Working Paper

Fourth Meeting of Board of Studies

Center for Plant Sciences & Biodiversity,

University of Swat

Held on 27th February, 2019

MEMBERS OF BOARD OF STUDIES

1. **Prof. Dr. Hassan Sher** **(Convener)**
   Director,
   Center for Plant Sciences & Biodiversity, University of Swat

2. **Prof. Dr. Tanveer Barni** **(Member)**
   Department of Botany, University of Peshawar

3. **Prof. Dr. Muhammad Hamayun** **(Member)**
   Department of Botany, Abdul Wali Khan University, Mardan

4. **Prof. Dr. Ghulam Dastagir** **(Member)**
   Department of Botany, University of Peshawar

5. **Dr. Haidar Ali** **(Member)**
   Assistant Professor, CPS&B, University of Swat

6. **Dr. Ahmad Ali** **(Member)**
   Assistant Professor, CPS&B, University of Swat

7. **Prof. Dr. Siraj Ahmad** **(Member)**
   GPG Jahanzeb College, Saidu Sharif, Swat

8. **Dr. Asghar Ali** **(Member)**
   Associate Professor, Dr. Khan Shaheed Govt. Degree College Kabal, Swat

9. **Dr. M. Ajmal** **(Member)**
   Assistant Professor, Department of Botany, AKL College Matta

10. **Dr. Zahid Ullah** **(Member)**
    Assistant Professor, CPS&B, University of Swat

11. **Dr. Zakia Ahmad** **(Member)**
    Assistant Professor, CPS&B, University of Swat

Note: The Quorum for meeting of the Board of Studies should be one half of the members, a fraction being counted as one.

FOURTH MEETING OF BOARD OF STUDIES

ATTENDANCE SHEET

Name	Signature
Dr. Hassan Sher (Convener) Director, CPS&B, University of Swat	
Prof. Dr. Tanvir Barni (Member) Department of Botany, University of Peshawar	ABSENT
Prof. Dr. Muhammad Hamayun (Member) Department of Botany, Abdul Wali Khan University, Mardan	
Prof. Dr. Ghulam Dastagir (Member) Department of Botany, University of Peshawar	27/2/19
Dr. Haidar Ali (Member) Assistant Professor, CPS&B, University of Swat	
Dr. Ahmad Ali (Member) Assistant Professor, CPS&B, University of Swat	
Prof. Dr. Siraj Ahmad (Member) GPG Jahanzeb College, Saidu Sharif, Swat	
Dr. Asghar Ali (Member) Associate Professor, Dr. Khan Shaheed Govt. Degree College Kabal, Swat	
Dr. M. Ajmal (Member) Assistant Professor, Department of Botany, AKL College Matta	
Dr. Zahid Ullah, (Member) Assistant Professor, CPS&B, University of Swat.	
Dr. Zakia Ahmad (Member) Assistant Professor, CPS&B, University of Swat	ABSENT

Verified by Director

Minutes of 4th Meeting of the Board of Studies for Botany
Centre for Plant Sciences and Biodiversity
University of Swat

Fourth meeting of the Board of Studies (BoS) for Botany, Centre for Plant Sciences and Biodiversity (CPS&B) was held on February 27, 2019 at 10:00 AM in the **Committee Room, Main Administration Block, F-Sector, Kanju, University of Swat,** to discuss agenda item already circulated among the respected members.

The BoS comprised of the following members:-

1. **Prof. Dr. Hassan Sher** **(Convener)**
   Director, Centre for Plant Sciences and Biodiversity, University of Swat

2. **Prof. Dr. Tanveer Barni** **(Member)**
   Department of Botany, University of Peshawar

3. **Prof. Dr. Muhammad Hamayun** **(Member)**
   Department of Botany, Abdul Wali Khan University, Mardan

4. **Prof. Dr. Ghulam Dastagir** **(Member)**
   Department of Botany, University of Peshawar

5. **Dr. Haidar Ali** **(Member)**
   Assistant Professor, CPS&B, University of Swat

6. **Dr. Ahmad Ali** **(Member)**
   Assistant Professor, CPS&B, University of Swat

7. **Prof. Dr. Siraj Ahmad** **(Member)**
   GPG Jehanzeb College, Saidu Sharif, Swat

8. **Dr. Asghar Ali** **(Member)**
   Associate Professor, Dr. Khan Shaheed Govt. Degree College Kabal, Swat

9. **Dr. M. Ajmal** **(Member)**
   Assistant Professor, Department of Botany, AKL College Matta

10. **Dr. Zahid Ullah** **(Member)**
    Assistant Professor, CPS&B, University of Swat

11. **Dr. Zakia Ahmad** **(Member)**
    Assistant Professor, CPS&B, University of Swat

All members except Prof. Dr. Tanveer Barni and Dr. Zakia Ahmad attended the meeting.

The meeting was chaired by Prof. Dr. Hassan Sher, Director, CPS&B, University of Swat and was started with recitation of the Holy Quran. The Director welcomed all members of the BoS and thanked them for sparing valuable time out of their busy schedule to attend the meeting.

After initial remarks and briefing on 3rd meeting of the BoS held on February 19, 2016, the Director opened the forum for discussion on agenda items one by one.

1) Agenda Item No. I.

Subject: **Approval of Scheme of studies for BS Botany four years Program**

Recommendations: The semester coordinator for BS Botany, Miss. Shazia was asked to present agenda items. After thorough discussion, all the members of Board of Studies unanimously recommended the presented scheme of studies. Furthermore, it was recommended that the following minor changes may be incorporated in the scheme of studies:

1. It was unanimously recommended that uniform Course Codes of all the offered courses of BS Botany may be adopted as per University of Swat approved format.
2. As per HEC curriculum guidelines a minimum of 124 credit hours are required for award of BS Degree in Botany, whereas, for taking admission in M.Phil Botany, a student must pass 130 credit hours in BS Botany. It was, therefore, unanimously recommended that a minimum of 130 Credit Hours must be included in BS Botany Syllabus.
3. In the General-II course i.e. "Introduction to Environmental Science" Credit Hour were erroneously written as 3 (3+0), which is being corrected as 3 (2+1).
4. Repetition of topics / course contents were identified and subsequently removed from the course i.e. English-I (ENG-106), English-II (ENG-156), Introduction to Statistics (BOT-154) and Biostatistics (BOT-251).
5. Title of Optional Course i.e. "Medicinal Plants" (BOT-504) was changed to "Pharmacognosy" (BOT-504).
6. After thread bar deliberation it was unanimously recommended that only those students who obtain a CGPA of 3.0 out of 4.0 will be allowed to opt Research Project / Thesis / Internship or Optional Paper at BS level.
7. Reshuffling of courses among semesters is allowed in conditions like unavailability of subject teachers etc.
8. BoS recommended approval of modified scheme of studies for BS Botany degree program (Annex-I).

2) Agenda Item No. II:

Subject: **Approval of the scheme of studies and courses for M.Sc. (Botany) 2 years program**

Recommendations: The semester Coordinator for M.Sc. Botany, Dr. Zahid Ullah was asked to present agenda items. After thorough discussion all the members of the BoS recommended the scheme of studies, course titles and course contents of M.Sc. Botany (2-year) program for further approval of the Competent Authority. The following minor changes were recommended:-

1. As per Uniform University approved course code policy, the course codes were changed, starting from 501, 551, 601 and 651 for semester I, II, III and IV respectively.
2. Course outcomes were incorporated and recommended unanimously by BoS.
3. Minor changes in course contents, updating bibliography and deletion of repeated contents were approved.
4. It was unanimously recommended that minimum CGPA for opting research thesis at M.Sc Botany may be 03 out of 04.
5. The BoS also recommended that the elective course i.e. "Medicinal Plants" Bot-655 may be opted in place of "Applied Mycology Bot-657" in semester 4th.
6. Reshuffling of courses between semesters is allowed in conditions like unavailability of subject teachers etc.
7. BoS unanimously recommended the modified scheme of studies for M.Sc. Botany degree program (Annex-II).

3) Agenda Item No. III

Subject **Approval of scheme of studies and courses for M.Phil. and Ph.D. (Botany)**

Recommendation: The semester Coordinator for M.Phil. and Ph.D. (Botany), Dr. Ahmad Ali was asked to present agenda items. After thorough discussion on various M.Phil. and Ph.D. courses, BoS recommended the presented courses and titles for further approval. Furthermore, the scheme of studies for M.Phil and Ph.D degree program was also recommended for approval. The already taught courses to M.Phil. and Ph.D. were recommended/approved as such, however, the following minor changes were proposed for incorporation in future:

1. As per HEC guidelines, it was recommended that the course codes for M.Phil. Botany may start from BOT-701, while course codes for Ph.D. Botany may start from BOT-801.
2. It was recommended that since majority of the courses in M.Phil./Ph.D. Botany are advance courses, therefore, definitions should be avoided/minimized and recent advancements in concerned subjects may be added in the course contents.
3. It was recommended that course titled "Mushroom Biology" (BOT-824) may be included in the list of optional courses for M.Phil./Ph.D. Botany degree program.
4. It was recommended that title of the course "Research Methodology" may be changed to "Research Techniques and Report Writing" and the improved course contents are recommended for further approval.
5. In the course titled "Advanced Pharmacognosy" (BOT-714), it was recommended that text book "Teaching practicum in Pharmacognosy" by Vladimir- Knezevic may be added to the recommended books.
6. It was recommended that Seminar-I (credit hour 01) and Intensive Studies (credit hour 01) may be included in the syllabus/course work of M.Phil. Botany.
7. It was also recommended that Seminar-II (credit hour 01) may be included in the syllabus/course work of Ph.D. Botany.

8. The BoS recommended the scheme of studies for M.Phil. and Ph.D. Botany degree program for further approval. The BoS also recommended approval of all courses, course codes and titles of the subjects (Annex-III and IV) for M.Phil. and Ph.D. Botany, respectively.
9. Updated list of National and International examiners for thesis evaluation was unanimously recommended by all the members of BoS. (Annex-V and VI).

Any other item with the permission of the Chair:-

1. Keeping in view the diverse bioecological nature of the region, BoS Unanimously recommended that Center for Plant Sciences and Biodiversity may offer M.Phil and Ph.D Degree Programs in Biodiversity in the upcoming Spring Semester, 2020 after fulfillment all codal formalities.

The meeting was adjourned with vote of thanks to and by the Chair.

ANNEX-I

TEMPLATE FOR 4-YEAR BS DEGREE PROGRAMME

SR.	CATEGORIES	NO. OF COURSES MIN– MAX	CREDIT HOURS MIN – MAX
1.	Compulsory Requirement (No Choice)	9 – 9	25 – 25
2.	General Courses to be chosen from other departments	7 – 8	21 – 24
3.	Discipline Specific Foundation Courses	9 – 10	30 – 33
4.	Major Courses including research project / Internship	11 – 13	36 – 42
5.	Electives within the major	4 – 4	12 – 12
	Total	**40 – 44**	**124 – 136**

- Total numbers of Credit hours 124-136
- Duration 4 years
- Semester duration 16-18 weeks
- Semesters 8
- Course Load per Semester 12-18 Cr hr
- Number of courses per semester 4-6

LAYOUT FOR BS BOTANY (4 – YEAR PROGRAMME)

9-Compulsory Courses (25 Cr. H)		**7-8 General courses 21-24 Cr. H**	
Subjects	**Cr.Hr.**	**Subjects**	**Cr.Hr**
1. ENGLISH I (Functional English)	3	1. General Course-I ***	3
2. ENGLISH II(Communication Skill)	3	2. General Course-II***	3
3. ENGLISH III (Technical Report Writing & presentation skills)	3	3. General Course-III ***	3
		4. General Course-IV ***	3
	3	5. General Course-V ***	3
4. ENGLISHVI*	2	6. General Course-VI ***	3
5. PAKISTAN STUDIES	2	7. General Course-VII ***	3
6. ISLAMIC STUDIES / ETHICS	3	8. General Course-VIII***	3
7. MATHEMATICS	3		
8. BIOSTATISTICS	3		
9. INTRODUCTION TO COMPUTER			
	25		**24**

Discipline Specific Foundation Courses 9-10 courses (30-33 Cr.H)		**Major courses, 11-13 (36-42 Cr.H)**	
Subjects	**Cr. Hr**	**Subjects**	**Cr. Hr**
1. Diversity of Plants	4	1. Phycology & Bryology	3
2. Plant Systematics, Anatomy & Development	4	2. Mycology & Plant Pathology	3
		3. Plant Systematics	3
3. Cell Biology, Genetics & Evolution	4	4. Genetics-I	3
		5. Plant Biochemistry-I	3
4. Plant Physiology & Ecology	3	6. Plant Physiology-I	3
5. Biodiversity & Conservation	3	7. Molecular Biology	3

6. Bacteriology & Virology 7. Diversity of Vascular Plants 8. Plant Anatomy 9. Plant Ecology-I	3 3 3 3	8. Plant Biochemistry-II 9. Plant Ecology-II 10. Plant Physiology-II 11. Genetics II 12. Environmental Biology	3 3 3 3 3
	32		**36**

4 Elective Courses within the major including research project/internship	
4 Courses	
12 Credit Hours	
Subject	Cr. Hr
1. Elective-I / Research Project / Internship/ *Optional	3
2. Elective-II University Option	3
3. Elective-III Research Project / Internship/ *Optional	3
4. Elective-IV University Option	3
Total	**12**

- University has the option to recommend any other course in lieu of English IV
- University may recommend any other course in lieu of Mathematics
- To be chosen from list of General Courses

SCHEME OF STUDIES FOR BS FOUR YEARS PROGRAM

Semester	Course Codes	Course Titles	Course Nature	Theory	Lab	Cr. Hrs.
First	**BOT-101**	**Diversity of Plants**	Foundation-I	3	1	4
	ENV-102	**Introduction to Environmental Sciences**	General-II	2	1	3
	ZOOL-103	**Principle of Animal Life-1**	General-I	2	1	3
	MATH-104	**Mathematics-1 (Algebra)**	Compulsory	3	0	3
	PS-105	**Pakistan Studies**	Compulsory	2	0	2
	ENG-106	**English-I (Functional English)**	Compulsory	3	0	3
	Total Cr. H. of Semester			**15**	**3**	**18**
Second	**BOT-151**	**Plant Systematic, Anatomy and Development/ Embryology**	Foundation-II	3	1	4
	GEO-152	**Introduction to Geography of Pakistan**	General-IV	2	1	3
	ZOOL-153	**Principle of Animal Life-II**	General-III	2	1	3
	BOT-154	**Introduction to Statistics**	Compulsory	3	0	3
	ISL-155	**Islamic Studies**	Compulsory	2	0	2
	ENG-156	**English-II (Communication Skills)**	Compulsory	3	0	3
	Total Cr. H. of Semester			**15**	**3**	**18**
Third	**BOT-201**	**Cell Biology, Genetics and Evolution**	Foundation-III	3	1	4
	CHE-202	**Chemistry-I (Inorganic Chemistry)**	General-VI	2	1	3
	ZOOL-203	**Animal Diversity-I**	General-V	2	1	3
	CM-204	**Introduction to Computer**	Compulsory	2	1	3
	ENG-205	**English-III (Technical Report Writing & Presentation Skill)**	Compulsory	3	0	3
	Total Cr. H. of Semester			**12**	**4**	**16**
Fourth	**BOT-251**	**Biostatistics**	Compulsory	2	1	3
	ZOOL-252	**Animal Diversity-II**	General-VII	2	1	3
	BOT-253	**Plant Physiology and Ecology**	Foundation-IV	3	1	4
	BOT-254	**Biodiversity and Conservation**	Foundation-V	3	1	4
	BOT-255	**Plant Systematics**	Major-III	2	1	3
	Total Cr. H. of Semester			**12**	**5**	**17**
Fifth	**CHE-301**	**Chemistry-II (Organic Chemistry)**	General-VIII	2	1	3
	BOT-302	**Bacteriology and Virology**	Foundation-VI	2	1	3
	BOT-303	**Phycology and Bryology**	Major-I	2	1	3
	BOT-304	**Mycology and Plant Pathology**	Major-II	2	1	3
	BOT-305	**Diversity of Vascular Plants**	Foundation-VII	2	1	3
	Total Cr. H. of Semester			**10**	**5**	**15**
Sixth	**BOT-351**	**Genetics-I**	Major-IV	2	1	3
	BOT-352	**Plant Biochemistry-I**	Major-V	2	1	3
	BOT-353	**Plant Ecology-I**	Foundation-IX	2	1	3
	BOT-354	**Plant Physiology-I**	Major-VI	2	1	3
	BOT-355	**Research Methodology**	Elective-I	2	1	3
	Total Cr. H. of Semester			**10**	**5**	**15**
Seventh	**BOT-401**	**Molecular Biology**	Major-VII	2	1	3
	BOT-402	**Plant Biochemistry-II**	Major-VIII	2	1	3
	BOT-403	**Plant Ecology-II**	Major-IX	2	1	3
	BOT-404	**Plant Anatomy**	Foundation-VIII	2	1	3
		*** University Option (Elective Courses)**	Elective IV-X	2	1	3

	----------	**RESEARCH PROJECT/INTERNSHIP/ OPTIONAL PAPER**	Elective-II	2	1	3
	Total Cr. H. of Semester			**12**	**6**	**18**
Eighth	**BOT-451**	**Plant Physiology-II**	Major-X	2	1	3
	BOT-452	**Genetics-II**	Major-XI	2	1	3
	BOT-453	**Environmental Biology**	Major-XII	2	1	3
		RESEARCH PROJECT/INTERNSHIP/ OPTIONAL PAPER	Elective-III	2	1	3
		*** University Option (Elective Courses)**	Elective IV-X	2	1	3
	Total Cr. H. of Semester			**10**	**5**	**15**
Grand total of Cr. Hours						**132**

*Semester Coordinator in consultaion with the Head of Department based on requirement and availability of relevant teacher(s), will ofter the course(s) from Elective-II to Elective-VII.

Subject Specific Elective Courses		
Course Nature	**Course Title (Course Code)**	**Credit hours**
ELECTIVE-IV	Palynology (BOT-501)	2+1 (3)
ELECTIVE-V	Plant Pathology (BOT-502)	2+1 (3)
ELECTIVE-VI	Advanced Molecular Biology (BOT-503)	2+1 (3)
ELECTIVE-VII	Pharmacognosy (BOT-504)	2+1 (3)
ELECTIVE-VIII	Advanced Plant Systematics (BOT-505)	2+1 (3)
ELECTIVE-IX	Applied Mycology (BOT-506)	2+1 (3)
ELECTIVE-X	Plant Breeding (BOT-507)	2+1 (3)

DETAIL OF COURSES

FOR BS (4 – YEAR) IN BOTANY

1st Year

1st Semester

Title of the Course: **DIVERSITY OF PLANTS**
Course Code: **BOT-101**
Credit Hours: **4 (3+1)**
Course Nature: **Foundation-I**

Objectives of the course:
To introduce the students to the diversity of plants and their structures and significance.

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

1. Viruses (RNA and DNA types) with special reference to TMV;
2. Bacteria and Cyanobacteria (Nostoc, Anabaena, Oscillatoria) with reference to biofertilizers, pathogenicity and industrial importance;
3. Algae (Chlamydomonas, Spirogyra, Chara, Vaucheria, Pinnularia, Ectocarpus, Polysiphonia)
4. Fungi (Mucor, Penicillium, Phyllactinia, Ustilago, Puccinia, Agaricus), their implication on crop production and industrial applications.
5. Lichens (Physcia)
6. Bryophytes: Riccia, Anthoceros, Funaria
7. Pteridophytes: Psilopsida (Psilotum), Lycopsida (Selaginella), Sphenopsida (Equisetum), Pteropsida (Marsilea)
8. Gymnosperms
    i. Cycas
    ii. Pinus
    iii. Ephedra
9. Angiosperms: Monocot (Poaceae), Dicot Solanaceae)

Lab Outline:

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

Recommended Books:

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
9. Marti. J. Ingrouille & Plant: Diversity and Evolution. 2006 CUP
10. Taylor, T. N. & Taylor, E. D. 2000. Biology and Evolution of Fossil Plants. Prentice Hall. N. Y.
11. Hussain, F. 2012. A Text Book of Botany and Biodiversity. Pak Book Empire.

Journals / Periodicals:
Pakistan Journal of Botany, American Journal of Botany, Canadian Journal of Botany, Annals of Botany.

Course Outcome: To introduce the diversity of plants, their structures and significance.

Title of the Course: INTRODUCTION TO ENVIRONMENTAL SCIENCES

Course Code: ENV-102
Credit Hours: **3 (2-1)**
Course Nature: General-II

Objectives of the course:
To introduce the students with basic concepts and the history of development of Environmental Science as an academic discipline, its importance in human life, its interdisciplinary nature and provide students with an understanding of the relationships between different components of environment, current global, and national environmental challenges for sustainable development.

Course Outlines

1. Introduction: basic concepts, history, nature and scope of Environmental Science and its contribution to society.
2. Different aspects of environment: physical, ecological, socio-economic, ethical, philosophical.
3. Major components of environment: physico-chemical, biological and social, and their relationships with various environmental factors.
4. Human environment and its problems: global, national, regional.
5. Environmental challenges for sustainable development: current and future trends in population growth, environmental pollution, development in industry and agriculture, urbanization, poverty and resource depletion.

Lab Outline:

i. A: Study of various soil profiles and determination of their moisture contents.
ii. B: Analyzing the quality of different water samples by physical and chemical tests.
iii. Visit to local areas - river /forest/ Horticulture farm/ grassland /catchments etc. to document components of ecosystem.
iv. Measurement of environmental factors on land, water and air

Recommended Books:

1. Botkin, D.B & Keller, E.A *Environmental Science: Earth as a Living Planet*. 6th Ed. John Wiley & Sons, 2007.
2. McKinney, M.L., Schoch, R.M. & Yonavjak. *Environmental Science: systems and solutions,* L. 4th Ed. Jones & Bartlett Publishers, 2007
3. Wright, R.T. & Nebel, B.J *Environmental Science: Toward a Sustainable Future,*. 10th Ed. Pearson Educational, 2007.
4. Miller, G., Thomson *Environmental Science: working with the Earth.* Learning, 2002.

Course Outcome:
To introduce the basic concepts and the history of development of Environmental Science as an academic discipline, its importance in human life, its interdisciplinary nature and provide an understanding of the relationships between different components of environment, current global, and national environmental challenges for sustainable development.

Title of the course: PRINCIPLES OF ANIMAL LIFE-I

Course Code: ZOOL-103
Credit Hours: 3 (2+1)
Course Nature: General-I

Aims and Objectives*:*

The course aims to impart knowledge and understanding of:

i. The concept and status of Zoology in life sciences.
ii. The common processes of life through its chemistry, biochemical and molecular processes.
iii. The structure and function of cell organelle and how common animal cell diversified in various tissues, organs and organ systems.
iv. Biochemical mechanisms eventually generating energy for animal work.
v. Animals and their relationship with their environment.

Course Contents

1. **Place of Zoology in Science**
   A one-world view: genetic unity, the fundamental unit of life, evolutionary oneness and the diversity of life, environment and world resources; what is zoology? The classification of animals; the scientific method.
2. **The Chemical Basis of Animal Life**
   Atoms and elements: building blocks of all matter; compounds and molecules: aggregates of atoms; acids, bases, and buffers; the molecules of animals: fractional account of carbohydrates, lipids, proteins, nucleotides and nucleic acids based on their structural aspects.
3. **Cells, Tissues, Organs, and Organ System of Animals** Structure and functions of cell membranes; various movements across membranes; cytoplasm, organelles, and cellular components: functional account of ribosomes, endoplasmic reticulum, golgi apparatus, lysosomes, mitochondria, cytoskeleton, cilia and flagella, centrioles and microtubules, and vacuoles based on their structural aspects. The nucleus: nuclear envelope, chromosomes and nucleolus. Tissues: diversity in epithelial tissue, connective tissue, muscle tissue and nervous tissue to perform various functions. Structural integrations for functions in organs and organ systems.
4. **Energy and Enzymes: Life's Driving and Controlling Forces** Energy and the laws of energy transformation; activation energy; enzymes: structure, function and factors affecting their activity; cofactors and coenzymes; ATP: how cells convert energy? An overview.
5. **How Animals Harvest Energy Stored in Nutrients**
   Glycolysis: the first phase of nutrient metabolism; fermentation: "life without oxygen"; aerobic respiration: the major source of ATP; metabolism of fats and proteins; control of metabolism; the metabolic pool.
6. **Ecology I: Individuals and Populations**
   Animals and their abiotic environment; populations; interspecific interactions.

7. **Ecology II: Communities and Ecosystems**
   Community structure and diversity; ecosystems; ecosystems of the earth; ecological problems; human population growth, pollution, resource depletion and biodiversity.

Lab Outline:

i. Tests for different carbohydrates, proteins and lipids.
   Note: Emphasis on the concept that tests materials have been ultimately obtained from living organisms and constituted their body.
ii. Study of the prepared slides of epithelial tissue (squamous, cuboidal, columnar), connective tissue (adipose, cartilage, bone, blood), nervous tissue and muscle tissue (skeletal, smooth and cardiac).
   Note: *Prepared microscopic and/or projection slides and/or CD ROM computer projections must be used.*
iii. Plasmolysis and deplasmolysis in blood.
iv. Protein digestion by pepsin.
v. Ecological notes on animals of a few model habitats.
vi. Field observation and report writing on animals in their ecosystem (a terrestrial and an aquatic ecosystem study).

Recommended Books:

1. Campbell, N.A. BIOLOGY, 6th Edition. 2002. Menlo Park, California: Benjamin/Cummings Publishing Company, Inc.
2. Hickman, C.P., Roberts, L.S. and Larson, A. INTEGRATED PRINCIPLES OF ZOOLOGY, 12th Edition (International), 2004. Singapore: McGraw Hill.
3. Hickman, C.P. and Kats, H.L., LABORATORY STUDIES IN INTEGRATED PRINCIPLES OF ZOOLOGY. 2000. Singapore: McGraw Hill.
4. Kent, G.C. and Miller, S. COMPARATIVE ANATOMY OF VERTEBRATES, 2001. New York: McGraw Hill. Miller, S.A. and Harley, J.B. ZOOLOGY, 6th Edition (International), 2005. Singapore: McGraw Hill.
5. Miller, S.A. GENERAL ZOOLOGY LABORATORY MANUAL. 5th Edition (International), 2002. Singapore: McGraw Hill.
6. Molles, M.C. ECOLOGY: CONCEPTS AND APPLICATIONS. 6th Edition. 2005. McGraw Hill, New York, USA.
7. Odum, E. P. FUNDAMENTALS OF ECOLOGY. 3rd Edition. 1994.
8. Pechenik, J.A. BIOLOGY OF INVERTEBRATES, 5th Edition (International), 2000. Singapore: McGraw Hill.
9. Slingby, D. and Cook, C., PRACTICAL ECOLOGY. 1986. McMillan Education Ltd. UK.

Course Outcome:

At the end of this course, the students will be able to understand the basic knowledge of animal life.

Title of the course: MATHEMATICS- I (ALGEBRA)
Course Code: MATH-104
Credit Hours: 3 (3 + 0)
Course Nature: Compulsory

Objectives of the Course:
To prepare the students, not majoring in mathematics, with the essential tools of algebra to apply the concepts and the techniques in their respective disciplines.

Course Outline:

1. *Preliminaries:* Real-number system, complex numbers, introduction to sets, set operations, functions, types of functions. *Matrices:* Introduction to matrices, types, matrix inverse, determinants, system of linear equations, Cramer's rule.
2. *Quadratic Equations:* Solution of quadratic equations, qualitative analysis of roots of a quadratic equation, equations reducible to quadratic equations, cube roots of unity, relation between roots and coefficients of quadratic equations.
3. *Sequences and Series:* Arithmetic progression, geometric progression, harmonic progression. *Binomial Theorem:* Introduction to mathematical induction, binomial theorem with rational and irrational indices. *Trigonometry:* Fundamentals of trigonometry, trigonometric identities.

Recommended Books:

1. Dolciani M. P, Wooton W, Beckenback E F, Sharron S, *Algebra 2 and Trigonometry*, 1978, Houghton & Mifflin, Boston.
2. Kaufmann J. E, College *Algebra and Trigonometry*, 1987, PWS-Kent Company, Boston
3. Swokowski E. W., *Fundamentals of Algebra and Trigonometry* (6^{th} edition), 1986
   PWS-Kent Company, Boston

Student's Output: To understand majoring in mathematics, with the essential tools of algebra to apply the concepts and the techniques in their respective disciplines.

Title of the course: PAKISTAN STUDIES

Course Code: PS-105
Credit Hours: 2 (2+0)
Course Nature: Compulsory

Objectives of the Course:

i. Develop vision of historical perspective, government, politics, contemporary Pakistan,
ideological background of Pakistan.
ii. Study the process of governance, national development, issues arising in the modern age
and posing challenges to Pakistan.

Course Outline

1. Historical Perspective

1. Ideological rationale with special reference to Sir Syed Ahmed Khan, Allama Muhammad Iqbal and Quaid-i-Azam Muhammad Ali Jinnah.
2. Factors leading to Muslim separatism
3. People and Land
4. Indus Civilization ii. Muslim advent
iii. Location and geo-physical
features.

2. Government and Politics in Pakistan

1. Political and constitutional phases:

i. 1947-58
ii. 1958-71
iii. 1971-77
iv. 1977-88
v. 1988-99
vi. 1999 onward

3. Contemporary Pakistan

a. Economic institutions and issues
b. Society and social structure
c. Ethnicity
d. Foreign policy of Pakistan and challenges
e. Futuristic outlook of Pakistan

Recommended Books:

1. Afzal, M. Rafique. *Political Parties in Pakistan,* Vol. I, II & III. Islamabad: National Institute of Historical and cultural Research, 1998.
2. Akbar, S. Zaidi. *Issue in Pakistan's Economy.* Karachi: Oxford University Press, 2000.
3. Amin, Tahir. *Ethno - National Movement in Pakistan,* Islamabad: Institute of Policy Studies, Islamabad.
4. Aziz, K. K. *Party, Politics in Pakistan,* Islamabad: National Commission on Historical and Cultural Research, 1976. *State & Society in Pakistan,* The Macmillan Press Ltd 1980.
5. Burke S.M. and Lawrence Ziring. Pakistan's Foreign policy: An Historical analysis. Karachi: Oxford University Press, 1993.

6. Haq, Noor ul. *Making of Pakistan: The Military Perspective.* Islamabad: National Commission on Historical and Cultural Research, 1993.
7. Mehmood, Safdar. *Pakistan Political Roots & Development.* Lahore, 1994.
8. Mehmood, Safdar. *Pakistan Kayyun Toota,* Lahore: Idara-e-Saqafat-e-Islamia, Club Road, nd.
9. Muhammad Waseem, Pakistan Under Martial Law, Lahore: Vanguard, 1987.
10. Sayeed, Khalid Bin. *The Political System of Pakistan.* Boston: Houghton Mifflin, 1967.
11. Wilcox, Wayne.*The Emergence of Banglades.,* Washington: American Enterprise, Institute of Public Policy Research, 1972.
12. Ziring, Lawrence. *Enigma of Political Development.* Kent England: WmDawson & sons Ltd, 1980.
13. Zahid, Ansar. *History & Culture of Sindh.* Karachi: Royal Book Company, 1980.

Course Outcome:

At the end of this course, the students will developed vision of historical perspective, government, politics, contemporary Pakistan, ideological background of Pakistan.

Title of the course: ENGLISH-I (Functional English)

Course Code: ENG-106

Credit hours: 3(3+0)

Course Nature: Compulsory

Objectives of the Course:

To enhance language skills and develop critical thinking

Course Contents:

Basics of Grammar, Parts of speech and use of articles, Sentence structure, Active and passive voice, Practice in unified sentence, Analysis of phrase, clause and sentence structure, Transitive and intransitive verbs, Punctuation and spelling

Comprehension

Answers to questions on a given text

Discussion

General topics and every day conversation (topics for discussion to be at the discretion of the teacher keeping in view the level of students)

Listening

To be improved by showing documentaries/films carefully selected by subject teachers)

Translation skills

Urdu to English

Paragraph writing

Topics to be chosen at the discretion of the teacher

Presentation skills

Introduction

Note: Extensive reading is required for vocabulary building

Recommended Books:

1. **Functional English**

a) Grammar

1. Practical English Grammar by A. J. Thomson and A. V. Martinet. Exercises 1. Third Edition. Oxford University Press. 1997. ISBN 0194313492

2. Practical English Grammar by A. J. Thomson and A. V. Martinet. Exercises 2. Third edition.Oxford University Press. 1997. ISBN 0194313506

b) Writing

1. Writing. Intermediate by Marie-Christine Boutin, Suzanne Brinand and FrancoiseGrellet. Oxford Supplementary Skills. Fourth Impression 1993. ISBN 0 19 435405 7 Pages 20-27 and 35-41.

c) Reading/Comprehension

1. Reading. Upper Intermediate. Brain Tomlinson and Rod Ellis. Oxford Supplementary Skills. Third Impression 1992. ISBN0 19 453402

Course Outcome: At the end of this course, english language skills and critical thinking of the students will improved

1st Year

2nd Semester

Title of the Course: **PLANT SYSTEMATICS, ANATOMY AND DEVELOPMENT/EMBRYOLOGY**

Course Code: **BOT-151**

Credit Hours: **4 (3+1)**

Course Nature: **Foundation-II**

Objectives of course:

To understand: 1. various systems of classification, identification and nomenclature of Angiosperms, 2- Structures and functions of tissues and organs at embryonic level.

Course Outline:

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). Vienna 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
iv. Rosaceae
v. Euphorbiaceae
vi. Cucurbitaceae
vii. Lamiaceae (Labiatae)
viii. Apiaceae (Umbelliferae)
ix. Asteraceae
X. Liliaceae (Sen.Lato)

Anatomy

i. Cell wall: structure and chemical composition
ii. Concept, structure and function of various tissues like: Parenchyma, Collenchyma, Epidermis (Stomata, Trichomes), Xylem, Phloem
iii. Meristem: types, stem and root apices Vascular cambium Structure and development of root, stem and leaf. Primary and secondary growth of dicot stem, periderm
Characteristics of wood: diffuse porous and ring porous, sap and heart wood, soft and hard wood, annual rings.

Development/Embryology

i. Structure of Ovule Megasporogenesis Megagametophyte
ii. Endosperm formation
iii. Parthenocarpy
iv. Polyembryony

Lab Outline:

Plant Systematics

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.
3. Field trips shall be undertaken to study and collect local plants.
4. Students shall submit 40 fully identified herbarium specimens.

Anatomy and Embryology

1. Study of stomata and 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.
5. Anatomy of germinating seeds
6. Study of pollens

Recommended Books:

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.
5. Stuessy, T. F. 1990. Plant Taxonomy. Columbia University Press, USA.
6. Lawrence, G. H. M. 1951 Taxonomy of Vascular Plants. MacMillan & Co. New York.
7. Panday, B. P. 2004. A textbook of Botany (Angiosperms). S. Chand and Co. New Delhi.
8. Raymond E, S. E. Eichhorn. 2005. Esau's Plant Anatomy. Meristems cells and tissues of the plant body, 3rd Ed. John Wiley & Sons. Inc.
9. Fahn, A. 1990. Plant Anatomy. Pergamon Press, Oxford.
10. Esau, K. 1960. Anatomy of Seed Plants. John Wiley, New York.
11. Maheshwari, P. 1971. Embryology of Angiosperms, McGraw-Hill. New York.
12. Eames A. J. and L. H Mac Daniels. 2002. An Introduction to Plant Anatomy. Tata-Mac Graw-Hill Publishing Company, Limited, New Delhi.
13. Pullaiah, T. 2007. Taxonomy of Angiosperms. 3rd Edition, Regency Publications, New Delhi.
14. Naik, V. N. 2005 Taxonomy of Angiosperms. 20th Reprint. TataMacGraw-Hill Publishing Company, Limited New Delhi.
15. Rajput, M. T., S. S. Hassney and K. M. Khan. 1996. Plant Taxonomy. New Trends Computer Service, Hyderabad, Sindh, Pakistan.

Journals / Periodicals:

Pakistan Journal of Botany, Taxon, Phyton.

Course Outcome: To understand: 1. various systems of classification, identification and nomenclature of Angiosperms, 2- Structures and functions of tissues and organs at embryonic level.

Title of the Course: INTRODUCTION TO GEOGRAPHY OF PAKISTAN

Course Code: GEO-152
Credit hours: 3(2+1)
Nature of Course: General-IV

Objectives of the Course:

This course attempts to impart knowledge about the relationship between man and physical, socio-economic and cultural environment with special reference to Pakistan, including land, population, human settlements, resources and related human activities.

Course Outline:

1. **Relief:** General structure and relief, physiographic regions, rainfall, soil of Pakistan
2. **Climate:** Geographic factors, temperature, pressure and winds, climatic regions
3. **Natural Vegetation:** Forests, grass lands, Desert and semi deserts
4. **Irrigation:** Means of irrigation, Principal canal systems, waterlogging and salinity
5. **Power and Development:** Hydroelectric projects, thermal projects, problems of power resource development
6. **Agriculture:** Chief crops and their distribution
7. **Mining:** Major minerals, their distribution and development
8. **Industries:** Major industries, their distribution and relation to raw materials and markets
9. **Communication:** Railways, road, airways and waterways, their distribution and problems
10. **Development:** Population, distribution, rural and urban, religion, languages, growth of population
11. **World relations:** Pakistan and her neighbors, Pakistan and Muslim world, Pakistan and the world
12. **Map work:** Scale types and their method of conservation, study and interpretation of ordinance survey maps of Pakistan, Map projections, General principles, classification and choices of projections, Construction of the following projections
13. **Practicals:** Scale types and their methods of construction**,** Study and interpretation of ordnance survey maps of Pakistan
14. **Map projections:** General principles, classification and choices of projections, Construction of following projections

a. Mercator projection

b. Zenithal projection

c. Conical projection with one standard parallel

d. Bonn projection

Recommended Books:

1. Ahmad, K. S. (1978) Geography of Pakistan, Oxford University Press, Oxford.
2. Burkey, J. S. (1991) Pakistan the continuing search for Nationhood, Western Press Oxford, UK.
3. Davidson, A. P. & Ahmad, M. (2003) Privatization and the Crisis of Agricultural Extension: The Case of Pakistan, King's Soas Studies in Development Geography, Ashgate Publishing, New Delhi.
4. Dichter, D. (1967) Geography of N-W.F.P, Oxford University Press, Oxford. Hameed, A. (1972) Study of the Middle Indus Basin, San Francisco State College, San Francisco.
5. Johnson, B.L.C (198).
6. Khan, F. K. (1991) Geography of Pakistan, Oxford University Press, Karachi Spate, O. H. K. (2004) India and Pakistan, Munshiram Mohoanlal Publications Pvt. Ltd., UK.
7. Tayyeb, A. (1973) A Political Geography of Pakistan, Oxford University Press. Oxford.

Course Outcome: To impart knowledge about the relationship between man and physical, socio-economic and cultural environment with special reference to Pakistan, including land, population, human settlements, resources and related human activities.

Title of the course: PRINCIPLES OF ANIMAL LIFE-II
Course Code: ZOOL-153
Course Credit Hr: 3 (2+1)
Nature of the course: General-III

Objectives of the course:

i. The course imparts knowledge and understanding of: cell division and its significance in cell cycle.
ii. Concepts and mechanisms of inheritance pattern, chromosome and gene linkage and molecular basics of genetics.
iii. Animal behaviour and communication.
iv. Theories of evolution, gene flow and mechanism of evolution with reference to animals and diversity.

Course Contents

1. Cell Division

Mitosis, cytokinesis, and the cell cycle: an overview; control of the cell cycle; meiosis: the basis of sexual reproduction; gamete formation.

2. Inheritance Patterns

The birth of modern genetics; Mendelian inheritance patterns; other inheritance patterns; environmental effects and gene expression.

3. Chromosomes and Gene Linkage

Eukaryotic chromosomes; linkage relationships; changes in chromosome number and structure.

4. Molecular Genetics: Ultimate Cellular Control

DNA: the genetic material; DNA replication in eukaryotes; genes in action; control of gene expression in eukaryotes; mutations; applications of genetic technologies; recombinant DNA.

5. Animal Behaviour

Four approaches to animal behaviour; proximate and ultimate causes; anthropomorphism; development of behavior; learning; control of behavior; communication; behavioral ecology; social behavior.

6. Evolution: A Historical Perspective

Pre-Darwinian theories of change; Lamarck: an early proponent of evolution; early development of Darwin's ideas of evolution and evidences; the theory of evolution by natural selection; evolutionary thought after Darwin; biogeography.

7. Evolution and Gene Frequencies

The modern synthesis: a closer look; the Hardy-Weinberg theorem; evolutionary mechanisms: population size, genetic drift, natural selection, gene flow, mutation, and balanced polymorphism; species and speciation; rates of evolution; molecular evolution; mosaic evolution.

Lab Outline:

1. Study of mitosis in onion root tip.
2. Study of meiosis in grasshopper testis (students should prepare the slide).
3. Problem based study of Mendelian ratio in animals.
4. Multiple alleles study in blood groups.
5. Survey study of a genetic factor in population and its frequency.
6. Study of karyotypes of *Drosophila*, mosquito.
7. Study of cytochemical detection of DNA in protozoa and avian blood cell.

8. Study to demonstrate nervous or endocrine basis of behaviour (conditioned reflex or aggression or parental behavior).
9. Study to demonstrate social behaviour (documentary film be shown, honey bee, monkey group in a zoo).

Recommended Books:

1. Hickman, C.P., Roberts, L.S. and Larson, A. INTEGRATED PRINCIPLES OF ZOOLOGY, 11th Edition (International), 2004. Singapore: McGraw Hill.
2. Miller, S.A. and Harley, J.B. ZOOLOGY, 5th Edition (International), 2002. Singapore: McGraw Hill.
3. Pechenik, J.A. BIOLOGY OF INVERTEBRATES, 4th Edition
4. (International), 2000. Singapore: McGraw Hill.
5. Kent, G.C. and Miller, S. COMPARATIVE ANATOMY OF VERTEBRATES. 2000. New York: McGraw Hill.
6. Campbell, N.A. BIOLOGY, 6th Edition. Menlo Park, California: 2002. Benjamin/Cummings Publishing Company, Inc.

Course Outcome:

The students will be able to understand the structure and functions of animal cell.

Title of the course: INTRODUCTION TO STATISTICS
Course Code: **BOT-154**
Credit Hours: 3 (3+0)

Course objectives: To equip the graduates with the knowledge of Introductory Statistics.

1. What is Statistics?

Definition of Statistics, Population, sample Descriptive and inferential Statistics, Observations, Data, Discrete and continuous variables, Errors of measurement, Significant digits, Rounding of a Number, Collection of primary and secondary data, Sources, Editing of Data. Exercises.

2. Presentation of Data

Introduction, basic principles of classification and Tabulation, Constructing of a frequency distribution, Relative and Cumulative frequency distribution, Diagrams, Graphs and their Construction, Bar charts, Pie chart, Histogram,

Frequency polygon and Frequency curve, Cumulative Frequency Polygon or Ogive, Historigram, Ogive for Discrete Variable. Types of frequency curves. Exercises.

3. Measures of Central Tendency

Introduction, Different types of Averages, Quantiles, The Mode, Empirical Relation between Mean, Median and mode, Relative Merits and Demerits of various Averages. Properties of Good Average, Box and Whisker Plot, Stem and Leaf Display, definition of outliers and their detection. Exercises.

4. Measures of Dispersion

Introduction, Absolute and relative measures, Range, The semi-Inter-quartile Range, The Mean Deviation, The Variance and standard deviation, Change of origin and scale, Interpretation of the standard Deviation, Coefficient of variation, Properties of variance and standard Deviation, Standardized variables, Moments and Moments ratios. Exercises.

5. Probability and Probability Distributions.

Discrete and continuous distributions: Binomial, Poisson and Normal Distribution. Exercises

6. Testing of Hypothesis- Single Population

Introduction, testing of hypothesis and confidence interval about the population mean and proportion for small and large samples, Exercises

i. Testing of Hypotheses-Two or more Populations
   Introduction, Testing of hypothesis and confidence intervals about the difference of population means and proportions for small and large samples, Analysis of Variance and ANOVA Table. Exercises

ii. Testing of Hypothesis-Independence of Attributes
Introduction, Contingency Tables, Testing of hypothesis about the Independence of attributes. Exercises.

iii. Regression and Correlation
Introduction, cause and effect relationships, examples, simple linear regression, estimation of parameters and their interpretation. r and R^2.

iv. Correlation. Coefficient of linear correlation, its estimation and interpretation. Multiple regression and interpretation of its parameters. Examples

Recommended Books

1 Walpole, R. E. 1982. "Introduction to Statistics", 3rd Ed., Macmillan Publishing Co., Inc. New York.

2 Muhammad, F. 2005. "Statistical Methods and Data Analysis", Kitab Markaz, Bhawana Bazar Faisalabad.

Course Outcome:

At the end of this course the students will be able to use the basic statistical tools for the a nalysis of data.

