M.TECH- MOLECULAR MEDICINE

This M.Tech. program will provide training in the field of Molecular Medicine. The course is offered by the Division of Molecular Medicine, Amrita Centre for Nanosciences and Molecular Medicine, Amrita Institute of Medical Sciences and Research Centre, Amrita Vishwa Vidyapeetham. Molecular medicine is the study of molecular and cellular phenomena in biological systems that enhances our understanding of human diseases and facilitates discovery research in disease prevention, diagnosis and therapy. Molecular Biology offers new technology tools to probe the living organism, both in diagnostics and therapy. The integration of these two disciplines offers opportunities for many new fundamental insights into the mechanisms of disease and avenues for diagnostics and therapy that could not have been imagined even a decade earlier.

One of the unique strengths of this course is its emphasis on an interdisciplinary approach whereby medical sciences, molecular biology, and nanotechnology areas can be addressed. This is possible because this Centre offers other courses in Nanotechnology and Bio-Nanotechnology. Students will be encouraged to participate in interdisciplinary learning activities, and some of the courses from different programs are jointly offered.
# Curriculum

## First Semester

<table>
<thead>
<tr>
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**Total Credits 24**

*Noncredit course*

## Second Semester

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**Total Credits 15**

## Third Semester

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**Total Credits 13**
### Fourth Semester

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<td><strong>Overall Total Credits</strong> 64</td>
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18MM601 CELL AND DEVELOPMENTAL BIOLOGY 3-0-0-3

Cell Biology: Cell chemistry and biosynthesis: the chemical components of a cell, catalysis and the use of energy by cells, how cells obtain energy from food; Classification and properties of cell: Introduction to different types of cells; Membrane structure: the lipid bilayer, membrane proteins; Membrane transport of small molecules and electrical properties of membranes: principles of membrane transport, active membrane transport, ion channels; Intracellular compartments and protein sorting: compartmentalization of cells, the transport of molecules between the nucleus and cytosol, transport of proteins to different organelle; Intracellular vesicular traffic: molecular mechanisms, transport from the ER through the golgi apparatus, transport from the trans-golgi network to lysosomes, endocytosis, exocytosis; Mechanisms of cell communication: general principles, signaling through GPCRs and enzyme-coupled surface receptors, signaling pathways dependent on regulated proteolysis of latent gene regulatory proteins; Cytoskeleton: self-assembly and dynamic structure of cytoskeletal filaments, molecular motors, cytoskeleton and cell behavior, Cell cycle: an overview, cell cycle control system, control of cell division and cell growth; Apoptosis: cell death, extrinsic and intrinsic pathways; Cell junctions, cell adhesion and extracellular matrix: cadherins and cell-cell adhesion, tight junctions, passageways from cell to cell, integrins and cell-matrix adhesion, extracellular matrix. Germ cells: Primordial germ cells, Meiosis, Eggs, Sperms. Developmental biology: Universal mechanisms of animal development, Development from the perspective of a single cell, The molecular genetics of pattern formation, The patterning of anteroposterior axis, Organogenesis and patterning of appendages, The shaping of the vertebrate body, The mouse development, Neural development.

TEXT BOOK:

REFERENCE:
changes – Hypertrophy, hyperplasia, atrophy and metaplasia, fluid handling disturbances, malignant cellular changes, immunological & metabolic responses, and healing. The second segment covers the study of diseases based on organ systems: Cardiovascular, pulmonary, gastrointestinal, hepato-biliary, renal, musculoskeletal and nervous system disorders. Changes at the level of tissues and cells will be studied within each disease. Conditions such as diabetes, obesity, and hypertension, that are estimated to form the bulk of healthcare load in the next few years, will be given special emphasis. Aetiological and mechanistic basis of these conditions will be discussed in detail.

**TEXT BOOK:**


**REFERENCE:**

18MM603  CLINICAL BIOCHEMISTRY AND PROTEOMICS  3-0-0-3

**Clinical Biochemistry:** Biochemistry & Medicine, how cells can respond to changes in biochemical environments, key organic molecules used by living systems, bioenergetics: the role of ATP, biologic oxidation, glycolysis & the oxidation of pyruvate, clinical significance of glycolytic pathway, the citric acid cycle, metabolism of glycogen, gluconeogenesis, the Calvin cycle and the pentose phosphate pathway, control of the blood glucose and associated clinical diseases, the respiratory chain & oxidative phosphorylation, biosynthesis of fatty acids, oxidation of fatty acids: Structures & function of proteins & enzymes, mechanism of action of enzymes and its regulation.

**Proteomics:** What is proteome and proteomics, how it is different from genomics, different types of proteomics, significance of sample preparation in proteomics, significance of choosing different methods for proteome analysis, different methods used for proteomic analysis, principles of mass spectroscopy, how proteins are identified using mass spectrometry, Protein fragmentation; Peptide enrichment and separation; Ionization and its Importance; Time of Flight, MS/MS analysis, Peptide fragmentation and peptide sequencing, Identification of proteins using search engines/programs, Accuracy of these identified proteins with respect to protein identity, significance of mass spectrometry in clinics, clinical proteomics and examples of clinical proteomics.

