

**REVISED CURRICULUM
OF
BIO-TECHNOLOGY**

**Curriculum Development Project
Sponsored by
Ministry of Science & Technology
Islamabad**



**HIGHER EDUCATION COMMISSION
H-9, ISLAMABAD
2003**

CURRICULUM DIVISION, HEC

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*Composed by **Mr. Zulfiqar Ali**, HEC, Head Office, Islamabad*

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PREFACE

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

In exercise of the powers conferred by Sub-section (1) of section 3 of the Federal Supervision of Curricula Textbooks and Maintenance of Standards of Education Act 1976, the Federal Government vide Notification No.D773/76-JEA (Cur.), dated December 4, 1976, appointed Higher Education Commission as the Competent Authority to look after the Curriculum Revision Work beyond Class XII at Bachelor level and onwards to all Degrees, Certificates and Diplomas awarded by Degree Colleges, Universities and other Institutions of higher education.

In pursuance of the above decisions and directives, the Commission is continually performing curriculum revision in collaboration with the Universities. According to the decision of the 44th Vice-Chancellors' Committee, curriculum of a subject must be reviewed after every 3 years. For the purpose, various Committees are constituted at the national level comprising senior teachers nominated by the Universities. Teachers from local degree colleges and experts from user organizations, where required, are also included in these Committees.

The National Curriculum Revision Committee on **Biotechnology** in its meeting held in May 2003 at the H.E.C. Head Office, Islamabad finalized the draft curriculum after due consideration of the comments and suggestions received from the Universities and Colleges where the subject under consideration is taught.

The Final draft prepared by the Curriculum Revision Committee duly approved by competent authority is being circulated for implementation by the Universities.

(PROF. DR. ALTAF ALI G. SHAIKH)
D.G. (CURRICULUM)

June 2003

INTRODUCTION

The final meeting of National Curriculum Revision Committee for **Biotechnology** was held on May, 5-7, 2003 at the Higher Education Commission, Islamabad.

The following attended:

1. Prof. Dr. Muhammad Waheed Akhtar, Convener
Director,
Institute of Bio-Chemistry & Bio-technology,
University of the Punjab, Lahore.
2. Dr. Anwar Nasim, Member
Adviser (Science),
COMSTECH,
3-Constitutional Avenue,
G-5/2, Islamabad.
3. Prof. Dr. Muhammad Umar Dahot, Member
Director,
Institute of Bio-technology and Genetic Engineering,
University of Sindh,
Jamshoro.
4. Prof. Dr. Habib-ur-Rehman, Member
Chairman,
Deptt. of Chemistry,
University of Azad Jammu & Kashmir,
Muzaffarabad.
5. Prof. Dr. Farrukh Hussain, Member
Director,
Centre of Bio-Technology,
University of Peshawar, Peshawar.
6. Dr. A.M. Khalid, Member
Director,
National Institute for Bio-Technology & Genetic Engg.,
(NIBGE), P.O. Box. 577, Faisalabad.
7. Dr. Aleem Ahmed Khan, Member
Associate Professor,
Institute of Pure & Applied Biology,
Bahauddin Zakariya University,
Multan.

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|-----|--|-----------|
| 8. | Dr. Iftikhar Ahmad Khan, Chairman, Deptt. of Plant Breeding & Genetics, Director, Centre of Agri. Biochemistry and Biotechnology, University of Agriculture, Faisalabad. | Member |
| 9. | Prof. Dr. Zahoor Ahmed Swati, Director, Institute of Bio-Technology & Genetic Engg., NWFP Agricultural University, Peshawar. | Member |
| 10. | Dr. Mrs Tahira Shafiq, Head, Centre for Environmental Protection Studies, Pakistan Council of Scientific & Industrial Research, PCSIR, Laboratories Complex, Lahore. | Member |
| 11. | Dr. Zubeda Chaudhary, Scientific Officer, Agriculture Biotechnology Programme, National Agriculture Research Centre (NARC), Islamabad. | Member |
| 12. | Dr. Hamid Rashid, Programme Leader, Agricultural Biotechnology Programme National Agricultural Research Centre, (NARC) Islamabad. | Member |
| 13. | Prof. Dr. Ihsan Illahi, Centre of Biotechnology, University of Peshawar, Peshawar | Member |
| 14. | Mr. Ghulam Hussain, Lecturer, Institute of Bio-Technology & Genetic Engg., NWFP Agricultural University, Peshawar. | Member |
| 15. | Prof. Dr. Azra Khanum, Chairperson, Dept. of Biological Sciences University of Arid Agriculture, Rawalpindi. | Secretary |

Prof. Dr. Altaf Ali G. Shaikh, Director General (Curriculum) welcomed the participants of the meeting on behalf of the Chairman, HEC and briefed them of the obligations of the Commission to review, revise curriculum every three years as per provision of the Act of the parliament 1976.

The committee before taking up the regular agenda unanimously agreed to select **Prof. Dr. Muhammad Waheed Akhtar**, as its Convener and **Prof. Dr. Azra Khanum**, as Secretary.

OBJECTIVES

Biotechnology, a discipline which deals with living organisms or their products in large scale industrial processes or human services, is an old field but its potentials have been vastly enhanced by the development of recombinant DNA technology and other related advancements in the recent past. The fusion between the recombinant DNA technology and cell and tissue culture techniques with the traditional methodologies has strengthened this discipline with tremendously vast potentials for applications. Humans around the world are already reaping immense benefits from these advancements in the sectors of health, agriculture, industry and environment.

Teaching and research in the field of biotechnology must be strengthened in Pakistan not only to assimilate the progress made in the world but also to undertake research for solving our own specific problems. This would be possible only by producing well-trained scientific manpower in our country. It is therefore urgently required that well-planned academic programmes in biotechnology are incorporated in our higher education system.

Biotechnology is a highly interdisciplinary field. Whereas it requires inputs from biochemistry, microbiology, chemistry, chemical engineering and other disciplines, the aspects like product development, marketing, etc., have also to be included in formal training programs in biotechnology.

Realizing the importance of strengthening teaching and research in this field, the HEC of Pakistan constituted a committee to develop curricula of biotechnology for our educational Institutions. The contents proposed for the various programs have been designed keeping in view the student background, the current developments in the field and our specific requirements. It is hoped that these will generally be adopted by Institutions in the country. However, the Institutions may decide to lay emphasis on particular aspects and include specific advanced courses according to specific needs and expertise and facilities available.

The effort in developing this curriculum shall hopefully help in producing well-trained professionals who shall be instrumental in establishing and developing this crucial science and technology in Pakistan.

**SCHEME OF STUDIES FOR
B.Sc (TWO YEARS)
BIOTECHNOLOGY (ELECTIVE)**

Students who have studied Chemistry and Biology at F.Sc. level shall be eligible to opt for this elective subject at B.Sc. level.

Subject combination: Biotechnology, Chemistry and any one from Botany/Zoology.

| | |
|----------------------------|-------------------|
| Biotechnology Theory I | 75 |
| Biotechnology Practical I | 25 |
| Biotechnology Theory II | 75 |
| Biotechnology Practical II | <u>25</u> |
| Total Marks | <u>200</u> |

BIOTECHNOLOGY THEORY I

| | |
|-------------------------------------|-------------|
| Chemistry of Biological Systems | 10 Lectures |
| Carbohydrates, Lipids and Membranes | 15 Lectures |
| Amino Acids, Proteins and Enzymes | 25 Lectures |
| Cell Biology | 20 Lectures |
| Introduction to Metabolism | 30 Lectures |
| Biotechnology Laboratory I | |

BIOTECHNOLOGY THEORY II

| | |
|-----------------------------|-------------|
| Microbiology and Genetics | 20 Lectures |
| Molecular Biology | 30 Lectures |
| Elements of Biotechnology | 30 Lectures |
| Industrial Biotechnology | 20 Lectures |
| Biotechnology Laboratory II | |

DETAIL OF COURSES B.Sc (TWO YEARS)

BIOTECHNOLOGY THEORY I

Chemistry of Biological Systems

10 Lectures

Introduction, historical perspectives and scope of biotechnology.

Unique properties of carbon, nature of organic matter; overview of biological molecules and their structures including proteins, carbohydrates, lipids and nucleic acids; introduction to metabolic processes and energy balances; brief description of expression and transmission of genetic information; biochemical basis of structural and functional variations in the living being.

Prebiotic molecular evolution and origin of living systems; review of the variety and ecology of the living world; evolution of life.

Carbohydrates, Lipids and Membranes

15 Lectures

Classification of carbohydrates; structures and functions of mono-, oligo- and polysaccharides; structural polysaccharides; storage polysaccharides; other carbohydrates of biological interest, proteoglycans and glycoproteins. Lipid classification; structure, properties and functions of different types of lipids; micelles; bilayers and liposomes; structure and functions of biological membranes.

Amino Acids, Proteins and Enzymes

25 Lectures

Amino acids of proteins, general properties, classification, acid-base properties, optical activity; classification, properties and functions of proteins; introduction to protein structure.

General characteristics of enzymes, nomenclature and classification; substrate specificity; enzyme kinetics, Michaelis-Menten equation; effect of various factors on rate of reactions; vitamins and cofactors.

Cell Biology

20 Lectures

Introduction to cell theory and cell structure; chemical composition of cell; types of cell organelles, structure and their functions; separation of cell organelles; transport properties of cell membrane; cell cycle; mitosis; molecular organization and functional role; meiosis, division and genetic consequences; comparison with mitosis; chromosomal aberrations, variation in chromosome number and structure; basis of heredity; chromosomes of bacteria; viruses and their functions.

Introduction to Metabolism

30 Lectures

Introduction to metabolism; sources of glucose to the organism (exogenous and endogenous); digestion and absorption of carbohydrates; utilization and storage of glucose; anaerobic (glycolysis) and aerobic oxidation of glucose (TCA cycle); electron transport chain; alternate pathways of carbohydrate metabolism (HMP shunt); gluconeogenesis; glycogen metabolism; an overview of photosynthetic process.

