Maulana Abul Kalam Azad University of Technology, West Bengal
(formerly West Bengal University of Technology)

Department of Biotechnology

M.Sc. (Biotechnology)
Master of Science in Biotechnology

Syllabus 2020
(Two-Year Course)

(Syllabus of Biotechnology is adapted & modified from the syllabus prescribed by the Department of Biotechnology, Govt. of India, with slight modification)

M.Sc Biotechnology (2-Year, 4-Semester Course) (2020)

S. No.	Paper Code	Course Title	Contact Hrs/ wk L-T-P	Credits
SEMESTER ONE				
1	MSUBT-101	Biochemistry	3-0-0	3
2	MSUBT-102	Laboratory Techniques and Safety	3-0-0	3
3	MSUBT-103	Cell and Molecular Biology	3-0-0	3
4	MSUBT-104	Biostatistics	3-0-0	3
5	MSUBT-105	General Microbiology	3-0-0	3
6	MSUBT-191	Laboratory I: Biochemistry and Analytical Techniques	0-0-6	3
7	MSUBT-192	Laboratory II: Microbiology	0-0-6	3
8	MSUBT-193	Laboratory III: Lab for Data Analysis using Statistical Software	0-0-4	2
9	MSUBT-181	Seminar / Journal Presentation		1
		TOTAL		**24**
SEMESTER TWO				
1	MSUBT-201	Genetics and Molecular Diagnostics	3-0-0	3
2	MSUBT-202	Bioprocess Engineering and Technology	3-0-0	3
3	MSUBT-203	Immunology	3-0-0	3
4	MSUBT-204	Genetic Engineering	3-0-0	3
5	MSUBT-205	Applied Bioinformatics	3-0-0	3
6	MSUBT-206	Choice Based Courses (From MOOCs Basket)		2
7	MSUBT-291	Laboratory IV: Molecular Biology & Genetic Engineering	0-0-6	3
8	MSUBT-292	Laboratory V: Immunology	0-0-6	3
9	MSUBT-281	Seminar / Journal Presentation		1
		TOTAL		**24**
SEMESTER THREE				
1	MSUBT-301	Industrial Biotechnology	3-0-0	3
2	MSUBT-302	Plant & Animal Cell Culture Technology	3-0-0	3
3	MSUBT-303	Genomics and Proteomics	3-0-0	3
4	MSUBT-304	Intellectual Property Rights, Biosafety and Bioethics	3-0-0	3
5	MSUBT-305	Choice Based Courses (From Elective Basket)	2-0-0	2
6	MSUBT-306	Choice Based Courses (From MOOCs Basket)		2
7	MSUBT-391	Laboratory VI: Bioprocess Engineering and Technology	0-0-6	3
8	MSUBT-392	Laboratory VII: Applied Bioinformatics	0-0-6	3
9	MSUBT-381	Project Proposal Presentation		2
		TOTAL		**24**
SEMESTER FOUR				
1	MSUBT-481	Dissertation		22
2	MSUBT-482	Industry/ Lab visit		1
3	MSUBT-483	Seminar / Journal Presentation		1
		TOTAL		**24**
		TOTAL CREDITS		**96**

Recommended Electives

Code	Subject
MSUBT-305A	Principles of Ecology
MSUBT-305B	Research Methodology and Writing
MSUBT-305C	Nanobiotechnology
MSUBT-305D	Enzyme Technology
MSUBT-305E	Plant Molecular Biology
MSUBT-305F	Medical Devices
MSUBT-305G	Environmental Biotechnology

Semester One

1.Biochemistry	MSUBT 101	Credits 3
Unit I **Basic chemistry**	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 der Walls 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 II **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 III **Enzyme kinetics**	Enzyme Classification, 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 IV **Glycobiology**	Sugars-mono, di, and polysaccharides with specific reference to glycogen, amylose. lipids- structure and properties of important members of storage and membrane.	

Unit V **Nucleic acid**	Nucleosides, nucleotides, nucleic acids - structure, a historical perspective leading up to the proposition of DNA double helical structure.
Unit VI **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 VII **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.
Recommended Text books and References	1. Stryer, L. (2015). Biochemistry. (8th ed.) New York: Freeman. 2. Lehninger, A. L. (2012). Principles of Biochemistry (6th ed.). New York, NY: Worth. 3. Voet, D., & Voet, J. G. (2016). 4. Biochemistry (5th ed.). Hoboken, NJ: J. Wiley & Sons. 5. Dobson, C. M. (2003). Protein Folding and Misfolding. Nature, 426(6968), 884-890. doi:10.1038/nature02261. 6. Richards, F. M. (1991). The Protein Folding Problem. Scientific American, 264(1), 54-63. doi:10.1038/scientificamerican 0191-54.

