7. Chesworth,. J.M., Strichbury T. and Scaife., J. R. 1998. An introduction to agricultural biochemistry. Chapman and Hall, London.
8. Mckee, T. and Mckee, J.R. 1999. Biochemistry – An Introduction. WCB/McGraw-Hill, New York, Boston, USA.
9. Lea, P.J.. and Leegood, R.C. 1993. Plant Biochemistry and Molecular Biology. Wiley and Sons, New York.
10. Abdes, R.H. Frey, P.A. and Jencks W.P. 2004, Biochemistry, Jones and Bartlet, London.
11. Goodwin T.W. and Mercer, E.I. 1997. Introduction to Plant Biochemistry. Pergamon Press, Oxford.
12. Heldt, H-W. 2004. Plant Biochemistry. 3rd Edition, Academic Press, U.K.

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Plant Ecology I

3(2+1)

1. Introduction: history and recent developments in ecology
2. Soil: Nature and properties of soil (Physical and Chemical). Water in the soil-plant-atmosphere continuum. The ionic environment and plant ionic relations, Nutrient cycling. Physiology and ecology of N, S, P and K nutrition. Heavy metals (brief description), Salt and drought stress and osmoregulation. Soil erosion
3. Light and temperature: Nature of light, Factors affecting the variation in light and temperature, Responses of plants to light and temperature, Adaptation to temperature extremes,
4. Carbon dioxide: Stomatal responses, water loss and CO₂-assimilation rates of plants in contrasting environments. Ecophysiological effects of changing atmospheric CO₂ concentration. Functional significance of different pathways of CO₂ fixation. Productivity: response of photosynthesis to environmental factors, C and N balance

5. Water: Water as an environmental factor, Role of water in the growth, adaptation and distribution of plants, Water status in soil., Water and stomatal regulation, Transpiration of leaves and canopies.
6. Oxygen deficiency: Energy metabolism of plants under oxygen deficiency, Morpho-anatomical changes during oxygen deficiency, Post-anoxic stress
7. Wind as an ecological factor.
8. Fire as an ecological factor.

Practicals:

1. Determination of physico-chemical properties of soil and water.
2. Measurements of light and temperature under different ecological conditions.
3. Measurements of wind velocity.
4. Measurement of CO₂ and O₂ concentration of air and water.
5. Effect of light, temperature, moisture, salinity and soil type on germination and growth of plants.
6. Measurement of ions, stomatal conductance, osmotic potential, water potential, xylem pressure potential, leaf area and rate of CO₂ exchange in plants in relation to various environmental conditions.

Books recommended:

1. Schultz et al. 2005. Plant Ecology, Springer-Verlag
2. Bazzaz, F.A. 2004. Plants in Changing Environments: Linking Physiological, Population, and Community Ecology, Cambridge University Press
3. Chapin, F.S. et al. 2002. Principle of Terrestrial Plant Ecology, Springer-Verlag
4. Lambers, H. et al. 2002. Plant Physiological Ecology, Springer-Verlag
5. Larcher, W. 2003., Physiological Plant Ecology: Ecophysiology and Stress Physiology of Function Groups - Springer-Verlag
6. Nobel, P.S 1999, Physico-chemical and Environmental Plant Physiology, Academic Press

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Plant Physiology-I

3(2+1)

1. **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. CO₂ reduction (dark reactions) - C₃ pathway and Photorespiration, Regulation of C₃ pathway, C₄ pathway and its different forms, C₃-C₄ intermediates, CAM pathway. Methods of measurement of photosynthesis.

2. **Respiration:** Synthesis of hexose sugars from reserve carbohydrates. Mechanism of respiration- Glycolysis, Differences between cytosolic and chloroplastidic glycolysis, Oxidative decarboxylation, Krebs cycle, Regulation of glycolysis and Krebs cycle, Electron transport and oxidative phosphorylation. Aerobic and anaerobic respiration. Energetics of respiration. Pentose phosphate pathway. Glyoxylate cycle. Cyanide resistant respiration.
3. **Translocation of Food:** Pathway of translocation, source and sink interaction, materials translocated, mechanism of phloem transport, loading and unloading.
4. **Leaves and Atmosphere:** Gaseous exchange, mechanism of stomatal movement (photoactive opening; scotoactive closing and opening). Factors affecting stomatal movement.
5. **Assimilation of Nitrogen, Sulphur and Phosphorus:** The nitrogen cycle. Nitrogen fixation. Pathways of assimilation of nitrate and ammonium ions. Assimilation of sulphur and phosphorus.

