CURRICULUM

OF

BIOTECHNOLOGY

BS (4 Years)/MS & MPhil

(2013)

HIGHER EDUCATION COMMISSION
ISLAMABAD

CURRICULUM DIVISION, HEC

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PREFACE

The curriculum, with varying definitions, is said to be a plan of the teaching-learning process that students of an academic programme are required to undergo. It includes objectives & learning outcomes, course contents, scheme of studies, teaching methodologies and methods of assessment of learning. Since knowledge in all disciplines and fields is expanding at a fast pace and new disciplines are also emerging; it is imperative that curricula be developed and revised accordingly.

University Grants Commission (UGC) was designated as the competent authority to develop, review and revise curricula beyond Class-XII vide Section 3, Sub-Section 2 (ii), Act of Parliament No. X of 1976 titled **"Supervision of Curricula and Textbooks and Maintenance of Standard of Education".** With the repeal of UGC Act, the same function was assigned to the Higher Education Commission (HEC) under its Ordinance of 2002, Section 10, Sub-Section 1 (v).

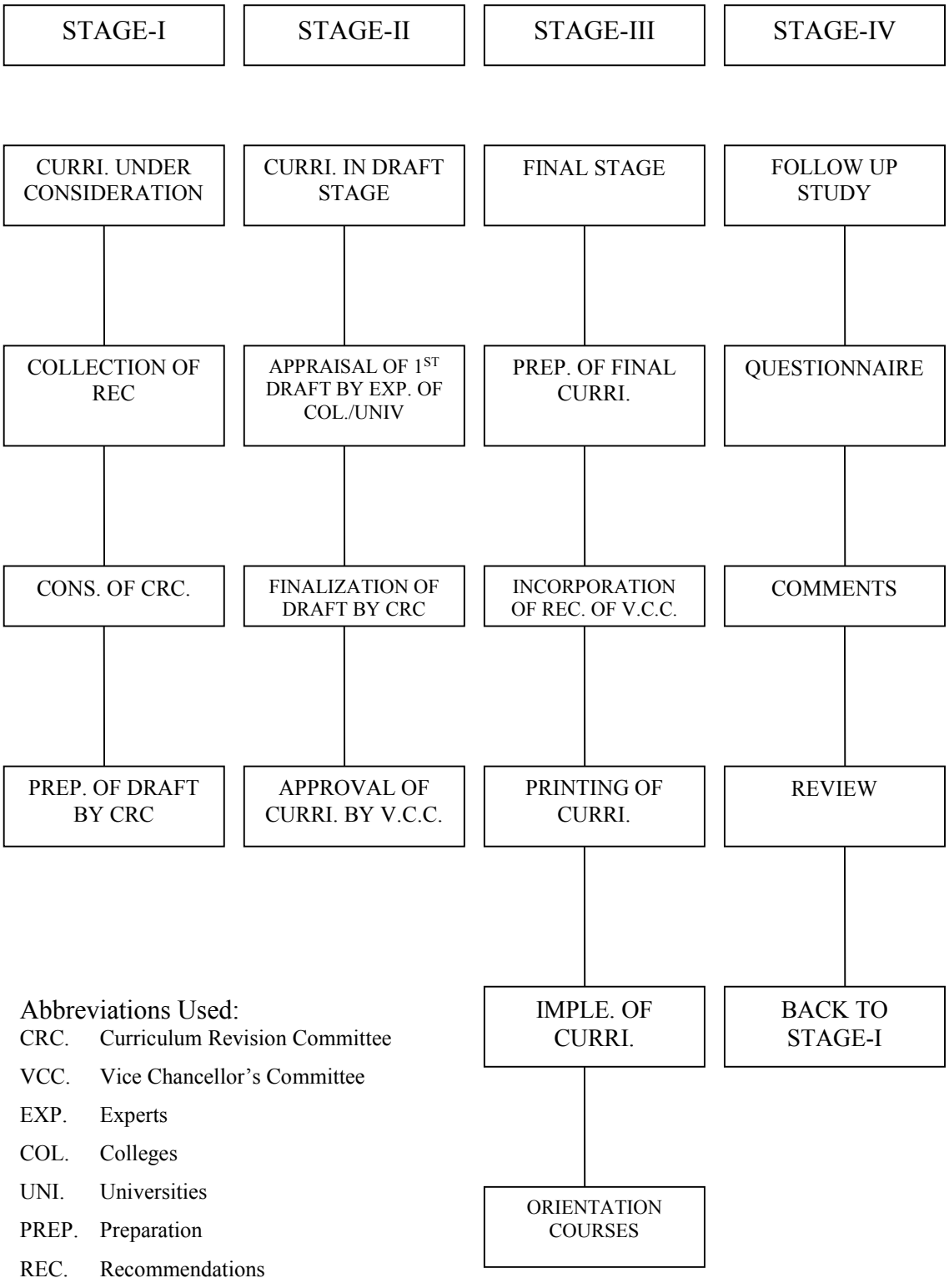
In compliance with the above provisions, the Curriculum Division of HEC undertakes the revision of curricula after every three years through respective National Curriculum Revision Committees (NCRCs) which consist of eminent professors and researchers of relevant fields from public and private sector universities, R&D organizations, councils, industry and civil society by seeking nominations from their organizations.

In order to impart quality education which is at par with international standards, HEC NCRCs have developed unified templates as guidelines for the development and revision of curricula in the disciplines of Basic Sciences, Applied Sciences, Social Sciences, Agriculture and Engineering in 2007 and 2009.

It is hoped that this curriculum document, prepared by the respective NCRC's, would serve the purpose of meeting our national, social and economic needs, and it would also provide the level of competency specified in Pakistan qualification Framework to make it compatible with international educational standards. The curriculum is also placed on the website of HEC (www.hec.gov.pk).

(Fida Hussain)
Director General (Academics)

CURRICULUM DEVELOPMENT PROCESS



Abbreviations Used:

CRC. Curriculum Revision Committee

VCC. Vice Chancellor's Committee

EXP. Experts

COL. Colleges

UNI. Universities

PREP. Preparation

REC. Recommendations

RATIONALE

Biotechnology refers to the employment of various types of "technology" to use, exploit, modify or improve existing biological processes for a specific purpose; its overarching goal is to enhance the quality of human life - be it directly or indirectly - by producing and/or developing effective pharmaceuticals, bioenergy, disease-resistant and high-yield crops as well as animals, and microbes for remediation in an efficient, cost-effective and ethically responsible manner. The field has already shown immense promise and further innovations are certain to culminate in dramatic improvements in existing technologies and outcomes. Biotechnology is the next wave of change that is likely to be as sweeping and invasive as that brought about by information technology.

The developed countries are focusing to expand and capitalize on biotechnology. America is leading the biotechnology industry; having reached the mark of US$ 72 Billion in 2009 it expected to grow at the cumulative annual growth rate (CAGR) of 7% to reach approximately US$ 95 Billion by the end of this year. Cutting-edge work is also going on in the United Kingdom, Germany, Korea, China and Japan. According to the new research report, "Asia Pacific Biotechnology Market (2008-2012)", the Asia-Pacific biotech market is projected to grow at a CAGR of around 16% during 2010 – 2012. Japan and China are dominating biotech industry at the regional forefront, while higher growth rates have been expected in emerging markets like Malaysia, India, and Singapore.

Pakistan has recently initiated investment on the applications of biotechnology, especially in agriculture for developing insect-resistant and high yield crops, vaccine production, textile, leather and chemical industries, health, bioinformatics and environmental biotechnology. The Government of Pakistan has invested over US$ 20 million in biotechnology research and hundreds of scientists are working in more than 31 public and private sector biotechnology research centres. There are various funding mechanisms now in place to support research and development in different disciplines of biotechnology. Many international institutions including Asian Development Bank, Islamic Development Bank, World Bank, USAID, Rockefeller Foundation and Australian Centre for International Agriculture Research also provide financial assistance for selected biotech projects.

With remarkable advancements in agriculture, biomedical research and pharmaceutical industry, biotechnology has become a major discipline which is likely to play an increasingly significant role in improving the economies of different countries, and especially those which are developing. Pakistan must do its utmost to impart quality education in this exciting and promising field to its undergraduate and graduate students. The proposed Biotechnology curriculum has been developed with immense enthusiasm, passion and responsibility. It is anticipated that its successful implementation in all institutions across Pakistan will culminate in the production of well-trained graduates who are much sought after by educational institutions and corporations within Pakistan and abroad.

INTRODUCTION:

The members of National Curriculum Revision Committee on Biotechnology developed frame work and revised the curriculum in two different meetings. The first meeting was held on January 2-4, 2013 at Higher Education Commission, Regional Centre, Lahore. The Second meeting was held on May 15-17, 2013 at HEC Regional Centre, Peshawar. The following experts attended these meetings:

1. **Dr. Zabta Khan Shinwari** **Convener**
   Professor & Chairperson
   Department of Biotechnology
   Quaid-I-Azam University
   Islamabad

2. **Dr. Sohail Asif Qureshi** **Member & Secretary**
   Professor & Dean
   Department of Biology
   Lahore University of Management Sciences (LUMS)
   Sector U", Defense Housing Authority (DHA)
   Lahore Cantt

3. **Dr. Muhammad Mukhtar** **Member**
   Professor and Vice Chancellor
   The Islamia University of Bahawalpur
   Bahawalpur

4. **Dr. Shagufta Naz** **Member**
   Professor and Head of Department
   Department of Biotechnology & Microbiology
   Lahore College for Women University
   Jail Road, Lahore

5. **Dr. Javed Iqbal Mirza** **Member**
   Professor
   Institute of Molecular Biology & Biotechnology
   University of Lahore
   Defense Road Campus
   Lahore

6. **Dr. Ahmad Mukhtar Khalid** **Member**
   Professor
   Department of Biological Sciences
   University of Sargodha
   Sargodha

7. **Dr. Quratulain Syed** **Member**
   Chief Scientific Officer
   Department of Food & Biotechnology
   Research Centre (FBRC)
   PCSIR Laboratories
   Ferozepur Road
   Lahore

8. Mr. Muhammad Ali Bohyo **Member**
Director
Institute of Biomedical Technology
Liaquat University of Medical & Health Sciences
Jamshoro

9. Dr. Ikram-ul-Haq **Member**
Director
Institute of Industrial Biotechnology
Government College University
Lahore

10. Dr. Rehana Asghar **Member**
Professor
Department of Biotechnology
Mirpur University of Science & Technology
Main Campus
Mirpur

11. Dr. Muhammad Javaid Asad **Member**
Associate Professor
Department of Biochemistry
PMAS Arid Agriculture University
Rawalpindi

12. Dr. Asma Gul **Member**
Assistant Professor & Chairperson
Department of Bioinformatics & Biotechnology
International Islamic University
H-10, Islamabad

13. Dr. Aneela Yasmin **Member**
Assistant Professor & Chairperson
Department of Biotechnology
Sindh Agriculture University
Tandojam

14. Dr. Iqbal Munir **Member**
Professor
Institute of Biotechnology and Genetic Engineering (IBGE)
The University of Agriculture
Peshawar

15. Dr. Mustafa Kamal **Member**
Associate Professor & Chairperson
Department of Biotechnology
University of Karachi
Karachi

16. **Dr. Azra Yasmin** — **Member**
Associate Professor & Chairperson
Department of Environmental Sciences
Fatima Jinnah Women University
The Mall, Rawalpindi