2. Laboratory Techniques & Safety	**MSUBT 102**	**Credits 3**
Unit I **Laboratory safety**	Basic goal of Chemical hygiene and lab safety, Occupational Safety and health administration (OSHA), Safety precaution, Health hazard, Chemical and biological hazard, Personal protective equipment	
Unit II **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 III **Electrophoretic techniques and blotting techniques**	Theory and application of Polyacrylamide and Agarose gel electrophoresis; Capillary electrophoresis; 2D Electrophoresis; Immunoelectrophoresis, Isoelectric focussing, Disc gel electrophoresis; Gradient electrophoresis; Pulsed field gel electrophoresis, Western blot, Eastern blot, Southern blot, Northern blot.	
Unit IV **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 V **Centrifugation**	Basic principles; Mathematics & theory (RCF, Sedimentation coefficient etc); Types of centrifuge, Micro centrifuge, 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 VI	Optical microscopy, Electron microscopy, Confocal microscopy
Microscopy	
Unit VII	DNA and Amino acid Sequencing, DNA CHIP, Microarray, Subtractive Hybridization, RNase protection assay, ELISA, Mass spectroscopy, Infra-red spectroscopy, NMR, Circular Dichroism
Advanced techniques	
Recommended Text books and References	1. Cantor & Schimmel : Biophysical Chemistry (Part I, II & III) 2. A. Lehninger : Principles of Biochemistry 3. Freifelder D., Physical Biochemistry, Application to Biochemistry and Molecular Biology, 2nd Edition, W.H. Freeman & Company, San Fransisco, 1982. 4. Keith Wilson and John Walker, Principles and Techniques of Practical Biochemistry, 5th Edition, Cambridge University Press, 2000. 5. D. Holme & H. Peck, Analytical Biochemistry, 3rd Edition, Longman, 1998. 6. R. Scopes, Protein Purification - Principles & Practices, 3rd Edition, Springer, Verlag, 1994. 7. Selected readings from Methods in Enzymology, Academic Press.

3. Cell and Molecular Biology	**MSUBT 103**	**Credits 3**
Unit I	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.	
Dynamic organization of cell		
Unit II	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, trancriptional 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, ribosomes-composition and assembly; universal genetic codes, degeneracy of codons, Wobble hypothesis; Iso-accepting tRNA; mechanism of initiation, elongation and
Chromatin structure and dynamics		

	termination; co- and post-translational modifications, mitochondrial genetic code.
Unit III **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 IV **Cellular processes**	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 V **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 VI **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.
Recommended Text books and References	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. Krebs, J. E., Lewin, B., Kilpatrick, S. T., & Goldstein, E. S. (2014). Lewin's Genes XI. Burlington, MA: Jones & Bartlett Learning. 4. Cooper, G. M., & Hausman, R. E. (2013). The Cell: a Molecular Approach (6th Ed.). Washington: ASM ; Sunderland. 5. Hardin, J., Bertoni, G., Kleinsmith, L. J., & Becker, W. M. (2012). Becker's World of the Cell. Boston (8th Ed.). Benjamin Cummings. 6. Watson, J. D. (2008). Molecular Biology of the Gene (5thed.). Menlo Park, CA: Benjamin/Cummings

4. Biostatistics	MSUBT 104	Credits 3
Unit I **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 II **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 III **Tests of hypothesis**	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.	
Recommended Text books and References	1. Aitken, M., Broadhursts, B., & Haldky, S. (2009) Mathematics for Biological Scientists. Garland Science. 2. Billingsley, P. (1986). Probability and Measure. New York: Wiley. 3. Rosner, B. (2000). Fundamentals of Biostatistics. Boston, MA: Duxbury Press. 4. Daniel, W. W. (1987). Biostatistics, a Foundation for Analysis in the Health Sciences. New York: Wiley., 264(1), 54-63. doi:10.1038/scientificamerican 0191-54.	