Practicals

1. To determine the volume of CO₂ evolved during respiration by plant material.
2. To determine the amount of O₂ used by respiring water plant by Winkler Method.
3. Separation of chloroplast pigments on column chromatogram and their quantification by spectrophotometer.
4. To extract and separate anthocyanins and other phenolic pigments from plant material and study their light absorption properties.
5. To categorize C₃ and C₄ plants through their anatomical and physiological characters.
6. To regulate stomatal opening by light of different colours and pH.

Books Recommended

1. Dennis, D.T., Turpin, D.H., Lefebvre, D.D. and Layzell, 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, R.K.M. 2001. Environmental Physiology of Plants. Academic Press, UK.
4. Heldt, H-W. 2004. Plant Biochemistry. 3rd Edition, Academic Press, U.K.
5. Ihsan Illahi, 1991. Plant Growth, UGC Press, Islamabad.
6. Ihsan Illahi, 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. 1992. Plant Physiology. 5th Edition. Wadsworth Publishing Co. Belmont CA.
10. Taiz, L. and Zeiger, E. 2002. Plant Physiology. 3rd Edition. Sinauers Publ. Co. Inc. Calif.
11. W.B. Hopkins. 1999. Introduction to Plant Physiology. 2nd Ed. John Wiley and Sons. New York.
12. Epstein, E. and Bloom, A.J. 2004. Mineral Nutrition of Plants: Principles and Perspectives. 2nd Edition. Sinauer Associates, California, USA.
13. Kirkham, M.B. 2004. Principles of Soil and Plant Water Relations. Elsevier, Amsterdam, Netherlands.

Bot-512

RESEARCH METHODOLOGY

1(1+0)

Research Methods (planning research, various methods, analyzing results, giving reports, etc.) research process including: formulating research questions; sampling (probability and nonprobability); measurement (surveys, scaling, qualitative, unobtrusive); research design (experimental and quasi-experimental); data analysis; and, writing the research paper, the major theoretical and philosophical underpinnings of research including: the idea of validity in research; reliability of measures; and ethics

Books Recommended

1. Shank, G. D. 2002. Qualitative research : a personal skills approach. Upper Saddle River, N.J.Columbus, Ohio: Prentice Hall;Merrill/Prentice Hall.
2. Brizuela, B. M. 2000. Acts of inquiry in qualitative research. Cambridge, MA: Harvard Educational Review

3. Shank, G. D. 2001, Qualitative Research: A Personal Skills Approach
4. Paul Leedy, 2004, Practical Research : Planning and Design (8th, Edition), Jeanne Ellis Ormrod

4th Year

7th Semester

Bot-601

Molecular Biology

3(2+1)

1. Nucleic Acids: DNA-circular and superhelical DNA. Renaturation, hybridization, sequencing of nucleic acids, synthesis of DNA
2. Proteins: Basic features of protein molecules. Folding of polypeptide chain, α -helical and β -secondary structures. Protein purification and sequencing.
3. Transcription: Enzymatic synthesis of RNA, transcriptional signals
Translation: The genetic code. The Wobbling, polycistronic and monocistronic RNA. Overlapping genes.
4. Gene regulation in Eukaryotes: Differences in genetic organization and prokaryotes and eukaryotes. Regulation of transcription, initiation, regulation of RNA processing, regulation of nucleocytoplasmic mRNA transport, regulation of mRNA stability, regulation of translation, regulation of protein activity.
4. Plant Omics: Transcriptomics; DNA libraries, their construction, screening and application. Microarray of gene technology and its application in functional genomics.
5. Proteomics; structural and functional proteomics. Methods to study proteomics
Metabolomics; methods to study metabolomics; importance and application of metabolomics.
6. Bioinformatics and computational biology. Levels, scope, potential and industrial application of bioinformatics and computational biology.