Digestion, absorption and transport of lipids; utilization and storage of lipids; fatty acid oxidation; outlines of biosynthesis of fatty acids, glycerides, phospholipids, glycolipids and sterols

Digestion and absorption of proteins; transamination, deamination and decarboxylation reactions; urea cycle.

Digestion, absorption and outline of metabolism of purines, pyrimidines and nucleotides; uric acid formation.

An outline of integration of metabolic pathways and their regulation; controls and disorders of metabolic pathways.

Biotechnology Laboratory I

Microscopic examination of prokaryotic and eukaryotic cells; preparation of slides to show stages of cell division; study of some properties of biological molecules.

Distinction between pentoses and hexoses, reducing and non-reducing sugars, mono-, di- and polysaccharides; estimation of glucose in a mixture of monosaccharides; estimation of sucrose by polarimeter; paper chromatography of sugars; extraction of glycogen from liver; acid and enzymatic hydrolysis of glycogen.

Lipid separation from brain tissue and fractionation by TLC; tests for fats, sterols and phospholipids; estimation of cholesterol; acid, saponification and iodine values of fat.

Hydrolysis of a protein and qualitative tests for amino acids; paper chromatography of amino acids; estimation of proteins by Lowry's, dye-binding and Kjeldahl's methods; titration curves of amino acids.

Preparation and assay of peroxidase; effect of pH, temperature and substrate concentration on activity.

BIOTECHNOLOGY THEORY II

Microbiology and Genetics

20 Lectures

Classification and characteristics of main groups of microorganisms; light microscopy and microbial identification; biophysical and biochemical factors for growth; culture enrichment and isolation; anaerobic cultures; solid cultures; batch and continuous cultures; methods of growth measurement; culture preservation; gene transfer by transformation, transduction and conjugation; microbial metabolism; bacteriophages, structure and biology; transducing particles.

Genes, chromosomes and the mechanism of Mendelian inheritance, multiple alleles and gene interaction, epistasis, pleiotropy, sex-linked inheritance, sex-linked genes, sex anomalies; crossing over, linkage analysis; genomic analysis and modifications; crossing over and gene mapping in higher eukaryotes.

Molecular Biology

30 Lectures

Mendelian inheritance and DNA as a carrier of genetic information; double-helical structure of DNA; prokaryotic and eukaryotic chromosomal DNA; DNA replication in prokaryotes and eukaryotes.

RNAs and their role in protein synthesis; RNA polymerase and transcription; regulation of transcription in prokaryotes; post transcriptional processing.

The genetic code; structure of transfer RNA; ribosome structure; translational process, protein synthesis inhibitors; control of eukaryotic translation; post translational modification; regulation of gene expression.

An outline of recombinant DNA methodology; nucleic acid fractionation and sequencing; potentials of recombinant DNA technology; DNA sequencing and genomics.

Elements of Biotechnology

30 Lecture

Biotechnological processes; microbial growth kinetics; shake-flask, solid state, anaerobic, batch and continuous fermentations; pilot scale and scaling up of fermentations; bioinstrumentation and computer control of fermentation processes; immobilized enzymes and cells; mammalian and plant cell culture; industrially important micro-organisms and biotechnological products; economic aspects of fermentation processes; biotechnology in health, agriculture, industry and environment; future trends in biotechnology.

Industrial Biotechnology

20 Lecture

Water pollution and effluent treatment, biodegradation of xenobiotic chemicals; ethanol and related fermentations; production of industrial enzymes; fermentation for the production of pharmaceutical products including antibiotics, hormones vaccines, etc.; production of other chemicals of industrial importance; microbial metal leaching; industrial production processes.

Biotechnology Laboratory II

Different methods for growing microorganisms; culture preservation; experiments to determine some metabolic functions using microorganisms; preparation, restriction analysis and fractionation of chromosomal and plasmid DNA

Books Recommended:

1. Fundamentals of Biochemistry, D. Voet, J.G. Voet, C. W. Pratt. 1999. John Wiley and Sons, New York.
2. Principles of Biochemistry, A. L. Lehninger, D.L. Nelson and M.M. Cox, 3rd Edition. 2000. Worth Publishers, New York.
3. Biochemistry, G. Zubay, 4th Edition. 1998. Brow Dubuque, Iowa.
4. Biochemistry, L. Stryer, 5th Edition. 2000. W.H. Freeman and Co.
5. Harper's Biochemistry, R.K. Murray, D.K. Grammer, P.A. Mayes, V. W. Rodwell, 25th Edition. 2000. Appleton and Lange.
6. Principles of Microbiology, Ronald M. Atlas, 2nd Edition. 1997. W.C. Publishers.
7. Concepts in Biochemistry, R. F. Boyer. 1999. Books –Cole Publishing Co., USA.
8. Human Genetics: Concepts and Applications. Lewis, R. 1997. WCB-McGraw Hill Publishers, USA.
9. Microbiology: Concepts and Applications. M.J., Pleczar, E.C.S Chan, and N. R Krieg,. 2000. McGraw Hill Inc., New York.
10. Microbial Manual of Methods for General Bacteriology, American Society for Microbiology. 1981.
11. Short Protocols in Molecular Biology, Frederick M. Ausubel, 4th Edition. 1999. John Wiley and Sons.
12. Basic Biotechnology, Attedge, C. R. and Kristiansen, B. 2001. Cambridge University Press, U.K.
13. The Nucleic Acid Protocols Handbook. Ralph Rapley. 2000. Humana Press.
14. Basic Techniques in Molecular Biology. S. Surzyeki. 2000. Springer.
15. An Introduction to Genetic Engineering. Desmond S. T. Nicholl. 2002. Cambridge.
16. Molecular Biotechnology: Principles and Applications of Recombinant DNA. B. R. Glick and J. J. Pasternak. 2002. ASM Press

SCHEME OF STUDIES FOR M.Sc. BIOTECHNOLOGY (TWO YEARS)

This course is proposed for two year M.Sc. Bio-technology degree. These courses are for the students who have done B.Sc. (14 years) with relevant subjects (Chemistry/Botany/Zoology). But have not studied biochemistry or biotechnology as an elective subject at B.Sc. level. The courses for the students, who have studied biochemistry or biotechnology as an elective subject at B.Sc. level, shall be designed separately.

SEMESTER – I

| COURSE NO. | TITLES | CREDITS |
|-------------------|-------------------------------------|----------------|
| Biotech-01 | Chemistry of Biological system | 2 |
| Biotech-02 | Cell Biology and Genetics | 2 |
| Biotech-03 | Amino Acids, Proteins and Enzymes | 3 |
| Biotech-04 | Carbohydrates, Lipids and Membranes | 2 |
| Biotech-05 | Molecular Biology | 2 |
| Biotech-06 | Laboratory – I | 2 |
| Biotech-07 | Laboratory – II | 2 |

SEMESTER – II

| | | |
|------------|---|---|
| Biotech-08 | Principles of Microbiology and Immunology | 2 |
| Biotech-09 | Metabolism | 3 |
| Biotech-10 | Genetic Engineering | 2 |
| Biotech-11 | Biotechniques | 2 |
| Biotech-12 | Biostatistics and Biomathematics | 2 |
| Biotech-13 | Laboratory - III | 2 |
| Biotech-14 | Laboratory - IV | 2 |

SEMESTER – III

| | | |
|------------|--|---|
| Biotech-15 | Principles of Biochemical Engineering | 2 |
| Biotech-16 | Elements of Biotechnology | 2 |
| Biotech-17 | Industrial Biotechnology | 2 |
| Biotech-18 | Plant and Animal Cell Biotechnology | 2 |
| Biotech-19 | Skills and Research Methodology for Biotechnologists | 3 |
| Biotech-20 | Laboratory – V | 2 |
| Biotech-21 | Laboratory – VI | 2 |

SEMESTER – IV

| | | |
|------------|------------------------------|---|
| Biotech-22 | Computer and Bioinformatics | 3 |
| Biotech-23 | Environmental Biotechnology | 2 |
| Biotech-24 | Medical Biotechnology | 2 |
| Biotech-25 | Thesis/Four Optional Courses | 8 |

The optional courses to be selected from amongst the following:-

OPTIONAL COURSES

| | |
|------------|---|
| Biotech-26 | Protein Structure, Function and Engineering |
| Biotech-27 | Advanced Molecular Biology |
| Biotech-28 | Advanced Immunology |
| Biotech-29 | Advanced Microbiology |
| Biotech-30 | Industrial Enzymology |
| Biotech-31 | Renewable Resource Technology |
| Biotech-32 | Agricultural Biotechnology |
| Biotech-33 | Waste Biotechnology |
| Biotech-34 | Pharmaceutical Biotechnology |
| Biotech-35 | Food Biotechnology |
| Biotech-36 | Mixed Microbial Processes |
| Biotech-37 | Aquaculture Biotechnology |

| | |
|------------|---|
| Biotech-38 | Marine Biotechnology |
| Biotech-39 | Biodiversity and Genetic Conservation |
| Biotech-40 | Cell and Tissue Culture |
| Biotech-41 | Transgenic Plants |
| Biotech-42 | Transgenic Animal |
| Biotech-43 | Stem Cells and Therapeutic Cloning |
| Biotech-44 | Gene Therapy |
| Biotech-45 | Genomics |
| Biotech-46 | Proteomic |
| Biotech-47 | Safety Considerations for Biotechnology Processes |

DETAIL OF COURSES FOR M.Sc. BIOTECHNOLOGY (TWO YEARS)

SEMESTER – 1

BIOTECH-1 CHEMISTRY OF BIOLOGICAL SYSTEMS 2 Credits

Introduction, historical perspective and scope of biotechnology; nature of organic matter and review of organic reaction mechanisms; chemical structure and biological function; properties of water and aqueous solution; chemical equilibria, review of thermodynamic principles. Prebiotic molecular evolution and origin of life, a review of the variety and ecology of the living world; biochemical basis of structural and functional variations in the living beings; evolution of life.