5. Microbiology	MSUBT 105	Credits 3
Unit I **Microbial characteristics**	Introduction to microbiology and microbes, history & scope of microbiology, morphology, structure, growth and nutrition of bacteria, Microbial fermentation, Microbial energetics, biosynthesis of enzymes , activation energy, endergonic and exergonic reaction, autotrophic and heterotrophic generation of ATP, Photophosporylation, fermentation vs respiration, bacterial growth curve, bacterial culture methods; antimicrobial resistance.	
Unit II **Microbial diversity & and taxonomy**	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 archaea, Thermoplasm; Eukaryotes: algae, fungi, slime molds and protozoa; extremophiles and unculturable microbes, Molecular Taxonomy, Identification and characterization of unknown microbes.	
Unit III **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 IV **Bacterial genetics:**	Mutation and recombination in bacteria, plasmids, transformation, transduction and conjugation; Transposon, Prokaryotic gene expression.	
Unit V **Interaction of microbes with its environment**	Antibiotic, Probiotic, Prebiotic, drug resistance, multiple drug resistance, Host- pathogen interaction.	
Recommended Text books and References	1. Joanne M. Willey, Linda Sherwood, Christopher J. Woolverton; (2011) Prescott's Microbiology, McGraw Hill. 2. Michael Joseph Pelczar, Eddie Chin Sun Chan, Noel R. Krieg; (1993) Microbiology by Pelczar. McGraw Hill. 3. Gerard J. Tortora, Berdell R. Funke, Christine L. Case; (2015); Microbiology by Tortora. Pearson Education.	

6. Laboratory I Biochemistry & Analytical Techniques	MSUBT 191	Credits 3
Syllabus	1. Preparing various stock solutions and working solutions that will be needed for the course. 2. To prepare an Acetic-Na Acetate Buffer and validate the Henderson-Hasselbach equation. 3. To determine an unknown protein concentration by plotting a standard graph of BSA using UV-Vis Spectrophotometer and validating the Beer- Lambert's Law. 4. Titration of Amino Acids and separation of aliphatic, aromatic and polar amino acids by thin layer chromatography. 5. Purification and characterization of an enzyme from a recombinant source (such as Alkaline Phosphatase or Lactate Dehydrogenase or any enzyme of the institution's choice). a) Preparation of cell-free lysates b) Ammonium Sulfate precipitation c) Ion-exchange Chromatography d) Gel Filtration e) Affinity Chromatography f) Dialysis of the purified protein solution against 60% glycerol as a demonstration of storage method g) Generating a Purification Table (protein concentration, amount of total protein; Computing specific activity of the enzyme preparation at each stage of purification) h) Assessing purity of samples from each step of purification by SDS-PAGE Gel Electrophoresis i) Enzyme Kinetic Parameters: Km, Vmax and Kcat. 6. Experimental verification that absorption at OD260 is more for denatured DNA as compared to native double stranded DNA. reversal of the same following DNA renaturation. Kinetics of DNA renaturation as a function of DNA size. 7. Identification of an unknown sample as DNA, RNA or protein using available laboratory tools. (Optional Experiments) 8. Biophysical methods (Circular Dichroism Spectroscopy, Fluorescence Spectroscopy). 9. Determination of mass of small molecules and fragmentation patterns by Mass Spectrometry.	
Recommended Text books and References	1. Joanne M. Willey, Linda Sherwood, Christopher J. Woolverton; (2011) Prescott's Microbiology, McGraw Hill. 2. Michael Joseph Pelczar, Eddie Chin Sun Chan, Noel R. Krieg; (1993) Microbiology by Pelczar. McGraw Hill. 3. Gerard J. Tortora, Berdell R. Funke, Christine L. Case; (2015); Microbiology by Tortora. Pearson Education.	

7. Laboratory II Microbiology	MSUBT 192	Credits 3
Syllabus	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. Antibiotics assay 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.	
Recommended Text books and References	1. Cappuccino, J. G., & Welsh, C. (2016). Microbiology: a Laboratory Manual. Benjamin-Cummings Publishing Company. 2. Collins, C. H., Lyne, P. M., Grange, J. M., & Falkinham III, J. (2004). Collins and Lyne's Microbiological Methods (8th ed.). Arnolds. 3. Tille, P. M., & Forbes, B. A. Bailey & Scott's Diagnostic Microbiology.	

8. Laboratory III Data Analysis by Software	MSUBT 193	Credits 2
Syllabus	1. Introduction to different statistical software. 2. Determination of mean, median, mode of given data set. 3. Determination of standard deviation and standard error of a given data set. 4. Preparation of different types of graph from a given data set. 5. Determination of statistical significance of the experimental data: Paired and unpaired t test and p value determination 5. Nonparametric Mann-Whitney test, including confidence interval of difference of medians. 6. Wilcoxon test with confidence interval of median. 7. Usage of two- and three-way anova. 8. Kaplan-Meier survival analysis	

