Program Specific Outcomes

The vision of the program is to foster high quality innovative research & teaching program and interdisciplinary knowledge to develop specialist academicians and intellectual leaders with excellent professional skills in biomedical sciences for better understanding and management of human health and disease. With this in mind the mandate of the program is to develop a multidisciplinary knowledge centre and provide high quality world-class teaching and research in biomedical sciences. To educate and train a new generation of young minds in biomedical sciences. To create a passion for research while inculcating a scientific temperament and a knowledge inquisitive mind with the main aim of contributing towards human health through basic cum applied research. Intellectual grooming of each student to be a potential leader in biomedical sciences. To teach beyond textbooks and rejuvenate the spirit of science.

For achieving this, ACBR has structured its course amalgamating Biology and Chemistry in a fine mix. This gives each student an in depth view of biology via the prism of chemistry. To this end the fourth semester curricula has been designed to lay more emphasis on laboratory oriented training with only two theory papers having 40% weightage and a dissertation with 60% weightage. The dissertations are evaluated by a committee that include external experts from outside the center while at the same time making sure that that the PI is not part of the evaluation process. This gives an objective transparent and effective evaluation of each student's aptitude and attitude towards high quality research as fixed marks are allocated for regularity and research ethics in the laboratory.

Course Outcome

Each semester of MSc consists of five papers and one practical through Semester I and II (Part I) and semester III. Semester IV (Part II) comprises Optional Papers from which each student has to select two papers and

undertake Dissertation work. It is mandatory for each student to complete a Dissertation, assigned at the end of 2nd Semester and complete at the end of 4th Semester. It comprises of bench work.

In the I semester, the course focuses on strengthening of basic subjects such as Genetics, cell biology, biochemistry, organic chemistry, and medical microbiology.

Semester I

MBS 101: Organic Chemistry – I

Reactive Intermediates in Organic Reactions

CO1. Introduction to reactive intermediates in organic reactions
CO2. Carbocations stability and synthesis and generation
CO3. Carbocation reactions and applications
CO4. Carbanions stability, synthesis and properties
CO5. Carbanion Reactions for C-C bond formation
CO6. Free Radicals; Stability and Generation
CO7. Free radical properties and reactions
CO8. Benzynes and reactions involving benzynes
CO9. Carbenes, radical cations and radical anions

Stereochemistry of Organic Compounds

CO10. Introduction to Stereochemistry, Definition of polarized light, use of polarimeter in determining optical rotation
CO11. Symmetry elements
CO12. Chirality, Prochirality, Definition of enantiomer, diastereomers
CO13. Absolute and relative configuration (R/S notation)
CO14. Stereospecific and Stereoselective Reactions
CO15. Definition of conformation Projection formulae (Fischer, Sawhorse and Newman Projection Formulae)
CO16. E& Z notations, cyclohexane diols

Mechanism and stereochemistry of following reactions

CO17. Substitution reactions

CO18. Elimination reactions

CO19. Substitution vs Elimination

CO20. Ester hydrolysis

CO21. Aromaticity and Huckel rule

CO22. Mechanism of Electrophilic substitution reactions

CO23. Mechanism of Nucleophilic Aromatic substitution reactions

CO24. Orbital symmetry and Woodward Hofmann rules

CO25. Woodward Hoffman rules

Asymmetric synthesis

CO26. Asymmetric Synthesis and its importance in drug discovery

CO27. Basic terms related to topic: enantiomeric excess, stereoselectivity stc.

CO28. Crams rules and applications in asymmetric synthesis with examples

CO29. Prelogs Rule and related reactions

CO30. Asymmetric synthesis in biological systems

CO31. Asymmetric epoxidation examples e.g. Sharpless epoxidation and application

Heterocyclic Chemistry

CO32. Heterocyclic Nomenclature- Trivial names , Replacement method

CO33. Hantzsch-Widman (IUPAC or Systematic) method , Practice problem

CO34. Aromaticity in heterocyclic compounds

CO35. Structure and reactivity of five member heterocycles

CO36. Synthesis of five member heterocycles

CO37. Structure and reactivity of six member heterocycles

CO38. Synthesis of six member heterocycles

CO39. Structure and reactivity of Fused ring heterocycles

CO40. Synthesis of fused ring heterocycles

CO41. Significance of heterocyclic compounds in biomedical science

MBS 102: BIOCHEMISTRY

CO1. Amino acids and peptide bonds Properties of peptide backbone, concept of torsion angles, peptide unit

CO2. Ramachandran Plot and its applications

CO3. Concepts of secondary, tertiary, motif, domain and quarternary structure

CO4. Types of secondary structures (alpha helix, beta sheets, turns, loops), details of structure, hydrogen bonding pattern, abundance and stabilities

CO5. Supersecondary structures, packing patterns of alpha helix, parallel and anti-parallel beta sheets, functional motifs

CO6. Tertiary fold, concept of PDB, fold type, superfamily, family, species with examples

CO7. Protein folding, chaperones, protein quality control system

CO8. Mutation and protein folding defects, enhanced degradation, aggregation

CO9. diseases due to proteopathy, trafficking defects, amyloidosis

CO10. Protein stability, equilibrium concept, denaturation and need for denaturation study, introduction to common denaturants,

CO11. denaturation mechanism by SDS, urea, GdmCl and heat, Concepts of kosmotrophs and chaotrophs, Hoffmeister series and its significances, salting in and salting out principles

CO12. Concept of Chromatography, Separation techniques (ion exchange, Gel filtration, Affinity)

CO13. Concept of active site, enzyme kinetic parameters, Km, Vmax, kcat and Michaelis-Menton equations

CO14. Measurement of enzymatic parameters, Models of enzyme catalysis, their validities in terms of increasing reaction rate.

CO15. Transition state, substrate complementariness to the transition state, concept of thermodynamic favorability of enzyme-catalyzed reaction

CO16. Mechanism of enzyme catalysis, general acid-base catalysis, covalent catalysis, electrostatic catalysis, metal ion catalysis with suitable examples nad pathways where the mechanisms are operating

CO17. Enzyme kinetics, concept of steady state and pre-steady state kinetics, reaction rate, order and initial velocity, derivation of Michaelis-menton equation

CO18. Mechanisms of enzyme inhibition, interpretation based of Line-weaver Burk plot

CO19. Effect of Temperature, salts and pH on enzyme catalysis

CO20. Strategies that help to regulate enzyme function in the cells, effect of limited proteolysis, allostery, post-translation modification to enzyme regulation with examples, feedback inhibition

CO21. Concept of allostery, co-operativity with reference to hemoglobin structure, its ligands CO2, NO2 and CO

CO22. Zymogens, proteases and common protease inhibitors, Bi-substrate enzyme kinetics, ping-pong and sequencial mechanisms with appropriate examples

CO23. Protein sequencing, N-terminal and C-terminal analysis, Edman degradation, Automatic sequencing

CO24. Concept of origin of replication, semiconservative hypothesis.

CO25. Mechanism of DNA Replication: Structure and function of DNA polymerases.

CO26. Role of helicase, primase, gyrase, topoisomerase and other proteins in DNA replication in E.coli.

CO27. Replication of viruses

CO28. Replication in eukaryotes, Initiation of replication

CO29. Elongation and termination of DNA synthesis.

CO30. DNA Repair

CO31. Basic concepts of transcription in prokaryotes using E-coli as an example

CO32. Structure & function of RNA polymerases.

CO33. Transcription initiation,

CO34. Transcription initiationcontd

CO35. Transcription elongation and termination.

CO36. Transcription in eukaryotes–

CO37. Structure of TFIID, and other transcription factors,

CO38. enhancers, silencers, insulators,
CO39. general concept of regulation of transcription (in brief).
CO40. Post-transcritional modifications,
CO41. Ribozymes–Structure and mechanism of action.
CO42. Translation Translation in Prokaryotes-initiation:
CO43. activation of amino acid, role of 30s and 50s ribosomal subunits
CO44. role of 30s and 50s ribosomal subunits, initiation factors
CO45. Shine-dalgarno sequences. Kozak sequences, selection of first AUG,
CO46. Elongation factors, peptidyl transferase termination signal, release factors, Inhibition of protein synthesis - by antibiotics.

