Syllabus

M.Sc. Programme

Course No.	*Title of the Course*	*Credits*
1st Semester		
*ABT 501	Principles of Biotechnology	3+0
ABT 502	Principles of Microbiology	2+1
ABT 503	Molecular Genetics	3+0
ABT 504	Molecular Cell Biology	3+0
*ABT 505	Biotechnology Lab-I	0+ 3
2nd Semester		
*ABT 551	Plant Tissue Culture and Genetic Transformation	2+ 2
ABT 552	Plant Genetic Engineering	3+ 0
ABT 553	Bioinformatics	2+ 1
ABT 554	Biosafety, IPR and Bioethics	2+0
*ABT-555	Fundamentals of Molecular Biology	3+ 0
ABT 556	Environmental Biotechnology	2+0
3rd Semester		
ABT 601	Immunology and Molecular Diagnostics	2+1
*ABT 602	Biotechnology Lab-II	0+3
*ABT 603	Genomics and Proteomics	3+0
ABT 604	Molecular Breeding	3+ 0
ABT 655	Microbial/Industrial Biotechnology	2+1
ABT 656	Nanobiotechnology	2+0
ABT 649	Seminar-I	1+0
4th Semester		
ABT 699	Seminar-II	1+0

*Core Courses

M.Sc. Courses

ABT 501: Principles of Biotechnology **3+0**

UNIT I: The structure of DNA; Function of genes and genomes; Restriction enzymes and vectors; Methods of recombinant DNA technology; Nucleic acid hybridization; PCR and its applications.

UNIT II: Molecular markers (RFLP, RAPD, SSR, AFLP, SNP, EST etc.) and their applications; DNA sequencing.

UNIT III: Applications of gene cloning in basic and applied research; Genomics, transcriptomics and proteomics.

UNIT IV: Genetic engineering and transgenics, General application of biotechnology in agriculture, medicine, animal husbandry, environmental remediation, energy production and forensics.

UNIT V: Public perception of biotechnology; Bio-safety and bioethics issues; Intellectual property rights in biotechnology.

ABT 502: Principles of Microbiology 2+1

UNIT I: Development of microbiology in the 18^{th} and 19^{th} century. Morphology, structure and function of prokaryotic and eukaryotic cell. Archea. Classification of prokaryotes – Basic principles and techniques used in bacterial classification.

UNIT II: Evolutionary relationship among prokaryotes. Phylogenetic and numerical taxonomy. Use of DNA and r-RNA sequencing in classifications.

UNIT III: Study of major groups of bacteria belonging to Gracilicutes, Firmicutes, Tanericutes and Mendosicutes.

UNIT IV: Viruses – morphology, classification and replication of plant, animal and bacterial viruses. Cultivation methods of viruses. Immune response – specific and non-specific resistance. Normal microflora of human body; some common bacterial and viral diseases of humans and animals.

Practical: Methods of isolation, purification and maintenance of microorganisms from different environments (air, water, soil, milk and food); Enrichment culture technique – isolation of asymbiotic, symbiotic nitrogen fixing bacteria. Isolation of photosynthetic bacteria; Use of selective media, antibiotic resistance and isolation of antibiotic producing microorganisms; Morphological, physiological and biochemical characterization of bacteria.

ABT 503: Molecular Genetics 3+0

UNIT I: Mendelian principles of inheritance, molecular genetic systems, genetic variation, mutation, physical, chemical and insertional mutagenesis, site-directed mutagenesis, recombination and repair.

UNIT II: Gene mapping and tagging, tag based gene isolation, fine structure analysis of genetic loci and complementation test, deletion mapping.

UNIT III: Organization of genes in prokaryaotes and eukaryotes, gene and genome evolution, identification of cis-regulatory elements, transacting factors and regulation of gene expression at different levels.

UNIT IV: Deciphering of genetic code, gene-protein colinearity, gene-enzyme relationship, molecular gene concept. Plasmids and their inheritance.

UNIT V: Introduction of genetic markers, classification and comparison of markers, basis of DNA polymorphism, principles and applications of genome mapping and DNA fingerprinting, genome analysis, classical and modern methods, principles of structural and functional genomics approaches.

ABT 504: Molecular Cell Biology 3+0

UNIT I: General structure and constituent of cells; Similarities and distinction between plant and animal cells; Cell wall, cell membrane, cell surface related function.

UNIT II: Structure and function of major organelles: nucleus, chloroplasts, mitochondria, endoplasmic reticulum, microbodies, golgi apparatus, vacuoles.

UNIT III: Organellar genomes and their manipulation; Ribosome in relation to cell growth and cell division; Cyto-skeletal elements; Water, protein and ion transport.