Title of the course: ISLAMIC STUDIES

Course Code: ISL-155

Credit hours: 2 (2+0)

Course Nature: Compulsory

Objectives of the Course:
This course is aimed at:

1. To provide Basic information about Islamic Studies
2. To enhance understanding of the students regarding Islamic Civilization
3. To improve Students skill to perform prayers and other worships
4. To enhance the skill of the students for understanding of issues related to faith and religious life.

Course Outline:
Introduction to Quranic Studies

1) Basic Concepts of Quran
2) History of Quran
3) Uloom-ul -Quran

Study of Selected Text of Holly Quran

1) Verses of Surah Al-Baqra Related to Faith(Verse No-284-286)
2) Verses of Surah Al-Hujrat Related to Adab Al-Nabi (Verse No-1-18)
3) Verses of Surah Al-Mumanoon Related to Characteristics of faithful (Verse No-1-11)
4) Verses of Surah al-Furqan Related to Social Ethics (Verse No.63-77) 5) Verses of Surah Al-Inam Related to Ihkam(Verse No-152-154)

Study of Selected Text of Holly Quran

1) Verses of Surah Al-Ihzab Related to Adab al-Nabi (Verse No.6,21,40,56,57,58.)
2) Verses of Surah Al-Hashar (18,19,20) Related to thinking, Day of Judgment
3) Verses of Surah Al-Saf Related to Tafakar,Tadabar (Verse No-1,14)

Seats of Holy Prophet (S.A.W) I

1) Life of Muhammad Bin Abdullah (Before Prophet Hood)
2) Life of Holy Prophet (S.A.W) in Makkah
3) Important Lessons Derived from the life of Holy Prophet in Makkah

Seerat of Holy Prophet (S.A.W) II

1) Life of Holy Prophet (S.A.W) in Madina

2) Important Events of Life Holy Prophet in Madina
3) Important Lessons Derived from the life of Holy Prophet in Madina

Introduction To Sunnah

1) Basic Concepts of Hadith
2) History of Hadith
3) Kinds of Hadith
4) Uloom –ul-Hadith
5) Sunnah & Hadith
6) Legal Position of Sunnah

Selected Study from Text of Hadith

Introduction to Islamic Law & Jurisprudence

1) Basic Concepts of Islamic Law & Jurisprudence
2) History & Importance of Islamic Law & Jurisprudence
3) Sources of Islamic Law & Jurisprudence
4) Nature of Differences in Islamic Law
5) Islam and Sectarianism

Islamic Culture & Civilization

1) Basic Concepts of Islamic Culture & Civilization
2) Historical Development of Islamic Culture & Civilization
3) Characteristics of Islamic Culture & Civilization
4) Islamic Culture & Civilization and Contemporary Issues

Islam & Science

1) Basic Concepts of Islam & Science
2) Contributions of Muslims in the Development of Science
3) Quranic & Science

Islamic Economic System

1) Basic Concepts of Islamic Economic System
2) Means of Distribution of wealth in Islamic Economics
3) Islamic Concept of Riba
4) Islamic Ways of Trade & Commerce

Political System of Islam

1) Basic Concepts of Islamic Political System
2) Islamic Concept of Sovereignty
3) Basic Institutions of Govt. in Islam

Islamic History

1) Period of Khlaft-E-Rashida
2) Period of Ummayyads
3) Period of Abbasids

Social System of Islam

1) Basic Concepts Of Social System Of Islam
2) Elements Of Family
3) Ethical Values Of Islam

Reference Books:

1) Hameed ullah Muhammad, "Emergence of Islam" , IRI, Islamabad
2) Hameed ullah Muhammad, "Muslim Conduct of State"
3) Hameed ullah Muhammad, 'Introduction to Islam
4) Mulana Muhammad Yousaf Islahi,"
5) Hussain Hamid Hassan, "An Introduction to the Study of Islamic Law" leaf Publication Islamabad, Pakistan.
6) Ahmad Hasan, "Principles of Islamic Jurisprudence" Islamic Research Institute, International Islamic University, Islamabad (1993)
7) Mir Waliullah, "Muslim Jrisprudence and the Quranic Law of Crimes" Islamic Book Service (1982)
8) H.S. Bhatia, "Studies in Islamic Law, Religion and Society" Deep & Deep Publications New Delhi (1989)

Dr. Muhammad Zia-ul-Haq, "Introduction to Al Sharia Al Islamia" Allama Iqbal Open University, Islamabad (2001)

Course Outcome:

1 To Provide Basic information about Islamic Studies
2 To understanding of the Islamic Civilization
3 To improve their skills to perform prayers and other worships

Title of the course: ENGLISH-II (COMMUNICATION SKILLS)
Course Code: ENG-156
Credit hours: 3(3+0)
Course Nature: Compulsory

Objectives of the Course:

Enable the students to meet their real-life communication needs.

Course Contents

Paragraph writing
Practice in writing a good, unified and coherent paragraph

Communication skills
7Cs of communication skills

CV and job application
Translation skills
Urdu to English

Study skills
Skimming and scanning, intensive and extensive, and speed reading, summary and précis writing and comprehension

Academic skills
Letter/memo writing, minutes of meetings, use of library and internet

Interview skills
Personality development (emphasis on content, style and pronunciation)

Note: documentaries to be shown for discussion and review

Recommended Books:

1. Thomson A.J. and A.V. Martinet Practical English Grammar. Exercises 2. Third edition. Oxford University Press 1986. ISBN 0 19 431350 6.
2. Marie-Chrisitine Boutin, Suzanne Brinand and Francoise Grellet Writing. Intermediate. Oxford Supplementary Skills. Fourth Impression 1993. ISBN 019 435405 7 Pages 45-53 (note taking).
3. Rob Nolasco.Writing. Upper-Intermediate Oxford Supplementary Skills. Fourth Impression 1992. ISBN 0 19 435406 5 (particularly good for writing memos, introduction to presentations, descriptive and argumentative writing).
4. Brian Tomlinson and Rod Ellis Reading. Advanced. Oxford Supplementary Skills. Third Impression 1991. ISBN 0 19 453403 0. 2.

Course Outcome: To have improved communication skills

2nd Year

3rd Semester
Title of the course: CELL BIOLOGY, GENETICS AND EVOLUTION
Course Code: BOT-201
Credit hours: 4 (3+1)
Nature of the course: Foundation-III

Specific objectives of course: To understand:

1. Structure and function of cell.
2. Nature of genetic material and hereditary process
3. Familiarization with evolutionary processes.

Course outline:

a) Cell Biology

1. Structure and Function of Bio-molecules: Carbohydrates, Lipids, Proteins, Nucleic Acids
2. Cell: Cell theory, cell types (prokaryotes, eukaryotes), basic properties of cell.
3. Brief description of following cell organelles:
    i. Cell wall
    ii. Cell membrane
    iii. Nucleus
    iv. Endoplasmic reticulum
    v. Plastids
    vi. Mitochondria
    vii. Ribosomes
    viii. Dictyosomes
    ix. Vacuoles
4. Reproduction in somatic and embryogenic cell, mitosis, meiosis and cell cycle

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. Molecular genetics; DNA replication. Nature of gene, genetic code, transcription, translation, protein synthesis, regulation of gene expression (e.g. *lac* operon).
3. Chromosomal aberrations; Changes in the number of chromosomes. Aneuploidy and Euploidy. Changes in the structure of chromosomes, deficiency, duplication, inversion and translocation.

c) Evolution: Introduction and theories.

Lab Outline:

Cell Biology

i. Study of cell structure using compound microscope and elucidation of ultrastructure from electron microphotographs
ii. Measurement of cell size.
iii. Study of mitosis and meiosis by smear/squash method and from prepared slides.

iv. Study of chromosome morphology and variation in chromosome number.
v. Extraction and estimation of carbohydrate, protein, RNA and DNA from plant sources.

Genetics

i. Genetical problems related to transmission and distribution of genetic material.
ii. Identification of chromosomes in plant material. Carmine/orcein staining.
iii. Determination of blood groups

Recommended Books:

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.
8. Strickberger, M. W. 2000 Evolution. Jones & Bartlet Publishers Canada
9. Ingrouille M. J. & B. Eddie. 2006. Plant Diversity and Evolution. Cambridge University Press.
10. Bruce Albert et al. 2009. Essential cell biology. Garland Sciences Publishers.

Journals/Periodicals:

Theoretical & Applied Genetics, the Cell, Heredity.

Course Outcome: At the end of this course, the students will be able to understand the structure and functions of cell.

Title of the course: Chemistry-I (Inorganic Chemsitry)

Course Code: CHE-202
Credit hours: 3 (2+1)
Course Objectives:
The program is aimed that the student should learn:

i. The Development of periodic law and properties of elements in a systematic way.
ii. The principal of chemical bonding
iii. Chemistry of acid and bases
iv. Chemistry of p-block Elements

Course Outline:

1. The Periodic Law and Periodicity
Development of Periodic Table; Classification of elements based on *s, p, d* and *f* orbitals, group trends and periodic properties in *s, p, d* and *f* block elements, i.e., atomic radii, ionic radii, ionization potential, electron affinities, electronagetivities and redox potential.

2. Principles of Chemical Bonding
Types of chemical bonding; ionic bonding; the localized bond approach: VB theory, hybridization and resonance; the delocalized approach to bonding: molecular orbital theory as applied to diatomic and polyatomic molecules, three center bonds, bonding theory of metals and intermetallic compounds; conductors, insulators and semiconductors; bonding in electron deficient compounds; hydrogen bonding.

3. **Acids and Bases**
Concepts of acids and bases including SHAB concept, relative strength of acids and bases, significance of pH, pKa, pKb and buffer solutions. Theory of Indicators, solubility, solubility product, common ion effect and their industrial applications.

4. **Chemistry of p-block Elements**
Chemistry and structure of *p*-block elements; main emphasis on the chemistry and structure of noble gases and their compounds, chemistry and structure of interhalogens, pseudohalogens and polyhalides. Prediction of shapes of molecules using VSEPR model and hybridization.

Lab Outline:

1. **Laboratory Ethics and safety measures**
Awareness about the toxic nature of chemicals and their handling, cleaning of glassware, safe laboratory operations
2. **Qualitative analysis**
Analysis of four ions (two anions and two cations) from mixture of salts
3. **Quantitative analysis**
Laboratory work illustrating topics covered in the lectures of the said course.

Recommended Books

1. Huheey, J. E., Keiter, E. A. and Keiter, R. L., "Inorganic Chemistry: Principles of Structure and Reactivity", 4th Ed., Harper and Row, New York, 2001

2. Cotton, F. A., Wilkinson, G. and Gaus, P. L., "Basic Inorganic Chemistry", 3rd Ed., Wiley, New York, 1995.
3. Clyde Day, M. & Selbin, J., "Theoretical Inorganic Chemistry", 2nd Ed., Van Nustrand Reinhold, 1969.
4. Lee, J.D., "Concise Inorganic Chemistry", Chapman and Hall, 5th Edition,1996. Shriver, D. F., Atkins, P. W. and Langford, C. H., "Inorganic Chemistry", Oxford University Press, 2nd Edition, 1994.
5. Bassette, J., Denney, G. H. and Mendham, J., "Vogel's Textbook of Quantitative Inorganic Analysis Including Elementary Instrumental Analysis" English Language Book Society, 4th Edition, 1981.
6. Vogel, A. I., "A Textbook of Micro and Semi-micro Qualitative Inorganic Analysis" Longman Green & Co. 1995.

Course Outcum: To learn:

1. The Development of periodic law and properties of elements in a systematic way.
2. The principal of chemical bonding
3. Chemistry of acid and bases
4. Chemistry of p-block Elements

Title of the course: Animal Diversity-I

Course Code: ZOOL-203
Credit hours: 3 (2+1)
Course Nature: General-V

Aims and Objectives:
The course is designed to provide students with:

i. Concepts of evolutionary relationship of animal kingdom.
ii. Knowledge about animal kingdom, emphasizing their phylogenetic relationships and simple to complex mode of animal life.

Course Outline

1. **Introduction**
Classification of organisms; evolutionary relationships and tree diagrams; patterns of organization.

2. **Animal-Like Protists: The Protozoa**
Evolutionary perspective; life within a single plasma membrane; symbiotic life-styles. Protozoan taxonomy: (up to phyla, subphyla and super classes, wherever applicable). Pseudopodia and amoeboid locomotion; cilia and other pellicular structures; nutrition; genetic control and reproduction; symbiotic ciliates; further phylogenetic considerations.

3. **Multicellular and Tissue Levels of Organization**
Evolutionary perspective: origins of multicellularity; animal origins. Phylum porifera: cell types, body wall, and skeletons; water currents and body forms; maintenance functions; reproduction. Phylum cnidaria (coelenterata) the body wall and nematocysts; alternation of generations; maintenance functions; reproduction and classification up to class. Phylum ctenophora; further phylogenetic considerations.

4. **Triploblastics and Acoelomate Body Plan**
Evolutionary perspective; phylum platyhelminthes: classification up to class; the free-living flatworms and the tapeworms; phylum nemertea; phylum gastrotricha; further phylogenetic considerations.

5. **Pseudocoelomate Body Plan: Aschelminths**
Evolutionary perspective; general characteristics; classification up to phyla with external features; feeding and the digestive system; other organ systems; reproduction and development of phylum rotifera and phylum nematoda; phylum kinorhyncha. Some important nematode parasites of humans; further phylogenetic considerations.

6. **Molluscan Success**
Evolutionary perspective: relationships to other animals; origin of the coelom; molluscan characteristics; classification up to class. The characteristics of shell and associated structures, feeding, digestion, gas exchange, locomotion, reproduction and development, other maintenance functions and diversity in gastropods, bivalves and cephalopods; further phylogenetic considerations.

7. **Annelida: The Metameric Body Form**
Evolutionary perspective: relationship to other animals, metamerism and tagmatization; classification up to class. External structure and locomotion, feeding and the digestive

system, gas exchange and circulation, nervous and sensory functions, excretion, regeneration, reproduction and development, in polychaeta, oligochaeta and hirudinea; further phylogenetic considerations.

8. Arthropods: Blueprint for Success

Evolutionary perspective: classification and relationships to other animals; metamerism and tagmatization; the exoskeleton; metamorphosis; classification up to class; further phylogenetic considerations.

9. Hexapods and Myriapods: Terrestrial Triumphs

Evolutionary perspective; classification up to class. External structure and locomotion, nutrition and the digestive system, gas exchange, circulation and temperature regulation, nervous and sensory functions, excretion, chemical regulation, reproduction and development in hexapoda; insect behavior; insects and humans; further phylogenetic considerations.

Lab Outline:

1. Study of *Euglena, Amoeba, Entamoeba, Plasmodium, Trypanosoma, Paramecium* as representative of animal like protists. (Prepared slides).
2. Study of sponges and their various body forms.
3. Study of principal representative classes of phylum Coelenterata.
4. Study of principal representative classes of phylum Platyhelminthes.
5. Study of representative of phylum Rotifera, phylum Nematoda.
6. Study of principal representative classes of phylum Mollusca.
7. Study of principal representative classes of phylum Annelida.
8. Study of principal representative classes of groups of phylum Arthropoda.
9. Brief notes on medical/economic importance of the following: *Plasmodium, Entamoeba histolitica, Leishmania*, Liverfluke, Tapeworm, Earthworm, Silkworm, Citrus butterfly.
10. Preparation of permanent stained slides of the following: *Obelia, Daphnia*, Cestode, Parapodia of *Nereis.*

Recommended Books

1. Hickman, C.P., Roberts, L.S. and Larson, A. INTEGRATED PRINCIPLES OF ZOOLOGY, 11th Edition (International), 2004. Singapore: McGraw Hill.
2. Miller, S.A. and Harley, J.B. ZOOLOGY, 5th Edition (International), 2002. Singapore: McGraw Hill.
3. Pechenik, J.A. BIOLOGY OF INVERTEBRATES, 4th Edition (International), 2000. Singapore: McGraw Hill.
4. Kent, G.C. and Miller, S. COMPARATIVE ANATOMY OF VERTEBRATES. 2001. New York: McGraw Hill.
5. Campbell, N.A. BIOLOGY, 6th Edition. 2002. Menlo Park, California: Benjamin/Cummings Publishing Company, Inc.

Course Outcum: To understand the:

- Concepts of evolutionary relationship of animal kingdom.
- Knowledge about animal kingdom, emphasizing their phylogenetic relationships and simple to complex mode of animal life.

Title of the Course: **Introduction to Computer**
Course Code: **CM-204**

Credit hours: **3 (2+1)**

Course Nature: **Compulsory**

Objectives of the Course:

This is an introductory course on Computers (Information and Communication Technologies). Topics include ICT terminologies, hardware and software components, the internet and world wide web, and ICT based applications. Basic Knowledge of office software such as MS Word, Power Point and Excel sheets.

After completing this course, the students will be able to:

- Understand different terms associated with ICT
- Identify various components of a computer system
- Identify the various categories of software and their usage
- Define the basic terms associated with communications and networking
- Understand different terms associated with the Internet and World Wide Web.
- Use various web tools including Web Browsers, E-mail clients and search utilities.
- Use text processing, spreadsheets and presentation tools
- Understand the enabling/pervasive features of ICT

Course Outline:

1. Basic Definitions & Concepts
2. Hardware: Computer Systems & Components
3. Storage Devices Number Systems
4. Introduction to Programming, Databases and Information System Networks
5. Software: Operating Systems, Programming and Application Software
6. Data Communication
7. The Internet, Browsers and Search Engines
8. The Internet: Email, Collaborative Computing and Social Networking
9. The Internet: E-Commerce
10. IT Security and other issues
11. Text Processing (MS Word)
12. Presentation Tool (MS Power Point)
13. Spreadsheets (MS Excel)
14. Project Week
15. Review Week

Recommended Books:

1. Alexis Leon Fundamentals of Information Technology, Mathewsleon Leon press
2. Peter Norton Introduction to Computers 6th International Edition (McGraw HILL).
3. Sarah E. Hutchinson, Stacey C. Swayer Computers, Communications & information: A user's introduction

4. Williams Sawyer Using Information Technology: A Practical Introduction to Computer & Communications 6th Edition (McGraw HILL)

Course Outcome:

At the end of this course, the students will be able to understand the basic knowledge of Computer

Title of the course: English–III (Technical Writing and Presentation Skills)

Course code: ENG-205
Credit hours: 3(3+0)
Course Nature: Compulsory

Course Objectives: Enhance language skills and develop critical thinking

Course Contents

Interview skills

Essay writing
Descriptive, narrative, discursive, argumentative

Academic writing

How to write a proposal for research paper/term paper

How to write a research paper/term paper (emphasis on style, content, language, form, clarity, consistency)

Technical writing
Application method, Letter method, Use of Capitalization (usage of capital letters), Roles for summary writting

Progress report writing

Note: Extensive reading is required for vocabulary building

RECOMMENDED BOOKS:

1. Ron White. Oxford Supplementary Skills. Third Impression 1992. ISBN 0 19 435407 3
2. John Langan. College Writing Skills. Mc=Graw-Hill Higher Education. 2004.
3. Laurie G. Kirszner and Stephen R. Mandell. Patterns of College Writing; 4th edition) St. Martin's Press.
4. Janice Neulib, Kathleen Shine Cain, Stephen Ruffus, Maurice Scharton. The Mercury Reader. A Custom Publication. Compiled by norther Illinois University.

Course Outcome: At the end of this course, the writing skills of the students will improve.

2nd**Year**

4th Semester
Title of the course: **Biostatistics**
Course Code: **BOT-251**
Credit hours: **3 (2+1)**
Course Nature: **Compulsory**

Course outline:

1. Organizing and describing data (Standard distributions).
2. Random sampling and the binomial distribution, Probability, Types of Probabilities, Random variables, Combining probabilities, Probability distributions, Binomial distributions, Poisson and normal distributions, properties and applications.
3. Basic experimental design:
4. Concept and design, Principles of experiments, Observational studies, Planning of experiments, Replication and randomization, Field plot technique, Layout and analysis of completely randomized design, Randomized complete block design, Latin square design, Factorial design, Treatment comparison.
5. Tests of significance:
6. T-test: (Basic idea, confidence limits of means, significant difference of means, Chi square test: Basic idea, testing goodness of fit to a ratio, testing association (contingency table), F-test: Introduction and application in analysis of variance, LSD test, Duncan's New Multiple Range test (for comparison of individual means), Bonferroni test.
7. Unit organization, Basic one-way ANOVA, Types of sums of squares, How ANOVA works, The ANOVA Table. Two-way ANOVA-Factorial designs: (two-way Factorial analysis, calculating and analyzing the two-way ANOVA, Linear combination, multiple comparisons.
8. Sampling and Sampling Distributions
   Introduction, sample design and sampling frame, bias, sampling and non sampling errors, sampling with and without replacement, probability and nonprobability sampling, Sampling distributions for single mean and proportion, Difference of means and proportions. Exercises.
9. Hypothesis Testing
   Introduction, Statistical problem, null and alternative hypothesis, Type-I and Type-II errors, level of significance, Test statistics, acceptance and rejection regions, general procedure for testing of hypothesis. Exercises.

Lab outline:

i. Data collection, arrangement of data in frequency table, calculating frequency, cumulative frequency and preparation of Ogive.

ii. Calculating different measure of central tendency such as arithmetic means, harmonic mean, geometric mean, median and mode.

iii. Calculation of mean from grouped and ungrouped data.

iv. Calculation of variance and standard deviation from grouped and ungrouped data.

v. Calculating dispersion, relative dispersion, standard deviation, standard error, standard score and co-efficient variation by hand and machine method.

vi. Problems concerning probability, binomial distribution, Poisson distribution, Skewness and Kurtosis and T-test.

vii. Chi square test.

viii. Analysis of variance - one factor design.

ix. Multiple Analyses of Variance.

x. Determination of correlation by constructing different types of graphs such as scatter diagram, linear positive correlation, linear perfect negative correlation, no correlation and curvilinear correlation (second degree polynomial, third degree polynomial).

xi. Linear Regression and multiple regression models.

xii. MS Excel, MSTAT or relevant statistical software packages.

Recommended Books:

1. Harvey, M. 1995. Intuitive Bioostatistics. Oxford University Press. NY. Kuzma J. W. and Bohnenblust, S. E. 2001, Basis Statistics for the Health Sciences, McGraw-Hill International Education.
2. Onton, P., Adams, S. and Voelkar, D. H. 2001. Cliffnotes for statistics. Blackwell Scientific Publishers.
3. Pacano, M. and Gauvreau, K. 2000. Principles of Biostatistics.
4. Quinn, G. 2002. Experimental Design and Data Analysis for Biologists. Cambridge University Press.
5. Rosner, B. 2005. Fundamentals of Biostatistics. John Wiley & Sons.
6. Samuels, M. L. and Witmar, J. A. 2003. Statistics for life sciences. 3rd Edition. Cambridge University Press.
7. Triola, M. F. and Triola, M. M. 2005. Biostatistics for Biological and Health Sciences. Pearson Addison Wesley.
8. Zar, J. H., 1999. Biostatistical Analysis, Pearson Education.

Course Outcome: At the end of this course, the students will be able to use different statistical tools for the analysis of the data.

Title of the course: Animal Diversity-II (*Classification, Phylogeny and Organization)*

Course Code: ZOOL-252
Credit hours: 3 (2+1)
Course Nature: General-VII
Aims and Objectives:

The course provides knowledge and understanding about the different animal groups, emphasizing their phylogenetic relationships.

Course Outline:

1. **Echinoderms**
   Evolutionary perspective: relationships to other animals; echinoderm characteristics; classification up to class. Maintenance functions, regeneration, reproduction, and development in asteroidea, ophiuroidea, echinoidea, holothuroidea and crinoidea; further phylogenetic considerations; some lesser-known invertebrates: the lophophorates, entoprocts, cycliophores, and chaetognaths.
2. **Hemichordates and Invertebrate Chordates**
   Evolutionary Perspective: Phylogenetic Relationships; Classification up to subphylum or class where applicable; Further Phylogenetic Considerations.
3. **Fishes: Vertebrate Success in Water**
   Evolutionary perspective: phylogenetic relationships; survey of super class agnatha and gnathostomata; evolutionary pressures: adaptations in locomotion, nutrition and the digestive system, circulation, gas exchange, nervous and sensory functions, excretion and osmoregulation, reproduction and development; further phylogenetic considerations.
4. **Amphibians: The First Terrestrial Vertebrates**
   Evolutionary perspective: phylogenetic relationships; survey of order caudata, gymnophiona, and anura. Evolutionary pressures: adaptations in external structure and locomotion, nutrition and the digestive system, circulation, gas exchange, temperature regulation, nervous and sensory functions, excretion and osmoregulation, reproduction, development, and metamorphosis; further phylogenetic considerations.
5. **Reptiles: The First Amniotes**
   Evolutionary perspective: cladistic interpretation of the amniotic lineage; survey of order testudines or chelonia, rhynchocephalia, squamata, and crocodilia; evolutionary pressures: adaptations in external structure and locomotion, nutrition and the digestive system, circulation, gas exchange, and temperature regulation, nervous and sensory functions, excretion and osmoregulation, reproduction and development; further phylogenetic considerations.
6. **Birds: Feathers, Flight, and Endothermy**
   Evolutionary perspective: phylogenetic relationships; ancient birds and the evolution of flight; diversity of modern birds; evolutionary pressures: adaptation in external structure and locomotion, nutrition and the digestive system, circulation, gas exchange, and temperature regulation, nervous and sensory systems, excretion and osmoregulation, reproduction and development; migration and navigation.
7. **Mammals: Specialized Teeth, Endothermy, Hair, and Viviparity**
   Evolutionary perspective: diversity of mammals; evolutionary pressures: adaptations in external structure and locomotion, nutrition and the digestive system, circulation, gas exchange, and temperature regulation, nervous and

sensory functions, excretion and osmoregulation, behavior, reproduction and development.

Lab Outline:

i. Study of a representative of Hemichordate and Invertebrate Chordate.
ii. Study of representative groups of class Fishes.
iii. Study of representative groups of class Amphibia.
iv. Study of representative groups of class Reptilia.
v. Study of representative groups of class Aves.
vi. Study of representative groups of class Mammalia.
vii. Field trips to study animal diversity in an ecosystem.

Note: *Preserved specimen and/or colored projection slide and/or CD ROM projection of computer must be used.*

Recommended Books

1. Hickman, C.P., Roberts, L.S. and Larson, A. INTEGRATED PRINCIPLES OF ZOOLOGY, 11th Edition (International), 2004. Singapore: McGraw Hill.
2. Miller, S.A. and Harley, J.B. ZOOLOGY, 5th Edition (International) 2002. Singapore: McGraw Hill.
3. Pechenik, J.A. BIOLOGY OF INVERTEBRATES, 4th Edition (International), 2000. Singapore: McGraw Hill.
4. Kent, G.C. and Miller, S. COMPARATIVE ANATOMY OF VERTEBRATES. 2001. New York: McGraw Hill.
5. Campbell, N.A. BIOLOGY, 6th Edition. 2002. Menlo Park, California: Benjamin/Cummings Publishing Company, Inc.
6. Hickman, C.P. and Kats, H.L. LABORATORY STUDIES IN INTEGRATED PRINCIPLES OF ZOOLOGY. 2000. Singapore: McGraw Hill.
7. Miller, S.A. GENERAL ZOOLOGY LABORATORY MANUAL. 5th Edition (International), 2002. Singapore: McGraw Hill.

Course Outcome: the student will be able to differentiate various groups of invertebrates and vertebrate.

Title of the course: **Plant Physiology and Ecology**

Course Code: **BOT-253**
Credit hours: **4 (3+1)**
Nature of the course: **Foundation-IV**

Specific objectives of course:

- To provide comprehensive knowledge of functioning of organs, organelles and biomolecules,
- To enable the students to assess the effects of various environmental factors on plant growth and development.

Course Outline:

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 C_3 and C_4 plants. Factors affecting this process, Products of photosynthesis.

4. Respiration: Definition and respiratory substrates. chanism-Glycolysis, Krebs cycle. Electron transport and oxidative phosphorylation. Anaerobic respiration. Energy balance in aerobic and naerobic respiration, Respiratory quotients.

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 and seed bank.

7. Community Ecology

i. Ecological characteristics of plant community
ii. Methods of sampling vegetation (Quadrat and line intercept)
iii. Major vegetation types of the local area.

8. Ecosystem Ecology

i. Definition, types and components of ecosystem.
ii. Food chain and Food web.

iii. Applied Ecology: Causes, effects and control of water logging and salinity with respect to Pakistan

Lab Outline:

a) ***Plant Physiology***

i. Preparation of solutions of specific normality of acids/bases, salts, sugars, molal and molar solutions and their standardization.
ii. Determination of uptake of water by swelling seeds when placed in sodium chloride solution of different concentrations.
iii. Measurement of leaf water potential by the dye method.
iv. Determination of the temperature at which beet root cells lose their permeability.
v. Determination of the effects of environmental factors on the rate of transpiration of a leafy shoot by means of a porometer/cobalt chloride paper method.
vi. Extraction of chlorophyll from the leaves and separation of component pigments on a paper chromatogram. Study of absorption spectra using spectrophotometer.
vii. Estimation of oxygen utilized by a respiring plant by Winkler's method.

b) **Ecology**

i. Determination of physical and chemical characteristics of soil.
ii. Measurements of various population variables
iii. Measurement of vegetation by Quadrat and line intercept methods.
iv. Field trips to ecologically diverse habitats.
v. Measurements of wind velocity.
vi. Measurement of light and temperature.
vii. Effect of light and temperature on seed germination.

Recommended Books:

1. Ihsan, I. 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. 2006. Plant Physiology. 4th. Ed. 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, J. C. 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. Hussain, S. S. 1989. Pakistan Manual of Plant Ecology; National Book Foundation, Islamabad.
13. Larcher, W. 2003 Physiological Plant Ecology: Ecophysicology and Stress Physiology of Functions Groups – Springer Verlag.
14. Krebs, C. J. 1997. Ecology. Harper and Row Publishers.
15. Smith, R. L. 1996. Ecology and Field Biology. Addison Wesley Longman, Inc., New York.
16. Smith, R. L. 1998. Elements of Ecology. Harper and Row Publishers, New York.
17. Smith, R. L. 2004.Ecology and field biology. Addison Wesley Longman, Inc., New York.
18. Subrahmanyam, N. S. and Sambamurthy, A. V. S. S. 2000. Ecology. Narosa Publishing House, New Delhi.
19. Townsend, C. R., Harper, J. L. and Begon, M. E. 2002. Essentials of Ecology. Blackwell Scientific Publications, UK.
20. Odum, E. P. 1985. Basic Ecology. W. B. Saunders.

Journals/Periodicals: Plant
Physiology, Journal of Ecology

Course Outcome: To provide comprehensive knowledge of functioning of organs, organelles and biomolecules and enable to assess the effects of various environmental factors on plant growth and development.

Title of the Course: BIODIVERSITY AND CONSERVATION

Course Code: BOT-254
Credit Hours: 4 (3+1)
Course Nature: Foundation-V

Specific objectives of course:

To familiarize the students with the diversity of nature. Importance of biodiversity for survival and proper functioning of ecosystems.

Course Outline:

1. Biodiversity : Definition, types and threats
2. Threats to Biodiversity; deforestation, over grazing, erosion, desertification, ecosystem degradation, bio invasion, pollution and climate change
3. Biodiversity of Pakistan
4. Measuring biodiversity: Alpha, Beta and Gamma diversity; Systematic and functional diversity.
5. Ecological services, indirect value of ecosystem by virtue of their ecological functions, direct value of ecosystem (i.e. Utility of Bio resources) 6. Sustainable and unsustainable use of biological resources
7. Biodiversity Hot spots of Pakistan and the world.
8. International treaties/agreements regarding Biodiversity and conservation; CBD, CITES, Ramsar
9. Conservation strategies; *in situ*, *ex situ*, *in vitro* conservation
10. Conservation *vs* preservation
11. IUCN categorized protected areas in Pakistan; red listing
12. Environmental Impact Assessment.
13. Use of herbarium and Botanical Garden in biodiversity and conservation.
14. Concept of pastures and wild life management
15. Global Biodiversity Information Facility (GBIF)

Lab outline:

i. Inventory of plant biodiversity in various habitats.
ii. Field survey for baseline studies and Impact Assessment.
iii. Identification of wild plant species used by local communities in different ecosystems.

Recommended Books:

1. Abbasi, A. M., Khan, M. A., M. Ahmad and M. Zafar. 2012. Medicinal plant biodiversity of Lesser Himalaya Pakistan. Springer Publishers USA.
2. Hussain, F., 1991. Vegetation and ecology of lesser Himalaya. Department of Botany, Peshawar
3. Shinwari, M. I. and M. A. Khan. 1998. Ethnobotany of Margalla Hills. Department of Biological Sciences, Quaid-i-Azam University Islamabad Pakistan.
4. Shinwari, M. I., M. I. Shinwari and Shah, M. 2007. Medicinal Plants of Margalla Hills National Park Islamabad. Higher Education Commission Islamabad. Pp.218.
5. Heywood, V. (ed.). 1995. Global Biodiversity Assessment. Published for the United Nations Environment Programme. Cambridge University Press, Cambridge, UK.

6. Falk, D. A. & Holsinger, K. E. 1991. Genetics and Conservation of Rare Plants. Center for Plant Conservation. Oxford University Press, Oxford, UK.
7. Frankel, O. H., Brown, A. H. D. & Burdon, J. J. 1995. *The Conservation of Plant Biodiversity*. Cambridge University Press, Cambridge, UK.
8. IUCN. 1994. *IUCN Red List Categories.* As Approved by the IUCN Council. IUCN.
9. Leadlay, E. and Jury, S. 2006 Taxonomy and Plant Conservation. CUP.
10. Bush, M. B. 1997 Ecology of a changing Planet. Prentice hall. New Jersy.
11. French, H. 2000 Vanishing Borders- protecting the Planet in the age of globalization. W. W. Norton & Co.
12. Swanson, T. 2005 Global Action for Biodiversity. Earth Scan Publication Ltd.
13. Taylor, P. 2005 Beyond Conservation. Earth Scan Publication Ltd.

Journals /Periodicals

Systematics and Biodiversity, Biological Conservation.

Course Outcome: To have the knowledge of diversity of nature. Importance of biodiversity for survival and proper functioning of ecosystems.

Title of the Course: **Plant Systematics**

Course Code: **BOT-255**

Credit Hours: 3(2+1)

Specific objectives of course:

To know floral composition/system of classification focusing on identification, classification, description nomenclature and flora writings, monographs.

Course outline:

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.
9. 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.** Capparidaceae **8.** Caryophyllaceae; **9.** Chenopodiaceae; **10.** Convolvulaceae; **11.** Cucurbitaceae; **12.** Cyperaceae **13.** Euphorbiaceae; **14.** Fabaceae (Leguminosae); **15.** Lamiaceae (Labiatae); **16.** Liliaceae **17.** Magnoliaceae; **18.** Malvaceae; **19.** Myrtaceae; **20.** Orchidaceae; **21.** Papaveraceae; **22.** Poaceae (Gramineae); **23.** Ranunculaceae; **24.** Rosaceae; **25.** Salicaceae; **26.** Scrophulariaceae; **27.** Solanaceae.

Lab Outline:

i. Technical description of plants of the local flora and their identification up to species level with the help of a regional/Flora of Pakistan.
ii. Preparation of indented and bracketed types of keys.
iii. Preparation of permanent slides of pollen grains by acetolysis method and study of different pollen characters.
iv. Study of variation pattern in different taxa.
v. Submission of properly mounted and fully identified hundred herbarium specimens at the time of examination.

vi. Field trips shall be undertaken to study and collect plants from different ecological zones of Pakistan.

Recommended Books:

1. Ali, S.I. and Nasir, Y. 1990-92. Flora of Pakistan. Karachi Univ. Press, Karachi.
2. Ali, S.I. and Qaiser, M. 1992-2007 -todate. Flora of Pakistan. Karachi Univ. Press, Karachi.
3. Greuter,W., McNeill, J., Barrie, F.R., Burdet, H. M., Demoulin, V., Filguerras, T.S., Niclson, D.H. Silva, P.C., Skog, J.E., Trehane, P.,Turland, N.J. & Hawksworth, D.L.,(eds.) 2000. International code of botanical nomenclature (Saint Louis Code) adopted by the 16th International botanical congress St. Louis Missouri, July –August 1999. Koeltz, Konigstein. (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. 1970-89. 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. 2005. 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. Levin, D.A. 2000. The Origin, Expansion and Demise of Plant Species. Oxford University Press.
14. Shinwari, M. I. and M. A. Khan. 1998. Ethnobotany of Margalla Hills. Department of Biological Sciences, Quaid-i-Azam University Islamabad Pakistan.
15. Shinwari, M. I., M. I. Shinwari and Shah, M. 2007. Medicinal Plants of Margalla Hills National Park Islamabad. Higher Education Commission Islamabad. Pp.218.
16. Sivarajan V.V and N.K.P Robson 1991 Introduction to the Principles of Plant Taxonomy.
17. Radford, A.E., W.C. Dickison, J.R. Massey, and C. R. Bell. 1998 Vascular Plant Systematic. Harper and Row, New York.
18. Leadlay, E. and Stephen 2006. Taxonomy and Plant Conservation.
19. Rajput, M. T., S. Saliha and K. M. Khan. 1996 Plant Taxonomy. Nasim Book Depot Hyderabad.
20. Heywood V.H. 1978. Flowering Plants of the World. Oxford University Press.
21. Simpson, M.G. 2006. Plant Systematics. Elsevier Academic Press.
22. Soltis, D.E. P.S. Soltis, P.K Endress, and M.W. Chase, 2005. Phylogeny & evolution of angiosperms. Sinauers associates, Inc. Publishers.
23. Pullaiah, T. 2007 Taxonomy of Angiosperms 3rd Ed. Regency Publication, New Delhi.

Journals / Periodicals: Pakistan Journal Botany, Flora of Pakistan, Taxon, Botanical Journal of the Linnean Society.

Students Outcome: To know floral composition/system of classification focusing on identification, classification, description nomenclature and flora writings, monographs.

3rd Year

Semester 5th

Title of the Course: Chemistry-II (Organic Chemistry)
Course Code: CHE-301
Credit Hours: 03 (2+1)
Course Nature: General-VIII

Course Outline

Introduction to Organic Chemistry

Organic chemistry-the chemistry of carbon compounds; the nature of organic chemistry-a historical perspective.

Chemical Bonding and Properties of Organic Molecules

Localized and delocalized chemical bonding; concept of hybridization leading to bond angles, bond lengths, bond energies and shape of organic molecules; dipole moment; inductive and field effects; resonance; aromaticity; tautomerism; hyperconjugation; hydrogen bonding; acids and bases; factors affecting the strengths of acids and bases.

Classes and Nomenclature of Organic Compounds

Classification of organic compounds; development of systematic nomenclature of organic compounds; IUPAC nomenclature of hydrocarbons and heteroatom functional groups.

Functional Group Chemistry

A brief introduction to the chemistry of hydrocarbons, alkyl halides, alcohols, phenols, ethers, aldehydes, ketones, amines, and carboxylic acids and their derivatives.

Recommended Books:

1. Clayden, J., Greeves, N., Warren, S. and Wothers, P., "Organic Chemistry", Oxford University Press, New York.
2. Loudon, G. M., "Organic Chemistry", Oxford University Press, New York
3. Sorrell, T. N., "Organic Chemistry", Viva Books Private Ltd., New Delhi.
4. Finar, I. L., "Organic Chemistry", Vol. 1, Pearson Education, Delhi.
5. Carey, F. A., "Organic Chemistry", McGraw-Hill, New York.
6. Ahluwalia, V. K. and Goyal, M., "A Text Book of Organic Chemistry", Narosa Publishing House, New Delhi
7. March, J., "Advanced Organic Chemistry", John Wiley & Sons, New York.
8. Bansal, R. K., "Organic Reaction Mechanisms", Tata McGrawHill Publishing Company Ltd., New Delhi.
9. Pine, S. H., "Organic Chemistry", National Book Foundation, Islamabad.
10. Bailey Jr., P. S. and Bailey, C. A., "Organic Chemistry-A Brief Survey of Concepts and Applications", Prentice-Hall, New Jersey.

Title of the Course: Bacteriology and Virology

Course Code: **BOT-302**

Credit Hours: **3(2+1)**

Course Nature: **Foundation-VI**

Specific objectives of course: To understand the morphology, structure and economic importance of Viruses and Bacteria

Course outline:

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; **6.** Symptoms and control of major bacterial diseases in Pakistan;

Lab outline:

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.

Recommended Books:

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.
8. Molecular Plant-Microbe Interactions, Kamal Bouarab, Normand Brisson, Fouad Daayf (eds), 2009 MPG Books Group, Bodmin, UK.
9. Plant-Microbe Interactions Gary Stacey, Noel T. Keen (Eds) 2011, springer London.

Journals/Periodicals:

World Journal of Microbiology & Biotechnology, Current Microbiology, Journal of Industrial Microbiology and Biotechnology, Journal of General Virology, Journal of Virology.

Course Outcome: To understand the morphology, structure and economic importance of Viruses and Bacteria

Title of the Course: **PHYCOLOGY AND BRYOLOGY**

Course Code: **BOT-303**

Credit Hours: **3 (2+1)**

Course Nature: **Major-I**

Specific objectives of course: To understand the classification, morphology and economic importance of Algae and Bryophytes

Course outline:

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, Anthoceropsida and Bryopsida.

Lab Outline:

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.

Recommended Books:

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, Uni. of Peshawar.
8. Barsanti, L. and P. G. Gualtieri. 2006. Algae, anatomy, biochemistry, biotechnology. Taylor and Francis, New York.
9. Vashishta, B. R., A. K. Sinha and A. Kumar. 2010. Algae. S. Chand & Co.
10. Bellinger, E. G. and D. C. Sigee. 2010. Fresh water algae (Identification and use as bioindicators). John Wiley & Sons.
11. Hussain, F. 2013. Phycology. A text book of Algae. Pak Book Empire Lahore.
12. Vashishta, B. R., A. K. Sinha and A. Kumar. 2010. Bryophytes. S. Chand & Co. New Delhi.
13. Fida Hussain, Habib Ahmad and Syed Zahir Shah. 2012. The unicellular algae of District Peshawar, Pakistan. Lambert Publication, Germany.

Journals / Periodicals:

Pakistan Journal of Botany; International Journal of Phycology and Phycochemsitry; Bryology; Phycology.

Course Outcome: To understand the classification, morphology and economic importance of Algae and Bryophytes

Title of the Course: **MYCOLOGY AND PLANT PATHOLOGY**

Course Code: **BOT-304**

Credit Hours: **3(2+1)**

Course Nature: **Major-II**

Specific objectives of course: To introduce the students to Mycology and Diseases caused by Fungi.

Course outline:

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; 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, red rot of sugarcane etc. **6**. Systemic resistance: Induced systematic resistance (ISR), Acquired Systematic resistance (ASR).

Lab Outline:

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 pathogencity. Demonstration of control measures through chemotherapeutants.

Recommended Books:

1. Agrios, G.N., 2005. Plant Pathology, Academic Press, London.
2. Ahmad, I. and Bhutta, A.R., 2004. Textbook of Introductory Plant Pathol. Book Foundation, Pak.
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., 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.

Journals / Periodicals:

Pakistan Journal of Botany, Mycotoxin, Mycopath, Phytopathology, Australasian Journal of Plant pathology, Asian Journal of Plant Pathology, Annual Review of Plant Pathology.

Course Outcome: To introduce the students to Mycology and Diseases caused by Fungi.

Title of the Course: **Diversity of Vascular Plants**

Course Code: **BOT-305**

Credit Hours: **3(2+1)**

Course Nature: **Foundation-VII**

Specific objectives of course: To enable the students to understand and appreciate the biology and evolution of plant architecture

Course outline:

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. Cooksonia

General characters, classification, affinities and comparative account of evolutionary trends of the following phyla: Psilopsida (Psilotum), Lycopsida (Lycopodium, Selaginella), Sphenopsida (Equisetum), Pteropsida (Ophioglossum, Dryopteris and Azolla/Marsilea).

b) Origin and Evolution of seed habit.

c) Gymnosperms: Geological history, origin, distribution, morphology, anatomy, classification and affinities of Cycadofillicales, Bennettitales, Ginkgoales, Cycadales and Gnetales. Distribution of gymnosperms in Pakistan. Economic importance of gymnosperms. An introduction to the Gondwana flora of world.

d) Angiosperms: Origin, general characteristics, Importance, and life cycle of angiosperms

e) 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.