9.Seminar/ Journal Presentation	MSUBT 181	Credits 1

Semester Two

1. Genetics & Molecular Diagnostics	MSUBT 201	Credits 3
Unit I **Genetics of bacteria, bacteriophages and Yeast**	Concept of a gene in pre-DNA era; mapping of genes in bacterial and phage chromosomes by classical genetic crosses; genetic complementation and other genetic crosses using phenotypic markers; Meiotic crosses, tetrad analyses, non-Mendelian and Mendelian ratios	
Unit II **Drosophila genetics as a model of higher eukaryotes**	Monohybrid & dihybrid crosses, back-crosses, test-crosses, analyses of autosomal and sex linkages, screening of mutations based on phenotypes and mapping the same, hypomorphy, genetic mosaics, genetic epistasis in context of developmental mechanism.	
Unit III **Population genetics and genetics of evolution**	Introduction to the elements of population genetics: genetic variation, genetic drift, neutral evolution; mutation selection, balancing selection, Fishers theorem, Hardy- Weinberg equilibrium, linkage disequilibrium; in- breeding depression & mating systems; population bottlenecks, migrations, Bayesian statistics; adaptive landscape, spatial variation & genetic fitness.	
Unit IV **Genome Biology in Health, Disease Detection and Analysis; Molecular Oncology**	An overview of chromosomal structure & mutations; DNA polymorphism: human identity; clinical variability and genetically determined adverse reactions to drugs. ARMS PCR; ISH; FISH; ISA; RFLP; DHPLC; DGGE; CSCE; SSCP; EST; SAGE; Diagnostic proteomics: SELDI-TOF-MS; Bioinformatics data acquisition & analysis. Detection of predictive biomarkers for personalized onco-therapy of human diseases such as chronic myeloid leukemia, as well as matching targeted therapies with patients and preventing toxicity of standard systemic therapies.	
Unit V **Detection and Identity of Microbial Diseases, Inherited Diseases and Diagnostic Metabolomics**	Direct detection and identification of pathogenic-organisms through microscopy, ELISA, PCR and immunoprecipitation that are slow growing or currently lacking a system of in vitro cultivation as well as genotypic markers of microbial resistance to specific antibiotics. Exemplified by inherited diseases for which molecular diagnosis has provided a dramatic improvement of quality of medical care: e.g., Fragile X Syndrome: Metabolite profile for biomarker detection the body fluids/tissues in various metabolic disorders by making using LCMS & NMR technological platforms.	
Unit VI **Quality assurance and control**	Quality oversight; regulations and approved testing (according to ICMR guideline)	
Recommended Text books and References	1.Campbell, A. M., & Heyer, L. J. (2006). Discovering Genomics, Proteomics, and Bioinformatics. San Francisco: Benjamin Cummings. 2.Brooker, R. J. (2009). Genetics: Analysis & Principles. New York, NY: McGraw-Hill. 3.Glick, B. R., Pasternak, J. J., & Patten, C. L. (2010). Molecular Biotechnology: Principles and Applications of Recombinant DNA. Washington, DC: ASM Press. 4. Coleman, W. B., & Tsongalis, G. J. (2010). 4.Molecular Diagnostics: for the Clinical Laboratorian. Totowa, NJ:	

	Humana Press. 5.Hartl, D. L., & Jones, E. W. (1998). Genetics: Principles and Analysis. Sudbury, MA: Jones and Bartlett. 6.Pierce, B. A. (2005). Genetics: a Conceptual Approach. New York: W.H. Freeman. 7.Tamarin, R. H., & Leavitt, R. W. (1991). Principles of Genetics. Dubuque, IA: Wm. C. Brown. 8.Smith, J. M. (1998). Evolutionary Genetics. Oxford: Oxford University Press.

2. Bioprocess Engineering & Technology	**MSUBT 202**	**Credits 3**
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**	Fermented foods and beverages; food ingredients and additives prepared by fermentation and their purification; fermentation as a	

technology in food process operations and production, biofuels and biorefinery	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 Text books 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.

3.Immunology	**MSUBT 203**	**Credits 3**
Unit I **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 II **Immune responses generated by B and T lymphocytes**	Immunoglobulins - basic structure, classes & subclasses of immunoglobulins, antigenic determinants; multigene organization of immunoglobulin genes; B-cell receptor; Immunoglobulin superfamily; principles of cell signaling; 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 III **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 of Immunofluorescence Microscopy, Flurochromes; Staining techniques for	

	live cell imaging and fixed cells; Flow cytometry, Instrumentation, Applications.
Unit IV	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.
Vaccinology	
Unit V	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.
Clinical immunology	
Recommended Text books and References	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

4. Genetic Engineering	**MSUBT 204**	**Credits 3**
Unit I	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	
Introduction and tools for genetic engineering		
Unit II	Plasmids; Bacteriophages; M13 mp vectors; PUC19 and Bluescript vectors, hagemids; 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 as vectors, yeast vectors, shuttle vectors.	
Different types of vectors		
Unit III	Principles of PCR: 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; T-vectors; proof reading enzymes; PCR based site specific mutagenesis; PCR in molecular diagnostics; viral and bacterial	
Different types of PCR techniques		