BIOTECH-2 CELL BIOLOGY AND GENETICS 2 Credits

Introduction to cell theory and structure; chemical composition of cell; types of cell organelles, structure and their functions; separation of cell organelles; transport properties of cell membrane; cell cycle; mitosis; molecular organization and functional role; meiosis, division and genetic consequences; comparison with mitosis. Chromosomal aberrations, variation in chromosome number and structure; material basis of heredity; chromosomes of bacteria, viruses and their functions.

Genes, chromosomes and the mechanism of Mendelian inheritance, multiple alleles and gene interaction, epistasis, pleiotropy, sex determination and differentiation; sex-linked inheritance, sex-linked genes, sex anomalies; linkage and crossing over; linkage analysis and gene mapping in eukaryotes.

BIOTECH-4 AMINO ACIDS, PROTEINS AND ENZYMES 2 Credits

Amino acids, proteins and their properties; covalent structure of proteins; secondary structure; fibrous proteins; tertiary structure and globular proteins; protein stability; quaternary structure; protein folding; structure prediction; protein structure evolution.

General characteristics of enzyme reactions; enzyme nomenclature and classification; substrate specificity; co-enzymes; regulation of enzyme activity; chemical kinetics and enzyme kinetics, Michaelis-Menten equation; activation energy; effect of pH and other factors on rates of reactions; inhibition of enzymatic reactions and kinetics; bisubstrate reactions; catalytic mechanisms; structure and mechanics of lysozyme; serine proteases and glutathione reductase; immobilized enzymes.

BIOTECH-3 CARBOHYDRATES, LIPIDS AND MEMBRANES 2 Credits

Monosaccharides; classification; structures; sugar derivatives; oligo, polysaccharides and carbohydrate analysis; structural polysaccharides; storage polysaccharides; other carbohydrates of biological interest; proteoglycans and glycoproteins structure and function; bacterial cell-walls.

Lipid classification; structure and functions of different types of lipids; micelles; bilayers and liposomes; structure of biological membranes; kinetics and mechanisms of membrane transport; structure and functions of lipoproteins.

BIOTECH-5 MOLECULAR BIOLOGY 2 Credits

Chromosomes, Mendelian inheritance and DNA as a carrier of genetic information; double-helical structure of DNA; forces stabilizing nucleic acid structures; supercoiled DNA; nucleic acids fractionation and sequencing; chemical synthesis of oligonucleotides; DNA polymerase; DNA replication – general aspects and enzymes involved; prokaryotic and eukaryotic replication,

mechanisms; mutagenesis and mechanism of DNA repair; telomeres and aging; recombination and mobile genetic elements; DNA methylation.

RNAs and their role in protein synthesis; RNA polymerase and transcription; regulation of transcription in prokaryotes and eukaryotes; post transcriptional processing.

The genetic code; structure of transfer RNA; prokaryotic and eukaryotic ribosomal structure; translational processes and their control, protein synthesis inhibitors; post transnational modifications; protein targeting; protein degradation; nonribosomal polypeptide synthesis; structure and genomic organization, regulation of eukaryotic gene expression; cell differentiation; oncogenes and cancer.

BIOTECH-6

LABORATORY-I

2 Credits

Experiments to determine and characterize carbohydrates, amino acids, proteins and lipids. Experiments on assays, kinetics and characterization of enzymes.

BIOTECH-7

LABORATORY-II

2 Credits

Study of cell structure and division; separation and characterization of cell organelles; induction and demonstration of mutation by different agents; preparation and estimation of DNA and RNA; plasmid preparation, DNA restriction and gel electrophoresis.

SEMESTER – II

BIOTECH-8 PRINCIPLES OF MICROBIOLOGY 2 Credits

Light microscopy and microbial identification; biophysical and biochemical factors for growth, culture enrichment and isolation; anaerobic cultures; solid cultures; batch and continuous cultures; methods of growth measurement; culture preservation; mutation and protoplast fusion for culture improvement; gene transfer by transformation, transduction and conjugation; microbial metabolism; classification and characteristics of main groups of microorganisms; growth under extreme environments; archaebacteria; structure and biology of bacteriophages; animal and plant viruses.

Body defense mechanisms; the immune system; antibody structure; monoclonal and polyclonal antibodies

BIOTECH-9 METABOLISM 3 Credits

Introduction to metabolism; experimental study of metabolic pathways; role of ATP and other high energy compounds; glycolytic pathway and its significance; fermentation; metabolism of hexoses other than glucose; glycogen breakdown and synthesis pathways; regulation of glycogen metabolism and blood glucose levels; citric acid cycle and its regulation; mechanism of electron transport chain; oxidative phosphorylation and regulation of ATP production; gluconeogenesis; glyoxylate pathway; biosynthesis of oligosaccharides and glycoproteins; mechanism and regulation of pentose phosphate pathway; mechanisms of light and dark reactions in photosynthesis.

Lipid digestion, absorption and transport; fatty acid oxidation; ketone bodies; fatty acid and triglyceride synthesis; biosynthesis, transport and utilization of cholesterol; prostaglandins, prostacyclins, thromboxanes and leukotrienes; phospholipid and glycolipid metabolism.

Amino acid deamination mechanisms; urea cycle and its regulation; biosynthesis of essential and non-essential amino acids; metabolic breakdown of individual amino acids, amino acids as biosynthetic precursors; nitrogen fixation.

Chemical nature and synthesis of purine and pyrimidine ribonucleotides; formation of deoxyribonucleotides; nucleotide degradation; synthesis of nucleotide coenzymes; integration and organ specialization of energy metabolism.

Regulation, integration, controls and disorders of metabolic pathways.

BIOTECH-10 GENETIC ENGINEERING 2 Credits

An outline of DNA cloning experiment, cloning vectors including plasmids, bacteriophages, cosmids, YAC vectors, shuttle and expression vectors; tumor inducing (Ti) plasmids; restriction enzymes; gene splicing, genomic and cDNA libraries, screening methods for gene libraries. Southern and Northern blotting; chromosome walking; site specific mutagenesis; potentials of recombinant DNA technology; PCR; production of proteins; tissue culture techniques; transgenic organisms and gene therapies; restriction fragment length polymorphisms and disease detection (e.g. cystic fibrosis); human genome project; stem cells and therapeutic cloning; social considerations.

BIOTECH-11 BIOTECHNIQUES 2 Credits

General methods of fractionation and characterization of proteins and nucleic acids; dialysis; ultrafiltration; lyophilization; principles and application of visible; UV, IR, MALDI – TOF, NMR spectroscopy in biotechnology; flame photometry; atomic absorption; fluorescence spectroscopy; X-ray diffraction, principle and application in the study of proteins; principle and applications of electron microscopy; principle and applications of centrifugation; principles and applications of adsorption, partition, ion-exchange, hydrophobic and affinity chromatography; chromatofocussing; principles and applications of gas chromatography and HPLC; native and SDS-PAGE; isoelectric focussing; immunoelectrophoresis; 2-D gel electrophoresis; Western blotting, ELISA.

BIOTECH-12 BIO-STATISTICS AND BIO-MATHEMATICS 2 Credits

Basic statistics; organizing and summarizing data, population samples, bio-statistical analysis, ordered array, frequency distributions, polygons and curves, histograms; measures of central tendency, arithmetic mean; measures of dispersion, range, mean deviation, standard deviation and error, coefficient of variation; probability distributions, normal, binomial and Poisson distributions; hypothesis testing, statistical decision, one and two-sample hypothesis, Z-and other tests; simple linear regression and correlation; analysis of variance; nonparametric and distribution free tests.

Biomathematics, algebraic expressions, polynomials, factoring of polynomials, fractional expressions; the binomial theorem and its use; use of differentiation and integration highs and lows, a special kind of point, optimization, functions in reality, the exponential growth curve, the definite integral, properties and applications of definite integration.

Principles of calculus, trigonometry and algebra of importance for biotechnology.

BIOTECH-13 LABORATORY-III 2 Credits

Different methods for growing microorganisms; culture preservation. experiments to determine some metabolic functions using microorganisms and animal tissues; preparation and characterization of chromosomal, plasmid and bacteriophage DNA and RNA; mini project to clone a specific gene in E. coli; techniques used in molecular biology and genetic engineering.

BIOTECH-14 LABORATORY-IV 2 Credits

Use and demonstration of variety of chromatographic, electrophoretic and other techniques used for the study of biological compounds and reactions; Western blotting for protein identification.

SEMESTER – III

BIOTECH-15 PRINCIPLES OF BIOCHEMICAL ENGINEERING 2 Credits

Principles of chemical engineering; materials and energy balances and thermodynamics; industrial processes flow diagrams; survey of unit processes and flow diagrams; chemical and biochemical reactors; instrumentation and control; selected processes in downstream processing; novel bioreactor systems.

BIOTECH-16 ELEMENTS OF BIOTECHNOLOGY 2 Credits

Introduction to biotechnology; microbial growth kinetics; shake-flask, solid state, anaerobic, batch and continuous fermentations; pilot scale and scaling up of fermentations; bioinstrumentation and computer control of fermentation processes; immobilized enzymes and cells; mammalian and plant cell culture; industrially important microorganisms and biotechnological products; economic aspects of fermentation processes; biotechnology in health, agriculture and industry; future trends in biotechnology.

BIOTECH-17 INDUSTRIAL BIOTECHNOLOGY 2 Credits

Water pollution and effluent treatment, biodegradation of xenobiotic chemicals; ethanol and related fermentations; production of industrial enzymes; fermentation for the production of pharmaceutical products including antibiotics, hormones, vaccines, etc.; production of other chemicals of industrial importance; microbial metal leaching.

