Maulana Abul Kalam Azad University of Technology, West Bengal

Department of Biotechnology

M. Sc in Microbiology

Syllabus 2019-20

Code	Course Title	Contact Hrs./Wk	Credit
A	**Theory**	L-T-P	
MSUMC-101	Biochemistry	3-0-0	3
MSUMC-102	Laboratory Technique & safety	3-0-0	3
MSUMC-103	Cell & Molecular Biology	3-0-0	3
MSUMC-104	Biostatistics	3-0-0	3
MSUMC-105	General Microbiology	3-0-0	3
B	**Practical**		
MSUMC-191	Biochemistry & Analytical Techniques	0-0-6	3
MSUMC-192	Microbiology	0-0-6	3
MSUMC-193	Data analysis by software	0-0-4	2
C			
MSUMC-	Seminar		1

Semester I

181			
Semester Total			**24**

Code	Course Title	Contact Hrs./wk	Credit
A	**Theory**	**L-T-P**	
MSUMC-201	Agricultural & Soil Microbiology	3-0-0	3
MSUMC-202	Industrial Microbiology & Fermentation Technology	3-0-0	3
MSUMC-203	Immunology	3-0-0	3
MSUMC-	Genetic Engineering	3-0-0	3

Semester II

204			
MSUMC-205	Applied Bioinformatics	3-0-0	3
MSUMC-206	Choice based courses (from MOOCS basket)		2
B	**Practical**		
MSUMC-291	Genetic engineering	0-0-6	3
MSUMC-292	Immunology	0-0-6	3
C			
MSUMC-281	Seminar		1
Semester Total			**24**

Semester III

Code	Course Title	Contact Hrs./wk	Credit
A	**Theory**	L-T-P	
MSUMC-301	Virology	3-0-0	3
MSUMC-302	Environmental Microbiology	3-0-0	3
MSUMC-303	Medical Microbiology	3-0-0	3
MSUMC-304	IPR, Biosafety & Bioethics	3-0-0	3
MSUMC-305	Choice Based course (From Elective Basket) *	2-0-0	2
MSUMC-306	Choice Based course (from MOOCS basket)		2
B	**Practical**		
MSUMC-391	Applied Bioinformatics lab	0-0-6	3
MSUMC-392	Fermentation technology lab	0-0-6	3
C			
MSUMC-381	Project Proposal Presentation		2

Semester Total	24

* Elective subjects Basket

Code	Subject
MSMC-305A	Principles of Ecology
MSMC- 305B	Research methodology and Writing
MSMC-305C	Molecular diagnostics
MSMC-305D	Enzyme technology
MSMC-305E	Plant Molecular Biology

Semester – IV

Code	Course Title	Contact Hrs./wk	Credit
		L-T-P	
MSUMC-481	Project Work		22
MSUMC-482	Industry/ lab visit		1
MSUMC-483	Journal Club Presentation		1
Semester Total			24
Total Course Credit			96

Semester – I

MSUMC-101: Biochemistry credits 3

Unit 1: 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 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 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 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: Vitamins & cofactors

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. David L. Nelson; Michael M. Cox. Lehninger Principles of Biochemistry
2. L Stryer, Biochemsitry, Freeman publishing.

MSUMC-102: Laboratory Techniques & Safety

credits 3

Unit 1 : 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 2: Chromatography - Paper Chromatography, Thin-layer chromatography, Displacement chromatography, Gas chromatography, High performance / pressure liquid chromatography, Ion exchange chromatography, Size-exclusion chromatography, Affinity chromatography.

Unit 3: Electrophoresis and blotting - 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 4 :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 5 :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 6: Microscopy

Optical microscopy, Electron microscopy, Confocal microscopy, AFM, Flow cytometry, Instrumentation, Applications.

Unit 7: Advanced molecular biology techniques

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

Text/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.
5. D. Holme & H. Peck, Analytical Biochemistry, 3rd Edition, Longman, 1998.