	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 IV **Gene manipulation and protein-DNA interaction**	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 V **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-CAS9 with specific emphasis on Chinese and American clinical trials.
Recommended Text books and References	1. Old, R. W., Primrose, S. B., & Twyman, R. M. (2001). Principles of Gene Manipulation: an Introduction to Genetic Engineering. Oxford: Blackwell Scientific Publications. 2. Green, M. R., & Sambrook, J. (2012). Molecular Cloning: a Laboratory Manual. Cold Spring Harbor, NY: Cold Spring Harbor Laboratory Press. 3. Brown, T. A. (2006). Genomes (3rd ed.). New York: Garland Science Pub. 4. Selected papers from scientific journals, particularly Nature & Science. 5. Technical Literature from Stratagene, Promega, Novagen, New England Biolab etc.

5. Applied Bioinformatics	**MSUBT 205**	**Credits 3**
Unit I **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 II **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.	
Unit III	Representation of molecular structures (DNA, mRNA, protein), secondary	

Structure-related problems	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; RNA structure prediction; Mfold; Protein structure prediction by comparative modelling approaches(homology modelling, threading); Ab initio structure prediction: force fields, backbone conformer generation by Monte Carlo approaches, side-chain packing; Energy minimization; Molecular dynamics; Rosetta; Structure comparison (DALI, VAST etc.); CASP; Protein-ligand docking; Computer-aided drug design (pharmacophore identification); QSAR; Protein-Protein interactions.
Unit IV System-wide analyses	Transcriptomics: Microarray technology, expression profiles, data analysis; SAGE; Proteomics: 2D gel electrophoresis; Mass Spectrometry; Protein arrays; Metabolomics:13C NMR based metabolic flux analysis.
Recommended Text books and References	1. Lesk, A. M. (2002). Introduction to Bioinformatics. Oxford: Oxford University Press. 2. Mount, D. W. (2001). Bioinformatics: Sequence and Genome Analysis. Cold Spring Harbor, NY: Cold Spring Harbor Laboratory Press. 3. Bourne, P. E., & Gu, J. (2009). Structural Bioinformatics. Hoboken, NJ: Wiley-Liss. 4. Lesk, A. M. (2004). Introduction to Protein Science: Architecture, Function, and Genomics. Oxford: Oxford University Press. 5. Campbell, M & Heyer, L. J. (2006), Discovering Genomics, Proteomics and Bioinformatics, Pearson Education. 6. Oprea, T. (2005). Chemoinformatics in Drug Discovery, Volume 23. Wiley Online Library. 7. Gasteiger, J. & Engel,T. (2003), Chemoinformatics: a Textbook, Wiley Online Library.

6.Choice Based Courses	**MSUBT 206**	**Credits 2**
Syllabus	**From MOOCs Basket**	

7.Laboratory III Molecular Biology and Genetic Engineering	**MSUBT 291**	**Credits 3**
Syllabus	1. Concept of lac-operon: a) Lactose induction of B-galactosidase. b) Glucose Repression. c) Diauxic growth curve of E.coli 2. UV mutagenesis to isolate amino acid auxotroph 3. Phage titre with epsilon phage/M13 4. Genetic Transfer-Conjugation, gene mapping 5. Plasmid DNA isolation and DNA quantitation	

	6. Restriction Enzyme digestion of plasmid DNA 7. Agarose gel electrophoresis 8. Polymerase Chain Reaction and analysis by agarose gel electrophoresis 9. Vector and Insert Ligation 10. Preparation of competent cells 11. Transformation of *E.coli* with standard plasmids, Calculation of transformation efficiency 12. Confirmation of the insert by Colony PCR and Restriction mapping 13. Expression of recombinant protein, concept of soluble proteins and inclusion body formation in E.coli, SDS-PAGE analysis 14. Purification of His-Tagged protein on Ni-NTA columns a) Random Primer labeling b) Southern hybridization.
Recommended Text books and References	1. Green, M. R., & Sambrook, J. (2012). Molecular Cloning: a Laboratory Manual. Cold Spring Harbor, NY: Cold Spring Harbor Laboratory Press.

8.Laboratory IV Immunology	**MSUBT 292**	**Credits 3**
Syllabus	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. Flow cytometry, 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.	