MBS 103: CELL BIOLOGY

CO1. Biomembranes: Basic structure, lipid and protein composition
CO2. Basic structure, lipid and protein composition continued
CO3. Membrane functions
CO4. Transport of molecules across membranes.
CO5. Passive and active transport across membranes.
CO6. Factors regulating ion channels,
CO7. ABC pumps of bacteria.
CO8. Organelles of eukaryotic cells
CO9. Introduction basic structure and function of various organelles,
CO10. ER, golgi bodies
CO11. Mitochondria function
CO12. Mitochondria function continued
CO13. endosomes, lysosomes etc. separation
CO14. visualization methods of various cell organelles.
CO15. Muscle cells
CO16. Muscle cells continued
CO17. Nerve Cells
CO18. Nerve Cells continued
CO19. Nucleus and Chromosome Structure
CO20. Prokaryotic and Eukaryotic genome and its organization,
CO21. eukaryotic chromosome. Basic structure of DNA; hairpins and cruciform, Z-DNA, triple helix.
CO22. DNA Supercoiling: Histones, nonhistone proteins,

CO23. Topoisomerases and telomerase and their functions in chromatin structure. Yeast artificial chromosome.
CO24. The Cytoskeleton: Introduction
CO25. Cytoskeleton proteins,
CO26. Cell motility and shape
CO27. protein sorting
CO28. Transport of proteins.
CO29. Microfilaments and actin filaments
CO30. ECM Proteins
CO31. Cell Adhesion Cell-cell interaction,
CO32. Cell junctions, Adhesion proteins, Cell matrix interaction,
CO33. Integrins, Functional role of adhesion proteins.
CO34. Cycle cycle and its control: Loss of cell regulation by viral infection,
CO35. checkpoints in cell cycle regulation.
CO36. Cell to Cell Signaling Cell
CO37. Cell surface receptor
CO38. G-protein mediated signaling,
CO39. C-Amp, receptors tyrosine kinases, second messengers.
CO40. Cell death Apoptosis, Necrosis, Proapoptotic
CO41. Antiapoptotic proteins and mechanism of action Autophagy
CO42. Senescence, Cell death mechanisms in health and diseases.
CO43. Cell Differentiation, Cellular Stress Response,
CO44. Stress response proteins and pathways
CO45. Post translational modifications in stress response, General responses to hyperthermia nutritional deprivation and other stressors.

MBS 104 : MEDICAL MICROBIOLOGY

CO1: History and scope of medical microbiology

CO2: Colony morphology, Bacterial morphology : detailed structural features of gram positive and gram negative bacteria , Staining techniques for identification of bacteria

CO3: Detailed structure and functions of various organelles, cell wall, cell membrane, ribosomes, flagella, spores, capsules, storage components, quorum sensing.

CO4: Techniques to study morphology of bacteria, nutrition and growth of bacteria micro and micronutrients

CO5: Nutrition and condition requirements of bacteria : Macro and micronutrients,Temperature, moisture and dessication, oxygen and carbon dioxide requirements of bacteria .

CO6: Multiplication and bacterial growth and methods to study growth patterns in bacteria

CO7: Aseptic techniques, methods for pure culture isolation.

CO8: Types of Nutrient media for bacteria .Cultivation methods for bacteria. Aerobic and anaerobic culture methods

CO9: Identification of bacteria using biochemical methods

CO10: Microscopy: History, basic principles of microscopy

CO11: Bright field microscopy and phase contrast microscopy

CO12: Florescence microscopy, confocal microscopy, SEM and TEM

CO13: Disinfection and sterilization: definition, importance, Physical agents: autoclave, hot air sterilization, incinerators, pasteurisation,tyndallisation, methods of quality check.

CO14: Disinfection and sterilization: Radiation and filtration tequniques , Laminar flow hoods

CO15: Disinfection and sterilization: chemical disinfectants, uses of halogen compounds, alcohol based compounds, aldehydes, detergents, heavy metals. Methods for developments and quality check of disinfectants , phenol cofficient test.

CO16: Normal flora of human body and their significance

CO17: Nosocomial infections

CO18: GI tract infection: Staphylococcus , Bacillus , Campylobacter, Helicobacter sps.

CO19: GI tract infection: Salmonella, Shigella, Escherchia sps.

CO20: GI tract infection : Yersenia, Enterobacter, Vibrio,Pseudomonas ,Clostridium

CO21: Microbial pathogenicity, virulence factors and their effect on pathogenesis

CO22: Antimicrobial chemotherapy, structure and mechanism of action :Cell wall inhibitors, antimetabolites

CO23: Antimicrobial chemotherapy, structure and mechanism of action: protein synthesis inhibitors, Nucleic acid inhibitors Methods for estimation of antimicrobial activity
CO24: Mechanisms of Antibiotic resistance .
CO25: Literature for new emerging antibiotics
CO26: Genital tract infections: Chlamydia , Neisseria ,Syphilis
CO27: Urinary tract infections
CO28: New and re-emerging diseases
CO29: Bacterial infections of the respiratory system: commensals vs infectious organisms, Diagnosis and prevalence of Cornybacterium diphtheriae in India and the world
CO30: Virulence factors of Cornybacterium diphtheria, Treatment and management of Cornybacterium diphtheriae
CO31: Infections by Mycobacterium tuberculosis: Species and their location, Diagnosis of M. tb: Shortfalls and solutions
CO32: Current Vaccine and vaccines under trial
CO33: Treatment of drug sensitive and drug resistant M. tb, Alternative approaches to treat long-term persistent infection by M. tb
CO34: Infection by Staphylococcus aureus: identification in cultures and swabs, Virulent determinants of S. aureus: quorum sensing of antigenic repertoire
CO35: Treatment and Vaccine approaches, Current treatment and research trends in respiratory infections
CO36: Spore formation in fungi, Economic importance of fungi
CO37: Mycoses, Tenia Versicolor, White Piedra, Black Piedra
CO38: Dermatophytes, Dermatophytidis, Candidiasis, Cryptococcosis
CO39: Opportunistic Fungi, Ostomycosis
CO40: Fungal contaminants
CO41: Immunodiagnosis of fungal infections
CO42: Medical parasitology over view and classification of medically important parasites. Nematodes: Ascaris sp. , Necator americanus, Trichnella spiralis
CO47: Lymphatic filariasis, Wuchereria bancrofti, Brugia malayi, Mansonia ozardi
CO48 : Cestodes : Taenia solium, Taenia saginata, Diphyllobotherium latum
CO 49 : Trematode : Faciola hepatica , Faciolopsis buskii

CO50: Shapes and structure of viruses, classification of viruses
CO 51 : Life cycle of various viruses, brief overview of life cycle of all the viruses as per Baltimore system of classification.
CO52 : Effect of virus replication on host cells , Virus subversion of host protein synthesis machinery, Translation mechanism and its subversion by Viruses.
CO53: Arboviruses, their genetics, pathogenesis, epidemiology, diagnosis and clinical features with emphasis on Dengue, Zika and Chikungunya viruses.
CO54: Virus subversion of host macromolecular biosynthesis, Role of lipids in viral life cycle
C055: Viruses and type I IFN signaling with some recent advances in the field of type I IFN signaling and virology.
CO56: Genetics, pathogenesis, epidemiology, diagnosis and clinical features of small pox virus
CO57: Genetics, pathogenesis, epidemiology, diagnosis and clinical features of Herpes virus
CO58: Genetics, pathogenesis, epidemiology, diagnosis and clinical features of Adeno viruses, their importance in genetic engineering and gene therapy.
C059: Genetics, pathogenesis, epidemiology, diagnosis and clinical features of picorna viruses
CO60 : Genetics, pathogenesis, epidemiology, diagnosis and clinical features of Myxoviruses with special emphasis on Influenza virus. Cytopathic effects of and their inhibition

MBS 105: GENETICS

CO1. Introduction to the Science of Genetics: Genetic terminology Impact of Genetics on other disciplines.
CO2. Mendelian Genetics: Mendelian Laws of inheritance,
CO3. application in animal Genetics,
CO4. analysis of results of Genetic crosses by various methods.
CO5. Chromosomal basis of inheritance and data analysis: Sex chromosomes in grasshopper, Development of the concept of co-linearity of genes on chromosomes,

CO6. Non-disjunction in Drosophila and its role in deciphering chromosomal basis of inheritance.

CO7. Analysis of patterns of inheritance, Punnett square, statistical methods.

CO8. Deviations from Mendelian Genetics I: Codominance, incomplete dominance, RFLP markers, gene interactions, multiple alleles,

CO9. Understanding possible Molecular basis/biochemical basis of gene-interaction.

CO10. Mutation and mutational analysis: Spontaneous occurrence of mutations in bacteria Lederberg and Lederberg experiment,

CO11. Types of mutations i.e. point mutations, deletions, rearrangements, insertions, dynamic mutations (repeat expansions) with appropriate examples, Chromosomal anomalies.

CO12. Types of mutations i.e. point mutations, deletions, rearrangements, insertions, dynamic mutations (repeat expansions) with appropriate examples, Chromosomal anomalies. Continued.

CO13. Mutation mapping using balancers,

CO14. Clb technique in Drosophila.

CO15. Linkage as a deviation from Mendelian Genetics: Recombination, Gene mapping using Drosophila as an example, experiments demonstrating physical basis of recombination, crossing over.

CO16. Gene mapping using special systems, yeast and Neurospora.

CO17. Bacterial and Phage genetics: Transformation, transduction , Conjugation, genetic map construction in *E.coli*.

CO18. Phage genetics, fine structure of rII region, work of Seymour Benzer., highlighting the design of experiment and choice of the experimental model.

CO19. Genetic Variation; transposition and its application in genetic studies. Extra chromosomal inheritance, chloroplast and mitochondrial inheritance, mitochondrial mutations in yeast, human genetic disorders related to mitochondrial inheritance.

CO20. Deviations from Mendelian Genetics II: Genomic imprinting in insects, mice and man,

CO21. understanding molecular basis of epigenetic inheritance, human disorders related to imprinting, Prader Willi and Angelmen syndrome,

CO22. Molecular basis of Epigenetic regulation in H19 and Igf2 region, histone modification marks, Position effect variegation.