MSUMC-103: Cell and Molecular Biology

credits 3

Unit 1: Organization of cell :Universal features of eukaryotic 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: 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/References

1. Alberts, B., Johnson, A., Lewis, J., Raff, M., Roberts, K., & Walter, P. (2002). Molecular Biology of the Cell. New York: Garland Science.
2. Lodish, H. F. (2000). Molecular Cell Biology. 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. (2009). The Cell: a Molecular Approach. Washington: ASM; Sunderland.
5. Hardin, J., Bertoni, G., Kleinsmith, L. J., & Becker, W. M. (2012). Becker's World of the Cell. Boston: Benjamin Cummings.
6. Watson, J. D. (1987). Molecular Biology of the Gene (7th ed.). Menlo Park, CA: Benjamin/Cummings.
7. Tropp et al, Principles of Molecular Biology

MSUMC-104: Biostatistics credits 3

Unit 1: Introduction to Biostatistics

Basic definitions and applications. Sampling: Representative sample, sample size, sampling bias and sampling techniques. Sample distribution. 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 and Measure of dispersion

Mean, Medium and 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 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 Deviation. Randomized block design, complete block design.

Text/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.

MSUMC-105: General Microbiology3 Credits

Unit 1: 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 2: 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 3: Bacterial genetics:

Mutation and recombination in bacteria, plasmids, transformation, transduction and conjugation; Transposon, Prokaryotic gene expression.

Unit 4: Interaction of microbes with biotic and abiotic stress:

Antibiotic, Probiotic, Prebiotic, drug resistance, multiple drug resistance, Host-pathogen interaction.

Text/ Reference

1. M.T. Madigan and J.M. Martinko, Brock Biology of Microorganisms, 11th edition, Pearson Prentice-Hall, 2006.
2. Joanne M. Willey, Linda Sherwood, Christopher J. Woolverton; (2011) Prescott's Microbiology, McGraw Hill.
3. Michael Joseph Pelczar, Eddie Chin Sun Chan, Noel R. Krieg; (1993) Microbiology by Pelczar. McGraw Hill.
4. Gerard J. Tortora, Berdell R. Funke, Christine L. Case; (2015); Microbiology by Tortora. Pearson Education.
5. Microbial Genetics- David Freifelider

MSUMC-191: Biochemistry and Analytical Techniques credits 3

1. To prepare an Acetic-Na Acetate 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

MSUMC-192: Microbiology credits 3

1. Sterilization, disinfection, safety in microbiological laboratory.
2. Preparation of media for growth of various microorganisms.
3. Identification and culturing of various microorganisms.
4. Staining and enumeration of microorganisms.
5. Growth curve, measure of bacterial population by turbidometry and studying the effect of temperature, pH, carbon and nitrogen.
6. 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.

MSMB193: Data analysis by 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

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

Semester II

MSUMC-201: Agricultural and soil Microbiology

Credits 3

Unit I

History of soil microbiology, Soil microbiology- Stages of Soil Formation, Soil microbes, soil texture, structure, Soil pH, Conductivity etc.

Unit II

Microbial Metabolism - Biological N_2-fixation by Free living anaerobic (Clostridium), facultatively anaerobic (Azospirillum) and aerobic (Azotobacter), N_2-fixers associated with stem, root and leaf, Symbiotic N_2-fixation in legumes and non- legumes by Rhizobium and Frankia, N_2-fixation by cyanobateria. Requirement of ATP, O2-sensitivity and inhibition by ammonia and nitrogenous substance in the case of nitrogenase, Peculiarity of alternate nitrogenase of *Streptomyces thermoautotrophicus*.

Unit III

Biofertilizers and Biopesticides- Physical and Biological Nitrogen fixation- symbiotic and asymbiotic, mass production by Rhizobium, Azotobacter and Cyanobacteria, nitrifying and ammonifying bacteria, Denitrification of nitrate fertilizers to N2 and N2O (a green house gas) by denitrifying bacteria, free living and in association with Azolla, Phosphate solubilizing bacteria, PGPR, Mycorrhiza, Soil anerobic methanogens in rice field. Integrated nutrient management.

Unit IV

Effect of soil pH and heavy metals on microorganisms, Microbial antagonism in soil, Biological control of soil-borne microbial pathogens. Biopesticides, integrated pest management, organic farming, organic village etc. Eco-friendly Microbes; –Utilization of beneficial Microorganisms in sustainable Agriculture, Ice minus bacteria and microbial pesticides.