Lab Outline:

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

Recommended Books:

1. Beck, C.B. 1992. Origin and Evolution of Gymnosperms. Vol1&II, Columbia Uni. Press, New York.
2. Foster, A.S. & Gifford, E. M. Jr. 1998. Comparative Morph. of Vascular Plants. W. H. Freeman & Co.
3. Jones, D. 1983. Cycadales of the World, Washington, DC.
4. Mauseth, J.D. 1998. An Intro.to Plant Biology, Multimedia Enhanced, Jones & 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. Biol. of Plants, W.H. Freeman and Comp. Worth Pub.
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. 2000. The Biology and Evolution of Fossil Plants, Prentice Hall.
9. Stewart, W. N. and Rothwell, G.W. 1993. Paleobotany & the Evolution of Plants, Uni. Press, Cambridge.
10. Faegri, K., P.E. Kaland & K. Krzywinski 1989. Text Book of Pollen Analysis, Jhon Wiley & Sons. N.Y.
11. Vashishta, B. R., A. K. Sinha and A. Kumar. 2010. Pterodophyta. S. Chand & Co. New Delhi.
12. B. P. Panday. 2006. College Botany. Vol 1 & II. S. 7 th Edition. Chand & Co. New Delhi.
13. Vashishta, B. R., A. K. Sinha and A. Kumar. 2010. Gymnosperms. S. Chand & Co.

Journals / Periodicals: Pakistan Journal of Botany, New Phytologist, Review of Palaeobotany & Palynology, Palaeontographica, Palaeobotanist.

Course Outcome: To enable the students to understand and appreciate the biology and evolution of plant architecture

3rd Year

Semester 5th

Title of the Course: **GENETICS-I**

Course Code: **BOT-351**

Credit Hours: **3 (2+1)**

Nature of the Course: **Major-IV**

Specific Objectives of course: To understand the nature and function of genetic material.

Course Outline:

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

Lab Outline:

1. Numerical problems

a) Arrangement of genetic material:

i. Linkage and recombination. **ii**. Gene mapping in diploid. **iii**. Recombination in Fungi. **iv**. Recombination in bacteria. **v**. Recombination in viruses.

b) Population Genetics:

i. Gene frequencies and equilibrium. **ii**. Changes in gene frequencies.

2. Blood group and Rh-factor

3. Drosophila: i. Culture technique, **ii**. 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: **i.** Bacterial cultural techniques, Gram staining (E. coli, B. subtilis)

ii. Transformation. **iii**. Conjugation.

Recommended Books:

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, 2 nd Edition, Oxford University Press Inc. 10. 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.
9. Hartl, D. L. and Jones, E. W. 2005, Genetics - Analysis of Genes and Genomes, Jones and Bartlett Publishers. Sudbry, USA.
10. Hedrick, P. W. 2005. Genetics of Population. Jones and Bartlett Publisher, Sudbury, USA.
11. Mahmut Caliskan. 2012. The Molecular basis of plant genetic diversity. In Tech Publishers.
12. Ram J. Singh. 2011. Genetic resources, chromosome engineering and crop improvement. Medicinal plants. Vol. 6. CRC Press.
13. William S. Klug, Michael R. Cummings, Charlotte A. Spencer, Michael A. Palladino. 2011. Concepts of genetics. Pearson Educations.
14. Daniel Hartl. 2011. Genetics Johns and Bartlett Publishers.
15. David Hyde. 2008. Introduction to Genetic principles. McGraw-Hill.
16. Daniel, L. Hart, Elizabeth W. Jones. 2009. Analysis of genes and genomes. John and Barlett.
17. Noureddine Benkeblia. 2011. Sustainable agriculture and new biotechnologies. CRC Press.

Journals/Periodicals: J. Genetics, Theoretical and Applied Genetics, Cytologia, Chromosoma, Genome.

Course Outcome: To understand the nature and function of genetic material

Title of the Course: **PLANT BIOCHEMISTRY-I**

Course Code: **BOT-352**

Credit Hours: 3 (2+1)

Nature of Course: Major-V

Specific Objectives of course: To elucidate the structure and role of primary metabolites in plants

Course Outline:

1. **Introduction to photosynthetic organisms:** Bioenergetics and overview of photosynthesis, Photosynthesis: The Light Reaction Photosystems, ATP Synthesis, CO_2 Fixation, RuBisCo and enzyme kinetic, C-3 Cycle, C-4 Cycle, Regulation of photosynthesis.
2. **Introduction to carbohydrates:** Occurrence and classification, Sugar structures, synthesis of polysaccharides, Carbon metabolism in the chloroplast, Starch synthesis Pentose phosphate pathway, Carbon export, Sucrose synthesis and transport in vascular plants, Cellulose synthesis and composition of primary cell walls.
3. **Introduction to lipids:** Occurrence, classification. Structure and chemical properties of fatty acids, Fatty acid biosynthesis in plants, di and triglycerides, phospholipids, glycolipids, sulpholipids, waxes and sterols.
4. **Introduction to 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. Plant defense proteins and peptides, Defensins and related proteins, Synthesis and functions of non-ribosomal peptides.
5. **Introduction to Nucleic Acids:** General introduction. Purine and pyrimidine bases, nucleosides, nucleotides. Structure and properties of DNA and RNA. Types and functions of RNA. Nucleic Acid Metabolism.
6. **Introduction to Enzymes:** Nature and functions, I.U.E. classification with examples of typical groups. Isozymes, ribozymes, abzymes. Enzyme specificity. Enzyme kinetics. Nature of active site and mode of action. Allosteric enzymes and feedback mechanism. Enzymes with multiple functions - mechanisms and evolution. Isoprenoid metabolism, Biosynthetic pathways, Monoterpenes, sesquiterpenes, phytosterols, diterpenes, Enzymes with multiple functions - mechanisms and evolution.

Lab Outline:

i. Solutions, acids and bases. Electrolytes, non-electrolytes, buffers, pH. Chemical bonds.
ii. To determine the Rf value of monosaccharides on a paper Chromatogram.
iii. To estimate the amount of reducing and non-reducing sugars in plant material titrimetrically/spectrophotometrically.

iv. To determine the saponification number of fats.
v. To extract and estimate oil from plant material using soxhlet apparatus.
vi. Analysis of various lipids by TLC methods.
vii. To estimate soluble proteins by Biuret or Lowry or Dye-binding method.
viii. To estimate the amount of total Nitrogen in plant material by Kjeldahl's method.
ix. To determine the Rf value of amino acids on a paper chromatogram.
x. Extraction of Nucleic acids from plant material and their estimation by UV absorption or colour reactions.
xi. To estimate the catalytic property of enzyme catalase or peroxidase extracted from a plant source.
xii. To determine the PKa and isoelectric point of an amino acid.

Recommended Books:

1. Conn E. E. and Stumpf P. K. 2002. Outlines of Biochemistry, John Wiley and Sons Inc. New York.
2. Lehninger, A. L. 2004. 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. Lefkowits, 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. 2008. Plant Biochemistry. 3rd Edition, Academic Press, U. K.
13. Bowsher, C. 2008. Plant Biochemistry.
14. Campbell, M. K. and F. Shawn. 2008. Biochemistry 6th Edition.

Journals / Periodicals:

Plant Physiology and Biochemistry, Annual Review of Biochemistry, Biochemistry Journal, Critical Review in Biochemistry and Molecular Biology.

Course Outcome: To elucidate the structure and role of primary metabolites in plants

Title of the Course: **Plant Ecology-I**

Course Code: **BOT-353**

Credit Hours: **3 (2+1)**

Nature of the Course: Foundation-IX

Specific Objectives of course: To understand the role and interaction of plants with their environment

Course Outline:

Introduction: History and recent developments in ecology.

1. **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.
2. **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.
3. **Carbon dioxide:** Stomatal responses, water loss and CO_2-assimilation rates of plants in contrasting environments. Ecophysiological effects of changing atmospheric CO_2 concentration. Functional significance of different pathways of CO_2 fixation. Productivity: response of photosynthesis to environmental factors, C and N balance.
4. **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.
5. **Oxygen deficiency:** Energy metabolism of plants under oxygen deficiency, Morpho-anatomical changes during oxygen deficiency, Post-anoxic stress.
6. **Wind** as an ecological factor.
7. **Fire** as an ecological factor.

Lab Outline:

i. Determination of physico-chemical properties of soil and water.
ii. Measurements of light and temperature under different ecological conditions.
iii. Measurements of wind velocity.
iv. Measurement of CO_2 and O_2 concentration of air and water.
v. Effect of light, temperature, moisture, salinity and soil type on germination and growth of plants.
vi. Measurement of ions, stomatal conductance, osmotic potential, water potential, xylem. Pressure potential, leaf area and rate of CO_2 exchange in plants in relation to various environmental conditions.

Recommended Books:

1. M. Ahmad and S. S. Shaukat. 2012. A test book of vegetation ecology. Publisher Abrar Sons New Urdu Bazar Karachi.
2. Schultz, J. C. 2005. Plant Ecology, Springer-Verlag.
3. Bazzaz, F. A. 2004. Plants in Changing Environments: Linking Physiological, Population, and Community Ecology, Cambridge University Press.
4. Chapin, F. S. et al. 2002. Principle of Terrestrial Plant Ecology, SpringerVerlag.
5. Lambers, H. et al. 2002. Plant Physiological Ecology, Springer-Verlag.
6. Larcher, W. 2003., Physiological Plant Ecology: Ecophysiology and Stress Physiology of Function Groups-Springer-Verlag.
7. Nobel, P. S 1999, Physico-chemical and Environmental Plant Physiology, Academic Press.
8. Lambers, H. T. L. Pons and F. Stuart. 2008. Plant Phyiological Ecology.
9. Smith, R. L. 2004. Ecology and field Biology. Addison Wesley Longman, Inc., New York.
10. Barbour, M. G., Burke, J. H and Pitts, W. D. 2004 Terrestrial Plant Ecology, The Benjamin, Cumming Publishing C. Palo Alto, California, USA.
11. Smith R. L. 1998 Elements of Ecology. Harper & Row Publishing.
12. Townsend. C. R. Begon. M and J. L Harper. 2002 Essentials of ecology. Blackwell Publishing.
13. Gurevitch. J. Scheiner, S. M. and G. A Fox. 2006 The Ecology of Plants\. Sinaur Associate Inc.
14. Hussain. F. 1989. Field and Laboratory Manual of Plant Ecology, National Academy of Higher Education, Islamabad.
15. Hussain. S. S. 1989. Pakistan Manual of Plant Ecology. National Book Foundation Islamabad.
16. More. P. D. and Chapman S. B. 1986 Methods in Plant Ecology, Blackwell Scientific Publication Oxford.
17. Rashid, A. 2005. Soil Science. National Book Foundation, Islamabad.

Journals / Periodicals:

Pakistan Journal of Botany, Journal of Ecology, Journal of Applied Ecology, Ecology, Journal of Arid Environment.

Course Outcome: To understand the role and interaction of plants with their environment

Title of the Course: **Plant Physiology-I**

Course Code: **BOT-354**

Credit Hours: **3 (2+1)**

Nature of the Course: Major-VI

Specific Objectives of course: To provide comprehensive knowledge on some vital functions and mechanisms of plants.

Course Outline:

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. CO_2 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 regulation. Factors affecting stomatal regulation.
5. **Assimilation of Nitrogen, Sulphur and Phosphorus:** The nitrogen cycle. Nitrogen fixation. Pathways of assimilation of nitrate and ammonium ions. Assimilation of sulphur and phosphorus.

Lab Outline:

i. To determine the volume of CO_2 evolved during respiration by plant material.
ii. To determine the amount of O_2 used by respiring water plant by Winkler Method.
iii. Separation of chloroplast pigments on column chromatogram and their quantification by spectrophotometer.
iv. To extract and separate anthocyanins and other phenolic pigments from plant material and study their light absorption properties.
v. To categorize C3 and C4 plants through their anatomical and physiological characters.
vi. To regulate stomatal opening by light of different colours and pH.

Recommended Books:

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. 2006. Plant Physiology. 4th Edition. Sinnauers 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.
14. Barton, W. 2007. Recent Advances in Plant Physiology.

Journals/Periodicals:

Pakistan Journal of Botany, Plant Physiology, Physiologia Plantarum, Planta, Annual Review of Plant Biology, Journal of Plant Physiology.

Course Outcome: To provide comprehensive knowledge on some vital functions and mechanisms of plants.

Title of the Course: **Research Methodology**

Course Code: **BOT-355**

Credit Hours: **3(2+1)**

Nature of the Course: **Elective-II**

Course Objective

To enable the students to understand various aspects of research, including planning, data collection, analysis, interpretation, presentation of data, writing and submission of research papers and thesis.

Course Outline:

1. Research Methodology: An introduction, definition and the philosophy of science and research.
2. Review of literature. Collection and sources of secondary information.
3. Identification of research problem and formulation of research questions.
4. Hypothesis, their types, experimentation, validation, theories and laws.
5. Research methods, planning research, collection of data, sampling (probability and nonprobability); measurement (surveys, scaling, qualitative, quantitative); data analysis and interpretation of results, writing thesis, research paper and report.
6. The idea of validity in research; reliability of measurements and research ethics. Reference writing: for books, journals, report, proceedings, unpublished thesis and articles.
7. Understanding the complete peer review process of a research journal.
8. Understanding the concept of Plagiarism and use of turnitin software.

LAB OUTLINE:

i. Demonstration of the already prepared sample synopsis by each student (15 minutes)
ii. Preparation of poster presentation (Competition)
iii. Analysis of sample experimental data
iv. Writing of sample abstract; **5.** Writing of sample synopsis
v. Writing of sample research paper; **7.** Writing sample report

Recommended Books:

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.
5. Cothari, C. R. 1990. Research Methodology methods and techniques.

6. Jonker, J and Pennink, B. 2008. The Essence of Research Methodology: A concise guide for master and Ph.D. students.
7. Ravindran, A. R. 2009. Operation Research Methodologies.
8. Worall, J. and Gregory. 1989. Currie the Methodology of scientific research programs V-I.
9. Singh, Y. K. 2006. Fundamentals of Research Methodology.

Journals/Periodicals:

Pakistan Journal of Botany; Plant Physiology; Physiologia Plantarum; Planta; Annual Review of Plant Biology; Journal of Plant Physiology.

Course Outcomes: At the end of the course, the students will be able to understand various aspects of research, including planning, data collection, analysis, interpretation, presentation of data, writing and submission of research papers and thesis.

4th year

Semester 7th

Title of the Course: **Molecular Biology**

Course Code: **BOT-401**

Credit Hours: **3 (2+1)**

Nature of the Course: **Major-VII**

Specific Objectives of course: To disseminate the knowledge of molecular basis of life

Course Outline:

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

Lab Outline:

i. Extraction of RNA, DNA and proteins.

ii. Electrophoreses: One and two dimensional.

iii. Purification of proteins, RNA and DNA.

iv. Amplification using PCR. **5.** Northern, Western and Southern Blotting.

Recommended Books:

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. McGraw-Hill, St. Louis.
9. Lehninger, A. L. 2004. Principles of Biochemistry. Worth Publishers Inc.
10. David Figurski. 2013. Genetic manipulation of DNA and protein, example from current research. In Tech Publishers.
11. Bruce Alberts et al. 2007. Molecular biology of the cell. 5th Edition. Garland and Sons.
12. M. Madan Babu. 2013. Bacterial gene regulations and transcription network. Caister Publishers. Academic Publishers.

Course Outcome: At the end of the course, the students will be able to understrand the knowledge of molecular basis of life.

Title of the Course: **PLANT BIOCHEMISTRY-II**
Course Code: **BOT-402**
Credit Hours: **3(2+1)**
Nature of the Course: **Major-VIII**

Specific Objectives of course: To explicit the fundamentals of metabolic energy, Metabolism and Plant constituents.

Course Outline:

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 betaoxidation 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.

Outline:

i. Separation of soluble proteins by polyacrylamide gel (PAGE) electrophoresis.
ii. Separation of nucleic acids by gel electrophoresis.
iii. To estimate the amount of vitamin C in a plant organ (orange, apple juice).
iv. To determine potential alkaloids in plants.
v. To estimate terpenoids in plants.

Recommended Books:

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. Lefkowits, 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. Taiz, L. and Zeiger, E. 2006. Plant Physiology. 4th Edition. Sinnauers Publ. Co. Inc. Calif.
10. Lea, P.J. and Leegood, R.C. 1993. Plant Biochemistry and Molecular Biology. Wiley and Sons, New York.

11. Abides, R.H., Frey P.A. and Jencks, W.P. 1992. Biochemistry, Jones and Bartlet, London.
12. Goodwin T.W. and Mercer, E.I. 1997. Introduction to Plant Biochemistry. Pergamon Press, Oxford.
13. Heldt, H-W. 2008. Plant Biochemistry. 3rd Edition, Academic Press, U.K.
14. Campbell, M.K. and F. Shawn. 2008. Biochemistry 6th Edition.

Journals / Periodicals:

Plant Physiology & Biochemistry; Annual Review of Biochemistry; Biochemistry Journal; Critical Review in Biochemistry and Molecular Biology.

Course Outcome: This course will enable the students to understand the basic structure, functions and biosynthesis of bio-molecules.

Title of the Course: **PLANT ECOLOGY-II**

Course Code: **BOT-403**

Credit Hours: **3(2+1)**

Nature of the Course: **Major-IX**

Specific Objectives of course: To provide comprehensive knowledge of population, community, ecosystem ecology and its relevance to mankind.

Course Outline:

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

Lab Outline:

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

Recommended Books:

1. Ahmad, M. and S. S. Shaukat. 2012. A test book of vegetation ecology. Publisher Abrar Sons, New Urdu Bazar, Karachi.
2. Schultz J.C. 2005. Plant Ecology, Springer-Verlag
3. Townsend C.R. Begon. M and J.L. Harper 2002. Essentials of Ecology, Blackwell Publishing,
4. Chapin, F.S. et al. 2002. Principle of Terrestrial Plant Ecology, Springer-Verlag,
5. Gurevitch, et al., 2002.The Ecology of Plants, Sinauer Associates, Inc.

6. Barbour M. G. et al., 1999, Terrestrial Plant Ecology, The Benjamin-Cumming Publishing Co.
7. Smith, R. L. 1998. Elements of Ecology by Harper & Row Publishers.
8. Moore P.D. and Chapman S. B. 1986. Methods in Plant Ecology, Blackwell Scientific Publication, Oxford.
9. Hussain, S. Pakistan Manual of Plant Ecology.
10. Hussain, F. 1989. Field and Laboratory Manual of Plant Ecology, National Academy of Higher Education. Islamabad.
11. Lambers, H., T. L. Pons and F. Stuart. 2008. Plant Phyiological Ecology.
12. Larcher. W. 2003 Physiological Plant Ecology. Ecophysiology and Stress Physiology of Function Groups. Springer- Verlag.

Journals / Periodicals: Ecology, Journal of Ecology, Journal of Applied Ecology

Course Outcome: This course will enable the students to understand the basic knowledge of population ecology, community ecology and ecosystem ecology.

Title of the Course: **PLANT ANATOMY**

Course Code: **BOT-404**

Credit Hours: **3(2+1)**

Course Nature: **Foundation-VIII**

Specific objectives of course: To provide the students understanding about anatomical features of vascular plants.

Course outline:

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, bundlesheaths 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: **a.** Flower, **b.** Seed, **c.** Fruit.
9. Economic aspects of applied plant anatomy
10. Anatomical adaptations
11. Molecular markers in tree species used for wood identification.

Lab outline:

i. 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.
ii. Study of abnormal/unusual secondary growth.
iii. Peel and ground sectioning and maceration of fossil material.
iv. Comparative study of wood structure of Gymnosperms and Angiosperms with the help of prepared slides.

Recommended Books:

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. Clerondon 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. Clerondon Press, Oxford.
8. Metcalfe, C.R. 1971. Anatomy of the Monocotyledons.V. Cyperaceae. Clerondon 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
11. Raymond, E.S. and E. Eichhorn. 2005. Esau's Plant Anatomy; Meristematic cells and tissues of plant body. John Willey Sons.
12. Eames, A.J. and L.H. Mac Daniels. 2002. An introduction to Plant Anatomy. Tat Mac-Graw Hill Publishing Company Limited, New Delhi.

Journals/Periodicals: Pakistan Journal of Botany.

Course Outcome: To provide the students understanding about anatomical features of vascular plants.

4th year

Semester 8th

Title of the Course: **PLANT PHYSIOLOGY-II**

Course Code: **BOT-451**

Credit Hours: **3 (2+1)**

Nature of the Course: **Major-X**

Specific Objectives of course: To give it comprehensive and advance knowledge of growth regulators, mechanism of water uptake and role of essential nutrients in plant metabolism.

Course Outline:

1. **Plant Growth Regulators:** Major natural hormones and their synthetic analogues. Bioassay, structure, biosynthesis, receptors, signal trasduction and mode of action, transport, physiological effects of Auxins, Gibberellins, Cytokinins, Abscisic acid, Ethylene, Polyamines, Brassinosteriods, Jasmonates, and Salicylic acid.
2. **Water Relations:** The soil -plant -atmosphere continuum - an overview. Structure of water. Physico-chemical properties of water. Water in the soil and its potentials. Water in cell components. Absorption of water in plants (pathways and driving forces, 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. Circadien rhythms. Classification of plants according to photoperiodic reaction, photoperiodic induction, locus of photoperiodic reaction and dark periods in photoperiodism. Role of photoperiodism in flowering. Biochemical signaling involved in flowering. Vernalization and its effect on flowering. Floral meristem and floral organ development. Floral organ identity genes and the ABC model.
6. **Signal transduction** and gene regulation in prokaryotes and eukaryotes.
7. **Dormancy:** definition and causes of seed dormancy; methods of breaking seed dormancy; types and physiological process of seed germination.

8. **Plant Movements:** Tropic movement-phototropism, gravitropism and their mechanism. Nastic movements.

Lab Outline:

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

Recommended Books:

1. Dennis, D. T., Turpin, D. H., Lefebvre, D. D. and Layzell, D. B. 1997. Plant Metabolism. 2nd Edition. Longman Group, U. K. Dey, P. M. and Harborne, J. B. 1997. Plant Biochemistry. Harcourt Asia PTE Ltd. Singapore.
2. Fitter, A. and Hay, R. K. M. 2001. Environmental Physiology of Plants. Academic Press, UK.
3. Heldt, H. W. 2004. Plant Biochemistry. 3rd Edition, Academic Press, U.K.
4. Ihsan Illahi, 1991. Plant Growth, UGC Press, Islamabad.
5. Ihsan Illahi, 1995. Plant Physiology, Biochemical Processes in Plants, UGC Press.
6. Nobel, P. S. 1999. Physicochemical and Environmental Plant Physiology. Academic Press, UK.
7. Press, M. C., Barker, M. G., and Scholes, J. D. 2000. Physiological Plant Ecology, British Ecological Society Symposium, Volume 39, Blackwell Science, UK.
8. Salisbury F. B. and Ross C. B. 1992. Plant Physiology. 5th Edition. Wadsworth Publishing Co. Belmont CA.
9. W. B. Hopkins. 1999. Introduction to Plant Physiology. 2nd Ed. John Wiley and Sons. New York.
10. Epstein, E. and Bloom, A. J. 2004. Mineral Nutrition of Plants: Principles and Perspectives. 2nd Edition. Sinauer Associates, California, USA.
11. Kirkham, M. B. 2004. Principles of Soil and Plant Water Relations. Elsevier, Amsterdam, Netherlands.
12. Barton, W. 2007. Recent Advances in Plant Physiology.
13. Taiz, L. and Zeiger, E. 2006. Plant Physiology. 4th Edition. Sinnauers Publ. Co. Inc. Calif.

Journals / Periodicals: Pakistan Journal of Botany, Plant Physiology, Physiologia Plantarum, Planta, Annual Review of Plant Biology, Journal of Plant Physiology.

Course Outcome: This course will provide the basic information about plant growth regulators, mechanism of water uptake and role of essestial nutrients in plant growth

Title of the Course: **Genetics-II**

Course Code: **BOT-452**

Credit Hours: **3 (2+1)**

Nature of the Course: **Major-XI**

Specific Objectives of Course: To introduce the students with recombination of genetic material at molecular levels with emphasis on introduction to biotechnology and genomics.

Course Outline:

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

Lab Outline:

i. Isolation and separation of DNA and protein on Gel electrophoresis.

ii. Bacterial chromosome; **ii**. Plasmid DNA (minipreps); **iii**. Plant DNA; **iv**. Protein.

iii. DNA Amplification by PCR.

Recommended Books:

1. Trun, N and Trempy 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.
11. 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.
12. Snyder, L and Champness W, 2003, Molecular Genetics of Bacteria, ASM Press.
13. Wilson, J. and Hunt, T. 2004. Molecular Biology of the cell – the problems book, Garland publishing Inc.
14. Anthony J. F Griffiths, Jeffrey H Miller, David T Suzuki, Richard C Lewontin, and William M Gelbart. W. H. 2009. An Introduction to Genetic Analysis, 7th Edition. Freeman and Company.
15. Hedrick, P. W. 2005. Genetics of Population. Jones and Bartlett Publisher, Sudbury, USA.
16. Mahmut Caliskan. 2012. The Molecular basis of plant genetic diversity. In Tech Publishers.
17. Ram J. Singh. 2011. Genetic resources, chromosome engineering and crop improvement. Medicinal plants. Vol. 6. CRC Press.
18. William S. Klug, Michael R. Cummings, Charlotte A. Spencer, Michael A. Palladino. 2011. Concepts of Genetics. Pearson Educations.
19. Daniel Hartl. 2011. Genetics Johns and Bartlett Publishers.
20. David Hyde. 2008. Introduction to Genetic principles. McGraw-Hill.
21. Daniel, L. Hart, Elizabeth W. Jones. 2009. Analysis of genes and genomes. John and Barlett.
22. Noureddine Benkeblia. 2011. Sustainable agriculture and new biotechnologies. CRC Press.

Journals / Periodicals:

J. Genetics, Theoretical and Applied Genetics, Cytologia, Chromosoma, Genome.

Course Outcome: At the end of this course, the students will understand the basic of gene functions, DNA extraction, amplification and gel electrophoresis.

Title of the Course: **Environmental Biology**

Course Code: **BOT-453**

Credit Hours: **3 (2+1)**

Nature of the Course: **Major-XII**

Specific Objectives of Course: To provide updated knowledge of environmental problems and sustainable environmental management.

Course Outline:

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 and global warming: 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.
12. Aerobiology (Pollen allergy & dust allergy).

Lab Outline:

i. Examination of industrial waste water and Municipal sewage and sludge for
   a. Total dissolved solids.
   b. pH and
   c. EC.

d. BOD/COD.
e. Chlorides, carbonate, and Nitrates.

ii. Examination of water samples forms different sites for the presence and diversity of organisms.

iii. Effect of air pollutants on plants.

iv. Visits to environmentally compromised sites and evolution of remediation methods.

Recommended Books:

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. French, 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. 2004. 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 Grossa Jr., J.M. 1996 Environmental geography: Science, land use, and earth systems. John Wiley and Sons.
9. Lambers, H., T. L. Pons and F. Stuart. 2008. Plant Physiological Ecology.
10. Mohamamd Ashfaq and Mushtaq A. Saleem. Environmental Pollution and Agriculture.
11. Shah Faisal Muhamamd and Sultan Mehmood. 2012. Lambert Publishers Germany.
12. Advanced Air and Noise Pollution Control, L. K. Wang, N. C. Pereira and Y. T. Hung, Humana Press, 2005.
13. Air Pollution Control Technology Handbook, K. B. Schnelle and C. A. Brown, CRC Press, 2002. Handbook of Solid Waste Management and Waste Minimization Technologies, N. P. Cheremisinoff, Butterworth-Heinemann, 2003.
14. Pollution Control In Process Industries, S. P. Mahajan, Tata McGraw-Hill, 1985.
15. Industrial Pollution control: issues and techniques, N. J. Sell, Van Nostrand Reinhold, 1992.
16. Environmental Biotechnology: Basic Concepts and Applications, I. S. Thakur, I.K. International Publishing House Pvt. Limited, 2006.
17. Vandermeer, John H. 2011. The ecology of agro-ecosystems - Jones and Bartlett Publishers; Sudbury, Mass; 2011 - xv, 387 p.
18. Greipsson, Sigurdur. 2011. Restoration ecology - Jones and Bartlett Publishers; Sudbury, MA; 2011 - xvi, 408 p.
19. Santra, S. C. 2010. Fundamentals of ecology and environmental biology - New Central Book Agency; London; 2010 - 353p.
20. Singh, M.P. 2007 Forest environment and biodiversity Daya; New Delhi; 2007 - 556p.

Journals/Periodicals: Environmental Biology, Environment, Bioremediation.

Course Outcome: This course will provide the knowledge of environmental problems and sustainable environmental management.

Course Nature	Course title	Credit hours
ELECTIVE-IV	Plant Pathology (BOT-501)	2+1 (3)
ELECTIVE-V	Palynology (BOT-502)	2+1 (3)
ELECTIVE-VI	Advanced Molecular Biology (BOT-503)	2+1 (3)
ELECTIVE-VII	Plant Breeding (BOT-504)	2+1 (3)
ELECTIVE-VIII	Advanced Plant Systematics (BOT-505)	2+1 (3)
ELECTIVE-IX	Applied Mycology (BOT-506)	2+1 (3)
ELECTIVE-X	Pharmacognosy (507)	2+1 (3)

*Semester Coordinator in consultaion with the Head of Department based on requirement and availability of relevant teacher(s), will ofter the course(s) from Elective-IV to Elective-X.

ELECTIVE COURSES

Elective/Optional paper for BS/ M.Sc

Title of the Course: Advanced Plant Systematics

Course Code: BOT-501

Credit Hours: **3 (2+1)**

Nature of the Course: Elective-VIII

Specific Objectives of the course:

1. This course will explore the theory and procedures of modern systematic analysis
2. Students will be expected to gain a working knowledge of techniques and approaches to Systematics (including phylogenetics and evolutionary processes)
3. Survey the sources and interpretation of systematic data

Course Outlines:

1. Taxonomy in practice: Roles of characters and states, criteria for selection of characters and states, kinds of characters and networks, good and bad characters, evolutionary patterns, choosing evolutionary trees.

2. Concepts of categories: the taxonomic hierarchy, Species, reality of species, naturalness of species, current species concepts, the subspecies, variety and form, biosystematic infraspecific categories, the Genus, the Families and higher categories.

3. Taxonomic information and data: Chemotaxonomy, cytology and cytogenetics, information from breeding systems, isolating mechanisms, information from plant geography and ecology, patterns of geographic distribution, disjunction and vicariance, vicariance biogeography, endemism, centres of diversity, alien plants.

4. Molecular phylogeny: Generating molecular data, analysis of molecular data, alignment of sequences, homoplasy and long branches, methods of phylogeny reconstruction, gene trees vs species trees, Maximum parsimony analysis, Minimum evolution/Neighbour-joining trees, The Neighbour-Joining algorithm, Maximum likelihood phylogenies, Markov Chain Monte Carlo Bayesian analysis.

5. The gathering and storage of Data: Botanical garden, Herbaria and Taxonomic experts, Floras and Monographs, Data information system, Botanical illustrations.

Laboratory/Practical

1. Students will choose a taxon at the level of genus or above that they will use as a case study to explore the various concepts introduced in the course. These will include the applications of molecular phylogenetics to the taxon.

2. Exploration of library and internet resources relevant to systematics or phylogenetics. In particular, the students shall learn the basics of the NCBI Taxonomy database and *BLAST* search algorithms.

3. Constructing phylogenetic trees using PAUP and MEGA from the NCBI sequences.

4. DNA extraction, purification, PCR, sequencing methods.

Recommended Books

1. Tod F. Stuessy (2009). Plant Taxonomy, '*the Systematic Evaluation of Comparative data'* Second Edition, Columbia University Press, New York.
2. Clive A. Stace (1989). Plant Taxonomy and Biosystematics. 2nd Edition.
3. Schuh, R.T. 2000. *Biological Systematics. Principles and Applications.* Cornell University Press, Ithaca, NY
4. Winston, J.E. 1999. *Describing Species. Practical Taxonomic Procedure for Biologists.* Columbia University Press, New York, NY
5. Michael G. Simpson (2010). Plant Systematics, 2nd Edition. Elsevier Academic Press, NY.
6. Hall, B.G. (2011). Phylogenetic Trees Made Easy - A How-To Manual. Fourth Edition. Sinauer, Sunderland M.A.
7. Hillis et al. (eds) (1996) Molecular Systematics, 2nd edition, Sinauer, Sunderland M.A.
8. Nei, M. & Kumar, S. (2000) Molecular Evolution and Phylogenetics. Oxford University Press.
9. Li, W.-H. (1997). *Molecular evolution*. Sinauer Associates, Sunderland, MA, USA.

Journals/ Periodicals

Plant Systematics, Cladistics, BMC Evolutionary Biology, Journal of Evolutionary Biology, Molecular Phylogenetics and Evolution, Systematic Biology, Taxon, Botanical Journal of the Linnean Society, Journal of the Missouri Botanical Garden, Trends in Ecology & Evolution.

Course Outcome: At the end of this course, the students will be able to understand the knowledge of techniques and approaches to Systematics including phylogenetics and evolutionary processes.

Title of the Course: **Applied Mycology**

Course code: BOT-506

Credit Hours: 03(2+1)

Nature of the Course: Elective-IX

Specific objectives: To understand applied aspects of fungi and modern trends in mycology

Course Outline:

1. Introduction: Mycodiversity of kingdom Fungi and fungi like organisms, application of mycology in field of medicine, agriculture, forestry, food and pharmaceutical industries.
2. Pharmaceutical and Chemical Commodities from Fungi: secondary metabolites of fungi, fungi as source of antibiotics, antioxidants, alcohols, alkaloids, vitamins and organic acids, commercial production of penicillins and cyclosporins
3. Food mycology, edible, poisonous and hallucinogenic mushrooms, mushroom farming; button, oyster and shiitake mushroom cultivation, food spoilage, cheeses, beer and wine production through fungi. Fungal toxicity; classes of mycotoxins and mycotoxicoses
4. Fungal ecology: Monitoring and inventorying of fungi, Sampling and collection techniques used for different group of fungi, Isolation of fungi from different substrates such soil, dung, air, water, from animal and plant tissues
5. Mycorrhizal association and type of mycorrhizal fungi, and their role in agriculture and forestry, endophytic fungi
6. Wood rotting fungi, Fungi as efficient decomposing agents, composting and role of fungi in soil formation
7. Mycoremediation: using fungi in controlling water pollutants and toxic industrial and domestic wastes, fungi as biopesticides
8. Myconanotechnology: Syntheses of myco-nanoparticles and their applications
9. Recent advances in fungal systematics and phlogeny: Molecular identification of fungi
10. Fungal genomics and proteomics
11. Fungal media types, preparation, preservation and maintenance

Lab outline:

Basic techniques applied in mycological laboratory (media, equipment, reagents).
Isolation and culturing techniques
Identification of fungi by using mycological keys.
Staining and microscopic techniques of fungal materials
Molecular techniques for identification of macro and microfungi

Recommended Books:

1. Deacon J.W., 2005. Fungal biology. Wiley-Blackwell, 4th ed.
2. Dijksterhuis J., Samson R. A., 2007. Food Mycology: A Multifaceted Approach to Fungi and Food. CRC Press.
3. Burgess Galloway L.D., 1937. Applied Mycology and Bacteriology
4. Arora D., Arora K., Bharat R., 1991. Handbook of Applied Mycology: Volume 1: Soil and Plants.

5. Randy B., 2006. Genes and Genomics, Volume 5 (Applied mycology and Biotechnology)
6. Khachatourians G.G., Arora D.K., 2001. Applied Mycology and Biotechnology: Agriculture and Food Production. Elsevier Science Pub Co., 1st ed.
7. Carlile M., Watkinson S., Graham G., 2001. The Fungi, 2nd ed. Academic Press.
8. Webster J., Weber R., 2007. Introduction to Fungi. Cambridge University Press; 3rd ed

Course Outcome: This course will provide the basic knowledge about the applied aspects of fungi.

Title of the Course: **Palynology**

Course Code: **BOT-501**

Credit hours: **3 (2+1)**

Nature of Course: **Elective-IV**

Specific Objectives of course:

1. To provide instructions on basic pollen taxonomy as an aid in identifying and classifying various palynoflora
2. To provide a general background of the enormous diversity of pollens
3. To understand the various applications of Palynology

Course Outline:

1. Palynology: Aeropalynology, Melissopalynology, Yellow rain, Pollen Allergy; History of Palynology, Palynology as a multidisciplinary field, Applications of Palynology, Palynology in relation to Plant Taxonomy.

2. Pollen Morphology: Polarity and Symmetry, Apertures, Pollen Wall, Structure and Sculpture, Harmomegathy and details of terminology involved in pollen description.

3. Methods: Acetolysis and Light Microscopy, Scanning Electron Microscopy, Transmission Electron Microscopy, New and improved methods in Palynology.

4. Status of Palynology in Pakistan.

Lab Outlines:

1. Preparation of glycerine gelly for pollen preparation
2. Pollen preparations of the local flora through acetolysis methods
3. Acetocarmine staining for light microscopy
4. Pollen fertility estimation
5. Microscopic studies of the quantitative and qualitative features of pollen grains

Recommended Books:

1. Blackmore, S. (2000) The palynological compass: the contribution of palynology to systematics. In: Nordenstam B, El-Ghazaly G, Kassas M (eds) Plant Systematics for the 21st Century. Portland Press, London.

2. Erdtman, G. (1952) Pollen Morphology and Plant Taxonomy. Angiosperms. Almqvist & Wiksell, Stockholm.

3. Erdtman, G. (1969) Handbook of Palynology. An Introduction to the Study of Pollen Grains and Spores. Munksgaard, Copenhagen.

4. Faegri, K and Iversen, J. (1989) Textbook of Pollen analysis. 4th ed. John Wiley & Sons, Chichester.

5. Hesse, M., Halbritter, H., Weber, M., Buchner, R., Frosch-Radivo, A., and Ulrich, S. (2008). Pollen terminology: an illustrated handbook (Springer).

6. Moore, P.D., and Webb, J.A. (1978). An illustrated guide to pollen analysis. London, etc: Hodder & Stoughton.

7. Punt, W., Hoen, P., Blackmore, S., and Le Thomas, A. (2007). Glossary of pollen and spore terminology. Review of Palaeobotany and Palynology *143*, 1-81.

8. Huang, T.C. (1972). Pollen Flora of Taiwan (National Taiwan University: Botany. Dept. Press).

9. Traverse, A (2007) Paleopalynology. 2nd ed., Springer, Dordrecht.

Journals / Periodicals:

Grana, Palynology Journal, Palynology and Paleobotany, Pakistan Journal of Botany, Turkish Journal of Botany, Canadian Journal of Botany, Nardic Journal of Botany, Botanical Journal of the Linnean Society, South African Journal of Botan.

Title of the Course: **PLANT PATHOLOGY**
Course code: **BOT-502**
Credit Hours: **3(2+1)**
Nature of the Course: **Elective-V**

Specific objectives: To understand causes, mechanisms classification and economic importance of plant diseases

Course Outline:

1. Introduction to pathology and plant diseases, history, scope of phytopathology, economic importance of plant disease.
2. Nature, classification of plant diseases.
3. Symptoms of plant diseases, nature and types
4. Nature, classification, growth and reproduction of plant pathogens.
5. Pathogenesis and parasitism: phenomenon of infection, disease development, host parasite relationship, resistance and susceptibility, plant defensive system, the effects of environments and nutrition on disease development
6. Production and liberation of inoculums, Transmission and dissemination of plant pathogens/inoculum
7. Disease detection and diagnosis
8. The principles of disease management: cultural, chemical, biological control of plant diseases, eradication, plant protection and sanitation , quarantines , disease resistant varieties
9. Epidemiology, disease forecast and loss assessment
10. Molecular mechanism of pathogen infection, disease development and transmission
11. Plant diseases: black rot of crucifers, loose smut of barley, black stem rust of wheat, white heart rot of deciduous trees, tobacco mosaic disease, white rust of crucifers, streak smut of wheat, powdery mildews of grasses and ornamental plants, white rust of crucifers, red rot of sugarcane, downy mildews of seedlings, late blight and early blight of potato, damping off caused by phythium spp. shisham dieback, citrus canker of citrus, apple scab, leaf curl of peaches, diseases of transect and storage.

Lab Outline:

i. Identification of major plant pathogens under lab and field conditions.

ii. Culture studies of some important plant pathogenic fungi, application of Koch's postulates for confirmation of pathogencity.

iii. Isolation, sterilization and culturing techniques of plant pathogens.

iv. Collection and studying diseased plant specimens.

Recommended Books:

1. Agrios, G.N., 2005. Plant Pathology, Academic Press, London.
2. Gail L. Schumann and Cleora J. D'Arcy, 2009. Essential Plant Pathology, Second Edition
3. Robert N. Trigiano 2007. Plant Pathology Concepts and Laboratory Exercises, Second Edition
4. Ahmad, I. and Bhutta, A.R., 2004. Textbook of Introductory Plant Pathology. Book Foundation, Pakistan.

5. Trigiano, R.N., Windham, M.T. and Windham, A.S., 2004. Plant Pathology: Concepts and Laboratory Exercises. CRC Press, LLC, N.Y.

Course Outcome: This course will enable the students to isolate pathogenic fungi from infected plant tissues.

Title of the course: **Plant Breeding**

Course Code: **BOT-507**

Credit hours: **3(2+1)**

Course Nature: **Elective-X**

Course Outline:

1. **Plant breeding and its Scope**: Definition, Plant breeding as an art and Science, Concept and Goals of Plant breeding.
2. **Genetic basis for Plant breeding**: Genetic consequences of hybridization, Quantitative inheritance, Population structure, Hardy-Weinberg Law, Combining ability, Heritability, Choice of breeding methods.
3. **Nature of Crops and Methods of breeding**: Mode of Reproduction, Incompatibility, Male sterility, Hybridization.
4. **Domestication and Introduction of Crop Plants**: Centers of Origin, Centers of diversity, Domestication of Crop plants, Introduction of Crop Plants.
5. **Mutation breeding**: Definition and history, Classification of mutation, Mutagens and their classification.
6. **Ploidy breeding**: Classification of Ploidy, Aneuploidy, Euploidy, Ploidy in Crop improvement.
7. **Breeding for Disease and Insects resistance**: Definition, Classification of resistance, Genetics of host parasite interaction, breeding for disease resistance.
8. **Achievements in Crop plants**:
    - Wheat
    - Rice
    - Maize
    - Cotton

Lab Outline:

1. Field study of Crop plants to observe pathogens causing diseases
2. Study of soil texture suitable for crop plants
3. Identification of the domesticated and introduced plants
4. Selection of elite genotypes for future breeding strategies
5. The construction of morphological data recording descriptors

Recommended Books:

1. Coors, J.G. and Pandey, S. (eds) (1999) *The Genetics and Exploitation of Heterosis in Crops*. American Society of Agronomy, Crop Science Society of America, and Soil Science Society of America,
2. Falconer, D.S. (1960) *Introduction to Quantitative Genetics*. Oliver and Boyd, London.

3. Gowen, J.W. (ed.) (1952) *Heterosis*. Iowa State University Press, Ames, Iowa.
4. Hanson, W.D. and Robinson, H.F. (eds) (1963) *Statistical Genetics and Plant Breeding*. Publication 982, National Academy of Sciences – National Research Council, Washington, DC.
5. Mather, K. (1949) *Biometrical Genetics*, 1st edn. Methuen, London.
6. Pollak, E., Kempthorne, O. and Bailey, T.B., Jr (eds) (1977) *Proceedings of International Conference on Quantitative Genetics*. Iowa State University Press, Ames, Iowa.
7. Schuler, J. (1988) Inserting genes affecting quantitative traits. In: Weir, B.S., Eisen, E.J., Goodman, M.M. and Namkoong, G. (eds) *Proceedings of the Second International Conference on Quantitative Genetics*. Sinauer Associates, Sunderland, Massachusetts, pp. 198–199.
8. Chahal, G.S. and S.S. Gosal. 2003. Principles and Procedures of Plant Breeding. Narosa Publishing House, New Delhi, India.
9. Singh, B. D. 2003. Plant Breeding: Principles and Methods. Kalyani Publishers, New Delhi, India.

Course Outcome: This course will provide the basic information about plant breeding techniques.

Title of the course: **Pharmacognosy**

Course Code: **BOT-504**

Credit hours: **3(2+1)**

Course Nature: **Elective-VII**

Objectives of the course:

The main objective of the course is to provide information about the medicinal uses of the local plants.

Course Outline

- Definition of pharmacology, drugs, crude drugs, official and unofficial drugs, cultivation, collection, curing, drying, preservation, evaluation and classification of drugs, therapeutic classes of drugs.
- Detail study of the following medicinal plants (Angiosperms), giving those synonyms, botanical origin, local names, distribution of plants, methods of cultivation, macroscopical characteristics of drugs. microscopical characteristics of drugs ,chemical constituents ,uses and adulterants with special refrence to species growing in Pakistan.
    1. Opium (Family Papaveraceae)
    2. Berberis (Family Berbaridaceae)
    3. Liquorice (Family Papaveraceae)
    4. Acacia (Family Mimosaceae)
    5. Cassia (Family Caesalpinaceae)
    6. Colchicum (Family liliaceae)
    7. Zingiber (Family Zingiberaceae)
    8. Mentha (Family Lamiaceae)
    9. Foeniculum (Family Apiaceae)
    10. Coriandrum (Family Apiaceae

Lab Outline:

1. Microscopical characters of the drugs using sectioning and powdered drugs
2. Macroscopic study of different gums and oils
3. Identification test for starch, Ca-oxalate
4. Identification tests for volatile and fixed oil, tannin and mucilage etc.