9.Seminar/ Journal Presentation	**MSUBT 281**	**Credits 1**

Semester Three

1. Industrial Biotechnology	MSUBT 301	Credits 3
Unit I **Process Design and Industrial Production**	Media and process optimization using Plackett Burman, Box Behnken and Central Composite design; Overproduction of microbial metabolites; Bioreactor scale-up based on constant power consumption per volume, mixing time, impeller tip speed (shear), mass transfer coefficients.	
Unit II **Biorefinery and Bioeconomy**	Concept of sustainability; Starch and sugar-based biorefinery; Biochemical biorefinery; Syngas biorefinery; Algal biorefinery; Pretreatment of biomass-complexity, challenges and methods; Microbial cell factory; Biomass logistics; Indian bioeconomy.	
Unit III **Production of commodity bioproducts**	First, second and third generations of bioethanol production; Production of butanol, 2,3-butanediol, 1,3-propanediol, Lactic acid, Succinic acid, Glutamic acid, Xylitol, Bioadipic acid.	
Unit IV **Development and production of vaccines**	Production of recombinant and synthetic vaccines, purification, evaluation of the efficacy, stability, formulation of the product.	
Unit V **Metabolic engineering for bioproduction**	Metabolic reconstruction and flux analysis; Redesigning metabolic pathways for improved product formation using synthetic biology approach.	
Recommended Text books and References	1. Raymond H. Myers, Douglas C. Montgomery and Christine M. Anderson-Cook (2009) Response Surface Methodology: Process and product optimization using designed experiments. John Wiley. 2. Alexander N Glazer and Hiroshi Nikaido (2007) Microbial Biotechnology. Cambridge University Press. 3. Peter F Stanbury, Allan Whitaker and Stephen J Hall (2017) Principles of Fermentation Technology. 3rd ed. Elsevier. 4. Wei-Shou Hu (2018) Engineering Principles in Biotechnology. John Wiley. 5. Virendra S Bisaria and Akihiko Kondo (2014) Bioprocessing of Renewable Resources to Commodity Bioproducts. John Wiley. 6. Christina D Smolke (2010) The Metabolic Pathway Engineering Handbook. CRC Press.	

2. Plant and Animal Cell Culture Technology	MSUBT 302	Credits 3
Unit I **Animal cell culture**	Animal cell culture; media composition and growth conditions; Animal cell and tissue, Animal cell culture preservation; Anchorage and non-anchorage dependent cell culture; Primary and secondary culture; Animal cell growth characteristics and kinetics; Micro & macro carrier culture; Hybridoma technology; Stem cell technology; Transgenic animals; Animal cloning; Mechanisms of drug resistance and cell death.	
Unit II **Plant Cell Culture**	Totipotency; Plant growth regulators; Regeneration and micropropagation of plants: clonal propagation, organogenesis, shoot-tip and meristem culture, haploid culture, triploid culture, protoplast culture; Somaclonal variation; Tissue culture and Cell suspension culture system: methodology, growth kinetics and nutrient optimization; Precursors and elicitors; Plant Transformation methods (emphasis on Agrobacterium mediated transformation); Hairy root culture; Plant products of industrial importance, Production of secondary metabolites	
Unit III **Secondary metabolite production**	Principles, design and operation of bioreactors: specific design criteria for mammalian and plant systems; Strategies for fermentation with recombinant organisms; Isolation, characterization and production of secondary metabolites from different plant cell types; Bioprocess monitoring and control: current practices in the bioprocess industries, advanced methodologies; Overview of downstream processing: centrifugation, filtration and chromatographic techniques.	
Recommended Text books and References	1. Butterworth Heinemann Ltd., (1994) Biotol Series, In vitro Cultivation of Plant cell. 2. Bhojwani S.S. and Razdan M.K. (1996) Plant Tissue Culture: Theory and Practice, a Revised Edition, Elsevier Science 3. T. A. Brown, (2001) Gene Cloning and DNA Analysis: an Introduction, Blackwell Science. 4. M. L Shuler and F. Kargi. (2002), Bioprocess Engineering, Prentice Hall Inc. 5. A. Slater, N. Scott and M. Fowler (2003), Plant Biotechnology: the Genetic Manipulation of Plants, Oxford University Press. 6. M. M. Ranga (2007), Animal Biotechnology, 3rd Revised Edition, Agrobios. 7. Freshney. (2016) Culture of Animal Cells. 8. Meyer, Handschel, Wiesmann (2009). Fundamentals of Tissue Engineering and Regenerative Medicine. 9. Selected Papers from Scientific Journals, particularly Nature & Science.	

