Maulana Abul Kalam Azad University of Technology, West Bengal

(Formerly West Bengal University of Technology)

Syllabus for M. Sc. In Biotechnology

Semester I

Code	Course Title	Contact Hrs./wk	Credit
A	**Theory**	**L- T -P**	
MSBT-101	Biochemistry	3-0-0	3
MSBT-102	Laboratory techniques	3-0-0	3
MSBT-103	Cell and Molecular Biology	3-0-0	3
MSBT-104	Biostatistics	3-0-0	3
MSBT-105	Microbiology	3-0-0	3
B	**Practical**		
MSBT-191	Biochemistry & Analytical Techniques Lab	0-0-6	3
MSBT-192	Microbiology Lab	0-0-6	3
MSBT-193	Cell Biology Lab	0-0-6	2
C			
MSBT-181	Seminar		1
Semester Total			24

MSBT101: Biochemistry credits 3

Unit 1: Basic chemistry for biologists

Formation of chemical bonds, molecular orbital (MO) theory and linear combination of atomic orbitals (LCAO),basics of mass spectrometry, molecules, Avogadro number, molarity, chemical reactions, reaction stoichiometry, rates of reaction, rate constants, order of reactions,kinetic versus thermodynamic controls of a reaction, reaction equilibrium (equilibrium constant); light and matter interactions (optical spectroscopy, fluorescence, bioluminescence, paramagnetism and diamagnetism, photoelectron spectroscopy; chemical bonds (ionic, covalent, Van derWalls forces); electronegativity, polarity; VSEPR theory and molecular geometry, dipole moment, orbital hybridizations; acids, bases and pH - Arrhenious theory, pH, ionic product of water, weak acids and bases,
conjugate acid-base pairs, buffers and buffering action etc; chemical thermodynamics - internal energy, heat and temperature, enthalpy (bond enthalpy and reaction enthalpy), entropy, Gibbs free energy of ATP driven reactions, spontaneity versus driven reactions in biology;bond rotations and molecular conformations - Newman projections, conformational analysis of alkanes, alkenes and alkynes; functional groups, optically asymmetric carbon centers, amino acids, proteins, rotational freedoms in polypeptide backbone (Ramachandran plot).

Unit 2 :Protein Structure

Water – properties of water, essential role of water for life on earth pH, buffer, maintenance of blood pH and pH of gastric juice, pH optima of different enzymes (pepsin, trypsin and alkaline phosphatase), ionization and hydrophobicity, emergent properties of biomolecules in water, biomolecular hierarchy,
macromolecules, molecular assemblies; Structure-function relationships: amino acids – structure and functional group properties, peptides and covalent structure of proteins, elucidation of primary and higher order structures, Ramachandran plot, evolution of protein structure, protein degradation and introduction to molecular pathways controlling protein degradation, structure-function relationships in
model proteins like ribonuclease A, myoglobin, hemoglobin, chymotrypsin *etc.*; basic principles of protein purification; tools to characterize expressed proteins; Protein folding: Anfinsen's Dogma, Levinthal paradox, cooperativity in protein folding, free energy landscape of protein folding and pathways of protein folding.

Unit 3: Enzyme

Enzyme catalysis – general principles of catalysis; quantitation of enzyme activity and efficiency; enzyme characterization and Michaelis-Menten kinetics; relevance of enzymes in metabolic regulation, activation,inhibition and covalent modification; single substrate enzymes;restriction enzymes and nucleoside monophosphate kinase; regulatory strategies with specific example of haemoglobin; isozymes; role of covalent modification in enzymatic activity; zymogens.

Unit 4 :Glycobiology

Sugars-mono, di, and polysaccharides with specific reference to glycogen, amylose. lipids- structure and properties of important members of storage and membrane.

Unit 5 :Nucleic acid

nucleosides, nucleotides, nucleic acids - structure, a historical perspective leading up to the proposition of DNA double helical structure.

Unit 6: Bioenergetics

Bioenergetics-basic principles; equilibria and concept of free energy; coupled interconnecting reactions in metabolism; oxidation of carbon fuels;Ca++ signaling pathways; glycolysis and gluconeogenesis;Citric acid cycle, entry to citric acid cycle, citric acid cycle as a source of biosynthetic precursors; Oxidative phosphorylation, Photosynthesis – chloroplasts and two photosystems; proton gradient across thylakoid membrane.

Unit 7: Role of vitamins & cofactors in metabolism

Calvin cycle and pentose phosphate pathway; glycogen metabolism, reciprocal control of glycogen synthesis and breakdown, elucidation of metabolic pathways; logic and integration of central metabolism;entry/ exit of various biomolecules from central pathways; principles of metabolic regulation; steps for regulation.

Texts/References:

1. M.T. Madigan and J.M. Martinko, Brock Biology of Microorganisms, 11th Edition,
Pearson Prentice-Hall, 2006.
2. L. Stryer, Biochemistry, 4th Edition, Freeman, 2002.
3. G. Gottschalk, Bacterial Metabolism, 2nd Edition, Springer-Verlag, New-York, Berlin. 1986.

MSBT102: Laboratory Techniques **credits 3**

Unit1 :Chromatography Techniques - Paper Chromatography, Thin-layer chromatography, Displacement chromatography, Gas chromatography, High performance / pressure liquid chromatography, Ion exchange chromatography, Size-exclusion chromatography, Affinity chromatography.

Unit 2: Electrophoretic techniques and blotting techniques - Theory and application of Polyacrylamide and Agarose gel electrophoresis; Capillaryelectrophoresis; 2D Electrophoresis; Immunoelectrophoresis, Isoelectric focussing, Disc gel electrophoresis; Gradient electrophoresis; Pulse field gel electrophoresis, Western blot, Eastern blot, Southern blot, Northern blot.

Unit 3 :Radioactivity - Radioactive & stable isotopes; Pattern and rate of radioactive decay; Units of radioactivity; Measurement of radioactivity; Geiger-Muller counter; Solid & Liquid scintillation counters (Basic principle, instrumentation & technique); Applications of isotopes in biochemistry; Autoradiography.

Unit 4 :Centrifugation - Basic principles; Mathematics & theory (RCF, Sedimentation coefficient etc); Types of centrifuge, Microcentrifuge, High speed & Ultracentrifuges; Preparative centrifugation; Differential & density gradient centrifugation; Applications (Isolation of cell components); Analytical centrifugation; Determination of molecular weight by sedimentation velocity & sedimentation equilibrium methods.

Unit 5: Microscopy

Optical microscopy, Electron microscopy, Confocal microscopy

Unit 6: Advanced techniques

DNA and Amino acid Sequencing, DNA CHIP, Microarray, Substractive Hybridization, RNase protection assay, ELISA, Mass spectroscopy, Infra red spectroscopy, NMR, Circular Dichroism

MSBT103:Cell and Molecular Biology credits 3

Unit 1: organization of cell :

Universal features of cells; cell chemistry and biosynthesis: chemical organization of cells; internal organization of the cell - cell membranes: structure of cell membranes and concepts related to compartmentalization in eukaryotic cells; intracellular organelles: endoplasmic reticulum and Golgi apparatus, lysosomes and peroxisomes, ribosomes, cellular cytoskeleton,mitochondria, chloroplasts and cell energetics; nuclear compartment: nucleus, nucleolus and chromosomes.

Unit 2:Chromatin structure :Chromatin organization - histone and DNA interactome: structure and assembly of eukaryotic and prokaryotic DNA polymerases, DNA-replication, repair and recombination; chromatin control: gene transcription and silencing by chromatin-Writers,-Readers and –Erasers;

Transcriptional control: Structure and assembly of eukaryotic and prokaryotic RNA Polymerases,promoters and enhancers, transcription factors as activators and repressors, transcriptional initiation, elongation and termination; post-transcriptional control: splicing and addition of cap and tail, mRNA flow through nuclear envelope into cytoplasm, breakdown of selective and specific mRNAs through interference by small non-coding RNAs (miRNAs and siRNAs), protein translation machinery, ribosomescomposition and assembly; universal genetic codes, degeneracy of codons, Wobble hypothesis; Isoaccepting tRNA; mechanism of initiation, elongation and termination; co- and post-translational modifications, mitochondrial genetic code.

