JAMIA HAMDARD

DEPARTMENT OF BIOTECHNOLOGY

FACULTY OF SCIENCE

Courses of study for M.Sc. in Biotechnology
(Modified - July 2004)

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HAMDARD UNIVERSITY
COURSES OF STUDY FOR M.Sc. IN BIOTECHNOLOGY

M.Sc. (Ist year)

5 Theory Papers of 100 marks each **500 marks**
(Sessionals - 25 marks each, final examination - 75 marks each)

CBT - 101 : **Biomolecule and Biochemical basis of life**
CBT - 102 : **Molecular Biology**
CBT - 103 : **Microbiology and Immunology**
CBT - 104 : **Cell Biology and Physiology**
CBT - 105 : **Genetics, Genomics and Genetic Engineering**

2 Laboratory Courses
CBT - 106 : **Practical Course I** **150 marks**
CBT - 107 : **Practical Course II** **150 marks**
(Sessionals - 25 marks each, final examination - 125 marks each)

M.Sc. (IInd year)

4 Theory Papers of 100 marks each **400 marks**
(Sessionals - 25 marks each, final examination - 75 marks each)

CBT - 201 : **Animal and Microbial Biotechnology**
CBT - 202 : **Plant Biotechnology**
CBT - 203 : **Environmental Biotechnology and Social and Ethical Aspects of Modern Biotechnology**
CBT - 204 : **Bioinformatics**

1 Laboratory Course
CBT - 205 : **Practical Course III** **100 marks**
(Sessionals - 25 marks, final examination - 75 marks)

2 Projects
CBT - 206 : **Project report of 6-8 weeks training in Industry or National Laboratory during summer vacation. Marks to be awarded on basis of report and seminar 100 marks**
CBT - 207 : **Major Project, Dissertation, Viva-voce examination and seminars** **200 marks**

Total **800 marks**

GRAND TOTAL **1600 marks**

Important : ***Candidate may please note that a minimum of 75% attendance (both in theory and practicals) is required, otherwise the candidate will not be allowed to appear in the annual examinations.***

CBT =101 : Biomolecules and Biochemical Basis of life

Total marks : 100
Time : 100 hours

Unit - I

Carbohydrates **:** Occurrence, classification, structure and functions, active groups and chemical properties of sugars, Monosaccharides, disaccharides and polysaccharides, Mucopolysaccharides, proteoglycans, glycolipids and blood group polysaccharides. Carbohydrate metabolism : aerobic and anaerobic pathways. Glycolysis, TCA cycle and alternate pathways of glucose metabolism. Gluconeogenesis, glycogen synthesis and breakdown. Bioenergetics : Oxidative phosphorylation. Electron transport chain and ATP production. Cytochromes and other electron acceptors.

Unit - II

Structure and properties of lipids, fatty acids, phsopholipids and other derived lipids; structure and functions of lipoproteins, cholesterol, steroids and prostaglandins, membranes. Lipid metabolism : α,β and φ oxidation of fatty acids, metabolism of fatty acids with even and odd carbon atoms, saturated and unsaturated fatty acids. Metabolism and synthesis of phospholipids, glycolipids, sphinglipids and other derived lipids. Mobilization of fats.

Unit - III

Proteins structure : Classification of amino acids; Primary, secondary, tertiary and quarternary sturcture of proteins. Determination of protein structure and its analysis, Ramachandran plot. Hydropathy plot, Protein folding. Metabolism : synthesis and metabolism of individual amino acids. Interrelationship of protein and carbohydrate metabolism. Urea cycle. Nitrogen balance. Regulation of cell metabolism. Inborn errors of metabolism.

Unit - IV

Enzymes : Characteristics, nomenclature and classification. Coenzyems and vitamins; Enzyme catalysed reactions, enzyme kinetics, biological importance of the study of enzyme kinetics. Factors affecting enzyme activity, inhibition of enzyme catalyzed reactions. Control of enzyme activity. Multifunctional enzymes, multi-enzyme complexes, Coupled reactions, Cyclic reactions. Purification of enzymes, water, salt and pH balance. Thermodynamics.