CO23. Genetic control mechanisms and generation of cellular asymmetry:

CO24. The lambda phage control of lytic and lysogenic phase,

CO25. molecular basis of regulatory mechanisms in phage lambda.

CO26. Mating type switching in *Saccharomyces cerevisiae* as a primer for generating asymmetry during development

CO27. Mating type switching in *Saccharomyces cerevisiae* as a primer for generating asymmetry during development continued…

CO28. Sex determination in Drosophila and humans: Chromosomal basis to genetic basis, Linking sex determination and dosage compensation in Drosophila, genetic and molecular basis.

CO29. X inactivation in mammals and its molecular basis, role of non-coding RNA

CO30. Introduction to developmental genetics: Early embryonic development in Drosophila.

CO31. Maternal inheritance,

CO32. genetic basis of axis determination,

CO33. regulatory cascade in development in Drosophila,

CO34. Homeotic genes and their regulation.

CO35. Introduction to human Genetics: Pedigree analysis and basic inheritance patterns in humans.

Population Genetics:

CO36. Definition, aim and scope of population genetics, population structure,

CO37. factors maintaining population boundaries, effective breeding size, gene pool.

CO38. The Hardy–Weinberg Law and its application,

CO39. factors affecting the Hardy- Weinberg equilibrium.

CO40. Human polymorphism (transient and balanced), relationship between sickle cell polymorphism and malaria,

CO41. other polymorphisms that may be an adaptation to malaria eg. G6PD deficiency.

CO42. Duffy blood groups, thalassemia and haptoglobins.

CO43. X linked polymorphism (G6PD and colour blindness).

CO44. Incompatibility Selection. Non-random mating, inbreeding and its consequences.

CO45. Migration and Genetics, types of migration, models to study genetic effects of migration,

CO46. gene flow, effects of gene flow, admixture and natural selection, calculation of admixture.

Semester II

MBS-201: ORGANIC CHEMISTRY-II

CO1. Introduction to Enzyme & Coenzyme Catalysis

CO2. Redox chemistry

CO3. NAD and NADH

CO4. FAD and FADH2

CO5. Mechanism of Alcohol dehyrogenase

CO6. Mechanism Of Propane diol dehydrase

CO7. Mechanism of Biotin action

CO8. Pyridoxal 5" phosphate action

CO9. Mechanism Of TPP & Coenzyme A

CO10. Brief introduction to action of lipoic acid, ascorbic acid

CO11. Mechanism of action of Tetrahydrofolate

CO12. Mechanism of action of Vitamin B12 catalysed rearrangement

CO13. Supramolecular chemistry

CO14. Nanotechnology Principles and applications

CO15. Nanotechnology in Medicine

CO16. Mechanism of action of Cytochrome P450

CO17. Aminoacids, peptides

CO18. Proteins structure and Functions.

CO19. Formation of Peptide Bonds.

CO20. Activation and Protecting groups

CO21. peptide bond formation synthetic reactions,

CO22. protein degradation and sequencing of amino acids,

CO23. DNA and RNA bases, nucleosides and nucleotides,

CO24. formation of N- and C- glycosides, phosphodiesters,

CO25. conformation and configuration of 5-carbon and 6-carbon sugars, maltose, sucrose and lactose,

CO26. conformation and configuration of 5-carbon and 6-carbon sugars, maltose, sucrose and lactose continued

CO27. glucosylamine, neuraminic and muramic acids.
CO28. Active methylene groups,
CO29. aldol and retroaldol reactions,
CO30. schiff bases and enamine reactions,
CO31. nitrogen, phosphorous and sulfur ylides,
CO32. Umpolung reaction with examples
CO33. Michael addition,
CO34. Polymer supported organic reactions,
CO35. phase transfer catalysis,
CO36. Equivalence of these reactions in biological systems
CO37. Hammett and Taft Equation
CO38. Hammett and Taft Equation continued
CO39. Hammett and Taft parameters
CO40. Steric and Solvent effects
CO41. Role of pH, reaction media on certain reactions.

MBS 202: MOLECULAR BIOLOGY AND BIOTECHNOLOGY

Regulation of gene expression in Prokaryotes

CO1. Coordinated control of clustered genes-operon model, with example of inducible systems like Lac– Operon.
CO2. Lac operon contd.
CO3. Role of cyclic AMP and sRNA
CO4. Arabinose operon
CO5. Repressible systems like Trp operon.
CO6. Trp operon cond.
CO7. Role of repressors and activators of transcription in regulation of phage-lytic and lysogeic pathways, lambda repressor.

Regulation of Gene expression in Eukaryotes

CO8. Introduction-Organization of genes in eukaryotic DNA
CO9. Repetitive DNA sequences, multiple regulatory sequences, activators
CO10. Activators contd, enhancers. Modular structure of transactivators,
CO11. Repressor complexes, mechanism of their function in gene regulation.
CO12. Post transcriptional regulation of transcription regulators by methylation, acetylation,
CO13. Hormones and protein-protein interactions.

CO14. Methods used to study protein-protein interactions (yeast two hybrid and co-Immunoprecipitation)

CO15. Methods used to study protein-DNA interactions (EMSA and DNA footprinting)

CO16. Diseases linked with gene expression.

Chromatin remodeling

CO17. Introduction to chromatin remodeling concepts and factors involved.

CO18. Role of various remodeling proteins such as NURF, ACF,

CO19. Role of CHRAC, SWI-SNF and

CO20. Locus control regions in gene regulation, diseases associated with it.

Oncogenes

CO21. Concept of transfection, transformation, tumours, cancer.

CO22. Retroviral and cellular oncogenes, their function

CO23. Basic mechanism of action of Oncogenes in regulating cell growth and development

CO24. Tumour suppressor genes and their function using P53 as an example

CO25. Rb protein and its mechanism of action.

Recombinant DNA technology and Biotechnology

CO26. Types of Restriction endonucleases and how to make

CO27. Types of Restriction endonucleases and how to make restriction maps continued

CO28. Other enzymes used in genetic engineering such as S1 nuclease,

CO29. polynuceotide kinase, mung bean nuclease etc.

CO30. Vectors cloning, prokaryotic and eukaryotic cloning vectors,

CO31. expression vectors,

CO32. Yeast vectors, shuttle vectors, YAC & BAC.

CO33. Yeast vectors, shuttle vectors, YAC & BAC continued

CO34. Principles of selection of specific cloned DNA -blue white selection,

CO35. Insertional inactivation, antibiotic markers used in prokaryotic and eukaryotic cloning. Detection and identification of cloned DNA sequences,

CO36. methods of sequencing of DNA.

CO37. Application and principles of Polymerase Chain Reaction

CO38. RT-PCR, RFLP analysis, real time PCR.

CO39. Mutagenesis – different methods used to generate mutants (deletion and point mutations).

CO40. Application of recombinant DNA technology: DNA fingerprinting,

CO41. gene therapy, diagnostics.
CO42. Bio-safety and ethics for recombinant DNA technology.

MBS 203: APPLICATION OF STATISTICS AND MATHEMATICS FOR BIOLOGY

CO1; Biostatistics: Definition, applications. Introduction to concept of measures of central tendency: Mean, median and mode.
CO2; Application of the measures of central tendency to biological samples.
CO3; Concept of mean deviation, standard deviation. Application of these concepts to biological samples.
CO4; Introduction to coefficient of variation. Solving problems based on this concept.
CO5; Measuring and understanding correlation, Karl Passions, Coefficient of correlation, Rank correlation. Solving problems based on this concept.
CO6; concept of regression analysis. Understanding regression equations. Solving suitable biological data using this concept.
CO7; Understanding the concept of probability. Deriving the probability formula. Application to biological data.
CO8; Concept of independent events, dependent events, mutually exclusive events, not mutually exclusive events. Application to biological data.
CO9; Coditional probability. Concept and definition with examples.
CO10; understanding Bayes theorem with examples.
CO11; understanding Binomial distribution. Application to biological data
CO12; understanding normal distribution. Application to biological data
CO13; application of binomial and normal distribution to biological data.
CO14; Introduction to methods of sampling. Explain with examples
CO15; 't' analysis. Applications. Solve using examples
CO16; 'Z' test. Concepts and Applications. Solve using examples
CO17; 'F' test. Concepts and Applications. Solve using examples for small samples
CO18; 'F' test. Concepts and Applications. Solve using examples for small samples

Bio-Mathematics

CO19; introduction to functions. Solve with examples
CO20; concept of limits. Definition and application
CO21; concept of continuity. Definition and application
CO22; Differentiation. Introduction to various formulae
CO23; Differentiation. Solving biological problems with various formulae.
CO24: Differentiation. Solving biological problems with various formulae.

