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

Department of Biotechnology

M.Sc. (Molecular Biology)
Master of Science in Molecular Biology

Syllabus 2019
(Two-Year Course)

M.Sc Molecular Biology (2-Year, 4-Semester Course) (2019)

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

ELECTIVES

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

Semester I

Semester – I

Code	Course Title	Contact Hrs./Wk	Credit
A	**Theory**	**L-T-P**	
MSUMB-101	Biochemistry	3-0-0	3
MSUMB-102	Laboratory Techniques	3-0-0	3
MSUMB-103	Cell and Molecular Biology	3-0-0	3
MSUMB-104	Biostatistics	3-0-0	3
MSUMB-105	Regulation of Gene Expression	3-0-0	3
B	**Practical**		
MSUMB-191	Biochemistry & Analytical Techniques Lab	0-0-6	3
MSUMB-192	Molecular Biology Lab	0-0-6	3
MSUMB-193	Lab for Data analysis using statistical software	0-0-6	2
C			
MSUMB-181	Seminar/ Journal Presentation		1
Semester Total			**24**

MSUMB101: 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 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 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.

MSUMB102:Lab 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; 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 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

MSUMB103: 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, ribosomes-composition and assembly; universal genetic codes, degeneracy of codons, Wobble hypothesis; Iso-accepting 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.

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.

MSUMB104: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.

MSUMB105:Regulation of Gene Expression

credits 3

Unit 1 Regulation of gene expression in prokaryotes and their viruses:

Constitutive, Inducible, and Repressible Gene Expression; Positive and Negative Control of gene expression b) Operons: Lac, Trp, Ara in Bacteria c) Switch between lysogeny and lysis in Bacteriophage Lambda d) Translational control of gene expression and post translational regulatory mechanism , Horizontal gene transfer

Unit 2 Regulation of Gene expression in Eukaryotes:

a) Spatial and temporal gene regulation of gene expression

b) Transcriptional control: RNA polymerases, cis-elements, transcription factors

c) Post transcriptional control: Alternate splicing, capping and poly-adenylation, RNA –editing, cytoplasmic control of mRNA stability

d) Environmental impact on transcription: Heat shock genes and Rubisco

e) Chromosome organization and long range control: Transcription in lampbrush and polytene chromosomes and chromatin loops, puffs and domains, matrix attachment regions, remodeling of chromatin structure, enhancers, long range and epigenetic control mechanisms, ENCODE project

f) Translational control of gene expression and post translational regulatory mechanism

g) RNA interference: mechanisms and enzymology; RISC complex formation; regulation of gene expression by miRNA pathway; plant-virus interactions and silencing of RNA. Epigenetics, methylation, acetylation & Histone modification, Transcriptomics, Metabolomics

Texts/References

1. Watson, J. D. (2008). Molecular Biology of the Gene (5th ed.). Menlo Park, CA:Benjamin/Cummings.
2. Benjamin Lewin, Gene IX, 9th Edition, Jones and Barlett Publishers, 2007.

MSUMB191: 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

MSUMB192: Molecular Biology lab

credits 3

1. Concept of lac-operon:
   a. lactose induction of β-galactosidase.
   b. Glucose Repression.
   c. Diauxic growth curve of *E. coli.*
2. UV mutagenesis to isolate amino acid auxotroph.
3. Phage titre with λ 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.
9. DNA Ligation.
10. Preparation of competent cells.
11. Transformation of *E.coli* with standard plasmids, Calculation of transformation efficiency.
12. Confirmation of the insert, Miniprep of recombinant plasmid DNA, 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.

MSUMB193: Data analysis using statistical software

credits 2

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
6. Nonparametric Mann-Whitney test, including confidence interval of difference of medians.
7. Wilcoxon test with confidence interval of median.
8. Usage of two and three way anova.
9. Kaplan-Meier survival analysis.

Semester II

Semester II

Code	Course Title	Contact Hrs./wk	Credit
A	**Theory**	**L-T-P**	
MSUMB-201	Neurobiology & Developmental Biology	3-0-0	3
MSUMB-202	Genomics & Proteomics	3-0-0	3
MSUMB-203	Immunology	3-0-0	3
MSUMB-204	Genetic Engineering	3-0-0	3
MSUMB-205	Applied Bioinformatics	3-0-0	3
MSUMB-206	Choice based courses (from MOOCS basket)		2
B	**Practical**		
MSUMB-291	Genetic engineering Lab	0-0-6	3
MSUMB-292	Immunology Lab	0-0-6	3
C			
MSUMB-281	Seminar/ Journal Club Presentation		1
Semester Total			**24**

MSUMB 201: Neurobiology & Developmental Biology credits 3

Unit 1 Introduction to the Nervous system, cellular and molecular building blocks, the structure of nervous systems

Unit 2 The Electrical Potential of a resting neuron, the nerve impulse, synaptic transmission, neurotransmitters and their release, integration of synaptic action

Unit 3 Properties of sensory systems, coding and control of sensory information, motor systems: muscle and its control, reflexes and pattern generation, sensory influence on motor output, the brain and motor output.