Books recommended

1. Cullis, C.A. 2004. Plant Genomics and Proteomics. Wiley-Liss, New York.
2. Gibson, G. and S.V. Muse, 2002. A Premier of Genome Science, Sinauer Associates Inc. Massachusetts.

3. Gilmartin, P.M. and C. Bowler. 2002. Molecular Plant Biology. Vol. 1 & 2. Oxford University Press, UK.
4. Lodish, H. et al., 2004. Molecular Cell Biology. 5th Edition. W.H. Freeman & Co., New York.
5. Malacinski, G. M. 2003. Essentials of Molecular Biology, 4th edition. Jones and Bartlett Publishers, Massachusetts.
6. Watson, J.D. et al. 2004. Molecular Biology of the Gene. Peason Education, Singapore.
7. Ignacimuthu, S. 2005. Basic bioinformatics. Narosa Publishing House, India.
8. Weaver, R.F. 2005. Molecular Biology. Mc|Graw Hill, St. Louis.

Bot-602

PLANT BIOCHEMISTRY-II

3(2+1)

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

Practicals

1. Separation of soluble proteins by polyacrylamide gel (PAGE) electrophoresis.
2. Separation of nucleic acids by gel electrophoresis.
3. To estimate the amount of vitamin C in a plant organ (orange, apple juice).
4. To determine potential alkaloids in plants.
5. To estimate terpenoids in plants.

Books Recommended

1. Conn E. E. and Stumpf, P.K. 2002. Outlines of Biochemistry, John Wiley and Sons Inc. New York.
2. Albert L. Lehninger, 1998. Principles of Biochemistry. Worth Publishers Inc.
3. Voet, D. Voet J.G. and Pratt, C.W. 1998. Fundamentals of Biochemistry, John Wiley and Sons, New York.
4. Dey, P.M. and Harborne, J.B. 1997. Plant Biochemistry. Harcourt Asia PTE Ltd. Singapore.
5. Smith; E L., Hill; R. L., Lehman; R. I., Lefkowitz, R J. and Abraham. H. Principles of Biochemistry, (General Aspects). White. International Student Edition. McGraw Hill International Book Company.
6. Zubay. G. 2003, Biochemistry, MacMillan Publishing Co., New York.
7. Chesworth,. J.M., Strichbury T. and Scaife, J. R. 1998. An introduction to agricultural biochemistry. Chapman and Hall, London.
8. Mckee, T. and Mckee, J.R. 1999. Biochemistry – An Introduction. WCB / McGraw-Hill, New York, Boston, USA.
9. Lea, P.J.. and Leegood, R.C. 1993. Plant Biochemistry and Molecular Biology. Wiley and Sons, New York.
10. Abides, R.H., Frey P.A. and Jencks, W.P. 1992. Biochemistry, Jones and Bartlet, London.
11. Goodwin T.W. and Mercer, E.I. 1997. Introduction to Plant Biochemistry. Pergamon Press, Oxford.
12. Heldt, H-W. 2004. Plant Biochemistry. 3rd Edition, Academic Press, U.K.

A Population Ecology

1. Population structure and plant demography.: Seed dispersal, Dormancy, Seed Bank, Seed dormancy, Recruitment, Demography
2. Life history pattern and resource allocation : Density dependent and density independent factors, Resource allocation, Reproductive effort, Seed size vs seed weight, Population genetics, Evolution

B Community Ecology : Historical development of community ecology, Community concepts and attributes, Methods of sampling of plant communities, Ecological succession, Community soil-relationship, Local Vegetation, Vegetation of Pakistan, Major formation types of the world

C Ecosystem Ecology : Ecological concepts of ecosystem ,Boundaries of ecosystem? Compartmentalization and system concepts, Energy flow in ecosystem, Biogeochemical cycles: water carbon and nitrogen Case studies: any example