CO25: Differentiation. Solving biological problems with various formulae.
CO26: Differentiation. Solving biological problems with various formulae.
CO27: Integration. Introduction to various formulae
CO28: Integration. Solving biological problems with various formulae.
CO29: Integration. Solving biological problems with various formulae.
CO30: Integration. Solving biological problems with various formulae.
CO31: Integration. Solving biological problems with various formulae..
CO32: Integration. Solving biological problems with various formulae.
CO33: concept of maxima. Solving problems using various theorems
CO34: concept of minima. Solving problems using various theorems
CO35: Differential equations: concept, derivations, applications.
CO36: Separable variables: concept and application to biological data
CO37: Homogenous, exact and linear equations of second order: concept and application to biological data
CO38: Matices: introduction to different forms, and definition
CO39: theorems in matrices: concept and application
CO40: theorems in matrices: concept and application
CO41: theorems in matrices: concept and application
CO42: Determinate: concept and derivation
CO43: application of determinate to biological problems
CO44: Characteristic eautions and roots application to biological data
CO45: Caley Hamilton theorem

MBS 204 : IMMUNOLOGY

CO1. History and scope of Immunology, over view of evolution of Immune system development

CO2. Introduction to Immune System , concepts of Innate and acquired Immune responses , Active and passive Immunity , Natural and artificial immunity, primary and secondary immune responses

CO3. Lymphoid System- overview . Lymphatic system and lymphocyte traffic .Lymphoid Tissue: Primary and Secondary Lymphoid organs. Anatomy and functional significance of Thymus, Bone marrow,

CO4. Anatomy and functional significance of various lymph nodes, MALT,GALT, NALT,ILT

CO5. Cells involved in the Immune Response : Structural and functional features of cells involved in immune responses and their relative significance. Lymphocytes(B& T lymphocytes), NK Cells

CO6. Mononuclear Phagocytes, Antigen- presenting cells, Polymorphonuclear cells, eosinophils, Basophils and mast cells, Cluster designation Ag specific receptors (comparison of Human and Mouse Lineages)

CO7. What is an immune response. Evolution of cells and molecules of the immune system with associated functions

CO8. Dendritic cells: discovery types and functions: DC 1 vs DC2 vs Follicular DC.
Antigen recognition processing, presentation and cross-presentation of antigens by DC subsets

CO9. Cytokines and chemokines: Diversity redundancy and functions during an immune response

CO10. DC priming of T independent antigens, DCs as imunotherapeutics

CO11. Innate immune system: overview. Cells and receptors of the innate immune system. Diversity in Antigen recognition receptors of innate immunity

CO12. Signaling from Toll Like Receptors

CO13. Cell surface and intracellular antigen/pathogen recognition systems: NOD/NLR/TLR9/

CO14. Secretory receptors of innate immune system and their functions

CO15. Innate memory and danger hypothesis

CO16. Macrophages: types, location and function.Neutrophils and NK cells: mode of action and neutralization of pathogens

CO17. Antibody Generation, structure and Function : Over View of Humoral immunity, Clonal Selection Theory, Immnoglobulins classes and their functions , Antibody Structure and Function

CO18. Antibody Effector Mechanisms, Antibody Receptors, Basis of Antibody Diversity, Mechanism of Immunogolubin Gene Recombination, and B cell development

CO19. Effect of Somatic Mutations on the Antibody Diversity, Mechanism of Ab Class switching.

CO20. Antibody Responses in vivo, Enhanced Secondary Responses ,Isotype switching, Affinity Maturation and development of Memory responses.

CO21. Major Histocompatibility Complex overview and significance. Structure of MHC Class I Molecules, Structure of MHC Class II Molecules,

CO22. Genomic Organisation of the MHC locus in Mice and Humans, Diversity of MHC molecules and their effect of immune response modulation.

CO23. Gene polymorphism and polygeny on MHC locus and their effect on the disease pattern wrt resistance and susceptibility to diseases.

CO24. Antigen Recognition and Presentation over view:

CO25. Structure and assembly of MHC molecules/Peptide Complexes. Antigen Processing and Presentation to T-lymphocytes (CD4+ and CD8+).

CO26. Complement System Nomenclature of complement system .Classical , Lectin and Alternative Activation of complement pathway, assays for complement activation.

CO27. Biological Effects of Complement system , Regulation of complement system. Complement system related diseases

CO28. Cell Mediated Immune Response Overview, T lymphocyte classification , lineage and development of T cells in thymus. Structure of T cell receptors , Mechanisms of recombination and diversity of TCR genes , self tolerance mechanisms. Regulation of innate and humoral responses by T cells. T cell APC interactions and modulation of Immune response.

CO29. T independent Defense Mechanisms, T dependent Defense Mechanisms, Cell Mediated Cytotoxicity. Idiotypic modulation of immune responses

CO30. Regulation of Immune Response : Antigens, classification of antigens based on their interaction and functions. Superantigens ,Interaction of Antigens with Antigen Presenting Cell, Antibody, Lymphocytes. Idiotypic Modulation of Response, Neuroendocrine Modulation of Responses, Genetic control of Immune Response.

CO31. Cell Migration and Adhesion

CO32. Patterns of Cell Migration, Structure and function of various adhesion Molecules, Mechanism of Cell Migration and their involvement in disease

CO33. Immunopathology : overview Rh- blood groupings, Autoimmune Diseases, Basis of breach of central and peripheral tolerance.

CO34. Immuno deficiencies, Genetic disorders congenital and acquired.

CO35. Hypersensitivity Reactions (type I and type IV), Role of 1gE, Mast cells, Genetic basis of Allergic Response and pathogenesis.

CO36. Immune Tolerance over view : Self Tolerance, Transplantation and Rejection mechanisms

CO37. Mechanism of Antigen-Antibody Interaction , Experiment based evidence to calculate antigen binding sites, avidity, affinity

CO38. Immunological Techniques : Principles, significance and methods ; Agglutination(Direct/Indirect) , Precipitation(Radial and double immunodiffusion) , Radioimmunoassays.

CO39. Immunological techniques : Immunoflorescence (direct/ indirect) , Enzyme linked Immunosorbent assay (principles of various types of ELISA) and its variants .

CO40. Magnetic cell sorting , Flowcytometry, western blotting ,

CO41. Techniques for generation of polyclonal and monoclonal antibodies. Hybridoma Technology for Mab Production.

CO42. Techniques for isolation of specific antibodies .

CO43. Gene Targeting: Knock out and Transgenic animals

CO44. Basis of Tumor Immunology

CO45. Vaccines : History and overview , adjuvants, Immune responses following vaccination

CO46. Various types of vaccines and methods of their development (3 lectures) with examples

MBS 205: HUMAN PHYSIOLOGY

Membrane physiology, nerve and muscle

CO1. Organization and functional systems of the cell with refers to nerve and muscle cells.

CO2. Transport of ions and molecules through cell membrane: diffusion and active transport.

CO3. Transport of ions and molecules through cell membrane: diffusion and active transport continued

CO4. Membrane potentials and action potentials: Resting membrane potential of nerves.

CO5. Nerve action potential.

CO6. Excitation and Contraction of skeletal muscle: Physiologic anatomy of skeletal muscle.

CO7. Molecular mechanisms of muscle contraction.

CO8. Energetics of muscle contraction. Excitation of skeletal muscle.

CO9. Neuromuscular transmission and excitation-contraction coupling.

Heart and circulation

CO10. Physiology of cardiac muscle.
CO11. Cardiac cycle, Regulation of heart pumping
CO12. Rhythmical excitation of heart,
CO13. Control of excitation and conduction in heart
CO14. Characteristics of normal electrocardiogram,
CO15. Cardiac arrhythmias
CO16. Cardiac arrhythmias continued
CO17. Physical characteristics and basic theory of circulation, Vascular distensibility
CO18. functions of arterial and venous systems

CO19. Microcirculation and lymphatic system, Capillary fluid exchange,
CO20. interstitial fluid and lymph flow
CO21. Local control of blood flow by tissues and humoral regulation,
CO22. Nervous regulation of circulation Cardiac output, venous return and their regulation
CO23. Heart sounds, dynamics of valvular and congenital heart defects,
CO24. Cardiac failure and circulatory shock.

Respiration

CO25. Pulmonary ventilation: mechanisms of pulmonary ventilation,
CO26. pulmonary volumes and capacities, alveolar ventilation.

CO27. Functions of respiratory passageways.
CO28. Pulmonary circulation,
CO29. pulmonary edema and pleural fluid
CO30. Physical principles of gas exchange,
CO31. Diffusion of gases through respiratory membrane
CO32. Transport of oxygen and carbon dioxide in blood and body fluids.
CO33. Transport of oxygen and carbon dioxide in blood and body fluids continued
CO34. Regulation of respiration: respiratory center, peripheral chemoreceptor system,
CO35. central chemoreceptor system and their regulatory function

Gastrointestinal physiology

CO36. General principles of gastrointestinal function - motility, nervous control, and blood circulation
CO37. General principles of gastrointestinal function - motility, nervous control, and blood circulation continued
CO38. Transport and mixing of food in the alimentary tract,
CO39. Ingestion of food.
CO40. Motor functions of stomach.
CO41. Movements of small intestine. Movements of colon
CO42. Secretary functions of alimentary tract: Secretion of saliva, Gastric secretion, Pancreatic secretion,
CO43. Secretion of bile by liver, Secretions of small and large intestine.

CO44. Digestion and absorption in gastrointestinal tract: Digestion of various foods,
CO45. Absorption in small intestine.