**TEXT BOOKS:**
**REFERENCE:**

**18MA613 STATISTICAL DATA ANALYSIS 1-0-1-2**

Introduction to Statistics-Need for Statistical Methods in Medicine, Public Health, Biology, Biotechnology & Nano Sciences – Their uses and Misuses, Types of Variables, Data collection Methods, Population and Sample.
Basics of Mathematics- Calculus ad Matrix Algebra.
Descriptive Data Analysis Methods-Statistical Tables, Diagrams & Graphs, Measures of Averages, Measures of Dispersion, Correlation Analysis Methods, Regression Analysis Methods.
Tests of Significance of Statistical Hypotheses- Concept of Statistical Hypotheses –Null and Alternative hypotheses, Type I and Type II errors, Significance level, Critical region and Power of a test , P- value and its interpretation; Large and Small Sample Test – Normal test, Student’s ‘t’ test, Chi-square tests, Analysis of variance & Non parametric methods.
Nonparametric methods-Non-parametric methods for estimation, Methods for tests of significance for the independent and correlated samples, Nonparametric Methods for more than two populations.
Multivariate analysis Methods- Principles of Multivariate analysis, Multivariate regression analysis, Multivariate logistic regression analysis.

**TEXT BOOK:**

**REFERENCE:**

**18MM621 IMMUNOLOGY 3-0-0-3**

**Basic concepts in immunology:** Cells and organs of the immune system, Principles of innate and adaptive immunity, The effector mechanisms of immunity, The complement system and innate immunity. The induced responses of innate immunity; Pattern recognition by cells of the innate immune system, Induced innate responses to infection.
Antigen Recognition by B-cell and T-cell Receptors: The structure of a typical antibody molecule, The interaction of the antibody molecule with specific antigen, Antigen recognition by T cells. Antigen presentation to T lymphocytes: The generation of αβ T-cell receptor ligands, The major histocompatibility complex and its function, Generation of ligands for unconventional T-cell subsets. Development of B and T lymphocytes: Development of B lymphocytes, Development of T lymphocytes, Positive and negative selection of T cells.

T cell mediated Immunity: Development and function of secondary lymphoid organs, Priming of naive T cells by pathogen-activated dendritic cells, General properties of effector T cells and their cytokines, T-cell-mediated cytotoxicity.

The humoral immune response: B-cell activation by antigen and helper T cells, The distributions and functions of immunoglobulin classes, The destruction of antibody-coated pathogens via Fc receptors.

Integrated dynamics of innate and adaptive immunity: Integration of innate and adaptive immunity in response to specific types of pathogens, Effector T cells augment the effector functions of innate immune cells, Immunological memory.

Manipulation of the immune response: Treatment of unwanted immune responses, Using the immune response to attack tumors, Fighting infectious diseases with vaccination.

Modulating the immune system through nanotechnology: Nanoparticles and the immune system, Nanoscale immune activation, Nanotechnology in vaccination, Nanoparticle-based vaccine carriers, Nanotechnology and immunosuppression, Nanoparticles as vehicles for immunosuppressants.

TEXT BOOK:

REFERENCE:

18MM622 MOLECULAR BIOLOGY 3-0-0-3

Cell and its molecules, DNA: Structure and function, Chromosome and chromatin, Genetic code, wobble hypothesis, RNA and types of RNA basic siRNA and its Dicer, RISC function, shRNA, miRNA and its function, siRNA and miRNA mediated pathways, miRNA and its function on disease, rasiRNA, tasiRNA, nat-siRNA, piRNA, PIWI, Piwi subfamily MIWI, MIWI2, MILI, Proteins and their structure, DNA replication and its regulation (prokaryotes and eukaryotes), Homologous and site specific recombination, DNA repair, Transcription and its regulation (prokaryotes and eukaryotes), Translation and its regulation (prokaryotes and eukaryotes), Gene structure, Repeats and clusters, Genome evolution, Gene expression, Gene expression regulations (prokaryotes and eukaryotes), operon, phage strategies, Epigenetics, Methylation, Histone modifications, Regulation of epigenetics, Regulatory RNAs, Gene regulation in development and evolution, DNA Mutation, Types of mutations, Genetic system of Mitochondira and plastids, Gene recombination, Systems biology, Gene identification, promoter identification, molecular biology techniques: Isolation and Quantification of DNA/RNA, PCR, Reverse transcriptase PCR, Real Time PCR, Bioinformatics, SDS PAGE,
2D gel electrophoresis, hybridization (southern, northern and western), sequencing, protein interaction studies.