Unit 4 Development, developmental plasticity, behavioural plasticity: learning, hormones and the nervous system

Unit 5 The neural basis of behavior, gene regulation in the nervous system

Unit 6 Gametogenesis, Types and structure of eggs, Fertilization, Mechanism of fertilization, fertilization in sea urchin, sperm activation, ovum activation, egg-sperm adhesion, acrosome reaction, prevention of polyspermy, cleavage and blastulation, types of cleavage and patterns of cleavage, Fate map, Gastrulation, different types of morphogenetic movements, placenta, In vitro Fertilization.

Texts/References

1. Foundations of Neurobiology, Fred Delcomyn
2. From Neuron to Brain, Nicholls, Martin and Wallace: Sinauer Associates
3. Developmental Biology, Gilbert

MSUMB 202: Genomics & Proteomics credits 3

Metagenomics

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

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

Transcriptomics

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 Visualization and Analysis, Construction and Analysis of GCNs.

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

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

MSUMB 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 of Immunofluorescence 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,

MSUMB 204: Genetic Engineering 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; DNaseI 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

MSUMB205 : 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; 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 4: System-wide analyses

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

MSUMB291: Lab On Genetic Engineering credits 3

1. Isolation of total genomic 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* (DH5 α) 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.

MSUMB 292: 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.

Semester – III

Semester – III

Code	Course Title	Contact Hrs./wk	Credit
A	**Theory**	**L-T-P**	
MSUMB-301	Plant Biotechnology	3-0-0	3
MSUMB-302	Immunotechnology	3-0-0	3
MSUMB-303	Signal Transduction & Oncology	3-0-0	3
MSUMB-304	IPR, Biosafety & Bioethics	3-0-0	3
MSUMB-305	Choice Based course (From Elective Basket)	2-0-0	2
MSUMB-306	Choice Based course (From MOOCS Basket)	2-0-0	2
B	**Practical**		
MSUMB-391	Applied Bioinformatics lab	0-0-6	3
MSUMB-392	Signal transduction lab	0-0-6	3
C			
MSUMB-381	Project Proposal Presentation		2
Semester Total			**24**

MSUMB301: Plant Biotechnology credits 3

Unit 1: Plant tissue culture

Plasticity and Totipotency, The culture environment, Plant Cell culture media, Plant growth regulators and function, Culture types- Callus, Cell-suspension culture, Protoplast culture, Root culture, Shoot tip and Meristem culture, Embryo culture, M icrospore culture, Somaclonal variation, Somatic Embryogenesis, Polyploidy, Androgenesis, Artificial Seed, Germplasm Conservation and Cryopreservation

Plant Genome: Organization and expression of plant genes

Gene structure and expression, regulation of gene expression, Implication of plant transformations, Plant signal transduction, G Protein, Role of Calcium in signaling, Protein kinases, Plant promoters, terminators, reporters, selectable markers, Clean Gene Technology, Gene Silencing

Unit 2: Genetic Transformation

Direct gene Transfer Techniques, Agrobacterium mediated gene transfer- Biology and molecular basis of Agrobacterium mediated plant transformation and its application, Plant vectors, Ri and Ti Plasmids, Opines and their significance

Mutagenesis and Cloning of Genes

Mendelian genetics, Concept of forward and reverse genetics, Molecular polymorphism, RFLP, RAPD, DNA Microsatellite, Linkage analysis, DNA polymorphic markers, QTL

Unit 3: Seed Science & Technology

Seed structure, Molecular aspects of seed germination, seed growth, seed quality assessment, seed architecture, crop cultivar fingerprinting, RFLP, RAPD, Image Analysis, SEM

Post Harvest Technology

Classification of ripening fruits, Physiological and biochemical changes of fruit ripening, Molecular mechanism of fruit ripening, Role of Ethylene in fruit ripening, Ripening specific genes

Unit 4: Plant Disease Resistance

Types of pathogen and their mode of action, Plant defence system, Constitutive and inducible defence, Genetic basis of plant pathogen interaction, R genes and R gene mediated resistance, Biochemistry and Molecular biology of defence reactions, Systemic acquired resistance, Role of Salicylic, Jasmonic acid and ethylene in plant defence

Plant Stress Response

Abiotic and biotic stress, Drought, salinity, heat, cold, nutrient, submergence stress, Pathogen stress, Osmotic adjustment and its role in drought and salinity tolerance, ABA in stress tolerance, Strategies for genetic engineering of stress tolerance