Kidneys and body fluids

CO46. Body fluid compartments: Basic principles of osmosis and osmotic pressure: Extracellular and intracellular fluids. Interstitial fluid and edema.
CO47. Urine formation by kidneys: Glomerular filtration,
CO48. renal blood flow and their control,
CO49. Functions of kidneys in homeostasis,
CO50. Determinants of glomerular filtration rate, Renal blood flow,
CO51. Tubular processing of glomerular filtrate, Reabsorption and secretion by renal tubules.
CO52. Reabsorption and secretion along different parts of nephron, Regulation of tubular reabsorption.
CO53. Regulation of extracellular fluid osmolarity and sodium concentration. Role of thirst in controlling extracellular fluid osmolarity and sodium concentration.
CO54. Integration of renal mechanisms for control of blood volume and extracellular fluid volume. Renal regulation of potassium, calcium, phosphate and magnesium. Regulation of acid-base balance.

Semester III
MBS 301: ADVANCE HUMAN PHYSIOLOGY

Sensory Physiology

CO1. Central nervous system synapses. Some special characteristics of synaptic transmission,

CO2. Sensory receptors. Neuronal circuits for processing information.

CO3. Somatic sensations: Tactile and position senses. Sensory pathways for transmission of somatic signals into the central nervous system.

CO4. Transmission in dorsal column – medial lemniscal system.

CO5. Pain, headache, and thermal sensations: Pain receptors and their stimulation,

CO6. Dual transmission of pain signals into the central nervous system. Referred and visceral pain.

CO7. Eye: Optics of vision, Receptor and neural function of retina,

CO8. Photochemistry of vision, Color vision, Neural function of retina.

CO9. Central neurophysiology of vision,

CO10. Organization and function of visual cortex

CO11. Hearing: Tympanic membrane and ossicular system, Cochlea,

CO12. Central auditory mechanisms,

CO13. Vestibular sensations and maintenance of equilibrium.

CO14. The chemical senses - taste and smell

CO15. The chemical senses - taste and smell continued

Nervous system: motor and integrative neurophysiology

CO16. Motor functions of spinal cord.

CO17. Spinal cord reflexes

CO18. Spinal cord reflexes continued

CO19. Muscle sensory receptors - muscle spindles and Golgi tendon organs and their roles in muscle control,

CO20. Flexor reflexes and withdrawal reflexes

CO21. Reflexes of posture and locomotion

CO22. Reflexes of posture and locomotion continued

CO23. Cortical and brain stem control of motor function: Motor cortex and corticospinal tract,

CO24. Role of brain stem in controlling motor function

CO25. Cerebellum, basal ganglia and motor control.

CO26. Integration of all parts of total motor control system
CO27. Cerebral Cortex:
CO28. intellectual functions of brain, learning and memory.
CO29. Physiologic anatomy of cerebral cortex.
CO30. Functions of specific cortical areas, Association areas. Function of brain in communication - language input and output.
CO31. Function of corpus callosum and anterior commissure.
CO32. Thoughts, consciousness and memory.
CO33. Behavioral and motivational mechanisms of brain.
CO34. Limbic system and hypothalamus. Activating-driving systems of brain.
CO35. Functional anatomy and functions of limbic system and hypothalamus.
CO36. States of brain activity. Sleep. Slow-wave sleep. REM sleep.
CO37. Basic theories of sleep. Brain waves. Origin in brain of brain waves (EEG).
CO38. Epilepsy, Psychotic behavior and dementia - roles of specific neurotransmitter systems.

MBS 302: PRINCIPLES OF MEDICINAL CHEMISTRY

CO1. Role of Medicinal Chemistry in discovery of drugs

Drug Design

CO2. Discovery of lead compound

CO3. Lead modification and conventional drug screening

CO4. Structural modification

CO5. Bioisosteres
CO6. Structure activity relationship
CO7. Quantitative structure activity relationships

CO8. Hammett equation based Hansch Approach
CO9. Free Wilson de novo approach
CO10. Topliss scheme
CO11. Batch-wise Cluster analysis

CO12. Introduction to molecular modeling and molecular graphics, pharmacophore descriptors

Receptors

CO13. Chemical nature of receptors

CO14. Neurotransmitters and their receptors

CO15. Receptor modulation and mimics

CO16. Receptor sites

CO17. Drug receptor interactions and active transport,

CO18. affinity and efficacy, antagonism, partial antagonism,

CO19. inverse agonism, allosteric binding sites

CO20. Chirality and receptor binding,

CO21. Signal transduction and second messenger systems,

CO22. classification of receptors and receptor subtypes.

CO23. Structure activity relationship illustrated with examples from Sulphonamides

CO24. b-lactams,

CO25. Quinolones and Nucleosides and Alkaloids.

Drug Metabolism

CO26. Biotransformation reactions Phase 1 and Phase II metabolism

CO27. Use of cytochrome P450 in drug metabolism,

CO28. Metabolism of primary secondary and tertiary amines

CO29. Glucuronidation reactions

CO30. Sulphation and Aminoacid conjugation reactions

CO31. Glutathione conjugation

CO32. Drug DNA interactions

CO33. Drug DNA interactions and their analysis

Enzyme Inhibition

CO34. Reversible and irreversible,

CO35. Adverse drug reactions,

CO36. Drugs acting on cell wall,

CO37. Fungal membrane and Nuclear membrane,

CO38. Drugs inhibiting protein synthesis.

MBS 303: ANALYTICAL & BIOMEDICAL TECHNIQUES AND INSTRUMENTATION

CO1. Introduction Principles of Instrumental Analysis, Types of Instrumental Methods to be covered in the course. Selecting an analytical method and developing a new Analytical Technique.

Separation Methods

CO2. An introduction to chromatographic separation theoretical basis

CO3. Various kinds of chromatographic techniques – for protein purification

CO4. Affinity, Ion exchange and size exclusion etc.

CO5. Gas Chromatography,

CO6. High Pressure Liquid Chromatography and FPLC,

CO7. Supercritical fluid chromatography

Mass Spectrometry

CO8. Explanation of mass Spectrometry. Forming charged particles: Electron impact (EI) and

CO9. Chemical Ionization(CI), and Fast Atom Bombardment (FAB), Field Desorption (FD),

CO10. Electrospray Ionization,

CO11. Matrix Assisted Laser Desorption Ionization (MALDI).

CO12. Mass Analyzers: Magnetic sector mass spectrometers, Double focusing mass spectrometers, Quadrupole pole mass spectrometers, ion cyclotron resonance,

CO13. Time of Flight mass analyzers. Combine the mass spectrometer with Gas Chromatography (GC/MS) and with liquid chromatography (LC/MS).

CO14. Applications of mass spectrometry in Biomedical field with various examples.

Nuclear Magnetic Resonance Spectroscopy

CO15. Theory of NMR: Quantum description,
CO16. Classical description – Processional motion, Larmour frequency,
CO17. Relaxation processes, T1 and T2 and their measurement.
CO18. Fourier Transform NMR: Pulsed excitation, FID, Types of NMR Spectra – Wild line and high resolution spectra.
CO19. NMR Spectrometers: Instrumentation.
CO20. Environmental Effects: Types, Chemical shift theory, Magnetic anisotropy,
CO21. Spin–spin splitting, first order and second order spectra,
CO22. Double Resonance Techniques, Proton on heteroatom.
CO23. Application of proton NMR: Identification of compounds.
CO24. 13C NMR: Proton decoupling: Broad band, off-resonance, Pulsed decoupling,
CO25. NOE, application to structure determination.
CO26. Magnetic Resonance Imaging: The concept of MRI,
CO27. Application in Muscle Physiology,
CO28. Functional mapping of brain; 31P, 19F, 23Na, 15N

Optical Methods and their applications in Biomedical Sciences

CO29. Ultraviolet / Visible molecular absorption spectroscopy basics,
CO30. Instrumentation of UV-VIS spectroscopy and applications
CO31. Fluorescence and Phosphorescence basic principle
CO32. Fluorescence -quenching, FRET and applications with examples
CO33. Infrared – vibrational spectroscopy introduction
CO34. Functional group identification
CO35. Effects of various factors on IR frequencies,
CO36. Concept of circularly polarized light and principles of CD
CO37. Principles of CD continued
CO38. CD instrumentation, concepts of band width, slid width, scan speed, and other factors in getting proper resolution of bands
CO39. Application of CD in macromolecular structure determination, binding studies and other applications
CO40. Confocal Microscopy: Applications in Cell Biology, Electron

Microscopy,

CO41. Techniques in Biology: tumor diagnosis and imaging, infectious diseases such as tuberculosis,

CO42. Introduction to flow cytometer: Need and versatility of FACS. Fluidics and Optics in FACS

CO43. Filters and detectors in FACS: choosing the right fluorochromes, compensation of overlapping emissions and

CO44. Plotting of data in various formats (Histograms/dot plots/ contour plots) Gating,

CO45. Principles of cell Sorting by FACS and MACS

MBS 304: MOLECULAR ONCOLOGY (Interdisciplinary)

The Cancer Problem

CO1. Introduction to Cancer, Global and Indian incidence, various types of cancers, Epidemiology,

CO2. Environmental carcinogens, chemical and physical carcinogens types with examples.

CO3. Various risk factors, life style, changing patterns, the Indian scenario.

Mechanisms of Carcinogenesis

CO4. Various theories, multi-step and multistage processes,

CO5. Initiation, Promotion and Progression of cancer.

CO6. Role of DNA damage, repair and mutations by physicochemical agents and viruses,

CO7. **I**nteraction of various agents in cancer

CO8. Differentiation: hyperplasia and precancerous lesions. Strategies of chemoprevention.