Recommended Books:

1. Tyler, V.L.E.R. Brady & E.F. Clayse. 1970. Pharmacognosy 6th Ed. Leimption London.
2. Trease G.D & W.C Evans.1985. Pharmacognosy 12th Ed, English Language. Soc. Bailere Tindall.

3. Jain, S.K. 1987. A manual of Ethnobotany. Scientific Publisher Johpur, India.
4. Willism, T.E.1998. Text book of Pharmacognosy. Churchill Ltd. Glouester Palace, W.I. London.
5. R S Satorkar and S D Bhandarkar, Pharmacology and Pharmacotherapeutics, Popular Prakashan, Bomby, 1993.
6. G E Trease and W C Evans, Pharmacognosy, W B Saunders, Philadelphia, Toronto, 2002.

Course Outcome: This course will enable the students about the local medicinal uses of plants.

ANNEX-II

SCHEME OF STUDIES FOR M.Sc. BOTANY 2 YEARS

Semester	Name of Subject	Theory	Lab	Total Crdt hours
First	FOUNDATION-I **Bot-501 Bacteriology and Virology**	2	1	3
	MAJOR-I **Bot-502 Phycology and Bryology**	2	1	3
	MAJOR-II **Bot-503 Mycology and Plant Pathology**	2	1	3
	FOUNDATION-II **Bot-504 Diversity of Vascular Plants**	2	1	3
	MAJOR-III **Bot-505 Plant Systematics**	2	1	3
	COMPULSURY-I **CS-506 Introduction to Computer**	2	1	3
				18
Second	MAJOR-IV **Bot-551 Genetics-I**	2	1	3
	MAJOR-V **Bot-552 Plant Biochemistry-I**	2	1	3
	FOUNDATION-III **Bot-553 Plant Ecology-I**	2	1	3
	MAJOR-VI **Bot-554 Plant Physiology-I**	2	1	3
	MAJOR-VII **Bot-555 Molecular Biology**	2	1	3
	ELECTIVE-I **Bot-556 Research Methodology**	2	1	3
				18
Third	FOUNDATION-IV **Bot-601 Plant Anatomy**	2	1	3
	COMPULSURY-II **Bot-602 Biostatistics**	2	1	3
	MAJOR-VIII **Bot-603 Plant Biochemistry-II**	2	1	3
	MAJOR-IX **Bot-604 Plant Ecology-II**	2	1	3
	MAJOR-X **Bot-605 Plant Physiology-II**	2	1	3
	ELECTIVE-II **Bot-606 Advanced Molecular Biology** RESEARCH PROJECT/ INTERNSHIP/*OPTIONAL PAPER	2	1	3
				18
Fourth	MAJOR-XI **Bot-651 Genetics-II**	2	1	3
	MAJOR-XII **Bot-652 Environmental Biology**	2	1	3

	ELECTIVE-III RESEARCH PROJECT/ THESIS/ INTERNSHIP/ *OPTIONAL PAPER **Bot-653 Plant Pathology**	2	1	3
	ELECTIVE-IV **Bot-654 Conservation Biology**	2	1	3
	ELECTIVE-V **Bot-655 Medicinal Plants**	2	1	3
	ELECTIVE-VI **Bot-656 Applied Ethnobotany**	2	1	3
				18
	TOTAL	**48**	**24**	**72**

Additional *Optional/ Elective Courses for M.Sc program

Semester	**New Course Codes**	**Course Titles**	**Theory**	**Lab**	**Cr. Hrs.**
3rd	**Bot-607**	Paleobotany and Palynology	2	1	3
	Bot-608	Advanced Plant Systematics	2	1	3
	Bot-609	Plant breeding	2	1	3
	Bot-610	World Major Biomes	2	1	3
	Bot-611	Edaphology	2	1	3
	Bot-612	Phytogeography	2	1	3
4th	**Bot-657**	Applied Mycology	2	1	3
	Bot-658	Plant Genomics	2	1	3
	Bot-659	Molecular Phylogenetics	2	1	3
	Bot-660	DNA Barcoding	2	1	3
	Bot-661	Economic Botany	2	1	3
	Bot-662	Taxonomy of Phanerogams	2	1	3
	Bot-663	Laboratory techniques in Botany	2	1	3
	Bot-664	Biotechnology and Genetic Engineering	2	1	3
	Bot-665	Tissue Culture	2	1	3
	Bot-666	Mushrooms	2	1	3

DETAIL OF COURSES FOR M.Sc. (2 – YEAR) BOTANY

SEMESTER--1

TITLE OF THE COURSE: BACTERIOLOGY AND VIROLOGY

COURSE CODE: BOT-501 **Credit Hours:** 3(2+1)

OBJECTIVES: To enable the students to understand the characteristics, structure, Classification and economic importance of Viruses and Bacteria.

COURSE OUTLINE:

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; **6.** Symptoms and control of major bacterial diseases in Pakistan;

c) Plant Microbe Interaction

Role of phytohormones in understanding interaction between disease causing bacteria and plant growth and development.

LAB OUTLINE:

a) Viruses

Observation of disease symptoms caused by plant viruses.

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.

COURSE OUTCOMES: At the completion of this course the students will be able to understand the general characteristics, classification, taxonomy, structural organization, useful aspects and diseases caused by Bacteria and Viruses.

RECOMMENDED BOOKS:

1. Black, J.G. 2017. Microbiology - Principles and Exploration, 10th Edition. John Wiley and Sons, Inc.

2. Prescott, L.M., Harley, J.P. and Klein, D.A. 2017. Microbiology, 10th Edition. McGraw Hill Companies, Inc.
3. Arora, D.R. 2012. 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. 2001. Plant Viruses as Molecular Pathogens, CRC 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.
8. Molecular Plant-Microbe Interactions, Kamal Bouarab, Normand Brisson, Fouad Daayf (eds), 2009 MPG Books Group, Bodmin, UK.
9. Plant-Microbe Interactions Gary Stacey, Noel T. Keen (Eds) 2011, springer London.

JOURNALS/PERIODICALS:

World Journal of Microbiology & Biotechnology, Current Microbiology, Journal of Industrial Microbiology and Biotechnology, Journal of General Virology, Journal of Virology.

TITLE OF THE COURSE: PHYCOLOGY AND BRYOLOGY

COURSE CODE: BOT-502 **Credit Hours:** 3(2+1)

OBJECTIVES: To acquaint the students with general features, classification, morphology, life cycles and economic importance of different groups of Algae and Bryophytes.

COURSE OUTLINE:

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

LAB OUTLINE:

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.

COURSE OUTCOMES: The student will be able to learn the characteristic features (photosynthetic pigments, motility, structural organization, and spores types), classification, life cycles, and economic importance of major orders and classes of Algae and Bryophytes.

RECOMMENDED BOOKS:

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, Uni. of Peshawar.
8. Barsanti, L. and P. G. Gualtieri. 2006. Algae, anatomy, biochemistry, biotechnology. Taylor and Francis, New York.
9. Vashishta, B. R., A. K. Sinha and A. Kumar. 2010. Algae. S. Chand & Co.
10. Bellinger, E. G. and D. C. Sigee. 2010. Fresh water algae (Identification and use as bioindicators). John Wiley & Sons.
11. Hussain, F. 2013. Phycology. A text book of Algae. Pak Book Empire Lahore.
12. Vashishta, B. R., A. K. Sinha and A. Kumar. 2010. Bryophytes. S. Chand & Co. New Delhi.
13. Fida Hussain, Habib Ahmad and Syed Zahir Shah. 2012. The unicellular algae of District Peshawar, Pakistan. Lambert Publication, Germany.

JOURNALS / PERIODICALS:

Pakistan Journal of Botany; International Journal of Phycology and Phycochemsitry; Bryology; Phycology.

TITLE OF THE COURSE: MYCOLOGY AND PLANT PATHOLOGY

COURSE CODE: BOT-503 **Credit Hours:** 3(2+1)

OBJECTIVES: To introduce the students to Mycology and Diseases caused by Fungi.

COURSE OUTLINE:

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:** Modern classification system of fungi. General characters, reproduction of Microsporidia, Rozellomycota, Blastocladiomycota, Chytridiomycota, Zoopagomycota, Mucoromycota, Ascomycota and Basidiomycota.
4. Symbiotic relationships of fungi with plants (entophytes, mycorrhiza) and algae (lichen) 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, red rot of sugarcane etc. **6**. Systemic resistance: Induced systematic resistance (ISR), Acquired Systematic resistance (ASR).

LAB OUTLINE:

c. Mycology

General characters and morphology of fungi: Microscopic study of zoospore and non-motile spore of fungi. Preparation of culture media for fungal culturing. Isolation and characterization of different fungi from air, soil and water.

d. Pathology

Isolation and characterization of some common plant pathogenic fungi from infected plants, demonstration practical application of Koch's postulates for confirmation of pathogenicity.

COURSE OUTCOMES: At the end of the course, the students would be able to understand the classification and morphology of fungi and the common plant diseases caused by fungi.

RECOMMENDED BOOKS:

1. Joseph Heitman, Barbara J. Howlett, Pedro W. Crous, Eva H. Stukenbrock, Timothy Y. James, Neil A. R. Gow. 2017. The Fungal Kingdom, American Society for Microbiology Washington, DC.
2. Spatafora, Joseph W., M. Catherine Aime, Igor V. Grigoriev, Francis Martin, Jason E. Stajich, and Meredith Blackwell. 2017. The fungal tree of life: from molecular systematics to genome-scale phylogenies. Microbiol Spectrum 5(5): FUNK-0053-2016. doi:10.1128/microbiolspec.FUNK-0053-2016.
3. Agrios, G.N., 2005. Plant Pathology, Academic Press, London.
4. Ahmad, I. and Bhutta, A.R., 2004. Textbook of Introductory Plant Pathol. Book Foundation, Pak.
5. Alexopoulos, C.J., Mims, C.W. and Blackwell, M., 1996. Introductory Mycology, 4th ed. John Wiley & Sons.
6. Khan, A.G. and Usman, R., 2005. Laboratory Manual in Mycology and Plant Pathology. Botany Department Arid Agriculture University, Rawalpindi.
7. Mehrotra, R.S. and Aneja, K.R., 1990. An Introduction to Mycology. Wiley and Eastern Ltd., India.
8. Moore-Landecker, E., 1996. Fundamentals of Fungi. 4th edn. Prentice Hall Inc., New Jersey, USA.
9. Trigiano, R.N., Windham, M.T. and Windham, A.S., 2004. Plant Pathology: Concepts and Laboratory Exercises. CRC Press, LLC, N.Y.

JOURNALS / PERIODICALS:

Mycotaxon, Studies in Mycology, Mycologia, MycoKeys, Phytopathology, Australasian Journal of Plant pathology, Asian Journal of Plant Pathology, Annual Review of Plant Pathology. Microbiology Spectrum, Fungal Diversity, Mycoscience.

TITLE OF THE COURSE: DIVERSITY OF VASCULAR PLANTS

COURSE CODE: BOT-504 **Credit Hours:** 3(2+1)

OBJECTIVES: To enable the students to understand the characteristics of Pteridophytes and Gymnosperms; including their classification, plant body, life cycle, fossil records. Pollen morphology and terminology used to describe them.

COURSE OUTLINE:

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. Cooksonia

General characters, classification, affinities and comparative account of evolutionary trends of the following phyla: Psilopsida (Psilotum), Lycopsida (Lycopodium, Selaginella), Sphenopsida (Equisetum), Pteropsida (Ophioglossum, Dryopteris and Azolla/Marsilea).

b) Origin and Evolution of seed habit.

c) Gymnosperms: Geological history, origin, distribution, morphology, anatomy, classification and affinities of Cycadofillicales, Bennettitales, Ginkgoales, Cycadales and Gnetales. Distribution of gymnosperms in Pakistan. Economic importance of gymnosperms. An introduction to the Gondwana flora of world.

d. Angiosperms: Origin, general characteristics, Importance, and life cycle of angiosperms

e) 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.

LAB OUTLINE:

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

COURSE OUTCOMES: The students should know about the evolutionary trends in pteridophytes and gymnosperms from fossil records to present day diversity. Will be able to identify the vast array of pollen types, and pollen science applications.

RECOMMENDED BOOKS:

1. Beck, C.B. 1992. Origin and Evolution of Gymnosperms. Vol1&II, Columbia Uni. Press, New York.
2. Foster, A.S. & Gifford, E. M. Jr. 1998. Comparative Morph. of Vascular Plants. W. H. Freeman & Co.
3. Jones, D. 1983. Cycadales of the World, Washington, DC.
4. Mauseth, J.D. 1998. An Intro.to Plant Biology, Multimedia Enhanced, Jones & 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. Biol. of Plants, W.H. Freeman and Comp. Worth Pub.
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. 2000. The Biology and Evolution of Fossil Plants, Prentice Hall.
9. Stewart, W. N. and Rothwell, G.W. 1993. Paleobotany & the Evolution of Plants, Uni. Press, Cambridge.
10. Faegri, K., P.E. Kaland & K. Krzywinski 1989. Text Book of Pollen Analysis, Jhon Wiley & Sons. N.Y.
11. Vashishta, B. R., A. K. Sinha and A. Kumar. 2010. Pterodophyta. S. Chand & Co. New Delhi.
12. B. P. Panday. 2006. College Botany. Vol 1 & II. S. 7 th Edition. Chand & Co. New Delhi.

JOURNALS / PERIODICALS: Pakistan Journal of Botany, New Phytologist, Review of Palaeobotany & Palynology, Palaeontographica, Palaeobotanist.

TITLE OF THE COURSE: PLANT SYSTEMATICS

COURSE CODE: BOT-505 **Credit Hours:** 3(2+1)

OBJECTIVES: To study the principles and philosophy of systematics, nomenclature and classification. To enable the students with methods of taxonomic evidences. To study the morphology and economic importance of flowering plant families and their phylogenetic relationship.

COURSE OUTLINE:

1. **Introduction**: Importance, scope and historical background of systemstics. Definition and concepts of the principles of systematics. Systematics as interdisciplinary science. Floristic phases of plant taxonomy.
2. **Species Concepts:** What is a species? Taxonomic species, Biological species, Micro and macro species, Species aggregate. Infra specific categories.
3. **Speciation**: Mechanism of speciation; isolating mechanisms; Mutation and hybridization; Polyploidy; Plant Breeding systems.
4. **Variation**: Types and sources of variation. Local and geographic patterns of 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:** Description (terminologies used), importance, types of data, methods of uses and shortcomings of taxonomic evidences: Morphology, Anatomy, Embryology, Chromospmes, Palynology, Biogeography, Numerical taxonomy and phonetics, Phytochemistry, Molecular Biology and phylogenetics.
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**: Origin and evolution of angiosperm, the earliest fossil records of angiosperms.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..
9. General characteristics, distribution, evolutionary trends, phyletic relationships and economic importance of the following families of angiosperm:

1. Apiaceae 2. Arecaceae 3. Apocynaceae 4. Asteraceae (Compositae) 5. Boraginaceae 6. Brassicaceae 7. Moraceae 8. Caryophyllaceae 9. Amaranthaceae 10. Convolvulaceae 11. Cucurbitaceae 12. Cyperaceae 13. Euphorbiaceae 14. Fabaceae 15. Lamiaceae 16. Liliaceae 17. Magnoliaceae 18. Malvaceae 19. Polygonaceae 20. Orchidaceae 21. Papaveraceae 22. Poaceae (Gramineae); 23. Ranunculaceae; 24. Rosaceae 25. Salicaceae 26. Scrophulariaceae 27. Solanaceae.

LAB OUTLINE:

1. Technical description of plants of the local flora and their identification up to species level with the help of a regional/Flora of Pakistan.
2. Preparation of indented and bracketed types of keys.
3. Preparation of permanent slides of pollen grains by acetolysis method and study of different pollen characters.

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

COURSE OUTCOMES: The students should be able to learn botanical terminology and identify different plant structures and organs. Should acquaint with the application of different tools and techniques in taxonomy. Will learn, and can identify the common flora of the region using taxonomic keys. Can refer plants to their respective families.

RECOMMENDED BOOKS:

1. Walter, S. J., C. S. Campbell., E. A. Kellogg., P. F. Stevens and M. J. Donoghue. 2015. Plant Systematics: A Phylogenetic Approach, 4th Edition. Sinauer Associates Oxford University Press.
2. Ali, S.I. and Nasir, Y. 1990-92. Flora of Pakistan. Karachi Univ. Press, Karachi.
3. Ali, S.I. and Qaiser, M. 1992-2018. Flora of Pakistan. Karachi Univ. Press, Karachi.
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. 1970-89. Flora of Pakistan. Karachi Univ. Press, Karachi.
7. Stace, C. A. 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. 2005. Taxonomy of Angiosperms. Tata McGraw Hill Pub. Company, New Delhi.
11. Stussy, T. F. 2009. Plant Taxonomy, Columbia University Press, USA.
12. Jeffrey C. 1980. An Introduction to Plant Taxonomy. Cambridge University Press.UK.
13. Radford, A.E., W.C. Dickison, J.R. Massey, and C. R. Bell. 1998 Vascular Plant Systematic. Harper and Row, New York.
14. Heywood V.H. 1978. Flowering Plants of the World. Oxford University Press.
15. Simpson, M.G. 2010. Plant Systematics. Elsevier Academic Press.
16. Soltis, D.E., P.S. Soltis, P.K Endress, and M.W. Chase. 2005. Phylogeny & evolution of angiosperms. Sinauers associates, Inc. Publishers.
17. Pullaiah, T. 2007. Taxonomy of Angiosperms 3rd Ed. Regency Publication, New Delhi.

JOURNALS / PERIODICALS: Pakistan Journal Botany, Flora of Pakistan, Taxon, Botanical Journal of the Linnean Society, Plant Systematics and Evolution, Turkish Journal of Botany, Botany, Annals of the Missorie Botanical Garden, Phytotaxa, Flora.

TITLE OF THE COURSE: INTRODUCTION TO COMPUTER

COURSE CODE: BOT-506 **Credit hours:** 3 (2+1)

OBJECTIVES:

To impart basic computing skills necessary for use of digital support to modern education for acquiring knowledge through offline and online resources, analysis of data, composition of data and presentation of data in the efficient and effective way.

COURSE OUTLINE:

1. Definition, Types and classification of computers.
2. Hardware: Input hardware, Storage hardware, processing hardware, output hardware.
3. Software: Application software, system software, software packages.
4. Operating system (Windows), internet, e-mail, Local Area Network, Configurations.
5. Introduction to MS-Word, MS-Excel, MS-Power Point, MS-Access.
6. Introduction to Bioinformatics and Computational Biology; Analysis, Storage and Retrieval of Genome Data; Sequence Data, Sequence Alignment and Phylogenetic Analysis Methods; UPGMA, Maximum likelihood and Maximum Parsimony analysis.

OUTCOMES:

The students should learn internet data surfing, writing and other operations in Microsoft word, Excel, and can present their data on power point. Can analyze and compute data using computer programs.

RECOMMENDED BOOKS:

1. Fundamentals of Computer. Long, l and Long, N. 6th Ed. 2001.
2. Microsoft office 2000. Courter, G and Marquis, A. BPB publication. 1999.
3. Computational Molecular Biology by P.A. Pevzner, Prentice hall of India Ltd. 2004.
4. Bioinformatics by David W. Mount, Cold Spring Harbor Laboratory Press. 2001.

SEMESTER 2

TITLE OF THE COURSE: GENETICS-I

COURSE CODE: BOT-551 **Credit Hours**: 3 (2+1)

OBJECTIVES: To understand the nature and function of genetic material.

COURSE OUTLINE:

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

LAB OUTLINE:

1. Numerical problems

a) Arrangement of genetic material:

i. Linkage and recombination. **ii**. Gene mapping in diploid. **iii**. Recombination in Fungi. **iv**. Recombination in bacteria. **v**. Recombination in viruses.

b) Population Genetics:

i. Gene frequencies and equilibrium. **ii**. Changes in gene frequencies.

2. Blood group and Rh-factor

3. Drosophila: i. Culture technique, **ii**. 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: **i.** Bacterial cultural techniques, Gram staining (E. coli, B. subtilis)

ii. Transformation. **iii**. Conjugation.

COURSE OUTCOMES: At the end of the course, the student would be able to understand the basic function and nature of genetic material.

RECOMMENDED BOOKS:

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, 2 nd Edition, Oxford University Press Inc. 10. 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.
9. Hartl, D. L. and Jones, E. W. 2005, Genetics - Analysis of Genes and Genomes, Jones and Bartlett Publishers. Sudbry, USA.
10. Hedrick, P. W. 2005. Genetics of Population. Jones and Bartlett Publisher, Sudbury, USA.
11. Mahmut Caliskan. 2012. The Molecular basis of plant genetic diversity. In Tech Publishers.
12. Ram J. Singh. 2011. Genetic resources, chromosome engineering and crop improvement. Medicinal plants. Vol. 6. CRC Press.
13. William S. Klug, Michael R. Cummings, Charlotte A. Spencer, Michael A. Palladino. 2011. Concepts of genetics. Pearson Educations.
14. Daniel Hartl. 2011. Genetics Johns and Bartlett Publishers.
15. David Hyde. 2008. Introduction to Genetic principles. McGraw-Hill.
16. Daniel, L. Hart, Elizabeth W. Jones. 2009. Analysis of genes and genomes. John and Barlett.
17. Noureddine Benkeblia. 2011. Sustainable agriculture and new biotechnologies. CRC Press.

JOURNALS/PERIODICALS: J. Genetics, Theoretical and Applied Genetics,

Cytologia, Chromosoma, Genome.

TITLE OF THE COURSE: PLANT BIOCHEMISTRY-I

COURSE CODE: BOT-552 **Credit Hours:** 3 (2+1)

OBJECTIVES: To elucidate the structure and role of primary metabolites in plants.

COURSE OUTLINE:

1. **Introduction to photosynthetic organisms:** Bioenergetics and overview of photosynthesis, Photosynthesis: The Light Reaction Photosystems, ATP Synthesis, CO_2 Fixation, RuBisCo and enzyme kinetic, C-3 Cycle, C-4 Cycle, Regulation of photosynthesis.

2. **Introduction to carbohydrates:** Occurrence and classification, Sugar structures, synthesis of polysaccharides, Carbon metabolism in the chloroplast, Starch synthesis Pentose phosphate pathway, Carbon export, Sucrose synthesis and transport in vascular plants, Cellulose synthesis and composition of primary cell walls.
3. **Introduction to lipids:** Occurrence, classification. Structure and chemical properties of fatty acids, Fatty acid biosynthesis in plants, di and triglycerides, phospholipids, glycolipids, sulpholipids, waxes and sterols.
4. **Introduction to 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. Plant defense proteins and peptides, Defensins and related proteins, Synthesis and functions of non-ribosomal peptides.
5. **Introduction to Nucleic Acids:** General introduction. Purine and pyrimidine bases, nucleosides, nucleotides. Structure and properties of DNA and RNA. Types and functions of RNA. Nucleic Acid Metabolism.
6. **Introduction to Enzymes:** Nature and functions, I.U.E. classification with examples of typical groups. Isozymes, ribozymes, abzymes. Enzyme specificity. Enzyme kinetics. Nature of active site and mode of action. Allosteric enzymes and feedback mechanism. Enzymes with multiple functions - mechanisms and evolution. Isoprenoid metabolism, Biosynthetic pathways, Monoterpenes, sesquiterpenes, phytosterols, diterpenes, Enzymes with multiple functions - mechanisms and evolution.

LAB OUTLINE:

1. Solutions, acids and bases. Electrolytes, non-electrolytes, buffers, pH. Chemical bonds.
2. To determine the Rf 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 Rf value of amino acids on a paper chromatogram.
10. Extraction of Nucleic acids from plant material and their estimation by UV absorption or colour reactions.
11. To estimate the catalytic property of enzyme catalase or peroxidase extracted from a plant source.
12. To determine the PKa and isoelectric point of an amino acid.

COURSE OUTCOMES: At the end of the course, the student should have a basic knowledge of the structure and role of primary metabolites of plants.

RECOMMENDED BOOKS:

1. Conn E. E. and Stumpf P. K. 2002. Outlines of Biochemistry, John Wiley and Sons Inc. New York.
2. Lehninger, A. L. 2004. 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. Lefkowits, 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. 2008. Plant Biochemistry. 3rd Edition, Academic Press, U. K.
13. Bowsher, C. 2008. Plant Biochemistry.
14. Campbell, M. K. and F. Shawn. 2008. Biochemistry 6th Edition.

JOURNALS / PERIODICALS:

Plant Physiology and Biochemistry, Annual Review of Biochemistry, Biochemistry Journal, Critical Review in Biochemistry and Molecular Biology.

TITLE OF THE COURSE: PLANT ECOLOGY-I

COURSE CODE: BOT-553 **Credit Hours**: 3 (2+1)

OBJECTIVES: To understand the role and interaction of plants with their environment.

COURSE OUTLINE:

Introduction: History and recent developments in ecology.

1. **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.
2. **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.
3. **Carbon dioxide:** Stomatal responses, water loss and CO_2-assimilation rates of plants in contrasting environments. Ecophysiological effects of changing atmospheric CO_2 concentration. Functional significance of different pathways of CO_2 fixation. Productivity: response of photosynthesis to environmental factors, C and N balance.
4. **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.
5. **Oxygen deficiency:** Energy metabolism of plants under oxygen deficiency, Morpho-anatomical changes during oxygen deficiency, Post-anoxic stress.
6. **Wind** as an ecological factor.
7. **Fire** as an ecological factor.

LAB OUTLINE:

1. Determination of physico-chemical properties of soil and water.
2. Measurements of light and temperature under different ecological conditions.
3. Measurements of wind velocity.
4. Measurement of CO_2 and O_2 concentration of air and water.
5. Effect of light, temperature, moisture, salinity and soil type on germination and growth of plants.
6. Measurement of ions, stomatal conductance, osmotic potential, water potential, xylem. Pressure potential, leaf area and rate of CO_2 exchange in plants in relation to various environmental conditions.

COURSE OUTCOMES: The student would be able to understand the role and interaction of plants with their environment.

RECOMMENDED BOOKS:

1. M. Ahmad and S. S. Shaukat. 2012. A test book of vegetation ecology. Publisher Abrar Sons New Urdu Bazar Karachi.
2. Schultz, J. C. 2005. Plant Ecology, Springer-Verlag.

3. Bazzaz, F. A. 2004. Plants in Changing Environments: Linking Physiological, Population, and Community Ecology, Cambridge University Press.
4. Chapin, F. S. et al. 2002. Principle of Terrestrial Plant Ecology, SpringerVerlag.
5. Lambers, H. et al. 2002. Plant Physiological Ecology, Springer-Verlag.
6. Larcher, W. 2003., Physiological Plant Ecology: Ecophysiology and Stress Physiology of Function Groups-Springer-Verlag.
7. Nobel, P. S 1999, Physico-chemical and Environmental Plant Physiology, Academic Press.
8. Lambers, H. T. L. Pons and F. Stuart. 2008. Plant Phyiological Ecology.
9. Smith, R. L. 2004. Ecology and field Biology. Addison Wesley Longman, Inc., New York.
10. Barbour, M. G., Burke, J. H and Pitts, W. D. 2004 Terrestrial Plant Ecology, The Benjamin, Cumming Publishing C. Palo Alto, California, USA.
11. Smith R. L. 1998. Elements of Ecology. Harper & Row Publishing.
12. Townsend. C. R. Begon. M and J. L Harper. 2002 Essentials of ecology. Blackwell Publishing.
13. Gurevitch. J. Scheiner, S. M. and G. A Fox. 2006 The Ecology of Plants\. Sinaur Associate Inc.
14. Hussain. F. 1989. Field and Laboratory Manual of Plant Ecology, National Academy of Higher Education, Islamabad.
15. Hussain. F. 1989. Pakistan Manual of Plant Ecology. National Book Foundation Islamabad.
16. More. P. D. and Chapman S. B. 1986 Methods in Plant Ecology, Blackwell Scientific Publication Oxford.
17. Rashid, A. 2005. Soil Science. National Book Foundation, Islamabad.

JOURNALS / PERIODICALS:

Pakistan Journal of Botany, Journal of Ecology, Journal of Applied Ecology, Ecology, Journal of Arid Environment.

TITLE OF THE COURSE: PLANT PHYSIOLOGY-I

COURSE CODE: BOT-554 **Credit Hours:** 3 (2+1)

OBJECTIVES: To provide comprehensive knowledge on some vital functions and mechanisms of plants.

COURSE OUTLINE:

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. CO_2 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 regulation. Factors affecting stomatal regulation.
5. **Assimilation of Nitrogen, Sulphur and Phosphorus:** The nitrogen cycle. Nitrogen fixation. Pathways of assimilation of nitrate and ammonium ions. Assimilation of sulphur and phosphorus.

LAB OUTLINE:

1. To determine the volume of CO_2 evolved during respiration by plant material.
2. To determine the amount of O_2 used by respiring water plant by Winkler Method.
3. Separation of chloroplast pigments on column chromatogram and their quantification by spectrophotometer.
4. To extract and separate anthocyanins and other phenolic pigments from plant material and study their light absorption properties.
5. To categorize C3 and C4 plants through their anatomical and physiological characters.
6. To regulate stomatal opening by light of different colours and pH.

COURSE OUTCOMES: At the end of the course, the student would have the basic knowledge about the mechanism of some vital functions plant tissues.

RECOMMENDED BOOKS:

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. 2006. Plant Physiology. 4th Edition. Sinnauers 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.
14. Barton, W. 2007. Recent Advances in Plant Physiology.

JOURNALS/PERIODICALS:

Pakistan Journal of Botany, Plant Physiology, Physiologia Plantarum, Planta, Annual Review of Plant Biology, Journal of Plant Physiology.

TITLE OF THE COURSE: MOLECULAR BIOLOGY

COURSE CODE: BOT-555 **Credit Hours:** 3 (2+1)

OBJECTIVES: To disseminate the knowledge of molecular basis of life.

COURSE OUTLINE:

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

LAB OUTLINE:

1. Extraction of RNA, DNA and proteins. **2.** Electrophoreses: One and two dimensional. **3.** Purification of proteins, RNA and DNA. **4.** Amplification using PCR. **5.** Northern, Western and Southern Blotting.

COURSE OUTLINES: At the end of the course, the student would be able to understand the molecular mechanism of Genes.

RECOMMENDED BOOKS:

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. McGraw-Hill, St. Louis.
9. Lehninger, A. L. 2004. Principles of Biochemistry. Worth Publishers Inc.
10. David Figurski. 2013. Genetic manipulation of DNA and protein, example from current research. In Tech Publishers.
11. Bruce Alberts et al. 2007. Molecular biology of the cell. 5th Edition. Garland and Sons.
12. M. Madan Babu. 2013. Bacterial gene regulations and transcription network. Caister Publishers. Academic Publishers.

TITLE OF THE COURSE: RESEARCH METHODOLOGY

COURSE CODE: BOT-556 **Credit Hours:** 3(2+1)

OBJECTIVES: To enable the students to understand various aspects of research, including planning, data collection, analysis, interpretation, presentation of data, writing and submission of research papers and thesis.

COURSE OUTLINE:

Research Methodology: An introduction, definition and the philosophy of science and research. Review of literature. Collection and sources of secondary information. Identification of research problem and formulation of research questions. Hypothesis, their types, experimentation, validation, theories and laws. Research methods, planning research, collection of data, sampling (probability and nonprobability); measurement (surveys, scaling, qualitative, quantitative); data analysis and interpretation of results, writing thesis, research paper and report. The idea of validity in research; reliability of measurements and research ethics. Reference writing: for books, journals, report, proceedings, unpublished thesis and articles. Understanding the complete peer review process of a research journal. Understanding the concept of Plagiarism and use of turnitin software.

LAB OUTLINE:

1. Demonstration of the already prepared sample synopsis by each student (15 minutes)
2. Preparation of poster presentation (Competition)
3. Analysis of sample experimental data
4. Writing of sample abstract; **5.** Writing of sample synopsis
6. Writing of sample research paper; **7.** Writing sample report

COURSE OUTCOMES: At the end of the course, the students will be able to understand various aspects of research, including planning, data collection, analysis, interpretation, presentation of data, writing and submission of research papers and thesis.

RECOMMENDED BOOKS:

10. Shank, G. D. 2002. Qualitative research: a personal skills approach. Upper Saddle River, N.J. Columbus, Ohio: Prentice Hall;Merrill/Prentice Hall.
11. Brizuela, B. M. 2000. Acts of inquiry in qualitative research. Cambridge, MA: Harvard Educational Review.
12. Shank, G. D. 2001, Qualitative Research: A Personal Skills Approach
13. Paul Leedy, 2004, Practical Research : Planning and Design (8th, Edition), Jeanne Ellis Ormrod.
14. Cothari, C. R. 1990. Research Methodology methods and techniques.
15. Jonker, J and Pennink, B. 2008. The Essence of Research Methodology: A concise guide for master and Ph.D. students.
16. Ravindran, A. R. 2009. Operation Research Methodologies.

17. Worall, J. and Gregory. 1989. Currie the Methodology of scientific research programs V-I.
18. Singh, Y. K. 2006. Fundamentals of Research Methodology.

JOURNALS/PERIODICALS:

Pakistan Journal of Botany; Plant Physiology; Physiologia Plantarum; Planta; Annual Review of Plant Biology; Journal of Plant Physiology.

SEMESTER 3

TITLE OF THE COURSE: PLANT ANATOMY

COURSE CODE: BOT-601 **Credit Hours:** 3(2+1)

OBJECTIVES: To provide the students understanding about anatomical features of vascular plants.

COURSE OUTLINE:

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: **a.** Flower, **b.** Seed, **c.** Fruit.
9. Economic aspects of applied plant anatomy
10. Anatomical adaptations
11. Molecular markers in tree species used for wood identification.

LAB OUTLINE:

1. Study of organization of shoot and root meristem, different primary and secondary tissues from the living and preserved material in macerates and sections, hairs, glands and other secondary structures.
2. Study of abnormal/unusual secondary growth.
3. Peel and ground sectioning and maceration of fossil material.
4. Comparative study of wood structure of Gymnosperms and Angiosperms with the help of prepared slides.

COURSE OUTCOMES: At the end of the course, the students would be able to knowledge about the anatomical features of vascular plants.

RECOMMENDED BOOKS:

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. Clerondon 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. Clerondon Press, Oxford.
8. Metcalfe, C.R. 1971. Anatomy of the Monocotyledons.V. Cyperaceae. Clerondon 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
11. Raymond, E.S. and E. Eichhorn. 2005. Esau's Plant Anatomy; Meristematic cells and tissues of plant body. John Willey Sons.
12. Eames, A.J. and L.H. Mac Daniels. 2002. An introduction to Plant Anatomy. Tat Mac-Graw Hill Publishing Company Limited, New Delhi.

JOURNALS/PERIODICALS: Pakistan Journal of Botany, TAXON, Annuls of Botany, American Journal of Botany.

TITLE OF THE COURSE: **BIOSTATISTICS**

COURSE CODE: BOT-602 **Credit hours:** 3 (2+1)

OBJECTIVES: To enable the students to understand the analyses and interpretation of data using statistical tools.

COURSE OULINE:

1. **Introduction objectives and scope:** Definition; Characteristics; Importance and limitations; Population and samples.
2. **Frequency distribution:** Variable types; Formation of frequency table from raw data; Summation, notation and statistical inference; Data transformation.
3. **Measures of central tendencies and dispersion:** Arithmetic mean; Median; Mode; Range; Variance; Standard deviation; Standard error of the mean; Mean deviation
4. **Organizing and describing data (Standard distributions):**
   i. Random sampling and the binomial distribution
   ii. Probability, Types of Probabilities, Random variables, Combining probabilities, Probability distributions, Binomial distributions.
   iii. Poisson and normal distributions, properties and applications.
5. **Basic experimental design:**
   i. Concept and design ii. Principles of experiments iii. Observational studies iv. Planning of experiments v. Replication and randomization vi. Field plot technique vii. Layout and analysis of completely randomized design viii. Randomized complete block design ix. Latin square x. Factorial design xi. Treatment comparison
6. **Tests of significance**:

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

7. **Introduction to comparing of means:**

   Unit organization, Basic one way ANOVA, Types of sums of squares, How ANOVA works, The ANOVA Table. Two-way ANOVA-Factorial designs: (two-way factorial analysis, calculating and analyzing the two-way ANOVA, Linear combination, multiple comparisons.

8. **Correlation and Regression.**

LAB OUTLINE:

1. Data collection, arrangement of data in frequency table, calculating frequency, cumulative frequency and preparation of Ogive.
2. Calculating different measure of central tendency such as arithmetic means, harmonic mean, geometric mean, median and mode.

3. Calculation of mean from grouped and ungrouped data.
4. Calculation of variance and standard deviation from grouped and ungrouped data.
5. Calculating dispersion, relative dispersion, standard deviation, standard error, standard score and co- efficient variation by hand and machine method.
6. Problems concerning probability, binomial distribution, T-test.
7. Chi square test.
8. Analysis of variance - one factor design.
9. Multiple Analyses of Variance.
10. Determination of correlation by constructing different types of graphs such as scatter diagram, linear positive correlation, linear perfect negative correlation, no correlation and curvilinear correlation (second degree polynomial, third degree polynomial).
11. Linear Regression and multiple regression models.
12. MS Excel, MSTAT or relevant statistical software packages.

COURSE OUTCOMES: At the end of the course, the students would be able to understand the analyses and interpretation of biological data using statistical tools.

RECOMMENDED BOOKS:

1. Harvey, M. 1995. Intuitive Bioostatistics. Oxford University Press. NY. Kuzma J. W. and Bohnenblust, S. E. 2001, Basis Statistics for the Health Sciences, McGraw-Hill International Education.
2. Onton, P., Adams, S. and Voelkar, D. H. 2001. Cliffnotes for statistics. Blackwell Scientific Publishers.
3. Pacano, M. and Gauvreau, K. 2000. Principles of Biostatistics.
4. Quinn, G. 2002. Experimental Design and Data Analysis for Biologists. Cambridge University Press.
5. Rosner, B. 2005. Fundamentals of Biostatistics. John Wiley & Sons.
6. Samuels, M. L. and Witmar, J. A. 2003. Statistics for life sciences. 3rd Edition. Cambridge University Press.
7. Triola, M. F. and Triola, M. M. 2005. Biostatistics for Biological and Health Sciences. Pearson Addison Wesley.
8. Zar, J. H., 1999. Biostatistical Analysis, Pearson Education.

Course outcomes: The student will be able to understand the classification, morphology and economic importance of Algae and Bryophytes

TITLE OF THE COURSE: PLANT BIOCHEMISTRY-II

COURSE CODE: BOT-603 **Credit Hours:** 3(2+1)

OBJECTIVES: To explicit the fundamentals of metabolic energy, Metabolism and Plant constituents.

COURSE OUTLINE:

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 betaoxidation 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.

LAB OUTLINE:

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

COURSE OUTCOMES: At the end of the course, the students would be able to the have the basic knowledge about the mechanism of plant metabolism.

RECOMMENDED BOOKS:

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. Lefkowits, 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. Taiz, L. and Zeiger, E. 2006. Plant Physiology. 4th Edition. Sinnauers Publ. Co. Inc. Calif.
10. Lea, P.J. and Leegood, R.C. 1993. Plant Biochemistry and Molecular Biology. Wiley and Sons, New York.
11. Abides, R.H., Frey P.A. and Jencks, W.P. 1992. Biochemistry, Jones and Bartlet, London.
12. Goodwin T.W. and Mercer, E.I. 1997. Introduction to Plant Biochemistry. Pergamon Press, Oxford.
13. Heldt, H-W. 2008. Plant Biochemistry. 3rd Edition, Academic Press, U.K.
14. Campbell, M.K. and F. Shawn. 2008. Biochemistry 6th Edition.

JOURNALS / PERIODICALS:

Plant Physiology & Biochemistry; Annual Review of Biochemistry; Biochemistry Journal; Critical Review in Biochemistry and Molecular Biology.

TITLE OF THE COURSE: PLANT ECOLOGY-II

COURSE CODE: BOT-604 **Credit Hours**: 3(2+1)

OBJECTIVES: To provide comprehensive knowledge of population, community, ecosystem ecology and its relevance to mankind.

COURSE OUTLINE:

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

LAB OUTLINE: 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-Blanqut. 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.

COURSE OUTCOMES: At the end of the course, the students would understand the population ecology, community ecology and ecosystem ecology and its relevance to mankind.

RECOMMENDED BOOKS:

1. Ahmad, M. and S. S. Shaukat. 2012. A test book of vegetation ecology. Publisher Abrar Sons, New Urdu Bazar, Karachi.
2. Schultz J.C. 2005. Plant Ecology, Springer-Verlag
3. Townsend C.R. Begon. M and J.L. Harper 2002. Essentials of Ecology, Blackwell Publishing,
4. Chapin, F.S. et al. 2002. Principle of Terrestrial Plant Ecology, Springer-Verlag,
5. Gurevitch, et al., 2002.The Ecology of Plants, Sinauer Associates, Inc.
6. Barbour M. G. et al., 1999, Terrestrial Plant Ecology, The Benjamin-Cumming Publishing Co.
7. Smith, R. L. 1998. Elements of Ecology by Harper & Row Publishers.
8. Moore P.D. and Chapman S. B. 1986. Methods in Plant Ecology, Blackwell Scientific Publication, Oxford.

9. Hussain, S. Pakistan Manual of Plant Ecology.
10. Hussain, F. 1989. Field and Laboratory Manual of Plant Ecology, National Academy of Higher Education. Islamabad.
11. Lambers, H., T. L. Pons and F. Stuart. 2008. Plant Phyiological Ecology.
12. Larcher. W. 2003 Physiological Plant Ecology. Ecophysiology and Stress Physiology of Function Groups. Springer- Verlag.

JOURNALS / PERIODICALS: Ecology, Journal of Ecology, Journal of Applied Ecology.

TITLE OF THE COURSE: PLANT PHYSIOLOGY-II

COURSE CODE: BOT-605 **Credit Hours:** 3 (2+1)

OBJECTIVES: To give it comprehensive and advance knowledge of growth regulators, mechanism of water uptake and role of essential nutrients in plant metabolism.

COURSE OUTLINE:

1. **Plant Growth Regulators:** Major natural hormones and their synthetic analogues. Bioassay, structure, biosynthesis, receptors, signal trasduction and mode of action, transport, physiological effects of Auxins, Gibberellins, Cytokinins, Abscisic acid, Ethylene, Polyamines, Brassinosteriods, Jasmonates, and Salicylic acid.
2. **Water Relations:** The soil -plant -atmosphere continuum - an overview. Structure of water. Physico-chemical properties of water. Water in the soil and its potentials. Water in cell components. Absorption of water in plants (pathways and driving forces, 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. Circadien rhythms. Classification of plants according to photoperiodic reaction, photoperiodic induction, locus of photoperiodic reaction and dark periods in photoperiodism. Role of photoperiodism in flowering. Biochemical signaling involved in flowering. Vernalization and its effect on flowering. Floral meristem and floral organ development. Floral organ identity genes and the ABC model.
6. **Signal transduction** and gene regulation in prokaryotes and eukaryotes.
7. **Dormancy:** definition and causes of seed dormancy; methods of breaking seed dormancy; types and physiological process of seed germination.
8. **Plant Movements:** Tropic movement-phototropism, gravitropism and their mechanism. Nastic movements.

LAB OUTLINE:

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

3. To investigate water potential of a plant tissue by dye method and water potential apparatus.
4. Determination of K uptake by excised roots.
5. Measurement of stomatal index and conductance.
6. Qualitative determination of K content in Guard cells by Sodium cobalt nitrite method.

COURSE OUTCOMES: At the end of the course, the students would have a comprehensive and advance knowledge of growth regulators, mechanism of water uptake and role of essential nutrients in plant metabolism.