17. **Dr. Mushtaq Ahmad** — **Member**
Assistant Professor & Chairperson
Department of Biotechnology
University of Science and Technology
Bannu

18. **Dr. Ibrar Khan** — **Member**
Assistant Professor
Centre of Biotechnology & Microbiology
University of Peshawar
Peshawar

19. **Dr. Aftab Ali Shah** — **Member**
Assistant Professor
Department of Biotechnology
University of Malakand
Chakdara, Lower Dir

20. **Dr. Midrar Ullah** — **Member**
Assistant Professor & Chairperson
Department of Biotechnology
Shaheed Benazir Bhutto University
Sheringal, Upper Dir

21. **Dr. Muhammad Irfan** — **Member**
Assistant Professor
Department of Biological Sciences
Forman Christian College (A Chartered University)
Ferozepur Road
Lahore

22. **Dr. Fauzia Yusuf Hafeez** — **Member**
Professor & Chairperson
Department of Biosciences
COMSATS Institute of Information Technology
Islamabad

23. **Dr. Muzammil Ahmad Khan** — **Member**
Assistant Professor
Center of Biochemistry and Biotechnology
Gomal University
Dera Ismail Khan

24. Dr. Farhad Ali **Member**
Assistant Professor
Department of Biotechnology
Bacha Khan University
Charsadda

Proceeding of the First NCRC Meeting

The meeting started with recitation of verses from the Holy Quran by Mr. Muhammad Arif, HEC Islamabad. Mr. Nazeer Hussain, Director HEC Regional Centre, Lahore welcomed the participants and assured them that the Regional Centre would extend all sort of facilities to make their stay comfortable at Lahore. Mr. Muhammad Arif, meeting coordinator from HEC Islamabad, briefed them about the overall structure of template/framework of BS (4-years) programme, being developed by the conveners of the National Curriculum Revision Committee in Basic, Social and Applied Sciences in their meeting, held on April 30, 2008 at HEC Islamabad. He requested the participants to include at least two subjects of social sciences in the list of general subjects and to recommend latest books of reading in the subject. He further suggested to the committee members to restrict the credit hours of the scheme in the range of 130 – 133 so that the universities should have an option to add more 3 Credit hours to fulfill the maximum limit of 136 Credit hours. The committee before taking up the regular agenda unanimously agreed to select Dr. Zabta K. Shinwari as Convener and Dr. Sohail A. Qureshi as Secretary of the meeting. After a long discussion, the following layout and scheme of study was developed:

STANDARDIZED FORMAT
FOR BS (4-YEARS) IN BIOTECHNOLOGY

STRUCTURE

Sr.	Categories	No. of courses	Credit Hours
1.	Compulsory courses	9	24
2.	General courses (to be chosen from other Departments)	8	24
3.	Discipline specific foundation courses	13	39
4.	Major courses (including Research Project/Internship)	13	35
5.	Electives within the major	4	12
	Total	**47**	**134**

- Total numbers of credit hours 134
- Duration 4 years
- Semester duration 16-18 weeks
- Semesters 8
- Course load per semester 15-18 Credit hours
- Number of courses per semester 5-6

LAYOUT FOR BS (4-YEAR) IN BIOTECHNOLOGY

Compulsory Requirements (i.e., student has no choice)		**General Courses** (to be chosen from other Departments)	
9 courses		**8 courses**	
24 Credit hours		**24 Credit hours**	
Subject	**Cr. hr**	**Subject**	**Cr. hr**
1. ENGLISH I	3+0	1. Physical Chemistry	3+0
2. ENGLISH II	3+0	2. Inorganic Chemistry	2+1
3. ENGLISH III	3+0	3. Organic Chemistry	2+1
4. PAKISTAN STUDIES	2+0	4. Ecology, Biodiversity & Evolution - I	3+0
5. ISLAMIC STUDIES	2+0	5. Ecology, Biodiversity & Evolution - II	2+1
6. BIOSAFETY & BIOETHICS	2+0	6. Biological Physics	3+0
7. MATHEMATICS - I (Pre-calculus)	3+0	7. Two social science courses from following list:	
8. BIOMATHEMATICS	3+0	a) Sociology	3+0
9. INTRODUCTION TO COMPUTER SCIENCE	2+1	b) Mass Communication	3+0
		c) Economics	3+0
		d) Marketing	3+0
		e) Environmental Policy	3+0
		f) Psychology	3+0
		g) Fine Arts	3+0
		h) Political Science	3+0
		i) International Affairs	3+0
		j) Public Administration	3+0
	24		**24**

Discipline Specific Foundation Courses		**Major Courses** (including research project/internship)		**Elective Courses within the major**	
13 courses		**13 courses**		**4 courses**	
39 Credit hours		**35 Credit hours**		**12 Credit hours**	
Subject	**Cr. hr**	**Subject**	**Cr. hr**	**Subject**	**Cr. hr**
1. Microbiology	2+1	1. Principles of Biochemical Engineering	2+1	**Elective – I**	3+0
2. Biochemistry-I	2+1	2. Agriculture Biotechnology	2+1*	**Elective - II**	3+0
3. Biochemistry-II	2+1	3. Health Biotechnology	3+0*	**Elective - III**	3+0
4. Cell Biology	2+1	4. Environmental Biotechnology	3+0*	**Elective - IV**	3+0
5. Classical Genetics	3+0	5. Food Biotechnology	3+0*	Note These courses will be selected from the list of elective courses.	
6. Probability & Biostatistics	3+0	6. Genomics & Proteomics	3+0		
7. Analytical Chemistry & Instrumentation	2+1	7. Bioinformatics	1+2		
8. Molecular Biol.	3+0	8. Industrial Biotechnology	3+0*		
9. Introduction to Biotechnology	3+0	9. Research Methodology & Skill Enhancement	3+0		
10. Immunology	3+0*	10. Seminar-I	1+0		
11. Methods in Molecular Biol.	1+2	11. Seminar-II	1+0		
12. Genetic Resources & Conservation	3+0	12. Research Project OR Internship OR Special Paper – I (M)	3+0		
13. Microbial Biotechnology	3+0*	13. Research Project OR Internship OR Special Paper – II (M)	3+0		
	39		**35**		**12**

** Weightage of theory and practical credits may be changed by an institution depending on the laboratory facilities available*

SCHEME OF STUDIES FOR 4-YEAR BACHELOR OF SCIENCE (BS) DEGREE IN BIOTECHNOLOGY

YEAR ONE - SEMESTER ONE

S. No	Name of Subject	Credits
1	English-I (C)	3+0
2	Pakistan Studies (C)	2+0
3	Mathematics-I (pre-calculus) (C)	3+0
4	Ecology, Biodiversity & Evolution – I (G)	3+0
5	Organic Chemistry (G)	2+1
6	Cell Biology (F)	2+1
	Total	17

YEAR ONE - SEMESTER TWO

S. No	Name of Subject	Credits
1	English-II (C)	3+0
2	Islamic Studies/Ethics (C)	2+0
3	Biomathematics (C)	3+0
4	Inorganic Chemistry (G)	2+1
5	Ecology, Biodiversity & Evolution – II (G)	2+1
6	Microbiology (F)	2+1
	Total	**17**

YEAR TWO - SEMESTER THREE

S. No	Name of Subject	Credits
1	English-III (C)	3+0
2	Introduction to Computer Science (C)	2+1
3	Physical Chemistry (G)	3+0
4	Any subject from Social Sciences (G)	3+0
5	Biochemistry-I (F)	2+1
6	Classical Genetics (F)	3+0
	Total	**18**

YEAR TWO - SEMESTER FOUR

S. No	Name of Subject	Credits
1	Biological Physics (G)	3+0
2	Probability & Biostatistics (F)	3+0
3	Any subject from Social Sciences (G)	3+0
4	Analytical Chemistry & Instrumentation (F)	2+1
5	Biochemistry-II (F)	2+1
6	Molecular Biology (F)	3+0
	Total	**18**

YEAR THREE - SEMESTER FIVE

S. No	Name of Subject	Credits
1	Introduction to Biotechnology (F)	3+0
2	Immunology (F)	3+0*
3	Methods in Molecular Biology (F)	1+2
4	Principles of Biochemical Engineering (M)	2+1
5	Bioinformatics (M)	1+2
	Total	**15**

YEAR THREE - SEMESTER SIX

S. No	Name of Subject	Credits
1	Genetic Resources & Conservation (F)	3+0
2	Microbial Biotechnology (F)	3+0*
3	Agriculture Biotechnology (M)	2+1
4	Food Biotechnology (M)	3+0*
5	Elective-I	3+0
6	Research Methodology & Skill Enhancement (M)	3+0
	Total	**18**

YEAR FOUR - SEMESTER SEVEN

S. No	Name of Subject	Credits
1	Health Biotechnology (M)	3+0*
2	Seminar-I (M)	1+0
3	Environment Biotechnology (M)	3+0*
4	Genomics and Proteomics (M)	3+0
5	Elective-II	3+0
6	Research Project OR Internship OR Special Paper – I (M)	3+0
	Total	**16**

YEAR FOUR - SEMESTER EIGHT

S. No	Name of Subject	Credits
1	Elective-III	3+0
2	Elective-IV	3+0
3	Seminar-II (M)	1+0
4	Industrial Biotechnology (M)	3+0*
5	Research Project OR Internship OR Special Paper – II (M)	3+0
6	Biosafety & Bioethics (C)	2+0
	Total	**15**

TOTAL CREDIT HOURS: 134

LIST OF ELECTIVE COURSES

▪ Animal Biotechnology	3+0*
▪ Marine Biotechnology	3+0*
▪ Radiobiology	3+0*
▪ Hospital Waste Management	2+1
▪ Water and Waste-water Treatment	2+1
▪ Nano Biotechnology	3+0*
▪ Fungal Biotechnology	3+0*
▪ Pharmaceutical Biotechnology	3+0*
▪ Biosensors	3+0*
▪ Biofuels and Bio refineries	3+0*
▪ Molecular Diagnostics	3+0*
▪ Cell and Tissue Culture	2+1
▪ Virology	3+0
▪ Fermentation Biotechnology	2+1

**Weightage of theory and practical credits may be changed by an institution depending on the laboratory facilities available*

Proceeding of the Final NCRC Meeting

The second & final meeting started with recitation from the Holy Quran by Mr. Abid Wahab, Assistant Director (Curriculum), HEC Islamabad. Mr. Zaheer Ahmed Awan, Director, HEC, Regional Centre, Peshawar welcomed the NCRC members in Biotechnology and assured that all available facilities would be extended to them to make their stay comfortable at Peshawar. Before the start of further proceedings of the meeting. After long discussion, the course outlines of all Foundation, Major and Elective courses, prepared by members assigned to them in the preliminary meeting, were taken up for thorough & detailed discussion . After discussion necessary changes were made in the courses. The details of finally developed courses are as follows:

DETAIL OF COURSES

BIOSAFETY AND BIOETHICS (2+0)

Course Objectives:

To acquaint students with principles of biosafety and ethical perspectives pertaining to biotechnology

Course Contents:

Introduction to Biosafety - definition, concept, uses and abuses of genetic information, and biohazards; good laboratory practices; risks related to genetically modified organisms (GMO); international rules and regulations for biosafety and GMOs; introduction to bioethics; ethical issues related to GMOs; euthanasia, reproductive and cloning technologies, transplants and eugenics; patenting, commercialization and benefit sharing; role of national bioethics committees; biosafety guidelines from a national perspective.