Unit 3:Cellular signalling, transport and trafficking: Molecular mechanisms of membrane transport, nuclear transport, transport across mitochondria and chloroplasts; intracellular vesicular trafficking from endoplasmic reticulum through Golgi apparatus to lysosomes/cell exterior.

Unit 4:Cell cycle and its regulation; cell division: mitosis, meiosis and cytokinesis; cell differentiation: stem cells, their differentiation into different cell types and organization into specialized tissues; cell-ECM and cell-cell interactions; cell receptors and trans-membrane signalling; cell motility and migration; cell death: different modes of cell death and their regulation.

Unit 5: Manipulating and studying cells: Isolation of cells and basics of cell culture; observing cells under a microscope, different types of microscopy; analyzing and manipulating DNA, RNA and proteins.

Unit 6:Genome instability and cell transformation: Mutations, proto-oncogenes, oncogenes and tumour suppressor genes, physical, chemical and biological mutagens; types of mutations; intra-genic and inter-genic suppression; transpositions- transposable genetic elements in prokaryotes and eukaryotes, role of transposons in genome; viral and cellular oncogenes; tumor suppressor genes; structure, function and mechanism of action; activation and suppression of tumor suppressor genes; oncogenes as transcriptional activators.

Unit 7:Mammalian genetics: Mendel's experiments, monohybrid and dihybrid cross, sexual reproduction applications of chi square test, deviation from Mendelian segregation, linkage, genetic map, Mendelism in human genetics: pedigree analysis, dosage compensation and sex determination, inheritance characteristics of sex-linked and autosomal traits,chromosome discovery, chromosomes as physical basis of inheritance, Polytene and lampbrush chromosomes, chromosomal aberrations and genetic load, sex-linked deleterious genes, extrachromosomal/non-Mendelian inheritance(episomes, mitochondria and chloroplasts), parental imprinting, Population Genetics-Variation and its modulation, effect of sexual reproduction on variation (Hardy-Weinberg Equilibrium), sources of variation, selection balanced polymorphism, random events.variation, selection balanced polymorphism, random events.

Text/ Reference

1. Alberts, B., Johnson, A., Lewis, J., Raff, M., Roberts, K., & Walter, P. (2008).Molecular Biology of the Cell (5th Ed.). New York: Garland Science.
2. Lodish, H. F. (2016). Molecular Cell Biology (8th Ed.). New York: W.H. Freeman.
3. Cooper, G. M., & Hausman, R. E. (2013). The Cell: a Molecular Approach (6th Ed.).Washington: ASM; Sunderland.

MSBT104: Biostatistics credits 3

Unit 1: Introduction to Biostatistics

Basic definitions and applications. Sampling: Representative sample, sample size, sampling bias and sampling techniques. Data collection and presentation: Types of data, methods of collection of primary and secondary data, methods of data presentation, graphical representation by histogram, polygon, ogive curves and pie diagram.

Unit 2 : Measures of central tendency: Mean, Median, Mode.

Measures of variability: Standard deviation, standard error, range, mean deviation and coefficient of variation. Correlation and regression: Positive and negative correlation and calculation of Karl-Pearsons co-efficient of correlation. Linear regression and regression equation and multiple linear regression, ANOVA, one and two way classification. Calculation of an unknown variable using regression equation.

Unit 3 :Tests of significance

Tests of significance: Small sample test (Chi-square t test, F test), large sample test (Z test) and standard error. Introduction to probability theory and distributions, (concept without deviation) binomial, poison and normal (only definitions and problems) Computer oriented statistical techniques. Frequency table of single discrete variable, bubble spot, computation of mean, variance and standard Deviations, t test, correlation coefficient. Randomized block design, complete block design, Usage of Statistical software.

MSBT105: Microbiology credits 3

Unit 1: Microbial characteristics

Introduction to microbiology and microbes, history & scope of microbiology, morphology, structure, growth and nutrition of bacteria, bacterial growth curve, bacterial culture methods; bacterial genetics: mutation and recombination in bacteria, plasmids, transformation, transduction and conjugation; antimicrobial resistance.

Unit 2 Microbial diversity

Microbial taxonomy and evolution of diversity, classification of microorganisms, criteria for classification; classification of bacteria; Cyanobacteria, acetic acid bacteria, Pseudomonads, lactic and propionic acid bacteria, endospore forming bacteria, Mycobacteria and Mycoplasma. Archaea: Halophiles, Methanogens, Hyperthermophilic archae, Thermoplasm; eukarya: algae, fungi, slime molds and protozoa; extremophiles and unculturable microbes.

Unit 3 Control of microorganisms

Sterilization, disinfection and antisepsis: physical and chemical methods for control of microorganisms, antibiotics, antiviral and antifungal drugs, biological control of microorganisms.

Unit 4 Virology

Virus and bacteriophages, general properties of viruses, viral structure, taxonomy of virus, viral replication, cultivation and identification of viruses; sub-viral particles – viroids and prions.

Unit 5 Host-microbes interaction

Host-pathogen interaction, ecological impact of microbes; symbiosis (Nitrogen fixation and ruminant symbiosis); microbes and nutrient cycles; microbial communication system; bacterial quorum sensing; microbial fuel cells; prebiotics and probiotics.

Recommended Textbooks and References:

1. Pelczar, M. J., Reid, R. D., & Chan, E. C. (2001). *Microbiology* (5th ed.). New York: McGraw-Hill.
2. Willey, J. M., Sherwood, L., Woolverton, C. J., Prescott, L. M., & Willey, J. M. (2011). *Prescott's Microbiology*. New York: McGraw-Hill.
3. Matthai, W., Berg, C. Y., & Black, J. G. (2005). *Microbiology, Principles and Explorations*. Boston, MA: John Wiley & Sons.

MSBT191: Lab on Biochemistry and Analytical Techniques **credits 3**

1. To prepare an Acetic-NaAcetate Buffer system and validate the Henderson-Hasselbach equation.
2. To determine an unknown protein concentration by plotting a standard graph of BSA using UV-Vis
Spectrophotometer and validating the Beer- Lambert's Law.
3. Titration of Amino Acids and separation of aliphatic, aromatic and polar amino acids by TLC.
4. An enzyme purification theme (such as *E.coli* Alkaline phosphatase or any enzyme of the institutions choice).
a) Preparation of cell-free lysates
b) Ammonium Sulfate precipitation
c) Ion-exchange Chromatagraphy
d) Gel Filtration
e) Affinity Chromatography
f) Generating a Purification Table
g) Assessing purity by SDS-PAGE Gel Electrophoresis
h) Assessing purity by 2-D gel Electrophoresis
i) Enzyme Kinetic Parameters: Km, Vmax and Kcat.
5. Biophysical methods (Circular dichroism spectroscopy, fluorescence spectroscopy).
6. Determination of mass of small molecules and fragmentation patterns by Mass Spectrometry

MSBT192: Lab on Microbiology credits 3

1. Sterilization, disinfection, safety in microbiological laboratory.
2. Preparation of media for growth of various microorganisms.
3. Identification and culturing of various microorganisms.
4. Staining and enumeration of microorganisms.
5. Growth curve, measure of bacterial population by turbidometry and studying the effect of temperature, pH, carbon and nitrogen.
6. Assay of antibiotics production and demonstration of antibiotic resistance.
7. Isolation and screening of industrially important microorganisms.
8. Determination of thermal death point and thermal death time of Microorganisms.
9. Determination of Minimum Inhibitory Concentration (MIC
10. Isolation and identification of bacteria from soil/water samples.