3.Genomics & Proteomics	MSUBT 303	Credits 3
Unit I **Metagenomics**	Metagenome Sequencing and Analysis, Presequencing Considerations, MPLING and Data Generation, Sequence Processing, Tools and Databases for Metagenomic Analysis, Application for Metagenomic Data Analysis	
Unit II **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 Genome Browser
Unit III	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
Transcriptomics	
Unit IV	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
Epigenomics	
Unit V	Protein Structure, Amino Acids, Peptide Bonds, Primary Structure, Secondary, Tertiary Structure, Quaternary, Experimental Determination of Amino Acid Sequences andProtein 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 RMSD over 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
Proteomics	
Recommended Text books and References	1. Branden and Tooze “Introduction to Protein Structure” 2. R. R. Sinden, “DNA Structure & Function” A. R. Leach “Molecular Modelling- Principles & Function” 3. Mount “Bioinformatics” Cold Spring Harbour 4. Arthur Lesk “Introduction to Bioinformatics

4. Intellectual Property Rights, Biosafety and Bioethics	**MSUBT 304**	**Credits 2**
Unit I	Introduction to intellectual property; types of IP: patents, trademarks, copyright & related rights, industrial design, traditional knowledge, geographical indications, protection of new GMOs; International framework for the protection of IP; IP as a factor in R&D; IPs of relevance to biotechnology and few case studies; introduction to history of GATT, WTO, WIPO and TRIPS; plant variety protection and farmers rights act; concept of ‘prior art’: invention in context of “prior art”; patent databases - country-wise patent searches (USPTO, EPO, India); analysis and report formation.	
Introduction to IPR		
Unit II	Basics of patents: types of patents; Indian Patent Act 1970; recent amendments; WIPO Treaties; Budapest Treaty; Patent Cooperation Treaty	

Patenting	(PCT) and implications; procedure for filing a PCT application; role of a Country Patent Office; filing of a patent application; precautions before patenting-disclosure/non-disclosure - patent application- forms and guidelines including those of National Bio-diversity Authority (NBA) and other regulatory bodies, fee structure, time frames; types of patent applications: provisional and complete specifications; PCT and conventional patent applications; international patenting-requirement, procedures and costs; financial assistance for patenting-introduction to existing schemes; publication of patents-gazette of India, status in Europe and US; patent infringement- meaning, scope, litigation, case studies and examples; commercialization of patented innovations; licensing – outright sale, licensing, royalty; patenting by research students and scientists-university/organizational rules in India and abroad, collaborative research - backward and forward IP; benefit/credit sharing among parties/community, commercial (financial) and non-commercial incentives.
Unit III **Biosafety**	Biosafety and Biosecurity - introduction; historical background; introduction to biological safety cabinets; primary containment for biohazards; biosafety levels; GRAS organisms, 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 vs cisgenic plants or products derived from RNAi, genome editing tools.
Unit IV **National and international regulations**	International regulations – Cartagena protocol, OECD consensus documents and Codex Alimentarius; Indian regulations – EPA act and rules, guidance documents, regulatory framework – RCGM, GEAC, IBSC and other regulatory bodies; Draft bill of Biotechnology Regulatory authority of India - containments – biosafety levels and category of rDNA experiments; field trails – biosafety research trials – standard operating procedures - guidelines of state governments; GM labeling – Food Safety and Standards Authority of India (FSSAI).
Unit V **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.
Recommended Text books and References	1. Ganguli, P. (2001). Intellectual Property Rights: Unleashing the Knowledge Economy. New Delhi: Tata McGraw-Hill Pub. 2. National IPR Policy, Department of Industrial Policy & Promotion, Ministry of Commerce, GoI 3. Complete Reference to Intellectual Property Rights Laws. (2007). Snow White Publication Oct. 4. Kuhse, H. (2010). Bioethics: an Anthology. Malden, MA: Blackwell. 5. Office of the Controller General of Patents, Design & Trademarks; Department of Industrial Policy & Promotion; Ministry of Commerce &

Industry; Government of India. http://www.ipindia.nic.in/
6. Karen F. Greif and Jon F. Merz, Current Controversies in the Biological Sciences-Case **Studies** of Policy Challenges from New Technologies, MIT Press
7. World Trade Organisation. http://www.wto.org
8. World Intellectual Property Organisation. http://www.wipo.int
9. International Union for the Protection of New Varieties of Plants. http://www.upov.int
10. National Portal of India. http://www.archive.india.gov.in
11. National Biodiversity Authority. http://www.nbaindia.org
12. Recombinant DNA Safety Guidelines, 1990 Department of Biotechnology, Ministry of Science and Technology, Govt. of India. Retrieved from http://www.envfor.nic.in/divisions/csurv/geac/annex-5.pdf
13. Wolt, J. D., Keese, P., Raybould, A., Fitzpatrick, J. W., Burachik, M., Gray, A., Wu, F. (2009). Problem Formulation in the Environmental Risk Assessment for Genetically Modified Plants. Transgenic Research, 19(3), 425-436. doi:10.1007/s11248-009-9321-9
14. Craig, W., Tepfer, M., Degrassi, G., & Ripandelli, D. (2008). An Overview of General Features of Risk Assessments of Genetically Modified Crops. Euphytica, 164(3), 853-880. doi:10.1007/s10681-007-9643-8
15. Guidelines for Safety Assessment of Foods Derived from Genetically Engineered Plants. 2008.
16. Guidelines and Standard Operating Procedures for Confined Field Trials of Regulated Genetically Engineered Plants. 2008. Retrieved from http://www.igmoris.nic.in/guidelines1.asp
17. Alonso, G. M. (2013). Safety Assessment of Food and Feed Derived from GM Crops: Using Problem Formulation to Ensure “Fit for Purpose” Risk Assessments.
Retrieved from
http://biosafety.icgeb.org/inhousepublicationscollectionbiosafetyreviews.