Practical

Determination of seed bank in various populations. Seed dispersal pattern of local populations. Demography and life history of local annual population. Study of community attributes. Sampling of vegetation including Quadrat, plotless, transect and Braun-Blanquet. Correlate soil properties with vegetation type. Field trip to study different communities located in different ecological regions of Pakistan. Slide show of the vegetation of Pakistan. Slide show of the major formations of the world. Soil physical and chemical properties

Books Recommended

1. Schultz et al. 2005. Plant Ecology, Springer-Verlag .
2. Townsend et al. (2003). Essentials of Ecology, Blackwell Publishing,
3. Chapin, F.S. et al. 2002. Principle of Terrestrial Plant Ecology, Springer-Verlag
4. Gurevitch, et al., 2002. The Ecology of Plants, Sinauer Associates, Inc.
5. Barbour M. G. et al., 1999, Terrestrial Plant Ecology, The Benjamin-Cumming Publishing Co.
6. Smith, R. L. 1998. Elements of Ecology by Harper & Row Publishers,
7. Moore P.D. and Chapman S. B. 1986. Methods in Plant Ecology, Blackwell Scientific Publication, Oxford.
8. Hussain, S. Pakistan Manual of Plant Ecology,
9. Hussain, F. 1989. Field and Laboratory Manual of Plant Ecology,

- National Academy of Higher Education. Islamabad
10. Lambers, H. et al., 2002. Plant Physiological Ecology, Springer-Verlag

Bot-604

Plant Physiology-II

3(2+1)

1. Plant Growth Regulators : Major natural hormones and their synthetic analogues. Bioassay, structure, biosynthesis, receptors, signal transduction and mode of action, transport, physiological effects of Auxins , Gibberellins, Cytokinins, Abscisic acid, Ethylene, Polyamines, Brassinosteroids, Jasmonates, and Salicylic acid.
2. Water Relations: The soil -plant -atmosphere continuum - an overview. Structure of water. Physico-chemical properties of water. Water in the soil and its potentials. Water in cell components. Absorption of water in plants (pathways and driving forces, Aquaporins,-their structure and types). Cell water relations terminology. Hofler diagram - analysis of change in turgor, water and osmotic potential with changes in cell volume. Modulus of elasticity coefficient; Hydraulic conductivity. Osmoregulation, Methods for measurement of water , osmotic and turgor potentials- Pressure chamber, psychrometry, pressure probe, pressure volume curve.
3. Plant Mineral Nutrition: Inorganic composition of plant and soil. Absorption of mineral nutrients - roots, mycorrhizae. Effect of soil pH on nutrient availability. Ion traffic into root. The nature of membrane carriers, channels and electrogenic pumps .Passive and active (primary and secondary) transports and their energetics. Essential and beneficial elements-their functions and deficiency symptoms in plants. Fertilizers and their significance in Agriculture.
4. Phytochromes: Discovery of phytochromes and cryptochromes. Physical and chemical properties of phytochromes. Distribution of phytochromes among species, cells and tissues and their role in biological processes. Phytochromes and gene expression.
5. Control of Flowering: Autonomous versus environmental regulation. Circadian rhythms. Classification of plants according to photoperiodic reaction, photoperiodic induction, locus of photoperiodic reaction and dark periods in photoperiodism. Role of photoperiodism in flowering. Biochemical signaling involved in flowering. Vernalization and its effect on flowering. Floral meristem and floral organ development. Floral organ identity genes and the ABC model.

6. Gene Regulation and Signal Transduction : Genome size and organization. Gene regulation in prokaryotes and eukaryotes. Signal transduction in prokaryotes and eukaryotes.

Practicals

1. To investigate the preferential absorption of ions by corn seedlings and potato slices.
2. To determine osmotic potential of massive tissue by freezing point depression method or by an osmometer.
3. To investigate water potential of a plant tissue by dye method and water potential apparatus.
4. Determination of K uptake by excised roots.
5. Measurement of stomatal index and conductance.
6. Qualitative determination of K content in Guard cells by Sodium cobalt nitrite method.