Recommended Books:

1. Altman A and Hasegawa PM, 2012. Plant Biotechnology and Agriculture: Prospects for the 21st Century. 1st Edition; Academic Press.
2. Laboratory Biosafety Manual, WHO, 2006. 3rd Edition; AITBS Publishers and Distributors, India. (Available online free of cost).
3. Furr AK, 2000. CRC Handbook of Laboratory Safety. 5th Edition; CRC Press.
4. Jose Maria A, 2003. Genes Technology and Policy. Available online at; http://www.apdip.net/publications/iespprimers/eprimer-genes.pdf
5. Krishna VS, 2007. Bioethics and Biosafety in Biotechnology. New Age International Publishers.
6. National Biosafety Guidelines, 2005. Pakistan Environmental protection Agency (*Available online*)

BIOMATHEMATICS (3+0)

Course Objectives:

This course aims to provide students with the essential concepts of biomathematics and how these can be employed for analyzing real data.

Course Contents:

Preliminaries: Real-number line, functions and their graphs, solution of equations involving absolute values, inequalities, binomial theorem and its use. *Limits and Continuity:* Limit of a function, left-hand and right-hand limits, continuity, continuous functions. *Derivatives and their Applications:* Differentiable functions, differentiation of polynomial, rational and transcendental functions, derivatives. *Integration and Definite Integrals:* Techniques of evaluating indefinite integrals, integration by substitution, integration by parts, change of variables in indefinite integrals. Application and importance of calculus for biotechnology; the exponential growth curve and growth equation.

Recommended Books:

1. Helfgott M, and Moore D, 2011. Introductory Calculus for the Natural Sciences. Create Space Independent Publishing Platform, USA.
2. Neuhauser C, 2010. Calculus for Biology and Medicine. Prentice Hall
3. Anton H et al., 2005. Calculus: A New Horizon. John Wiley, New York.
4. Thomas GB and Finney AR, 2005. Calculus. Addison-Wesley, Reading, USA.
5. Kumar A, 2011. Mathematics for biologist. First Edition; Alpha science international.

DETAIL OF GENERAL COURSES

ECOLOGY, BIODIVERSITY & EVOLUTION-I (3+0)

Course Objectives:

This course aims to introduce students to the fundamentals of ecology, biological diversity and evolution – key areas that are pertinent to modern day biology.

Course Contents:

Introduction; ecosystem and ecological pyramids; role of environment on phenotype of organisms; food chain, webs and trophic levels; factors influencing environment; impact of urbanization and industry on environment; population: air, water, land, thermal, radiation and noise; community ecology; atmosphere – composition and cycles; pollution; climate change (greenhouse effect and global warming); ozone layer – composition and state across the globe; waste and sewerage processing and disposal; microbes, plants and animal species; comparative study of life forms; features and characteristics of bacteria, archaea and eukaryotes; phylogenetic relationships between the three kingdoms; evolution of different members belonging to each of the three domains of life (with specific examples); models of speciation; causes and consequences of extinction.

Recommended Books:

See below

ECOLOGY, BIODIVERSITY & EVOLUTION – II (2+1)

Course Objectives:

This course is a continuation of Ecology, Biodiversity & Evolution – I and offers advanced concepts in these areas.

Course Contents:

Introduction to animal kingdom: features of protists, protozoa, annelids, arthropods, myriapods, echinoderms, chordates, amphibians, reptiles and birds. Plant biodiversity – history, importance, usefulness and evolution; importance of plants, their conservation and domestication; improvement of crops; impact of environment on loss of genetic diversity and speciation; *in situ* and *ex situ* conservation; evolution of microbes, plants and animals; origin of life; methods of studying evolution; construction of phylogenetic trees on basis of morphology and molecular markers; environmental ethics.

Practical:

Shape and structure of different classes of microbes, plants and animals by light microscopy; study of euglena, amoeba, entamoeba, plasmodium and paramecium (from slides); sponges and their various body forms; cnindaria; platyhelminths; nematodes; molluscs; annelids; pisces; amphibians; reptilian; aves; mammalia; pond freshwater ecosystem; vegetation profile; grassland, rangeland and forest; biotic and abiotic factors of grassland, rangeland and aquatic ecosystem including methods of sampling; analysis of plant communities by different methods and decomposition of leaf litter by organisms.

Recommended Books:

1. Davet P, 2004. Microbial ecology of soil and plant growth. Science Publishers.
2. Nico et al., 2006. An Introduction to Ecological Genomics. 1st Edition; Oxford University Press.
3. Aston et al., 2004. Ecological Genetics: Planning and Application. Blackwell Science (UK).
4. Costa LG, and Eaton DL, 2006. Gene-Environment Interactions: Fundamentals of Ecogenetics. 1st Edition; John Wiley and Sons.
5. Freeland JR, 2005. Molecular Ecology. 1st Edition; John Wiley and Sons.
6. Wenz PS, 2001. Environmental Ethics Today. Oxford University Press.
7. Louis P and Pojman LP, 2007. Environmental Ethics: Readings in Theory and Application. 5th Edition; Wadsworth Publishing.
8. Light A, and Rolston III H, 2002. Environmental Ethics. 1st Edition; Wiley Blacwell Publishing.
9. Raven PH, and Berg LR, 2005. Environment. 5th Edition; John Wiley and Sons.

BIOLOGICAL PHYSICS (3+0)

Course Objectives:

This course is intended for students studying life sciences and aims to impart fundamental concepts of physics in the context of biological systems.

Course Contents:

Essentials of thermodynamics; concept of entropy, enthalpy and Gibb's free energy; order and disorder in biological systems; molecules, diffusion, random walks and friction; methods of studying macromolecules; interactions of molecules in 3-D space – determining binding and dissociation constants; molecular motors; sedimentation; Reynold's number; chemical forces and self-assembly; physics of ion channels.

Recommended Books:

1. Nelson P, 2004. Biological Physics, Energy, Information and Life. First Edition; WH Freeman & Company.
2. Kirsten et al., 2010. Introduction to Biological Physics for the Health and Life Sciences. Second Edition; John Wiley & Sons.
3. Davidovits P, 2013. Physics for Biology & Medicine. Fourth Edition; Academic Press.
4. Newman, 2008. Physics of the Life Sciences. Springer.
5. Duncan, 1975. Physics for Biologist. Blackwell Science.

DETAIL OF DISCIPLINE-SPECIFIC FOUNDATION COURSES

CELL BIOLOGY (2+1)

Course Objectives:
To acquaint students with features of eukaryotic cells, functions of different compartments and the overall structure/ultrastructure of cells as visualized by electron microscopy.

Course Contents:
Introduction to cell theory including historical perspective; overview of membrane structure and chemical constituents of the cell; function, isolation and molecular organization of cellular organelles specifically the endoplasmic reticulum, lysosome, micro-bodies, mitochondrial ultra-structure and function, chloroplast ultra-structure and the mechanism of photosynthesis; composition and structure of membranes; membrane receptors and transport mechanisms; cell movement - structure and function of cytoskeleton, centriole, cilia and flagella; nucleus; structure and function of chromosomes; cell cycle, mitosis and meiosis.

Practical:
Microscopy and staining techniques; study of prokaryotic, eukaryotic, plant and animal cells; cell structure in the staminal hair of *Tradescantia*; study of different types of plastids; cellular reproduction; Mitosis: smear/squash preparation of onion roots.

Recommended Books:

1. Alberts B and Johnson A, 2006. Molecular Biology of the Cell. 4th Edition; Garland Publishers, New York. (available at www.ncbi.nlm.nih.gov)
2. Karp, 2002. Cell and Molecular Biology. 3rd Edition; John Wiley and Sons, New York.
3. Alberts et al., 2009. Essential Cell Biology. 3rd Edition; Garland Publishers, New York.
4. Lodish et al,. 2007. Molecular Cell Biology. 6th Edition; Freeman and Company, New York. (available at www.ncbi.nlm.nih.gov)
5. Cooper GM and Hausman RE, 2009. The Cell, a molecular approach. 5th Edition; Sinauer Associates, Inc.

MICROBIOLOGY (2+1)

Course Objectives:
This course aims to familiarize students with fundamentals of prokaryotic and eukaryotic microbial life including viruses.

Course Contents:
Overview and history of microbiology including microbial diversity (Archaea, bacteria, fungi, algae, protozoa), nutrition, growth, metabolism; cultivation; viruses; control of microorganisms: sterilization and disinfection, antimicrobial agents, antibiotics, antibiotic resistance and susceptibility, antifungal and antiviral agents; cell death; symbiosis, carbon, nitrogen, sulfur and phosphorus cycles; microbiology of soil, freshwater and seawater.

Practical:
Sterilization techniques; culturing of bacteria in liquid and on solid medium; Gram-staining of bacteria; colony and cell morphology; bacterial cell count and growth curves; biochemical tests.

Recommended Books:

1. Alcamo IE, 2010. Fundamentals of Microbiology. 9th Edition, Jones and Bartlett Publishers.
2. Madigan MT and Martinko J, 2010. Brock Biology of Microorganisms. 13th Edition; Pearson College Div.
3. Talaro KP, 2009. Foundations in Microbiology: Basic Principles. 7th Edition; McGraw-Hill Publisher.
4. Black JG, 2007. Microbiology: principles and explorations. 7th Edition; John Wiley and Sons.
5. Baker et al., 2006. Instant Notes in Microbiology. 3rd Edition; Taylor and Francis.
6. Prescott et al., 2005. Microbiology. 6th Edition; McGraw-Hill Medical Publishing.
7. Cappuccino JG and Sherman N, 2013. Microbiology: a laboratory manual. 10th Edition; Pearson Education.

BIOCHEMISTRY- I (2+1)

Course Objectives:
This course aims to provide students with fundamental knowledge of the molecules of life, as well as their function in the context of a living cell.

Course Contents:
Introduction to biochemistry; water, pH, buffers, and biochemical composition of cells; carbohydrates - structure and classification; proteins - overview with emphasis on their composition and structure, classification and function; lipids - structure, classification and biological significance; enzymes - properties, nomenclature, classification, and factors affecting enzyme activity including inhibitors and potentiators, basic kinetics, derivation of Km and V_{max}; coenzymes and vitamins; nucleic acids - structure and function.

Practical:
Preparation of laboratory solutions and pH determination; qualitative and quantitative tests for carbohydrates, proteins and lipids; enzyme assays and the effect of pH, temperature and substrate concentration on enzyme activity.

Recommended Books:

1. Nelson DL and Cox MM, 2012. Lehninger Principles of Biochemistry. 6th Edition; WH Freeman, New York. (available at www.ncbi.nlm.nih.gov)
2. Stryer et al., 2006. Biochemistry. 6th Edition; WH Freeman, New York. (available at www.ncbi.nlm.nih.gov)
3. Voet D and Voet TG, 2008. Biochemistry. 4th Edition; John Wiley and Sons, New York.
4. Murray et al., 2012. Harper's Illustrated Biochemistry. 29th Edition; McGraw-Hill Medical Publishing.

5. Ferrier DR, 2013. Lippincott's Biochemistry. 6th Edition; Lippincott Williams &Wilkin Publishing Company.
6. Schantz JT, 2007. A Manual for Biochemistry Protocols. World Scientific Publishing. (*available online*)

BIOCHEMISTRY- II (2+1)

Course Objectives:

This course is a continuation of Principles of Biochemistry I, and aims to familiarize students with the key concepts of intermediary metabolism of proteins, nucleic acids, carbohydrates and lipids.