5.Choice Based Courses	**MSUBT 305**	**Credits 2**
Syllabus	**From Elective Basket**	
MSUBT-305A	**Principles of Ecology**	
MSUBT-305B	**Research Methodology and Writing**	
MSUBT-305C	**Nanobiotechnology**	
MSUBT-305D	**Enzyme Technology**	
MSUBT-305E	**Plant Molecular Biology**	
MSUBT-305F	**Medical Devices**	
MSUBT-305G	**Environmental Biotechnology**	

6.Choice Based Courses	MSUBT 306	Credits 2
Syllabus	**From MOOCs Basket**	

7. Laboratory V Bioprocess Engineering & Technology	MSUBT 391	Credits 3
Syllabus	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 Text books 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.	

8.Laboratory VI Applied Bioinformatics	MSUBT 392	Credits 2

Syllabus	1. Using NCBI and Uniprot web resources. 2. Introduction and use of various genome databases. 3. Sequence information resource: Using NCBI, EMBL, Genbank, Entrez, Swissprot/TrEMBL, UniProt. 4. Similarity searches using tools like BLAST and interpretation of results. 5. Multiple sequence alignment using ClustalW. 6. Phylogenetic analysis of protein and nucleotide sequences. 7. Use of gene prediction methods (GRAIL, Genscan, Glimmer). 8. Using RNA structure prediction tools. 9. Use of various primer designing and restriction site prediction tools. 10. Use of different protein structure prediction databases (PDB, SCOP, CATH). 11. Construction and study of protein structures using Deepview/PyMol. 12. Homology modelling of proteins. 13. Use of tools for mutation and analysis of the energy minimization of protein structures. 14. Use of miRNA prediction, designing and target prediction tools.

9.Project Proposal Preparation	MSUBT 381	Credits 2

Unit I **Project Proposal Preparation**	Selection of research lab and research topic: Students should first select a lab wherein they would like to pursue their dissertation. The supervisor or senior researchers should be able to help the students to read papers in the areas of interest of the lab and help them select a topic for their project. The topic of the research should be hypothesis driven. Review of literature: Students should engage in systematic and critical review of appropriate and relevant information sources and appropriately apply qualitative and/or quantitative evaluation processes to original data; keeping in mind ethical standards of conduct in the collection and evaluation of data and other resources. Writing Research Proposal: With the help of the senior researchers, students should be able to discuss the research questions, goals, approach, methodology, data collection, etc. Students should be able to construct a logical outline for the project including analysis steps and expected outcomes and prepare a complete proposal in scientific proposal format for dissertation.
Unit II **Poster Presentation**	Students will have to present the topic of their project proposal after few months of their selection of the topic. They should be able to explain the novelty and importance of their research topic.
Unit III **Oral Presentation**	At the end of their project, presentation will have to be given by the students to explain work done by them in detail. Along with summarizing their findings they should also be able to discuss the future expected outcome of their work.

Semester Four

1.Dissertation	MSUBT 481	Credits 22

Syllabus	Based on the project proposal submitted in earlier semester, students should be able to plan, and engage in, an independent and sustained critical investigation and evaluate a chosen research topic relevant to biological sciences and society. They should be able to systematically identify relevant theory and concepts, relate these to appropriate methodologies and evidence, apply appropriate techniques and draw appropriate conclusions. Senior researchers should be able to train the students such that they can work independently and are able to understand the aim of each experiment performed by them. They should also be able to understand the possible outcomes of each experiment. At the end of their project, thesis has to be written giving all the details such as aim, methodology, results, discussion and future work related to their project. Students may aim to get their research findings published in a peer-reviewed journal. If the research findings have application-oriented outcomes, the students may file patent application.
Planning & performing experiments	
Thesis writing	

2.Industry/ Lab Visit	MSUBT 482	Credits 1

3.Seminar/ Journal Presentation	MSUBT 483	Credits 1

****