Books Recommended

1. Dennis, D.T., Turpin, D.H., Lefebvre, D.D. and Layzell, 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, R.K.M. 2001. Environmental Physiology of Plants. Academic Press, UK.
4. Heldt, H-W. 2004. Plant Biochemistry. 3rd Edition, Academic Press, U.K.
5. Ihsan Illahi, 1991. Plant Growth, UGC Press, Islamabad.
6. Ihsan Illahi, 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. 1992. Plant Physiology. 5th Edition. Wadsworth Publishing Co. Belmont CA.
10. Taiz, L. and Zeiger, E. 2002. Plant Physiology. 3rd Edition. Sinauer's Publ. Co. Inc. Calif.
11. W.B. Hopkins. 1999. Introduction to Plant Physiology. 2nd Ed. John Wiley and Sons. New York.

12. Epstein, E. and Bloom, A.J. 2004. Mineral Nutrition of Plants: Principles and Perspectives. 2nd Edition. Sinauer Associates, California, USA.
13. Kirkham, M.B. 2004. Principles of Soil and Plant Water Relations. Elsevier, Amsterdam, Netherlands.

Bot-605 BIODIVERSITY & CONSERVATION 3(2+1)

1. Introduction and importance of biodiversity :Species diversity, Ecological diversity, Genetic diversity, Social diversity
2. i Causes and depletion of biodiversity: Habitat loss, Habitat fragmentation, Over-exploitation, Climatic changes, Invasive species, .Seawater intrusion
 - ii The value of species
 - iii How species become endangered?
 - iv Extinction of species, present rate. Theory of mass extinction
 - v Inventory and monitoring of biodiversity
 - vi Importance of red data book
 - vii *In situ* and *ex situ* conservation of plants
 - viii Implementation of laws (protection and conservation of various taxa.
 - ix Sustainable use of biodiversity (plant wealth)
 - x Protected areas of Pakistan
 - xi Criteria for determining different categories of protected areas
 - xii Baseline study
 - xiii Impact assessment
 - xiv Management plan for protected area
 - xv IUCN categories for threatened species
 - xvi Criteria for recognizing different categories of threatened species
 - xv Gene bank management and operation
 - xvi Public awareness strategies.
 - xvii Population explosion
 - xviii Biodiversity action plan for Pakistan
 - xix Role of herbaria and botanical gardens in conservation.

Practicals

- 1 Causes of local species extinction.
- 2 Field excursion.
- 3 Data collection.
- 4 Preparation of an inventory of the flora of a given region.
- 5 To carry on base line study of any designated category.

Book Recommended

1. Bush, M.B. 1997. Ecology of a Changing Planet. Prentice Hall.
2. Cunnighum, A.B. 2001. Applied ethnobotany: People, wild plant use and conservation. Earthspan Publications.
3. Cotton, C.M. (1996). Ethnobotany Principle Application. John Wiley & Sons Chichester, UK.
4. De Klemm, C. (1990) Wild plant conservation, IUCN, Gland.
5. Dyke, F.V. (2003). Conservation Biology. Mc Graw Hill, New York.
6. Grombridge, B. & Jenkins, M. D. (2002). World Atlas of Biodiversity: Earths Living Resources in the 21st. Century, University. California Press, Berkeley.
7. Heywood, V.H. 1995. Global Biodiversity Assessment. Cambridge University Press and UNEP.
8. Krishnamurthy, K.V. 2003. A Textbook of biodiversity Science publishers Inc. Enfield, NH, USA.
9. Levine, D.A. 2000. The origin, expansion and demise of plant species. Oxford University Press.
10. Ministry of Environment, IUCN, WWF. 1998. Biodiversity Action Plan for Pakistan.
11. Primack, R.B. 1998. Essentials of conservation Biology. Sinaur Association Pub. Mass. USA.
12. Virchow, D. (1998). Conservation of Genetic Resources. Springer-Verlag, Berlin

Bot-606

Genetics II

3(2+1)

1. Recombinant DNA :Recombinant DNA Technology – Introduction, Basic Techniques, PCR and Rt PCR, Restriction enzymes, Plasmids, Bacteriophages as tools, the formation of recombinant DNA, recombinant DNA methodology, recombinant DNA and social responsibility, Site directed Mutagenesis, DNA sequencing.
2. Application of Recombinant DNA: Applications of recombinant DNA technology using prokaryotes, recombinant DNA technology in eukaryotes: An overview, transgenic yeast, transgenic plants, transgenic animals, screening for genetic diseases, identifying disease genes, DNA typing, gene therapy, genetically modified organisms and apprehensions.