Tumor types and leukemia

CO9. Benign and malignant tumors, localized and metastatic disease

CO10. Schemes of classification, WHO classification, staging and grading, degree of malignancy.

CO11. Introduction to leukemia, Classification of leukemia, types of chromosomal translocations.

CO12. Chronic leukemias using example of CML

CO13. Acute leukemias: AML and ALL

Tumor Immunology

CO14. Immune suppression and role of immune survelliance in growth of tumors. Tumor specific antigens and immune response.

CO15. Modulation of immune response and immunotherapy, cancer vaccines.

Modulation of the Eukaryotic Cell Cycle and cell death in cancer

CO16. Cell cycle and its control:

CO17. Mechanism of deregulation of cell cycle during cancer.

CO18. Apoptosis, **and** Necrosis regulation in normal cell and dysregulation in cancer

CO19. Proapoptotic and Antiapoptotic proteins and mechanism of action in controlling apoptosis.

Cell Interactions in Development of cancer

CO20. Cell-cell interaction, integrins, and other proteins involved in cellular adhesion.

CO21. Concept of invasion, changes in cellular proteins.

CO22. Details of mechanism of invasion by cancerous cells.

CO23. Angiogenesis and various factors involved in angeiogenesis

CO24. Mechanism of angiogenesis and Neoangiogenesis,

CO25. Stem Cell Differentiation, Morphogens

Experimental Model Systems in Cancer Research

CO26. Basic concept, Microbial Models, Primary Cell Cultures, Established Cell Lines,

CO27. Organ Cell Cultures, Spheroids.

Tumor suppressor genes and Viral oncogenes

CO28. Mechanisms of action of P53 in cancer

CO29. Mechanisms of action of P53 in cancer contd

CO30. Altered mechanisms of action of Rb protein in cancer cells

CO31. Ras action in normal and transformed cells

CO32. Role and mechanism of viral oncogenes with examples.

CO33. Role of oncogenes in gene regulation using examples erb, rel,

CO34. Role of oncogenes jun-fos, large Tantigen etc in gene regulation.

Growth factor-signalling pathways in cancer

CO35. Relationship between oncogene products and growth factors,
CO36. using example of Src,
CO37. Wnt, Abl,
CO38. GAP and growth factors.
CO39. Effect of viral infection on signal transduction.

Cancer genetics, familial cancers.

CO40. Cancer genetics, familial cancers contd

Emerging Cancer Therapy

CO41. Cellular, tissue and molecular markers,
CO42. potential targets for Cancer Therapy,
CO43. Drug Discovery Strategy.

MBS 305: TOXICOLOGY & PHARMACOLOGY

CO1. Introduction to pharmacology, scope of pharmacology.
CO2. Routes of administration of drugs, their advantages and disadvantages.
CO3. Various processes of absorption of drugs and the factors affecting them;
CO4. Adsoption, metabolism, distribution and excretion of drugs.
CO5. Pharmacodynamics: General mechanism of drug action and the factors, which modify drug action.
CO6. Pharmacological classification of drug
CO7. Drugs acting on the central nervous system: Anesthetics,
CO8. Pshychopharmacological agents
CO9. Drugs acting on the autonomic nervous system: Cholinergic drugs, anticholinergic drugs, anticholinesterase drugs,
CO10. Adrenergic drugs and adrenergic receptor blockers,
CO11. Neuron blockers and ganglion blockers,
CO12. Neuromuscular blockers, drugs used in myasthenia gravis.
CO13. Hormones and hormone antagonists,
CO14. Drugs acting on the respiratory system- bronchodilators, expectorants and antitussive agents,
CO15. Drugs acting on the digestive system,
CO16. Cardiovascular drugs, cardiotonics, antianginal agents, antihypertensive agents,

CO17. peripheral vasodilators
CO18. drugs used in atherosclerosis, coaogulants and anticoaogulants.
CO19. Principles of Toxicology Definition, scope and different branches of toxicology.
CO20. A brief review of toxic substances: Synthetic organic compounds: Chemical additives in food, Chemicals in the work place, Solvents, Pesticides, Cosmetics, Drugs of abuse. Inorganic chemicals:
CO21. Industrial and chemical environmental inorganic toxicants polluting air/ water/ food
CO22. Naturally occurring poisons: Mycotoxins, Bacterial toxins, Plant toxins and Animal toxins.
CO23. Types of toxicity and its measurement: Acute,
CO24. Sub-acute or Chronic and its manifestations.
CO25. Mode of application/ administration/ exposure, in-vitro tests, Dose response relationship,
CO26. Measurement of TD 50/ TC 50 and LD 50/ LC 50.
CO27. Subacute and chronic toxicity. Risk and safety analysis: Margin of safety, Therapeutic index, Ideal therapeutic index.
CO28. Inter-species extrapolation of dose-response data, NOEL, ADI, TLV, WHO standards.
CO29. Special toxicity studies: Carcinogenecity,
CO30. teratogenicity,
CO31. in-vitro mutagenicity tests.
CO32. Epidemiology of toxicity: Cohort study, Retrospect study,
CO33. Case-control study, Cross-sectional study, Confounding.
CO34. Pharmacokinetic aspects of toxicants: Absorption, Distribution, Metabolism and Excretion (ADME) of drugs and chemicals. A general study only. Site of metabolism, Metabolizing enzymes of liver, kidney, lung, GI tract, skin and their role in activation and detoxification of drugs and chemicals.
CO35. Physiological (route of exposure, species, sex and age), Nutritional and environmental (temperature, altitude and circadian rhythms related) factors affecting metabolism, detoxification and toxic responses of drugs and chemicals.
CO36. Organ toxicities Hepatotoxicity: A brief description of morphological and functional aspects of liver with special reference to hepatotoxicity,

various hepatotoxic agents, types of liver injuries- Fatty liver formation, Necrosis, Cholastosis, Hepatitis, Fibrosis, Cirrhosis, Carcinogenesis.

CO37. Nephrotoxicity: A brief description of morphological and functional aspects of kidney in relation of nephrotoxicity, nephrotoxic agents, Detailed mechanisms of chemical induced nephrotoxicity. Cardiovascular toxicity:

CO38. A brief description of mechanisms of cardiovascular toxicity and cardiotioxic agents- subcellular and biochemical mechanisms.

CO39. Neurotoxicity: A brief description neurotoxic agents and types of neurotoxic effects- Axanopathy, Neropathy, Neuronopathy, Mylenopathy.

CO40. Broncho-pulmonary (inhalation) toxicity. Gastro - intestinal toxicity.

CO41. Skin toxicity/ photosensitivity. Tests for evaluation of toxicities in different organs.

CO42. Therapeutic aspects: General measures and treatment of poisoning cases,

CO43. Specific antidotes, Agents of first choice, Contraindications.

Semester IV

MBS 401: Dissertation Project

All the students of the M.Sc. Biomedical Science course have to carry out a dissertation course during IV semester. The students are placed in various laboratories in ACBR, other Departments of DU and collaborating Institutes such as INMAS, IGIB, VPCI etc. The students are required to work on experiment based research projects and also do two course works out of following.

MBS 402: GENOME BIOLOGY (Interdisciplinary)

CO1. Introduction: Overview of genomics. To highlight how biology is a network of interactions direct and indirect. What is the difference between genetics and genome biology? The transition from reductionist to comprehensive approach in understanding biological systems.

CO2. Role of model organisms in genetic studies in the pre-genomic era and their relevance; Cell cycle gene discovery using *Saccharomyces cerevisea*: Tetrad analysis, isolation of mutants (e.g. cell cycle mutants) and their characterization, gene identification.

CO3. *Caenorhabditis elegans* and discovery of RNAi.

CO4. *Mus musculus*: Generation of knockouts and transgenic for tissue expression analysis.

CO5. Conventions of nomenclature of genes and gene products in different model systems (www.ncbi.nlm.nih.gov).

CO6. Pedigree Analysis and deviations from basic pedigree patterns: Mitochondrial inheritance**.**

CO7. Deviations from the basic pedigree patterns- non-penetrance, variable expressivity, pleiotropy, late onset, dominance problems, anticipation, genetic heterogeneity, genomic imprinting and uniparental disomy, spontaneous mutations and X-inactivation (Website: OMIM)

CO8. Deviations from the basic pedigree patterns continues

CO9. Human Genome Project**:** History, organization and goals of human genome project**.**

CO10. Tools (Vectors- BAC, PAC, YAC and sequencing techniques) and approaches (Hierarchial and shotgun sequencing),

CO11. Outcomes and ethical issues.

CO12. Organisation of the Human Genome: General features: Gene density, CpG islands, RNA-encoding genes, Gene clusters**,** Diversity in size and organization of genes**,**

CO13. Types of repetitive DNA**,** Pseudogenes**,** Genetic markers and their applications.