Text/References:

1. M.T. Madigan and J.M. Martinko, Brock Biology of Microorganisms, 11th edition, Pearson Prentice-Hall, 2006.
2. Joanne M. Willey, Linda Sherwood, Christopher J. Woolverton; (2011) Prescott's Microbiology, McGraw Hill.
3. Michael Joseph Pelczar, Eddie Chin Sun Chan, Noel R. Krieg; (1993) Microbiology by Pelczar. McGraw Hill.
4. Gerard J. Tortora, Berdell R. Funke, Christine L. Case; (2015); Microbiology by Tortora. Pearson Education.
5. A.J. Salle Fundamental Principles of Bacteriology, Tata McGraw-Hill Education

MSUMC-202: Industrial Microbiology & Fermentation technology

Credits 3

Unit I Introduction to industrial microorganisms - History of industrial microbiology, Isolation, screening and maintenance of industrially important microbes; microbial growth kinetics (with reference to industrially useful microorganisms); strain improvement for increased yield and other desirable characteristics.

Unit 2: Methods in fermentation- Batch, fed-batch and continuous operations; chemostat and Turbidostat systems; immobilized cell systems; media formulation and optimization; sterilization of media and air; oxygen transfer and kLa in fermentation

Unit 3: Downstream process for microbial products- Separation of insoluble products : filtration, centrifugation, sedimentation, flocculation; cell disruption; Separation

of soluble products: liquid- liquid extraction, precipitation, chromatography, reverse osmosis, crystallization , ultra and micro filtration; drying and packaging.

Unit 4: Fermented foods and beverages- Food ingredients and additives by fermentation; fermentation as a method of preparing and preserving foods; microbes and their use in pickling, producing colours, flavours and alcoholic beverages; 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; probiotics, prebiotics and synbiotics and food additives.

Unit 5: Industrial products- Titre, yield and productivity; Raw materials for industrial production; Bioethanol, Baker's yeast, Lactic acid, Amino acids (L-Lysine and L-Glutamic acid), Citric acid, Penicillin, Glutathione, Insulin, Amylase, Protease, High-fructose corn syrup and vaccines.

Text/References:

1. M.T. Madigan and J.M. Martinko, Brock Biology of Microorganisms, 11th edition, Pearson Prentice-Hall, 2006.
2. Joanne M. Willey, Linda Sherwood, Christopher J. Woolverton; (2011) Prescott's Microbiology, McGraw Hill.
3. Michael Joseph Pelczar, Eddie Chin Sun Chan, Noel R. Krieg; (1993) Microbiology by Pelczar. McGraw Hill.
4. Gerard J. Tortora, Berdell R. Funke, Christine L. Case; (2015); Microbiology by Tortora. Pearson Education.
5. A.J. Salle Fundamental Principles of Bacteriology, Tata McGraw-Hill Education
6. Casida L.E.J.R. Industrial Microbiology
7. E. M. T. El-Mansi, C. F. A. Bryce, Arnold L. Demain, A.R. Allman (2012) Fermentation Microbiology and Biotechnology

MSUMC-203: Immunology credits 3

Unit 1 : 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

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

MSUMC-204: Genetic Engineeringcredits 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 vectors; PUC19 and pBluescript 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-CAS9 with specific emphasis on Chinese and American clinical trials.

Texts/References

1. Jocelyn E. Krebs, Elliott S. Goldstein, Stephen T. Kilpatrick. Lewin's Gene XII,
2. David Baltimore and Harvey Lodish Molecular cell Biology, 6th Edition
3. James D. Watson (2017) Molecular Biology of the Gene (2017) Pearson Publisher
4. Brown, T. A. (2006). Genomes (3rd ed.). New York: Garland Science Pub
5. S. Primrose, R. Twyman, B. Old, and G. Bertola (2006), Principles of Gene Manipulation and Genomics, Blackwell Publishing Limited; 7th Edition
6. Green, M. R., & Sambrook, J. (2012). Molecular Cloning: a Laboratory Manual. Cold

Spring Harbor, NY: Cold Spring Harbor Laboratory Press.