Course Contents:

Introduction to metabolism and basic aspects of bioenergetics and biochemical thermodynamics (endergonic and exergonic reactions); phosphoryl group transfer and ATP production; metabolism, oxidation-reduction; carbohydrate metabolism and regulation (glycolysis, glycogenolysis; gluconeogenesis; pentose phosphate pathway); citric acid cycle (reactions, energetics and control), electron transport chain, oxidative phosphorylation, shuttle mechanisms (glycerol-phosphate shunt), lipid metabolism (energy yield from fatty acid oxidation, ketone bodies, acyl glycerol, compound lipids, cholesterol); photosynthesis; Calvin Cycle; metabolism of nitrogenous compounds (amino acid synthesis, catabolism, purine and pyrimidine synthesis); nucleic acid metabolism and control; urea cycle; integration of metabolism.

Practical:

Basic biochemical methods such as iodine test for polysaccharides, fermentation of sugars by Baker's yeast; isolation of amylose and amylopectin from starch; extraction of glycogen from liver; acid and enzymatic hydrolysis of glycogen; extraction and estimation of lipids from plant tissue/seed and lipid separation from different tissues; fractionation by thin layer chromatography (TLC).

Recommended Books:

1. Nelson DL and Cox MM, 2012. Lehninger Principles of Biochemistry. 6th Edition; WH Freeman, New York. (available at www.ncbi.nlm.nih.gov)
2. Stryer et al., 2006. Biochemistry. 6th Edition; WH Freeman, New York. (available at www.ncbi.nlm.nih.gov)
3. Voet D and Voet TG, 2008. Biochemistry. Fourth Edition; John Wiley and Sons, New York.
4. Murray et al., 2012. Harper's Illustrated Biochemistry. 29th Edition; McGraw-Hill Medical Publishing.
5. Ferrier DR, 2013. Lippincott's Biochemistry. 6th Edition; Lippincott Williams &Wilkin Publishing Company.
6. Schantz JT, 2007. A Manual for Biochemistry Protocols. World Scientific Publishing. (*available online*)

ANALYTICAL CHEMISTRY AND INSTRUMENTATION (2+1)

Course Objectives:

To acquaint students with key analytical chemistry concepts involving identification and analysis at the molecular level by introducing a variety of analytical chemistry techniques and their applications at the molecular level**;** designing analytical chemistry methods to obtain analysis data with the high precision and accuracy from experiments**;** demonstrating biochemical laboratory techniques and explaining the theory and background behind these techniques.

Course Contents:

Introduction to various analytical techniques; principles and applications of various types of chromatography including paper, thin layer, gel filtration, ion-exchange, affinity, high performance liquid chromatography (HPLC), gas chromatography, GC-MS and LC–MS; spectroscopy types including nuclear magnetic resonance (NMR), visible, ultraviolet, luminescence, flame, atomic absorption, fluorescence, emission and inductively coupled plasma emission spectroscopy (ICPMS); principles and applications of flow cytometry; introduction to X-ray diffraction; general analytical instrumentations and methods of fractionation and characterization of proteins and nucleic acids including dialysis, ultra-filtration, lyophilisation, ultracentrifuge and amino acid analyzer.

Practical:

Separation of biomolecules by paper, column and thin layer chromatography; determination of molecular weight of proteins by gel filtration; identification of sugars, proteins, electrolytes etc. by UV/Visible spectrophotometer; determination of sodium and potassium content in blood serum by flame photometer and mineral analysis of plant tissues using atomic absorption spectrophotometer.

Recommended Books:

1. Boyer RF, 2011. Biochemistry Laboratory: Modern Theory and Techniques. Second Edition; Prentice Hall
2. Wilson K, 2010. Principles and Techniques of Biochemistry and Molecular Biology. Seventh Edition; Cambridge University Press.
3. Christian GD, 2003. Analytical Chemistry. Sixth Edition, John Wiley and Sons, New York.
4. Chung et al., 2005. Analytical Methods validation and Instrument Performance verification. First Edition; John Wiley and Sons, New York.
5. Sharma BK, 2005. Instrumental Method of Chemical analysis. First Edition; Meerut Goel Publishing House, India.
6. Harris DC, 2010. Quantitative Chemical analysis. Eighth Edition; WH Freeman, New York.

IMMUNOLOGY (3+0)

Course Objectives:
To acquaint students with the basic principles of innate and adaptive immune systems.

Course Contents:
Overview of the immune system as the body's main defence mechanism; elements of innate and acquired immunity; cells and organs of the immune system; properties of antibodies and antigens together with their structure, function and interactions; genetics of antibody structure and diversity; expression of immunoglobulin genes; VDJ recombination; antigen processing and presentation; major histocompatibility complex; monoclonal and polyclonal antibodies; T-cell receptors, maturation, activation, and differentiation; B-cell generation, activation, and differentiation; complement system, hypersensitivity, cytokines, resistance and immune response to infectious diseases, cell-mediated effector response, leukocyte migration and inflammation, vaccines, diseases of the immune system - autoimmunity, transplantation immunology.

Practical:
Agglutination tests; enzyme-linked immunosorbent assay (ELISA); blood group determination (ABO and Rh); Western blot; Ouchterlony analysis

Recommended Books:

1. Kuby J, 2007. Immunology. 6th Edition; WH Freeman, New York.
2. Janeway et al., 2001. Immunobiology - The immune system in health and disease. 5th Edition; Garland Science Publisher, New York.
3. Anderson WL, 1999. Immunology. 1st Edition; Wiley-Blackwell.
4. Delves PJ et al., 2012. Roitt's Essential Immunology. 12th Edition. Wiley-Blackwell
5. Abbas AK and Lichtman AH, 2010. Basic Immunology: Functions and Disorders of the Immune System. Third illustrated Edition; Saunders Publisher.
6. Harlow E and David L, 1988. Antibodies, A laboratory Manual. 1st Edition; Cold Spring Harbor laboratory Press.

GENETIC RESOURCES AND CONSERVATION (3+0)

Course Objectives:
To acquaint students with importance of bio-resources and their conservation especially in relation to Pakistan.

Course Contents:
Introduction to genetic resources and their significance; plant genetic resources - utilization, opportunities and constraints; strategic role of plant genetic resources in achieving global food security and sustainable agriculture; overview of wild and domesticated genetic resources of Pakistan; genetic diversity in endangered species; genotype-environment interactions; gene pools and genetic boundaries; genetic drift, inbreeding, migration and gene flow; introduction to extinction and its causes; threatened animal and plant species; conservation of genetic resources through mapping of existing biological diversity; assessing

conservation status; management strategies; laws and treaties of conservation; quarantine regulations; future prospects of genetic conservation.

Recommended Books:

1. Primack RB, 2012. A Primer of Conservational Biology. 5th Edition; Sinauer Associates Inc.
2. Virchow D, 1999. Conservation of Genetic Resources: Costs and Implications for a Sustainable Utilization of Plant Genetic Resources for Food and Agriculture. Springer.
3. Mills LS, 2012. Conservation of Wildlife Populations: Demography, Genetics, and Management.2nd Edition; Wiley-Blackwell.
4. Kamau EC and Winter G, 2009. Genetic Resources, Traditional Knowledge and the Law: Solutions for Access and Benefit Sharing. 1st Edition; Earthscan.
5. Primack RB, 2010. Essentials of Conservational Biology. 5th Edition; Sinauer Associates Inc.
6. Frankham R, 2010. Introduction to Conservation Genetics. 2nd Edition; Cambridge University Press.

PROBABILITY AND BIOSTATISTICS (3+0)

Course Objectives:

To acquaint students with statistical techniques frequently used in biology to process real data.

Course Contents:

Frequency distribution, exercise frequency distribution, measures of central tendency, measures of dispersion and measures of location. Second part of the study will cover the areas of statistical hypothesis and significance, null and alternative hypothesis, confidence interval, tests involving binomial distribution, tests involving normal distribution, F-distribution, student's t-distribution, chi-square test, tests of independence and contingency tables. In the third part lectures will cover the following topics: Analysis of Variance (ANOVA), LSD test, experimental designs, Completely Randomized Design (CRD), Randomized Complete Block Design (RCBD), Latin Square Design, Markov chains and Models and their applications in Bioinformatics such as gene predication, sequence analysis, profile HMMs, probabilistic approaches to phylogeny, etc.

Recommended Books:

1. Mann PS, 2010. Introductory Statistics. 7th Edition; John Wiley and Sons.
2. Freund JE and Perles MB, 2005. Modern Elementary Statistics; 12th Edition. Pearson.
3. Chaudhry SM, 2005. Introduction to statistical theory. 6th Edition; Markazi Kutub Khana, Lahore.
4. Chernick MR and Friis RH, 2003. Introductory Biostatistics for the Health Sciences: Modern Applications Including Bootstrap. First Edition; Wiley Inter science.
5. Le CT, 2003. Introductory Biostatistics. First Edition; Wiley Inter science.

INTRODUCTION TO BIOTECHNOLOGY (3+0)

Course Objectives:
To acquaint students with the basic concepts and significance of biotechnology as it stands today.

Course Contents:
Biotechnology- definition and history; foundations of biotechnology and interdisciplinary pursuit; branches and/or applications of biotechnology in medicine, agriculture (food, livestock, fisheries, algae, fungi, etc.); protection of biotechnological products; safety in biotechnology; public perception of biotechnology; biotechnology and ethics; biotechnology and the developing world

Recommended Books:

1. Daugherty E, 2012. Biotechnology: Science for the New Millennium. 1st Edition, Revised; Paradigm Publication.
2. Smith JE, 2009. Biotechnology. 5th Edition; Cambridge University Press.
3. Nicholl TSD, 2004. An Introduction to Genetic Engineering. 2nd Edition; Cambridge University Press, UK.
4. Purohit SS, 2005. Biotechnology Fundamentals & Application. 4th Edition; Agro Bios, India.
5. Ratlegde C and Kristiansen B, 2006. Basic Biotechnology. 2nd Edition; Cambridge University Press, UK.
6. Thomas JA and Fuchs RL, 2002. Biotechnology and Safety Assessment. 3rd Edition; Academic Press, UK.

MICROBIAL BIOTECHNOLOGY (3+0)

Course Objectives:
To acquaint students with how modern methods may be employed to enhance the characteristics of microbes that are commonly used in various industries including food, agriculture and pharmaceutical.

Course Contents:
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 environmental sources; lab scale production of bacterial enzymes; lab-scale production of alcohol by yeast; the use of microbes in bioleaching; use of microbes in microbial enhanced oil recovery.

Recommended Books:

1. Glick BR et al., 2009. Molecular Biotechnology: Principles and Applications of Recombinant DNA. 4th Edition; ASM Press.

2. Mukhopadhyay SN, 2004. Process Biotechnology Fundamentals. 2nd Edition. Anshan Publisher.
3. Goodsell DS, 2004. Bionanotechnology: Lessons from Nature. John Wiley and Sons.
4. Ray RC, 2005. Microbial Biotechnology in Agriculture and Aquaculture. NBN International.
5. Kreuzer H and Massey A, 2005. Biology and Biotechnology Science, Applications, and Issues. 1st Edition; ASM Press.
6. Harding SE, 2010. Biotechnology and Genetic Engineering Reviews. 1st Edition. Nottingham University Press.

CLASSICAL GENETICS (3+0)

Course Objectives:
To acquaint students with classical aspects of genetics.