RECOMMENDED BOOKS:

1. Dennis, D. T., Turpin, D. H., Lefebvre, D. D. and Layzell, D. B. 1997. Plant Metabolism. 2nd Edition. Longman Group, U. K. Dey, P. M. and Harborne, J. B. 1997. Plant Biochemistry. Harcourt Asia PTE Ltd. Singapore.
2. Fitter, A. and Hay, R. K. M. 2001. Environmental Physiology of Plants. Academic Press, UK.
3. Heldt, H. W. 2004. Plant Biochemistry. 3rd Edition, Academic Press, U.K.
4. Ihsan Illahi, 1991. Plant Growth, UGC Press, Islamabad.
5. Ihsan Illahi, 1995. Plant Physiology, Biochemical Processes in Plants, UGC Press.
6. Nobel, P. S. 1999. Physicochemical and Environmental Plant Physiology. Academic Press, UK.
7. Press, M. C., Barker, M. G., and Scholes, J. D. 2000. Physiological Plant Ecology, British Ecological Society Symposium, Volume 39, Blackwell Science, UK.
8. Salisbury F. B. and Ross C. B. 1992. Plant Physiology. 5th Edition. Wadsworth Publishing Co. Belmont CA.
9. W. B. Hopkins. 1999. Introduction to Plant Physiology. 2nd Ed. John Wiley and Sons. New York.
10. Epstein, E. and Bloom, A. J. 2004. Mineral Nutrition of Plants: Principles and Perspectives. 2nd Edition. Sinauer Associates, California, USA.
11. Kirkham, M. B. 2004. Principles of Soil and Plant Water Relations. Elsevier, Amsterdam, Netherlands.
12. Barton, W. 2007. Recent Advances in Plant Physiology.
13. Taiz, L. and Zeiger, E. 2006. Plant Physiology. 4th Edition. Sinnauers Publ. Co. Inc. Calif.

JOURNALS / PERIODICALS: Pakistan Journal of Botany, Plant Physiology, Physiologia Plantarum, Planta, Annual Review of Plant Biology, Journal of Plant Physiology.

TITLE OF THE COURSE: ADVANCED MOLECULAR BIOLOGY

COURSE CODE: BOT-606 Credit Hours: 3 (2+1)

OBJECTIVES: To provide updated and advanced knowledge of Molecular Biology.

COURSE OUTLINE:

1. Biological Heredity and Variation: Mendelian inheritance, Segregation at one locus, Segregation a two loci and Quantitative inheritance
2. Chromatin: Nucleosomes, Higher order chromatin organization, Chromatin and chromosome function and Molecular structure of the bacterial nucleoid.
3. Chromosome Mutation: Numerical chromosome mutations, Structural chromosome mutations, the environment in development.
4. DNA Methylation and Epigenetic Regulation: DNA methylation in prokaryotes and eukaryotes;
5. Epigenetic gene regulation by DNA methylation in plants.
6. Genomes and Mappping: Physico-chemical properties of the genome, Genome size and sequence components, Gene structure and higher-order genome organization, Gene mapping and Physical mapping.
7. Mobile Genetic Elements: Transposons, Retroelements; .Mechanisms and consequences or transposition.
8. Mutation and Selection: Structural and functional consequences of mutation, Mutant alleles and the molecular basis of phenotype, Mutations in genetic analysis.
9. Plasmids: Plasmid classification, Plasmid replication and maintenance.
10. Recombinant DNA and Molecular Cloning: Molecualr cloning, Strategies for gene, Characterization of cloned DNA isolation, Expression of cloned DNA, Analysis of gene regulation and transgenesis.
11. RNA Processing: Maturation of untranslated RNAs, End-modification and methylation of mRNA, RNA splicing, RNA editing.

LAB OUTLINE:

1. Genetic Engineering Techniques.
2. Microarray Techniques.
3. Organelles Genome Study.
4. Protein Synthesis Study.
5. Characterization of cloned DNA isolation.

COURSE OUTCOMS: At the end of the course, the students will be able understand the advanced knowledge of Molecular Biology.

RECOMMENDED BOOKS:

1. Twyman R.M. (1998) Advanced Molecular Biology: A Concise Reference. BIOS Scientific Publishers, Oxford, UK.
2. Cullis, C. A. (2004) Plant Genomics and Proteomics, John Wiley & Sons, Inc.
3. Gibson G. and Muse S.V. 2002. A premier of Genome Science. Sinauer Assoc., Sunderland, Massachusetts.
4. Gilmartin P.M. and Bowler C. 2002. Molecular Plant Biology. Vol. 1&@. Oxford University Press, UK.

5. Lodish H. et al. 2004. Molecular Cell Biology. 5th Edition. W.H. Freeman & Co. New York.
6. Malacinski, G.M. 2003. Essentials of Molecular Biology. 4th Edition. Jones and Bartlettt Puvlihers, Massachusetts.
7. Ignacimuthu S. 2005. Basic Bioinformatics. Narosa Publishing House, India.
8. Weaver R.F. 2005. Molecular Biology. McGraw Hill, St. Louis.
9. Watson J.D. et al. 2004. Molecular Biology of the Gene. Peason Education, Singapore

SEMESTER 4

TITLE OF THE COURSE: GENETICS-II

COURSE CODE: BOT-651 **Credit Hours**: 3 (2+1)

OBJECTIVES: To introduce students' recombination of genetic material at molecular levels with emphasis on introduction to biotechnology and genomics.

COURSE OUTLINE:

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

LAB OUTLINE:

Problems relating to the theory.

1. Isolation and separation of DNA and protein on Gel electrophoresis.

i. Bacterial chromosome; **ii**. Plasmid DNA (minipreps); **iii**. Plant DNA; **iv**. Protein.

2. DNA Amplification by PCR.

COURSE OUTCOMES: At the end of the course, the students will be able to have the basic mechanism of genetic recombination and its role in biotechnology.

RECOMMENDED BOOKS:

1. Trun, N and Trempy 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.
11. 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.
12. Snyder, L and Champness W, 2003, Molecular Genetics of Bacteria, ASM Press.
13. Wilson, J. and Hunt, T. 2004. Molecular Biology of the cell – the problems book, Garland publishing Inc.
14. Anthony J. F Griffiths, Jeffrey H Miller, David T Suzuki, Richard C Lewontin, and William M Gelbart. W. H. 2009. An Introduction to Genetic Analysis, 7th Edition. Freeman and Company.
15. Hedrick, P. W. 2005. Genetics of Population. Jones and Bartlett Publisher, Sudbury, USA.
16. Mahmut Caliskan. 2012. The Molecular basis of plant genetic diversity. In Tech Publishers.
17. Ram J. Singh. 2011. Genetic resources, chromosome engineering and crop improvement. Medicinal plants. Vol. 6. CRC Press.
18. William S. Klug, Michael R. Cummings, Charlotte A. Spencer, Michael A. Palladino. 2011. Concepts of Genetics. Pearson Educations.
19. Daniel Hartl. 2011. Genetics Johns and Bartlett Publishers.
20. David Hyde. 2008. Introduction to Genetic principles. McGraw-Hill.
21. Daniel, L. Hart, Elizabeth W. Jones. 2009. Analysis of genes and genomes. John and Barlett.

JOURNALS / PERIODICALS:

J. Genetics, Theoretical and Applied Genetics, Cytologia, Chromosoma, Genome, DATABASE, Nature Genetics.

TITLE OF THE COURSE: ENVIRONMENTAL BIOLOGY

COURSE CODE: BOT-652 Credit Hours: 3 (2+1)

OBJECTIVES: To provide updated knowledge of environmental problems and sustainable environmental management.

COURSE OUTLINE:

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 and global warming: 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.
12. Aerobiology (Pollen allergy & dust allergy).

LAB OUTLINE:

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.

COURSE OUTCOMES: At the end of the course, the students would be able to understand the current environmental problems and sustainable environmental management.

RECOMMENDED BOOKS:

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. French, 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. 2004. 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 Grossa Jr., J.M. 1996 Environmental geography: Science, land use, and earth systems. John Wiley and Sons.
9. Lambers, H., T. L. Pons and F. Stuart. 2008. Plant Physiological Ecology.
10. Mohamamd Ashfaq and Mushtaq A. Saleem. Environmental Pollution and Agriculture.
11. Shah Faisal Muhamamd and Sultan Mehmood. 2012. Lambert Publishers Germany.
12. Advanced Air and Noise Pollution Control, L. K. Wang, N. C. Pereira and Y. T. Hung, Humana Press, 2005.
13. Air Pollution Control Technology Handbook, K. B. Schnelle and C. A. Brown, CRC Press, 2002. Handbook of Solid Waste Management and Waste Minimization Technologies, N. P. Cheremisinoff, Butterworth-Heinemann, 2003.
14. Pollution Control In Process Industries, S. P. Mahajan, Tata McGraw-Hill, 1985.
15. Industrial Pollution control: issues and techniques, N. J. Sell, Van Nostrand Reinhold, 1992.
16. Environmental Biotechnology: Basic Concepts and Applications, I. S. Thakur, I.K. International Publishing House Pvt. Limited, 2006.
17. Vandermeer, John H. 2011. The ecology of agro-ecosystems - Jones and Bartlett Publishers; Sudbury, Mass; 2011 - xv, 387 p.
18. Greipsson, Sigurdur. 2011. Restoration ecology - Jones and Bartlett Publishers; Sudbury, MA; 2011 - xvi, 408 p.
19. Santra, S. C. 2010. Fundamentals of ecology and environmental biology - New Central Book Agency; London; 2010 - 353p.
20. Singh, M.P. 2007 Forest environment and biodiversity Daya; New Delhi; 2007 - 556p.

JOURNALS/PERIODICALS: Environmental Biology, Environment, Bioremediation.

TITLE OF THE COURSE: PLANT PATHOLOGY

COURSE CODE: BOT-653 Credit Hours: 3(2+1)

OBJECTIVES: To understand causes, mechanisms classification and economic importance of plant diseases.

COURSE OUTLINE:

1. Introduction to pathology and plant diseases, history, scope of phytopathology, economic importance of plant disease.
2. Classification of plant diseases.
3. Symptoms of plant diseases, nature and types
4. Nature, classification, growth and reproduction of plant pathogens.
5. Parasitism and Disease Development: pathogenesis and parasitism, host range of pathogen, development of disease in plants, the disease cycle, relationship of disease cycle and epidemics.
6. How pathogens attack plants: mechanical forces exerted by pathogen on host tissues, chemical weapons of pathogen.
7. Plant defensive system against fungal infection.
8. Molecular mechanism of host-pathogen interactions.
9. Role of environmental conditions in disease development.
10. Disease detection and diagnosis
11. The principles of disease management: cultural, chemical, biological control of plant diseases, eradication, plant protection and sanitation, quarantines, disease resistant varieties
12. Epidemiology, disease forecast and loss assessment.

Plant diseases

Black rot of crucifers, loose smut of barley, black stem rust of wheat, white heart rot of deciduous trees, tobacco mosaic disease, white rust of crucifers, streak smut of wheat, powdery mildews of grasses and ornamental plants, white rust of crucifers, red rot of sugarcane, downy mildews of seedlings, late blight and early blight of potato, damping off caused by phythium spp. shisham dieback, citrus canker of citrus, apple scab, leaf curl of peaches, diseases of transect and storage.

LAB OUTLINE:

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. Isolation, sterilization and culturing techniques of plant pathogens. Collection and studying diseased plant specimens.

COURSE OUTCOMES: At the end of the course, the students would be able to prepare media for culturing of fungi and would be able to isolate fungi from infected plant tissue.

RECOMMENDED BOOKS:

1. Agrios, G.N. 2005. Plant Pathology, Academic Press, London.
2. Schumann, G. L. and Cleora J. D'Arcy. 2009. Essential Plant Pathology, Second Edition.

3. Robert N. Trigian. 2007. Plant Pathology Concepts and Laboratory Exercises, Second Edition
4. Ahmad, I. and Bhutta, A.R. 2004. Textbook of Introductory Plant Pathology. Book Foundation, Pakistan.
5. Trigiano, R.N., Windham, M.T. and Windham, A.S., 2004. Plant Pathology: Concepts and Laboratory Exercises. CRC Press, LLC, N.Y.

TITLE OF THE COURSE: **CONSERVATION BIOLOGY**

COURSE CODE: BOT-654 **Credit Hours:** 3(2+1)

OBJECTIVES: To understand the importance of biodiversity, threats and conservation measures.

COURSE OUTLINE:

1. Introduction and importance of biodiversity: Species diversity,
2. Ecological diversity, Genetic diversity, Social diversity
3. Importance of Biodiversity (food, fodder, shelter, aesthetics, climate regulation, soil formation, role in hydrological cycle, genetic diversity,); the value of species.
4. Causes and depletion of biodiversity: Habitat loss, Habitat fragmentation, Over-exploitation, Climatic changes, Invasive species, Seawater intrusion
5. How species become threatened. Characteristics of extinction proven species. Extinction of species, present rate. Theory of mass extinction
6. Inventory and monitoring of biodiversity
7. Importance of red data book
8. In situ and ex situ conservation of plants
9. Implementation of laws (protection and conservation of various taxa.
10. Sustainable use of biodiversity (plant wealth)
11. Protected areas of Pakistan. Criteria for determining different categories of protected areas. Management plan for protected area
12. IUCN categories for threatened species. Criteria for recognizing different categories of threatened species
13. Gene bank management and operation
14. Public awareness strategies.
15. Biodiversity action plan for Pakistan
16. Role of herbaria and botanical gardens in conservation.

LAB OUTLINE:

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.

COURSE OUTCOMES: At the end of the course, the students would be able to understand the importance of biodiversity, threats and conservation measures.

RECOMMENDED BOOKS:

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. Earthscan 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. Krishmamurthy, 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
13. Falk, D.A. & Holsinger, K.E. 1991. Genetics and Conservation of Rare Plants. Center for Plant Conservation. Oxford University Press, Oxford, UK.
14. Frankel, O.H., Brown, A.H.D. & Burdon, J.J. 1995. The Conservation of Plant Biodiversity. Cambridge University Press, Cambridge, UK.
15. IUCN. 1994. IUCN Red List Categories. As Approved by the IUCN Council. IUCN.
16. French, H. 2000 Vanishing Borders- protecting the Planet in the age of globalization. W.W. Norton & Co.
17. Swanson, T. 2005. Global Action for Biodiversity. Earth Scan Publication Ltd.
18. Taylor, P. 2005 Beyond Conservation. Earth Scan Publication Ltd.
19. Leadlay, E. and Jury, S. 2006. Taxonomy and Plant Conservation. CUP.

JOURNALS / PERIODICALS: Systematics and Biodiversity, Biological Conservation.

TITLE OF THE COURSE: MEDICINAL PLANTS

COURSE CODE: BOT-655 **Credit Hours: 3(2+1)**

OBJECTIVES: To enable the students about the pharmaceutical constituents of plants of some families.

COURSE OUTLINE:

- Definition of pharmacology, drugs, crude drugs, official and unofficial drugs, cultivation, collection, curing, drying, preservation, evaluation and classification of drugs, therapeutic classes of drugs.
- Detail study of the following medicinal plants (Angiosperms), giving those synonyms, botanical origin, local names, distribution of plants, methods of cultivation, macroscopical characteristics of drugs. microscopical characteristics of drugs, chemical constituents, uses and adulterants with special reference to species growing in Pakistan.

1) Ephedraceae (Ephedra)
2) Ranunculaceae (Aconitum)
3) Papaveraceae (Opium)
4) Paeoniaceae (Paeonia)
5) Berberis (Family Berbaridaceae)
6) Podophyllaceae (Podophyllum)
7) Fabaceae (Liquorice, Senna, Acacia, Cassia fistula)
8) Colchicum (Family Liliaceae)
9) Allium (Alliaceae)
10) Zingiber (Family Zingiberaceae)
11) Lamiaceae (Mentha, Thymus, Ajuga)
12) Apiaceae (Foeniculum, Coriandrum)

LAB OUTLINE:

1) Microscopical characters of the drugs using sectioning and powdered drugs
2) Macroscopic study of different gums and oils
3) Identification test for starch, Ca-oxalate
4) Identification tests for volatile and fixed oil, tannin and mucilage etc.

COURSE OUTCOMES: At the end of this course, the students would be able to understand the knowledge of plant biochemical compounds and their role in medicines.

RECOMMENDED BOOKS:

1) Tyler, V.L.E.R. Brady & E.F. Clayse. 1970. Pharmacognosy 6th Ed. Leimption London.
2) Trease G.D & W.C Evans.1985. Pharmacognosy 12th Ed, English Language. Soc. Bailere Tindall.
3) Jain, S.K. 1987. A manual of Ethnobotany. Scientific Publisher Johpur, India.
4) Willism, T.E.1998. Text book of Pharmacognosy. Churchill Ltd. Glouester Palace, W.I. London.
5) R S Satorkar and S D Bhandarkar. 1993. Pharmacology and Pharmacotherapeutics, Popular Prakashan, Bomby.
6) G E Trease and W C Evans, Pharmacognosy, W B Saunders. 2002. Philadelphia, Toronto.

TITLE OF THE COURSE: APPLIED ETHNOBOTANY

COURSE CODE: BOT-656 Credit Hours: 3(2+1)

OBJECTIVE: To provide updated and advanced knowledge of Ethnobotany for enhancing the people-plants relationship and rural development through conservation.

COURSE OUTLINE:

1) Introduction: scope, significance, history, developments and branches
2) Historical roots of ethnobotany in Pakistan: Tibbe-unani, ayruvedic, economic plants, contribution of early medical botanists.
3) Relationship of ethnobotany with ecology, cultural anthropology, agronomy, forestry, horticulture
4) Principles and Methods of Ethnobotany: field observation, documentation, laboratory studies, identification, voucher specimens, data analysis, database establishment and quantitative assessment.
5) Traditional use of plants: belief and myths, medicinal use, bush food, architectural use, landscaping, social norms and conservation ethics.
6) Folklore nomenclature and modern classification.
7) Traditional management models: value system, wild plant management, agro-forestry and home gardens, the use of rights and privileges for plant resource management.
8) Ethnobotany and community institutions development.
9) Medical Ethnobotany: history, scientific basics, traditional medical system, traditional medical knowledge and its recognition by WHO, cultural interpretation, methods of study, new drug development, value added products, conservation and traditional medicines.
10) Phytochemistry: secondary metabolites in medicinal plants, their extraction, purification and storage.
11) Recognition of traditional knowledge as a national resource, WTO, TRIPS and other international treaties.

PRACTICAL OUTLINE:

1) Techniques of planning and conducting ethnobotanical studies.
2) Data collection and analysis for ethnobotanical studies.
3) Field visit, questionnaire development, data interpretation for conservation of plant resources.
4) Plant collection and authentic identification with pertinent literature. Conducting interviews with indigenous people for documentation of indigenous knowledge.

COURSE OUTCOMES: At the end of this course, the students would understand the knowledge of Ethnobotany for enhancing the people-plants relationship and rural development through conservation.

RECOMMENDED BOOKS:

1. Balick, M. J. 1997. Plants, peoples and culture: The science of ethnobotany. W. H. Freeman & Company.
2. Charlson, T. J. S. and L. Maffi. 2004. Ethnobotany and conservation of biocultural diversity (advances in economic botany Vol. 15). New York Botanical Garden Press.
3. Cotton, C. M. 1996. Ethnobotany: Principles and applications. Hohn Willey Publication.

4. Cunningham, A. B. 2001. Applied ethnobotany: people, wild plant use and conservation. Earthscan, London, Sterling, VA.
5. Goodman, S. M. and A. Ghafoor, 1992. The Ethnobotany of Southern Baluchistan with particular reference to medicinal plants. Fieldiana: Botany, New series 31: 1-84.
6. Levetin, E. and K. McMahon. 2005. Plants and society. 4th Edition. McGraw Hill Publication USA.
7. Martin, G. J. 2004. Ethnobotany: A methods manual (people and plants conservation) Earthscan, London, Sterling, VA
8. Minnis, P. E., 2002. Ethnobotany: A reader. University of Oklahoma Press.
9. Oguamanam, C. 2006. International Law and indigenous knowledge: Intellectual property, Plant Biodiversity and traditional medicine. Sinuar Publication USA
10. Schultes, R. E. 2005. Ethnobotany: The evolution of a discipline. Timber Press Incorporated.
11. Tuxil, J. and G. P. Nabhan. 2001. People, plants and protected areas. Earthscan, London, Sterling, VA.

LIST OF OPTIONAL COURSES FOR MSC BOTANY (2 YEARS)

ELECTIVE COURSES

Elective/Optional paper for BS/ M.Sc

TITLE OF THE COURSE: ADVANCED PLANT SYSTEMATICS

COURSE CODE: BOT-608 Credit Hours: 3(2+1)

OBJECTIVES:

1. This course will explore the theory and procedures of modern systematic analysis
2. Students will be expected to gain a working knowledge of techniques and approaches to Systematics (including phylogenetics and evolutionary processes)
3. Survey the sources and interpretation of systematic data

COURSE OUTLINES:

1. Taxonomy in practice: Roles of characters and states, criteria for selection of characters and states, kinds of characters and networks, good and bad characters, evolutionary patterns, choosing evolutionary trees.

2. Concepts of categories: the taxonomic hierarchy, Species, reality of species, naturalness of species, current species concepts, the subspecies, variety and form, biosystematic infraspecific categories, the Genus, the Families and higher categories.

3. Taxonomic information and data: Chemotaxonomy, cytology and cytogenetics, information from breeding systems, isolating mechanisms, information from plant geography and ecology, patterns of geographic distribution, disjunction and vicariance, vicariance biogeography, endemism, centres of diversity, alien plants.

4. Molecular phylogeny: Generating molecular data, analysis of molecular data, alignment of sequences, homoplasy and long branches, methods of phylogeny reconstruction, gene trees vs species trees, Maximum parsimony analysis, Minimum evolution/Neighbour-joining trees, The Neighbour-Joining algorithm, Maximum likelihood phylogenies, Markov Chain Monte Carlo Bayesian analysis.

5. The gathering and storage of Data: Botanical garden, Herbaria and Taxonomic experts, Floras and Monographs, Data information system, Botanical illustrations.

LABORATORY/PRACTICAL:

1. Students will choose a taxon at the level of genus or above that they will use as a case study to explore the various concepts introduced in the course. These will include the applications of molecular phylogenetics to the taxon.

2. Exploration of library and internet resources relevant to systematics or phylogenetics. In particular, the students shall learn the basics of the NCBI Taxonomy database and *BLAST* search algorithms.

3. Constructing phylogenetic trees using PAUP and MEGA from the NCBI sequences.

4. DNA extraction, purification, PCR, sequencing methods.

COURSE OUTCOMES: At the end of this course, the students will be able to perform the procedures of modern systematic analysis using phylogenetic tools.

RECOMMENDED BOOKS:

1. Tod F. Stuessy (2009). Plant Taxonomy, '*the Systematic Evaluation of Comparative data'* Second Edition, Columbia University Press, New York.
2. Clive A. Stace (1989). Plant Taxonomy and Biosystematics. 2nd Edition.
3. Schuh, R.T. 2000. *Biological Systematics. Principles and Applications.* Cornell University Press, Ithaca, NY
4. Winston, J.E. 1999. *Describing Species. Practical Taxonomic Procedure for Biologists.* Columbia University Press, New York, NY
5. Michael G. Simpson (2010). Plant Systematics, 2nd Edition. Elsevier Academic Press, NY.
6. Hall, B.G. (2011). Phylogenetic Trees Made Easy - A How-To Manual. Fourth Edition. Sinauer, Sunderland M.A.
7. Hillis et al. (eds) (1996) Molecular Systematics, 2nd edition, Sinauer, Sunderland M.A.
8. Nei, M. & Kumar, S. (2000) Molecular Evolution and Phylogenetics. Oxford University Press.
9. Li, W.-H. (1997). *Molecular evolution.* Sinauer Associates, Sunderland, MA, USA.

JOURNALS/ PERIODICALS: Plant Systematics, Cladistics, BMC Evolutionary Biology, Journal of Evolutionary Biology, Molecular Phylogenetics and Evolution, Systematic Biology, Taxon, Botanical Journal of the Linnean Society, Journal of the Missouri Botanical Garden, Trends in Ecology & Evolution.

TITLE OF THE COURSE: PALEOBOTANY AND PALYNOLOGY

COURSE CODE: BOT-607 Credit Hours: 3(2+1)

OBJECTIVES:

1. To provide instructions on basic pollen taxonomy as an aid in identifying and classifying various palynoflora

2. To provide a general background of the enormous diversity of pollens

3. To understand the various applications of Palynology

COURSE OUTLINE:

1. Palynology: Aeropalynology, Melissopalynology, Yellow rain, Pollen Allergy; History of Palynology, Palynology as a multidisciplinary field, Applications of Palynology, Palynology in relation to Plant Taxonomy.

2. Pollen Morphology: Polarity and Symmetry, Apertures, Pollen Wall, Structure and Sculpture, Harmomegathy and details of terminology involved in pollen description.

3. Methods: Acetolysis and Light Microscopy, Scanning Electron Microscopy, Transmission Electron Microscopy, New and improved methods in Palynology.

4. Status of Palynology in Pakistan.

LAB OUTLINES:

1. Preparation of glycerine gelly for pollen preparation

2. Pollen preparations of the local flora through acetolysis methods

3. Acetocarmine staining for light microscopy

4. Pollen fertility estimation

5. Microscopic studies of the quantitative and qualitative features of pollen grain.

COURSE OUTCOMES: At the end of this course, the students would be able understand the pollen surface features and its role in identification of plants.

RECOMMENDED BOOKS:

1. Blackmore, S. (2000) The palynological compass: the contribution of palynology to systematics. In: Nordenstam B, El-Ghazaly G, Kassas M (eds) Plant Systematics for the 21st Century. Portland Press, London.
2. Erdtman, G. (1952) Pollen Morphology and Plant Taxonomy. Angiosperms. Almqvist & Wiksell, Stockholm.
3. Erdtman, G. (1969) Handbook of Palynology. An Introduction to the Study of Pollen Grains and Spores. Munksgaard, Copenhagen.
4. Faegri, K and Iversen, J. (1989) Textbook of Pollen analysis. 4th ed. John Wiley &
5. Sons, Chichester.
6. Hesse, M., Halbritter, H., Weber, M., Buchner, R., Frosch-Radivo, A., and Ulrich, S. (2008). Pollen terminology: an illustrated handbook (Springer).
7. Moore, P.D., and Webb, J.A. (1978). An illustrated guide to pollen analysis. London, etc: Hodder & Stoughton.
8. Punt, W., Hoen, P., Blackmore, S., and Le Thomas, A. (2007). Glossary of pollen and spore terminology. Review of Palaeobotany and Palynology *143*, 1-81.

9. Huang, T.C. (1972). Pollen Flora of Taiwan (National Taiwan University: Botany. Dept. Press).
10. Traverse, A (2007) Paleopalynology. 2nd ed., Springer, Dordrecht.

JOURNALS / PERIODICALS:

Grana, Palynology Journal, Palynology and Paleobotany, Pakistan Journal of Botany, Turkish Journal of Botany, Canadian Journal of Botany, Nardic Journal of Botany, Botanical Journal of the Linnean Society, South African Journal of Botan.

TITLE OF THE COURSE: PLANT BREEDING

COURSE CODE: BOT-609 Course Outline: 3(2+1)

OBJECTIVES: To provide the basic knowledge of crop breading.

COURSE OUTLINE:

1. **Plant breeding and its Scope**: Definition, Plant breeding as an art and Science, Concept and Goals of Plant breeding.
2. **Genetic basis for Plant breeding**: Genetic consequences of hybridization, Quantitative inheritance, Population structure, Hardy-Weinberg Law, Combining ability, Heritability, Choice of breeding methods.
3. **Nature of Crops and Methods of breeding**: Mode of Reproduction, Incompatibility, Male sterility, Hybridization.
4. **Domestication and Introduction of Crop Plants**: Centers of Origin, Centers of diversity, Domestication of Crop plants, Introduction of Crop Plants.
5. **Mutation breeding**: Definition and history, Classification of mutation, Mutagens and their classification.
6. **Ploidy breeding**: Classification of Ploidy, Aneuploidy, Euploidy, Ploidy in Crop improvement.
7. **Breeding for Disease and Insects resistance**: Definition, Classification of resistance, Genetics of host parasite interaction, breeding for disease resistance.
8. **Achievements in Crop plants**:
    - Wheat
    - Rice
    - Maize
    - Cotton

LAB OUTLINE:

1. Field study of Crop plants to observe pathogens causing diseases
2. Study of soil texture suitable for crop plants
3. Identification of the domesticated and introduced plants
4. Selection of elite genotypes for future breeding strategies
5. The construction of morphological data recording descriptors

COURSE OUTCOMES: At the end of this course, the students would be able to describe the basic mechanism of crop breading.

RECOMMENDED BOOKS:

1. Coors, J.G. and Pandey, S. (eds) (1999) *The Genetics and Exploitation of Heterosis in Crops*. American Society of Agronomy, Crop Science Society of America, and Soil Science Society of America,
2. Falconer, D.S. (1960) *Introduction to Quantitative Genetics*. Oliver and Boyd, London.
3. Gowen, J.W. (ed.) (1952) *Heterosis*. Iowa State University Press, Ames, Iowa.
4. Hanson, W.D. and Robinson, H.F. (eds) (1963) *Statistical Genetics and Plant Breeding*. Publication 982, National Academy of Sciences – National Research Council, Washington, DC.
5. Mather, K. (1949) *Biometrical Genetics*, 1st edn. Methuen, London.
6. Pollak, E., Kempthorne, O. and Bailey, T.B., Jr (eds) (1977) *Proceedings of International Conference on Quantitative Genetics*. Iowa State University Press, Ames, Iowa.

7. Schuler, J. (1988) Inserting genes affecting quantitative traits. In: Weir, B.S., Eisen, E.J., Goodman, M.M. and Namkoong, G. (eds) *Proceedings of the Second International Conference on Quantitative Genetics*. Sinauer Associates, Sunderland, Massachusetts, pp. 198–199.
8. Chahal, G.S. and S.S. Gosal. 2003. Principles and Procedures of Plant Breeding. Narosa Publishing House, New Delhi, India.
9. Singh, B. D. 2003. Plant Breeding: Principles and Methods. Kalyani Publishers, New Delhi, India.

TITLE OF THE COURSE: APPLIED MYCOLOGY

COURSECODE: BOT-657 Credit Hours: 3(2+1)

OBJECTIVES: To understand the applied aspects of fungi and modern trends in mycology.

COURSE OUTLINE:

1. Introduction: Mycodiversity of kingdom Fungi and fungi like organisms, application of mycology in field of medicine, agriculture, forestry, food and pharmaceutical industries.
2. Pharmaceutical and Chemical Commodities from Fungi: secondary metabolites of fungi, fungi as source of antibiotics, antioxidants, alcohols, alkaloids, vitamins and organic acids, commercial production of penicillins and cyclosporins
3. Food mycology, edible, poisonous and hallucinogenic mushrooms, mushroom farming; button, oyster and shiitake mushroom cultivation, food spoilage, cheeses, beer and wine production through fungi. Fungal toxicity; classes of mycotoxins and mycotoxicoses
4. Fungal ecology: Monitoring and inventorying of fungi, Sampling and collection techniques used for different group of fungi, Isolation of fungi from different substrates such soil, dung, air, water, from animal and plant tissues
5. Mycorrhizal association and type of mycorrhizal fungi, and their role in agriculture and forestry, endophytic fungi
6. Wood rotting fungi, Fungi as efficient decomposing agents, composting and role of fungi in soil formation
7. Mycoremediation: using fungi in controlling water pollutants and toxic industrial and domestic wastes, fungi as biopesticides
8. Myconanotechnology: Syntheses of myco-nanoparticles and their applications
9. Recent advances in fungal systematics and phylogeny: Molecular identification of fungi
10. Fungal genomics and proteomics
11. Fungal media types, preparation, preservation and maintenance

LAB OUTLINE:

Basic techniques applied in mycological laboratory (media, equipment, reagents).

Isolation and culturing techniques

Identification of fungi by using mycological keys.

Staining and microscopic techniques of fungal materials

Molecular techniques for identification of macro and microfungi.

COURSE OUTCOMES: At the end of the course, the students would be able to prepare media for culturing of fungi and would be able to isolate fungi from soil, plant tissue and air.

RECOMMENDED BOOKS:

1. Deacon J.W., 2005. Fungal biology. Wiley-Blackwell, 4th ed.
2. Dijksterhuis J., Samson R. A., 2007. Food Mycology: A Multifaceted Approach to Fungi and Food. CRC Press.
3. Burgess Galloway L.D., 1937. Applied Mycology and Bacteriology.
4. Arora D., Arora K., Bharat R., 1991. Handbook of Applied Mycology: Volume 1: Soil and Plants.
5. Randy B. 2006. Genes and Genomics, Volume 5 (Applied mycology and Biotechnology).

6. Khachatourians G.G., Arora D.K., 2001. Applied Mycology and Biotechnology: Agriculture and Food Production. Elsevier Science Pub Co., 1st ed.
7. Carlile M., Watkinson S., Graham G., 2001. The Fungi, 2nd ed. Academic Press.
8. Webster J., Weber R., 2007. Introduction to Fungi. Cambridge University Press; 3rd ed.

JOURNALS / PERIODICALS: Mycologia; Fungal Ecology; Mycotaxon; Experimental Mycology; Bulletin of the British Mycological Society, Medical Mycology, Fungal Biology.

Annex-III

SCHEME OF STUDIES AND COURSES SYLLABUS FOR M.PHIL. BOTANY DEGREE PROGRAM

M.Phil in Botany will be 30 credit hours after 16 years of relevant education i.e. BS 4 years Botany (minimum 124 credit hours after HSSC/F.Sc/Grade 12 equivalent with Biology), or 2 years M.Sc. 2 years in the subject of Botany, Forestry, Biotechnology, Agriculture, or its equivalent degree from HEC recognized University.

M.Phil Botany degree program shall comprise minimum 4 semesters spread over 2 years with 2 semesters a year and maximum duration will be 4 years. Moreover, maximum duration will be subjected to M.Phil/PhD byelaws, University of Swat and- HEC notifications time to time.

Minimum 50% cumulative score out of admission test as per HEC guidelines will be required at the time of admission to M.Phil in Botany degree program.

Category wise credit hours distribution is as follows:

Sr.No.	Categories	No. of Courses	Credit Hours	Description/Distribution
1	Core/Major Courses	2+2	4 x 3 = 12	Two courses each in semester 1 and 2 to be selected from the list recommended/approved by the BoS/University
2	Elective/Minor	2+2	4 x 3 = 12	Two courses in each semester (first two) from the list recommended/approved by the BoS/University.
3	Research work/Thesis	-	06	Mandatory in minimum two semesters (3^{rd} and 4^{th})
	Total	08	30	

Note:

1. *Research work will be allotted to students after minimum qualification of 18 credit hours course work, but it is mandatory to pass remaining credits before thesis submission.*

List of Courses for M.Phil. Botany

Course Code	Course Title	Credit Hrs.
Core/Major Courses		
BOT-701	Advances in Biodiversity Conservation	3
BOT-702	Vegetation Ecology	3
BOT-703	Advances in Phytosociology	3
BOT-704	Advanced Plant Physiology	3
BOT-705	Flowering Plants Systematics and Evolution	3
BOT-706	Principles of Plant Systematics	3
Elective/MinorCourses		
BOT-711	Research Techniques and Report Writing	3
BOT-712	Plant Breeding and Genetics	3
BOT-713	Advances in applied Ethnobotany	3
BOT-714	Advanced Pharmacognosy	3
BOT-715	Plant Growth and Development	3
BOT-716	Invasive Plant Species	3
BOT-717	Molecular Systematics and Phylogenetics	3
BOT-718	Techniques in Molecular Biology	3
BOT-719	Proteomics and Genomics	3
BOT-720	Seminar I (M.Phil Botany)	1
BOT-721	Microbial Biotechnology	3
BOT-722	Phytoremediation	3
BOT-723	Nano Biotechnology	3
BOT-724	DNA Barcoding in Plants	3
BOT-725	Applied Biostatistics	

Note:

- *Under special circumstances like unavailability of teacher or less number of students or vice versa, M.Phil scholars can opt course(s) from the list recommended for PhD Botany.*

ADVANCES IN BIODIVERSITY CONSERVATION

COURSE CODE: BOT-701 Credit hours: 3(2+1)

OBJECTIVES:

To familiarize the students with different forms of biodiversity, threats to biodiversity and its conservation, importance of biodiversity for survival and proper functioning of ecosystems.

COURSE CONTENTS:

- Biodiversity :Definition as defined in the Convention of Biological Diversity (CBD).
- Concept of Biodiversity, Importance and types of Biodiversity
- Threats to Biodiversity; deforestation, over grazing, erosion, desertification, ecosystem degradation, bio invasion, pollution and climate change. Conservation of Biodiversity.
- Eco-ethic and sustainability ethic in the context of Biodiversity.
- Ecosystem services in the context of Biodiversity
- Biodiversity and Synergies effects between adaptation and mitigation to combat climate change.
- Biodiversity of Pakistan and Biodiversity Action plan for Pakistan.
- Measuring biodiversity: Alpha, Beta and Gamma diversity; Systematic and functional diversity
- Ecological services, indirect value of ecosystem by virtue of their ecological functions, direct value of ecosystem (i.e. Utility of Bio resources)
- Sustainable and unsustainable use of biological resources and role of traditional knowledge in biodiversity conservation; Agrobiodiversity and land use planning.
- Biodiversity Hot spots of Pakistan and the world.
- International treaties/agreements regarding Biodiversity and conservation; CBD, CITES, Ramsar and achai 20-20 targets
- Conservation strategies; *in situ, ex situ, in vitro* conservation
- Conservation *vs* preservation and public awareness strategies.
- IUCN categorized protected areas in Pakistan.
- Protected areas in Pakistan, kinds, distribution and management, National and international agencies concerned with biodiversity and conservation.
- IUCN categories of threatened species and criteria for recognizing different categories of threatened species and red listing.
- Environmental Impact Assessment.
- Use of herbarium and Botanical Garden in biodiversity and conservation.
- Concept of pastures and wild life management

- Global Biodiversity Information Facility (GBIF)

LAB OUTLINE:

1 Preparation of inventory of biodiversity in various habitats.
2 Field survey for baseline studies and Impact Assessment.
3 Identification of wild plant species used by local communities in different ecosystems.
4 Field excursion and data collection

RECOMMENDED BOOKS:

1. Agroecology: Science of Sustainable Agriculture. Altreri, M.A. Westview Press, Boulder, USA. 1995.
2. Biodiversity action plan for Pakistan.
3. Biodiversity: An introduction.(2nd Ed.) Gaston, K.J. & Spicer, J. Blackwell, Oxford. UK. 2004.
4. Bush, M.B. 1997 Ecology of a changing Planet. Prentice hall. New Jersy.
5. Conserving Living Natural Resources. Weddell, B.J. Cambridge University Press. Cambridge, UK. 2002.
6. Environmental profile of Pakistan
7. Essentials of Conservation Biology. Primack, R.B. Sinauer Assocaites, Inc. Publishers Sunderland, USA. 2002.
8. Falk, D.A. & Holsinger, K.E. 1991. Genetics and Conservation of Rare Plants. Center for Plant Conservation. Oxford University Press, Oxford, UK.
9. Frankel, O.H., Brown, A.H.D. & Burdon, J.J. 1995. *The Conservation of Plant Biodiversity*. Cambridge University Press, Cambridge, UK.
10. French, H. 2000 Vanishing Borders- protecting the Planet in the age of globalization. W.W. Norton & Co
11. Heywood, V. (ed.). 1995. Global Biodiversity Assessment. Published for the United Nations Environment Programme. Cambridge University Press, Cambridge, UK.
12. Hussain, F., 1991. Vegetation and ecology of lesser Himalaya. Department of Botany, Peshawar
13. IUCN. 1994. *IUCN Red List Categories.* As Approved by the IUCN Council. IUCN.
14. Leadlay, E. and Jury, S. 2006 Taxonomy and Plant Conservation. CUP.
15. National and Provincial conservation strategies of Pakistan.
16. Swanson, T. 2005 Global Action for Biodiversity. Earth Scan Publication Ltd.
17. Taylor, P. 2005 Beyond Conservation. Earth Scan Publication Ltd.

VEGETATION ECOLOGY

COURSE CODE: BOT-702 **Credit hours: 3(2+1)**

OBJECTIVE:

To familiarize the students with the basic and advanced techniques and principles of Ecology.

COURSE CONTENT:

- Ecology: Definitions, Basic concept, Branches, Some important development in Ecology.
- Climatic zones of the world: Tropical, Sub tropical, Coastal Arid, Semi-arid, Mediterranean, Temperate, Polar.
- Biomes of the world: Tropical rain forest, Tropical seasonal forest, subtropical desert, woodland, scrubland, temperate rain forest, temperate seasonal forest, temperate grassland, boreal forest, tundra.
- Vegetation of Pakistan: Tropical, Sub tropical, Temperate (Moist and dry), Subalpine, Alpine.
- Phytogeography: Classification of the world vegetation, Phytogeographical regions of Pakistan (Indian, Saharo-Sindian, Irano-Turanan, Sino Japanese)
- Ecological zones of Pakistan: Indus Delta Mangrove, the Thar desert, Thorn forest, Desert Basin of Balochistan, Subtropical forest of Balochistan, Juniper forest of Balochistan, Sub-tropical deciduous forest, Chalghoza forest, Himalayan moist and dry temperate forest, Trans-Himalayan Plateau.
- Phytosociological Attributes: Qualitative, Quantitative, Synthetic, Physiognomic.
- Population Structure and Dynamics: Density, Stratifications, Pyramid, diameters or cover size frequency distribution, Height frequency distribution, Age classes, growth rate classes, regeneration status, Minimum viable population, Maximum sustainable yield, Overshoot Population, Population cycle, Population ecology, Population genetics, Population modelling, Ecological modelling.
- Vegetation Sampling Methods: Line intercept methods, Transects, Belt transects, Gradsect, Point contact method, Quadrat method, Nearest neighbour method, Random pairs method, Closest individual method, Point centered quarter method, Y-method, Bitterlich variable plot method, Remote sensing and GIS sampling method.
- Systems of vegetation classification/analysis: The Zurich, Uppsala, American, British, Raunkaier, Braun-Blanquet, Advance classifications based on Floristic Composition, Biological Spectrum, Structural Attributes, Remote sensing & GIS, Cluster Analysis (Objective classification).

- Cluster Analysis: Types, Divisive methods, Agglomerative methods, TWANSPAN, Ward's cluster analysis.
- Ordination of Vegetation: Techniques, Formal Ordination methods (PCA, PCoA, CANCOR, SCA, MDA, CANOCO) and Informal Ordination methods (Polar ordination, Maarel's method, Swan-Dix-Wherham's ordination, NMDS).
- Status of Vegetation Analysis in Pakistan: Observational studies, Qualitative studies, Quantitative studies without multivariate analysis, Quantitative studies with multivariate analysis, Vegetation population dynamics studies, Species diversity studies, Functional studies,

LAB OUTLINE:

- Climatic and Vegetation Maps study
- Examples of Qualitative sampling
- Examples of Quantitative sampling
- Examples of Synthetic sampling
- Examples of Physiognomic sampling
- Review of research articles related to Vegetation Studies in Pakistan

COURSE OUTCOME:

At the end of the course the students would be able to understand the basic and advanced techniques and principles of Ecology.

RECOMMENDED BOOKS:

1. Agarwal. S.K (2008). Fundamentals of Ecology. Cambridge University Press. ISBN 13 978-0-521-86480-0.
2. Ahmed and Shaukat (2012). A textbook of Vegetation Ecology. Abrar sons, Karachi.
3. Archibold, O.W. (1995). Ecology of World Vegetation. London.: Chapman and Hall. pp. 510 p. ISBN 0 412 44290 6.
4. Barbour, Burk and Pitts (1980). Terrestrial Plant Ecology. The Benjamin/Cummings Publishing Company London, Sydney, California.
5. Charles J. Krebs (1999). Ecological methodology Benjamin/Cummings, Science - 620 pages
6. Dieter Mueller-Dombois, Heinz Ellenberg (2003). Aims and methods of vegetation ecology. Blackburn Press, 547 pages
7. E. Van Der Maarel. (2005). Vegetation Ecology. John Wiley & Sons, 2005 - Science -395 pages
8. Harper, (1959) - Plant communities - 325 pages

9. Karshaw (1973). Quantitative and dynamic Plant Ecology. William clowes and sons ltd. London.
10. Kaushika and Kaushika (2004). Energy, Ecology and Environment. Capital publishing company. New York.
11. Keddy, Paul A. (2007). Plants and Vegetation.
12. Mackenzie, Ball and Virdee (1988). Ecology. Bios scientific publishers. UK.
13. Peter B. Kaufman (1989). Plant Their Biology and importance.
14. Shaukat and Siddiqui. (2005). Essentials of Mathematical Ecology.

Stanley Adair Cain, G. M. de Oliveira Castro. (1959). Manual of Vegetation Analysis.

ADVANCES IN PHYTOSOCIOLOGY

COURSE CODE: BOT-703 CREDIT HOURS: 3(2+1)

OBJECTIVES:

To familiarize the students with different forms and aspects of vegetation sciences.