BIOTECH-18 PLANT AND ANIMAL CELL BIOTECHNOLOGY 2 Credits

Plant breeding; cell and tissue culture; plant transformation; methods of transformation in plants including competence, electrooration, microinjection, particle gun and agrobacterium; methods for assessing transformation, transgenic crops for herbicide, pest, fungal, bacterial and viral resistance.

Animal cell culture; requirements of small and large scale cell cultures; transient and stable expression systems, viruses as expression vectors; embryonic stem cell and somatic cell cloning; genetically modified organisms; biosafety guidelines.

**BIOTECH-19 SKILLS AND RESEARCH METHODOLOGY FOR
BIOTECHNOLOGISTS 3 Credits**

Overview of scientific research; improvement through research; nature of scientific inquiry; applications of research in industry; choosing a project; development of a research project; writing a research grant application; role of students; supervisor's role; designing and investigation; identifying the level within investigation; deciding on techniques to be employed; analysis of results; control, samples and replications; reviewing the literature; primary and secondary sources; scientific record keeping; use of microorganisms, animals, plants and humans in experimentation; use of pathogens in experiments; conflict of interests; ownership of data; writing, presentation and publishing the scientific papers; filing patent application.

BIOTECH-20 LABORATORY-V 2 Credits

Study of unit operations of chemical and biochemical engineering and related aspects; experiments including physical and nutritional aspects of microbial fermentations, aerobic and anaerobic, batch and continuous cultures; product recovery, etc.

BIOTECH-21 LABORATORY-VI 2 Credits

Handling and preservation of animal cells, primary culture of chick embryo fibroblasts, cloning of animal cells; culture of lymphoid cells; cytotoxicity evaluation; cell transformation.

Stock solution and media preparation, sterilization techniques, callus culture, *in Vitro* multiplication, micropropagation, plant regeneration and embryogenesis.

SEMESTER - IV

BIOTECH-22 COMPUTER AND BIOINFORMATICS 3 Credits

Introduction to computer hardware and software; computer applications for biotechnologists, basic principles, spreadsheet work, word processing, graphical and statistical analysis packages, document preparation; software for biotechnology teaching and research. Websites retrieving for biotechnological information; genomic and proteomic data; interpretation of sequence data.

BIOTECH-23 ENVIRONMENTAL BIOTECHNOLOGY 2 Credits

Environmental biotechnology and society; environmental assessment of biotechnological processes, marine environment, agricultural environment; extreme environments; disposal of domestic and industrial waste and pollutants; microbial transformations; bioremediation of soil and water, role of biofertilizers and bio insecticides; microbial deodorization; coal and oil desulphurisation; biosafety guidelines.

BIOTECH-24 MEDICAL BIOTECHNOLOGY 2 Credits

Conventional medical biotechnology; contemporary issues in medical biotechnology; introduction to principles of gene therapy and gene delivery system; human genome, detection of gene mutations; tissue engineering and transplantation; drug delivery; biodegradable polymers; practical and theoretical problems of modern methods of disease therapy; production of therapeutical monoclonal antibodies and their uses; role of organ transplantation in curing and

new organ production; use of transgenic animals in therapy; the principles and practices of transfusion techniques; preparation of blood components and their use; essentials of osteopathic principles; human and veterinary osteopathy and bone grafting; ethical issues in gene therapy and tissue engineering.

Biotech-25 Thesis/four Optional Courses 8

OPTIONAL COURSES

| | |
|------------|---|
| BIOTECH-26 | PROTEIN STRUCTURE, FUNCTION AND ENGINEERING |
| BIOTECH-27 | ADVANCED MOLECULAR BIOLOGY |
| BIOTECH-28 | ADVANCED IMMUNOLOGY |
| BIOTECH-29 | ADVANCED MICROBIOLOGY |
| BIOTECH-30 | INDUSTRIAL ENZYMOLOGY |
| BIOTECH-31 | RENEWABLE RESOURCE TECHNOLOGY |
| BIOTECH-32 | AGRICULTURAL BIOTECHNOLOGY |
| BIOTECH-33 | WASTE MANAGEMENT BIOTECHNOLOGY |
| BIOTECH-34 | PHARMACEUTICAL BIOTECHNOLOGY |
| BIOTECH-35 | FOOD BIOTECHNOLOGY |
| BIOTECH-36 | MIXED MICROBIAL PROCESSES |
| BIOTECH-37 | AQUACULTURE BIOTECHNOLOGY |
| BIOTECH-38 | MARINE BIOTECHNOLOGY |
| BIOTECH-39 | BIODIVERSITY AND GENETIC CONSERVATION. |
| BIOTECH-40 | CELL AND TISSUE CULTURE |
| BIOTECH-41 | TRANSGENIC PLANTS |
| BIOTECH-42 | TRANSGENIC ANIMAL |
| BIOTECH-43 | STEM CELLS AND THERAPEUTIC CLONING |
| BIOTECH-44 | GENE THERAPY |
| BIOTECH-45 | GENOMICS |
| BIOTECH-46 | PNTOMICS |
| BIOTECH-47 | SAFETY CONSIDERATIONS FOR BIOTECHNOLOGY PROCESSES |

Books Recommended:

1. Fundamentals of Biochemistry, D. Voet, J.G. Voet, C. W. Pratt. 1999. John Wiley & Sons, New York.
2. Principles of Biochemistry, A. L. Lehninger, D.L. Nelson and M.M. Cox, 3rd Edition. 2000. Worth Publishers, New York.
3. Biochemistry, G. Zubay, 4th Edition. 1998. Brown Dubuque, Iowa.
4. Biochemistry, L. Stryer, 5th Edition. 2002). W.H. Freeman & Co.
5. Harper's Biochemistry, R.K. Murray, D.K. Grammer, P.A. Mayes, V. W. Rodwell, 25th Edition. 2000. Appleton & Lange.
6. Principles of Microbiology, M Ronald. Atlas, 2nd Edition. 1997. W.C. Publishers.
7. Concepts in Biochemistry, R. F. Boyer. 1999. Books –Cole Publishing Co., USA.
8. The Basic Protein and Peptide Protocols, J.M. Walker. 1994. Humana Press.
9. Human Genetics: Concepts and Applications. R. Lewis, 1997. WCB-McGraw Hill Publishers, USA.
10. Microbiology: Concepts and Applications. M.J., Pleczar, E.C.S. Chan, and N. R Krieg,. 2000. McGraw Hill Inc., New York.
11. Fundamentals of Enzymology. N. Price, and L. Stevens, 1999. 3rd Edition. Oxford University Press Inc., New York.
12. Immunology: A short course. El. Benjanini, R Coico,. and G Sunshine,. 2000. 4th Edition 2000. Wiley-Liss Inc., Canada.
13. Molecular Biology of the Cell, Bruce Alberts, Alexander Johnson, 4th Edition, Garland Sciences.
14. Molecular Biology and Biotechnology, J. M. Walker and E.B. Gingold, 3rd Edition. 1993. Royal Chemistry Society.
15. Molecular Cell Biology, H. Lodish, A. Berk, S. Zipursky, 4th Edition. 2000. W. H. Freeman.
17. Cell and Molecular Biology, G. Karp, 3rd Edition. 2002. John Wiley and Sons.
18. Advanced Molecular Biology, M. Twynmen. 1999. Viva Books Pvt. Ltd.
19. Immunology, I. Riott, J. Brostoff, D. Male, 6th Edition. 2001. Mosby.
20. Immunology, R. A. Goldsby, T. J. Kindt, Osborne, 4th Edition. 2000. W. H. Freeman.
21. Biostatistics, Davul, 5th Edition. 1996.
22. Primer of Biostatistics, S. A. Glantz, 2nd Edition. 1989. McGraw Hill.
23. Microbial Manual of Methods for General Bacteriology, American Society for Microbiology. 1981.
24. Short Protocols in Molecular Biology, Frederick M. Ausubel, 4th Edition. 1999. John Wiley and Sons.
25. Basic Biotechnology. C. R. Attege, and B. Kristiansen, 2001. Cambridge University Press, U.K.
26. Biostatistics in Clinical Medicine. Intigener, J. A., Mosteller, F., Thibean, L. A. and Ware, J. H.. 1994. McGraw Hill Inc., New York.

27. Basic and Clinical Biostatistics. Saunders, B.D. and Trapp, R. G.. 1993. Appleton and Lange, USA.
28. How to develop and write a Research Paper. Hemden, Cash P. 1998. ARCO.
29. Floriculture; Principles and Species. J. M. Dole, and H.F. Wilkins 1999. Ball Publishing, USA.
30. Year Book of International Horticulture Statistics. I Siegmund, and F. Heinrichs, 2000. Ball Publishing, USA. .
31. Principles of Tissue Engineering. R.P Lanza,, R. Langer, and J Vacanti,, 2000. 2nd Edition. Academic Press, California.
32. Plant Biotechnology. S. Ignacimutu, 1997. Oxford IBH Publisher, N. Delhi.
33. Plant Biotechnology and Molecular Biology: A Laboratory Manual M. S.. Punia, 1999. Scientific Publishers, Jodhpur.
34. Applied Plant Biotechnology. V.L.,Chopra, V.S. Malik and S.R. Bhat. 2000. Oxford IBH Publishers, New Delhi.
35. A Manual of Basic Technique. F, R. Ian. 2000. A. R. Liss, Inc., New York.
36. Application of Microbes in Biotechnology. Lee, Y.K. and C.L. Poh and H. M. Tan. 1999. Springer-verlag.
37. Introductory Practical Biochemistry. S. K Sawhney, and. R Singh, (Eds) 2000. Narosa Pub. House New Delhi.
38. Biotransformations. K. Faber1999. Springer-verlag
39. Analysis of Plant Waste Materials. H. G. Linskens, and J. F. Jackson. 1999. Springer-verlag.
40. The Protein Protocols Handbook, 2nd Edition. J. M. Walker. 2002. Humana Press.
41. Introduction to Bioinformatics. (A Theoretical and Practical Approach). S. A. Krawetz and D. Womble. 2002. Humana Press.
42. The Nucleic Acid Protocols Handbook. R. Rapley. 2000. Humana Press.
43. Downstream Processing of Protein Protocols. M.A. Desai. 2000. Humana Press.
44. Glossary of Biotechnology Terms. 3rd Edition. K. R. Nill. 2002. CRC, Press
45. Basic Techniques in Molecular Biology. S. Surzyeki. 2000. Springer.
46. Introduction to Proteomics: Tools for the New Biology. D. C. Liebler. 2002. Humana Press.
47. Current Protocols in Molecular Biology. F. M. Ausubel. 2001. Cold-Springer-Harbor.
48. Molecular Cloning: A laboratory Manual 3 Vol. Set. Sambrook. D.W. Russell 3rd Edition, CSHL Press..
49. An Introduction to Genetic Engineering. D. S. T. Nicholl. 2002 Cambridge.
50. Molecular Biotechnology: Principles and Applications of Recombinant DNA. B. R. Glick and J. J. Pasternak. 2002. ASM Press
51. DNA Cloning: A Practical Approach, 2nd edition.4 Volumes. D.M Clover. 1995. Oxford University Press.