7. Selected Papers from Scientific Journals, particularly Nature & Science.

8. Technical Literature from Stratagene, Promega, Novagen, New England Biolab etc.

MSUMC-205: 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:13C NMR based metabolic flux analysis.

Text/References:

1. Mount, D. W. (2001). Bioinformatics: Sequence and Genome Analysis. Cold Spring
Harbor, NY: Cold Spring Harbor Laboratory Press.
2. Bourne, P. E., & Gu, J. (2009). Structural Bioinformatics. Hoboken,

NJ: Wiley-Liss.
3. Lesk, A. M. (2004). Introduction to Protein Science: Architecture, Function, and Genomics. Oxford: Oxford University Press.
4. Campbell, M & Heyer, L. J. (2006), Discovering Genomics, Proteomics and Bioinformatics, Pearson Education.
5. Oprea, T. (2005). Chemoinformatics in Drug Discovery, Volume 23. Wiley Online Library.
6. Gasteiger, J. & Engel,T. (2003), Chemoinformatics: a Textbook, Wiley Online Library.

MSUMC- 291: 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. 1. Designing of primers for directional cloning.
6. Cloning of a candidate gene by directional cloning method.
7. Plasmid isolation by Alkaline Lysis method.
8. Isolation of plant total protein from plant leaves and analysis of the isolated protein by SDS-PAGE

9. Screening of recombinant clones by blue white screening.

MSUMC- 292: 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. 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.

Semester III

MSUMC-301: Virology credits 3

Unit 1. Nomenclature & classification systems of viruses and Morphology of Viruses

Structure of Viruses- Enveloped and Non enveloped viruses, Capsid symmetries – Icosohedral, Polyhedral and Helical, Structural components of virus – Protein - Envelope proteins, Matrix proteins and Lipoproteins, Genome – dsDNA, ssDNA, dsRNA, ssRNA (positive sense, negative sense), linear, circular, segmented.

Unit 2: Cultivation and assay of viruses

Cultivation of viruses using embryonated eggs, experimental animals and cell cultures (Cell- lines, cell strains and transgenic systems). Purification of viruses by adsorption, precipitation, enzymes, serological methods – haeme agglutination and ELISA. Assay of viruses – Physical and Chemical methods (Electron Microscopy and Protein and Nucleic acids studies.) Infectivity Assays (Plaque and end-point) Genetic analysis of viruses by classical genetic methods.

Unit 3: Entry and Replication of viruses

Mechanism of virus adsorption and entry into host cell, Genome replication, Post transcriptional processing, Translation of viral proteins, Protein nucleic acid interactions and genome packaging Assembly, exit and maturation of progeny virions, Replicative strategies employed by animal DNA viruses. Replicative strategies employed by animal RNA viruses.

Unit 4: Pathogenesis of Viruses

Host and virus factors involved in pathogenesis, patterns of infection, pathogenesis of animal viruses Adenovirus, Herpes virus, Hepatitis virus, Picorna virus, Poxvirus and Orthomyxovirus, pathogenesis of plant (TMV) and insect viruses (NPV). Host cell transformation by viruses and oncogenesis of DNA and RNA viruses.

Unit 5: Control of Viruses and Emerging Viruses

Control of viral infections through vaccines, interferons and chemotherapeutic agents. Structure, genomic organization, pathogenesis and control of Human immunodeficiency virus.

Text/References:

1. Flint et al. Principles of Virology 4th Edition ASM publisher
2. Vinod Singh. Text Book of Virology (2010).
3. Leonard C. Norkin. Virology: Molecular Biology and Pathogenesis (2010)

MSUMC-302: Environmental Microbiology Credits3

Unit 1 Environmental factors

Introduction to environment; pollution and its control; pollution indicators; Biodiversity and its conservation; Role of microorganisms in geochemical cycles; Influence on growth and distribution of Microbes, Temperature, Ph, Radiation, osmotic and salt stress etc, BOD, COD, POC, Ammonia, Nitrate, Phosphate etc.