MSBT193: Lab on Cell Biology credits 2

1. Basic principles of Cyto-Genetics procedures
2. Setting up Laboratory
3. Peripheral Blood Cyto-Genetics Methods
4. Chromosome staining
5. Microscopy ; Imaging
6. Chromosome analysis ; Karyotype reporting
7. Interpretation ; Recommendations in Abnormal Chromosome study
8. Chromosomal syndromes identification ; Karyotyping

Semester-II

Code	Course Title	Contact Hrs./wk	Credit
A	**Theory**	**L-T-P**	
MSBT-201	Plant and Animal Biotechnology	3-0-0	3
MSBT-202	Bioprocessess Technology	3-0-0	3
MSBT-203	Immunology	3-0-0	3
MSBT-204	Recombinant DNA Technology	3-0-0	3
MSBT-205	Bioinformatics	3-0-0	3
MSBT-206	Choice based courses (from MOOCS basket)		2
B	**Practical**		
MSBT-291	Recombinant DNA Technology Lab	0-0-6	3
MSBT-292	Immunology Lab	0-0-6	3
C			
MSBT-281	Seminar		1
Semester Total			**24**

MSBT 201:Plant and Animal Biotechnology

Unit I :Plant tissue culture and animal cell culture

Plant tissue culture: historical perspective; totipotency; organogenesis; Somatic embryogenesis; establishment of cultures – callus culture, cell suspension culture, media preparation – nutrients and plant hormones; sterilization techniques; applications of tissue culture - micropropagation; somaclonal variation; androgenesis and its applications in genetics and plant breeding; germplasm conservation and cryopreservation; synthetic seed production; protoplast culture and somatic hybridization - protoplast isolation; culture and usage; somatic hybridization - methods and applications; cybrids and somatic cell genetics; plant cell cultures for secondary metabolite production.

Animal cell culture: brief history of animal cell culture; cell culture media and reagents; culture of mammalian cells, tissues and organs; primary culture, secondary culture, continuous cell lines, suspension cultures; application of animal cell culture for virus isolation and *in vitro* testing of drugs, testing of toxicity of environmental pollutants in cell culture, application of cell culture technology in production of human and animal viral vaccines and pharmaceutical proteins

Unit II Plant genetic manipulation : Genetic engineering: *Agrobacterium*-plant interaction; virulence; Ti and Ri plasmids; opines and their significance; T-DNA transfer; disarmed Ti plasmid; Genetic transformation - *Agrobacterium*-mediated gene delivery; cointegrate and binary vectors and their utility; direct gene transfer - PEG-mediated, electroporation, particle bombardment and alternative methods; screenable and selectable markers;characterization of transgenics; chloroplast transformation; marker-free methodologies; advanced methodologies - cisgenesis, intragenesis and genome editing; molecular pharming - concept of plants as biofactories, production of industrial enzymes and pharmaceutically important compounds.

Unit III Animal reproductive biotechnology

Animal reproductive biotechnology: structure of sperms and ovum; cryopreservation of sperms and ova of livestock; artificial insemination; super ovulation, embryo recovery and *in vitro* fertilization; culture of embryos; cryopreservation of embryos; embryo transfer technology; transgenic manipulation of animal embryos; applications of transgenic animal technology;

animal cloning - basic concept, cloning for conservation for conservation endangered species.

Unit V Molecular mapping and marker assisted selection

Molecular markers - hybridization and PCR based markers RFLP, RAPD, STS, SSR, AFLP, SNP markers; DNA fingerprinting-principles and applications; introduction to mapping of genes/QTLs; marker-assisted selection - strategies for Introducing genes of biotic and abiotic

Recommended Textbooks and References:

1. Chawla, H. S. (2000). *Introduction to Plant Biotechnology*. Enfield, NH: Science.
2. Razdan, M. K. (2003). *Introduction to Plant Tissue Culture*. Enfield, NH: Science.
3. Slater, A., Scott, N. W., & Fowler, M. R. (2008). *Plant Biotechnology: an Introduction to Genetic Engineering*. Oxford: Oxford University Press.
4. Buchanan, B. B., Gruissem, W., & Jones, R. L. (2015). *Biochemistry & Molecular Biology of Plants*. Chichester, West Sussex: John Wiley & Sons
Glick, B. R., & Pasternak, J. J. (2010). *Molecular Biotechnology: Principles and Applications of Recombinant DNA*. Washington, D.C.: ASM Press.
7. Brown, T. A. (2006). *Gene Cloning and DNA Analysis: an Introduction*. Oxford: Blackwell Pub.
8. Primrose, S. B., & Twyman, R. M. (2006). *Principles of Gene Manipulation and Genomics*. Malden, MA: Blackwell Pub.
9. Slater, A., Scott, N. W., & Fowler, M. R. (2003). *Plant Biotechnology: The Genetic Manipulation of Plants*. Oxford: Oxford University Press.

MSBT202: Bioprocess Engineering & Technology

Unit I

Basic principles of biochemical engineering

Isolation, screening and maintenance of industrially important microbes; microbial growth and death kinetics (an example from each group, particularly with reference to industrially useful microorganisms); strain improvement for increased yield and other desirable characteristics.

Unit II

Stoichiometry and models of microbial growth

Elemental balance equations; metabolic coupling – ATP and NAD+; yield coefficients; unstructured models of microbial growth; structured models of microbial growth.

Unit III

Bioreactor design and analysis

Batch and continuous fermenters; modifying batch and continuous reactors: chemostat with recycle, multistage chemostat systems, fed-batch operations; conventional fermentation v/s biotransformation; immobilized cell systems; large scale animal and plant cell cultivation; fermentation economics; upstream processing: media formulation and optimization; sterilization; aeration, agitation and heat transfer in bioprocess; scale up and scale down; measurement and control of bioprocess parameters.

Unit IV

Downstream processing and product recovery

Separation of insoluble products - filtration, centrifugation, sedimentation, flocculation; Cell disruption; separation of soluble products: liquid-liquid extraction, precipitation, chromatographic techniques, reverse osmosis, ultra and micro filtration, electrophoresis; final purification: drying; crystallization; storage and packaging.

Unit V

Fermentation economics

Isolation of micro-organisms of potential industrial interest; strain improvement; market analysis; equipment and plant costs; media; sterilization, heating and

cooling; aeration and agitation; bath-process cycle times and continuous cultures; recovery costs; water usage and recycling; effluent treatment and disposal

Unit VI

Applications of enzyme technology in food processing

Mechanism of enzyme function and reactions in process techniques; enzymatic bioconversions *e.g.* starch and sugar conversion processes; high-fructose corn syrup; interesterified fat; hydrolyzed protein *etc.* and their downstream processing; baking by amylases, deoxygenation and desugaring by glucoses oxidase, beer mashing and chill proofing; cheese making by proteases and various other enzyme catalytic actions in food processing.

Unit VII

Applications of microbial technology in food process operations and production, biofuels and biorefinery

Fermented foods and beverages; food ingredients and additives prepared by fermentation and their purification; fermentation as a method of preparing and preserving foods; microbes and their use in pickling, producing colours and flavours, alcoholic beverages and other products; process wastes-whey, molasses, starch substrates and other food wastes for bioconversion to useful products; bacteriocins from lactic acid bacteria – production and applications in food preservation; biofuels and biorefinery

Recommended Textbooks and References:

1. Shuler, M. L., & Kargi, F. (2002). *Bioprocess Engineering: Basic Concepts.* Upper Saddle River, NJ: Prentice Hall.
2. Stanbury, P. F., & Whitaker, A. (2010). *Principles of Fermentation Technology*. Oxford: Pergamon Press.
3. Blanch, H. W., & Clark, D. S. (1997). *Biochemical Engineering.* New York: M. Dekker.
4. Bailey, J. E., & Ollis, D. F. (1986). *Biochemical Engineering Fundamentals*. New York: McGraw-Hill.
5. El-Mansi, M., & Bryce, C. F. (2007). *Fermentation Microbiology and Biotechnology.* Boca Raton: CRC/Taylor & Francis.