**SCHEME OF STUDIES FOR B.Sc. (HONS) BIOTECHNOLOGY
FOUR YEARS**

Year-1

SEMESTER – I

| COURSE NO. | TITLE | CREDITS HR |
|-------------------|--|-------------------|
| BIOTECH-01 | General Biology (for Pre-Engineering) or | 3 (2 –1) |
| BIOTECH-02 | Mathematics (for Pre-Medical) | 3 (3 –0) |
| BIOTECH-03 | Physical Chemistry | 3 (2 - 1) |
| BIOTECH-04 | Introductory Biotechnology I | 3 (3 - 0) |
| BIOTECH-05 | Basics in Computer | 2 (2 - 0) |
| BIOTECH-06 | English Composition I | 2 (2 - 0) |
| BIOTECH-07 | Pakistan Studies | 2 (2 - 0) |

SEMESTER – II

| | | |
|------------|-------------------------------|-----------|
| BIOTECH-08 | Plant Science | 3 (2 - 1) |
| BIOTECH-09 | Animal Sciences | 3 (2 - 1) |
| BIOTECH-10 | Organic Chemistry I | 3 (2 - 1) |
| BIOTECH-11 | English Composition II | 2 (2 - 0) |
| BIOTECH-12 | Social/Islamic Studies | 2 (2 - 0) |
| BIOTECH-13 | Introductory Biotechnology II | 2 (2 - 0) |

Year-II

SEMESTER – III

| | | |
|------------|------------------------|-----------|
| BIOTECH-14 | Biological Chemistry I | 3 (2 - 1) |
| BIOTECH-15 | Cell Biology | 3 (2 - 1) |
| BIOTECH-16 | Microbiology | 3 (2 - 1) |
| BIOTECH-17 | Organic Chemistry II | 3 (2 - 1) |
| BIOTECH-18 | Biomathematics | 3 (3 - 0) |

SEMESTER – IV

| | | |
|------------|-------------------------|-----------|
| BIOTECH-19 | Biological Chemistry II | 3 (2 - 1) |
| BIOTECH-20 | Principles of Genetics | 3 (2 - 1) |
| BIOTECH-21 | Plant Physiology | 3 (2 - 1) |
| BIOTECH-22 | Enzymology | 3 (2 - 1) |
| BIOTECH-23 | Biostatistics | 3 (3 - 0) |

Year-III

SEMESTER-V

| | | |
|------------|-----------------------------|-----------|
| BIOTECH-24 | Metabolism I | 3 (2 - 1) |
| BIOTECH-25 | Molecular Biology | 3 (2 - 1) |
| BIOTECH-26 | Microbial Genetics | 3 (2 - 1) |
| BIOTECH-27 | Elements of Biotechnology | 3 (2 - 1) |
| BIOTECH-28 | Techniques of Biotechnology | 3 (2 - 1) |

SEMESTER-VI

| | | |
|------------|---------------------------------------|-----------|
| BIOTECH-29 | Metabolism II | 3 (2 - 1) |
| BIOTECH-30 | Recombinant DNA Technology | 3 (2 - 1) |
| BIOTECH-31 | Plant Biotechnology | 3 (2 - 1) |
| BIOTECH-32 | Animal Biotechnology | 3 (2 - 1) |
| BIOTECH-33 | Principles of biochemical engineering | 3 (2 - 1) |

Year-IV

SEMESTER-VII

| | | |
|------------|---|-----------|
| BIOTECH-34 | Bioinformatics | 3 (3 - 0) |
| BIOTECH-35 | Immunology | 3 (2 - 1) |
| BIOTECH-36 | Industrial Biotechnology | 3 (2 - 1) |
| BIOTECH-37 | Environmental Biotechnology | 3 (2 - 1) |
| BIOTECH-38 | Skills and Research Methodology for Biotechnologies | 3 (3 - 0) |

SEMESTER-VIII

| | | |
|------------|-----------------------------------|-----------|
| BIOTECH-39 | Medical Biotechnology | 2 (2 - 0) |
| BIOTECH-40 | Food Biotechnology | 3 (2- 1) |
| BIOTECH-41 | Economic and Business Application | 2 (2 - 0) |
| BIOTECH-42 | Thesis | 8 (0 - 8) |
| OR | | |
| | Four Optional Courses | 8 (8-0) |

OPTIONAL COURSES

| | |
|------------|---|
| BIOTECH-43 | Protein Structure, Function and Engineering |
| BIOTECH-44 | Advanced Molecular Biology |
| BIOTECH-45 | Advanced Immunology |
| BIOTECH-46 | Advanced Microbiology |
| BIOTECH-47 | Industrial Enzymology |
| BIOTECH-48 | Renewable Resource Technology |
| BIOTECH-49 | Agricultural Biotechnology |
| BIOTECH-50 | Waste Management Biotechnology |
| BIOTECH-51 | Pharmaceutical Biotechnology |
| BIOTECH-52 | Proteomics |
| BIOTECH-53 | Mixed Microbial Processes |
| BIOTECH-54 | Aquaculture Biotechnology |
| BIOTECH-55 | Marine Biotechnology |
| BIOTECH-56 | Biodiversity and Genetic Conservation |
| BIOTECH-57 | Cell and Tissue Culture |
| BIOTECH-58 | Transgenic Plants |
| BIOTECH-59 | Transgenic Animal |
| BIOTECH-60 | Stem Cells and Therapeutic Cloning |
| BIOTECH-61 | Gene Therapy |
| BIOTECH-62 | Genomics |
| BIOTECH-63 | Safety Considerations for Biotechnology Processes |

BIOTECH-06 ENGLISH COMPOSITION I 2 (2- 0) Credits

Same course as for other Bachelor degrees.

BIOTECH-07 PAKISTAN STUDIES 2 (2- 0) Credits

Same course as for other Bachelor degrees.

SEMESTER-II

BIOTECH-08 PLANT SCIENCES 3 (2-1) Credits

Theory:

Plant kingdom. Brief introduction to plant kingdom. Virology; generally morphology, biochemical nature and biological importance of virus. Bacteriology; introduction, morphology, structure, classification and biological importance of bacteria. Mycology; general introduction, classification and structure. Economic importance along with pathogeni city of: phytophthora, ustilago, puccinia, penicillium, claviceps, yeast and agumeus. Phycology; general introduction and structure. Economic importance of Cyanophyta, Chlertophyya, basclariophyta; pheophyta and rhodophyta (Examples. nostoc, chara, pinnularia, ectocarpus and batrachospermum. Lichenology, genral account, structure and biological importance with reference to marchantia, anthoceres and polytrichum. Pterodohytes, general morphological account, reproduction, economic importance with reference to adiantum and marsilea. Gymnosperms; general morphology, distribution and economic importance of conifers. Angiosperms; general introduction, economic importance with special reference to the following familieis, ranunculaceae rosaccae, fabaceae, solanceac, poaceae.

Practical:

Study of the representatives of the above groups. Field trips to the various locations for collection field observation and submit their collection at the time of examination, study of medicinal plants, collection of diseased leaves due to viruses.

BIOTECH-09 ANIMAL SCIENCES**3 (2-1) Credits**

Introduction to animal kingdom. Protozoa; general organization with economic importance of leishmania. Trypanosoma, Entamoeba, Giardia, and Plasmodium. Porifera; general organization and importance of sponges. Coelenterates; general organization and economic importance of coelenterates (Coral reefs and polymorphism). Platyhelminthes; general organization and economic importance of fasciola hepatica and Tania solium. Nematoda, diagnostic features and biological importance of ascaris. Annelida; diagnostic features and economic importance of annelids with special reference to leech. Molluska; characteristic and economic importance of mollusks with special reference to fresh water mussel. Arthropoda; diagnostic features of the phylum and economic importance of honey bee and silkworm. Echinodermates; Diagnostic features of echinodermates with special reference to starfish. Vertebrata; diagnostic features of the 5 classes. Study structure and functions of the digestive, circulatory, respiratory, excretory, nervous, endocrine and reproductive systems of rabbit.

Practical:

General survey of each phylum and group from invertebrata to vertebrata, collection and identification of importance local fauna. Dissection of cockroach, pigeon, rabbit and rat. Brief introduction of evolution, zoogeography and wild life of Pakistan.

BIOTECH-10 ORGANIC CHEMISTRY I**3 (2-1) Credits**

Same course as for other Bachelor degrees

BIOTECH-11 ENGLISH COMPOSITION II**3 (2-1) Credits**

Same course as for other Bachelor degrees

BIOTECH-12 SOCIAL/ISLAMIC STUDIES**2 (2-0) Credits**

Same course as for other Bachelor degrees

BIOTECH-13 INTRODUCTORY BIOTECHNOLOGY-II 2 (2-0) Credits

The organism and relationship between primary and secondary metabolism, cell cycle (bacterial growth).