CO14. Techniques for Genomics: Radiation Hybrids in mapping,

CO15. Polymorphism screening (Genotyping of SNPs and Microsatellite markers),

CO16. Expression analysis and

CO17. proteome analysis

CO18. Whole genome mapping strategies: Physical Maps

CO19. different types- restriction and cytogenetic maps

CO20. Genetic Maps,

CO21. Genotypic and Allelic frequencies,

CO22. Haplotype construction (two loci using SNPs and/or microsatellites)

CO23. Identification of Genetic Basis of Disease**:**

CO24. Forward and Reverse Genetics**/** Top-down and Bottom- up approaches

CO25. Positional and Candidate Gene approaches,

CO26. Positional- cloning approach with Examples.

CO27. Genome of model organisms and pathogens and Comparative Genomics: Overview of prokaryotic and eukaryotic genomes: *E. coli, Yeast, Drosophila, Mouse, M. tuberculosis* and *Plasmodium*,

CO28. C-value, number of genes and complexity of genomes, Conservation and diversity of genomes.

CO29. Implications of Genome Research: Diagnosis and screening of Genetic Disorders

CO30. Prenatal genotyping for mutations in β- globin gene and sickle cell aneamia

CO31. Pharmacogenomics, Genetic polymorphism in drug metabolism genes e.g. CytP450 and GST

CO32. their effect on drug metabolism and drug response.

CO33. Website based analysis and seminars by students interspersed with lectures

CO34. Cytogenetic techniques (including Karyotyping and FISH).

CO35. Polymorphism screening (Genotyping of SNPs and Microsatellite markers). Expression analysis and proteome analysis

MBS 403: CONCEPTS IN DRUG DISCOVERY AND MECHANISM
(Interdisciplinary)

CO1. Existing drugs as lead compounds for new discovery: Development of sulphonamides

CO2. β-lactams development SAR, resistance, mechanism of action

CO3. Quinolones various generations of quinalones, their SAR, resistance and mechanism of action

CO4. Nucleosides, Alkaloids based drugs as Antiviral agents,

CO5. Nucleotide based antiviral agents and rational drug design based detailed SAR and mechanism of action.

CO6.Combinatorial Chemistry: Definition and need in Medicinal chemistry
CO7. Various general methods used in this type of chemistry
CO8. Detailed Methodology of combinatorial Synthesis with case studies
CO9 Parallel synthesis
CO10. Deconvolution identification methods of Combinatorial Library

CO11. Concepts in drug delivery systems
CO12. Various biological barriers encountered by drugs inside system
CO13. drug delivery devices: implants, minipumps,
CO14. mechanism of controlled drug release,
CO15. soluble delivery systems: micro and nano systems,
CO16. Nanotechnology based drug delivery systems
CO17. Routes of drug delivery systems - oral, skin
CO18. Pulmonary, nasal, cardiovascular etc.

CO19. Pharmacogenetics: Population variation in drug metabolism;
CO20. Genetic variability; polymorphism relating to receptors with examples
CO21. Variability of genes in drug metabolism and mechanisms
CO22. molecular markers and Single nucleotide polymorphism as markers for emerging concepts in pharmacogenetics.

CO23. Receptor Chemistry and Biology: Chemistry of membrane receptors
CO24. Intracellular receptors types;
CO25. Isolation and characterization of receptors;
CO26. Regulation of receptor number and affinity;
CO27. Receptor cross-talk; Organ Receptors;
CO28. Non-liganded and constitutive receptor activation;
CO29. r -DNA receptor bioassays;
CO30. Desensitization of receptors;
CO31. Receptors as targets for vaccines and newer drug development.

CO32 to CO42: Student seminar: Students are encouraged to select research papers involving above topics and give seminar of the theoretical and practical aspects of these topics in research.

MBS 404: ADVANCED MEDICINAL CHEMISTRY (Interdisciplinary)

CO1 Introduction to metal complexes

CO2 Metal complexes contd.

CO3 Mechanism of Ligand Substitution reactions

CO4 Metal containing imagining agents

CO5 Synthesis and uses of Technipine

CO6. Drugs acting on Novel Targets

CO7. β-tubulin inhibitors and their mechanism.

CO8. Kinase inhibitors e.g. AKt inhibitors, discovery of gleevac etc.

CO9. HIV inhibitors: integrase inhibitors SAR and mechanism

CO10. CCR5 inhibitors, detailed SAR and mechanism of action.

CO11. New drugs developed for tuberculosis and other infectious diseases.

CO12. Drugs developed for cardiovascular disease Cholesterol, absorption inhibitors e. g. ezetimibe

CO13. glycoprotein inhibitor e.g. abciximab

CO14. Renin inhibitors e.g. aliskerin

CO15. Drug Discrimination Subjects, Dose and the parameters, Nature of the stimulus,

CO16. Stereoselectivity, Specificity, Locus and mechanism of action,

CO17. Structure activity studies with examples

CO18. Role of Biotechnology in Drug Discovery

CO19. The impact of biotechnology on small-molecular drug discovery and development.

CO20. Examples of approved biotechnology based drugs: Monoclonal antibodies,

CO21. Interferon alpha, Interferon beta, Interferon gamma, Inter leukins,

CO22. Growth hormones, Antisense nucleotides,

CO23. Use of Transgenic animal models for drug evaluation

CO24. Introductions to various Molecular Modelling and Computer Aided Design methods

CO25. Molecular and quantum mechanics based methods

CO26. Concepts of energies of molecular systems, energy minimization methods etc.

CO27. Basic elements contributing to 3D-structure,

CO28. Macromolecular structure database: Its constitution and attributes,

CO29. Sequence Homology, sequence alignment methods

CO30. Homology based modeling,
CO31. Modeling Ligand –Protein association: Docking methods,
CO32. Molecular Mechanics, Molecular Dynamics.
CO33. Various Computational approaches to drug design with case studies
CO34. Ligand based drug design and virtual screening, 2D and 3D QSAR, ADMET etc.
CO35-40. Hands on training sessions to students on various drug design methods

Students Seminar

CO41 to CO48: Student seminar: Students are encouraged to select research papers involving above topics and give seminar of the theoretical and practical aspects of these topics in research.

MBS 405: RADIATION BIOLOGY

CO1; concept of Electromagnetic radiation and radioactivity.
CO2;Radiation sources and radionuclides.
CO3; Measurement units of exposed and absorbed radiation.
CO4; Interaction of radiation with matter, excitation and ionization.
CO5; concept of Radiochemical events relevant to radiation biology. Dosimetry: introduction and application
CO6; how does radiation interact with nucleic acids, side effects associated with them
CO7; how does radiation interact with proteins, side effects associated with them
CO8; how does radiation interact with lipids, side effects associated with them
CO9; how does radiation interact with carbohydrates, side effects associated with them
CO10; introduction to ionizing radiation, effects of cellular life, based on biophysiacal models.
CO11; effect of ionizing radiation on the cell cycle events.
CO12; introduction to mutations, types and impact
CO13; impact of mutations with examples
CO14; introduction to DNA repair pathways,
CO15; regulation of DNA repair pathways
CO16; Mechanistic and regulatory aspects of DNA repair.
CO17; Role of DNA repair in aging
CO18; Role of DNA repair in genetic diseases

CO19; understanding biological dosimetry: Micronuclei formation,
CO20; concept of Chromosome aberration with examples
CO21; introduction to mutation assays.
CO22; **Systemic effects of radiation:** Acute, delayed and late radiation effects (with particular reference to nervous system.
CO23; **Systemic effects of radiation** on gastrointestinal and hematopoitic syndrome.
CO24; concept of Carcinogenesis and teratogenesis.
CO25; Radiosensitization and Radioprotection: concept and application
CO26; **Behavioral Radiation Biology:** Effects of radiation on nervous systems (in vitro studies).
CO27; Effects of low and high doses of radiation on nervous system
CO29; Effects of low and high doses of radiation on behaviour.
CO30; **introduction to** Biological basis of ICRP recommendations
CO31; Introduction to Low dose effects of natural radiation and man made radiation, CO32; introduction to Ultraviolet radiation and environment.
CO33; Radiation therapy: concepts and applications
CO34: Nuclear medicine: therapeutic aspects, introduction
CO35: Management of radiation injuries
CO36: Tumor physiology and radiation treatment
CO37; Tumor physiology and response.
CO38: Tumor physiology: predictive assay, adaptive response
CO39 Tumor physiology: improvement in tumor radiotherapy
CO40: Tumor physiology: Applications, emerging trends
CO41: Concept of Low-dose hypersensitivity, Bystander effects,.
CO42: Concept of Radiation induced alterations in signal transduction.
CO43; different aspects of radiation medicine
CO44; radioasensitization: concept and application
CO45; Radio protection : concept and application

MBS 406: TOPICS IN CLINICAL RESEARCH

CO1: Introduction to Clinical Research
CO2: Definition, Scope and Types of Clinical Research
CO3: Understanding Epidemiology, (infectious disease,cancer and genetics)
CO4:Pharmacology and Pharmaceuticals,