MSBT 203: Immunology credits 3

Unit 1 : Fundamental concepts and anatomy of the immune system

Components of innate and acquired immunity; Phagocytosis; Complement and Inflammatory responses; pathogen recognition receptors (PRR) and pathogen associated molecular pattern (PAMP); Haematopoesis; Organs and cells of the immune system- primary and secondary lymphoid organs; Lymphatic system; Lymphocyte circulation; Lymphocyte homing; Mucosal and Cutaneous associated Lymphoid tissue.(MALT&CALT); Mucosal Immunity; Antigens -immunogens, haptens; Major Histocompatibility Complex - MHC genes, MHC and immune responsiveness and disease susceptibility, HLA typing.

Unit 2: Immune responses generated by B and T lymphocytes

Immunoglobulins-basic structure, classes and subclasses of immunoglobulins, antigenic determinants; Multigene organization of immunoglobulin genes; VDJ Recombination, B-cell receptor; Immunoglobulin superfamily; Principles of cell signaling; Immunological basis of self -non-self discrimination; Kinetics of immune response, memory; B cell maturation, activation and differentiation; Generation of antibody diversity; T-cell maturation, activation and differentiation and T-cell receptors; Functional T Cell Subsets; Cell-mediated immune responses,ADCC; Cytokines-properties, receptors and therapeutic uses; Antigen processing and presentation-endogenous antigens, exogenous antigens, non-peptide bacterial antigens and super-antigens; Cell-cell co-operation, Hapten- carrier system.

Unit 3: Antigen-antibody interactions

Precipitation, agglutination and complement mediated immune reactions; Advanced
immunological techniques - RIA, ELISA, Western blotting, ELISPOT assay, immunofluorescence, flow cytometry and immunoelectron microscopy; Surface plasma resonance, Biosenor assays for assessing ligand -receptor interaction, CMI techniques lymphoproliferation assay, Mixed lymphocyte reaction, Cell Cytotoxicity assays, Apoptotosis, Microarrays, Transgenic mice, Gene knock outs, CD nomenclature, Identification of immune Cells; Principle ofImmunofluorescence Microscopy, Flurochromes; Staining techniques for live cell imaging and fixed cells; Flow cytometry, Instrumentation, Applications.

Unit 4: Vaccinology

Active and passive immunization; Live, killed, attenuated, sub unit vaccines; Vaccine technology- Role and properties of adjuvants, recombinant DNA and

protein based vaccines, plant-based vaccines, reverse vaccinology; Peptide vaccines, conjugate vaccines; Antibody genes and antibody engineering- chimeric and hybrid monoclonal antibodies; Catalytic antibodies and generation of immunoglobulin gene libraries.

Unit V Clinical Immunology

Immunity to Infection: Bacteria, viral, fungal and parasitic infections (with examples from each group); Hypersensitivity - Type I-IV; Autoimmunity; Types of autoimmune diseases; Mechanism and role of CD4+ T cells; MHC and TCR in autoimmunity; Treatment of autoimmune diseases; Transplantation- Immunological basis of graft rejection; Clinical transplantation and immunosuppressive therapy; Tumor immunology - Tumor antigens;Immune response to tumors and tumor evasion of the immune system, Cancer immunotherapy; Immunodeficiency- Primary immunodeficiencies, Acquired or secondary immunodeficiencies. Immunoglobulin therapy, Specific and nonspecific immunotherapy for Asthma and allergic diseases.

Text/ Reference

1. Kuby, RA Goldsby, Thomas J. Kindt, Barbara, A. Osborne Immunology, 6th Edition, Freeman, 2002.
2. Brostoff J, Seaddin JK, Male D, Roitt IM., Clinical Immunology, 6th Edition, Gower Medical Publishing,2002.
3. Janeway et al., Immunobiology, 4th Edition, Current Biology publications., 1999.
4. Paul, Fundamental of Immunology, 4th edition, Lippencott Raven,

MSBT-204: Recombinant DNA Technology credits 3

Unit 1: Tools for genetic engineering:

Impact of genetic engineering in modern society; general requirements for performing a genetic engineering experiment; restriction endonucleases and methylases; DNA ligase, Klenow enzyme, T4 DNA polymerase, polynucleotide kinase, alkaline phosphatase; cohesive and blunt end ligation; linkers; adaptors; homopolymeric tailing; labelling of DNA: nick translation, random priming, radioactive and non-radioactive probes; hybridization techniques: northern, southern, south-western and far-western and colony hybridization,
fluorescence *in situ* hybridization.

Unit 2: Vectors

Plasmids; Bacteriophages; M13 mp vectors; PUC19 and Bluescript vectors, phagemids; Lambda vectors; Insertion and Replacement vectors; Cosmids; Artificial chromosome vectors (YACs; BACs); Principles for maximizing gene expression: expression vectors, pMal, GST, pET-based vectors; Protein purification: His-tag; GST-tag; MBP-tag *etc.* Intein-based vectors; Inclusion bodies; methodologies to reduce formation of inclusion bodies;
mammalian expression and replicating vectors; Baculovirus and *Pichia*vectors system, plant based vectors, Ti and Ri plasmids as vectors, yeast vectors, shuttle vectors.

Unit 3: PCR and cloning

primer design; fidelity of thermostable enzymes; DNA polymerases; types of PCR –multiplex, nested; reverse-transcription PCR, real time PCR, touchdown PCR, hot start PCR, colony PCR, asymmetric PCR, cloning of PCR products; TA cloning vectors; proof reading enzymes; PCR based site specific mutagenesis; PCR in molecular diagnostics; viral and bacterial detection; sequencing methods; enzymatic DNA sequencing; chemical sequencing of DNA; automated DNA sequencing; RNA sequencing; chemical synthesis of oligonucleotides; mutation detection: SSCP, DGGE, RFLP, RAPD, AFLP, DNA microsatellite, DNA marker, Polymorphism, Positional cloning, functional cloning, therapeutic cloning.

Unit 4: cDNA analysis

Insertion of foreign DNA into host cells; transformation, electroporation, transfection; construction of libraries; isolation of mRNA and total RNA; reverse transcriptase and cDNA synthesis; cDNA and genomic libraries; construction of microarrays – genomic arrays, cDNA arrays and oligo arrays; study of protein-DNA interactions: electrophoretic mobility shift assay; DNase I footprinting; methyl

interference assay, chromatin immunoprecipitation; protein-protein interactions using yeast two-hybrid system; phage display.

Unit 5: Gene silencing and genome editing technologies

Gene silencing techniques; Transposon and jumping gene, introduction to siRNA; siRNA technology; Micro RNA; construction of siRNA vectors; principle and application of gene silencing; gene knockouts and gene therapy; creation of transgenic plants; debate over GM crops; introduction to methods of genetic manipulation in different model systems *e.g.* fruit flies (*Drosophila*), worms (*C. elegans*), frogs (*Xenopus*), fish (zebra fish) and chick; Transgenics - gene replacement; gene targeting; creation of transgenic and knock-out mice; disease model; introduction to genome editing by CRISPR-CAS with specific emphasis on Chinese and American clinical trials.

Texts/References

1. Gene XII, Lewin's
2. Molecular cell Biology, David Baltimore and Harvey Lodish

MSBT205:: Applied Bioinformatics credits 3

Unit 1: Sequence-alignment related problems

Sequence databases; Similarity matrices; Pairwise alignment; BLAST; Statistical significance of alignment; Sequence assembly, Multiple sequence alignment; Clustal Phylogenetics: distance based approaches, maximum parsimony.

Unit 2: Pattern analysis in sequences

Motif representation: consensus, regular expressions; PSSMs; Markov models; Regulatory sequence identification using Meme; Gene finding: composition based finding, sequence motif-based finding.

Units 3: Structure-related problems

Representation of molecular structures (DNA, mRNA, protein),secondary structures, domains and motifs; Structure classification(SCOP, CATH); Visualization software (Pymol, Rasmol etc.);Experimental determination of structures (X-ray crystallography,NMR); Structure databases; Secondary structure prediction; RNAstructure prediction; Mfold; Protein structure prediction by comparative modelling approaches(homology modelling, threading);Ab initio structure prediction: force fields, backbone conformergeneration by Monte Carlo approaches, side-chain packing; Energyminimization; Molecular dynamics; Rosetta; Structure comparison(DALI, VAST etc.); CASP; Protein-ligand docking; Computer aided drug design (pharmacophore identification); QSAR; Protein-Proteininteractions.