History and application of genetic engineering; genome, management and analysis, basic tools of genetic engineering (isolation, cutting, ligation etc); mechanisms of gene transfer; DNA sequencing and genome libraries.

Introduction to nature, classification and action; application of enzymes in genetic and protein engineering. Introduction to role of enzymes in industrial product synthesis.

Cell tissue culture details of culture techniques (explant, sterilization, growth, differentiation, etc), applications.

Principles of microbial growth; important products formation. bioreactor/fermenter technology .

Pharmaceuticals and bio-pharmaceuticals, antibiotics, vaccines etc. Introduction to gene therapy and AIDS.

SEMESTER - III

BIOTECH-14 BIOLOGICAL CHEMISTRY I 3 (2-1) Credits

Theory:

Amino acids, proteins and their properties; covalent structure of proteins; secondary structure; fibrous proteins; tertiary structure and globular proteins; protein stability; quaternary structure; protein folding; structure prediction; protein structure evolution, chemical nature and role of purines, pyrimidines, nucleosides and nucleotides.

Practical:

Hydrolysis of a protein and qualitative tests for amino acids; paper chromatography of amino acids; estimation of proteins by Lowry's, dye-binding and Kjeldahl's methods; titration curves of amino acids.

BIOTECH-15 CELL BIOLOGY**3 (2-1) Credits****Theory:**

Introduction to cell theory and structure; chemical composition of cell; types of cell organelles, structure and their functions; separation of cell organelles; transport properties of cell membrane; cell cycle; mitosis; molecular organization and functional role; meiosis, division and genetic consequences; comparison with mitosis, chromosomal aberrations, variation in chromosome number and structure; material basis of heredity; chromosomes of bacteria, viruses and their functions.

Genes, chromosomes and the mechanism of Mendelian inheritance, multiple alleles and gene interaction, epistasis, pleiotropy, sex determination and differentiation; sex-linked inheritance, sex-linked genes, sex anomalies; linkage and crossing over; linkage analysis and gene mapping in eukaryotes.

Practical:

Microscopic examination of prokaryotic and eukaryotic cells; preparation of slides to show stages of cell division; study of some properties of biological molecules. Study of cell structure and division; separation and characterization of cell organelles

BIOTECH-16 MICROBIOLOGY**3 (2-1) Credits****Theory:**

Light microscopy and microbial identification; biophysical and biochemical factors for growth, culture enrichment and isolation; anaerobic cultures; solid cultures; batch and continuous cultures; methods of growth measurement; culture preservation; mutation and protoplast fusion for culture improvement; gene transfer by transformation, transduction and conjugation; microbial metabolism; classification and characteristics of main groups of microorganisms; growth under extreme environments; archaebacteria; structure and biology of bacteriophages and animal and plant viruses.

Distinction between pentoses and hexoses, reducing and non-reducing sugars, mono-, di- and polysaccharides; estimation of glucose in a mixture of monosaccharides; estimation of sucrose by polarimeter; paper chromatography of sugars; extraction of glycogen from liver; acid and enzymic hydrolysis of glycogen.

Lipid separation from brain tissue and fractionation by TLC; tests for fats, sterols and phospholipids; estimation of cholesterol; acid, saponification and iodine values of fat.

BIOTECH-20 PRINCIPLES OF GENETICS

3 (2-1) Credits

Theory:

Heredity and variations; morphology and structure of eukaryotic chromosomes, mitosis and meiosis; monohybrid, dihybrid, trihybrid crosses, Mendelian parameters and their locations; gene interaction and lethality, modifications of Mendelian ratios, modifying gene and lethal genes; penetrance, expressivity's, pleiotropism and phenocopies, twin studies, nature and nurture.

Chromosome mapping, crossing over, methodology of mapping, interference, coefficient of coincidence; blood groups; sex chromosomes, sex linked inheritance and sex determination.

Practicals:

Problems related to Mendelian inheritance; gene interaction; gene mapping; ABO blood groups and Rh factors, drosophila culture techniques; study of mitosis and meiosis, using onion root tips and flower buds.

BIOTECH-21 PLANT PHYSIOLOGY

3 (2-1) Credits

Theory:

Plant structure; introduction to tissues and tissue systems in primary plant body. Water Relations. The plant-soil atmosphere continuum. (An overview). Physio-chemical properties of water. Water in the soil and its potentials. Water absorption, ascent and role in plant development.

Translocation of food; materials translocated, pathways, source-sink interaction. Mechanism of phloem transport.

Leaves and atmosphere; gaseous exchange, stomatal structure, mechanism and factors affecting stomatal movement.

Plant mineral nutrition. Importance of minerals, their absorption and role in plant development. Fertilizers and their significance in agriculture.

Photosynthesis. Concept. An overview of the mechanism. Pigments and photosynthetic activity. Photo system I and II. Photophosphorylation and its mechanism. Dark reactions (CO₂ reduction), C₄ and CAM pathways. Respiration; concept, respiratory substrates and quotient. Mobilization of substrates. Mechanism of aerobic and Anaerobic respiration. Electron transport, ATP formation and oxidative phosphorylation. Pentose phosphate pathway, Fermentation. Control and factors affecting respiration.

Assimilation of nitrogen, sulphur and phosphorus. Nitrogen cycle and fixation, sulphur and phosphorus assimilation.

Plant growth and development.

Phytochromes and role in biological processes. Phytohormones-kinds, structure and mechanism of action. Physiological effects of auxins, gibberellins, cytokinins, abscisic acid and ethylene. Photoperiodism and mechanism. Control of flowering, metabolic aspects of senescence, aging and death. Role of hormones in seed germination.

Gene regulation and signal transduction.

Practical:

Identification of C₃ and C₄ leaves; identification of stomatal types; study of special epidermal cells; study of T.S. of stem and root; determination of water potential by Chardakov's method; effect of light on and stomatal movements; measurement of water content, relative turgidity and water saturation deficit (WST), extraction of chlorophyll from leaves and separation of pigments; oxygen estimation by Winkler's methods; estimation of amylase form

germinating wheat grains; measurement of relative growth rate (RGR); measurement of specific leaf area and plant activity.

BIOTECH-22 ENZYMOLOGY

3 (2-1) Credits

Theory:

General characteristics of enzyme reactions; enzyme nomenclature and classification; substrate specificity; co-enzymes; regulation of enzyme activity; chemical kinetics and enzyme kinetics, Michaelis-Menten equation; activation energy; effect of pH and other factors on rates of reactions; inhibition of enzymatic reactions and kinetics; bisubstrate reactions; catalytic mechanisms; structure and mechanics of lysozyme; serine proteases and glutathione reductase; immobilized enzymes.

Practical:

Preparation and assay of amylase/peroxidase; effect of pH, temperature, enzyme and substrate concentration on activity; effect of cofactors, activators and inhibitors; determination of enzyme kinetics, k_m and V_{max} ; enzyme stability.

BIOTECH-23 BIOSTATISTICS

3 (3-0) Credits

Basic statistics for biotechnology; organizing and summarizing data, population samples, bio-statistical analysis, ordered array, frequency distributions, polygons and curves, histograms; measures of central tendency, arithmetic mean; measures of dispersion, range, mean deviation, standard deviation and error, coefficient of variation; probability distributions, normal, binomial and poisson distributions; hypothesis testing, statistical decision, one and two-sample hypothesis, Z-and other tests; simple linear regression and correlation; analysis of variance; nonparametric and distribution free test.

SEMESTER – V

BIOTECH-24 METABOLISM-I

3 (2-1) Credits

Theory:

Introduction to metabolism; experimental study of metabolic pathways; role of ATP and other high energy compounds; glycolytic pathway and its significance; fermentation; metabolism of hexoses other than glucose; glycogen breakdown and synthesis pathways; regulation of glycogen metabolism and blood glucose levels; citric acid cycle and its regulation; mechanism of electron transport chain; oxidative phosphorylation and regulation of ATP production; gluconeogenesis; glyoxylate pathway; biosynthesis of oligosaccharides and glycoproteins; mechanism and regulation of pentose phosphate pathway; mechanisms of light and dark reactions in photosynthesis.

Lipid digestion, absorption and transport; fatty acid oxidation; ketone bodies; fatty acid and triglyceride synthesis; biosynthesis, transport and utilization of cholesterol; prostaglandins, prostacyclines, thromboxanes and leukotrienes; phospholipid and glycolipid metabolism.

Practicals:

Determination of glucose, lactic acid, citric acid, succinic acid etc; determination of fatty acid, triacylglycerol, glycerol, phospholipids and cholesterol.

BIOTECH-25 MOLECULAR BIOLOGY

3 (2-1) Credits

Chromosomes, Mendelian inheritance and DNA as a carrier of genetic information; double-helical structure of DNA; forces stabilizing nucleic acid structures; supercoiled DNA; nucleic acids fractionation and sequencing;

chemical synthesis of oligonucleotides; DNA polymerase; DNA replication, general aspects and enzymes involved; prokaryotic and eukaryotic replication mechanisms; mutagenesis and mechanism of DNA repair; telomeres and aging; recombination and mobile genetic elements; DNA methylation.

RNAs and their role in protein synthesis; RNA polymerase and transcription; regulation of transcription in prokaryotes and eukaryotes; post transcriptional processing.

The genetic code; structure of transfer RNA; prokaryotic and eukaryotic ribosomal structure; translational processes and their control, protein synthesis inhibitors; post translational modifications; protein targeting; protein degradation; nonribosomal polypeptide synthesis; structure and genomic organization, regulation of eukaryotic gene expression; cell differentiation; oncogenes and cancer.

Practicals:

Preparation and estimation of DNA and RNA; plasmid preparation; DNA restriction and gel electrophoresis.