COURSE CONTENT:

- Concept of Phytosociology: Englo-American and European traditions of vegetation studies; Recent trends in vegetation studies;. Clements and Tansley concepts of vegetation analysis and units, Individualist concept and coninuum concept.
- Physiognomic, functional and structural bases of vegetation description.
- Organization of communities: Sampling methods, Releves transects and isonomes, minimal area, Various approaches to classifying vegetation
- Analysis of vegetation: Association table; Sub-Associations and Variants; Structure in time and space; Environmental gradients; Vegetation changes in space and time; Community pattern.
- Classification and ordination: Basic units, Different systems of classification; Details of Zurich-Montpellier system.
- Climate: Climatic diagrams; Climatic regions of Pakistan on the basic of rainfall and temperature; Vegetation and Ecological Zones of Pakistan.
- Classification of the world vegetation

LAB OUTLINE:

- Measurement and description of vegetation (Braun-Blanquet Method); Cover, Sociability, Density, Frequency.
- Minimal area determination preparation of Raw Table and Association Table; Delimitation of Association; Sub Association and variant.
- Preparation of Climatic Diagrams using metrological data of different regions of Pakistan.
- Study of climatic regions of Pakistan on the basis of temperature, rainfall distribution and vegetation of each region.
- Use of different softwares to perform multivariate analyses.
- Field excursion and data collection

COURSE OUTCOME:

At the end of the course the students would have been familiarized with different forms and aspects of vegetation sciences.

RECOMMENDED BOOKS:

1. Ahmed M, 2012, Text Book of vegetation ecology. Publisher Akbar son Karachi
2. Bush, M.B. 1997 Ecology of a changing Planet. Prentice hall New Jersy.

3. Cain S.A. 1944. Foundation of plant Geography. Harper and Brother.
4. Dombois and Ellenberg, 1976. *Aims and Methods of vegetation Ecology.* John Willey and Sons, London.
5. Environmental profile of Pakistan 1995, planning commission of Pakistan
6. Gaston, K.J. and Spicer, J. 2004. Biodiversity: An introduction. (2nd Ed). Blackwell Publishing, Oxford. UK 2004.
7. Hussain, F and Illahi A. 1991. Vegetation and ecology of lesser Himalaya. Department of Botany, Peshawar
8. Kent M. 2011. Vegetation description and data analysis: A practical approach. (2nd Ed.). Willey Blackwell.
9. Shimwell, D.W. 1971. *Description and Classification of vegetation*. Mueller,
10. Whitakker, R.H 1973. Ordination and classification of communities, Handbook of vegetation sciences part 5 The Hayge Junk.
11. Whitakker. R.H. 1975. Communities and ecosystem 2nd Ed. Macmillan New York.

ADVANCED PLANT PHYSIOLOGY

COURSE CODE: BOT-704 **CREDIT HOURS:** 3 (2+1)

OBJECTIVES:

- To explore recent advancements in plant water relations. Transport and translocation of water and solutes and how plants acquire, utilize, and regulate the flow of water between plant and environment.
- To understand how mineral nutrients are obtained, metabolized and transported by plants.
- To explore the physiological details of photosynthesis and respiration.
- To understand regulation of plant growth and development by phytohormones and the environment.

COURSE CONTENTS

1. **Plant water relations**: Water transport processes; Pressure driven bulk flow; Free energy status of water; Water potential gradient; Van't Hoff relations and matric potential; Hydraulic conductivity; Apoplast, transmembrane, and symplast pathways; Water transport through the xylem.
2. **Stress Physiology**: Physiological and biochemical basis of abiotic stresses, Plant responses to various stresses including drought, salinity, temperature, chemical and minerals; Global perspectives of drought; Mechanisms of drought tolerance in crop plants; Strategies for improving water use efficiency; Photosynthetic adjustments to drought; Relationships of drought with phytohormones; Molecular farming - plant environment and architecture.
3. **Phytohormones**: Major phytohormones and their synthethic analogues; Structure, biosynthesis, receptors and mode of action, transport, physiological effects of phytohormones. Detailed account of Polyamines, Brassinosteriods, Jasmonates and Salicylic acid.
4. **Plant Mineral Nutrition:** Inorganic composition of plant and soil; Ion traffic into root; The nature of membrane carriers, channels and electrogenic pumps .Passive and active transports and their energetics; Molecular physiology of mineral nutrient acquisition, transport, and utilization.
5. **Molecular determination of plant and cell architecture**: Genome organization and expression, protein synthesis; Molecular basis of energy flow in plants - photosynthesis, respiration and photorespiration; Molecular principles of metabolic and developmental integration - long distance transport; Phytochrome, photomorphogenic responses, signal perception and transduction; Vegetative and reproductive development; Senescence and programmed cell death.

LAB OUTLINE:

1. Atomic absorption spectrophotometry of mineral nutrients
2. Measurement of stomatal index and conductance.
3. Qualitative determination of K content in Guard cells by Sodium cobalt nitrite method.
4. To determine osmotic potential of massive tissue by freezing point depression method or by an osmometer.
5. To investigate the preferential absorption of ions by corn seedlings and potato slices.

COURSE OUTCOMES:

At the end of the course, the students will be able to:

1. Understand advanced knowledge of recent concepts in plant Physiology
2. Evaluate the role of nutrients in plant metabolism and the impacts of metabolic processes relating to nutrient assimilation.
3. Understand the knowledge of various abiotic stresses to plants and advanced strategies to improve tolerance
4. Understand plant growth and development, and its regulation by hormones and the environment.

RECOMMENDED BOOKS

1. Barton, W. 2007. Recent Advances in Plant Physiology.
2. Epstein, E. and Bloom, A.J. 2004. Mineral Nutrition of Plants: Principles and Perspectives. 2nd Edition. Sinauer Associates, California, USA.
3. Taiz, L. and Zeiger, E. 2006. Plant Physiology. 4th Edition. Sinnauers Publ. Co. Inc. Calif.
4. W.B. Hopkins. 2008. Introduction to Plant Physiology. 4th Ed. John Wiley and Sons. New York.

RECOMMENDED JOURNALS

Plant Physiology; Current Opinion in Plant Biology; Critical Reviews in Plant Sciences; Annual Review of Plant Biology; Trends in Plant Science; The Plant Cell; The Plant Journal; Plant Cell and Environment; Physiologia Plantarum; Advances in Agronomy.

FLOWERING PLANTS SYSTEMATICS AND EVOLUTION

Course Code: BOT-705 **Credit Hours**: **3 (2+1)**

OBJECTIVES:

1. This course will explore the phylogenetic relationship of the angiosperms.
2. Students will be expected to gain a working knowledge of techniques and approaches to Systematics (including phylogenetics and evolutionary processes)
3. Survey the sources and interpretation of systematic data

COURSE CONTENTS:

Phylogenetic relationships of Angiosperms:

Basal Angiosperms (ANITA Grade): Amborellales [Amborellaceae], Nymphaeales [Nymphaeaceae].

Magnoliids: Magnoliales [Magnoliaceae]

Monocots: Acorales [Acoraceae], Alismatales [Araceae, Potamogetonaceae], Liliales [Liliaceae], Asparagales [Orchidaceae, Amaryllidaceae, Asparagaceae].

Commelinids: Arecales [Arecaceae], Poales [Juncaceae, Cyperaceae, Poaceae], Commelinales [Commelinaceae], Zingiberales [Zingiberaceae].

Eudicots: Ranunculales [Papaveraceae, Ranunculaceae].

Core Eudicots: Saxifragales [Saxifragaceae, Cynomoriaceae].

Rosids: Fabid/Rosid I: Malpighiales [Violaceae, Salicaceae, Euphorbiaceae], Fabales [Fabaceae], Rosales [Rosaceae, Rhamnaceae, Moraceae, Urticaceae], Cucurbitales [Cucurbitaceae]. Malvid/Rosid II: Malvales [Malvaceae], Brassicales [Brassicaceae], Caryophyllales [Polygonaceae, Caryophyllaceae, Amaranthaceae, Cactaceae].

Asterids: [Primulaceae]. Euasterids: Lamiid/Asterid I: Gentianales [Gentianaceae, Apocynaceae], Solanales [Convolvulaceae, Solanaceae], Boraginales [Boraginaceae], Lamiales [Oleaceae, Scrophulariaceae, Lamiaceae, Orobanchaceae, Verbenaceae, Acanthaceae]. Campanulid/Asterid II: Asterales [Campanulaceae, Asteraceae], Apiales [Apiaceae].

LABORATORY/PRACTICAL:

1. 1. Plant Collection of 100 identified plants with typed labels and field notebook
2. Lab practicals dissections, and illustrations of the available flora of the families included in Syllabus.
3. Use of different keys for taxonomic identifications
4. Methods of taxonomic Data retrieval, analysis and interpretation (Cladistics, Phenetics, Numerical Taxonomy).
5. Exploration of Taxonomic Databases (The Plant List, Tropicos, IPNI, Symbiota, GBIF etc.)

COURSE OUTCOMES:

1. The students after completion of the course will be able to recognize and identify the common flowering plants of the region.
2. Will be able to learn the diagnostic features of genera and families.
3. Will be able to learn the different terminologies as well as the phylogenetic structure of the flowering plants.

Recommended Books

10. Tod F. Stuessy (2009). Plant Taxonomy, '*the Systematic Evaluation of Comparative data'* Second Edition, Columbia University Press, New York.
11. Clive A. Stace (1989). Plant Taxonomy and Biosystematics. 2nd Edition.
12. Schuh, R.T. (2000). *Biological Systematics. Principles and Applications.* Cornell University Press, Ithaca, NY
13. Winston, J.E. (1999). *Describing Species. Practical Taxonomic Procedure for Biologists.* Columbia University Press, New York, NY
14. Michael G. Simpson (2010). Plant Systematics, 2nd Edition. Elsevier Academic Press, NY.
15. Li, W.-H. (1997). *Molecular evolution*. Sinauer Associates, Sunderland, MA, USA.
16. Judd, Walter S., Campbell, Christopher S., Kellogg, Elizabeth A., Stevens, Peter F. and Donoghue, Michael J., 2008. Plant Systematics: a Phylogenetic Approach, 3rd ed. Sinauer Associates, Inc., Sunderland, Massachusetts.
17. Heywood, V.H. (1993). Flowering plants of the world. Chrysalis Books.
18. Gurcharan Singh, (2010). Plant Systematics: an integrated approach. 3rd Edition. Science Publishers, New Delhi, India.
19. Harris, J. G. and M. W. Harris. (2001). *Plant Identification Terminology: An Illustrated Glossary*. 2nd ed. Spring Lake Publications.
20. Plant family descriptions: http://biodiversity.bio.uno.edu/delta/angio/
21. Angiosperm phylogeny website: http://www.mobot.org/MOBOT/research/APweb/welcome.html

Journals/ Periodicals

Plant Systematics, Molecular Phylogenetics and Evolution, Systematic Biology, Taxon, Botanical Journal of the Linnean Society, Journal of the Missouri Botanical Garden, Turkish Journal of Botany, Pakistan Journal of Botany, Plant Systematics and Evolution, Nordic Journal of Botany, Aliso, Australian Journal of Botany, Systematic Botany, Bangladesh Journal of Plant Taxonomy.

PRINCIPLES OF PLANT SYSTEMATICS

COURSE CODE: BOT-706 CREDIT HOURS: 3 (2+1)

OBJECTIVES:

1. To enable the students to understand the philosophy of plant nomenclature and classification.
2. This course will explore the theory and procedures of modern systematic analysis
3. Students will be expected to gain a working knowledge of techniques and approaches to Systematics (including phylogenetics and evolutionary processes)
4. Survey the sources and interpretation of systematic data

COURSE CONTENTS:

The science of plant systematics: as an interdisciplinary science, advancement levels in plant systematics, phylogenetic approach, and modern applications of plant systematics. Methods and Principles of Plant Systematics: Taxonomic identification keys; Botanical Nomenclature and ICN; Classification systems of flowering plants, historical background, artificial, natural, phonetic, phyletic and cladistics (phylogenetic) approaches with emphasis on APG system. Taxonomic categories (genus, species and subspecific categories), Species concepts, Taxonomic Characters, Molecular systematics and phylogenetics, Phenetics, morphometrics and Numerical Taxonomy. Taxonomic evidences: Morphology, Phytogeography, Breeding Systems, Biosystematics, Palynology, Chemotaxonomy; Endemism, Centres of diversity, disjunction and vicariance, Alien Flora. The gathering and storage of Data: Botanical garden, Herbaria and Taxonomic experts, Floras and Monographs, Data information system, Botanical illustrations.

LAB OUTLINEOutlines:

- Phylogenetic reconstruction of selected taxonomic groups.
- Character and character states construction for phenetic studies.
- Use of MEGA, BioEdit, PAUP* and other computer algorithm for visualizing cladograms and character evolution.
- Exercise on use of botanical nomenclature and ICN rules.
- OUTCOMES of terminology and structures in living plant materials.
- Field Excursion for specimens collections.

COURSE OUTCOMES:

- The students will learn the principles, methods, and philosophy of nomenclature and classification.
- Will be able to apply the techniques of palynology, phytochemistry, molecular biology, anatomy, chromosomes morphology and breeding systems in plant systematics.

Recommended Books

1. Angiosperm phylogeny website: http://www.mobot.org/MOBOT/research/APweb/welcome.html
2. Clive A. Stace. (1989). Plant Taxonomy and Biosystematics. 2nd Edition.

3. Gurcharan Singh. (2010). Plant Systematics: an integrated approach. 3rd Edition. Science Publishers, New Delhi, India.
4. Harris, J. G. and Harris, M.W. (2001). *Plant Identification Terminology: An Illustrated Glossary*. 2nd ed. Spring Lake Publications.
5. Heywood, V.H. (1993). Flowering plants of the world. Chrysalis Books.
6. Judd, Walter S., Campbell, Christopher S., Kellogg, Elizabeth A., Stevens, Peter F. and Donoghue, Michael J. (2008). Plant Systematics: a Phylogenetic Approach, 3rd ed. Sinauer Associates, Inc., Sunderland, Massachusetts.
7. Li, W.-H. (1997). *Molecular evolution*. Sinauer Associates, Sunderland, MA, USA.
8. Michael G. Simpson. (2010). Plant Systematics, 2nd Edition. Elsevier Academic Press, NY.
9. Plant family descriptions: http://biodiversity.bio.uno.edu/delta/angio/
10. Schuh, R.T. (2000). *Biological Systematics. Principles and Applications.* Cornell University Press, Ithaca, NY
11. Tod F. Stuessy. (2009). Plant Taxonomy, '*the Systematic Evaluation of Comparative data'* Second Edition, Columbia University Press, New York.
12. Winston, J.E. (1999). *Describing Species. Practical Taxonomic Procedure for Biologists.* Columbia University Press, New York, NY

JOURNALS/ PERIODICALS

Plant Systematics, Molecular Phylogenetics and Evolution, Systematic Biology, Taxon, Botanical Journal of the Linnean Society, Journal of the Missouri Botanical Garden, Turkish Journal of Botany, Pakistan Journal of Botany, Plant Systematics and Evolution, Nordic Journal of Botany, Aliso, Australian Journal of Botany, Systematic Botany, Bangladesh Journal of Plant Taxonomy.

RESEARCH TECHNIQUES AND REPORT WRITING

COURSE CODE: BOT-711 **Credit hours: 3(2+1)**

OBJECTIVES:

Developing analytical approaches and synthetic skills for experimentation and presentation of scientific findings.

COURSE CONTENT:

Planning research project: definition of research, problem identification, feasibility, analysis of problem, defining objectives and goals, sources of secondary information, review of literature, development of hypothesis, determination of statistical design, methods for collection and analysis of data.

Reference writing: for books, journals, reports, personal communication, internet search etc.

Preparation of research project: types of research report, structure, graphics, draft preparation, revision, editing and submission.

Evaluation of a research project, peer review process, general evaluation criteria.

Paper writing and poster preparation.

LAB OUTLINE

Use of Turnitin and Endnote softwares. Developing a research project / proposal. Conducting a standard review of literature and preparing a review research article. Submitting it to a peer reviewed journal.

RECOMMENDED BOOKS:

1. Arifullah, S. and K. M. Bhatti. (1998). Research process simplified. PanGraphic (Pvt.) Limited. Islamabad.
2. Bausell, R.B. (1991). Advanced Research Methodology: An Annotated Guide to sources. Scarecrow Press, University of Minnesota. pp. 903.
3. Corner, M. 1993. Writing successfully in science. Chapman and Hall. N. Y.
4. Creswell, J. W. (2013). Qualitative inquiry and research design: Choosing among five approaches (3rd ed.). Thousand Oaks, CA: Sage.
5. Dawidowicz, P. (2010). Literature Reviews Made Easy: A Quick Guide to Success. Information Age Publishing Inc: Charlotte, NC.
6. Denzin, N. K., & Lincoln, Y. S. (Eds.). (2005). The SAGE handbook of qualitative research (3rd ed.). Thousand Oaks, CA: Sage.

7. Hashmi, N. (1983). Style manual of technical writing. Pakistan Economic Analysis Network Project, Islamabad.
8. Jones, A., R. Reed and J. Weyers. 1994. Practical skills in biology. Longman Scientific and Technical Publication.
9. LeCompte, M. D., Millroy, W. L., & Preissle, J. (1992). The handbook of qualitative research in education. San Diego, CA: Academic Press.
10. Marshall, C., & Rossman, G. B. (2010). Designing qualitative research (5th ed.). ThousandOaks, CA: Sage

PLANT BREEDING AND GENETICS

COURSE CODE: BOT-712 **Credit hours:** 3 (2+1)

OBJECTIVES:

Analyzes the historical evolution of plant breeding, knowing which have been the key scientific and technical advances that have influenced its development or accelerated its results.

COURSE CONTENTS:

Definition and Differences of Breeding, Variety, Cultivar, Line, Land race, phenotype, genotype, Heritability.

Breeding methods of Self i.e. Introduction, Selection (Pure line/Mass), Hybridization (bulk/pedigree method), Single seed descent method, Back cross,

Breeding methods for cross-pollinated crops

Mendalian genetics: Mendel laws, ratios, deviation from Mendel, gene interaction, sex linked traits, environmental effect on genes.

DNA structure; DNA replication; Transcription; Translation; Mutations; Chromosomal aberrations

LAB OUTLINE

Flower structures of different crops. Emasculation in Maize wheat, and oil seed crop, Breeding in Wheat, Maize and oil seed crops, Microscopy, Cell structure, DNA Isolation, GEL electrophoresis

COURSE OUTCOMES:

At the end of course, the students will have thorough knowledge of the importance of plant genetic resources as a source of variability in plant breeding programs, and knows the appropriate processes for their collection, conservation, evaluation and use.

RECOMMENDED BOOKS:

1. Klug, W. S. and Cummings, M.R. (2003). Concepts of Genetics. (7 th ed.), Pearson Education, Singapore.
2. Khan, M. A. and M. Ahmad. 2008. Plant Breeding. Daya Publishing House, New Delhi, India.
3. Chahal, G.S. and S.S. Gosal. 2003. Principles and Procedures of Plant Breeding. Narosa Publishing House New Delhi India.

4. Griffiths, A. J. F., J. H. Miller, D. T. Suzuki, R.C. Lewontin and W.M. Gelbart. 2005. An Introduction to Genetic Analysis. W.H. Freeman and Company, New York. USA.
5. Singh, B. D. 2004. Genetics. Kalyani Publishers, New Delhi, India.

ADVANCES IN APPLIED ETHNOBOTANY

COURSE CODE: BOT-713 CREDIT HOURS: 3(2+1)

OBJECTIVE:

To familiarize the students with the tools and techniques for documenting the indigenous use practices in natural and managed ecosystems and engaging them in critical thinking and discussions regarding latest issues of plant resource use and the mitigation measures.

COURSE CONTENT:

- Ethnobotany in Global Context. History, Scope and Nomenclature of Ethnobotany. Ethnobotany and its relation to conservation of plant material.
- Temporal and spatial changes in Ecosystems induced by indigenous use pattern.
- Access to resources and land tenure models.
- Conservation status of ethnobotanically important plants.
- Traditional ecological knowledge and resource management.
- Complementary and Alternative Medicine.
- Western Herbal Tradition, Materia medica, Toxicities and Interactions, herbal preparations.
- Drug discovery and the science behind the folklore. Benefit sharing and the Convention for Biological Diversity.
- Types and importance of questionnaires. Methods of interviewing, sample ethnobotanical interviewing. Statistical analysis in Ethnobotany.
- Use of taxonomic knowledge in Ethnobotany.
- Involving the local farmers of community in Ethnobotanical investigations.
- Survey of local market regarding Ethnobotanical products, including high value crops.
- Harvesting of Ethnobotanical products and their impact on sustainability of the plant population.
- Description of major plants of Khyber Pakhtunkhwa used by the local community in different ways.

LAB OUTLINE:

- Identification of ethnobotanically important plants in the area.
- Collecting and preparing herbarium plant specimens of Ethnobotanically important plants.
- Study of inventories used in the traditional medicine.
- Development and use of questionnaire for ethnobotanical use.
- Field trips to indigenous people hamlets for providing opportunities for hands-on experiences with techniques and methods used by field ethnobotanists.

- Field trips to local plants market for documenting the indigenous use pattern.

COURSE OUTCOME:

At the end of the course the student would be familiarized with the tools and techniques for conducting the ethnobotanical studies and critical thinking and discussions regarding latest issues of plant resource use and the mitigation measures.

RECOMMENDED BOOKS:

1. Alexiades, M (ed). 1996. Selected guidelines for ethnobotanical research; A Field Manual. Advances in Economic Botany, New York Botanical Gardens.
2. Bridges, K., W. Bridges and Y. Han Lau. 2006. The skill acquisition process relative to ethnobotanical methods. Ethnobotany Research & Applications 4:115-118.
3. Curnmgham, A.B. 2001. Applied Ethnobotany: People, Wild Plant Use and Conservation. W.W.F. Series.
4. Fuller, R. J. M. 2007. Guidelines for using video to document plant practices. Ethnobotany Research & Applications 5:219-231.
5. Laird, S.A. (ed.) 2002. Biodiversity and Traditional Knowledge: Equitable Partnerships in Practice. London; Sterling, VA: Earthscan Publications Ltd.
6. Martin, G.J. 2004. Ethnobotany: A methods manual. Chapman and Hall.
7. Shanley, P., A.R. Pierce, S.A. Laird and A. Guillen (Eds.). 2002. Tapping the Green Market: Certification and Management of Non-Timber Forest Products. London, Sterling, Earthscan.
8. Tuxill, J. and G.P. Nabhan. 2001. People, Plants and Protected Areas: A guide to In-situ Management. London : Earthscan, cop.

ADVANCED PHARMACOGNOSY

COURSE CODE: BOT-714 **CREDIT Hours: 3(2+1)**

OBJECTIVES:

To familiarize the students with basic concepts of Phramacognosy and their application.

COURSE CONTENT:

- Definition of pharmacognosy, drugs, crude drugs, official and unofficial drugs, fracture and its types for drug identification, cultivation, collection, curing, drying, preservation, evaluation and classification of drugs, therapeutic classes of drugs.
- Detail study of the following families representative medicinal plants distribution in Pakistan, giving them synonyms, botanical origin, local names, distribution all over the world, methods of cultivation, macroscopical characteristics of drugs. microscopical characteristics of drugs ,chemical constituents, uses and adulterants with special reference to species growing in Pakistan.
    A. Gymnosperms: Ephedra (Family Ephedraceae),
    B. Angiosperms:
        11. Opium (Family Papaveraceae)
        12. Berberis (Family Berbaridaceae)
        13. Liquorice (Family Papaveraceae)
        14. Acacia (Family Mimosaceae)
        15. Tragacanth (Leguminoseae)
        16. Tamarind (Leguminoseae)
        17. Linum (Linaceae)
        18. Euclyptus (Myrtaceae)
        19. Caryophyllus (Caryophylaceae)
        20. Cassia (Family Caesalpinaceae)
        21. Colchicum (Family liliaceae)
        22. Zingiber (Family Zingiberaceae)
        23. Mentha (Family Lamiaceae)
        24. Thyme (Lamiaceae)
        25. Foeniculum (Family Apiaceae)
        26. Coriandrum (Family Apiaceae)
        27. Asafoetida (Family Apiaceae)
        28. Ammi (Apiaceae)
        29. Rawulfia (Apocyanaceae)

30. Strophanthus (Apocyanaceae)

LAB OUTLINE:

- Microscopical characters of the drugs using sectioning and powdered drugs
- Macroscopic study of different gums and oils
- Identification test for starch, Ca-oxalate
- Identification tests for volatile and fixed oil, tannin and mucilage etc.

COURSE OUTCOMES:

At the end of the course, the students would be familiarized with the basic concepts of Phramacognosy and their application.

Recommended books:

1. Trease, G.E. and Evans, W.C. 2002. Pharmacognosy, W. B. Saunders, Philadelphia, Toronto.
2. Goodman Gillman, Pharmacological basis of therapeutics. McGrawHill Book Company, New York, 1996.
3. Jain, S.K. 1987. A manual of Ethnobotany. Scientific Publisher Johpur, India.
4. Usmanghani, K. 1985. Chemical Pharmacognosy, University Grants Commission, Islamabad.
5. Satorkar, R.S. and Bhandarkar, S.D. 1993.Pharmacology and Pharmacotherapeutics, Popular Prakashan, Bomby.
6. Trease G.D and Evans, W.C.1985. Pharmacognosy 12th Ed, English Language. Soc. Bailere Tindall.
7. Tyler, V.L.E.R. Brady and Clayse, E.F. 1970. Pharmacognosy 6th Ed. Leimption London.
8. Vladimir-Knezevic, S. and Blazekovic, B. 2008. Teaching practicum in Pharmacognosy I, Faculty of Pharmacy and Biochemistry, Zagreb.
9. Willism, T.E. 1998. Text book of Pharmacognosy. Churchill Ltd. Glouester Palace, W.I. London.

PLANT GROWTH AND DEVELOPMENT

COURSE CODE: BOT-715 **CREDIT HOURS:** 3 (2+1)

OBJECTIVES:

1. To explores the basic foundations of plant growth and development.
2. To explore unique aspects of plants, ranging from the single cell to the whole organism, and integration of events at the cellular level with whole plant development.
3. In depth study of molecular and genetic mechanisms underlying plant physiological processes.

COURSE CONTENTS

Unique and important features of plants: Plant structures and organs (shoot, root, flower); Embryogenesis and meristems; , Molecular mechanisms of organ formation.

Genetic feedback loops and organ specification: Meristem function, SAM and RAM maintenance; Leaf initiation, patterning and phyllotaxy; Position vs lineage, periclinal chimeras; Auxin gradients and organ specificity; Water and solute movement, vascular structure, carbon assimilation and transport; Gene reporter constructs, methods of gene expression visualization.

Photoreceptors: Light signalling and development, phototropism and gravitropism; Molecular signal transduction and development; Light perception and development; Photoreceptors and developmental signaling.

Phytohormones and development: Auxin and polar growth, organ movement; Gibberellins and cell expansion, seed germination; Cytokinins and cell division; Ethylene, Abscisic Acid and stress response; Newly discovered phytohormones.

Photoperiod responses: Circadian rhythms; How plants tell time, Flowering and floral induction, florigen; Plant response to environment.

RECOMMENDED BOOKS

1. Barton, W. 2007. Recent Advances in Plant Physiology. Barman Press. ISBN:1406748595.
2. Griffiths A., Wessler, S. Lewontin, R. and Carroll, S. Introduction to Genetic Analysis, 9th edition.
3. Snustad, D.P., Simmons, M.J. and Jenkins, J.B. Principles of Genetics. 2006. 8th edition. John Wiley Publ. ISBN: 9780471311966.
4. Taiz, L. and Zeiger, E. 2010. Plant Physiology. 5th Edition. Sinnauers Publ. Co. Inc. Calif.
5. W.B. Hopkins. 2008. Introduction to Plant Physiology. 4th Ed. John Wiley and Sons. New York.

RECOMMENDED JOURNALS

Advances in Agronomy; Plant Physiology; Journal of Experimental Botany; Trends in Plant Science; Functional Plant Biology; The Plant Journal; Plant Cell and Environment; Theoretical and Applied Genetics.

INVASIVE PLANT SPECIES

COURSE CODE: BOT-716 **CREDIT HOURS:** 3 (2+1)

OBJECTIVES:

The overall goal of this course is to understand what environmental and biologic factors contribute to the successful invasion of plants across a landscape and what strategies can be used to mitigate or eradicate those species. Specific objectives include:

• Define invasive species from legal and ecological perspectives

• Examine hypotheses that explain why plants become invasive

• Survey the ecological, economic, and social impacts of invasive plants

• Discuss management strategies to mitigate or eradicate invasions

COURSE OUTLINE:

1. Invasive plants: What are they? Terminology involved in classification, Ecological, Taxonomic and Geographic definitions and characterizations.

2. How are they located? a) Eyewitness accounts b) Herbarium records c) Systematic floristic surveys d) Deliberate searches e) Remote sensing

3. What makes a species invasive? a) Competition hypothesis b) Escape from biotic constraints hypothesis c) BCW hypothesis d) Microevolutionary change hypothesis e) Vacant niche hypothesis f) Biodiversity hypothesis g) Variable resource hypothesis h) Disturbance and land use hypothesis i) Anthropogenic hypothesis j) Environmental change hypothesis

4) Modeling plant invasions a) Models of plant invasions b) Single species model c) Models of interacting populations

5) Impacts a) Ecological i) Species replacement ii) Ecosystem functions iii) Threatened & endangered species b) Economic i) Total environmental damage estimates ii) Methodology (1) Cost effectiveness analyses (2) *Ex ante* analyses c) Social i) Water quantity and quality ii) Human health

RECOMMENDED BOOKS:

1. Bright, Chris (1998). Life Out of Bounds: Bioinvasion in a Borderless World. New York: W.W. Norton & Co. New York: W. W. Norton.
2. Burdick, Alan (2005). Out of Eden: An Odyssey of Ecological Invasion. New York: Farrar, Straus, and Giroux.
3. Constanza, Robert, John H. Cumberland, Herman Daly, Robert Goodland, and Richard B. Norgaard (2014). An Introduction to Ecological Economics, Second Edition. Boca Raton, Fla.: CRC Press.

4. Cox, George W (2004). Alien Species and Evolution: The Evolutionary Ecology of Exotic Plants, Animals, Microbes, and Interacting Native Species. Washington, D.C.: Island Press.
5. Drake, James A. (2009). ed. *Handbook of Alien Species in Europe*. Springer Netherlands, 2009.
6. Elton, Charles S. (2000) The Ecology of Invasions by Animals and Plants. Chicago: University of Chicago Press.
7. McNeely, Jeffry A., Harold A. Mooney, Laurie E. Neville, Peter Johan Schei, and Jeffery K. Waage, (2001). eds. *Global Strategy on Invasive Alien Species*. Gland, Switzerland: IUCNGlobal Invasive Species Programme.
8. Mooney, Harold A., and Richard J. Hobbs, (2000). eds. Invasive Species in a Changing World. Covelo, Calif.: Island Press.
9. Perrings, C., M. Williamson, and S. Dalmazzone (2000). eds. *The Economics of Biological Invasions*. Northampton, Mass.: Edwar Elgar Publishing.
10. Shigesada, N., and K. Kawasaki (1997). *Biological Invasions: Theory and Practice*. New York: Oxford University Press.
11. Simberloff, Daniel, and M. Rejmánek, eds (2011). Encyclopedia of Biological invasivions. University of California Press..
12. Van Driesche, J., and R. Van Driesche (2000). Nature Out of Place: Biological Invasions in the Global Age. Washington, D.C.: Island Press.

Journals / Periodicals:

Invasive Plant Science and Management, Aquatic Invasions, Biodiversity, Biological Control, Biological Invasions, Diversity and Distributions: A Journal of Biological Invasions and Biodiversity, Environmental Research, International Journal of Biodiversity and Conservation, Invasive Plant Science and Management, Management of Biological Invasions, New Zealand Plant Protection Journal.

MOLECULAR SYSTEMATIC AND PHYLOGENETICS

COURSE CODE: BOT-717 **CREDIT HOURS:** 3 (2+1)

OBJECTIVES:

1. Students will gain a general understanding of the importance, application, and practice of systematic biology.
2. Describe plant relationships depicted on phylogenetic trees with proper terms
3. Exhibit basic knowledge in molecular approaches applied to systematics
4. Demonstrate knowledge in the current understanding of angiosperm phylogeny and evolution.

COURSE OUTLINES:

1. Introduction to biosystematics, Taxonomy versus systematic, Operations of taxonomy, the species concepts, Characters in general: Epistemology, Nominalism versus realism, Typology versus population thinking. Schools of thought in systematic, Qualities of Taxonomic Characters

Character similarity, Reductionism and holism.

2. What is a phylogeny? Determining evolutionary history. Character, character states and networks. Evolutionary trees and rooting, choosing trees, summarizing evolutionary trees, the probability of evolutionary change in characters. Do we believe the evolutionary tree? Describing evolution, mapping character on trees.

3. Plant genomes, chloroplast DNA structure, rbcL, matK, and other plastid gene; mitochondrial genes, nuclear genes.

4. Generating molecular data, analysis of molecular data, alignment of sequences, homoplasy and long branches, methods of phylogeny reconstruction, gene trees vs species trees, Maximum parsimony analysis, Minimum evolution/Neighbour-joining trees, The Neighbour-Joining algorithm, Maximum likelihood phylogenies, Markov Chain Monte Carlo Bayesian analysis.

5. DNA Barcoding, DNA sequence management and analysis softwares, ClustalW, Muscel, MEGA, PAUP.

LABORATORY/PRACTICAL

1. Students will choose a taxon at the level of genus or above that they will use as a case study to explore the various concepts introduced in the course. These will include the applications of molecular phylogenetics to the taxon.

2. Exploration of library and internet resources relevant to systematics or phylogenetics. In particular, the students shall learn the basics of the NCBI Taxonomy database and *BLAST* search algorithms.

3. Constructing phylogenetic trees using PAUP and MEGA from the NCBI sequences.

4. DNA extraction, purification, PCR, sequencing methods.

RECOMMENDED BOOKS

1. Hall BG (2011) Phylogenetic Trees Made Easy - A How-To Manual. Fourth Edition. Sinauer, Sunderland M.A.
2. Hillis et al. (eds) (1996) Molecular Systematics, 2nd edition, Sinauer, Sunderland Ma.
3. Li, W.-H. (1997). *Molecular evolution*. Sinauer Associates, Sunderland, MA, USA.

4. Lynch, M. (2007). The origins of genome architecture. Sinauer Associates, Sunderland, MA, USA
5. Nei M & Kumar S (2000) Molecular Evolution and Phylogenetics. Oxford University Press.
6. Page RDM & Holmes EC (1998) Molecular Evolution - A Phylogenetic Approach. Blackwell, Oxford.
7. Panchen AL (1992) Classification, Evolution, and the Nature of Biology. Cambridge University Press, Cambridge.

Journals/ Periodicals

Cladistics, BMC Evolutionary Biology, Evolution, Evolution and Development, Evolutionary Bioinformatics, Genome Biology, Journal of Evolutionary Biology, Journal of Molecular Evolution, Molecular Ecology, Molecular Phylogenetics and Evolution, Systematic Biology, Taxon, Botanical Journal of the Linnean Society, Journal of the Missouri Botanical Garden, Plant Systematics, Trends in Ecology & Evolution.

TECHNIQUES IN MOLECULAR BIOLOGY
COURSE CODE: BOT-718 CREDIT HOURS: 3(2+1)

OBJECTIVES:

- To understand key experimental techniques used in modern molecular biology research.
- To gain practical basis for academic studies/professional practice in areas related to molecular biology

COURSE CONTENTS

Theory about techniques in molecular biology with an emphasis on:

Different types of centrifugations; Different techniques used for gene amplification; Primer designing; PCR types; (inverse, touchdown, nested, hemi nested, pit stop, multiplex, reverse transcriptase) and its applications; Detection of mutations and/or SNPs; RFLP; Analysis of nucleic acids by gel electrophoresis (horizontal, vertical, pulse field, denaturing gradient gel); Analysis of proteins by native and SDS gels; Generation of antibodies and their uses; Enzyme-linked immunosorbant assay; Southern, Western, Northern blotting; Protein purification by different chromatographic techniques, Sanger sequencing.

LAB OUTLINE

Preparation of stock and working solutions; Isolation of nucleic acids and their quantification; Gel electrophoresis; Polymerase chain reaction (PCR); Detection of mutations by restriction fragment length polymorphism; Preparation of chemically competent cells; Transformation of bacteria with plasmid DNA; Analysis of proteins by SDS-PAGE

COURSE OUTCOMES:

At the end of the course, the students should be able to:

a) Understand, and perform, the most important methods in molecular biology
b) Understand the molecular approach used in research relevant for understanding the development and treatment of plant disease

RECOMMENDED BOOKS

1. Allison, L.A. (2011). Fundamental Molecular Biology. 2nd Edition. Wiley Sons.
2. Arora, D. K., Das, S. and Sukumar, M. (2013). Analyzing microbes: Manual of molecular biology techniques. Berlin: Springer.
3. Carson, S., Miller, H. B. and Witherow, D. S. (2012). Molecular biology techniques: A classroom laboratory manual. Amsterdam: Elsevier /Academic Press.
4. Espina, V. and Liotta, L. (2012). Molecular Profiling: Methods and Protocols; Volume 823, Springer Science+Business Media, LLC.
5. Gerald Karp, G., Janet Iwasa, J. and Wallace Marshall, W. (2016). Karp's Cell and Molecular Biology, 8th Edition . John Willey and Sons, Inc.
6. Lodish., H., Berk, A., Kaiser, C.A., Krieger, M., Bretscher, A., Ploegh, H. and Martin, K. (2016). Molecular Cell Biology. 8th Edition. W.H. Freeman.

7. Surzycki, S. (2000). Basic Techniques in Molecular Biology. Berlin: Springer.
8. Watson, J.D., Gann, A., Levine, M. and Losicks, R. (2013). Molecular Biology of the Gene. The Benjumen Cummings Publishing Company, California

Wilson, J. and Hunt, T., 2015. Molecular Biology of the Cell. 6th Edition Garland Sciences, Taylor and Francis.

PROTEOMICS AND GENOMICS

COURSE CODE: BOT-719 **CREDIT HOURS: 3(2+1)**

OBJECTIVES:

- The overarching goal of this course is to provide students with a thorough overview of both the theoretical and experimental aspects of structural and functional proteomics as well as genomics.

COURSE CONTENTS

Organization and structure of genomes; Genome sequencing genetic mapping (RFLP, microsatellite, SNP); High resolution physical mapping (STS, EST); Comparative genomics and genome evolution, hierarchical and whole genome shotgun sequencing; DNA sequencing strategies, Manual and automated sequencing, different platforms used for next generation sequencing sequence assembly, obstacles and solutions; Estimating gene number over prediction and under prediction, homology searches, exon prediction programs, integrated gene finding software packages; structural variation in the genome and its applications; DNA microarray.

Expression, structural and functional proteomics; Cellular communication/signalling pathways; Protein-protein interactions and validation - yeast two hybrid system; Affinity purification-mass spectrometry (AP-MS), Tandem affinity purification (TAP); Tagging, fluorescence resonance energy transfer (FRET) and coimmunoprecipitation.

LAB OUTLINE

In silico analysis and comparison of different genomes; Differential proteome analysis by 2D gel electrophoresis; *In silico* analysis and comparison of different proteomes

COURSE OUTCOMES:

At the end of the course, the scholars should be able to:

1. Distinguish between genetic and physical maps.
2. Describe the different techniques used for sequencing a genome.
3. Describe how proteomics application in molecular biology research can be helpful in solving the complex biological and biochemical processes

RECOMMENDED BOOKS

1. Alexander, N. G. and. Hiroshi. N. (2007). Microbial Biotechnology. Ch. The world of Omics: Genomics, Transcriptomics, Proteomics and Metabolomics pp147-168. Springer
2. Field, D. and Davies, N.(2015). Biocode: The new age of genomics. Oxford University Press.
3. Guenter, K. (2015). The Dictionary of Genomics, Transcriptomics and Proteomics. 5th Edition. Published by Wiley Blackwell.

4. Hon-Chiu, E.W.L. (2012). Integrative Proteomics. Intech publishing. Germany.
5. Pevsner, J. (2015). Bioinformatics and functional genomics. 3rd Edition. John Willey and Sons, New Jersey.
6. Reinders, J. (2016). Proteomics in systems biology: Methods and protocols. New York: Humana Press.
7. Twyman. R. M. (2004). Principles of Proteomics. Taylor and Francis.

Seminar-I

COURSE CODE: BOT-720 **CREDIT HOURS: 1(1+0)**

MICROBIAL BIOTECHNOLOGY

COURSE CODE: BOT-721 **CREDIT HOURS: 3(2+1)**

OBJECTIVES:

To introduces students to microbial biotechnology and the use of microbes to generate useful products.

COURSE CONTENTS

Introduction, issues and scope of microbial biotechnology; Genetically modified microorganisms; Microbes as tools for microbiological research; Biotechnological potential of microbes; Significance of microorganisms in food production, Fermentation, pharmaceutical and other industries; Vaccine development and production; Microbiological mining, biofuels and use of microbes in petroleum industry; Plant-microbe interactions; Bio-fertilizers, biopesticides, composting; Antimicrobials; Significance of microbial biotechnology in the economic development of Pakistan.

PRACTICAL

Isolation and screening of potential microbes from different environmenta; Lab scale production of bacterial enzymes; Lab-scale production of alcohol by yeast; Use of microbes in bioleaching.

OUTCOMES:

At the end of the course, the scholars should be able to have thorough knowledge about how modern methods may be employed to enhance the characteristics of microbes that are commonly used in various industries including food, agriculture and pharmaceutical.

RECOMMENDED BOOKS

1. Alexander, N.G. and Hiroshi. N. (2007). Microbial Biotechnology. Ch. The world of Omics: Genomics, Transcriptomics, Proteomics and Metabolomics pp147-168. Springer.
2. Guenter, K. (2015). The Dictionary of Genomics, Transcriptomics and Proteomics. 5th Edition. Published by Wiley Blackwell.
3. Hon-Chiu, E.W.L. (2012). Integrative Proteomics. Intech publishing. Germany.
4. Jung, K. (2016). Statistical analysis in proteomics. New York: Humana Press
5. Reinders, J. (2016). Proteomics in systems biology: Methods and protocols. New York: Humana Press.

6. Sechi, S. (2016). Quantitative proteomics by mass spectrometry. New York: Humana Press.
7. Twyman. R. M. 2004. Principles of Proteomics. Taylor and Francis.

PHYTOREMEDIATION

COURSE CODE: BOT-722 CREDIT HOURS: 3 (2+1)

OBJECTIVES:

- The students in this course will get a good understanding of the processes involved in phytoremediation, i.e. the use of plants and their associated microbes to remediate environmental pollution.
- Students will know which technologies are used in which cases, and why. They will know in some detail about the biological mechanisms involved in pollutant uptake, accumulation and transformation.
- The students will obtain some basic insight into plant-microbe interactions involved in phytoremediation, the effects of soil properties and environmental conditions, and risk assessment.

COURSE CONTENTS:

Introduction to Phytoremediation, Phytoremediation strategies: phytoextraction, phytostabilization, etc. Phytoremediation of inorganics - types of inorganic pollutants (heavy metals, metalloids, nitrate etc, radionuclides, cations vs. anions) - plant uptake, translocation mechanisms for inorganics - plant accumulation, biotransformation, tolerance mechanisms for inorganics.

Phytoremediation of organics - types of organic pollutants - mechanisms involved in plant uptake, translocation, degradation of organics - Phytoremediation of organics

Risk assessment issues in phytoremediation, Exercise in cleanup strategy development

Plant-microbe-soil interactions and their relevance for phytoremediation.

COURSE OUTCOMES

- At the end of the course the students will be able to design a phytoremediation plan for a given site.
- The students will also be informed about the phytoremediation job market and funding opportunities

RECOMMENDED BOOKS

1. Ajay Singh. (2011). Applied Bioremediation and Phytoremediation (Soil Biology)
2. Bernard R. Glick. (2015). Beneficial Plant-Bacterial Interactions.
3. Daniel G. Strawn & Hinrich L. Bohn & George A. O'Connor. (2015). Soil Chemistry.
4. Leila Darwish (2013). Phytoremediation: Transformation and Control of Contaminants.
5. Leila Darwish. (2013). Earth Repair: A Grassroots Guide to Healing Toxic and Damaged Landscapes.
6. Roscoe Wilfred Thatcher. (2011). The Chemistry of Plant Life.

NANO BIOTECHNOLOGY

COURSE CODE: BOT-723 CREDIT HOURS: 3(2+1)

OBJECTIVES:

- To know about the biomaterials, approaches and applications of nanotechnology in living systems

COURSE CONTENTS

Biomaterials: 1st, 2nd and 3rd generation biomaterials, their historical overview and current directions; Nanobiotechnology, nanoscience and nanotechnology; Top down and bottom up approaches to analyze nanoscopic properties; Nanoparticles and nanoscale materials; Cellular nano and microstructures; Nanocarbon tubes, abalone shells; Nanomanipulation via different types of microminipulators; Nanoprobes and probe array; DNA nanotechnology and DNA-modified surfaces; Applications of nanobiotechnology in living systems.