Unit 4: System-wide analyses

Transcriptomics: Microarray technology, expression profiles, data analysis; SAGE; Proteomics: 2D gel electrophoresis; MassSpectrometry; Protein arrays; Metabolomics:13C NMR based metabolic flux analysis

MSBT291:Lab On Recombinant DNA Technology Credits3

1. Isolation of totalgenomic DNA from bacteria and plants samples.
2. PCR amplification of a candidate gene from the isolated genomic DNA and analysis of the PCR product by agarose gel electrophoresis.
3. Cloning of the PCR amplified product in pGEM-T Easy vector.
4. Preparation of *E. Coli* (DH5α) competent cells.
5. Transformation of plasmid DNA in *E.coli* DH5α.
6. Screening of recombinant clones by blue white screening.
7. Designing of primers for directional cloning.
8. Cloning of a candidate gene by directional cloning method.

9. Plasmid isolation by Alkaline Lysis method.
10. Isolation of plant total protein from plant leaves and analysis of the isolated protein by SDS-PAGE.

MSBT292: Lab on Immunology credits 3

1. Antibody titre by ELISA method.
2. Double diffusion, Immuno-electrophoresis and Radial Immunodiffusion, Complement fixation test.
3. SDS-PAGE, Immunoblotting, Dot blot assays
4. Demonstration of Phagocytosis of latex beads
5. Separation of mononuclear cells by Ficoll-Hypaque
6. Flowcytometry, identification of T cells and their subsets
7. Culture of Macrophage cell and demonstration of Phagocytosis of latex beads
8. Determination of Blood group of an individual and differential leucocyte count under a microscope.
9. Cryopreservation of cultured cells and cell revival.

MSBT206:(MOOCS Basket)

MSBT206A	**Bioreactor**
MSBT 206B	**Human molecular genetics**
MSBT 206C	**Cell Culture Technology**
MSBT 206D	**Biomolecules: structure, function in health & Disease**
MSBT 206E	**Environmental Remediation for contaminated sites**
MSBT 206F	**Applied Environmental Microbiology**
MSBT 206G	**Medical Biomaterials**
MSBT 206H	**Principles and Applications of NMR Spectroscopy**
MSBT 206I	**Current Regulatory Requirements For Conducting Clinical Trials In India For Investigational New Drugs/new Drug (Version 2.0)**
MSBT 206J	**Entrepreneurship essentials**
MSBT 206K	**Introduction to research**
MSBT 206L	**Integrated pest Management**
MSBT 206M	**Health Research Fundamentals**
MSBT 206N	**Immunology**
MSBT 206O	**Big Data, Genes, and Medicine**
MSBT 206P	**Wild life ecology**
MSBT 206Q	**Optical spectroscopy and microscopy: fundamentals of optical measurements and instrumentation**

Semester III

Code	Course Title	Contact Hrs./wk	Credit
	Theory	**L- T -P**	
MSBT-301	Food Biotechnology	3-0-0	3
MSBT-302	Environmental BioTechnology	3-0-0	3
MSBT-303	Genomics and proteomics	3-0-0	3
MSBT-304	IPR Biosafety and Bioethics	3-0-0	3
MSBT-305 Elective	Elective (Choice From Basket)	3-0-0	3
MSBT-306(MOOCS)	(Choice from MOOCSBasket)		2
B	**Practical**		
MSBT-391	Applied Bioinformatics Lab	0-0-6	3
MSBT-392	Bioprocess Lab	0-0-6	3
C			
MSBT-381	Project Proposal/seminar		1
Semester Total			**24**

MSBT301: Food Biotechnology credits 3

Unit 1: Introduction to food science and technology

Basics of chemistry of food constituents- carbohydrates, proteins, lipids, vitamins, minerals, water (different forms of water present in foods and their effect on quality and preservation of foods), minor constituents affecting texture, colour, taste, odour; Food microbiology, Food biochemistry, Food additives, General food composition and effect of food constituents on food quality.

Unit 2 : Standards for food analysis

Standards of identity, purity and methodology for analysis of: a) Cereals, legumes, oil seeds and their products; b) Fruits, vegetables, tubers and their products; c) Tea, coffee, cocoa, chocolate, spices, condiments; d) Milk and milk products; e) Meat, fish and poultry products; f) Miscellaneous foods *e.g.* fermented products.

Unit 3 Food processing and preservation

Introduction to food processing of various foods including dairy, bakery, brewing, fruit and vegetable products, plantation products; pro and prebiotics.

Principles of food preservation by: Dehydration, Thermal treatments like pasteurization, sterilization, canning, retorting *etc.* Low temperature *i.e.* chilling and freezing, Chemical preservation/ bio-preservation, Traditional methods like salting/ syruping, pickling, fermentation *etc.* Non thermal processes like MAP, irradiation, high pressure processing *etc.* Hurdle technology.

Unit 4 : Food biotechnology

Fermentative production of enzymes used in food industry; solid state fermentation; recovery of enzymes from natural sources; cheese making and whey processing, impact of enzyme technology (bioethanol, protein hydrolysates, bioactive peptides); enzymatic processing of fruit juices. Role of enzymes in baking, meat and meat processing; comparative methods of toxicity test in (novel) foods; biosensors; enzymatic approach to tailor made fats; catabolic processes and oxygen-dependent reactions in food; use of lipases and reactions in organic solvents and two phases

Unit 5: Methods in food analysis

Spectroscopic analysis of foods – basic principles, UV, visible, fluorescence, IR, AAS, MS,NMR; Chromatographic analysis of foods – basic principles, HPLC, GC, GLC, principles and applications. **Advanced techniques in food analysis-** Analysis of vitamins, pigments, flavours, extraneous matter, pesticides and mycotoxins;

Microscopic analysis of foods, SEM and XRD; other methods- potentiometry, enzymatic, immunoassays, thermal analysis; Analysis of genetically modified foods.

Unit 6 : Importance of nutrigenomics

- Bioactive components of food; nutraceuticals; effective gene expression; epigenetic process; signal transduction; recent developments in field of nutrigenomics

Unit 7 Food safety and security

Consumer concerns about risks and values, biotechnology & food safety, Ethical issues concerning GM foods; testing for GMOs; current guidelines for the production, release and movement of GMOs; Future and applications of food biotechnology in India.

MSBT302:: Environmental Biotechnology credits 3

Unit 1: Composition and chemistry of environment-2L

Earth atmosphere, Aquatic Environments, terrestrial environments, environmental indicators

Unit II pollutions of environment- 8 lectures

Air pollution- Definition, Source of pollution and pollutants, Air Quality index, Atmospheric dispersion modeling, indoor air quality(IAQ)Acid rain, Chlorofluorocarbon, Ozone depletion, Green house gases, Cox, NOx, VOC, SO2, Mercury, Dioxin, and Furan, Smog, and health effects, Water pollution- definition , Nonpoint sources, Water quality indicators, Particulate matter, metal, plastic, Wastes, Eutrophication, Marine pollution, Ocean acidification, Oil spill, Ship pollution , Soil surface runoff, Thermal pollution, Water borne disease and water quality, Water stagnation.
Soil pollution-Definition, pollution by herbicide, pesticides and fungicides, trace element, soil guideline values-SGVs.

Unit III

Global warming and Major organizations & Inter-government treaties – Global Atmosphere Watch, Greenhouse effect, Ozone problem and consequences, National Ambient Air Quality Standards, Montreal Protocol, Nitrogen Oxide Protocol, Kyoto Protocol, CLRTAP, DEFRA, EPA.

Unit IV Effects of toxicity on environment

Toxicology of gaseous pollutants; Toxic metals in environment; Toxicity of pesticides; solvents, ionizing radiations; Soil toxicology.