BIOTECH-26 MICROBIAL GENETICS

3 (2-1) Credits

Theory:

Morphology and life cycles of bacteria and viruses; recombination in bacteria, transformation, transduction and conjugation, their types, mechanisms and significance. gene mapping in bacteria; mode of action of antibiotics and development of resistance; extra chromosomal elements; plasmids classification with emphasis on R-factors, bacteriocins, biodegradative and yeast plasmids; transposable elements; IS elements, types and function; prophage-structure, life cycle integration and significance, transposition; integrons; recombination in bacteriophages; virulent and avirulent phages.

Practicals:

Growth curve of bacteria; induction of lytic cycle by U.V; oligodynamic action of metals on bacteria and yeast; detection of R-plasmids in bacterial strains; detection of transposons in bacterial strains; curing of bacterial plasmids; detection of mutants using replica plating techniques; transfer of genetic markers

through conjugation; gene mapping by interrupted mating in bacteria and detection of mutagenic activity by Ames test/yeast system.

BIOTECH-27 ELEMENTS OF BIOTECHNOLOGY 3 (2-1) Credits

Theory:

Introduction to biotechnology; microbial growth kinetics; shake-flask, solid state, anaerobic, batch and continuous fermentations; pilot scale and scaling up of fermentations; bioinstrumentation and computer control of fermentation processes; immobilized enzymes and cells; mammalian and plant cell culture; industrially important micro-organisms and biotechnological products; economic aspects of fermentation processes; biotechnology in health, agriculture and industry; future trends in biotechnology.

Practicals:

Preparation and characterization of chromosomal, plasmid and bacteriophage DNA and RNA; mini project to clone a specific gene in E. coli; techniques used in molecular biology and genetic engineering

BIOTECH-28 TECHNIQUES OF BIOTECHNOLOGY 3 (2-1) Credits

Theory:

General methods of fractionation and characterization of proteins and nucleic acids; dialysis; ultrafiltration; lyophilisation; principles and application of visible, UV, IR, MALDI – TOF, NMR spectroscopy in biotechnology; flame photometry; atomic absorption, fluorescence spectroscopy; X-ray diffraction, principle and application in the study of proteins; principle and applications of electron microscopy; principle and applications of centrifugation; principles and applications of adsorption, partition, ion-exchange, hydrophobic and affinity chromatography; chromatofocussing; principles and application of gas chromatography and HPLC; native and SDS-PAGE; isoelectric focussing,; immunoelectrophoresis; . 2-D gel electrophoresis; Western blotting; ELISA.

Practicals:

Use and demonstration of variety of chromatographic, electrophoretic and other techniques used for the study of biological compounds and reactions. Western blotting for protein identification.

SEMESTER - VI

BIOTECH-29 METABOLISM II

3 (2-1) Credits

Theory:

Amino acid deamination mechanisms; urea cycle and its regulation; biosynthesis of essential and non-essential amino acids; metabolic breakdown of individual amino acids, amino acids as biosynthetic precursors; nitrogen fixation.

Chemical nature and synthesis of purine and pyrimidine ribonucleotides; formation of deoxyribonucleotides; nucleotide degradation; synthesis of nucleotide coenzymes; integration and organ specialization of energy metabolism.

Regulation, integration, controls and disorders of metabolic pathways

Practicals:

Determination of proteins, amino acid, urea, uric acid, NH₃; separation of nucleotides and nucleosides by TLC.

BIOTECH-30 RECOMBINANT DNA TECHNOLOGY

3 (2-1) Credits

Theory:

An outline of DNA cloning experiment, cloning vectors including plasmids, bacteriophages, cosmids, YAC vectors, shuttle and expression vectors; tumor inducing (Ti) plasmids; restriction enzymes; gene splicing, genomic and cDNA libraries, screening methods for gene libraries; Southern and Northern blotting; chromosome walking; site specific mutagenesis; potentials of recombinant DNA technology; PCR; production of proteins; tissue culture techniques; transgenic organisms and gene therapies; restriction fragment length polymorphisms and disease detection (e.g. cystic fibrosis); human genome project; stem cells and therapeutic cloning; social considerations.

Practicals

PCR, Southern and Northern blotting; RFLP.

BIOTECH-31 PLANT BIOTECHNOLOGY

3 (2-1) Credits

Theory:

History of plant tissue culture; different basic media and their components; totipotency; callus culture; haploid production; organogenesis; embryogenesis; somaclonal variation, in vitro multiplication, cell and protoplast culture; cryopreservation; germ plasma preservation. Plant genetic engineering; delivery system (electroporation, agrobacterium and particle gun); transgenic plant production and molecular analysis; GM crops and their assessment; biosafety guidelines; marker assisted selection; DNA fingerprinting; biofertilizers and bio insecticides

Practical:

Seed culture; embryo culture; anther culture, microspore culture for double, haploid, micro propagation by auxiliary buds; adventitious shoot proliferation; plant regeneration by organogenesis; somatic embryogenesis from callus culture; meristems culture for virus elimination; *in vitro* fertilization; protoplast isolation and culture; agrobacterium mediated transformation; ELISA to certify pathogen free plants.

BIOTECH-32 ANIMAL BIOTECHNOLOGY

3 (2-1) Credits

Theory:

History and application of cell and tissue culture techniques; cell and its environment; factors effecting growth of cultured cells; contact inhibition, cell types and morphology, cell strains. Establishment of cell lines; cell cycle, chromosomes, polyploidy, karyotypes; genetics of cells in culture; cell transformation with physical, chemical and biological agents; origin of mutant cell line, negative selection, cell fusion, heterokaryons and hybridomas.

Practicals:

in immune response; cytokines; complement; hypersensitivity reactions; type I, II, III, IV; autoimmunity; resistance and immunization to infectious diseases; applications of immunological functions.

Practicals:

Ouchterlony immuno-double diffusion test; widal tests; ELISA; production of polyclonal activities.

BIOTECH-36 INDUSTRIAL BIOTECHNOLOGY 3 (2-1) Credits

Water pollution and effluent treatment, biodegradation of xenobiotic chemicals; ethanol and related fermentations; production of industrial enzymes; fermentation for the production of pharmaceutical products including antibiotics, hormones, vaccines, etc. production of other chemicals of industrial importance; microbial metal leaching.

Practicals:

Experiments including physical nutritional aspect of microbial fermentations; aerobic and anaerobic, batch and continuous cultures; ethanol production; product recovery etc.

BIOTECH-37 ENVIRONMENTAL BIOTECHNOLOGY 3 (2-1) Credits

Theory:

Environmental biotechnology and society; environmental assessment of biotechnological processes, marine environment, agricultural environment; extreme environments; disposal of domestic and industrial wastes and pollutants; microbial transformations; bioremediation of soils and water, role of bio-fertilizers and bio insecticide/microbial deodorization; coal and oil desulphurisation; biosafety guidelines.

Practicals:

Determination of heavy metal ions from various sources; biodegradation of vast and pollutants; cellulose decomposition.

BIOTECH-38 SKILLS AND RESEARCH METHDOLOGY FOR BIOTECHNOLOGISTS 3 (3-0) Credits

Overview of scientific research; improvement through research; nature of scientific inquiry; applications of research in industry; choosing a project; development of a research project; writing a research grant application; role of students; supervisor's role; designing and investigation; identifying the level within investigation; deciding on techniques to be employed; analysis of results; control, samples and replications; reviewing the literature; primary and secondary sources; scientific record keeping; use of microorganisms, animals, plants and humans in experimentation; use of pathogens in experiments; conflict of interests; ownership of data; writing, presentation and publishing the scientific papers; filing patent application.

SEMESTER VIII

BIOTECH-39 MEDICAL BIOTECHNOLOGY 2 (2 - 0) Credits

Conventional medical biotechnology; contemporary issues in medical biotechnology; introduction to principles of gene therapy and gene delivery system; human genome, detection of gene mutations; tissue engineering and transplantation; drug delivery; biodegradable polymers; practical and theoretical problems of modern methods of disease therapy; production of therapeutical monoclonal antibodies and their uses; role of organ transplantation in curing and new organ production; use of transgenic animals in therapy; the principles and practices of transfusion techniques; preparation of blood components and their use; essentials of osteopathic principles; human and veterinary osteopathy and bone grafting; ethical issues in gene therapy and tissue engineering.

BIOTECH-40 FOOD BIOTECHNOLOGY**3 (2 - 1) Credits**

The large scale biotechnology; isolation, preservation and improvement of industrial microorganism; the scope of biotechnology in the food and drink industry; dairy products; production of cheese, yogurt, butter cultured buttermilk, cultured sour cream; cereal products; bread and backed goods; starch hydrolysate brewing alcoholic beverage production, beer, wine, spirits, cider, and vinegar products; traditional tormented protein food, single cell protein; mycoprotein, food additives amino acids, vitamins and pigments, flavoring oil and fats, gum and thickness; preservation of fruits and vegetables; soya products; and fruit juices and other fruit products.

Practicals:

Visits to industry, milk and milk products; plain and flavored yogurt; cheese preparation; beverages; malt and malt extract preparation. Preservation of foods, vegetables and fruits, pectin production, enzymatic activity in juices; cereal products; plain and sour bread.

BIOTECH-41 ECONOMIC AND BUSINESS APPLICATION**2 (2 - 0) Credits**

The University and the corporation; multinational corporation and biotechnology. R and D contracts; introduction to finance; time, risk and return; trade off, time value, money; funding agencies and financial institutions; financial market; biotech-economics; consumer behaviour and demand; production costs, supply and price determination; competition and market; macroeconomics linkages to biotechnology; marketing biotechnology; commodities; biotechnology market regulations, patents, intellectual property rights; plant variety Protection Act.