PRACTICAL

1. Construction of silver nanoparticles.
2. Construction of Zinc quantum dots.
3. Study of antimicrobial activity of nanoparticles
4. Biofilm formation and bio luminous determination.
5. Quorum sensing in biofilms in the presence of nanoparticles

OUTCOMES:

At the end of the course, the scholars should be able to have thorough knowledge of applications of nanotechnology in living systems

RECOMMENDED BOOKS

1. Greco, R.S., Prinz, F.B., Smith, R.I. and Prinz, F.B. (2004). Nanoscale Technology in Biological Systems, CRC Press, Boca Raton.
2. Kelsall, R., Hamley, I.W. and Geoghegan, M. (2005). Nanoscale Science and Technology, John Willey and Sons, N.Y.
3. Kumar, N. and Kumbhat, S. (2016). Essentials in nanoscience and nanotechnology. New Jersey : Wiley
4. Mansoori, G.A. (2005). Principles of Nanotechnology: Molecular-Based Study of Condensed Matter in Small Systems, World Scientific Publishing Company, N.J.
5. Scherge, M., Gorb, S.N. and Stanislav, S.N.G. (2001). Biological Micro- and Nanotribology, Springer-Verlag, N.Y.
6. Slingerland, J. 2016. Nanotechnology. Essential Library, an imprint of Abdo Publishing.

DNA BARCODING IN PLANTS

COURSE CODE: BOT-724 CREDIT HOURS: 3 (2+1)

OBJECTIVES: To abreast students about the applications of DNA barcoding in plants

COURSE CONTENTS:

Foundations of DNA Barcoding: The state of biodiversity science, The taxonomic impediment, The short history of a discipline. Community standards and best practices: The importance of standards, the markers of choice and their specifics, Specimen preparation and laboratory workflows. DNA Barcode analytics: Data repositories (BOLD, INSDC databases), Methods for species identification by querying data repositories, Tree building methods and sequence analysis. DNA Barcoding and Taxonomy: Voucher specimens, integrated taxonomy, and Cryptic species. Applied DNA Barcoding I (Ecology, Conservation Biology & Evolution), DNA Barcoding in ecology, How DNA Barcoding can aid in Conservation biology, the evolution of a gene. Applied DNA Barcoding II (Food safety, Pest and Health Management, Invasive Species): Do you really know what you eat? DNA Barcoding for food and drug safety, Detection of agricultural pests and disease vectors, DNA Barcoding in early-warning systems concerning invasive species. Applied DNA Barcoding III (Biosurveillance, Habitat Monitoring): Species inventories, DNA Barcoding of indicator species, Long term monitoring utilizing modern genetics. Future trends in DNA Barcoding: Next generation sequencing, Environmental DNA detection, Miniaturization and mobile devices.

COURSE OUTCOMES

At the end of the course, the successful student will be able to

1. Describe and comprehend the genetic background of DNA Barcoding, and evaluate potential technical challenges.
2. Identify species by performing data base queries with common databases and interpretation of results.
3. Critically evaluate studies that utilized DNA-based taxonomy.
4. Develop skills to make informed decisions about molecular marker choice and laboratory needs.
5. Synthesize knowledge and effectively communicate about DNA Barcoding for grant proposals and interaction with policy makers.

RECOMMENDED BOOKS:

1. Chase MW, Cowan RS, Hollingsworth PM, et al (2007) A proposal for a standardised protocol to barcode all land plants. Taxon 56(2):295–299
2. Ida Lopez, David L. Erickson (2012). DNA Barcodes: Methods and Protocols. Humana Press,
3. Nikolaus J. Sucher, James R. Hennell, Maria C. Carles. DNA Fingerprinting, DNA Barcoding, and Next Generation Sequencing Technology in Plants
4. Subrata Trivedi, Hasibur Rehman, Shalini Saggu, Chellasamy Panneerselvam, Sankar Ghosh (2018). DNA Barcoding and Molecular Phylogeny. Springer.
5. Textbook: Gene Cloning and DNA Analysis: An Introduction, 5th edition, 2006. Author: Terence A. Brown. Blackwell Science Ltd. Pp 386. ISBN 978-1-4051-1121-8. Laboratory Manual: Laboratory DNA Science: An Introduction to Recombinant DNA Techniques and

Methods of Genome Analyis. 1995. Mark V. Bloom, Greg A. Freyer and David A. Miklos. Benjamin Cummings, NY. Pp 434. ISBN 0-8053-3040-2.

6. Weising K (2005) DNA fingerprinting in plants: principles, methods, and applications. Taylor & Francis Group, Boca Raton

Annex-IV

SCHEME OF STUDIES AND COURSES SYLLABUS FOR P.HD BOTANY DEGREE PROGRAM.

Minimum course work for Ph.D in Botany will be 18 credit hours, preferably required to be completed in the first year as per HEC guidelines along with 9 credit hours of thesis.

Ph.D scholars can opt courses from the list given below:

Course Code	Course Title	Credit Hrs.
BOT-801	Biosystematics	3
BOT-802	Advances in Plant Taxonomy	3
BOT-803	Dendrochronology	3
BOT-804	Agrostology	3
BOT-805	Palynology	2
BOT-806	Herbarium Techniques and Management	3
BOT-807	Phytogeography	3
BOT-808	Plant Functional Genomics	3
BOT-809	Geographic Information System (GIS)	3
BOT-810	Molecular Cell Biology	3
BOT-811	Allelopathy	3
BOT-812	Edaphology	3
BOT-813	Recombinant DNA Technology	3
BOT-814	Plant Ecophysiology	3
BOT-815	Plant Enzymology	3
BOT-816	Soil Microbiology	3
BOT-817	Fungal Biotechnology	3
BOT-818	Advanced Bioinformatics	3
BOT-819	Molecular Developmental Biology	3
BOT-820	Seminar II	1
BOT-821	World Major Biomes	2
BOT-822	Cytogenetics	3
BOT-823	Advances in Plant Anatomy	3
BOT-824	Mushroom Biology	3
BOT-825	Ectomycorhizal Biotechnology	3
BOT-826	Ecotoxicology	3

Note:

- *Under special circumstances like unavailability of teacher or less number of students or vice versa, Ph.D scholars can opt course(s) from the list recommended for M.Phil Botany.*

BIOSYSTEMATICS

COURSE CODE: BOT-801 **Credit hours: 3(2+1)**

Objective:

To familiarize the students with the basic and advanced techniques and principles of biosystematics.

Course content:

Importance of plant collection. Importance of field observations data. Herbarium as the reservoir of the natural history of a land and source of information for researchers in other fields, e.g phytochemistry, geographers, etc.

Important herbaria of the world. Herbaria in Pakistan. Pioneer plant collectors of the world. Plants collectors in Pakistan.

Principles for delimitation of various taxa. Concept of characters. Analytical and Synthetic characters. Good and bad characters. Quantitative and qualitative characters.

Detailed rules of botanical nomenclature.

Concept of specie and speciation. Biological Species Concept, Phylogenetic Species Concept, Typological Species Concept, Nominalistic Species Concept.

Taxonomic Evidence: Palynological, Chemotaxonomic, Molecular, Anatomical, Morphological etc.

Presentation of data: Keys and synopsis, Citations, Mapping, Geographical, morphological methods, illustrations, Tabulations, symbolic and graphic methods. Preparation of monographs, revisions, floristic works etc.

Endemics and endemism: Types of Endemism, Role of Environment in endemism; Role of Polyploidy in endemism, Role of hybridization in endemism.

Disjunct distribution; Introduction, Major disjuncts of the world with special reference to Pakistan.

Numerical Analysis of flora of Pakistan: The Phytogeographical elements: Bi and pluri regional elements.

Flora of Pakistan - a review.

LAB OUTLINE:

Plant collection methods and Herbarium Techniques.

Practice of Flora writing. Construction of indented and bracketed keys. Writing of technical description of taxa.

Familiarization with Index Kewensis, Taxonomic literature, and Floras of the region and other parts of the world.

Preparation of distribution maps of various taxa.

To find out the correlation between various morphological characters and geographical distribution in various taxa.

RECOMMENDED BOOKS:

1. Cain, R. (1947). Foundations of Plant Geography – Harper and Bros. Ltd. London.
2. Davis, P.H. and Heywood, V.H. (1963). Principles of Angiosperm Taxonomy. Oliver and Boyd, Edinburgh, London.
3. Good, R. (1947). The Geography of Flowering Plants – Longmans, Green and Co., London.
4. Hedge, I.C. (1986). Plant life of South-West Asia. - Proceedings of the Royal Society of Edinburgh.
5. Heywood, V.H. (1995). Global Biodiversity Assesment. UNEP and Cambridge University Press.
6. Kubitzki, K. 1990 – (2007). The Families and Genera of Vascular Plants. Vols. I – IX. Springer.
7. Lawrence, G.H.M. (1955). An Introduction to Plant Taxonomy. MacMillan Co., New York.
8. Lomolino, M.V. and Heany, L.R. (2004). Frontiers of Biogeography. Sinaur Associates, Inc.
9. Mabberley, D.J. (2000). The Plant Book. Cambridge University Press.
10. McNiell, J. (2006). International Code of Botanical Nomenclature – (Vienna Code). Regnum Vegetabile. Vol. 146. A.R.G. Gantner Verlag K. G.
11. Nasir, E., Ali, S.I., Nasir, Y. and Qaiser, M. (1970-2012). Flora of Pakistan. Vols. 1-218.
12. Simpson, M.G. (2010). Plant Systematics. Elsevier Academic Publishers.
13. Stace, C.A. (1989). Plant Taxonomy and Biosystematics. Edward Anold, London, Auckland.
14. Stewart, R.R. (1972). An Annotated Catalogue of Vascular Plants of Pakistan and Kashmir. Fakhri Printing Press, Karachi.
15. Stewart, R.R. (1972). An Annotated Catalogue of Vascular Plants of W. Pakistan and Kashmir. Fakhri Press, Karachi.
16. Stuessy, T.F. (1990). Plant Taxonomy – The Systematic Evaluation of Comparative Data. Columbia University Press. NY.

17. Zohary, M. (1973). Geobotanical Foundations of the Middle East I & II. - Gustav -Fische - Stuttgart.

ADVANCES IN PLANT TAXONOMY

COURSE CODE: BOT-802 CREDIT HOURS: 3(2+1)

OBJECTIVES:

To familiarize the students to advanced techniques in floristic and systematic research by developing their abilities and enhancing their capacities. This course will be used as an avenue for initiating development of a digital revision of the Flora of Pakistan (FoP), at least at the family level.

COURSE CONTENT:

- Introduction, goals and principles of systematics, theoretical frameworks; basic principles of International Code of Botanical Nomenclature (ICBN); current concepts of vascular plant taxonomy. Species concept and speciation. The family concept. Students will be required to understand how current interpretations differ from those in FoP.
- Interpreting the natural world to make it easier for humans to understand; names as tools for communication; elements of scientific names.
- Changing framework for plant systematics, similarity, evolution and phylogeny.
- Sources of systematic information (Morphology, Anatomy, Cytology, Chemistry, DNA, evaluating characters).
- Taxonomic system of the angiosperm phylogeny group.
- 8. Students will become familiar at least with 30 different vascular plant families. Diagnostic characteristics, distribution pattern, economic importance, evolutionary trends, phyletic relationship of the common families, viz. Apiaceae, Asclepiadaceae, Asteraceae, Boraginaceae, Brassicaceae, Caesalpiniaceae, Capparidaceae, Caryophyllaceae, Casuarinaceae, Chenopodiaceae, Convolvulaceae, Cucurbitaceae, Cyperaceae, Euphorbiaceae, Fabaceae, Juncaceae, Lamiaceae, Liliaceae, Magnoliaceae, Malvaceae, Mimosaceae, Myrtaceae, Orchidaceae, Papaveraceae, Poaceae, Ranunculaceae Rosaceae, Salicaceae, Scrophulariaceae, Solanaceae.
- Different types of keys. Herbarium specimens: plant material, data, importance of herbarium specimens.
- Systematics, conservation, and herbaria. Geography of communities. Concept of migration and dispersal strategies. Speciation. Extinction. Endemism. Geography of diversification.
- Mountain patterns in species richness.

LAB OUTLINE:

Field surveys of different phytogeographic regions of the country for practical plant collection, preparation of quality herbarium specimens and identification of phytogeographic

regions of the country. Use and construction of identification keys (indented, bract keys). Preserving plant material for specific purposes.

COURSE OUTCOMES:

At the end of the course the students would be familiarized with the advanced techniques in floristic and systematic research by developing their abilities and enhancing their capacities.

RECOMMENDED BOOKS:

1. **Ali, S. I. and M. Qaiser. 1986. Phytogeographical analysis of the phanerogames of Pakistan and Kashmir. Proc. Royal Soc. Edin Burgh, 89, B: 89-101.**
2. Ali, S. I. and M. Qaiser. 1993-2003. Flora of Pak. Nos. 194-210. Department of Botany, Karachi University, Karachi.
3. Ali, S.I. and Y. J. Nasir. 1989-1991. Flora of Pak. Nos. 191-193. Department of Botany, Karachi University, Karachi.
4. Bridson, B. and F. Forman. 1998. The herbarium handbook, ed. 3. Lubrecht &Cramer, Ltd.
5. Judd, W. S., C. S. Campbell, E. A. Kellogg, P. F. Stevens, and M. J. Donoghue. 2002. Plant systematics: a phylogenetic approach, Ed. 2. Sinauer Associates, Inc., US
6. Nasir, E. and S. I. Ali. 1970-1989. Flora of Pak. Nos. 1-190. Botany Department, Karachi University, Karachi. Pakistan Agricultural Research Council, Islamabad
7. Nicolson, D. H., J. Prado, P. C. Silva, J. E. Skog, J. H. Wiersema, and N. J. Turland. 2007. International Code of Botanical Nomenclature (Vienna Code) adopted by the Seventeenth International Botanical Congress Vienna, Austria, July 2005. Gantner, Ruggell, Austria.
8. Pavord, A. 2005. The naming of names. Bloomsbury, U.S.A.
9. Stace, C. 1992. Plant Taxonomy and Biosystematics. Edward Arnold. UK.

DENDROCHRONOLOGY

COURSE CODE: BOT-803 Credit hours: 3(2+1)

OBJECTIVES: To provide deep understanding of dendrochronology and familiarize the students with the importance and application of the field.

COURSE CONTENT:

- Introduction: definition and concepts, subfield, history, scope and application of dendrochrology.
- Principal of dendrochronology and tree rings dating.
- Presents and future prospects of dendeochronology and dendroclimatology (as emerging science).
- Secondary thickening, growth, rate, cambium and cambial initials, growth rings; false ring, forest tings. Double rings, complacent ring system in various type cross section, wood and wood types; easily and late wood, juvenile wood, heart and sap wood.
- Dendroclimatology; climate and climate system, correlation between climate and tree ring growth, climatograpy, dendrograph and dendrometer.
- Procedure of Chronology construction using tree rings systems, cross dating and master chronology
- Dendrochronological tools and techniques used in field and lab.
- Application of Dendrolimatology, dendroseimilogy, dendrohydrology, endrogeomorphology.

LAB OUTLINE:

Core and cross sectioning techniques of tree in the field.

Specimen preparation and mounting. Rings counting by using lab equipements

Tree rings chronology construction

Using various computer software for data analysis and interpretation

COURSE OUTCOME:

The students would have developed deep understanding of dendrochronology and familiarized with the importance and application of the field.

RECOMMENDED BOOKS:

1. Hussain, F. and Illahi A. 1991. Vegetation and ecology of lesser Himalaya. Department of Botany, Peshawar.

2. Whittaker, R.H. 1973. Ordination and classification of Communities. Handbook of vegetation sciences part 5. The Hauge Jaunk.
3. Whittaker, R.H 1975. Communities and ecosystem 2nd Ed. Macmillan York.
4. Environmental profile of Pakistan 1995, Planning Commission of Pakistan.
5. Cain S.A. 1944. Foundation of Plant Geography. Harper abd Brother, New York.
6. Biodiversity: An introduction (2nd Ed.) Gaston, K.J. & Spicer, J. Blackwell Publishing, Oxford UK.2004.
7. Bush, M.B. 1997 Ecology of a changing Planet. Prentice hall. New Jersy.
8. Ahmed M, 2012, Text book of vegetation ecology. Publisher Akbar son Karachi.

AGROSTOLOGY

COURSE CODE: BOT-804 CREDIT HOURS: 3 (2+1)

OBJECTIVES:

Students will be able to: 1) sight identify about 100 of the most common grass species in the region; 2) interpret diagnostic characteristics in the context of grass tribes and genera; 3) relate plant morphology to botanical terminology so that taxonomic keys are readily approachable; 4) combine sight-identification and taxonomic keys in order to expedite plant identification of grass species never-before encountered.

COURSE CONTENT:

- Introduction to Agrostology: Economic Agrostology; Classification of Grasses, Grasses as Economic Crops, Forage Grasses, Pasture Grasses, Meadow Grasses, Lawn Grasses, Ornamental Grasses, Grasses as Weeds, Medicinal Grasses.
- Detailed structure and variation in the grass plant; habit, stems, leaves, inflorescences, the spikelet, glumes, lemmas, paleas, rachilla, florets, awns, caryopsis.
- Systematic Agrostology: Origin and Evolution of Grasses, Ecology and Biogeography, Evolution of C4 photosynthetic pathway, Warm and Cool Season Grasses, Breeding Systems in Grasses, Polyploidy in Grasses.
- Phylogeny and Classification of Grasses, recent system of grass classification, GPWG
- Taxonomic treatment and phylogeny of subfamilies *Pooideae, Bambusoideae, Chloridoideae, Panicoideae, Arundinoideae, Aristidoideae, Danthonoideae* with emphasis on genera: *Agrostis, Alopecurus Avena, Brachiaria, Bromus, Calamagrostis, Elymus, Eragrostis, Festuca, Panicum, Pennisetum, Poa,* and *Setaria.*

COURSE OUTCOMES:

This module will enable the students to understand the structure and variation in grass plant and evolutionary inference through the taxonomic clades of grasses. The students will be able to identify the common grasses occurring in the Malakand region.

RECOMMENDED BOOKS:

1. Baum, B.R. (1987). Numerical taxonomic analyses of the Poaceae. In 'Grass Systematics and Evolution', pp. 334–342. (Eds T.R. Soderstrom, K.W. Hilu, C.S. Campbell and M.E. Barkworth.) (Smithsonian Inst.: Washington.)
2. Bor, N.L. (1960). Grasses of Burma, Ceylon, India and Pakistan. (Pergamon: Oxford.) (Excluding Bambuseae.)
3. Bor, N.L. (1970). Gramineae. In 'Flora Iranica', No. 70. (Ed. K.H. Rechinger.) (Akademische Druck- und Verlagsanstalt: Graz)
4. Brown, L. (1979). Grasses; an identification guide. Sponsored by the Roger Torey Peterson institute. New York USA.
5. Clifford, H.T. (1987). Spikelet and floral morphology. In 'Grass Systematics and Evolution', pp. 21–30. (Eds T.R. Soderstrom, K.W. Hilu, C.S. Campbell and M.E. Barkworth.) (Smithsonian Inst.: Washington.)

6. Clifford, H.T. and Watson, L. (1977). Identifying grasses: data, methods and illustrations. (Queensland University Press: Brisbane.)
7. Cope, T.A. (1982). Poaceae. In 'Flora of West Pakistan'. (Eds. E. Nasir and S.I. Ali.) (The Editors, sponsored by U.S. Department of Agriculture: Karachi.)
8. Gould, F.W. (1983). Grass systematics. 2nd edition. (McGraw-Hill: New York.)
9. Hitchcock, A.S. and Chase, A. (1950). Manual of the grasses of the United States. U.S. Dept of Agric., Misc. Publ. No. 200. (Govt Printing Office: Washington.)
10. Soreng, R.J., and Davis, J.I. (1998). Phylogenetics and character evolution in the Grass Family (Poaceae): Simultaneous analysis of morphological and chloroplast DNA restriction site character sets.*Botanical Review* 64, 1–85.
11. Surrey, W.L. Jacobs and Joy Everett (2000) Eds. Grasses; Systematics and Evolution. CSIRO Publishing, (PO Box 1139, Oxford Street), Collingwood VIC 3066 Australia.
12. Tsvelev, N.N. (1989). The system of grasses (Poaceae) and their evolution. *Bot. Rev.* 55, 141–204
13. Tutin, T.G., Heywood, V.H. *et al.* (eds) (1980). Flora Europaea. Vol. 5. Poaceae. (Cambridge University Press.)
14. Watson, L., and Dallwitz, M.J. (1992 onwards). Grass genera of the world: descriptions, illustrations, identification, and information retrieval; including synonyms, morphology, anatomy, physiology, phytochemistry, cytology, classification, pathogens, world and local distribution, and references. http://delta-intkey.com

JOURNALS AND PERIODICALS:

Grasses and Forage Science, Grassland Science, Australian Systematic Botany, Pakistan Journal of Botany, Systematic Botany, Taxon, Botanical Journal of the Linnean Society, Alpine Botany

PALYNOLOGY

COURSE CODE: BOT-805 CREDIT HOURS: 2 (1+1)

OBJECTIVE:

- To provide instructions on basic pollen taxonomy as an aid in identifying and classifying various palynoflora.
- To provide a general background of the enormous diversity of pollens
- To understand the various applications of Palynology

COURSE CONTENT:

- Palynology: Aeropalynology, Melissopalynology, Yellow rain, Pollen Allergy; History of Palynology, Palynology as a multidisciplinary field, Applications of Palynology, Palynology in relation to Plant Taxonomy.
- Pollen Morphology: Polarity and Symmetry, Apertures, Pollen Wall, Structure and Sculpture, Harmomegathy and details of terminology involved in pollen description.
- Methods: Acetolysis and Light Microscopy, Scanning Electron Microscopy, Transmission Electron Microscopy, New and improved methods in Palynology.
- Status of Palynology in Pakistan.

LAB OUTLINE:

- Preparation of glycerine Jelly for pollen preparation
- Pollen preparations of the local flora through acetolysis methods
- Acetocarmine staining for light microscopy
- Pollen fertility estimation
- Microscopic studies of the quantitative and qualitative features of pollen grains

COURSE OUTCOMES:

- On completion of the course the students will be able to clearly different pollen types, and their taxonomic affinities.
- The students will learn the procedures of acetolysis, and pollen analysis.
- The students will become aware of the various applications of pollen data in diverse fields including forensics, taxonomy, evolution, allergies and asthma, invasive species management, stratigraphic application and honey production.

RECOMMENDED BOOKS:

1. Blackmore, S. (2000). The palynological compass: the contribution of palynology to systematics. In: Nordenstam B, El-Ghazaly G, Kassas M (eds) Plant Systematics for the 21st Century. Portland Press, London.
2. Erdtman, G. (1952) Pollen Morphology and Plant Taxonomy. Angiosperms. Almqvist & Wiksell, Stockholm.
3. Erdtman, G. (1969) Handbook of Palynology. An Introduction to the Study of Pollen Grains and Spores. Munksgaard, Copenhagen.
4. Faegri, K and Iversen, J. (1989) Textbook of Pollen analysis. 4th ed. John Wiley & Sons, Chichester.

5. Hesse, M., Halbritter, H., Weber, M., Buchner, R., Frosch-Radivo, A., and Ulrich, S. (2008). Pollen terminology: an illustrated handbook (Springer).
6. Huang, T.C. (1972). Pollen Flora of Taiwan (National Taiwan University: Botany. Dept. Press).
7. Moore, P.D., and Webb, J.A. (1978). An illustrated guide to pollen analysis. London, etc: Hodder & Stoughton.
8. Punt, W., Hoen, P., Blackmore, S., and Le Thomas, A. (2007). Glossary of pollen and spore terminology. Review of Palaeobotany and Palynology *143*, 1-81.
9. Traverse, A. (2007). Paleopalynology. 2nd ed., Springer, Dordrecht.

JOURNALS / PERIODICALS:

Grana, Palynology Journal, Palynology and Paleobotany, Pakistan Journal of Botany, Turkish Journal of Botany, Canadian Journal of Botany, Nardic Journal of Botany, Botanical Journal of the Linnean Society, South African Journal of Botany.

HERBARIUM TECHNIQUES AND MANAGEMENT

COURSE CODE: BOT-806 CREDIT HOURS: 3 (2+1)

OBJECTIVES:

- The knowledge and skills to become a proficient herbarium technician
- An understanding of the principles of herbarium management
- An appreciation of the value of information available in a herbarium and making it accessible to a wider audience
- An opportunity to establish international contacts in a group with similar interests and aims.

COURSE CONTENTS:

1. Introduction to Herbarium: development, purpose and types of herbaria. Botanical Garden, Arboretum, Pinetum, Orchidarium, Bambusetum, Hurtorium, Fungarium, Museum.
2. Plant collecting and pressing: legal considerations; regulations and permitting. Protocols and guidelines for specimens collection and handling, Collecting techniques for specialty groups such as succulents, palms and bulky specimens, Field tools and Equipments, best practices for collecting Geographic Data in the field, field note books, Drying of plant specimens, Drying procedures, Plants identification, floras, monographs and other literature.
3. Specimens poisoning, treatments and pest control.
4. Plant Mounting and Specimen Preparation: Preparing specimens for mounting.
5. Incorporation of specimens into the herbarium, Herbarium Label, label design and production, Herbarium Sheets, Upkeep and organization of the collection: organization of families, genera, species; folder making; specimen repair, updating nomenclature, pest control and fumigation.
6. Accessioning and filing, Databasing, Digitization.
7. Ancillary Collections: spirit, wood, seed, DNA, seed bank. Managing visitors to the herbarium, Engaging with the public, Exchange of gifts.
8. Specimens loans; Incoming and Outgoing: Sort, check, count, record tally, pack, ship.
9. Essential literature and online resources, computers, databases, and the web, IPNI, GBIF, OpenHerbarium, Index Herbariorum, The Plant List, Species 2000, Tropicos, Darwin Core etc.
10. Herbarium Building, administrative structure, activities.
11. The Herbarium and Conservation, Introduction to the Global Strategy for Plant Conservation, IUCN Red Listing Permits
12. Tours and Fieldtrips

LAB OUTLINES

1. Identification tools: Keys, online resources.
2. Collection and preparation of 100 archival standard plant herbarium specimens.
3. Botanical Illustrations.
4. Exercise on Vegetative morphology

5. Exercise on reproductive morphology
6. Exercise on Herbarium digitization, DarwinCore, OpenHerbarium, IdigBio, GBIF
7. Field Trips

COURSE OUTCOMES

- At the end of the course, the students will have thorough understanding of the principles of herbarium management and functions.
- Will be able to learn the techniques and standard procedures of collection, filing, accessioning, and loan management.
- Will be able to understand the process of digitization, and online taxonomic databases.

RECOMMENDED BOOKS:

1. Bridson, Diane and Leonard Forman, editors. (1998). The herbarium handbook. 3rd ed. Royal Botanic Gardens, Kew, Great Britain. xii, 334 p.
2. DeWolf, Gordon P., Jr. (1968). Notes on Making an Herbarium. Arnoldia 28: 69-111.
3. Fosberg, F. Raymond and Marie-Helene Sachet. (1965). Manual for Tropical Herbaria. Regnum Vegetabile 39. IAPT, Utrecht, Netherlands.
4. Lawrence, George H. M. (1958). Field and Herbarium Techniques. Chapter XI (pp. 234-262) in: Taxonomy of Vascular Plants. The MacMillan Co., New York, NY. Leenhouts, P. W. 1968. A Guide to the Practice of Herbarium Taxonomy. Regnum Vegetabile 58. IAPT, Utrecht, Netherlands. 60 pp.
5. Metsger, Deborah A. and Sheila C. Byers, eds. (1999). Managing the modern herbarium : an inter-disciplinary approach. Contribution ... from the Centre for Biodiversity and Conservation Biology of the Royal Ontario Museum, no. 53. Society for the Preservation of Natural History Collections, Washington, DC, as a joint project with The Royal Ontario Museum, Centre for Biodiversity and Conservation Biology. xxii, 384 p.
6. Mori, Scott A., Amy Berkov, Carol A. Gracie and Edmund F. Hecklau. (2011). Tropical plant collecting : from the field to the internet. My career as a tropical botanist. TECC Editora, Florianópolis, Brazil. xvii, 332 p.
7. Nevling, Lorin I., Jr. (1973). Report of the Committee for Recommendations in Desirable Procedures in Herbarium Practice and Ethics. II. Brittonia 25(3): 307-310.
8. Shetler, S. G. (1969). The Herbarium: Past, Present, and Future. Proc. Biol. Soc. Wash. 82: 687-758.
9. Zycherman, Lynda A., editor, and John Richard Schrock, assistant editor. (1988). A guide to museum pest control. Foundation of the American Institute for Conservation of Historic and Artistic Works and Association of Systematic Collections, Washington, DC.
10. Croat, Thomas B. (1978). Survey of Herbarium Problems. Taxon 27(2/3): 203-218.

PHYTOGEOGRAPHY

COURSE CODE: BOT- 807 **CREDIT HOURS**: **3 (2+1)**

OBJECTIVES:

To enable the students to understand the basic and applied concepts, and scope of phytogeography, explaining various phenomena responsible for distribution of species throughout the world.

COURSE CONTENTS

- History, scope and interrelationship of phytogeography with allied subjects.
- Concepts and delimitation of phytogeographical regions of the world. Different schools of thoughts regarding phytogeography and floristic regions (provinces) of the world.
- Geographic distribution of species in the world.
- Phytogeographic analysis of Flora of Pakistan.
- Effect of climate on the geographic distribution of plants.
- Relationship of edaphology and geology with geographic distribution of plants.
- Relationship of ecological regions with phytogeographic regions of the world.
- Factors affecting geographic distribution of plants in the world.
- Concept of migration and seed dispersal mechanisms.
- Speciation, center of origin, center of radiation, center of diversity
- Extinction in the context of phytogeography.
- Evolution and phylogeny in relation with phytogeography.
- Endemism in the context of phytogeography.
- Species richness, the concept of barriers and hotspot.

COURSE OUTCOMES

The students will have adequate knowledge and understanding regarding the various concepts of phytogeography and different patterns of distribution and related phenomena.

RECOMMENDED BOOKS

1. Ali, S. I. & M. Qaiser. 1986. Phytogeographical analysis of the phanerogames of Pakistan and Kashmir. Proc. Royal Soc. Edin Burgh, 89 B: 89-101.
2. Brummitt, R. K., Pando, F., Hollis, S., & Brummitt, N. A. (2001). World geographical scheme for recording plant distributions (p. 153). International Working Group on Taxonomic Databases for Plant Sciences (TDWG).
3. Cox, C. Barry, & Peter Moore (2005). Biogeography: an ecological and evolutionary approach. Malden, MA: Blackwell Publications. John Willey and Sons Ltd. pp. 512.

4. Dansereau, Pierre. 1957. Biogeography; an ecological perspective. New York: Ronald Press Co.
5. Gailis, M. & Kalnin, S. eds. (2010). Biogeography; Nova science publishers. pp. 253.
6. Good, R. (1974). The geography of flowering plants. Longmans, London.
7. **Heads, M.J (2013). Biogeography of Australia: a molecular analysis. Cambridge University Press. pp 503.**
8. Humphries, C. J. & L. R. Paranti. 1986. Cladistic Biogeography, Oxford, Clarendon Press.
9. Huston, M. A. 1994. Biological Diversity. The coexistence of species on changing landscapes. Cambridge University Press.
10. **Lomolino, M.V., B.R. Riddle., R.J. Whittaker & J.H. Brown. (2010). Biogeography. Sinauer Associates Inc. USA.**
11. Lomolino, Mark V. & Lawrence R. Heaney. 2004. Frontiers of biogeography: new directions in the geography of nature. Sunderland, Mass: Sinauer Associates.
12. Quammen, David (1996). Song of the Dodo: Island Biogeography in an Age of Extinctions. New York: Scribner. p. 17. ISBN 978-0-684-82712-4.
13. Takhtajan, A. (1986). *Floristic Regions of the World*. (translated by T.J. Crovello & A. Cronquist). University of California Press, Berkeley, USA.
14. Whittaker, R.J & J.M. Fernandez-paacios. (2007). Island Biogeography: ecology, evolution and conservation. Oxford University Press.

PLANT FUNCTIONAL GENOMICS

COURSE CODE: BOT-808 **CREDIT HOURS:** 3 (2+1)

OBJECTIVES:

Successful application of genomics to plant improvement requires merging knowledge about how genomic information is generated to the practice of plant breeding, disciplines which may emphasize different aspects of the relationships between genotype and phenotype. This course intends to bridge this gap by focusing content on recent research articles that illustrate how current genomic biology impacts the three key elements of the plant improvement process: characterizing and assembling genetic variation, evaluation of phenotypes, and selection of superior genotypes.

Course Content.

Introduction to the Plant Breeding Process and Genomics: Overview of molecular breeding, the cultivar development process, and genetic gain; Sequence-based gene discovery and comparative genomics approaches; Demonstration of "in silico" gene discovery strategies.

Databases for discovery of plant improvement genes: DNA Sequence Variation and Genetic Diversity; Molecular marker development and genotyping methods; Applications of molecular markers to plant improvement; Demonstration of identifying sequence variation for molecular markers.

Genetic diversity analysis of plant improvement genes: Gene Expression Variation; mRNA profiling – overview of methods and applications to plant improvement; Molecular phenotyping, regulatory networks, and systems biology approaches; Demonstration of RNA profiling data analyses.

RNA expression profiling of plant improvement genes: Epigenomic Variation; Small RNAs and chromatin remodeling; Phenotypic impacts of epigenomic variation.

Epigenomic variation of plant improvement genes: Integrated Molecular Phenotyping; Genetic mapping and quantitative trait loci; Marker-assisted selection strategies – targeted intervals and genomic selection; Demonstration of integrated molecular phenotyping and genetic mapping.

Genetic mapping of plant improvement genes: Directed Genetic Variation; Forward and reverse genetics methods; Transgenic product development; Strategies for Design of Transgenic Products.

Functional analysis of plant improvement genes: Commercializing Genetic Improvements; Biotechnology regulation and intellectual property issues; Future prospects for genomics-driven plant improvement, course evaluations.

Review Paper on Genomics-Driven Plant Improvement. Each student will prepare a paper in the format of a *Trends in Plant Science* review article that summarizes strategies for applying genomics to the improvement of their chosen plant/crop trait.

Recommended Books

1. Acquaa G. 2012. Principles of Plant Genetics and Breeding. 2nd Edition. Publ. John Wiley and Sons, Ltd. ISBN 978-0-470-66476-6.
2. Stewart, C. Neal. 2008. Plant Biotechnology and Genetics: Principles, techniques and applications. Publ. John Wiley and Sons, Ltd. ISBN: 978-0-470-04381-3.
3. Ahmad, P. and Rasool S (Ed.). 2014. Emerging Technologies and Management of Crop Stress Tolerance: A Sustainable Approach. *Elsevier Inc.* 2: 315–345. doi.org/10 1016/B 978-0-12-800875-1.00014-4; ISBN: 9780128008751.
4. Leister, D. 2005. Plant Functional Genomics. Publ. Food Products Press. ISBN: 9781560229995.
5. Varshney, R. K. and Tuberosa R. (Ed.). Genomics-Assited Crop Improvement. Genomics Approaches and Platforms. Springer Publ. ISBN: 978-1-4020-6294-0.
6. Taiz, L. and Zeiger, E. 2006. Plant Physiology. 4th Edition. Sinnauers Publ. Co. Inc. Calif.

Recommended Journals

Plant Physiology; Crop Science; Critical Reviews in Plant Sciences; Journal of Genetics and Genomics; Molecular Breeding; Trends in Plant Science; The Plant Cell; Journal of Agricultural Science; The Plant Genome; Physiologia Plantarum; The Plant Biotechnology Journal.

GEOGRAPHIC INFORMATION SYSTEM (GIS)

COURSE CODE: BOT-809 CREDIT HOURS: 3(2+1)

OBJECTIVES:

To understand the principles, applications, modern trends, and pertinent issues of geographic information system in solving problems, to obtain and analyze different types of data, to develop an understanding of how to manipulate and apply vector and raster spatial data for various issues.

COURSE CONTENTS:

- Introduction to GIS
- Principles and concepts of GIS
- GIS database management and development
- GIS data sources
- Digitization of data/output, management, manipulation, analysis
- Modeling output and organization
- New way of looking GIS data and GIS technology
- Need for trained individuals
- Introduction of ILWIS or ArcGIS or MapInfo or ArcView or ERDAS GIS software
- Digitization of point, line and polygon
- GIS for analysis
- Application of GIS as a tool in development projects (agriculture, land use planning, forestay, wildlife management and monitoring)
- Change detection
- Global scale application

LAB / PRACTICAL:

- Georeferencing of the satellite imagery.
- Vector and raster imagery compilation
- Remote sensing of vegetation through high resolution imagery.

COURSE OUTCOMES:

At the end of the course the students would be able to understand the basic principles, and their applications pertinent to the geographic information systems identifying research questions and solving problems and understanding of how to manipulate and apply vector and raster spatial data for various issues.

RECOMMENDED BOOKS:

1. Aronoff, S. 1989. Geographic information system: a management perspective. W. D. L. Publishers, Ottawa.
2. Aronoff, S. 2005. Remote sensing for GIS managers. ESRI Press, New York.
3. Bernhardson, T. 1992. Geographic information system. Vik IT, Myrene, Norway.
4. Burrough, P. A. 2006. Principles of geographic information system for land resource assessment. Clarendon Press, Oxford.
5. Clark, K. C. 1997. Getting started with GIS. Prentice Hall, New York.
6. Lillesand, H., M. Kiefer and W. Ralph. 1994. Remote sensing and image interpretation. John Willey Sons, Inc. New York.
7. Magnir, D. J. 1991. Geographic Information System. Longman, London.
8. Masser, I. and M. Blakemore. 1991. Handling geographical information: methodology and potential applications. Longamn, New York.

MOLECULAR CELL BIOLOGY

COURSE CODE: BOT-810 **CREDIT HOURS: 3(2+1)**

Credit Hours: 3(2+1)

OBJECTIVES:

To develop basic knowledge and skills in cell and molecular biology and become aware of the complexity and harmony of the cell.

COURSE CONTENTS

The molecular genetics of the cell: The structure, function and synthesis of nucleic acids; The cell biology central dogma about the information flow in the cell; The structure of the genome; The gene concept and gene structure; DNA replication and repair. Genetic recombination; Transcription and translation and their regulation; Basic recombinant DNA techniques.

Cellular biology: The structure and ultrastructure of the cell; Organelles and membrane systems, their structure and function; Cell division: mitosis; Intracellular protein sorting and secretion as well as endocytosis; Cytoskeleton and cell motility; Extra- and intracellular signal transduction; Differences and similarities between prokaryotic and eukaryotic cells; Microscopy methods for structural analysis of the eukaryotic cell.

PRACTICAL

Cultivation of bacteria; Transformation; Isolation of plasmid DNA; PCR; Analysis of sequencing results.

Sterilisation techniques; General microscopy techniques; Cultivation of eukaryotic cells; Transfer of DNA to cells and analysis of gene expressions by means of Green Fluorescent Protein; Microscopy of DNA-stained cells.

OUTCOMES:

At the end of the course, the scholars should be able to:

a) Describe and carry out basic molecular genetic methods
b) Describe and carry out basic cell culture and microscopy.

RECOMMENDED BOOKS

1. Alberts, B., Bray, D., Hopkin, K., Johnson, A. D., Lewis, J., Raff, M., Roberts, K. and Walter, P. (2013). Essential Cell Biology; 4th Edition, Garland Sciences, New York, USA.
2. Gerald Karp, G., Janet Iwasa, J., Wallace Marshall, W., 2016. Karp's Cell and Molecular Biology, 8th Edition .John Willey and Sons, Inc.
3. Iwasa, J. and Marshall, W.K. (2016). Cell and Molecular Biology: Concepts and Experiments. (8th ed.) John Wiley & Sons' ISBN: 978-1-118-88614-4.
4. Karp, J. H. 2016. Cell and Molecular Biology. John Willey and Sons, Inc. New York. USA.

5. Plopper, G. 2014. Principles of Cell Biology; 2nd Edition, Jones & Bartlett Learning, Burlington, USA.
6. Wilson, J. and Hunt, T., 2015. Molecular Biology of the Cell. 6th Edition Garland Sciences, Taylor and Francis.

ALLELOPATHY

COURSE CODE: BOT-811 **CREDIT HOURS**: **3 (2+1)**

Objectives:

To educate students about allelopathic phenomena and its utilization in agro-ecosystem.

COURSE CONTENTS:

Theory Concept of allelopathy, history. Alleolpahtic plants, types of allelochemcials, mechanism of allelochemicals action. Factors influencing production and effectiveness of allelochemicals. Production, release, absorption and translocation of allelochemcials. Role of allelopathy in agro-eco system. Interactions among cropping systems. Utilization of allelopathy for pest management. Enhancing crop productivity by utilizing allelopathy. Recent research trends in alleloptathy. Practical Preparation of allelopathic plant water extracts. Comparison of crop cultivars for their allelopathic effects. Demonstration of allelopathic effects of crop extracts/residues on seed germination and seedling growth of crops/weeds. Identification of allelopathic chemicals.

COURSE OUTCOMES:

At the completion of the course the students will be able to identify the potential allelopathic plants, nature of allelochemicals and their utilization in plant disease control and increasing agriculture production.

RECOMMENDED BOOKS:

1. Gliessman, S. R. (2007). Field and laboratory investigations in Agroecology (2nd Edn). Taylor and Francis, USA.

2. Kohli, K.R., Singh, H.P. and Batish, D.R. (2004). Allelopathy in agroecosystems. IDBC Lucknow, India.

3. Macias, F.A., Galindo, C.G. and Molinillo, J.M.G.. (2003). Allleopathy: Chemistry and mode of action of allelochemicals.CRC Press, New York, USA.

4. Reigosa, M.J., Petdrol, N. and Gonzalez, L. (2006). Allelopathy: A physiological process with ecological implications. Springer, Heidelberg, Germany.

5. Rice, E.L. (1997). Allelopathy. (4th Ed.). Academic Press, Inc. Orlando, Florida, USA.

6. Zeng, R.S, Mallik, A.U. and Luo, S.M.. (2008). Allelopathy in sustainable agriculture and forestry. Springer, USA.

7. Rizvi, S.J. and Rizvi, V. (1992). Allelopathy-Basic and Applied Aspects. Chapman and Hall, London.

Journals/ Periodicals

Allelopathy Journal, International Journal of Agriculture and Biology, Journal of Agriculture and Forestry, Canadian Journal of Plant Pathology, European Journal of Plant Pathology

EDAPHOLOGY

COURSE CODE: BOT-812 Credit Hours: 3 (2+1)

OBJECTIVES:

To enable the students to understand the genesis, nature and properties of soil including soil chemistry, soil biology and soil physics.

To apply the knowledge gained in conservation, reclamation of soil, and its application in agriculture for maximizing crop yield.

COURSE CONTENTS:

The Soil in Perspective What is soil? Edaphology and Pedology, A field view of soil, Soil profile, Subsoil and Surface soil, Mineral vs. Organic soils. Four major Components of Soils, Mineral constituents in soils, Soil organic matter, Soil water, Soil air, clay and humus. Important Physical Properties of Mineral Soils Soil texture and Soil Structure, Classification of soil particles, Physical nature of soil separates, Soil texture classes. Mechanical analysis, Preparation of the Sample, Factors affecting dispersion, Methods for obtaining dispersion, Fractionation of the sample, Sieve method. Stokes' Law. Sedimentation methods, Determination of soil class, Particle and Bulk Density, Pore Space, Structure of mineral soils, Aggregation and its promotion, Structural management of soil, Soil Consistence. Soil Colloids General constitution of Silicate clays, Adsorbed cations, Silicate clay structure, Classification of Silicate clays, Chemical Composition of silicate clays, Cation exchange capacity of soils, Plasticity, Cohesion, Swelling, Shrinkage, Dispersion and Flocculation. Soil Water Structure and related properties of water, Soil water energy concept, Soil Moisture content versus Suction, Measuring Soil moisture, Capillary Fundamentals, Types of soil water movement, Saturated flow through soils, unsaturated flow in soils, Retention of soil moisture in the field, Conventional soil moisture classification, Factors affecting amount and use of available soil moisture, Capillarity and root extension. Soil Air and Soil Temperature Soil aeration definition, soil aeration problems in the field, Composition of soil air., Factors affecting the composition of soil air, Fick's Law, Aeration in relation to soil and crop management. Soil temperature, Specific Heat of soils, Volumetric Heat Capacity, Thermal diffusivity, and Conductivity, Fourier's Law, Movement of Heat in soil, Soil temperature control. Plant Nutrients and Fertilizers Factors controlling the growth of higher plants, The essential elements from air, water and soil, Soil solution, Soil and plant interrelations, fertilizer elements, Nitrogen Fertilizers, Phosphates Fertilizers, Potassium Fertilizers, Mixed Fertilizers, Methods of applying solid fertilizers, Application of liquid Fertilizers. Saline and Sodic Soils Climate and salinity, Some basic terms, Saline, Saline alkali and Sodic Soils, Diagnosis of Saline and Sodic Soils, Reclamation Steps of Salt-affected soils, Leaching Requirements, Crop tolerance to Salinity.