Unit V Bioremediation: Bioremediation: Fundamentals, methods and strategies of application (biostimulation, bioaugmentation) – examples, bioremediation of metals (Cr, As, Se, Hg), radionuclides (U, Te), organic pollutants (PAHs, PCBs, Pesticides, TNT *etc.*), technological aspects of bioremediation (*in situ, ex situ*). Role of environmental biotechnology in management of environmental problems, Advance oxidation technologies; High rate transpiration system (HRTS) , Physicochemical characteristics and treatment strategies in industrial waste and organic solvent. Biotechnological application of hazardous waste management of water; Use of microbial systems; Phytoremediation, Development of new biocatalysts to be applied in waste water biotechnology; Zerodischarge option.

Unit VI Bifules: Environmental Biotechnology and biofuels: biogas; bioethanol; biodiesel; biohydrogen; Description of the industrial processes involved, microorganisms and biotechnological interventions for optimization of production; Microbiologically enhanced oil recovery (MEOR); Bioleaching of metals; Production of bioplastics; Production of biosurfactants: bioemulsifiers; Paper production: use of xylanases and white rot fungi.

Recommended Textbooks and References:

1. G. M. Evans and J. C. Furlong (2003), *Environmental Biotechnology: Theory and Applications*, Wiley Publishers.
2. B. Ritmann and P. L. McCarty, (2000), *Environmental Biotechnology: Principle & Applications*, 2nd Ed., McGraw Hill Science.
3. Scragg A., (2005) *Environmental Biotechnology*. Pearson Education Limited.
4. J. S. Devinny, M. A. Deshusses and T. S. Webster, (1998), *Biofiltration for Air Pollution Control*, CRC Press.
5. H. J. Rehm and G. Reed, (2001), *Biotechnology – A Multi-volume Comprehensive Treatise*, Vol. 11, 2nd Ed., VCH Publishers Inc.

MSBT 303:Genomics& Proteomics credits 3

Unit1

Metagenomics

Metagenome Sequencing and Analysis , Presequencing Considerations, MPLING and Data Generation, Sequence Processing , Tools and Databases for Metagenomic Analysis, Application For Metagenomic Data Analysis

Unit2 Human Genomics

Human Genome and its Evolution, Overview of the Human Genome , Protein Coding Genes in the Human Genome ,RNA Coding Genes and Gene Expression Control Regions , Genomic Heterogeneity of the Human Genome , Genetic Changes That Made Us Human , Ancient Human Genomes, UCSC Human Genomr Browser

Unit 3Transcriptomics

What is the Transcriptome and how it is evaluated? Type of RNA molecules within Transcriptome, Transcriptome Evaluation Method: Microarray Analysis , DNA Microarrays, The Diversity of the Transcriptome, Transcriptome Analysis Throughout RNA-seq, Identification of Biomarkers and Expression Signatures, Methods for Gene Co-expression Network Visualizationand Analysis, Construction and Analysis of GCNs

Unit 4 Epigenomics

DNA Methylation, Epigenetic Mechanisms of Gene Regulation, Strategies for Epigenome Analysis, ChIP, ChIP-on-Chip, ChIP-Seq, Profiling of DNA Methylation, MeDIP-seq, Sequencing the Epigenome, Integrating Epigenomic Results, Visualizing the Epigenome, Epigenetics of Aging

Unit5 Proteomics

Protein Structure , Amino Acids, Peptide Bonds , Primary Structure , Secondary , Tertiary Structure , Quaternary ,Experimental Determination of Amino Acid Sequences and Protein Structures Protein 2D Gels ,Protein Western Blots . ,Mass Spectrometry, Chemical Identification of Amino Acids in Peptides , Analysis of Protein 3D Structure by X Ray Diffraction
and ,Other Assays for Protein Compositions and Interactions , Computational Methods for Modeling Molecular Structures , Molecular-Force-Field ,Molecular Dynamics ,Hydrogen Bonds . . , Computation and Minimization of , Solutions to the Problem of Minimization of RMSDover Rotations, Solutions to the Problem of Minimization of RMSD over Rotations and Solvent-Accessible Surface of a Protein, Computational Prediction of Protein Structure and Function , Inferring Structures of Proteins, Protein , De Novo Methods , Comparative Protein Modeling , Visualization of protein modeling by Swiss PDB package, Application of Biopolymer package in protein modeling, Necessary application of modeling in proteomics, Protein–Ligand Binding Analysis , Classification Based on Proteomic Assays

Texts/References

Branden and Tooze “Introduction to Protein Structure”
R. R. Sinden, “DNA Structure & Function”
A. R. Leach “Molecular Modelling- Principles & Function”
Mount “Bioinformatics” Cold Spring Harbour
Arthur Lesk “Introduction to Bioinformatics

MSMBT304: IPR, Biosafety &Bioethics. 3 Credits

Unit 1: IPR

IPR and its different forms,
PATENTS Macro economic impact of the patent system Patent and kind of inventions protected by a patent. Patent document and protection inventions. Granting of patent Rights of a patent. Searching a patent. Drafting of a patent. Filing of a patent The different layers of the international patent system (national, regional and international options) COPYRIGHT General Additional Reading: Latest editions of Designs Act, Copyright RELATED RIGHTS. Distinction between related rights and copyright. Rights covered by copyright.
TRADEMARKS What is a trademark. Rights of trademark. INDUSTRIAL DESIGNS Industrial design. Protection provided by industrial designs.Geographical indication, tradesecret

Unit 2: Bioethics

Introduction, ethical conflicts in biological sciences - interference with nature, bioethics in health care - patient confidentiality, informed consent, euthanasia, artificial reproductive technologies, prenatal diagnosis, genetic screening, gene therapy, transplantation. Bioethics in research – cloning and stem cell research, Human and animal experimentation, animal rights/welfare, Agricultural biotechnology - Genetically engineered food, environmental risk, labeling and public opinion. Sharing benefits and protecting future generations - Protection of environment and biodiversity – biopiracy.

Unit 3: Biosafety

Biosafety and Biosecurity - introduction; historical background; Introduction to biological safety cabinets; primary containment for biohazards; biosafety levels, biosafety levels of specific microorganisms; recommended biosafety levels for infectious agents and infected animals; definition of GMOs & LMOs; principles of safety assessment of transgenic plants – sequential steps in risk assessment; concepts of familiarity and substantial equivalence; risk – environmental risk assessment and food and feed safety assessment; problem formulation – protection goals, compilation of relevant information, risk characterization and development of analysis plan; risk assessment of transgenic crops vscisgenic plants or products derived from RNAi, genome editing tools.

MSBT391: Lab on Applied Bioinformatics
3 Credits

1 Downloading macromolecular sequences from the NCBI database in different file formats.
2 Creating a non-redundant database of sequences using CD-HIT.

3Identification of relatives from the database using BLAST search. Creation of a data-set on the basis of the E-value.
3 Using EMBOSS for local and global alignment of proteins.
4 Determination of domains present in proteins and comparison of domain architecture (DA) across different proteins.
5 Identification of repeats in proteins using Pfam.
6 Further identification of repeats left undetected by Pfam using multiple sequence analysis.
7 Construction of phylogenetic tree using PHYLIP

MSBT392: Lab on Bioprocess
3 Credits

1. Basic Microbiology techniques
    a) Scale up from frozen vial to agar plate to shake flask culture.
    b) Instrumentation: Microplate reader, spectrophotometer, microscopy.
    c) Isolation of microorganisms from soil samples.
2. Experimental set-up
    a) Assembly of bioreactor and sterilization.
    b) Growth kinetics.
    c) Substrate and product inhibitions.
    d) Measurement of residual substrates.
3. Data Analysis
    a) Introduction to Metabolic Flux Analysis (MFA).
4. Fermentation
    a) Batch.
    b) Fed-batch.
    c) Continuous.
5. Unit operations
    a) Microfiltrations: Separation of cells from broth.
    b) Bioseparations: Various chromatographic techniques and extractions.
6. Bioanalytics
    a) Analytical techniques like HPLC, FPLC, GC, GC-MS *etc.* for measurement of amounts of products/substrates.