UNIT IV: Trafficking of biomolecules, Cell division and regulation of cell cycle; transduction mechanisms.

ABT 505: Biotechnology Lab-I 0+3

UNIT I: Good lab practices, Growth of bacterial culture and preparation of growth curve.

UNIT II: Biochemical techniques, Preparation of buffers and reagents, electrophoresis-agarose and PAGE (nucleic acids and proteins), Principle of centrifugation.

UNIT III: Isolation of genomic and plasmid DNA from bacteria, Growth of lambda phage and isolation of phage DNA, Restriction digestion of plasmid and phage DNA.

UNIT IV: Chromatographic techniques (TLC, Gel filtration Chromatography, Ion exchange chromatography, Affinity chromatography).

ABT 551: Plant Tissue Culture and Genetic Transformation 2+2

UNIT I: History of plant cell and tissue culture; Culture media; Various types of culture; callus, suspension, nurse, root, meristem, etc.; *In vitro* differentiation: organogenesis and somatic embryogenesis; Plant growth regulators: effects on *in vitro* culture and regeneration.

UNIT II: Micropropagation; Anther and microspore culture; Somaclonal variation; *In vitro* mutagenesis; *In vitro* fertilization; *In vitro* germplasm conservation; Production of secondary metabolites; Synthetic seeds.

UNIT III: Embryo rescue and wide hybridization; Protoplast culture and regeneration; Somatic hybridization: protoplast fusion, cybrids, asymmetric hybrids, etc.

UNIT IV: Methods of plant transformation; Vectors for plant transformation; Genetic and molecular analyses of transgenics; Target traits and transgenic crops; Biosafety issues, testing of transgenics, regulatory procedures for commercial approval.

Practical: Laboratory set-up. Preparation of nutrient media; handling and sterilization of plant material; inoculation, subculturing and plant regeneration. Anther and pollen culture. Embryo rescue. Suspension cultures and production of secondary metabolites. Protoplast isolation, culture and fusion. Gene cloning and vector construction. Isolation of plasmids with reporter gene. Leaf disc transformation using *Agrobacterium* and establishment of transgenic plants. DNA extraction from transgenic plants, DNA estimation, PCR analysis. Southern blot analysis to prove T-DNA integration. Western blotting to study the accumulation of transgene-encoded protein.

ABT 552: Plant Genetic Engineering 3+0

UNIT I: ***Agrobacterium*** - plant interaction; Virulence; Ti and Ri plasmids; Opines and their significance; T-DNA transfer; Disarming the Ti plasmid, *Agrobacterium* - mediated gene delivery, co-integrate and binary vectors and their utility; Direct gene transfer - PEG-mediated, electroporation, particle bombardment and alternative methods; Scorable and selectable markers; Monocot transformation, promoters and polyA signals; Characterization of transgenics; Chloroplast transformation: advantages, vectors and successes; Marker-free methodologies; Gene stability and gene silencing, gene stacking.

UNIT II: Bacterial resistance, Viral resistance : coat protein mediated, nucleocapsid gene, Fungal diseases: chitinase, 1-3 β- glucanase, RIP, antifungal proteins, thionins, PR proteins, Insect pests resistance: Bt genes, Non-Bt like protease inhibitors, α- amylase inhibitor, nematodes resistance and herbicide resistance: phosphoinothricin, glyphosate, sulfonyl urea, atrazine, drought, salinity, thermal stress, flooding and submergence tolerance, post-harvest losses, long shelf life of fruits and flowers: use of ACC synthase, Polygalacturanase, ACC oxidase, male sterile lines: bar and barnase systems.

UNIT III: Genetic engineering for increasing crop productivity: enhancing photosynthetic, nutrient use and nitrogen fixing efficiencies of plants, manipulation of plant architecture and flowering behaviour.

UNIT IV: Genetic Engineering for quality improvement: Seed storage proteins; essential amino acids, Vitamins and minerals, heterologous protein production in transgenic plants for agriculture, industry and pharmaceuticals uses, biodegradable plastics, Plants as biofactories.

UNIT V: Role of antisense and RNAi in crop improvement, regulated and tissue specific expression of transgenes for crop improvement, Terminator gene technology, Environmental issues associated with transgenic crops, food safety issues and risk assessment of transgenic food crops.

ABT 553: Bioinformatics 2+1

UNIT I: Basic molecular biology; introduction to the basic principles of structure/function analysis of biological molecules; genome analysis; different types and classification of genome databases (e.g. DNA, Protein, EST, STS, SNPs, Unigenes etc.).

UNIT II: Statistical Techniques in Biological data: descriptive statistics, correlation and regression, multivariate analysis, resampling techniques.