3. 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. 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.
5. Mechanisms of Genetic Change II: Recombination: General homologous recombination, the holiday model, enzymatic mechanism of recombination, site-specific recombination, recombination and chromosomal rearrangements.
6. 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.
7. Human Genome Project :Strategies and application, achievement and future prospects.
8. Plant Genome Projects: Arabidopsis, achievement and future prospects. Other plant genome projects
9. Bioinformatics : Application of computational tests to the analysis of genome and their gene products
10. Bioethics : Moral, Religious and ethical concerns

Practicals

- 1 Problems relating to the theory
- 2 Isolation and separation of DNA and protein on Gel electrophoresis.
 - i) Bacterial chromosome
 - ii) Plasmid DNA (minipreps)
 - iii) Plant DNA
 - iv) Protein
- 3 DNA Amplification by PCR

Books Recommended

1. Trun, N and Trempey J.,2004, Fundamental Bacterial Genetics, Blackwell Publishing House.

2. Winnacker, E.L.2003, From Gene to Clones – Introduction to Gene Technology, Panima Publishing Corporation, New Delhi.
3. Beaycgamp T.L. and Walters L., Contemporary Issues in Bioethics, Wadsworth Publishing Company.
4. Brown, T.A.,2002 Genomes, Bios Scientific Publishers Ltd.
5. The Genome of Homo Sapiens, 2003, Cold Spring Harbor Laboratory Press.
6. Ignacimuthu, S. 2005, Basic Bioinformatics, Narosa Publishing House, India,.
7. Lwein, B. 2004, Gene VIII, Pearson Education Int..
8. Miglani, 2003, Advanced Genetics, Narosa Publishing House, India,.
9. Hartt, D. L, and Jones, E.W. 2005. Genetics, Analysis of Gene and Genomes. Jones and Bartlett Publishers, Sudbury, USA
10. Gelvin, S.B. 2000. Plant Molecular Biology Manual. Kluwer Academic Publishers.
9. Primrose, S.B., Twyman, R. M. and Old R.W. 2004. Principles of Gene Manipulation, an Introduction to Genetic Engineering (6th edition), Blackwell Scientific Publications.
10. Snyder, L and Champness W, 2003, Molecular Genetics of Bacteria, ASM Press,.
11. Wilson, J. and Hunt, T. 2004. Molecular Biology of the cell – the problems book, Garland publishing Inc.

8th Semester

Bot-607 ENVIRONMENTAL BIOLOGY 3(2+1)

1. Environment: Introduction, scope, pressure
2. Pollution: definition, classification and impact on habitats
 - i. 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.
 - ii. Water pollution: Major sources of water pollution and its impact on vegetation. prevention, control remediation, eutrophication, thermal pollution.
 - iii. Sediments pollution: fungicide, pesticides, herbicide, major sources of soil pollution and its impact. Prevention, control remediation. Heavy metal pollution. Tanneries. Hospital waste. Treatments of sewage, sludge, and polluted waters.
 - iv. Noise pollution

- v. Radiation pollution (including nuclear): Measurement, classification and effects, Principle of radiation protection, waste disposal
3. Forest: importance, deforestation, desertification and conservation
4. Ozone layer:
 - i. Formation
 - ii. Mechanism of depletion
 - iii. Effects of ozone depletion
5. Greenhouse effect: causes, impacts.
6. Human population explosion: impact on environment.
7. Impact assessment: Industrial urban, civil developments.
8. National conservation strategy: Brief review of major problems of Pakistan and their solutions.
9. Sustainable Environmental management
10. Wetlands and sanctuaries protection: The pressures, problems and solutions.
11. 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 forms different sites for the presence and diversity of organisms.
3. Effect of air pollutants on plants.
4. Visits to environmentally compromised sites and evolution of remediation 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 and 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.