Recommended Textbooks and References:

1. Shuler, M. L., & Kargi, F. (2002). *Bioprocess Engineering: Basic Concepts*. Upper Saddle River, NJ: Prentice Hall.
2. Stanbury, P. F., & Whitaker, A. (2010). *Principles of Fermentation Technology*. Oxford: Pergamon Press.
3. Blanch, H. W., & Clark, D. S. (1997). B*iochemical Engineering*. New York: M. Dekker.
4. Bailey, J. E., & Ollis, D. F. (1986). *Biochemical Engineering Fundamentals.* New York: McGraw-Hill.
5. El-Mansi, M., & Bryce, C. F. (2007). *Fermentation Microbiology and Biotechnology*. Boca Raton: CRC/Taylor & Francis.

(Elective)

MSBT305A: Medical Biotechnology

Unit 1.
Clinical biochemistry
7 lectures

Clinical specimen Considerations - Types of Samples, Sample Processing, Sample Variables, Chain of Custody; Infection control, the vascular system, composition and types of blood specimens, venipuncture, pediatric and geriatric venipuncture, capillary specimen collection, capillary puncture procedures. Place and time of sample collection, preservation, influence of nutrition, drugs, posture, *etc.* Choice and correct use of anticoagulants; Care of the specimens, identification, transport, storage, influence of temperature, freezing/thawing; Laboratory safety and regulations – Safety awareness, safety equipment, biological, chemical, fire and radiation safety; Method evaluation and quality management, Basic concepts, Reference interval study, Diagnostic efficiency, Method evaluation, Quality Control and quality management.

Unit 2
Tissue engineering Applications
5 lectures

Skin tissue engineering, Liver tissue engineering, Bone and cartilage tissue engineering, Nerve tissue engineering, Vascular tissue engineering, Muscle tissue engineering, Kidney tissue engineering.

Unit 3
Basics of stem cells and molecular manipulation techniques
8 lectures

Stem cells in tissue engineering, types of stem cells, cellular signalling and maintenance of stem cells, isolation, expansion, genetic manipulation, genomic reprogramming, and cloning of stem cells, clinical applications, adult and embryonic stem cells, germline stem cells, ethical issues. Gene silencing technology; Antisense therapy; miRNA, siRNA;

Tissue and organ transplantation; Transgenics and their uses; Gene therapy; selection of the right gene, cloning vectors and strategies, intracellular barriers to gene delivery;
overview of different vehicles for gene delivery, Retro and adeno virus mediated gene transfer; Liposome and nanoparticles mediated gene delivery; Overview of inherited and acquired diseases for gene, Cell and Tissue Culture, *Ex-vivo* and *in vivo* gene therapy, post therapy immune response, success rate, ethical issues.

Unit 4
Molecular therapeutics
20 lectures
Gene therapy; Intracellular barriers to gene delivery; Overview of inherited and acquired diseases for gene therapy; Retro and adeno virus mediated gene transfer; Liposome and nanoparticles mediated gene delivery; Cellular therapy; Recombinant therapy;
Clinical applications of recombinant technology; Erythropoietin; Insulin analogs and its role in diabetes; Recombinant human growth hormone; Streptokinase and urokinase in thrombosis; Recombinant coagulation factors; Immunotherapy; Monoclonal antibodies and their role in cancer; Role of recombinant interferons; Immunostimulants; Immunosupressors in organ transplants; Role of cytokine therapy in cancers; Types of
recombinant vaccines and clinical applications; Gene silencing technology; Antisense therapy; siRNA; Tissue and organ transplantation; Transgenics and their uses; Cloning; Ethical issues.

MSBT305B:
Agricultural Biotechnology (Elective)

Unit I
Plant water relation **6 lectures**
Introduction and role of Physiology in Agriculture – structure, properties and role of water in plants; soil and cell water terminologies; field capacity and PWP (Permanent Wilting Point); mechanism of water absorption; ascent of sap – theories; transpiration; stomatal structure – mechanism of stomatal movement; anti-transpirants.
Unit II
Plant nutrition **5 lectures**
Essential and beneficial nutrients – classification, functions and deficiency symptoms of primary, secondary and micro nutrients in plants; hidden hunger; mechanisms of nutrient absorption – chelates, foliar nutrition.
Unit III
Plant metabolism **8 lectures**
Photosynthesis – EMR and PAR; red drop and Emerson's enhancement effect;photochemical reactions; photolysis of water; Z scheme, photophosphorylation, reduction of CO2 *i.e.,* carbon assimilation in C3, C4 and CAM pathways, difference between three pathways; photorespiration and its significance; phloem loading and unloading; munch hypothesis; source and sink strength – manipulations; respiration; glycolysis, TCA cycle, oxidative phosphorylation - differences between oxidative phosphorylation and photophosphorylation; energy budgeting in respiration - respiratory quotient.

Unit IV

Plant growth **4 lectures**

Growth – growth curve; plant growth hormones/regulators (PGRs); physiological role and applications of auxins, gibberellins, cytokinin, ethylene and ABA; commercial uses of PGR's; senescence and abscission – classification; physiological and biochemical changes and its significance; photoperiodism; florigen theory of flowering; phytochrome; regulation of flowering in crops; vernalization; seed dormancy, breaking dormancy; seed germination, physiological basis of germination.

Unit V

Stress physiology **6 lectures**

Physiology of abiotic stresses in plants – water, drought, submergence and flooding stress, temperature; cold, heat, global warming, green-house gases and salt; salinity, sodicity and alkalinity – effects and tolerance mechanisms; Nutrients; deficiency and excess-tolerance mechanisms and Nutrient use efficiency.

UnitVI

Application of transgenic technology **12 lectures**

Applications of transgenic crop technology - Herbicide resistance; Pest resistance, Bt toxin, synthetic Bt toxin; Protease inhibitor; and other plant derived insecticidal genes; nematode resistance; Crop Engineering for disease resistance; genetic improvement of abiotic stress tolerance, Genetic engineering for male sterility- Barnase-Barstar; Delayed fruit ripening; polygalacturanase, ACC synthase, ACC oxidase. Engineering for nutritional quality - Improved seed storage proteins; Improving and altering the composition of starch and plant oils; enhancement of micro-nutrients – beta carotene,vitamin E, iron; Molecular pharming - micro-nutrients – beta carotene, vitamin E, iron; Molecular pharming - production of antibodies and pharmaceuticals in plants. Biosafety concerns of transgenic plants. Global status of transgenetic plants.

Recommended Textbooks and References:

1. Bob B. Buchanan, Wilhelm Gruissem and Russell L. Jones. 2015. *Biochemistry and Molecular Biology of Plants*. Second Edition. American Society of Plant Biology. John Wiley & Sons, Ltd, UK.
2. Lincoln Taiz, Eduardo Zeiger, Ian M. Moller and Angus Murphy (2015). *Plant Physiology*, 6th Edn, Sinauer Associates, Inc.
3. Maria Duca. 2015. *Plant Physiology*. 1st Edition. Springer International Publishing AG, Switzerland.
4. Peter Scott. 2008. *Physiology and Behaviour of Plants*. John Wiley & Sons Inc.USA
5. William G. Hopkins, Norman P. A. Huner. (2009). *Introduction to Plant Physiology*, 4th Edition.John Wiley & Sons, Inc. US.
6. Physiologia Plantarum. - www.Ingenta Connect.
7. www.new.phytologist.org.
8. *Plant Physiology and Development*, Retrieved from: http://6e.plantphys.net
9. Bhojwani, S.S and Razdan. M.K. (2009). *Plant Tissue Culture-Theory and Practice*. Elsevier India Pvt. Ltd.
10. Cassells, A. C and Peter B. Gahan. (2006). *Dictionary of Plant Tissue Culture*. Food Products Press, an Imprint of the Haworth Press, Inc., New York-London-Oxford

11. Adrian Slater, Nigel Scott and Mark Fowler. (2008). *Plant Biotechnology - the Genetic Manipulation of Plants*. Second Edition. Oxford University Press.