CBT =102 : Molecular Biology

Total marks : 100
Time : 100 hours

Unit - I

Nucleic acids : Properties, structure and functions. Primary, secondary and three dimensional structure of DNA and RNA. Various types of DNA and RNA molecules. Properties of DNA in solution. Denaturation of DNA. Tm, denaturation and renaturation kinetics. Nucleic acid degradation, Nucleases. Synthesis and breakdown of purine and pyrimidine nucleotides. Regulation and interconversion of ribonucleotides and deoxyribonucleotides. DNA as the genetic material : Chromatin organization. Histones and non histone proteins. Central dogma of molecular biology, exceptions to central dogma. Replication of DNA. Enzymes and events in DNA replication. RNA primer. Leading and lagging strands, Okazaki fragments. Role of gyrase and other DNA topoisomerases. Fidelity of replication. Methylation and other modifications.

Unit - II

Gene structure, promoter and other regulatory elements. Transcriptional unit. RNA synthesis. Enzymes and events in transcription, abortive initiation. Elongation and termination, rho dependent and rho-independent termination. Primary transcript, hmRNA splicing, capping, polyadenylation and other post-transcriptional modifications. Transport of RNA to cytoplasm. Replication of RNA genome of viruses. Reverse transcriptase and RNA replicase. Protein synthesis: Genetic code and its properties. Structure and function of ribosomes, tRNA and tRNA synthetase. Role of 'G' nucleotide Glycosylation and other post-translational modifications. Energetics of translation. Secretary proteins, signal peptide, SRP. Intracellular localization of proteins. Transport vesicles. Secretion and transport of proteins.

Unit - III

Regulation of gene expression : General considerations, various models. Transnational and tanscriptional regulation. The DNA binding motifs, Enzyme activation and repression, catabolic repression, operon theory. Attenuation. Regulation of lytic and lysogenic cascade. Control of tanscriptional termination-role of alternate RNA structure. Sporulation and importance of sigma factors in regulation of gene expression. Various factors affecting eukaryotic gene expression. Regulation by chromatin structure. Regulation of rRNA and rProtein synthesis. Phase variation and recombination. Control by steroid and other hormones. Gene expression in response to stress. The response elements.

Unit - IV

Mutation: Causes of mutation, spontaneous and induced mutation, selection, mutagens. DNA damage, repair mechanisms. Transposable elements. Retro-viruses and retro-transposable elements: LINE, SINE, Ty-1, Copia eements etc., Mechanism of transposition. Genetic basis of diseases. Molecular biology of genetic diseases. Molecular biology of genetic diseases. Molecular Biology of cancer. Oncognes and Proto-oncogenes. Gene Therapy-principles and concepts.

CBT =103 : Microbiology and Immunology

Total marks : 100
Time : 100 hours

Unit - I

Bacteria, Viruses and other micro-organisms. Classification, gram +ve and -ve bacteria, characteristics. Microbial growth and iths regulation. Antibiotics and anti-viral agents. Life cycle of viruses. Fungi, slime moulds, water moulds and algae. Bacteriophages, Lysogenic and Lytic cycle in a bacteriophage. Recombination in Bacteriophages.

Unit - II

The microbial genetics. Mechanism of gene transfer in bacteria. Conjugation, transduction and transformation. Induced mutation and identification of mutants. Reversal of mutation and revertants. Micro-organism and infection. Molecular biology of infectious diseases. HIV.

Unit - III

Infection and immunity. Acquired and adaptive immunity. Humoral and cell-mediated immunity. Active and passive immunity. Immune response. Clonal selection theory. Cells and organs of immune system. T and B cells, macrophages, dendritic cells, NK cells. Primary, secondary and tertiary lymphoid organs. Apoptosis, necrosis and inflammation. Antigens and immunogens. Haptens, lectins, antigenic determinants. T-cell dependent and T-cell-independent antigens. Superantigens, Adjuvants, Structure and functions of antiboides. Classes of immunolobulins. Antibody variants - Isotypes, allotpes, idiotypes, Monoclonal antibodies. Antigen-antibody interactions - Primary and secondary. Affinity and avidity. Immunoflurescence, Fluorescence quenching, RIA, ELISA, Western blotting, Immunoprecipitation, Agglutination, Immunoelectrophoresis, MLR, Elispot assay, Hemolytic plaque assay, Cytotoxicity assay, FACS. Organization of immunoglobulin genes. Genetic control and theories for immunological diversity. Allelic exclusion. Molecular basis of immune response.