Unit 2 Waste management

Solid and liquid waste management, water treatment plant, waste disposal system, Food spoilage, Food preservation and food safety management.

Unit 3 Biofuel

Environmental Biotechnology and biofuels: biogas; bioethanol; biodiesel; biohydrogen; Description of the industrial processes involved, microorganisms and biotechnological

interventions for optimization of production; Bioleaching of metals; Production of bioplastics; Production of biosurfactants: bioemulsifiers; Paper production: use of xylanases and white rot fungi. Bioremediation and Phytoremediation.

Text/Reference

1. G. M. Evans and J. C. Furlong (2003), Environmental Biotechnology: Theory and Applications, Wiley Publishers.
2. B. Ritmann and P. L. McCarty, (2000), Environmental Biotechnology: Principle & Applications, 2nd Ed., McGraw Hill Science.
3. Scragg A., (1999) Environmental Biotechnology. Pearson Education Limited.

MSUMC-303: Medical Microbiology credits 3

Unit 1 Disease epidemiology

Disease surveillance, disease transmission, Gene reservoir, Pathogenesis and virulence. Difference virulence factor related to bacterial diseases (enzymes, toxin, LPS, siderpohore). Opportunistic infections and Normal microflora of human.

Unit 2

Gram-positive cocci, disease produced by them and diagnostic approach; Gram-negative cocci, disease produced by them and diagnostic approach; Epidemiology, etiology, symptomatology, prevention and control of the following diseases: Cholera, Typhoid, tuberculosis; Prion related diseases, Protozoan disease (Malaria, leishmaniasis).

Unit 3

Introduction to medical mycology; Superficial & subcutaneous mycosis; Systemic & opportunistic mycosis; Introduction to parasitic diseases; Protozoan parasites of the intestines

Unit 4

Hospital Acquired infection control program & biological waste management.

Text/Reference

1. Murray Patrick R. Basic Medical Microbiology (2017) Elsevier
2. Ansari J (2012) Text Book of Medical Microbiology

MSUMC-304: IPR, Biosafety & Bioethics

credits 3

Unit I Intectual property rights

Iintectual property right and its importance. Types of 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 and its importance, Rights of trademark. INDUSTRIAL DESIGNS Industrial design. Protection provided by industrial designs.

Unit II 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. Bioweapons.

Unit III 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.

Text/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.

MSUMC-391: Applied Bioinformatics Lab 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.
3Identification of relatives from the database using BLAST search. Creation of a data-set on the basis of the E-value.
3 Using EMBOSS for local and global alignment of proteins.
4 Determination of domains present in proteins and comparison of domain architecture (DA) across different proteins.
5 Identification of repeats in proteins using Pfam.
6 Further identification of repeats left undetected by Pfam using multiple sequence analysis.
7 Construction of phylogenetic tree using PHYLIP.

MSUMC-392: Fermentation technology lab

credits 3

1. Isolation and screening of industrially important microorganisms
2. Plot microbial growth kinetics of an industrially important microorganism
3. Identify different parts of a bioreactor and understand their functions
4. Understanding of dissolved oxygen (DO) measurement system of a bioreactor and its calibration.
5. Microbial production of industrially important bioproduct and determine its yield and productivity.

Elective subjects:

1. MSUMC-305A Principles of Ecology Credit: 2

Unit I

The Environment

Physical environment; biotic environment; biotic and abiotic interactions. Habitat and Niche: Concept of habitat and niche; niche width and overlap; fundamental and realized niche; resource partitioning; character displacement.

Unit II

Population Ecology

Characteristics of a population; population growth curves; population regulation; life history strategies (r and K selection); concept of metapopulation – demes and dispersal, interdemic extinctions, age structured populations. Species Interactions: Types of interactions, interspecific competition, herbivory, carnivory, pollination, symbiosis.

Unit III

Community Ecology

Nature of communities; community structure and attributes; levels of species diversity and its measurement; edges and ecotones. Ecological Succession: Types; mechanisms; changes involved in succession; concept of climax. Ecosystem Ecology: Ecosystem structure; ecosystem function; energy flow and mineral cycling (C,N,P); primary production and decomposition; structure and function of some Indian

ecosystems: terrestrial (forest, grassland) and aquatic (fresh water, marine, eustarine). Biogeography: Major terrestrial biomes; theory of island biogeography; biogeographical zones of India.