BIOTECH-42 THESIS/FOUR OPTIONAL COURSES

OPTIONAL COURSES

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|------------|---|
| BIOTECH-43 | Protein Structure, Function and Engineering |
| BIOTECH-44 | Advanced Molecular Biology |
| BIOTECH-45 | Advanced Immunology |
| BIOTECH-46 | Advanced Microbiology |
| BIOTECH-47 | Industrial Enzymology |
| BIOTECH-48 | Renewable Resource Technology |
| BIOTECH-49 | Agricultural Biotechnology |
| BIOTECH-50 | Waste Management Biotechnology |
| BIOTECH-51 | Pharmaceutical Biotechnology |
| BIOTECH-52 | Proteomics |
| BIOTECH-53 | Mixed Microbial Processes |
| BIOTECH-54 | Aquaculture Biotechnology |
| BIOTECH-55 | Marine Biotechnology |
| BIOTECH-56 | Biodiversity and Genetic Conservation |
| BIOTECH-57 | Cell and Tissue Culture |
| BIOTECH-58 | Transgenic Plants |
| BIOTECH-59 | Transgenic Animal |
| BIOTECH-60 | Stem Cells and Therapeutic Cloning |
| BIOTECH-61 | Gene Therapy |
| BIOTECH-62 | Genomics |
| BIOTECH-63 | Safety Considerations for Biotechnology Processes |

Books Recommended:

1. Fundamentals of Biochemistry, D. Voet, J.G. Voet, C. W. Pratt. 1999. John Wiley & Sons, New York.
2. Principles of Biochemistry, A. L. Lehninger, D.L. Nelson and M.M. Cox, 3rd Edition. 2000. Worth Publishers, New York.
3. Biochemistry, G. Zubay, 4th Edition. 1998. Brown Dubuque, Iowa.
4. Biochemistry, L. Stryer, 5th Edition. 2002). W.H. Freeman & Co.
5. Harper's Biochemistry, R.K. Murray, D.K. Grammer, P.A. Mayes, V. W. Rodwell, 25th Edition. 2000. Appleton & Lange.

6. Principles of Microbiology, M Ronald. Atlas, 2nd Edition. 1997. W.C. Publishers.
7. Concepts in Biochemistry, R. F. Boyer. 1999. Books –Cole Publishing Co., USA.
8. The Basic Protein and Peptide Protocols, J.M. Walker. 1994. Humana Press.
9. Human Genetics: Concepts and Applications. R. Lewis, 1997. WCB-McGraw Hill Publishers, USA.
10. Microbiology: Concepts and Applications. M.J., Pleczar, E.C.S. Chan, and N. R Krieg,. 2000. McGraw Hill Inc., New York.
11. Fundamentals of Enzymology. N. Price, and L. Stevens, 1999. 3rd Edition. Oxford University Press Inc., New York.
12. Immunology: A short course. El., Benjanini, R Coico,. and G Sunshine,. 2000. 4th Edition 2000. Wiley-Liss Inc., Canada.
13. Molecular Biology of the Cell, Bruce Alberts, Alexander Johnson, 4th Edition, Garland Sciences.
14. Molecular Biology and Biotechnology, J. M. Walker and E.B. Gingold, 3rd Edition. 1993. Royal Chemistry Society.
15. Molecular Cell Biology, Lodish, Berk, Zipursky, 4th Edition. 2000. W. H. Freeman.
16. Cell and Molecular Biology, Karp, 3rd Edition. 2002. John Wiley and Sons.
17. Advanced Molecular Biology, M. Twynmen. 1999. Viva Books Pvt. Ltd.
18. Immunology, Riott, Brostoff, Male, 6th Edition. 2001. Mosby.
19. Immunology, A. Goldsby, J. Kindt, Osborne, 4th Edition. 2000. W. H. Freeman.
20. Biostatistics, Davul, 5th Edition. 1996.
21. Primer of Biostatistics, S. A. Glantz, 2nd Edition. 1989. McGraw Hill.
22. Microbial Manual of Methods for General Bacteriology, 1981. American Society for Microbiology.
23. Short Protocols in Molecular Biology, Frederick M. Ausubel, 4th Edition. 1999. John Wiley & Sons.
24. Basic Biotechnology. C. R. Attedge, and B. Kristiansen, 2001. Cambridge University Press, U.K.
25. Biostatistics in Clinical Medicine. Intigener, J. A., Mosteller, F., Thibean, L. A. and Ware, J. H.. 1994. McGraw Hill Inc., New York.
26. Basic and Clinical Biostatistics. Saunders, B.D. and Trapp, R. G./ 1993. Appleton and Lange, USA.
27. How to develop and write a Research Paper. Hemden, Cash P. 1998. ARCO.
28. Floriculture; Principles and Species. J. M. Dole, and H.F. Wilkins 1999. Ball Publishing, USA.
29. Year Book of International Horticulture Statistics. I Siegmund, and F. Heinrichs, 2000. Ball Publishing, USA. .
30. Principles of Tissue Engineering. R.P Lanza, R. Langer, and J Vacanti. 2000. 2nd Edition. Academic Press, California.

31. Plant Biotechnology. S. Ignacimutu, 1997. Oxford IBH Publisher, N. Delhi.
32. Plant Biotechnology and Molecular Biology: A Laboratory Manual M. S. Punia, 1999. Scientific Publishers, Jodhpur.
33. Applied Plant Biotechnology. V.L. Chopra, V.S. Malik and S.R. Bhat. 2000. Oxford IBH Publishers, New Delhi.
34. A Manual of Basic Technique. Freshney, R. Ian. 2000. Alan R. Liss, Inc., New York.
35. Application of Microbes in Biotechnology. Lee, Y.K. & C.L. Poh and H. M. Tan. 1999. Springer-verlag.
36. Introductory Practical Biochemistry. S. K Sawhney, and. R. Singh, (Eds) 2000. Narosa Pub. House New Delhi.
37. Biotransformations. K. Faber1999. Springer-verlag
38. Analysis of Plant Waste Materials. H. G. Linskens, and J. F. Jackson. 1999. Springer-verlag.
39. The Protein Protocols Handbook, 2nd Edition. M. Walker. 2002. Humana Press.
40. Introduction to Bioinformatics. (A Theoretical and Practical Approach). A. Krawetz and D. Womble. 2002. Humana Press.
41. The Nucleic Acid Protocols Handbook. Rapley. 2000. Humana Press.
42. Downstream Processing of Protein Protocols. A. Desai. 2000. Humana Press.
43. Glossary of Biotechnology Terms. 3rd Edition. R. Nill. 2002. CRC, Press
44. Basic Techniques in Molecular Biology. S. Surzyeki. 2000. Springer.
45. Introduction to Proteomics: Tools for the New Biology. C. Liebler. 2002. Humana Press.
46. Current Protocols in Molecular Biology. M. Ausubel. 2001. Cold-Springer-Harber.
47. Molecular Cloning: A laboratory Manual 3Vol. Set. Joseph Sambrook. 3rd Edition.
48. An Introduction to Genetic Engineering. Desmond S. T. Nicholl. 2002.
49. Molecular Biotechnology: Principles and Applications of Recombinant DNA. B. R. Glick and J. J. Pasternak. 2002. ASM Press
50. DNA Cloning: A Practical Approach, 2nd edition.4 Volumes. D.M Clover. 1995. Oxford University Press.
51. Microbial Genetics, Maloy S. R. , J. Jr Cronan, D. Freifelder, J. E. Cronan, Second Edition, Jones & Bartlett Pub; 1994
52. Molecular Genetics of Bacteria, Dale J. , 3rd edition, John Wiley & Son Ltd; 1998
53. Modern Microbial Genetics, Streips U. N. , R. E. Yasbin, 2nd edition, 2002, John Wiley & Sons.
Microbial Gene Techniques (Methods in Molecular Genetics Vol 6), Adolph K. W. Academic Press; 1995.

RECOMMENDATIONS

The committee made the following recommendations for implementation of courses in biotechnology and to ensure effective student learning:

1. Realizing the importance of biotechnology formal exposure to this subject should be started at an earlier level in the high school.
2. Keeping in view the lack of infrastructure of biotechnology in country, it is strongly felt that biotechnology should be included as one of the elective subjects at B.Sc level in the colleges where adequate facilities exist.
3. It was considered necessary that adequate facilities in the selected colleges including creation of academic posts in biotechnology and provision of other facilities be provided.
4. Higher degrees in biotechnology should be started only in those Universities, which have potential and expertise available. Further the HEC/National Commission of Biotechnology (NCB) should provide the funding for strengthening academic and laboratory facilities for these Universities.
5. HEC/NBC should ensure that biotechnology refresher courses/workshops/symposia are held regularly to train manpower for effective teaching of this subject at different levels. Further, adequate funds should be made available for such activities.
6. HEC/NCB should sponsor for the preparation of videos/CDs/lectures of national/international scientific/academic personnel on different topics and techniques of biotechnology. These should be readily available to all institutions involved in teaching /research in the field of biotechnology.

7. For professional universities like agriculture universities of Pakistan, a degree of agricultural biotechnology may be started and such Universities may be allowed to develop a uniform curriculum according to their specific needs that will cover the plant, animal and veterinary sciences.
8. It is recommended that HEC may constitute a NCRC for designing curricula for degree in Agricultural biotechnology.
9. As advancements are being made at a very rapid pace in the field of biotechnology, curriculum shall need to be revised at frequent intervals.
10. Biotechnology should be added as an optional subject in the Federal and Provincial competitive examinations for civil services.
11. The NCRC (Biotechnology) appreciates the efforts made by the HEC to develop new unified courses in biotechnology for the universities in this country. This committee is also of a strong opinion that merely introducing the new courses is not sufficient. It is also essential that steps are taken to ensure practices and facilities on a permanent basis for effective student learning.
12. This Committee strongly recommends that a separate monitoring and evaluation committee be formed to monitor the standard of teaching and research in biotechnology in the Universities.

The meeting concluded with a vote of thanks.

Convener

Secretary