Unit - IV

T cell Receptor. Complement system and mechanism of its fixation. Complement dificiencies. MHC. Cytokines-Interleukins, interferons, growth factors. Antigen processing and presentation. Accessory molecules. T helper-B cell interactions. T helper cell subsets regulating antibody production. Cytotoxic T cell mediated killing. Immunological tolerance and clonal energy. Allergy and hypersensitivity. Autoimmunity. Transplantation immunology - Graft rejection, graft versus host reaction. Tumor immunology. Immune response to infectious diseases. Immunosuppression - immunodeficiency diseases (eg.AIDS). Vaccines - Traditional and new generation vaccines. Immunological approaches to contraception, birth control vaccines. Regulation of pitutary gland by hypothalamus, the neuro-endocrine axis.

CBT =104 : Cell Biology and Physiology

Total marks : 100
Time : 100 hours

Unit - I

Detailed structure of the plant and animal cells. Structure and function of the subcellular organelles, cell wall and membrane, Biogenesis, structure and function of mitocondria and chloroplast genome, transcription and translation of organelle genes; Cell cycle, Molecular evolution.

Unit - II

Photosynthesis : Carbon reactions : C_{3}-, C_{4}- and CAM-pathway, photorespiration, synthesis, transport and storage of starch. Cyanide- resistant respiration, pentose phosphate pathway and lipid metabolism in plants. Mineral nutrients in plant metabolism, their uptake and assimilation in plants. Nitrogen fixation, molecular genetics of nif genes, nodule genes and nodule development. Secondary plant metabolites, their major classes, biosynthesis and functions.

Unit - III

Plant Growth, Development and Differentiation : The analysis of growth, embryogenesis, meristems, root and shoot development, senescence and programmed cell death. Phytoreceptors: Phytochrome and other photoreceptor-structure, functions and cellular as well as molecular modes of actions. Phytohormones-structure, biosynthesis and functions. Control of flowering. Stress Physiology - water deficit, and drought resistance. Chilling and freezing stress. Heat stress and heat shock. Salinity stress. Oxygen deficiency. Air pollution. Stress-induced gene expression.

Unit - IV

Signal Transduction : Receptors, first messengers, secondary messengers. Cascade systems - Hormones and hormonal cascade systems and its regulation. Role of G-proteins, CAMP, CGMP, Protein kinases, IP_3, Ca^{++}, NO. Signal transduction in plants: chemical signals-Hormones and phytochromes, phtoalexins. Physical signals-blue & Red light, Abiotic and Biotic signals, Host-pathogen interactions.

CBT =105 : Genetics, Genomics and Genetic Engineering

Total marks : 100
Time : 100 hours

Unit I

Mendelian and nonMendelian inheritance: Quantitative traits, Linkages, polyploidy, sex determination, extra-chromosomal inheritance. Conventional breeding methods in plants-advantages and disadvantages. **Reproduction in Plants-**Gamaete formation, pollination and fertilization in plants. Incompatibility in plants, methods to overcome incompatibility, Apromixis

Unit II

Characteristic features of plasmids, phages, cosmids, YAC and BAC, Properties of cloning vectors, selectable markers. Isolation, purification, fractionation and characterization of nucleic acids. Nucleic acid modifying enzymes, restriction endonucleases. Synthesis of cDNA and cloning strategies. Instruction of genomic libraries.

Unit III

Genome analysis, Mapping and Genomics- Nucleic acid, oligonucleotide and immunoscreening of libraries. Southern, Northern and Western blotting. Probe labelling and hybridization Restriction mapping. DNA and RNA fingerprinting. DNA sequencing- chemical and enzymatic methods.

Unit IV

Site directed mutagenesis. PCR and related techniques including RAPD and AFLP. RFLP and related techniques. In-Vitro Cell Free protein synthesis:- wheat germ S-30, Rabbit reticulocytes. In-vivo protein synthesis: frog oocyte system. Functional genomics and Proteomics. Micro arrays. Protein engineering. Phage display. Applications of recombinant DNA (rDNA) technology.

CBT =201 : Animal and Microbial Biotechnology

Total marks : 100
Time : 100 hours

Unit - I

Expression of cloned genes in heterologous systems. Bacterial, streptomyces. Yeast cell, insect cell and mammalian cell expression systems. Baculouvirus and vaccinia virus systems. Insect cell and mammalian cell culture. Primary and secondary cultures, cell lines. Production of bio-molecules of medical importance by rDNA technology, expression of independent and fused proteins, expression of simple and glycosylated proteins. Secretory signal and secretion of r-proteins. Choice of expression system. Expression strategies. Factors influencing the high level expression.

Unit - II

Purification of recombinant products. Production of GH, HBsAG, insulin, TPA, gonadotropins and other biomedical products. ETT and improvement of genetic constitution of livestock. DNA based diagnostic probes. Live recombinant vaccines. New approaches for the development of vaccines. Subunit vaccines, DNA vaccines.