CO5: Good Clinical Practices (GCP),
CO6: Process of Drug Development and
CO7: Drug Safety.
CO8: Introduction to Bioavailability and Bioequivalence.
CO9: Methods in Clinical Research and Clinical Trial: Design
CO10: Designing of protocol,
CO11: Pharmaco-epidemiology,
CO12: Introduction to Quality Assurance and quality control,
CO13: Good Laboratory Practice (GLP) and Accreditation,
CO14: Study population and sample size,
CO15: Medical report writing and publication of results.
CO16: Ethics in Clinical Research
CO 17: Definition and theories of Ethics and Foundation,
CO18: Independent Ethics Committee,
CO19: Informed Consent,
CO20:Integrity in Clinical Research,
CO21:Conflicts of Interest.
CO22: Regulatory Process in Clinical Research
CO23: History and Role of Regulations in Clinical Research,
CO24: US and Indian Regulatory system,
CO 25: EU Regulatory Affairs,
CO26: Non-Disclosure Agreement,
CO27:GMP regulations,
CO28:Patent and Patent laws
CO29: Clinical Research and Management Clinical Study Preparation, Pre-clinical Trials,
CO 30: Clinical trial phase I/II/III/IV, Documentation, Monitoring, Audit and Inspection of trial study, CO31: Pharmaco-vigilance, Drug Safety.
CO32: Biostatistics and Data Management Role of Statistics in clinical research, Trial design and analysis, Data management and validation,
CO33: Consideration of SAE (serious adverse effects),
CO34: Bioinformatics, software and IT in Clinical Research.
CO35 to CO40 : Students seminar and case studies

MBS 407: ADVANCED IMMUNOLOGY

CO1: Introduction to the Immune system,

CO2: Adaptive and innate immunity: regulation by Immunoglobulin gene expression, Immunoglobulin loci, TLRs, complement, diversity via gene translocation at Ig loci

CO3: Factors regulating immune effector functions

CO3: Structure, Function & Antigen processing on MHC class I and MHC class II, factors governing peptide binding, loading and presentation to T cells

CO4: Pathogen Interface with Antigen Presentation

CO4: Differentiation of T cells: TCR gene recombination, regulation and function therein

CO5: Factors regulating T cell diversity and cross-reactivity

CO7: Positive and Negative selection of T cells

CO8: Role of Costimulatory molecules in T cell selection

C08: T cell migration and turnover

CO9: T cell functions during various immune responses

C10: Signaling from innate, B cell and T cell receptors: avidity vs affinity of the interactions

C11: T cell response generation and magnitude of the immune response

C12: Heterogeneity in CD4 and CD8 T cell population

C13: CD4 T cell subsets and functions

C14: TH1/TH2/TH9/TH17/Tfh subsets and functions in immunity and disease.

C15: Hybridoma vs T cell clones vs transgenic vs Knockout mice: applications thereof

C16: Regulatory T cells and fine-tuning of immune response

C17: Solutions and compromises of studying T cells response

C18: T cell memory and short-term and long-term immunity

C20: Costimulatory networks in immune response building and maintenance

C21: Positive and negative costimulation by various molecules during building up, maintenance and termination of immune response

C22: Immune synapse and regulation of immune response to pathogens

C23: Introduction to Mucosal immunity vis-à-vis systemic immunity

C24: Intrinsic and extrinsic factors affecting immunity at mucosal surfaces

C25: Exploitation of gaps and weaknesses in the mucosal immunity by pathogens
C25: Mucosal vaccines and diseases
C26: Allergy and hypersensitivity reactions during an immune response
C28: Striking a balance between immunity to infections and allergy
C27: Immunity to Mycobacteria
C27: Immunity to Streptococcus pneumoniae and pneumonia vaccines
C28: Immunity to HIV: Pitfalls of immune-deficiency
C29: Immunity to Salmonella
C29: Systemic and organs specific Autoimmunity
C30: microRNAs in regulating immune responses and protozoan immunity
C31: Aging and Immunity and Immune-senescence
C32: Transplantation immunology and MHC restriction
C33: Immunity to cancers/tumors vs long-term persistent infections: similarities and differences
C34: Alternative approaches to chemotherapy vis immune-therapeutics and tweaking of the immune system
C35: Role of Autophagy in mediating immune responses
C36: Vaccines: short-term and long-term protection: inbuilt mechanisms of innate and adaptive memory:
C37: Organogenesis of secondary lymphoid organs : Overview of the immune system, localization of the lymphoid organs in the body, mouse and human.
C38: The gross anatomy and functional relevance of lymphoid organs.
C39: Review of Timeline based experiments (literature) of development of Peyer's patches
C40: Review of Timeline based experiments(literature) of development of lymph nodes
C41: Literature review of Early and late patterning of lymphoid genes
C42: Lymphotoxin signalling and secondary lymphoid organ development analysis of NALT ,MALT,Peyer's patches and lymphnode.

MBS 408: ADVANCED TOXICOLOGY & PHARMACOLOGY

CO1: Pharmacological classification of drugs; the discussion of drugs should emphasize the following aspects:Drugs acting on the central nervous system : General anesthetics, adjunction to anesthesia, intravenous anesthetics.
CO2: Analgesic and non-steroidal anti-inflammatory drugs,
CO3: narcotic analgesics, antirheumatic and antigout remedies,
CO4: sedatives and hypnotics, pshychopharmacological agents, anti-convulsants, analeptics.
CO5: Centrally acting muscle relaxants and anti-parkinsonism agents, anti-Alzheimer's drugs.
CO6:Local anesthetics.
CO7:Drugs acting on the eye, mydriatics, drugs used in glaucoma.
CO8:Drugs acting on the respiratory systembronchodilators,
CO10: expectorants and antitussive agents.
CO 11:Antacids, histamine and anti-histamines, prostaglandins.
CO12:Cardiovascular drugs, cardiotonics, antianginal agents, antihypertensive agents, peripheral vasodilators and drugs used in atherosclerosis.
CO13: Drugs acting on the blood and blood forming organs, haematinics, coagulants and anticoagulants, haemostatics, blood substitutes and plasma expanders.
CO14:Drugs affecting renal function- diuretics and antidiuretics.
CO15: Hormones and hormone antagonists- hypoglycemic agents, antithyroid drugs,
CO16: sex hormones and oral contraceptives, corticosteroids.
CO17: Drugs acting on the digestive system- carminatives, digestants, bitters, antacids and drugs used in peptic ulcer,
CO18:purgatives and laxtives, antidiarrhoeals, emetics, antiemetics.
CO19:Chemotherapy of microbial diseases, urinary antiseptics, sulfonamides,
CO20: penicillins, streptomycin, tetracyclines and other antibiotics;
CO21: antitubercular drugs, antifungal agents, antiviral drugs, antileprotic drugs.
CO22:Chemotherapy of protozoal diseases , Drugs used in cancer,
CO23: Disinfectants and antiseptics.
CO24: Environmental and Pesticide Toxicology

CO25 Metallic Pollutants Source, exposure, absorption, target site interactions and health hazards.: CO26 Mercury, lead and arsenic

CO27: cadmium and fluoride;

CO28: Pesticides Brief classification with examples,

CO29: residual and non-residual pesticides.

CO30: Mode of entry and mode of action of pesticides in target and non-target organisms;

CO31: metabolism of pesticides, phase I and phase II reaction, elimination.

CO32: Ecotoxicology: Impact of pesticides residues on ecosystems, non-target organisms;

CO33: Pesticide beioaccoumlation, biomagnification through food chain.

CO34: Environmental alteration of pesticides - microbial and solar,

C035: fate and dissipation of pesticides residue under tropical and temperature conditions.

CO36: Pesticide hazards to man Accidental and occupational exposure, entry through air, food and water,

CO37: Main routes of entry and factors affecting intake, distribution, biotransformation and elimination dynamics.

CO38: Residue levels in man: Indian experience Vs developed countries;

CO39: Residues in tissues and organs – distribution and redistribution; Pregnancy and transfer to fetus.

CO40: Health hazards: Non–fatal subtle levels, biochemical and physiological effects;

CO41: Parameters used in carcinogenic risk assessment of pesticide residues;

CO42: Animal experiments – carcinogenic, teratogenic and mutagenic tests;

CO43: Organochlorine insecticide residues as carcinogensparent status Carcinogens – phenoxyherbicides, arsenicals and HCB;

CO 44: Organochloro residue burden in newborn babies in developing countries and potential hazards.

Practicals and Dissertation

CO1: In the I semester hands-on training via practicals is carried out in Genetics, Biochemistry and Medical Microbiology on topics covered in the theory papers
CO2: In the II semester hands-on training via practicals is carried out in organic Chemistry, Immunology and Molecular Biology and Biotechnology on topics covered in the theory papers
CO3: In the III semester hands-on training via practicals is carried out in Advanced Human Physiology, Pharmacology & Toxicology and Analytical and Biomedical techniques and instrumentation on topics covered in the theory papers

CO4: **Dissertation**
The dissertation has a weightage of 60% in the IV semester. This gives an opportunity to each student to individually perform design a research problem and experiments. Laboratories a=to all the students are allocated at the end of the II semester so as to give them an opportunity to utilize the summer vacation in carrying out research in frontline areas.

Ph.D. Coursework

The Ph.D. course work is so designed to give kindle the research temperament of each student. The course begins with a paper on Research Methodology that induces a scientific temperament in the student and introduce the basic requirements for being a good and motivated researcher. Emphasis is laid on the need to identify a challenging research topic following an extensive literature survey. Learning how to design simple and complicated experiments, the need for reproducibility, analyses of the data obtained and its significance in moving forward follows this. In parallel, the student is also trained to follow ethical guidelines, display scientific integrity; identify conflict of interest and plagiarism issues while writing scientific documents.