UNIT III: DNA sequence retrieval system, various DNA and protein sequence file formats, Basic concepts of similarity searching and sequence alignments, pair wise and multiple sequence alignments, DNA sequence analysis, different gene prediction models and gene annotation tools, primer designing.

UNIT IV: Protein sequence analysis and structure prediction, comparative genome analysis, phylogenetic analysis, gene expression analysis tools.

Practical: Different types of databases and database search and retrieval, DNA and protein sequence analysis; Similarity searching and multiple alignments; Gene annotation; Phylogenetic analysis; Sequence analysis; Protein structure prediction; Analysis of microarray data.

ABT 554: Biosafety, IPR and Bioethics 2+0

UNIT I: Biosafety and risk assessment issues; Health aspects; toxicology, allergenicity; Ecological aspects.

UNIT II: Regulations; National biosafety policy and law. The Cartagena Protocol on biosafety. The WTO and other international agreements; Cross border movement of germplasm; Risk management issues;

UNIT III: Monitoring strategies and methods for detecting transgenics; Risks, benefits and impacts of transgenics to human health, society and the environment; Biosafety and biohazards; general principles for the laboratory and environmental biosafety.

UNIT IV: Environment Impact Assessment; Gene flow in natural and artificial ecologies; Sources of gene escape; Ecological risks of genetically modified plants.

UNIT V: Implications of intellectual property rights on the commercialization of biotechnology products.

ABT 555: Fundamentals of Molecular Biology 3+0

UNIT I: Historical developments of molecular biology; Nucleic acids as genetic material; Chemistry, structure and properties of DNA and RNA.

UNIT II: Genome organization in prokaryotes and eukaryotes; Chromatin structure and function; chromosome remodeling, DNA replication; DNA polymerases, topoisomerases, ligases, etc.; Molecular basis of mutations; DNA repair mechanisms; DNA recombination; Conjugation, Transduction and Transformation.

UNIT III: Transcription process;; RNA processing; small RNA*;* Reverse transcriptase; RNA editing; Ribosome structure and function; Organization of ribosomal proteins and RNA genes; Genetic code; Aminoacyl tRNA synthases.

UNIT IV: Translation and post-translational modifications; Operon concept; Lac Operon, attenuation of *trp* operon; important features of gene regulation.

ABT 556: Environmental Biotechnology 2+0

UNIT I: Basic concepts and environmental issues; types of environmental pollution; problems arising from high-input agriculture; methodology of environmental management; air and water pollution and its control; waste water treatment - physical, chemical and biological processes; need for water and natural resource management.

UNIT II: Microbiology and use of micro-organisms in waste treatment; biodegradation; degradation of xenobiotics, surfactants; bioremediation of soil and water contaminated with oils, pesticides and toxic chemicals, detergents etc.; aerobic processes (activated sludge, oxidation ditches, trickling filter, rotating drums etc.); anaerobic processes: digestion, filtration etc.

UNIT III: Renewable and non-renewable resources of energy; energy from solid waste; conventional fuels and their environmental impact; biogas; microbial hydrogen production; conversion of sugar to alcohol; gasohol; biodegradation of lignin and cellulose; biopesticides; biofertilizers; composting; vermiculture etc.

UNIT IV: Treatment schemes of domestic waste and industrial effluents; food, feed and energy from solid waste; bioleaching; enrichment of ores by microorganisms; global environmental problems: ozone depletion, UV-B, greenhouse effects, and acid rain; biodiversity and its conservation; biotechnological approaches for the management environmental problems.

ABT 601: Immunology and Molecular Diagnostics 2+1

UNIT I: History and scope of immunology; components of immune system: organs, tissues and cells,

UNIT II: Immunoglobulins chemistry, structure and functions; molecular organisation of immunoglobulins and classes of antibodies, antibody diversity; antigens, haptens, antigen-antibody interactions; immuno-regulation and tolerance; Allergies and hypersensitive response; immunodeficiency; vaccines.

UNIT III: Immunological techniques, immunological application in plant science, monoclonal antibodies and their uses, molecular diagnostics.

UNIT IV: Introduction to the basic principles of molecular technology and techniques used in pathogen detection; Principles of ELISA and its applications in viral detection,

UNIT V: Basics and procedures of PCR, real time PCR, PCR based and hybridization based methods of detection, microarrays based detection, multiplexing etc, detection of soil borne and seed born infections, transgene detection in seed, planting material and processed food, molecular detection of varietal impurities and seed admixtures in commercial consignments.

Practical: Purification of antigens and immunoglobuins. Estimation of immunoglobulins and their fragments. Production of antisera. Determination of titre of antisera. Immunodiffusion and immunoelectrophoresis, RIA, ELISA.