Unit IV:

Applied Ecology

Environmental pollution; global environmental change; biodiversity: status, monitoring and documentation; major drivers of biodiversity change; biodiversity management approaches. Conservation Biology: Principles of conservation, major approaches to management, Indian case studies on conservation/management strategy (Project Tiger, Biosphere reserves).

Text/References:

1. Chapman and Reiss. Ecology: Principles And Applications, 2nd Edition
2. Pd Sharma. Ecology and Environment. 13th edition
3. Eugene Odum. Fundamentals of Ecology.

2. MSUMC-305B Research methodology and Writing Credit:2

Unit I

History of science and science methodologies

Empirical science; scientific method; manipulative experiments and controls; deductive and inductive reasoning; descriptive science; reductionist vs holistic biology.

Unit II

Preparation for research

Choosing a mentor, lab and research question; maintaining a lab notebook. Computing skills for scientific research - web browsing for information search; search engines and their mechanism of searching; hidden Web and its importance in scientific research; internet as a medium of interaction between scientists; effective email strategy using the right tone and conciseness. Presentation skills - formal presentation skills; preparing and presenting using over-head projector, PowerPoint; defending interrogation; scientific poster preparation & presentation; participating in group discussions;

Unit III

Scientific communication

Technical writing skills – types of reports; layout of a formal report; scientific writing skills – importance of communicating science; problems while writing a scientific document; plagiarism, software for plagiarism; scientific publication writing: elements of a scientific paper including abstract, introduction, materials & methods, results, discussion, references; drafting titles and framing abstracts; publishing scientific papers – peer review process and problems, recent developments such as open access and non-blind review; plagiarism; characteristics of effective technical communication; scientific presentations; ethical issues; scientific misconduct.

Text/References:

1. Valiela, I. (2001). Doing Science: Design, Analysis, and Communication of Scientific Research. Oxford: Oxford University Press.
2. On Being a Scientist: a Guide to Responsible Conduct in Research. (2009). Washington, D.C.: National Academies Press.
3. Gopen, G. D., & Smith, J. A. The Science of Scientific Writing. American Scientist, 78(Nov-Dec 1990), 550-558.
4. Mohan, K., & Singh, N. P. (2010). Speaking English Effectively. Delhi: Macmillan India.
5. Movie: Naturally Obsessed, The Making of a Scientist.

3. MSUMC-305C Molecular diagnostics Credit:2

Unit I

Genome: resolution, detection and analysis

PCR: Real-time; ARMS; Multiplex; ISH; FISH; ISA; RFLP; DHPLC; DGGE; CSCE; SSCP; Nucleic acid sequencing: new generations of automated sequencers; Microarray chips; EST; SAGE; microarray data normalization & analysis; molecular markers: 16S rRNA typing; Diagnostic proteomics: SELDI-TOF MS; Bioinformatics data acquisition & analysis.

Unit II

Detection and identity of microbial diseases

Direct detection & identification of pathogenic-organisms that are slow growing or currently lacking a system of in vitro cultivation as well as genotypic markers of microbial resistance to specific antibiotics.

Unit III

Detection of inherited diseases

Exemplified by two inherited diseases for which molecular diagnosis has provided a dramatic improvement of quality of medical care: - Fragile X Syndrome: Paradigm of the new mutational mechanism of the unstable triplet repeats, von-Hippel Lindau disease: recent acquisition in the growing number of familial cancer syndromes.

Unit IV

Molecular oncology

Detection of recognized genetic aberrations in clinical samples from cancer patients; types of cancer-causing alterations revealed by next-generation sequencing of clinical isolates; predictive biomarkers for personalized onco-therapy of human diseases such as chronic myeloid leukemia, colon, breast, lung cancer and melanoma as well as matching targeted therapies with patients and preventing toxicity of standard systemic therapies.

Text/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. (1997). Molecular Diagnostics: for the Clinical Laboratorian. Totowa, NJ: Humana Press.