Course Contents:
Classical Mendelian genetics; monohybrid crosses, dominance, re-cessiveness, co-dominance, and semi-dominance; principle of independent assortment; dihybrid and trihybrid ratios; gene interactions; epistasis and multiple alleles; ABO blood type alleles and Rh factor alleles in humans; probability in Mendelian inheritance; structure of chromosomes; organization of genes and genomes; nucleic acid function; DNA as warehouse of genetic information; experimental evidence that DNA is genetic material; sex determination; linkage and crossing over.

Recommended Books:
1. Snustad DP and Simmons MJ, 2008. Principals of Genetics. 5th Edition; John Willy & Sons, New York.
2. Klug WS and Cumming MR, 2008. Concepts of Genetics. 9th Edition; Prentice Hall, USA.
3. Pierce B, 2004. Genetics: A Conceptual Approach. 2nd Edition; WH Freeman, New York.
4. Brooker R, 2011. Genetics: Analysis and Principles. 4th Edition; McGraw-Hill.
5. Pierce BA, 2011. Genetics: A conceptual approach. 4th Edition. WH Freeman Publisher.

MOLECULAR BIOLOGY (3+0)

Course Objectives:
To acquaint students with the chemistry and biology of macromolecules.

Course Contents:
Introduction to molecular biology and history; structure and function of DNA; chromatin and structure of chromosomes; protein structure and function; DNA replication in prokaryotes and eukaryotes; transcription in prokaryotes and eukaryotes; post transcriptional processing (e.g., RNA splicing, alternative splicing, editing); genetic code; translation, post-translational processing in prokaryotes and eukaryotes; protein folding, targeting and turnover; DNA

damage and repair, recombination and transposable elements. Signaling and control of gene regulation in prokaryotes and eukaryotes.

Recommended Books:

1. Nelson D and Cox MM, 2009. Lehninger Principles of Biochemistry. 5th Edition; WH Freeman, New York.
2. Lodish et al., 2012. Molecular Cell Biology. 7th Edition; WH Freeman, New York
3. Berg et al., 2006. Biochemistry. 6th Edition; WH Freeman, New York.
4. Alberts et al., 2007. Molecular Biology of the Cell. 5th Edition; Garland Science
5. Weaver R, 2011. Molecular Biology. 5th Edition; McGraw-Hill

METHODS IN MOLECULAR BIOLOGY (1+2)

Course Objectives:

To acquaint students with the experimental aspects of molecular biology

Course Contents:

Introduction to recombinant DNA technology; restriction and modifying enzymes; cloning and expression vectors and their types; expression of recombinant proteins and their purification by affinity chromatography; polymerase chain reaction (PCR) - types; (inverse, touch-down, nested, hemi-nested, pit stop, multiplex, reverse transcriptase, RACE, real-time) and its applications; detection of mutations and/or SNPs; DNA fingerprinting; analysis of nucleic acids by gel electrophoresis – horizontal, vertical, pulse field, denaturing gradient gel electrophoresis; analysis of proteins by native and SDS-PAGE; 2-D gels; generation of antibodies and their uses; enzyme-linked immunosorbant assay; Southern, Western, Northern blotting.

Practical:

Preparation of stock and working solutions; isolation of nucleic acids and their quantification; restriction digestion of DNA and preparation of restriction maps; 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

Recommended Books:

1. Ausubel FM, 2005. Short Protocols in Molecular Biology (2 volume set). 5th Edition; John Wiley and Son.
2. Green MR and Sambrook J, 2001. Molecular Cloning: A Laboratory Manual. 3rd Edition; Cold Spring Harbor Laboratory Press.
3. Primrose SB and Twyman R, 2006. Principles of Gene Manipulation and Genomics. 7th Edition; Wiley-Blackwell.
4. Wilson K and Walker J, 2010. Principles and Techniques of Biochemistry and Molecular Biology. 7th Edition; Cambridge University Press.
5. Walker JM and Rapley, 2008. Molecular Biomethods Handbook (Methods in Molecular Biology). 2nd Edition; Humana Press.

DETAIL OF MAJOR COURSES

RESEARCH METHODOLOGY & SKILL ENHANCEMENT (3+0)

Course Objectives:
To familiarize students with various methods used for conducting research and latest trends in the field of biotechnology through reading and understanding scientific literature, preparing scientific manuscripts, designing research projects and presenting them.

Course Contents:
Introduction; unethical academic practices (plagiarism); need of research and research types; extraction and review of literature; identifying a research problem and formulating a hypothesis; designing a study; data collection, interpretation and analysis; writing a research report, project, thesis and/or research article or review; preparing posters; making scientific presentations; intellectual property.

Recommended Books:

1. Bryman A, 2001. Social research methods. 2nd Edition; Oxford University Press.
2. Awan JA, 2003. Scientific Presentation. Unitech Communication, Faisalabad, Pakistan.
3. Kumar R, Kindersley D, 2010. Research Methodology: A step by step guide for beginners. Third Edition; SAGE Publications.
4. Kothari CR, 2004. Research Methodology: Methods and Techniques. Second Revised Edition; New Age International Publishers, New Delhi.
5. Durrani SA, 2004. Technical Writing. Higher Education Commission, Islamabad.

INDUSTRIAL BIOTECHNOLOGY (3+0)

Course Objectives:
To provide students with a broad-based introduction to the field of industrial biotechnology.

Course Contents:
Industrial biotechnology – introduction and scope; microorganisms commonly used in industry; media and nutritional requirements of industrial organisms; screening for productive strains and strain improvement; culture collections; fermentation and fermenters; extraction of fermented products; production of beer, wines, spirits and vinegar; use of single cell proteins as food products; biocatalysts; microbial insecticides; production of metabolites: organic acids and amino acids; vaccines and antibiotic production

Practical:
Isolation of *lactobacillus* from dairy products, fruit juices, etc.; fermentation of different sugars by bacteria (or other microorganisms); identification of proteases/ amylases producing bacteria; extraction of hydrolytic crude enzymes from microbes; effect of environmental factors (e.g., pH, temperature, salt, etc.) on activity of crude enzymes.

Recommended Books:

1. Okafor N, 2007. Modern Industrial Microbiology and Biotechnology. 1st Edition; Science Publishers, USA.
2. Waites et al., 2001. Industrial Microbiology: An Introduction. Blackwell Science Ltd.
3. Shara et al., 2009. Industrial Biotechnology. 1st Edition; Nova Science Publishers
4. Abhilasha MS, 2009. Industrial Biotechnology. ANE Books
5. Singh R and Ghosh S, 2004. Industrial Biotechnology. Global Vision Publishing House

HEALTH BIOTECHNOLOGY (3+0)

Course Objectives:

To acquaint students with biotechnology in healthcare including diagnostic tools, immunization and therapeutics.

Course Contents:

Introduction to health biotechnology; social acceptance of medical biotechnology; molecular basis of disease; molecular and genetic markers; detection of mutations and infectious agents; active and passive immunization; vaccines (live, killed, recombinant DNA vaccines, subunit vaccines, DNA vaccines, edible vaccines); organ transplantation; applications of transgenic animals (animal models of diseases, farming and enhancement of farm animals); drug delivery systems; blood transfusion and grafting techniques; pharmacogenetics; gene therapy; biopharmaceuticals from plants; stem cell technology

RECOMMENDED BOOKS:

1. Pongracz J. and Keen M. 2009. Medical Biotechnology. 1st Edition; Elsevier Health Sciences.
2. Schacter B. Z. 2005. Biotechnology and Your Health: Pharmaceutical Applications. Chelsea House Publishers,
3. Chetan DM and Dinesh KP, 2006. Health and Pharmaceutical Biotechnology. Firewall Media.
4. Bustillo LGT and Pena IG, 2012. Biotechnology: Health, Food, Energy and Environment Applications (Biotechnology in Agriculture, Industry and Medicine). Nova Science Publication.
5. Dogramatzis, 2010. Health care Biotechnology. 1st Edition; CRC Press

ENVIRONMENTAL BIOTECHNOLOGY (3+0)

Course Objectives:

To acquaint students with conservation and reclamation of environment through biotechnology

Course Contents:

Introduction to environmental biotechnology; fundamentals of biological interventions; genetic manipulation strategies in environmental biotechnology; pollution indicators and pollution control strategies; bioreactors; domestic waste water treatment; industrial effluent treatment; sludge treatment; contaminated

land and bioremediation; phytoremediation; landfills and composts; concept of integrated environmental biotechnology; biodegradation and biotransformation of hazardous chemicals; products of environmental biotechnology.

Practical:

Biodegradation of environmental pollutants by microorganisms; bacteriology of drinking water; microscopic studies of water specimens collected from various locations; field survey of polluted areas and field study for pollution indicators (e.g., plants, microorganisms and air).

Recommended Books:

1. Fluker MH, 2010. Environmental Biotechnology. CRC Press.
2. Faster CF and Wase J, 2004. Environmental Biotechnolog. John Willey & Sons.
3. Evans GM and Furlong JC, 2010. Environmental Biotechnology Theory and Application. 2nd Edition; Wiley-Blackwell Publishers.
4. Srinivas T, 2008. Environmental Biotechnology. 1st Edition; New Age International Publishers.
5. Spencer JFT and Spencer ALR, 2004. Environmental Microbiology: Methods and Protocols (Methods in Biotechnology). 1st Edition; Humana Press.
6. Hurst et al., 2007. Manual of Environmental Microbiology. 3rd Edition; ASM Publishers.

BIOINFORMATICS (1+2)

Objectives:

To familiarize students with biological data mining from online databases and the use of various bioinformatics tools for extracting and processing biological data.

Course Contents:

Introduction; bio-computing; biological databases - types and retrieval of nucleic acid (or genomic) or protein sequence information; sequence alignment - pairwise, multiple; phylogenetics; *in silico* identification of protein motifs and domains; structural bioinformatics of proteins and RNAs including protein modeling and prediction of their interactions with other proteins and small molecules; identification of genes and promoter regions within genomes; networks; strategies for whole genome sequencing and assembly.

Recommended Databases and Tools:

1. NCBI, PDB, EcoCyc, DDBJ, SWISS-PROT, TIGR, KEGG etc.
2. Bioedit, Repeatmasker, PHRED, PHRAP, BLAST, Prosite/BLOCKS/PFAM, CLUSTALW, Emotif, RasMol, Oligo, Primer3, Molscript, Treeview, Alscript, Genetic Analysis Software, Phylip, MEGA4.0 etc.

Recommended Books:

1. Claverie JM and Notredame C, 2006. Bioinformatics for Dummies. 2nd Edition; Wiley Publishing.
2. Xiong J, 2006. Essential Bioinformatics. 1st Edition; Cambridge University Press.
3. Xia X, 2007. Bioinformatics and the Cell: Modern Computational Approaches in Genomics, Proteomics and Transcriptomics. 1st Edition. Springer

4. Mathura V and Kangueane P, 2009. Bioinformatics: A Concept-Based Introduction. Springer
5. Mount DW, 2004. Bioinformatics Sequence and Genome Analysis. 2nd Edition; Cold Spring Harbor Laboratory Press.
6. Sperschneider V, 2008. Bioinformatics: Problem Solving Paradigms. Springer.

AGRICULTURE BIOTECHNOLOGY (3+0)

Course Objectives:
To acquaint students with techniques and skills employed for producing transgenic crops.