ABT 602: Biotechnology Lab-II 0+3

UNIT I: Isolation of plant DNA and RNA, spectrophotometric and gel quantification; Restriction digestion, agarose gel electrophoresis, hybridization, autoradiograph development, Dot blot analysis, Northern hybridization.

UNIT II: Gene cloning and blue white selection.

UNIT III: PCR and optimization of factors affecting PCR; Synthesis and cloning of cDNA and RT-PCR analysis.

UNIT IV: Western hybridization.

UNIT V: Molecular markers (RAPD, SSR, AFLP etc.) and their analysis.

ABT 603: Genomics and Proteomics 3+0

UNIT I: Structural genomics: Classical ways of genome analysis, large fragment genomic libraries; Physical mapping of genomes; Genome sequencing, sequence assembly and annotation; Comparative genomics, etc.

UNIT II: Functional genomics: DNA chips and their use in transcriptome analysis; Mutants and RNAi in functional genomics; Metabolomics and ionomics for elucidating metabolic pathways, etc.

UNIT III: Proteomics - protein structure, function and purification; Introduction to basic proteomics technology; Bioinformatics in proteomics; Proteome analysis etc.

UNIT IV: Applications of genomics and proteomics in agriculture, human health and industry.

ABT 604: Molecular Breeding 3+0

UNIT I: Principles of plant breeding; breeding methods for self and cross pollinated crops; Heterosis breeding; Limitations of conventional breeding; Aspects of molecular breeding.

UNIT II: Development of sequence based molecular markers - SSRs and SNPs; advanced methods of genotyping.

UNIT III: Mapping genes for qualitative and quantitative traits; QTL mapping using structured populations; AB-QTL analysis; association mapping of QTL; Fine mapping of genes/QTL; Map based gene/ QTL isolation and development of gene based markers.

UNIT IV: Methods of assessing genetic diversity and germplasm characterization, DNA fingerprinting and its application.

UNIT V: Allele mining by TILLING and Eco-TILLING; use of markers in plant breeding; Marker assisted selection (MAS) in backcross and hetersosis breeding; transgenic breeding; foreground and background selection; MAS for gene introgression and pyramiding: MAS for specific traits with examples.

ABT 655: Microbial/Industrial Biotechnology 2+1

UNIT I: Introduction, scope and historical developments; Isolation, screening and genetic improvement (involving classical approaches) of industrially important organisms.

UNIT II: Primary metabolism products, production of industrial ethanol as a case study; Secondary metabolites, bacterial antibiotics and non ribosomal peptide antibiotics; Recombinant DNA technologies for microbial processes; Strategies for development of industrial microbial strains with scale up production capacities; Metabolic pathway engineering of microbes for production of novel product for industry.

UNIT III: Microbial enzymes, role in various industrial processes, production of fine chemicals for pharmaceutical industries; Bio-transformations, Bioaugmentation with production of vitamin C as a case study; Bioreactors, their design and types; Immobilized enzymes based bioreactors; Microencapsulation technologies for immobilization of microbial enzymes.

UNIT IV: Industrial biotechnology for pollution control, treatment of industrial and other wastes,biomass production involving single cell protein; Bioremediation of soil; Production of eco-friendly agricultural chemicals, biopesticides, bioherbicides, biofertilizers, biofuels etc.

Practical: Isolation of industrially important microorganisms, their maintenance and improvement; Production of industrial compounds such as alcohol, beer, citric acid, lactic acid and their recovery; Study of bioreactors and their operations; Production of biofertilizers; Experiments on microbial fermentation process, harvesting purification and recovery of end products; Immobilization of cells and enzymes, studies on its kinetic behaviour; growth analysis and biomass estimation; Determination of mass transfer co-efficients.

ABT 656: Nanobiotechnology 2+0

UNIT I: Introduction to biomacromolecules: The modern concepts to describe the conformation and dynamics of biological macromolecules: scattering techniques, micromanipulation techniques, drug delivery applications etc.

UNIT II: Cellular engineering: signal transduction in biological systems, feedback control signalling pathways, cell-cell interactions etc. Effects of physical, chemical and electrical stimuli on cell function and gene regulation.

UNIT III: Chemical, physical and biological properties of biomaterials and bioresponse: biomineralization, biosynthesis, and properties of natural materials (proteins, DNA, and polysaccharides), structure-property relationships in polymeric materials (synthetic polymers and structural proteins); Aerosol properties, application and dynamics; Statistical Mechanics in Biological Systems,

UNIT IV: Preparation and characterization of nanoparticles; Nanoparticular carrier systems; Micro- and nano-fluidics; Drug and gene delivery system; Microfabrication, Biosensors, Chip technologies, Nanoimaging, Metabolic engineering and Gene therapy.