4. MSUMC-305D Enzyme technology Credit:2

Unit I

Enzymes, coenzymes and cofactors

Enzymes: Classification, mode of action, activation, specificity, Source of enzymes; production, isolation and purification of enzymes; Characterization in terms of pH,

temperature, ionic strength, substrate and product tolerance, effects of metal ions; Coenzymes and cofactors: Coenzymes, classification of vitamins, role and mechanism of action of some important coenzyme (NAD+/NADP+, FAD, lipoic acid, tetrahydrofolate, B12-coenzyme), role of cofactors with specific examples.

Unit II

Enzyme kinetics

Enzyme as biological catalysts; Enzyme action, active site, functional group, enzyme substrate complex, cofactors, Michaelis-Menten equation, Km and Vmax, enzyme inhibition; order of reaction, methods of plotting enzyme kinetics data; Enzyme turnover number. competitive, non-competitive, uncompetitive, irreversible; order of reaction, methods of plotting enzyme kinetics data; determination of Kcat, Km, Vmax, Ki, Half life, activation and deactivation energy etc, Cross-linked enzyme aggregates, Cross linked enzymes, enzyme crystals, their use and preparation; Solution of numerical problems; Energy yielding and energy-requiring reactions; Calculation of equilibrium constants; Activation energy etc.; Multisubstrate enzymes and kinetics mechanisms; Enzyme induction, repression, covalent modification, Isoenzymes, allosteric effects.

Unit III

Applications of enzyme technology

Immobilized enzyme technology: Different techniques of immobilization of enzymes and whole cells; Advantages and disadvantages of immobilization; Kinetics of immobilized enzymes, design and operation of immobilized enzymes reactors; Type of reactors, classification, retention of enzymes in a reactor, kinetics of enzyme reactors; Reactor performance with inhibition, operation of enzyme reactors; case studies; starch conversion; APA production, biotransformations using soluble as well as immobilized enzymes; Calculation of diffusional resistances and Thiele's modulus, multi-step immobilized enzyme systems; Solution of numerical problems; Application and future of immobilized enzyme technology; Enzyme in organic solvents and ionic liquids: Various organic solvents and ionic liquids used in biocatalysis; Potential in organic solvents and ionic liquids; Applications of enzymes in analysis.

Text/References

1. Stryer, L. (2002). Biochemistry. Freeman. New York.
2. Lehninger, A. L. (2004). Principles of Biochemistry (4th ed.). Worth. New York, NY

3. Voet, D., & Voet, J. G. (2004). Biochemistry (4th ed.). Wiley & Sons. Hoboken, NJ: J

4. Rehm, H. & J. Reed, G., (1986). Enzyme Technology. Volume 7a. John Wiley & Sons.

5. Irwin H. Segel, (1976). Biochemical Calculations: How to Solve Mathematical Problems in General Biochemistry, 2nd revised Ed. John Wiley & Sons.

6. Biotol, (1992). Bioreactor Design & Product Yield. Butterworth-Heinemann

7. Wang, D. I. C. (1979). Fermentation and Enzyme Technology. Wiley. New York.

4. MSUMC-305E Plant Molecular Biology Credit:2

Unit I: 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, Somaclonal variation, Somatic Embryogenesis, Polyploidy, Androgenesis, Artificial Seed, Agrobacterium mediated transformation.

Unit II: Plant Transcription Factor

Introduction to Transcription factor structure and function, Methods to study transcription factor structure and function, Different plant specific transcription factors and their functions, Different Plant transcription factors and their functions.

Unit III: Plant Physiology

Molecular mechanism of seed germination, significance of ABA and GA in seed germination, light control on flower development, short day plants and long day plants, ABC model of flowering, plant stress physiology, drought stress, salt stress, biotic stress, viral stress.

Unit IV: Plant Disease

How pathogen attack plants, Mechanism of plant defence against pathogen, Effect of pathogen on plant physiological functions, causative agent of plant disease like virus, fungi, bacteria, nematodes etc.

Semester IV

MSUMC- 481 Project Work Credit 22

Unit 1: Planning & performing Experiments

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.

Unit 2: Thesis Writing

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.