Course Contents:
Agriculture biotechnology and its applications in crop improvements; cell and plant tissue culture methodology; improvement of plants via plant cell culture; plant molecular biomarkers; direct and indirect methods of plant and animal transformation: gene gun method of transformation, *Agrobacterium* mediated transformation, chloroplast transformation and polyethylene glycol (PEG) mediated transformation; transgenic crops with herbicide, biotic and abiotic stress resistance; problems related to transgenic plants; genetically modified organisms (GMOs); field evaluation and commercialization of GMOs; possible effects of releasing GMOs into the environment; bio-fertilizers, bio-pesticides and their types; non-symbiotic nitrogen fixers; present and future prospects of bio-fertilizers.

Practical:
Preparation of Murashige and Skoog medium and stocks of macronutrients, micronutrients, and hormones; selection of ex-plant, medium preparation and callus induction; culturing *Agrobacterium* and using it to infect plant callus; selection of trans formant's; regeneration of plantlets and acclimatization; plant DNA extraction and PCR for detecting introduction of foreign DNA into plants.

Recommended Books:
1. Qaim M, 2010. Agricultural Biotechnology in Developing Countries: Towards Optimizing Benefits for Poor. Springer
2. Kemp Ken F, 2010. Genetic Modification of Plants: Agriculture, Horticulture and Forestry (Biotechnology in Agriculture and Forestry). Springer.
3. Herren RV, 2012. Introduction to Agricultural Biotechnology. 2nd Edition; Delmar Cengage Learning.
4. Slater A, 2008. Plant Biotechnology: The Genetic Manipulation of Plants. 2nd Edition; Oxford University Press, USA
5. Altman A, 2011. Plant Biotechnology and Agriculture: Prospects for the 21st Century. 1st Edition; Academic Press.

FOOD BIOTECHNOLOGY (3+0)

Course Objectives:
To acquaint students with the role of microorganisms in food and the food industry in addition to principles of enzymology, and food engineering

Course Contents:
Food composition, probiotics, fermented foods, food enzymes, colors and additives; overview of metabolic engineering of bacteria for food ingredients;

techniques used for production of food ingredients by microbes; genetic modification of plant starches for food applications; biotechnological approaches to improve nutritional quality and shelf life of fruits and vegetables; microbial food spoilage and food borne diseases; detection and control of food borne bacterial pathogens; food safety and quality control; international aspects of quality and safety assessment of food derived by modern biotechnology.

Practical:

Pure culture study of fermented products such as yogurt, bread, pickles, acetic acid etc.; isolation and handling of microbial flora of fermented products as *Lactobacilli, Saccharomyces, Aspergillus, Acetobacter* etc.; preparation of fermented products using pure cultures; effect of pH on the microbial flora of different fermented products.

Recommended Books:

1. Joshi VK, 2012. Food Biotechnology. 1st Edition; I K International Publishing House.
2. Campbell-Platt G, 2009. Food Science and Technology. 1st Edition; Wiley-Blackwell.
3. Singh RP, 2008. Introduction to Food Engineering. 4th Edition; Academic Press
4. Belitz HD, 2009. Food Chemistry. 4th Edition; Springer.
5. Nielsen SS, 2010. Food Analysis. 4th Edition; Springer

PRINCIPLES OF BIOCHEMICAL ENGINEERING (2+1)

Course Objectives:

To acquaint students with fundamentals of biochemical engineering.

Course Contents:

Introduction to microorganisms and biological molecules; principles of enzyme catalysis; methods of enzyme and cell immobilization; enzyme kinetics; internal mass transfer effect on immobilized growth; stoichiometry models of microbial growth; structured model, of microbial growth; bioreactors - continuous stirred tank bioreactors, plug-flow and packed bed bioreactors, imperfect mixing, fed batch bioreactors, gas liquid mass transfer in bioreactors, power requirement for bioreactor, sterilization and heat transfer in bioreactors; introduction to bioproduct recovery; biological product manufacturing; economic analysis of bioprocesses; case study: penicillin.

Practical:

Unstructured microbial growth with application of Monod model; inhibition kinetics and nutrient uptake rate; methods of immobilization via binding and physical retention; yield coefficient and stoichiometry; production of enzymes by structured and segregated models; bioreactor design and analysis (batch, fed-batch and continuous); enzyme catalysis in the CSTR; packed bed and plug flow bioreactor; rheology of fermentation broth; mixing and gas-liquid mass transfer, heat transfer, media and bioreactor sterilization techniques; techno-economic analysis of a typical bioprocess.

Recommended Books:

1. Douglas SC and Blanch HW, 1997. Biochemical Engineering. 2nd Edition; CRC Publishers.

2. Bailey et al., 1986. Biochemical Engineering Fundamentals. 2nd Edition; McGraw-Hill
3. Aiba et al., 1973. Biochemical Engineering. 2nd Edition; Academic Press.
4. Katoh S and Yoshida F, 2009. Biochemical Engineering, a textbook for engineers, chemists and biologists. Wiley VCH
5. Clark DS and Blanch HW, 1997. Biochemical Engineering, 2nd Edition (Chemical Industries). 2nd Edition; CRC Press.

GENOMICS AND PROTEOMICS (3+0)

Course 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 genomics as well as proteomics.

Course Contents:

Organization and structure of genomes; genetic mapping (RFLP, microsatellite, SNP); high-resolution physical mapping (STS, EST); flow cytometry; somatic cell and radiation hybrids; artificial chromosomes in bacteria and yeast; hierarchical and whole genome shotgun sequencing; DNA sequencing strategies - manual and automated sequencing, pyro-sequencing, Solexa, Helicos, Roche 454, real-time and nano-pore 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; microarray and RNA interference; 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 co-immunoprecipitation.

Recommended Books:

1. Strachan T and Read AP, 2010. Human Molecular Genetics. 4th Edition; Garland Science.
2. Saccone C and Pesole G, 2003. Handbook of Comparative Genomics: Principles and Methodology. 1st Edition; Wiley-Liss.
3. Town C, 2002. Functional Genomics. First Edition; Springer.
4. Krebs et al., 2010. Lewin Genes X. 10th Edition; Jones and Bartlett Publishers.
5. Al-Rubeai M and Fussenegger M, 2010. Systems Biology (Cell Engineering). 1st Edition; Springer.

DETAIL OF ELECTIVE COURSES

ANIMAL BIOTECHNOLOGY (2+1)

Course Objectives:
To acquaint students with techniques for engineering transgenic animals and embryonic micromanipulations

Course Contents:
Introduction and history of transgenic animals; role of synthetic peptides/proteins in animal health; use of monoclonal antibodies as a diagnostic/therapeutic agents; cytokines and their potential therapeutic value as applicable to the diagnosis of microbial infections; micromanipulations of farm animal embryos; use of biotechnological techniques in animal breeding strategies; gene transfer through embryo microinjection; ethical and social issues in animal biotechnology.

Practical:
Aquaculture methods and various DNA recombinant techniques for animal biotechnology

Recommended Books:

1. Freshney IR, 2010. Culture of animal cells: A manual of basic techniques and specialized application. 6th Edition; Wiley-Blackwell
2. Masters JR, 2000. Animal cell culture. 3rd Edition; Oxford University Press.
3. Lanza et al., 2001. Methods of tissue engineering Academic Press Inc.
4. Doyle et al., 1998. Cells and tissue culture: Laboratory procedures in biotechnology. Wiley, John and Sons.
5. Barnum S, 2004. Biotechnology: An Introduction (with Infotrac) Brooks /Cole.
6. Tourte Y and Catherine TC, 2005. Genetic Engineering and Biotechnology: Concepts, Methods, and Agronomic Applications. Science Publishers.
7. Houdebine LM, 2003. Animal Transgenesis and Cloning. 1st Edition; John Wiley and Sons.

MARINE BIOTECHNOLOGY (3+0)

Course Objectives:
To acquaint students with recent advancements in the field of marine biotechnology and how molecular techniques may be applied for studying marine organisms.

Course Contents:
Introduction to marine microorganisms and marine biotechnology; marine flora/phytoplankton; aquaculture techniques; marine microbes of biotechnological importance; primary and secondary metabolites (e.g., antibiotics, organic acids, toxins, etc); role of marine microbes in global carbon cycling; genomics of marine organisms; recent progress in discovery of drugs and enzymes from marine sources.

Recommended Books:

1. Gal YL, 2010. Marine Biotechnology I (Advances in Biochemical Engineering Biotechnology). Springer.
2. Gal YL, 2010. Marine Biotechnology II (Advances in Biochemical Engineering Biotechnology). Springer.
3. Kim SK, 2011. Handbook of Marine Microalgae: Biotechnology and Applied Physiology. 1st Edition; Wiley.
4. Johansen MN, 2011. Microalgae: Biotechnology, Microbiology and Energy. Nova Science Pub Inc.
5. Buchholz R, 2012. Microalgae Biotechnology. Walter De Gruyter Inc.
6. Gal YL 2010. New Developments in Marine Biotechnology. Springer

RADIOBIOLOGY (3+0)

Course Objectives:

To acquaint students with use of radiation and radioactive materials in agriculture, health and basic research

Course Contents:

Introduction to radiobiology, radioisotopes and types and sources of radiation; physics of radioactive substances; effects of radiation on living cells; exposure and radiation dose-effect; molecular basis of cellular effects and cell radiation sensitivity; radiation therapy, radiation protection, safety measures and treatment of radiation injuries; fundamental aspects and relationship of imaging physics and radiobiology including current regulation and recommendations in radiation biology, radiological technologies and labeling techniques; use of radioisotopes as diagnostic and therapeutic tools.

Practical:

To enhance awareness of radiation use, visits to different medical centers/hospitals will be arranged for students for studying different types of radiation in use for treating various conditions; visit to different stations/offices where any type of radio waves, electromagnetic waves etc. are in continuous use and collecting data about any harmful effects.

Recommended Books:

1. Wambersie A, 2007. Introduction to Radiobiology. Tylor and Francis.
2. Nias AHW, 2007. Introduction to Radiobiology. Academic Press.
3. Forshier CM, 2008. Essentials of Radiation, Biology and Protection. 2nd Edition. Cengage Learning Press
4. Washington CM, 2009. Principles and Practice of Radiation Therapy. Elevier Health Sciences
5. Dder Kogel AV and Joiner M, 2009. Basic Clinical Radiobiology. 4th Edition; A Hodder Arnold Publication

HOSPITAL WASTE MANAGEMENT (2+1)

Course Objectives:
To acquaint students with the principles and applications of clinical waste management.

Course Contents:
An introduction to the management of infectious materials/waste; various types of infectious material and methods of their handling and disposal; laboratory and hospital acquired infections - possible sources and causes; hazardous microorganisms; basic containment rules and laboratory contamination levels, control measures; guidelines for workers in microbiology and pathology labs, and post-mortem rooms; rules for safe conduct during field work and outdoor activities; risk assessment including recognition of hazards; competence and elimination of hazards; collection of data, etc.; risk group personnel and their education, training and monitoring; radiation hazards and disposal of radioactive waste.

Practical:
Techniques for waste minimization; waste sorting; anaerobic and aerobic compositing; industrial and hospital waste treatment processes.