Unit 5 : Plant as Biofactories

Biofermentation, Production of industrial enzymes, pigments, biofertilizers, biopesticides, cell culture for secondary metabolites production. Biogas, Bioplastic, Biofuels, Biosensors

Eco-biotechnology

Plant genetic resources, Crop gene bank, Plant breeders right and farmers right, patenting of biological materials

MSUMB302: Immunotechnology credits 3

Unit 1: Drugs

Antimetabolites, corticosteroids, anti-inflammatory agents

Cytokinins Cytokinins regulating immune inflammation: interleukin-4, interleukin-10, interleukin-12

The interferons: Basic biology and therapeutic potential Treatment of inflammatory diseases

Unit 2: Macromolecules Intravenous immunoglobulin therapy, Treatment of angioedema resulting from Cl inhibitor deficiency

Antibodies and antibody based therapy

Characteristics of animal cells and their implication on process design, Nutritional requirements and serum free culture of mammalian cells, Kinetics of growth and product formation. Reactor systems for large-scale production using animal cells. Production of Polyclonal antibodies with different types of antigens :antigen preparation and modification, adjuvant, dose and route of antigen administration, collection of sera, purification of antibodies. Inhibitors of tumor necrosis factor, targeting the IL2 receptor with antibodies or chimeric toxins, monoclonal antibodies to CD3 Hybridome technology – production and applications of monoclonal antibodies for diagnosis and therapy.

Unit 3: Immunotherapy for allergic diseases

Specific and nonspecific immunotherapy for Asthma and allergic diseases, insect stings etc Vaccine and peptide therapy

Unit 4: Transplantation

Renal, pancreas, cardiac, lung, liver transplantation, xenotransplantation, Cellular therapy, Drug therapy in HIV Tumor Immunology, AIDS and other Immunodeficiencies.

MSUMB303: Signal Transduction & Oncology

credits 3

Unit 1: Cell communication

Concepts of signal molecules, Receptors- G protein linked receptors and G protein mediated signaling, Second messengers, Role of Calcium, lipid signaling- Phospholipase and Phosphoinocitides signaling, Signaling through enzyme linked cell surface receptors- Cytokine receptors and JAK-STAT pathway, Receptor tyrosine kinases, Map kinase pathways, Down modulation of a signal.

Integration of Signals and Gene controls

Experimental approaches for building a comprehensive view of signal induced responses, responses of cells to environmental influences.

Unit 2: The cell cycle and programmed cell death

Overview of cell cycle, Components of the cell cycle control system- the checkpoints and Cdks, Intracellular control of cell cycle, Programmed cell death, Extracellular control of cell division, cell growth and apoptosis

The mechanics of cell division

Mitosis and cytokinesis

Cell junction, Cell adhesion and the extracellular matrix

Cell junction, cell-cell adhesion, the extracellular matrix of animals, integrins

Unit 3: Oncology

Tumor Cells and Onset of Cancer, Chemical carcinogenesis Biochemistry and molecular biology of cancer, Genetic basis of cancer, Oncogenes and Oncogenic Mutations and Growth Promoting Proteins, Mutations causing loss of growth inhibiting and cell cycle controls, Role of carcinogens and DNA repair in cancer, viral and cellular oncogenes, tumor suppressor genes.

MSUMB304: IPR, Biosafety & Bioethics credits 3

Unit 1: IPR

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.

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 vs cisgenic plants or products derived from RNAi, genome editing tools.

MSUMB391: Lab on Signal Transduction credits 3

1) Tissue Culture Methods: Growth and maintenance of human neuroblastoma SH-SY5Y cells/ human liver carcinoma Hep G2 cells including safety measures.
2) Generation of oxidative stress by Thyroid hormone / H_2O_2 treatment; lipid peroxidation assays (TBARS) and Reactive oxygen species (ROS) generation assays.
3) H_2O_2 induced DNA fragmentation assays.
4) Thyroid hormone induced gene expression: transfection of luciferase reporter constructs of Thyroid hormone response element (TRE) and subsequent luciferase assays.
5) Infection of Tomato plants by Tomato leaf curl virus and monitoring of viral load at 15dpi, 25dpi and 30dpi using molecular approach.
6) Isolation of virus genomic component from field grown infected plants.
7) Study of expression of different stress specific marker genes for the corresponding stress treatments in plants.
8) Histochemical and fluorometric GUS assay.
9) Seed viability test.

MSUMB392: Lab on Applied Bioinformatics credits 3

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

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

Semester IV

Semester – III

Code	Course Title	Contact Hrs./wk	Credit
		L-T-P	
MSUMB-481	Project Work	0-0-0	22
MSUMB-482	Industry/Lab Visit		1
MSUMB-483	Journal Club presentation		1
Semester Total			**24**

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