MSBT305C: Nano-biotechnology (Elective)

Unit I

Introduction to Nanobiotechnology

Introduction to Nanobiotechnology; Concepts, historical perspective; Different formats of nanomaterials and applications with example for specific cases; Cellular Nanostructures; Nanopores; Biomolecular motors; Bio-inspired Nanostructures,Synthesis and characterization of different nanomaterials.

Unit II

Nano – films

Thin films; Colloidal nanostructures; Self Assembly, Nanovesicles; Nanospheres; Nanocapsules and their characterisation.

Unit III

Nano particles

Nanoparticles for drug delivery, concepts, optimization of nanoparticle properties for suitability of administration through various routes of delivery, advantages, strategies for cellular internalization and long circulation, strategies for enhanced permeation through various anatomical barriers.

Unit IV

Applications of nano – particles

Nanoparticles for diagnostics and imaging (theranostics); concepts of smart stimuli responsive nanoparticles, implications in cancer therapy, nanodevices for biosensor development.

Unit V

Nano – materials

Nanomaterials for catalysis, development and characterization of nanobiocatalysts, application of nanoscaffolds in sythesis, applications of nanobiocatalysis in the production of drugs and drug intermediates.

Unit VI

Nano – toxicity

Introduction to Safety of nanomaterials, Basics of nanotoxicity, Models and assays for Nanotoxicity assessment; Fate of nanomaterials in different stratas of environment;Ecotoxicity models and assays; Life Cycle Assessment, containment.

MSBT305D:
Bioentrepreneurship (Elective)

Unit I
Innovation and entrepreneurship in bio-business
8 lectures
Introduction and scope in Bio-entrepreneurship, Types of bio-industries and competitive dynamics between the sub-industries of the bio-sector (*e.g.* pharmaceuticals *vs.* Industrial biotech), Strategy and operations of bio-sector firms: Factors shaping opportunities for innovation and entrepreneurship in bio-sectors, and the business implications of those opportunities, Alternatives faced by emerging bio-firms and the relevant tools for strategic decision, Entrepreneurship development programs of public and private agencies (MSME, DBT, BIRAC, Make In India), strategic dimensions of patenting & commercialization strategies.

Unit II
Bio markets -business strategy and marketing
8 lectures
Negotiating the road from lab to the market (strategies and processes of negotiation with financiers, government and regulatory authorities), Pricing strategy, Challenges in marketing in bio business (market conditions & segments; developing distribution channels, the nature, analysis and management of customer needs), Basic contract principles, different types of agreement and contract terms typically found in joint venture and development agreements, Dispute resolution skills.

Unit III
Finance and accounting 8 lectures
Business plan preparation including statutory and legal requirements, Business feasibility study, financial management issues of procurement of capital and management of costs, Collaborations & partnership, Information technology.

Unit IV
Technology management
8 lectures
Technology – assessment, development & upgradation, Managing technology transfer, Quality control & transfer of foreign technologies, Knowledge centers and Technology transfer agencies, Understanding of regulatory compliances and procedures (CDSCO, NBA, GCP, GLA, GMP).

MSBT305E: Tissue Engineering and artificial organs (Elective)

Unit I
Introduction to tissue engineering
2 L

Introduction, importance and scope of tissue engineering.

Unit II
5L
Biomaterials and scaffolds
Introduction to biomaterials and scaffolds; Requirements of biomaterials as Tissue Engineering scaffolds, Properties and types of scaffolds, Tissue specific scaffolds.

Unit III
Scaffold Preparation
5 lectures
Different methods employed in the synthesis of scaffolds and ways to process them.
Unit IV
Biology of animal cell
5 lectures
Animal cell biology, stem cells, organization of cells into tissues, tissue microenvironment, tissue injury and wound healing.

Unit V
4L
Biosensors for optimal tissue engineering
Biosensing techniques, Real time sensing in tissue engineering, in vivo implementations and challenges faced
UnitVI
Host-graft response
2 lectures
Review of basic immunology, response of body to foreign materials
Unit VII
Cell / Tissue-scaffold interaction
5 lectures
Animal cell culture on scaffolds, consequences, optimization strategies and important considerations.

Unit VIII
Tissue engineering applications

12 lectures
Skin tissue engineering, Liver tissue engineering, Bone and cartilage tissue engineering, Nerve tissue engineering, Vascular tissue engineering, Muscle tissue engineering and Kidney tissue engineering; Regulatory Affairs, Ethical issues and their impact on tissue engineering.

MSBT305F: Environment and Biotechnology (Elective)

UNIT 1
Interaction of man and environment, comparison of natural and man-made production processes, sources and types of wastes and pollutants generated by various human activities, biological, chemical and physical hazards from pollutants, black-listed pollutants by EEC

UNIT 2
Environmental survey methods- relative and absolute methods for estimating plant population sizes and community structure, survey designs, distribution patterns and quadrate sizes, design of survey program for single species and communities. Ecological; sampling theory- sample sizes, location of sampling efforts, methods of sampling.

UNIT 3
Treatment of solid wastes, landfills- application and hazardous effects, Public health and water quality, waste water and sewage treatment, aerobic waste water treatment: method, aerobic reactors and microorganisms involved. Anaerobic waste water treatment: method, digester and microorganisms involved. Sludge treatment, purification of drinking water.

UNIT 4
Biomagnification, Xenobiotics, types of recalcitrant xenobiotics, Hazards from Xenobiotics, Hydrocarbon degradation, biodegradation of halogenated compounds, cometabolism vs gratuitous metabolism, capacity of xenobiotics degradation, role of mixed microbial population in xenobiotics degradation, practical application of xenobiotics degradation, microbial remediation, phytoremediation.

UNIT 5
Air quality index, IAQ, CFC, Global warming, heavy metal pollution and effects, Green house effects, Radioactive contamination, Radiation poisoning and remedial measures, ozone layer depletion and effects, air quality standards, Montreal protocol, nitrogen oxide protocol, Kyoto protocol, EPA, DEFRA, Pollution control- monitoring and environmental management, toxicity testing, environmental risk assessment

Unit 6

Biotechnology and agriculture- Bioinsecticides: *Bacillus thuringiensis*, Baculoviruses, uses, genetic modifications and aspects of safety in their use; Biofungicides: Description of mode of actions and mechanisms (*e.g. Trichoderma, Pseudomonas fluorescens*); Biofertilizers: Symbiotic systems between plants – microorganisms (nitrogen fixing symbiosis, mycorrhiza fungi

symbiosis), Plant growth promoting rhizobacteria (PGPR) – uses, practical aspects and problems in application.

MSBT-306(MOOCS)

A. Computer aided drug design (NPTEL)
B. Functional Genomics (NPTEL)
C. Introduction to proteogenomics (NPTEL)
D. Industrial Biotechnology (NPTEL)
E. Medical Nanotechnology (NPTEL)
F. Dairy and food process and products technology (NPTEL)
G. Anatomy: Musculoskeletal and Integumentary systems (EDX)
H. Bioistatistics and design of experiments
I. Waste water treatment and recycling
J. Plant molecular Biology
K. Patenting
L. Introduction to genetics and evolution,
M. Molecular Diagnostics
N. Cell culture technologies
O. Biomolecules: Structure, Function in Health and Disease
P. Bioinformatics: algorithms and applications
Q. Bioengineering: An interface with biology and medicine
R. Computational Systems Biology
S. Current regulatory requirements for conducting clinical trials in India for investigational new drug/new drug (Version 2.0)
T. Sericulture Technology(CEC via Swayam)

Semester IV

Code	Course Title	Contact Hrs./wk	Credit
B	**Project**	**L- T -P**	
MSBT491	**Project work**	**3**	**22**
MSBT492	**Journal Club**	**3**	**1**
MSBT493	**Industry and Lab visit 3**	**3**	**1**
Semester Total			**24**