Recommended Books:

1. LaGrega et al., 2001. Hazardous Waste Management. 2nd Edition; McGraw-Hills.
2. McDougall et al., 2001. Integrated Solid Waste Management: A Life Cycle Inventory. 2nd Edition; Blackwell Publishers.
3. WHO Biosafety Manual, World Health Organization, 2001. WHO, Geneva.
4. Garvin ML, 1995. Infectious Waste Management: A Practical Guide. Lewis Publishers, Inc.
5. Wayne LT, 1995. Biohazardous Waste: Risk Assessment, Policy, and Management. Lewis Publishers, Inc.
6. Hickman HL and Anderson WC , Principles of Integrated Solid Waste Management. MSW Management

WATER AND WASTE WATER TREATMENT (2+1)

Course Objectives:
To acquaint students with the principles and applications of treatment systems for water, waste water and hazardous wastes.

Course Contents:
Water and wastewater sources and characteristics; drinking water treatment process; industrial effluent treatment process; novel treatment processes and recycling technology; theory and application of commonly used processes; sedimentation, coagulation, filtration, disinfection, gas transfer, activated sludge, trickling filters, oxidation ponds, sorption, and sludge stabilization and disposal; process combinations to produce treatment systems; role of microorganisms in waste treatment; utilization and management of waste; microbial characterization.

Practical:

Designing individual aerobic and anaerobic unit processes; physicochemical characteristics of drinking water and waste water; analytical analysis of drinking and waste water for detecting heavy metals and minerals.

Recommended Books:

1. Metcalf and Eddy, 2003. Waste water Engineering: Treatment, Disposal, and Reuse. 4th Edition; McGraw-Hill.
2. Clark N and Crull A, 1997. Bioremediation of Hazardous Wastes, Waste Water and Municipal Waste. Business Communication
3. Maier et al., 1999. Environmental Microbiology. Academic Press Inc.
4. Bitton G, 2011. Wastewater Microbiology. 4th Edition; Wiley-Blackwell.
5. Csuros M and Csuros C, 1999. Microbiological Examination of Water and Wastewater. 1st Edition; CRC Press.

NANOBIOTECHNOLOGY (3+0)

Course Objectives:

To acquaint students with key integrative technologies and use of nanoparticles in biological systems

Course Contents:

Introduction; interface between nanotechnology and bio-nanotechnology; manipulating molecules; carbon fullerenes and nanotubes; non-carbon nanotubes and fullerene-like materials; quantum dots; nanowires, nanorods and other nanomaterial's; magnetic nanoparticles; natural biological assembly at the nanoscale and nanometric biological assemblies (complexes); nanobionics and bio-inspired nanotechnology; applications of biological assemblies in nanotechnology; medical, cosmetics, agriculture, water and other applications of nano-biotechnology; future prospects of nano-biotechnology; use of nanotechnology for diagnosing and curing disease.

Recommended Books:

1. Gazit E, 2007. Plenty of Room for Biology at the Bottom: An Introduction to Bionanotechnology. 1st Edition; Imperial College Press.
2. Renugopalakrishnan V and Lewis RV, 2006. Bio-nanotechnology: Proteins to Nano devias. Springer.
3. Greco et al., 2004. Nano Scale Technology in Biological Systems. CRC Press.
4. Mirkin CA and Niemeyer CM, 2007. Nano-biotechnology II: More Concepts and Applications. John Wiley & Sons.
5. Niemeyer CM and Mirkin CA, 2004. Nano-biotechnology. 1st Edition; Wiley VCH.

FUNGAL BIOTECHNOLOGY (3+0)

Course Objectives:

To acquaint students with the understanding of fungi and their utilization in industry and agriculture

Course Contents:

Introduction to mycology; production techniques used in fungal biotechnology; metabolites produced by fungi; utilization of fungi in medical and agricultural

biotechnology; industrial uses of fungi including food manufacturing; bio-deterioration and biodegradation; biotechnology and the control of pathogenic fungi; current applications of fungal biotechnology and screening of fungal metabolites; mycotoxins.

Practical:

Fungal morphology; identification of fungi; sexual and asexual reproductive structures of fungi; DNA extraction from hyphae and zoospores; molecular techniques for detecting genetic variations among different fungi.

Recommended Books:

1. Tkacz JS and Lange L, 2004. Advances in fungal Biotechnology for Industry, Agriculture and Medicine. 1st Edition; Springer.
2. Arora et al., 2003. Fungal Biotechnology in Agricultural, Food and Environmental Applications. 1st Edition; CRC Press.
3. An Z, 2004. Handbook of Industrial Mycology. 1st Edition; CRC Press
4. Sati SC, 2007. Recent Mycological Research: Fungal Biotechnology. IK International Publishing House.
5. Rai M, 2009. Advances in Fungal Biotechnology. IK International Publishing House
6. Carlile et al, 2001.The Fungi. 2nd Edition; Academic Press
7. Arora et al., 2003. Handbook of Fungal Biotechnology. 2nd Edition; CRC Press.
8. Oliver RP and Schweizer M, 1999. Molecular Fungal Biology. 1st Edition; Cambridge University Press.
9. Frisvad et al., 1998. Chemical Fungal Taxonomy. 1st Edition; CRC Press.

PHARMACEUTICAL BIOTECHNOLOGY (3+0)

Course Objectives:

To familiarize students with the general process of drug development, basic concepts of biopharmaceuticals and how they are better than conventional drugs.

Course Contents:

Introduction and basic concepts of pharmaceutical biotechnology; properties of an effective drug; drug development process; selection of a lead molecule from available pool, lab scale studies, pilot scale studies and clinical trials (Phase I, II and III); drug toxicity; impact of genomics and other related technologies on drug discovery; use of DNA and protein microarrays in identification of disease targets and for monitoring effectiveness of drugs; pharmacogenomics; plants and microorganisms as sources of drugs; polymers: classification, polymerization and characterization; controlled drug release system and its advantages and disadvantages over conventional release methods; legal and regulatory issues.

Recommended Books:

1. Kayser O, 2012. Pharmaceutical Biotechnology: Drug Discovery and Clinical Application. 2nd Edition; Wiley-Blackwell.
2. Kokate C, 2012. Textbook of Pharmaceutical Biotechnology. ELSEVIER
3. Crommelin et al.,2007. Pharmaceutical Biotechnology: Fundamentals and Applications. 3rd Edition. Informa Healthcare.

4. am Ende DJ, 2010. Chemical Engineering in the Pharmaceutical Industry: R&D to Manufacturing. 1st Edition; Wiley
5. Subramanian G, 2012. Biopharmaceutical Production Technology. 1st Edition. Wiley-VCH.

BIOSENSORS (3+0)

Course Objectives:
To acquaint students with fundamentals of sensors that are capable of specifically detecting minute quantities of various individual biomolecules or those displayed on cellular or viral surfaces.

Course Contents:
Introduction; miniaturization and microsystems including sensing by optical techniques, field-effect transistors, ion-selective and enzyme-sensitive electrodes; biological signals and their types; amperometric biosensors based on redox enzymes, potentiometric biosensors and enzyme field effect transistors (ENFET); thermal biosensors; optical biosensors based on redox enzymes; indirect affinity sensors; optical and electrical antibody-based biosensor; direct affinity detection using surface plasmon resonance and piezoelectric biosensors.

Recommended Books:
1. Nielson et al., 2003. Bioreaction Engineering Principles. 2nd Edition; Kluwer Academic / Plenum Publisher, New York.
2. Monsi et al., 2011. Fermentation Microbiology and Biotechnology. 3rd Edition; CRC Press.
3. Bone S and Zaba B, 1992. Bioelectronics. 1st Edition; Wiley.
4. Hall EAH, 1991. Biosensors. John Wiley & Sons.
5. Koryta J, 1993. Ions, Electrodes and Membranes. 2nd Edition; John Wiley & Sons.

BIOFUELS AND BIOREFINERIES (3+0)

Course Objectives:
To acquaint students with the sources of biomass and their extraction and processing for common use.

Course Contents:
Biofuels - introduction, types and sources; agro-industrial byproducts and biodegradable materials; genomics of biofuels; metabolic engineering; bio-refineries; biobased industrial products; basics of green bio-refineries; agriculture, forestry and primary refinery raw material; lingo-cellulosic feedstock bio-refinery; whole-crop bio-refinery based on wet/dry milling and products from whole-crop bio-refinery; fundamental sugar platform and syngas platform.

Recommended Textbooks:
1. Kamm et al., 2006. Biorefinery-Industrial Processes and Products Status Quo and Future Directions. Wiley-VCH.
2. Meroehr, 2001. Biotechnology of Ethanol. Wiley-VCH
3. Verts et al., 2010. Biomass to Biofuels: Strategies for Global Industries. 1st Edition; Wiley.

4. Lee S and Shah YT, 2012. Biofuels and Bioenergy: Processes and Technologies (Green Chemistry and Chemical Engineering). First Edition; CRC Press.

MOLECULAR DIAGNOSTICS (3+0)

Course Objectives:
To acquaint students with modern techniques used in molecular diagnostics.

Courses Contents:
Introduction and applications of molecular diagnostics techniques in agriculture and forensic sciences; polymerase chain reaction (PCR); detection of mutations and single nucleotide polymorphisms (SNPs) by restriction fragment length polymorphisms (RFLPs); DNA sequencing; blotting techniques (e.g., Southern, Northern and Western); enzyme-linked immunosorbant assays (ELISA); immunofluorescence staining and immunohistochemistry; micro-arrays; *in situ* hybridization; molecular cytogenetics.

Practical:
ELISA; PCR. Visits to various diagnostic, pathology laboratories and/or research institutes.

Recommended Books:
1. Debnath et al., 2010. Molecular Diagnostics: Promises and Possibilities. Springer
2. Deniese D Wilson, 2008. Manual of Laboratory and diagnostic tests. McGraw-Hills publisher.
3. Brown TA, 2010. Gene Cloning and DNA analysis. 6th Edition. Wiley-Blackwell Publishing.
4. Buckingham et al., 2007. Molecular Diagnostics Fundamentals, Methods, and Clinical Applications. First Edition. FA Davis Publisher.
5. Walker JM and Rapley R, 2005. Medical Biomethods Handbook. Humana Press.

CELL AND TISSUE CULTURE (2+1)

Course Objectives:
The aim of this course is to provide students with a thorough understanding of the importance of cell, tissue and organ culture and its application in life sciences.

Course Outline:
Plant cell and tissue culture: requirements for *in vitro* cultures; culture facilities; sterile techniques; media preparation and handling; callus cultures; cell suspension cultures; protoplast culture; haploid cultures, organ culture; meristem culture for virus elimination; embryo culture and embryo rescue; regeneration of plants and micro-propagation; somaclonal variation; industrial uses of plant cell culture; tissue culture in genetic engineering and biotechnology. **Mammalian cell culture**: origin and principles of cell culture; qualitative characteristics of cell cultures; cell counting and analysis; cryopreservation; cell banking and subculture (variety of different systems); primary cell culture techniques;

development of immortalized cell line; detection of microbial contaminants; animal cells for bioassays and bioproducts; design and operation of animal cell culture bioreactors for therapeutic protein production; growth environment; Stem cell culture

Recommended Books:

1. Setlow JK, 2000. Genetic Engineering: Principles and Methods. Kluwer Academic Publishers.
2. Nicholl DST, 2002. An Introduction to Genetic Engineering. 2nd Edition; Cambridge University Press.
3. Gale YL, 2002. Genetic Engineering.
4. Razdan MK, 2003. Introduction to Plant Tissue Culture. 2nd Edition; Intercept, New York, USA.
5. Lanza et al., 2000. Principles of Tissue Engineering. 2nd Edition; Academic Press, California.
6. Ignacimutu S, 1997. Plant Biotechnology. Oxford IBH Publisher.
7. Punia MS, 1999. Plant Biotechnology and Molecular Biology: A Laboratory Manual. Scientific Publishers.