LAB OUTLINE

1. To determine Type of Soil
2. To determine the pH value of soil sample
3. To determine the Particle Density of given soil sample
4. To determine the Bulk Density of an undisturbed soil sample
5. To determine the Soil Moisture by Soil Tensiometer

6. To determine the Moisture Content by Gravimetric Method
7. To analyse the Soil Sample by Sieve Analysis
8. To determine the Density of Soil Suspension in grams per litre by using Hydrometer
9. To determine NPK of a given soil sample

COURSE OUTCOMES:

The students will be capable of understanding the nature and properties of soil, characteristics of different kinds of soils, conservation and reclamation of soils, and methods for improvements of soils for agriculture production.

RECOMMENDED BOOKS:

1. **Henry D. Foth. (1990). Fundamentals of Soil Science - 8th edition.**
2. **Neil C. Brady. (2010). Elements of Nature and Properties of Soils - 3rd edition**
3. Rashid, A. and Memon, K.S. (1996). Soil Science. National Book Foundation, Islamabad.
4. Raymond, R. Weil and Brady, N.C. (2016). The Nature and Properties of Soils (15th Edition). Macmillan Co. Ltd. USA.

JOURNALS/PERIODICALS

Plant, Soil and Environment, Soil Science, Soil Use and Management, Canadian Journal of Soil Science, Communication in Soil Science and Plant Analysis, Soil and Water Science, Soil Chemistry and Biology, Plant and Soil.

RECOMBINANT DNA TECHNOLOGY

COURSE CODE: BOT-813 **CREDIT HOURS: 3(2+1)**

OBJECTIVES:

- To explore and understand the isolation and purification of nucleic acids, mechanisms of gene cloning, practical aspects of recombinant DNA technology, model organisms in recombinant DNA technology, recombinant gene expression systems.

COURSE CONTENTS

- Introduction to Recombinant DNA technology; Recombinant DNA; GMOs
- Fundamentals of Gene cloning; Enzymes used in Genetic Engineering; Host controlled restriction and modification system; Nomenclature, properties and mode of action of Restriction Endonucleases; Restriction mapping.
- Alkaline Phosphatase; Reverse Transcriptase; DNA Polymerase; T4 Polynucleotide Kinase; Terminal Transferase; DNA Ligases; Double linkers; adapters; Homopolymer tailing.
- Cloning and Expression vectors; Mechanism of gene cloning in bacterial plasmids (pBR322); Bacteriophages; Cosmids; Bacterial Artificial Chromosomes (BACs); Yeast Artificial Chromosomes (YACs); Elimination of restriction sites, Insertion and replacement vectors.
- Selection of Recombinants; Insertional selection inactivation method; Blue-White and Red-White selection methods.
- Plant cell transformation using Liposomes; Agrobacterium based plasmid vectors; gene gun method; Electroporation and Ultrasonication.
- DNA (Gene) Library: Genomic and cDNA Library; PCR and RT-PCR; Primer designing; Site-directed mutagenesis; DNA Sequencing: Sanger and Coulson Method; Analysing DNA Sequences.

LAB OUTLINE

Restriction analysis of chromosome and Plasmids DNA; Elution of DNA fragments from agarose gel; Analysis of plasmid DNA samples; Melting point determination of the oligonucleotides; Transformation systems; Electro blotting

COURSE OUTCOMES:

After the completion of this course, student will be able:

c) To have good conceptual knowledge of gene cloning related techniques.
d) To apply the recombinant DNA techniques or procedures during the lab sessions and their research.
e) To solve all problems related to cloning through visits to Biotechnology labs at Research Centers or Universities.
f) To demonstrate the basic techniques involved in recombinant DNA manipulations including DNA restriction, ligation, transformation and selection of recombinant plasmid

RECOMMENDED BOOKS

1. Bahadur, B., Venkat Rajam, M., Sahijram, L., Krishnamurthy, K.V. (2015) Plant Biology and Biotechnology, Volume II: Plant Genomics and Biotechnology. Springer India. Doi:10.1007/978-81-322-2283-5
2. Bommarius, A.S. and Riebel, B.R. (2004) Applications of Recombinant DNA Technology: Directed Evolution in Biocatalysis, Wiley-VCH Verlag Gmbh & Co. KGaA, Weinheim, FRG. Doi: 10.1002/352602363
3. Brown, T.A. (2016) *Gene cloning and DNA Analysis*. 7th Edition. John Wiley and Sons Ltd., Chicester, UK.
4. Curtis, M.D. (2008) Recombinant DNA. Vector Design and Construction in Plant Biotechnology and Genetics: Principles, Techniques and Applications (ed C.N. Stewart), John Wiley & Sons, Inc., Hoboken, N.J, USA. Doi:101002/978047028014
5. Glick, B.R., Pasternak, J.J., Cheryl, L. and Patten, C.L. (2009). Molecular Biotechnology: Principles and Applications of Recombinant DNA; 4th Edition, ASM Press, Washington, USA.
6. Harris, J.R. et al., (2006) In Vitro Techniques, in Cell Biology Protocols (eds J. R. Harris, J. Graham and D. Rickwood, John Wiley & Sons, Ltd. Chishester, UK. Doi:10.1002/0470033487
7. Primrose, S.B. and Twyman, R. (2009) Principles of gene manipulation and genomics. 8th Edition, Wiley-Blackwell, Oxford, UK.
8. Rajagopal K. (2012) Recombinant DNA Technology and Genetic Engineering. Tata McGraw Hill Educaiton Private Limited
9. Schwab, H. (2001) Principles of Genetic Engineering for Escherichia coli in Biotechnolgoy Set. Second Edition (eds H.J. Rehm and G. Reed), Wiley-VCH Velag GmbH, Weinheim, Germany. Doi:10.1002/9783527620999
10. Watson, J.D., Meyers, R.M., Caudy, A.A. and Witkowski, J.A. (2007) Recombinant DNA: Genes and Genomes - A Short Course; 3rd Edition, Cold Spring Harbor Laboratory Press, New York, USA.

Teaching Methodology

- Oral lectures and multimedia presentation
- Class discussion and quizzes
- Assignments and project presentations

PLANT ECOPHYSIOLOGY

COURSE CODE: BOT-814 **CREDIT HOURS: 3(2+1)**

Objectives:

- To explore physiological mechanisms underlying the growth, reproduction, survival, abundance and geographic distribution of plants.

Course Contents

1. **Introduction** What is Plant ecophysiology? Resources, tradeoffs, limitations, acclimation, adaptations.
2. **Characterization of the Physical Environment in the Changing World:** Climate and Vegetation; the principle of limiting factors; Plants and microclimates.
3. **Resource Acquisition Aboveground:** Radiation balance and leaf energy budgets; Limitations to photosynthesis: an overview; Photosynthetic adaptation to light and temperature; Stomatal and biochemical control of leaf gas exchange; Stable isotopes, water-use efficiency, and photosynthetic performance; Variation in Photosynthetic pathways; Canopy architecture and productivity.
4. **Below Ground Processes and Plant Response**: Water in plants, in soils and in the atmosphere; Root systems and water capture; Water use and tissue water relations; Adaptation to water stress - Drought - Salinity – Flooding; Nitrogen availability, requirements, symbiosis, use-efficiencies; Soil factors and edaphic adaptations.
5. **Resource Balance in Plants:** Carbon allocation - construction costs, storage, turnover, patterns and phenology; The ecophysiology of defense against herbivory.
6. **Ecophysiology Above the Individual Level**: Ecophysiology in plant populations; Ecophysiological aspects of competition; Life history variation and physiology; Reproductive ecophysiology; The ecophysiology of succession.
7. **Physiology and Evolution**: The evolution of physiological performance; Evolution, phylogeny, and physiological adaptation.

LAB/Field

A field trip shall be scheduled which will include field activities demonstrating techniques in plant ecophysiology.

Outcomes:

At the end of the course, the students should be able to:

- **a)** Describe the physiological adaptations of plants to different environmental stresses,
- **b)** Explain how plant physiology is impacted by environmental variability and climate change,
- **c)** Describe how climate change could lead to altered patterns of plant distribution and allocation, and how this could feed back to have global impacts

Recommended Books

5. Larcher, W. (2003). *Physiological Plant Ecology.* Fourth edition. Springer-Verlag, Berlin, Germany.
6. Pearcy, R.W., Ehleringer, J., Mooney, H.A. and Rundel, R.W. (1989). *Plant Physiological Ecology.* editors. Chapman and Hall, New York, New York, USA.
7. Smith, R.L. and Smith, T.M. (2009). *Elements of Ecology.* 8th Edition.
8. Taiz, L. and Zeiger, E. (2002).*Plant Physiology.* 3rd edition.

PLANT ENZYMOLOGY

COURSE CODE: BOT-815 **CREDIT HOURS: 3(2+1)**

OBJECTIVES:

- To understand the basics of enzyme kinetics, pathways, mechanisms of their control and the importance of the parameters describing the kinetics.

COURSE CONTENTS

Introduction to plant enzymes - nomenclature, classification; Ribozyme; General characteristics of theories of enzyme catalysis; Enzyme and substrate specificity; Isozymes, coenzymes, cofactors; Regulation of enzyme activity; chemical kinetics and enzyme kinetics, Michaelis- Menten equation; Effect of various factors on rate of reactions, inhibition of enzymatic reactions and kinetics; Multi-enzyme system and bi-substrate reactions, catalytic mechanisms; Regulatory enzymes, immobilized enzyme and enzyme assays; Chromatography (gel filtration, ion exchange).

PRACTICAL

Extraction and estimation of enzymes from different sources; Acid and enzymatic hydrolysis of glycogen and starch; Biosynthesis of enzymes by fungi and bacteria; Effect of Temperature on enzymes stability and activity; Effect of Substrate concentration on enzyme activity; Effect of Enzyme concentration on enzyme activity; Effect of pH on enzyme activity.

OUTCOMES:

At the end of the course, the scholars should be able to understand the mechanism of action of enzymes, the construction and purpose of the important parts of the enzyme molecule

RECOMMENDED BOOKS

1. Bisswange, H. (2011). Practical Enzymology. Wiley-VCH. Publishers.
2. Bowden, A.C. (2012). Fundamentals of Enzyme Kinetics 4th Edition. Wiley-Blackwell.
3. Okotore, R.O. (2015). Essentials of Enzymology. Publisher XLIBRIS.
4. Sauro, M.H. (2012). Enzyme Kinetics for Systems Biology Ambrosius Publishing.
5. Voet, D., Voet, J.G. and Pratt, C.W. (2002). Fundamentals of Biochemistry; John Willey and Sons. Inc., New York.

SOIL MICROBIOLOGY

COURSE CODE: BOT-816 **CREDIT HOURS: 3(2+1)**

OBJECTIVES:

- To understand the ecological interaction of microorganisms.

COURSE CONTENTS

Elements of soil formation and conservation; Soil microbial population and methods of study with their advantages and disadvantages; Role of microorganisms in mineral transformations with special and detailed emphasis on Carbon and Nitrogen transformations. Brief introduction to Sulphur and Phosphorus; Introduction to soil ecology and rhizosphere. Plant-microbe interactions and microbe-microbe interactions and their impact on soil fertility and formation of compost and humus; Biotechnological potentials of soil microorganisms; Importance of the subject in the agricultural development of Pakistan; Problems of salinity and water logging and the methods of land reclamations; Microbial remediation: salt, heavy metals and pesticides; Biofertilizers; Mycorrhiza.

PRACTICAL

a) Role of microbes in soil formation.
b) Reduction of metallic salts by microbial activity.
c) Buried slide technique.
d) Isolation of antibiotic producing and pesticide degrading microbes.
e) Effects of biofertilizer on plant growth and health

OUTCOMES:

- At the end of the course, the scholars should be able to examine the major kinds of interactions of microorganisms, and the habitats where microorganisms can be found

RECOMMENDED BOOKS

1. Carrey. (2013). Recent Advances in Soil Microbiology and Soil Biotechnology. RDM.
2. Diane Tice, D. (2005). Principles and Applications of Soil Microbiology. 2nd Edition. Oxford University Press.
3. Geoffrey R. and Dixon,G.F. (2010). Soil Microbiology and Sustainable Crop Production: 1st Edition. Springer-Verlag New York, LLC.
4. Paul, E.A. (2007)..Soil Microbiology, Ecology and Biochemistry .Elsevier Science. Varma, A., 2010. Advanced Techniques in Soil Microbiology: 1st Edition .Springer-Verlag New York, LLC.
5. Vallabhaneni, S. (2012). Soil Microbiology- A Laboratory Manual. LAP Lambert Academic Publishing AG & Co. KG.

FUNGAL BIOTECHNOLOGY

COURSE CODE: BOT-817 **CREDIT HOURS: 3(2+1)**

OBJECTIVES:

To develop basic knowledge about fungi and their role in industry and agriculture.

COURSE CONTENTS:

Introduction to Fungi: positioning within living organisms and biosphere, life cycle (including mating, sporulation), cellular composition of fungi.

Biotechnological applications of fungi and their derivatives during history: bread making, alcohol production, applications in industry (paper, food, textile), applications in medical science, bioconversion and bio-ethanol.

Recombinant Technology in Fungi: composition of the different types of fungal vectors, selection markers, transformation strategies, gene replacement or inactivation.

Myconanotechnology: Syntheses of myco-nanoparticles and their applications.

Fungi in Agricultural Biotechnology: fungal endophytes and endomycorrhizae, their role in plant growth, and disease protection.

Fungal Fermentations Systems and Products: fermentations systems, commercial fungal products, biotechnological uses of fungal enzymes, fungal antibiotics, fungal secondary metabolites.

PRACTICAL:

Morphology of fungi; Identification of fungi on the basis of sexual & asexual reproductive structures.

Culturing of fungi on different culture media.

DNA extraction; from fungal hyphae & spores.

Study of genetical variations of different fungi by using molecular techniques.

OUTCOMES:

At the end of the course, the scholars should be able to:

a) Describe and carry out culture techniques of fungi
b) Describe and carry out microscopy and basic molecular genetic methods

RECOMMENDED BOOKS:

1. Anke, T. (ed.) (1991) *Fungal Biotechnology*, Chapman and Hall, London.
2. Walsh, G. and Headon, D. (1994) *Protein Biotechnology*, John Wiley and Sons, Inc., New York.
3. Curran, B.P.G. and Bugeja, V. (2009) The biotechnology and molecular biology of yeast, in: *Molecular Biology and Biotechnology* (ed. J.M. Walker and R. Rapley), Royal Society of Chemistry, Cambridge, pp. 159–191.
4. An, Z. (ed.) (2005) *Handbook of Industrial Mycology*, Taylor & Francis Group.
5. Baltz, R.H., Davies, J.E. and Demain, A.L. (eds) (2010) *Manual of Industrial Microbiology and Biotechnology*, 3rd edition, American Society for Microbiology.
6. Boulton, C. and Quain, D. (2006) *Brewing Yeast and Fermentation*, Blackwell Publishing.
7. Cheung, P.K. (ed.) (2008) *Mushrooms as Functional Foods*, John Wiley & Sons, Ltd.
8. Fratamico, P.M., Annous, B.A. and Gunther, N.W. (eds) (2009) *Biofilms in the Food and Beverage Industries*, Woodhead Publishing Ltd.
9. Montville, T.J. and Matthews, K.R. (2008) *Food Microbiology: An Introduction*, 2nd edition, American Society for Microbiology.
10. Robson, G.D., van West, P. and Gadd, G.M. (eds) (2007) *Exploitation of Fungi*, Cambridge University Press.
11. Walker, G.M. (1998) *Yeast: Physiology and Biotechnology*, Wiley.

ADVANCED BIOINFORMATICS

COURSE CODE: BOT-818 CREDIT HOURS: 3 (2+1)

OBJECTIVES:

This course presents the basic principles and concepts in exploring sequence storage, retrieval and analysis.

Course CONTENTS

Introduction, history, timeline, databases, sequence storage, retrieval and analysis, similarity and homology, creating alignments, local and global alignment, pairwise and multiple sequence alignments, phylogenetic analysis, dot matrix plots, dynamic programming algorithm, word (k-tuple) methods, substitution matrices PAM and BLOSUM, scoring algorithms, gap penalties, online tools BLAST, BLAT and FASTA, PDB file structure. Lab Outline Accessing NCBI, ENSEMBL, UniProt , Genbank, EMBL, SWISS-PROT, Accessing structural databases including PDB, SCOP and CATH, EXPASY and FASTA using tools for pairwise and multiple sequence alignment, Phylogenetic analysis, Bioedit. Introduction to genome, gene prediction in prokaryotes and eukaryotes, ORF, TFBS, codon usage table, EST and SNP databases, primer designing, restriction enzyme databases, RNA structure prediction, computational secondary and tertiary protein structure prediction methods, structure optimization and refinement methods, hydrogen bonding, PTMs of proteins, Chou Fasman, PHD and PSIPred, neural network, X-ray crystallography, NMR, ab initio, threading and homology modeling methods, protein fold identification using Pfam (A & B) and other tools.

LAB OUTLINE:

Accessing NCBI, ENSEMBL, UniProt , Genbank, EMBL, SWISS-PROT, Accessing structural databases including PDB, SCOP and CATH, EXPASY and FASTA using tools for pairwise and multiple sequence alignment, Phylogenetic analysis, Bioedit. Online tools: Gene finder, ORF finder, EST database, SNP data, Primer 3, protein structure prediction using online server, protein structure visualizing using visualization programs, Secondary structure prediction, using pfam database.

COURSE OUTCOMES:

- OUTCOMES about different databases of molecular data
- Data search and retrieval from NCBI, EMBL etc.
- Be able to carryout phylogenetic reconstruction, sequence alignment

RECOMMENDED BOOKS

1. Arthur M. Lesk, “Introduction to Bioinformatics”, Oxford University Press.
2. David Mount. “Bioinformatics: Sequence and Genome analysis”, Cold Spring Harbour Laboratories.
3. Ignacimuthu S.J. “Basic Bioinformatics”, Narosa Publishing House.
4. Krawetz. Stephen A. “Introduction to Bioinformatics: A Theoretical and Practical Approach”, Humana Press.

5. Rastogi, P. and Mendiritta, N. “Bioinformatics: Methods and Applications: Genomics, Proteomics and Drug Discovery”, PrenticeHall of India Pvt.Ltd.
6. Richard S. Larson. “Bioinformatics and drug discovery”, Humana Press.
7. Yadav Neelam, “A Hand Book of Bioinformatics”, Anmal Publications Pvt.Ltd.

MOLECULAR DEVELOPMENTAL BIOLOGY

COURSE CODE: BOT-819 CREDIT HOURS: 3 (2+1)

OBJECTIVES:

- To enable the students to understand the fundamental processes that occur within the cell
- account for mechanisms that control development under the life cycle of the plant
- explain how environmental factors are integrated and influence the development of plants
- discuss applications of basic plant research to growth and development of plants within agriculture and horticulture
- Identify and discuss ethical aspects related to genetic engineering.

COURSE CONTENTS:

The course focuses on mechanisms on the molecular, cell and organism level that control the different phases in the development of the plant such as embryogenesis, germination, vegetative growth and reproductive growth.

Introduction: Approaches and tools in plant development research. Morphogenesis at the cellular level. Development of gametophytes and fertilization. Organ generation and growth: meristem structure and function. Morphogenesis at the organ level: leaves and roots. Morphogenesis at the plant level: branching and secondary growth. Molecular Basis of embryogenesis and meristem development, Flower Development, Cell-cell signaling during pollen pistil interactions, Molecular mechanisms of hormonal signaling during plant development, Senescence and Programmed Cell Death.

Lab?PRACTICAL:

1) Identification of Developmental Mutants of Arabidopsis

2) Isolation of T-DNA insertion lines through PCR

3) Study of pollen-pistil interactions using fluorescence staining and microscopy

4) ABA sensitivity assays to isolate Arabidopsis ABA mutants

5) Identification of senescence mutants - Use of DEX-inducible vector

COURSE OUTCOMES:

On successful completion of this module, students should be able to:

- Understand basic principles in plant development.
- Read plant developmental biology literature.
- Plant experiment in plant developmental biology

Recommended Books:

1. Biochemistry & Molecular Biology of Plants by B. Buchanan, W.Gruissem, R. Jones (Eds). American Society of Plant Physiology, Rockville, MD, 2000
2. Gilbert, S. (2016). **Textbook: Developmental Biology,** 11th edition.. ISBN: 978-1-60535-470-5.
3. Growth and Development (2012) X. Chen and T. Laux (Eds) Current Opinion in Plant Biology 15(1): 1-110

4. Mechanisms in Plant Development by O. Leyser and S. Day. Blackwell Science, Ltd., Oxford, 2003
5. Molecular Biology of the Cell by B. Alberts, A. Johnson, J. Lewis, M. Raff, K. Roberts and P. Walter. Garland Science, 5th edition, 2008
6. Taiz, L. and Zeiger, E. (2015).*Plant Physiology*. 6th edition.
7. The Arabidopsis Book. American Society of Plant Biologists, Rockville, MD, 2002 to 2012.

Seminar-II

Course Code: BOT-820 **Credit Hours 1(1+0)**

WORLD MAJOR BIOMES

COURSE CODE: BOT-821 **CREDIT HOURS**: **3 (2+1)**

OBJECTIVES: To gain knowledge about world major biomes

COURSE CONTENTS

Biogeography: effect of glaciations, continental drift, distribution patterns, extinctions. Temperature: latitude, continentality, elevation, microclimates. Precipitation: high and low pressure zones, dominant wind, orographic precipitation, rain shadow. Climate: evapotranspiration (effect on productivity), climate of Pakistan. Biodiversity gradients, ecosystem structure (life forms, vertical structure, horizontal patterns, temporal patterns, adaptations to fire, wind, water, heat, cold). Koppen climate types and their biomes.

Biomes terrestrial: definition and distribution, Whittaker's biome diagram. Temperate Biomes: Temperate coniferous forest (boreal, mountain), temperate deciduous forest, temperate grasslands, temperate rainforest. Tropical Biomes: tropical rainforest, tropical montane rain forest and tropical alpine ecosystems. Arctic tundra and temperate alpine ecosystems. Mediterranean scrub. Hot and cold deserts, and semi-deserts. Effects of climate change on terrestrial ecosystems: arctic, boreal, temperate, and tropical. Terrestrial ecosystem restoration for conservation of biodiversity.

LAB OUTLINE:

Lab 1. Vegetation data; set soils to dry; weigh wet soil cans; place nutrient capture resins (Plant Root Simulator (PRS) probes) in pots with sampled soils Lab 2. Count growth rings on tree cores Lab 3. Calculating tree basal area and vegetation analysis; site data interpretation

COURSE OUTCOMES:

- The students will be able to understand the role of temperature, precipitation, and humidity in formation of different types of climates and associated biomes.
- The students will be able to identify flora and fauna associated with different Koppen Biomes.

RECOMMENDED BOOKS:

1. "Köppen Biomes", http:// www.tesarta.com/www/resources/library/ biomes.html (Dec 2000)
2. "The World's Biomes: Tundra", http://www.latymer-upper.org/geog/sixth/ tundra%20the%20not%20do%20barren%20land.htm, (July 2000).
3. Kaplan, E. (1996). Biomes of the World: Tundra. Hong Kong: Marshall Cavendish Corporation.
4. Stralhler, Arthur N. Strahler, Alan H. (1997). Elements of Physical Geography . John Wiley & Sons.

PERIODICALS/JOURNALS

Ecology, Ecology Letters, Biomes, Ecosystems,

CYTOGENETICS

Course Code: BOT-822 **CREDIT HOURS: 3(2+1)**

OBJECTIVES:

- To provide a working knowledge of cytogenetics, the preparation of materials for study, and the importance of chromosomal variations in structure and number in such fields as plant and animal breeding, population genetics, evolutionary genetics, taxonomy, and the medical sciences

COURSE CONTENTS

Generalized Cell: cell organelles, Morphology of chromosomes, Ultrastructure of chromosomes, Cell cycle and division, Mitosis and meiosis; Life cycles: fungi, yeasts, protozoa, higher plants and animals. Linkage and crossing over, its mechanism and cytological evidences; Chromosome function: Lyon hypothesis; Special types of chromosomes: polytene, lampbrush and B-chromosomes, Position effects; Chromosomal aberrations: Variations in chromosome number and structure. Chromosome systems (parthenogenesis and apomixis). Induced chromosome doubling and behaviour of chromosomes in interspecific and intraspecific crosses, molecular cytogenetic techniques.

PRACTICAL

a) Microscopy; simple, compound, phase contrast, dark field, fluorescent, SEM, TEM.
b) Study of mitosis and meiosis in plants and animals.
c) Preparation of permanent slides.
d) Study of special types of chromosomes.
e) Problems on gametogenesis and chromosomal aberrations. o Staining techniques.

OUTCOMES:

At the end of the course, the scholars should be able to recognize, describe and discuss in detail the different aspects of chromosomal structure, number, and behavior, and their effects at the organismal, population and species levels.

RECOMMENDED BOOKS

1. Albert's, B., Bray, D., Lewis, J.; Raff, M., Roberts, K. and Watson, J.D. (1994). Molecular Biology of the Cell, Garland Publishing Inc. New York. 1994.
2. Darnell, Jr.J. Lodisch, H. and Balimore, D. (1990). Molecular Biology of the Cells, Scientific American Inc. N.Y. 1990.
3. Lodish, H., Baltimore, D., Berk, A., Zipursky, S.L. Matsudaira, P. and Darnell, J. (2001). Molecular Biology of the Cell. Scientific American Books, W.H. Freeman and Company, New York. 2001.
4. Robertis De., E.P. and De. Roberts, E.M.F. (2001). Cell and Molecular Biology, 8th Edition, Holt Lea and Fbiger, New York. 2001 2.
5. Singh, R.J. (2002). Plants Cytogenetics. 2nd Ed. CRC Press, USA. 2002.

ADVANCES IN PLANT ANATOMY

Course code: BOT-823 CREDIT HOURS: 3 (2+1)

OBJECTIVES: To provide the students understanding about anatomical features of vascular plants.

COURSE CONTENTS:

1. 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 and periderm etc.
2. Secretory tissues: Laticifers (classification, distribution, development, structural characteristics, functions) and Resin Canals.
3. Anatomy of reproductive parts: a. Flower b. Seed c. Fruit d. Pollens e. Spores
4. Economic aspects and application of applied plant anatomy in various applied fields.
5. Anatomical adaptations. Wood anatomy in relation to Phylogeny.
6. Morphogenesis: Tissues and Organ Culture.
7. Microscopy and Micrometry: TEM, SEM, Light Microscopy, Phase Contrast Microscopy. Use of Microtome.
8. Characteristics of wood: diffuse porous and ring porous, sap and heart wood, soft and hard wood, annual rings.

LAB OUTLINE:

1. Study of organization of shoot and root meristem, different primary and secondary tissues from the living and preserved material in macerates and sections, hairs, glands and other secondary structures.
2. Study of abnormal/unusual secondary growth.
3. Peel and ground sectioning and maceration of fossil material.
4. Comparative study of wood structure of Gymnosperms and Angiosperms with the help of prepared slides.

COURSE OUTCOMES: At the end of the course the students would have understanding about advances in anatomical features of plants.

RECOMMENDED BOOKS:

1. Cutler, D. F. 1969. Anatomy of the Monocotyledons. IV. Juncales. Clarendon Press, Oxford.
2. Cutler, D. F. 1978. Applied Plant Anatomy. Longman Group Ltd. England
3. Dickison, W. C. 2000. Integrative plant anatomy. Academic Press, U. K.
4. Eames A. J. and L. H Mac Daniels. 2002. An Introduction to Plant Anatomy. Tata-Mac Graw-Hill Publishing Company, Limited, New Delhi.
5. Esau, K. 1960. Anatomy of Seed Plants. John Wiley, New York.
6. Fahn, A. 1990. Plant Anatomy. Pergamum Press, Oxford.

7. Lawrence, G. H. M. 1951 Taxonomy of Vascular Plants. MacMillan & Co. New York.
8. Maheshwari, P. 1971. Embryology of Angiosperms, McGraw-Hill. New York.
9. Mauseth, J. D. 1998. An Introduction to Plant Biology: Multimedia Enhanced. Jones and Bartlett Pub. UK
10. Metcalf, C. R. and Chalk, L. 1950. Anatomy of the Dicotyledons. Clerondon Press. Oxford.
11. Metcalfe, C. R. 1960. Anatomy of the Monocotyledons. Gramineae. Clerondon Press, Oxford.
12. Metcalfe, C. R. 1971. Anatomy of the Monocotyledons.V. Cyperaceae. Clerondon Press, Oxford.
13. Moore, R. C., W. D. Clarke and Vodopich, D. S. 1998. Botany. McGraw Hill Company, U.S.A.
14. Naik, V. N. 2005 Taxonomy of Angiosperms. 20th Reprint. TataMacGraw-Hill Publishing Company, Limited New Delhi.
15. Panday, B. P. 2004. A textbook of Botany (Angiosperms). S. Chand and Co. New Delhi.
16. Pullaiah, T. 2007. Taxonomy of Angiosperms. 3rd Edition, Regency Publications, New Delhi.
17. Raymond, E. S. and E. Eichhorn. 2005. Esau's Plant Anatomy; Meristematic cells and tissues of plant body. John Willey Sons Inc.
18. Stuessy, T. F. 1990. Plant Taxonomy. Columbia University Press, USA.
19. Vaughan, J. G. 1990. The structure and Utilization of Oil Seeds. Chapman and Hall Ltd. London.

MUSHROOM BIOLOGY

Course Code: BOT-824 **Credit Hours: 3(2+1)**

OBJECTIVES:

To develop basic knowledge about mushrooms and their role in food and medicine.

COURSE CONTENTS:

Introduction to Mushrooms: classification and categorization of mushrooms, life-cycle (sporocarps, mycelia), diversity in sporocarps.

Identification of mushrooms: general macroscopic characteristics (form, color, size and shape of fruiting bodies), specific macroscopic characteristics (pileus shape, stipe shape, gills attachment, cap margin, gill edge, veil remnants, Cortina etc), microscopic features (spore: spore print, size, shape, presence or absence of germ-pore; fertile cells, sterile cells on gill faces and edge; pileus hyphae, stipe hyphae, presence or absence of clamp connections).

Molecular techniques in mushroom identification: DNA extraction, PCR amplification and sequencing of ITS barcode, phylogenetic analyses of fungal sequences.

Edible mushrooms: common edible mushrooms of northern Khyber Pakhtunkhwa.

Poisonous mushrooms: poisonous mushrooms and their mycotoxins.

Ectomycorrhizal mushrooms: ectomycorrhizal association of mushrooms with pine, cedar, oaks etc.

PRACTICAL:

Morphology of mushrooms; Form, size, color and shape of macroscopic features of mushrooms

Microscopic study: light microscopy of spores, basidia, cystidia and other hyphae of mushrooms, spore print

DNA extraction; from hyphae & spores, PCR amplification and phylogenetic analyses of fungal barcode (ITS).

OUTCOMES:

At the end of the course, the scholars should be able to:

a) Characterize mushrooms macroscopically and microscopically

b) Describe and carry out the basic molecular barcoding of mushrooms

RECOMMENDED BOOKS

1. McKnight, K.H. and McKnight, V.B. (1987) Peterson Field Guide, Mushrooms. Houghton Mifflin Company, Boston.

2. Moore, S. and O'Sullivan, P. (2014) A guide to common fungi of the Hunter-Central Rivers region. Publisher Hunter Local Land Services, NSW.

3. Phillips, R. (1994) Mushrooms and other Fungi of Great Britain and Europe. Macmillan, London.

4. Robinson, R. (2003) Fungi of the South West Forests. Department of Conservation and Land Management, Bush Books, Perth.

5. Shepherd, C.J. and Totterdell, C.J. (1988) Mushrooms and Toadstools of Australia. Inkata Press, Melbourne.

6. Singer, R. (1986) The Agaricales in Modern Taxonomy. 4th edition. Koelz Scientific Books, Koenigstein.

ECTOMYCORHIZAL BIOTECHNOLOGY

Course Code: BOT-825 **Credit Hours: 3(2+1)**

OBJECTIVES:

To develop basic knowledge of mycorrhizae and their role in plant development

COURSE CONTENTS:

Ectomycorrhizae: Ectomycorrhizal symbionts, their systematic and diversity, morph types and their Structure, Methods of identification, Ectomycorrhizae in conifers and deciduous trees. Growth physiology of ECM fungi.

Culturing of ECM Fungi/Morph types: Methods for obtaining cultures from vegetative and reproductive parts of Macro fungi on different synthetic media, maintenance of isolated cultures. Ectomycorrhizal inoculum and inoculation techniques

Ecological and Biotechnological Aspects: Ectomycorrhizal communities and their ecological studies, Transformation of Ectomycorrhizal fungi, Ectomycorrhizal establishment, Ectomycoremediation, Mycobioindication, Biotechnological potential of ECM.

Future aspects of Ectomycorrhizal technology: Introduction of efficient Ectomycorrhizal fungi. Cultivation of ECM fungi. Multiplication of isolated cultures for spawn marketing and inoculation to the test production and Application of ECM fungi in afforestation and reforestation.

PRACTICALS:

- Methods to describe the Macro fungi, morph types and their diversity.
- Isolation of cultures from both partners i.e. Macro fungi and Morph types.
- Methods of Syntheses of Ectomycorrhiza with a host plant and its application in the field.
- Field trips to different forest areas. Students will visit forest areas to collect 50 samples of Macro fungi and ectomycorrhizas (Conifers and Deciduous trees).

OUTCOMES: The student will learn about Ectomycorrhizal; their identification, isolation and multiplication. They will also know how the produced Ectomycorrhizae can be used for reforestation programs.

RECOMMENDED BOOKS:

1. Agerer R. *Colour Atlas of Ectomycorrhizae*. Department of Biology, Biodiversity Research, University of Munchen, Germany
2. Mark M, Brundrett, N. Bougher, B. Dell, T. Grove & N. Malajczuk, *Working with Mycorrhizas in Forestry & Agriculture* CSIRO Centre for Mediterranean Agricultural Research.Wembley, W Australia.

3. Raiand M, Varma A. *Diversity and Biotechnology of Ectomycorrhizae*. Springer-Verlag Berlin Heidelberg.

Schenk N.C. *Methods and Principals of Mycorrhizal Research.* The American Phytopathological Society. St. Paul. Minnesot

ECOTOXICOLOGY

Course code: BOT-826 CREDIT HOURS: 3 (2+1)

OBJECTIVES: To provide the students understanding about environmental hazardous materials and its importance,

COURSE CONTENTS:

Introduction to Environmental Toxicology: Importance, nature and scope of environmental toxicology, our changing environment and changing disease pattern (Cancer, birth defects, reproductive damage and respiratory diseases).

Environmental Toxicants: Inorganic and Organic, Gaseous toxicants, Particulate matter, Photochemical smog and Environmental metals, their occurrence, sources and effects.

Factors Affecting Xenobiotic Action: Introduction, Physicochemical properties, Environmental Factors, Biological factors, Nutritional factors, Interactions

Damage Processes and Action of Toxicants: Introduction, sources of pollution, pollutant uptake, transport, plant injury, Mechanism of action, Secondary action as a result of the presence of a pollutant.

Ecological Risk Assessment

Components, use, importance and frame works for ecological risk assessment. Usefulness of ecological risk assessment predictions.

Pesticides and related materials: Introduction; Insecticides; Herbicides; their characteristics and impacts.

Mutagenic Pollutants: Introduction: Types and effects of Mutations Induction of Mutations (UV light, (lionizing Radiations and Chemical mutagens.

Environmental Cancer: Introduction: Causes and development of cancer. Metastasis and classification of carcinogens. Metabolism of chemical carcinogens

LAB OUTLINE:

1. Study of different instruments for measurement of environmental toxicology.
2. Measurement of different inorganic environmental toxicants.
3. Measurement of different organic environmental toxicants.
4. Measurement of different environmental heavy metals.
5. Measurement of different inorganic environmental toxicants and their visible symptoms on plants.
6. Measurement of different organic environmental toxicants and their visible symptoms on plants.

COURSE OUTCOMES: At the end of the course the students would have

1. Good understanding of environmental hazardous materials and its importance,
2. Knowledge of nature and scope of environmental toxicology in our changing environment and changing disease pattern.

RECOMMENDED BOOKS:

1. William F. Bennett. 1996.*Nutrient Deficiencies and Toxicities in Crop Plants.* APS Press, The American Phytopathological Society, ST. Paul, Minnesota 202 pp.
2. Lawrence E. Datnoff., Wade H. Elmer., Don M. Huber. 2007. *Mineral Nutrition and Plant Disease.* American Phytopathological Society. 278 pp.
3. Nand Kumar Fageria. 2008. *The Use of Nutrients in Crop Plants*. CRC Press. Boca Raton. 448 pp.
4. Alan Scaife, Mary Turner. 1983. *Diagnosis of Mineral Disorders in Plants: Vegetables.* Science. 95 pp.
5. Ming-Ho Yu. 2005. Environmental Toxicology CRC press, USA.
6. Gurjar, B.R., Molina, L.T and Ojha, C.S.P. 2010. Air Pollution: health and Environmental Impacts. CRC Press, USA.
7. Chiras, D.D. 2006. Environmental Sciences. Jones and Bartlett Publishers. Boston, Toronto, London.
8. Miller, Jr., G.T. 2000. Living in the Environment (Twelfth Edition). Brooks/Cole. Thompson Learning. Canada, U.K. U.S.A.

Annex-V

List of Foreign Examiners for Phd Thesis Evaluation

01	**Dr. William Bockus** Professor 4733 Throckmorton, Kansas State University, Department of Plant Pathology, Manhattan KS 66506-5502, United States. Telephone: 785-532-1378 Fax:785-532-5692 Email: bockus@ksu.edu http://www.plantpath.ksu.edu/p.aspx?tabid=410&ItemID=42&mid=74&staff_category=Faculty
02	**Dr. Daniel Potter** Professor 2041 Wickson,Department ofPlant Sciences, University of California, Davis, United States. Telephone:(+1 530) 754-6141 Email: dpotter@ucdavis.edu Webpage:http://biosci3.ucdavis.edu/FacultyAndResearch/FacultyProfile.aspx?FacultyID=14091
03	**Dr. David Burslem** Professor The Institute of Biological and Environmental Sciences Zoology Building Tillydrone Avenue Aberdeen, AB24 2TZ, United Kingdom. Telephone: +44 (0)1224 272695 Email:zoooffice@abdn.ac.uk
04	**Dr. Marty Dickman** Professor, Director Director, Institute for Plant Genomics and Biotechnology, Texas A &M University, United States. Telephone:979-862-4788 Email: mbdickman@tamu.edu Webpage:http://ipgb.tamu.edu/people/dickman-marty/
05	**Dr. Sarah Gurr** Professor Geoffrey Pope Building, University of Exeter, Stocker Road, Exeter EX4 4QD UK. Office 218, United Kingdom. Telephone: +44 (0) 1392 723791 Internal Tel: 3791

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07	**Dr. Robert L. Gilberston** Professor Department of Plant Pathology. University of California One Shields Avenue - Davis, CA 95616-8751. Department Business Office: 354 Hutchison Hall, United States. Telephone: 530-752-3163 Fax: 530-752-5674 Email: rlgilbertson@ucdavis.edu Webpage:http://plantpathology.ucdavis.edu/faculty/Gilbertson_Robert_L/
08	**Dr. Michael Heinrich** Professor, Head of Centre Room 204, University College London, School of Pharmacy, 29-39 Brunswick Square, London WC1N 1A, United Kingdom. Telephone:0207 753 5844 Email: m.heinrich@ucl.ac.uk Webpage:http://iris.ucl.ac.uk/iris/browse/profile?upi=MHEIN39
09	**Dr. Andrea Pieroni** Professor University of Gastronomic Sciences, Pollenzo Campus Piazza Vittorio Emanuele 9, Pollenzo-12042 Bra (Cn), Piedmont, Italy. Telephone: +39 0172 458575 Fax:+39 0172 458500 Email: a.pieroni@unisg.it Webpage: www.andreapieroni.eu
10	**Dr. HeikoBalzter** Professor,Director University Road, Leicester, LE1 7RH, United Kingdom. Telephone: +441162523820 Fax: +441162523854

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11	**Dr. Sue Page** Professor, Head of the Department Department of Geography, University of Leicester,University Road, Leicester, LE1 7RH, United Kingdom. Telephone: +441162523318 Fax: +441162523854 Email: sep5@le.ac.uk Webpage:www.le.ac.uk/clcr
12	**Dr. Tijen Demiral** Associate Professor Department of Biology, Faculty of Science & Arts, Osmanbey Campus, Harran University, Sanliurfa 63300, Turkey. Telephone: 0090 414 3183000 / 3559 (ext.) Cell: 0090 532 1756035 Fax:00904143183541 Email:tijen.demiral@harran.edu, tijen.demiral@gmail.com
13	**Dr. David Guest** Professor Department of Plant and Food Sciences, C81 - ATP - The Biomedical Building, University of Sydney, Australia. Telephone: +61 2 8627 1026 Fax:+61 2 8627 1099 Email: david.guest@sydney.edu.au Webpage:http://sydney.edu.au/agriculture/academic_staff/david.guest.php
14	**Dr. Eileen Scott** Professor School of Agriculture, Food and Wine, The University of Adelaide, Adelaide SA 5005, Australia. Telephone:+61 8 8313 7109 Fax:+61 8 8313 7266 Email: eileen.scott@adelaide.edu.au Webpage:http://www.adelaide.edu.au/directory/eileen.scott
15	**Dr. Shauna Somerville** Professor Shauna SomervilleProfessor, Plant & Microbial BiologyEnergy Biosciences Building, 2151 Berkeley Way Berkeley, CA 94720, United States.

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16	**Dr. Steven A. Whitham** Professor, Director Steven A. Whitham,Department of Plant Pathology & Microbiology, Iowa State University 419 Bessey Hall Ames, IA 50011-1020, United States Telephone: 515-294-4952 Fax:515-294-9420 Email:swhitham@iastate.edu Webpage:https://www.plantpath.iastate.edu/people/steven-whitham
17	**Dr. Sun Hang** Professor 132# Lanhei Road, Heilongtan, Kunming 650201, Yunnan, China Telephone:+86 871 65223223 Fax: +86 871 65223223 Email: hsun@mail.kib.ac.cn
18	**Dr. Timothy D. Murray** Professor Department of Plant Pathology, PO Box 646430, Washington State University, Pullman WA 99164-6430, United States. Telephone: (509)335-7515 Fax:(509)335-9581 Email: tim.murray@wsu.edu Webpage:http://plantpath.wsu.edu/people/faculty/murray/
19	**Dr. Christopher A. Clark** Professor Christopher A. Clark, Department of Plant Pathology & Crop Physiology Louisiana State UniversityBaton Rouge, LA 70803-1720, United States. Telephone: (225)-578-1381 Fax:(225) 578-1415 Email: cclark@agctr.lsu.edu Webpage:http://www.lsu.edu/ppcp/faculty_staff/clark/
20	**Dr. Juan Luis Jurat-Fuentes** Associate Professor

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21	**Dr. Bryce Falk** Professor Department of Plant Pathology - University of California, One Shields Avenue - Davis, CA 95616-8751. Department Business Office: 354 Hutchison Hall, United States. **Telephone:** 530-752-0302 **Fax:** 530-752-5674 **Email:** bwfalk@ucdavis.edu **Webpage:**http://plantpathology.ucdavis.edu/faculty/Falk_Bryce/
22	**Dr. Jerry Bartz** Associate Professor Plant Pathology Department, Institute of Food and Agricultural Sciences, University of Florida, Gainesville, FL 32611-0690, United States. Telephone: (352) 273-4638 Fax:(352) 392-6532 Email: softbart@ufl.edu Webpage:http://plantpath.ifas.ufl.edu/faculty/Bartz/faculty-Bartz.shtml
23	**Dr. Peter Balint-Kurti** Professor Department of Plant Pathology,North Carolina State University, 2572 Thomas Hall, CB 7616, Raleigh, NC 27695-7616, United States. Telephone: (919) 515-3516 Fax:(919) 856-4816 Email: pjbalint@ncsu.edu Webpage:http://plantpath.cals.ncsu.edu/people/faculty/peter-balint-kurti/
24	**Dr. Lee KeatTeong** Professor PusatPengajianKejuruteraanKimia,KampusKejuruteraan, UniversitiSains Malaysia, Seri Ampangan, 14300 NibongTebal, SeberangPerai Selatan, Pulau Pinang Telephone: 604599599, 6401/6407 Fax: 6045941013 Email:Ktlee@usm.my

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