MS TWO YEARS PROGRAMME

MS two years programme will include two semesters of course work and two semesters of research. In the first year 6-8 courses of 24 /30 credit hours of course work will be taught. The subjects will be based upon the expertise of the concerned university. Qualifying CGPA for research will be 2.75 and candidates have to get through the comprehensive examination.

Research will be carried out in 2nd year (3rd and 4th semester). The research work will be 6 credit hours.*

The candidates will be required to give a seminar before submitting the research thesis.

1. Molecular Biology
2. Plant Physiology and Biochemistry
3. Plant Ecology
4. Mycology
5. Stress Biology
6. Biosystematics
7. Genetics
8. Plant Pathology
9. Mycorrhiza
10. Paleobotany
11. Palynology
12. Allelopathy
13. Microbiology
14. Environmental Biology
15. Range Land Ecology
16. Biotechnology
17. Plant Tissue and Cell Culture
18. Ethnobotany
19. Genetic Engineering
20. Pollution
21. Proteomics
22. Economic Botany
23. Genomics

* As per HEC policy and international standards credit hours for MS would be 30 credit, 24 credit hours for courses and 6 credit hours for research.

24. Morphogenesis
25. Medicinal Plants
26. Phycology
27. Applied Anatomy
28. Cytogenetics
29. Taxonomy
30. Physiological Ecology
31. Microbial Ecology
32. Forensic Botany
33. Virology
34. Bacteriology
35. Plant Population Biology
36. Medical Mycology
37. Plant Breeding
38. Industrial Mycology
39. Biological clock
40. Biophysics
41. Bioinformatics
42. Bioethics
43. Bioinstrumentation
44. Biodegradation and bioremediation
45. Mushroom cultivation
46. Bryology
47. Pteridology
48. Gymnosperm
49. Plant Microbe interaction
50. Industrial Microbiology
51. Conservation Biology
52. Radiation Biology
53. Signal transduction and gene expression
54. Salinity and waterlogging
55. Plant nutrition and soil fertility
56. Biohazards and Biosafety
57. Biology of halophytes

In addition to the above-mentioned specializations, the respective universities may include any new specializations based on the expertise available at their institution.

RECOMMENDATIONS

In the last two decades there have been tremendous advances and research work in biological sciences. The subject of Botany has undergone cataclysmic changes and presently is a very dynamic and experimental science. With advances in Plant Sciences botany has established itself as a discipline, which has a key role in biotechnology and environmental biology.

The proposed scheme of studies and courses are updated and all disciplines have been given due share. Keeping the revised syllabus in view the committee unanimously recommended that:

- a. Colleges which at present are successfully running M. Sc. Program may be allowed to switch over to new system for awarding BS degree.
- b. For faculty development, it should be ensured that every university organize refresher courses for affiliated and other degree colleges as prescribed by HEC.
- c. It should be made compulsory for college faculty involved in graduate education to attend the refresher courses organized by the Universities once in three years.
- d. Adequate funds be allocated to equip general/research labs for effective teaching of the revised syllabus.
- e. Adequate funds be allocated for replenishing the departmental libraries with latest text books/scientific literature. Lack of resources to update the libraries with relevant current journals is a major obstacle in the promotion of research and improvement in educational standards.
- g. The present committee reiterated that the recommendations of the previous committees that the text books written by renowned teachers/researchers/experts of different disciplines in Botany, be published by HEC.
- h. In future any college considered for affiliation at BS level must have all basic infrastructure/staff/equipment as presented by the NCRC.
- i. There should be at least 8 teachers exclusively for BS/B.Sc. classes. Of these, at least two should be Ph. D, two M. Phil/MS and the rest be provided opportunities for improvement of qualifications.
- j. Physical facilities regarding equipment/chemicals/library as laid down at the time of affiliation must be provided on recurrent basis and such a

post-graduate department should have at least four lecture rooms, four laboratories and a sectional library.

- k. HEC should initiate and finance a programme for bright students to study special courses in other universities where better facilities and expertise are available.

The meeting ended with a vote of thanks by the Convener on behalf of all the members for the efforts HEC is making in updating the syllabus commensurate with the needs of future.