VIROLOGY (3+0)

Course Objectives:

Aim of this course is to provide a generalized overview of virology as its stands today.

Course Contents:

Historical perspective; general properties of viruses; classification and nomenclature; virus structure and assembly; replication cycle and genetics of viruses; animal and plant viruses; propagation, detection and quantification of viruses; pathogenesis and immune response of viral infections; laboratory diagnosis of viral diseases; vaccines and antiviral drugs; epidemiology; tumor viruses; viral vectors and gene therapy; emerging viruses; specific aspects of selected viral diseases

Recommended Books:

1. Flint et al., 2009. Principles of Virology. ASM Press, USA.
2. Lal S, 2007. The Biology of Emerging Viruses. Wiley-Blackwell, USA.
3. Carter J Saunders V. Virology: Principles and Applications. First Edition; Wiley.
4. Wagner et al., 2007. Basic Virology. Third Edition; Wiley-Blackwell
5. Flint SJ, 2009. Principles of Virology, Vol. 2: Pathogenesis and Control. 3rd Edition; AMS Press

FERMENTATION BIOTECHNOLOGY (2+1)

Course Objectives:

To acquaint students with theoretical and experimental techniques used for fermentation.

Course Contents:

Overview of fermentation technology: definition, economics, applications; strain development and improvement: isolation of microorganisms - plating, criteria for selection and improvement through genetic engineering; growth requirement of various organisms and media preparation; stoichiometry of microbial growth; preparation of inoculum; microbial growth kinetics in batch culture; continuous culture; sterilization: modes & kinetics of sterilization, design of batch and continuous sterilization process, air sterilization & theory of fibrous filters; fluid rheology: classification, Newtonian & non-Newtonian factors effecting $K_L a$ in fermentation vessel; design of bioreactors and configuration for free and immobilized cells; waste treatment; tissue engineering for plant and animal cell cultures; aeration and agitation; product recovery; scaling-up of fermentation process

Practical:

Initiation of a bacterial/plant or animal cell/tissue culture in a simple conical flask or in a fermenter depending on availability and its handling according to the techniques introduced in theory as sterilization, media formulation, growth kinetics, product recovery etc.

Recommended Books:

1. Doran PM, 2012. Bioprocess Engineering Principles.2nd Edition; Academic Press.
2. McNeil B, 2008. Practical Fermentation Technology. John Willey & Sons
3. El-Mansi et al., 2007. Fermentation Microbiology and Biotechnology.CRC Press.
4. Shuler ML and Kargi F, 2002. Bioprocess Engineering: Basic concept. Prentice Hall.

MS/MPHIL BIOTECHNOLOGY COURSES

1. Modern Biotechnology: Principles & Applications
2. Biostatistics & Laboratory Mathematics
3. Bioethics, Biosecurity, Biosafety& Dual Use Education
4. Bioprocess Technology
5. Advances in Cell and Molecular Biology
6. Recent trends in Molecular Diagnostics
7. Research Methods in Biotechnology
8. Advances in Environmental Biotechnology
9. Biotechnology Law & Regulation
10. Molecular Basis of Plant Development
11. Advances in Pharmacogenomics
12. Advances in Molecular Genetics
13. Advances in Protein Chemistry
14. Advances in Bioinformatics
15. Biophysics
16. Advances in Fermentation Technology
17. Advances in Immunology
18. Metabolic Pathways in Plants
19. Regulation of Gene Expression
20. Molecular Evolution
21. Molecular Basis of Plant Breeding
22. Advances in Fungal Biotechnology
23. Advances in Microbiology
24. Advances in Microbial Genetics
25. Recent trends in Biochemical Engineering
26. Protein Engineering and Enzyme Technology
27. Bioremediation and biodegradation
28. Biotechnology of Nonrenewable Resources
29. Advances in Plant Biotechnology
30. Metabolic Engineering and Biofuels
31. Advances in Agriculture Biotechnology
32. Applications of Nanobiotechnology
33. Advances in Industrial Biotechnology
34. Advances in Animal Biotechnology
35. Advances in Biosensor Technologies
36. Forensic Sciences
37. Advances in Plant Tissue Culture
38. Advances in animal cell Culture
39. Medicinal Plant Biotechnology
40. Recombinant DNA Technology
41. Biopharming in Plants, Principles and Techniques
42. Advances in Proteomics
43. Advances in Genomics
44. Microbial Enzyme Technology

45. Biological Safety and Risk Management
46. Advances in Biochemistry
47. Cellular Signaling
48. Advances in Health Biotechnology
49. Advances in Vaccine Research
50. Molecular Systematics

DETAIL OF COMPULSORY COURSES

COMPULSORY COURSES IN ENGLISH FOR BS (4 YEAR) IN BASIC & SOCIAL SCIENCES

English I (Functional English)

Objectives: 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. 3rd Edition. Oxford University Press. 1997. ISBN 0 194313492
      2. Practical English Grammar by A. J. Thomson and A. V. Martinet. Exercises 2. Third edition. Oxford University Press. 1997. ISBN 0 194313506

b) Writing
   1. Writing. Intermediate by Marie-Christine Boutin, Suzanne Brinand and Francoise Grellet. 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. ISBN 0 19 453402 2.

d) Speaking

English II (Communication Skills)

Objectives: Enable the students to meet their real life communication needs.

Course Contents:

Paragraph writing

Practice in writing a good, unified and coherent paragraph

Essay writing

Introduction

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

Presentation skills

Personality development (emphasis on content, style and pronunciation)

Note: documentaries to be shown for discussion and review

Recommended Books:

Communication Skills

a) Grammar

1. Practical English Grammar by A. J. Thomson and A. V. Martinet. Exercises 2. 3rd Edition. Oxford University Press 1986. ISBN 0 19 431350 6.

b) Writing

1. Writing. Intermediate by Marie-Chrisitine Boutin, Suzanne Brinand and Francoise Grellet. Oxford Supplementary Skills. Fourth Impression 1993. ISBN 0 19 435405 7 Pages 45-53 (note taking).
2. Writing. Upper-Intermediate by Rob Nolasco. Oxford Supplementary Skills. Fourth Impression 1992. ISBN 0 194354065 (particularly good for writing memos, introduction to presentations, descriptive and argumentative writing).

c) Reading

1. Reading. Advanced. Brian Tomlinson and Rod Ellis. Oxford Supplementary Skills. Third Impression 1991. ISBN 0 19 4534030.

2. Reading and Study Skills by John Langan
3. Study Skills by Riachard Yorky.

English III (Technical Writing and Presentation Skills)

Objectives: Enhance language skills and develop critical thinking

Course Contents:

Presentation 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 Report writing

Progress report writing

Note: Extensive reading is required for vocabulary building

Recommended Books:

Technical Writing and Presentation Skills

a) Essay Writing and Academic Writing
   1. Writing. Advanced by Ron White. Oxford Supplementary Skills. Third Impression 1992. ISBN 0 19 435407 3 (particularly suitable for discursive, descriptive, argumentative and report writing).
   2. College Writing Skills by John Langan. Mc=Graw-Hill Higher Education. 2004.
   3. Patterns of College Writing (4th edition) by Laurie G. Kirszner and Stephen R. Mandell. St. Martin's Press.

b) Presentation Skills
c) Reading
   The Mercury Reader. A Custom Publication. Compiled by norther Illinois University. General Editiors: Janice Neulib; Kathleen Shine Cain; Stephen Ruffus and Maurice Scharton. (A reader which will give students exposure to the best of twentieth century literature, without taxing the taste of engineering students).

Pakistan Studies
(Compulsory)

Introduction/Objectives:

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

Course Outline:

1. **Historical Perspective**
   a. Ideological rationale with special reference to Sir Syed Ahmed Khan, Allama Muhammad Iqbal and Quaid-i-Azam Muhammad Ali Jinnah.
   b. Factors leading to Muslim separatism
   c. People and Land
      i. Indus Civilization
      ii. Muslim advent
      iii. Location and geo-physical features.
2. **Government and Politics in Pakistan**
   Political and constitutional phases:
   a. 1947-58
   b. 1958-71
   c. 1971-77
   d. 1977-88
   e. 1988-99
   f. 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. Burki, Shahid Javed. *State & Society in Pakistan,* The Macmillan Press Ltd 1980.
2. Akbar, S. Zaidi. *Issue in Pakistan's Economy.* Karachi: Oxford University Press, 2000.
3. S.M. Burke and Lawrence Ziring. Pakistan's Foreign policy: An Historical analysis. Karachi: Oxford University Press, 1993.
4. Mehmood, Safdar. *Pakistan Political Roots & Development.* Lahore, 1994.
5. Wilcox, Wayne.*The Emergence of Banglades.,* Washington: American Enterprise, Institute of Public Policy Research, 1972.
6. Mehmood, Safdar. *Pakistan Kayyun Toota,* Lahore: Idara-e-Saqafat-e-Islamia, Club Road, nd.

7. Amin, Tahir. *Ethno - National Movement in Pakistan,* Islamabad: Institute of Policy Studies, Islamabad.
8. Ziring, Lawrence. *Enigma of Political Development.* Kent England: WmDawson & sons Ltd, 1980.
9. Zahid, Ansar. *History & Culture of Sindh.* Karachi: Royal Book Company, 1980.
10. Afzal, M. Rafique. *Political Parties in Pakistan,* Vol. I, II & III. Islamabad: National Institute of Historical and cultural Research, 1998.
11. Sayeed, Khalid Bin. *The Political System of Pakistan.* Boston: Houghton Mifflin, 1967.
12. Aziz, K.K. *Party, Politics in Pakistan,* Islamabad: National Commission on Historical and Cultural Research, 1976.
13. Muhammad Waseem, Pakistan under Martial Law, Lahore: Vanguard, 1987.
14. Haq, Noor ul. *Making of Pakistan: The Military Perspective.* Islamabad: National Commission on Historical and Cultural Research, 1993.

ISLAMIC STUDIES
(Compulsory)

Objectives:

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.

Detail of Courses:

Introduction to Quran 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)

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

Note: One course will be selected from the following six courses of Mathematics.

COMPULSORY MATHEMATICS COURSES FOR BS (4 YEAR)

(FOR STUDENTS NOT MAJORING IN MATHEMATICS)

MATHEMATICS -I (Pre-calculus)

Prerequisite(s): Mathematics at secondary level
Credit Hours: 3 + 0

Specific 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:

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.

Quadratic Equations: Solution of quadratic equations, qualitative analysis of roots of a quadratic equations, equations reducible to quadratic equations, cube roots of unity, relation between roots and coefficients of quadratic equations.

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:

Dolciani MP, Wooton W, Beckenback EF, Sharron S, *Algebra 2 and Trigonometry*, 1978, Houghton & Mifflin,

Boston (suggested text):

Kaufmann JE, College *Algebra and Trigonometry*, 1987, PWS-Kent Company, Boston
Swokowski EW, *Fundamentals of Algebra and Trigonometry* (6th edition), 1986, PWS-Kent Company, Boston

Note: ***General Courses from other Departments***

Details of courses may be developed by the concerned universities according to their Selection of Courses as recommended by their Board of Studies.

Recommendation

Specialized training/orientation should be made mandatory in order to enhance and improve the content level of faculty. Curriculum based training carrying new scope and concepts should be initiated by HEC on regular basis with special reference to applied science/IT to make it more relevant to societal and industrial needs.