Unit - III

Hybridoma technology. Production of monoclonal antibodies applications. Engineering of MoAbs. Multipotent antibodies. Humanization and antigenization of MoAbs. Cell and enzyme immobiliztion- Methods of immbilization, kinetics and uses of immobilized enzymes. Bioreactors using immobilized enzymes. Applications of immobilized enzymes in medical science.

Unit - IV

Fermentation-scope, classification based on nature of the product and kinetics of cell growth. Substrates for fermentation. Isolation and preservation of cultures. Various types of fermenters. Common problems. Downstream processing-Purification of products. Industrial biotechnology. Biosensors and analytical applications. Biocatalyst technology.

CBT =202 : Plant Biotechnology

Total marks : 100
Time : 100 hours

Unit - I

Plant cell and tissue culture techniques : Principle and methods of various explants, possible in vitro responses, organogenesis, embryogenesis and micropropogation. Tissue culture as a source of genetic variability. Haploids and their utilization. Triploid plants. Nucellus culture. Embryo rescue for viable hybrids. Use of tissue culture in crop improvement programmes such as the development of herbicide, pesticide, salt stress and infection resistant plants. Tissue and cell culture for enhanced production of intermediary metabolites. Application of plant cell, tissue and organ culture. Role of mycrorrhiza in growth and development of transplants.

Unit - II

Transformation of plant cells and protoplasts: Vectors with special reference to Ti palsmids, selectable markers and reporter genes. Microprojectile bombardment mediated transformation. Elctroporation, micro-injection. Protoplast isolation and transformations. Isolation and transformation of plastids and mitochondria. Somatic hybridization. Molecular mechanism of *Agrobacterium* mediated gene transfer. SS Molecular techniques for the identification of transgenics, Analysis of transgenic plants for copy number, transgene stability, transgene silencing and inheritance

Unit - III

Development of transgenic plants. Plastome engineering and its applications. Metabolic engineering. Genetic engineering for modified carbohydrates, proteins and lipid metabolism in plants. Development of abiotic and biotic stress tolerant/resistant plants. Male sterility in transgenic plants.

Unit - IV

Application of plant genetic engineering: Transgenic plants for the production of human therapeutics and edible vaccines, Transgenics with increased shelf-life of fruits, Plants for higher biomass/biofuel production, Herbicide resistant plants, Insect pest resistant plants and transgenics with novel traits; Ecological impact of transgenic crops.

CBT 203 :Environmental Biotechnology and social and Ethical Aspects of Modern Biotechnology

Total marks : 100
Time : 100 hours

Unit I

Biotechnology and Environment : Development and uses of biofertilizers and biopesticides. Bioindicators. Food chain and biomagnification of non-degradable pollutants. Carry over effects of herbicides and pesticides. Non-conventional and renewable energy sources in management of the environmental pollution.

Unit II

Management of waste land, water and solids: Conventional and advanced technology of treatments of sewage and industrial effluents. Emerging biotechnological processes in water and water treatments. Landfils composition, earthwork treatment. Processing an recycling of organic residues. Bioremediation and biorestoration of degraded lands.

Unit III

Biodegradation of xenobiotic compounds: Degradation of aromatic compounds, chlorinated hydrocarbons, polyaromatic hydrocarbons, pesticides and surfactants. Biological leaching and mining, extraction of metals from ores, recovery of metals from solutions. Microbial treatments of oil pollution. Microbes in petroleum and desulphurization of coal.

Unit IV

Biotechnology and Society : Socio-economic aspects of use of cloned genes in medicine, agriculture, industry, and ecoprotection Ethical aspects of modern Biotechnology, Intellectual property rights-objectives of patent system, Basic principles and general requirements of patent law. Patentable subjects and protection in biotechnology; Paris convention and other international, UPOV convention. IPR and plant genetic resources, GATT and TRIPS, Biosafety-Objectives, definition, recombinant DNA safety; safety from genetically engineered organisms; Biological containment (BC) and physical containment (PC); Biosafety levels; Environmental laws. Plant biotechnology and biosafety.

CBT 204 :Bioinformatics

Total marks : 100
Time : 100 hours

Unit I

Data collection and presentation : Source of data, classification of data, type of diagrams and graphs, pictorial representation of frequency distribution in histograms and frequency polygons. Measures of central tendency : Arithmetic means, median, quartile deviation, mean deviation, standard deviation, variance and coefficient of variation. Probability : Probability measures, addition theorem of probability, multiplication theorem of probability, conditional probability and mathematical expectation. Test of significance : Standard error, students-t-test, significance test for large samples, significance test for difference of proportions. F-test, Chi-square test.

Unit II

Correlation : Positive and negative correlation, Karl Pearson's coefficient of correlation, ranks correlation coefficient. Regression : Liner regression, curvilinear regression, regression lines by least square methods, analysis of variance : One way classification, two way classification the complete randomized block design. Association of attributes : Comparison of observed and expected frequencies method, proportion method, Yule's coefficient of association, coefficient of contingency.

Unit III

Computer - Basic, Input/output units, Computer memory memory cell, memory organization, ROM, Serial access memory, Binary arithmetic, Logic Circuits, Processors, Computer architecture, Computer Languages. Assembly languages, Higher level programming languages, Compilation. Tools to build compilers, Operating systems, Batch OS, Multi programming OS, Time sharing OS, PC-OS, MS-DOS, UNIX, Microkernel based OS, Windows NT etc.

Unit IV

Applications of computer in Biotechnology, Biological data bases for nucleic acids and proteins : Pubmed, NCBI and EBI. Retrieval of data from public data bases, Other bioinformatic resources on NET, Computational methods for sequence analysis : PSI, BLAST

Unit V

Genome analysis and gene identification, Genome comparison and analysis, Phylogenic analysis, Primer designing, Molecular imaging and design, Prediction of 3-dimensional structure of proteins.

Practical Course - I

Total marks : 150
Time :200 hours

Theory, principles and demonstration of various research techniques used in Biotechnology

Spectroscopy : Lambert - Beer law, Ultraviolet and visible Spectroscopy, Colorimetric and spectrophotometirc methods for Qualitative analysis of biomolecules. Quantitative estimation of reducing and non-reducing sugars, amino acids, proteins and lipids and phytochemicals.

Biochemical estimation on blood and other body fluids.

Centrifugation : Subcellular fractionation and gradient centrifugation.

Chromatography : Affinity chromatography, HPLC, GLC, Thin layer chromatography, size Exclusion (Gel Filtration) chromatography, Ion-exchange chromatography.

Isoelectric focussing,

Ammonium sulphate precipitation.

Isolation purification, characterization and estimation of proteins, gel electrophoresis.

Enzyme isolation and study of the detailed enzyme kinetics.

Practical Course - II

Total marks : 150
Time : 200 hours

Buffer and solutions

Sterilization techniques, preparation of media, anitbiotics, other solutions and plates for bacterial cultures.

Growth and transformation of bacteria

Isolation, Purification and estimation of plasmid, phage and genomic DNA, Spectrophotometric analysis of DNA. Tm of dis DNA.

Restriction analysis and electrophoresis of DNA
Electrphoresis : Agarose gel electrophoresis, Polyacrylamide gel electrophoresis

Isolation, purification, electrophoresis and estimation of RNA

Blotting : Southern, Northern and Western blotting

Measurement of radioactivity, labelling of probes and molecular hybridization. Geiger-Mueller counter and Scintillation Counters, Enhanced Chemiluminescence (ECL), Autoradiography; RIA and ELISA

Isolation and culture of soil micro flora (*Rhizobia)*

Immunization of mice with purified proteins.

Practical Course - III

Total marks : 150
Time : 200 hours

Animal and Insect cell culture : general consideration

Requirements of Different types of cells, preparation of culture media, serum etc.

Maintenance of culture
Trypsinization and subculturing
Cryo-preservation and revival of frozen cultures

Suspension culture of insect cells

Transfection of cells with recombinant plasmid
Subcloning of genes and construction of expression cassettes
Transfection of CHO cells by $Ca_3(PO_4)_2$ co-precipitation method
Transfection of Fibroblast cells
Transfection of insect cells using lipofection

Marker genes suitable for selection
Amplification of dhfr gene by methotrexate
RIA analysis to assay the recombinant protein

Basics of plant Tissue Culture

Types of Explants, Media etc. Role of hormones and plant growth regulators on morphogenesis and differentiation, Protoplast isolation and cultures, Genetic Transformation of plants
Agrobacterium mediated
Direct DNA uptake method
Selection of transformants, and Reporter gene activity

Amplification of a DNA fragment by PCR.
DNA sequencing
RFLP analysis
Isoenzyme analysis
Stress induced proteins.