**TEXT BOOK:**

**REFERENCES**
*Molecular Biology of the Gene, Seventh Edition*, James D. Watson, Cold Spring Harbor Laboratory; Tania A. Baker, Massachusetts Institute of Technology; Alexander Gann, Cold Spring Harbor Laboratory; Michael Levine, University of California, Berkeley; Richard Losick, Harvard University, 2013

**18MM623 BIOCHEMISTRY LAB 1-0-1-2**

Using balances and pipettes, making of solutions of given normality, Knowing pH meters: Preparation of buffers, determination of pKa values and Dissociation constant of a given acid, Titration of amino acids, Spectrophotometry: Determination of concentration of proteins, Recording absorption, Spectra of a given protein and chromophore, Difference spectra, Cell culture and extraction of proteins, Centrifugation and ultracentrifugation, Protein estimation: Lowry, BCA and Bradford methods, Protein fractionation: Salting-in and salting-out, Enzyme assays, Chromatography: Gel filtration; Ion exchange; affinity; high performance liquid chromatography (HPLC), SDS Electrophoresis, western blotting

**TEXT BOOKS:**

**18MM624 MOLECULAR BIOLOGY LAB 1-0-1-2**

Isolation of chromosomal DNA from Escherichia coli; Agarose gel electrophoresis, Isolation of chromosomal DNA from human blood; Isolation of plasmid DNA from Escherichia coli; Nucleic acid quantification; Polymerase chain reaction (PCR), Restriction digestion, Restriction fragment length polymorphism (RFLP), RNA isolation from Escherichia coli; cDNA synthesis, Reverse Transcriptase PCR, DNA sequencing, Real time PCR.

**TEXT BOOK**
Cell culture module introduces the students to the basics of cell culture. The course provides students with sufficient knowledge and laboratory skills needed in the academia and industry for carrying out basic cell culture techniques properly and safely. On completion of the course, the student should be able to: account at a general level for the function, maintenance and working of Bio-safety Cabinets (BSC) and be able to work in BSCs with a good sterilisation technique, account for different preventive measures to avoid contamination of cell cultures and how a contaminated cell culture may be treated, account in detail for sterilisation equipment and sterilisation techniques, account for different cell-culture media and important components in the media; be able to apply basic cell-culture techniques, such as cell counting using hemocytometer and harvesting of cells.

Explain different factors of significance in the cultivation of cells *in vitro* and be able to maintain cell lines in culture for a longer period of time without contamination.

**Contents**-The course starts with theory i.e. basic lecture about a general lay out of a cell culture lab, physical environment needed for the cell culture, growth media and its composition, Biosafety cabinets (BSC), its use in cell culture and how to work in a BSC, contamination during cell culture and how to control it, culturing and splitting of cell lines, cryopreservation of cells and cell viability assays. After qualifying the Biosafety examination, students start working in the cell culture lab. The laboratory work starts in small groups. In the practical laboratory work, the students will have hands-on experience in counting, harvesting, culturing and maintaining cell lines.

**Animal handling techniques** – animal feed, gavage, different routes of injection, ethical treatment of animals and Institutional Animal Ethics Committee policies.

**TEXT BOOK:**

**REFERENCE:**

**18HU601 AMRITA VALUES PROGRAM**

Culture – definition and scope. Values and culture, cultural freedom
Culture and Education
Culture of Research – creativity and responsibility in research
Spirituality and Culture – spirituality as a way of life, spirituality and religion
Culture and women – gender oppression, motherhood
Culture and the Media
Culture and Politics – national values and political harmony
Philosophy and Culture, epistemology
SECOND SEMESTER

18MM626 MOLECULAR BASIS OF DISEASES 2-0-0-2


TEXT BOOK:
William B Coleman, Gregory Tsongalis, Molecular Pathology – The Molecular Basis of Human Disease, Academic Press, 2018

18MM627 GENETIC ENGINEERING 3-0-0-3

Genetic engineering, Restriction enzymes, Classification, Nomenclature, Activity, Restriction mapping of DNA Molecular cloning, Vectors: plasmids, phages and cosmids, Cloning strategies: PCR, TA cloning, Gateway cloning etc, Construction of genomic libraries, Expression systems: bacterial, yeast, insect, mammalian, plant, Transfer of gene techniques: Transformation, transfection and transduction, Expression of cloned DNA and its analysis, Application of recombinant DNA technology, DNA manipulation and analysis, (e.g.: production of insulin), r-DNA vaccines, Gene therapy, RNA technology for Genetics, SiRNA technology and mechanisms, RNAi functions and experimental strategy, Transgenics versus Genetic and its applications, Generation of Gene targeting mice, FLOXED, FRT, LoxP strategy, advantages of knockout and knock in mice, Targeted technology (insertion, deletion), Gene editing via CRISPR CAS9 technology, Gene targeting in embryonic stem cells, Targeted disruption for conventional inactivation of mouse genes, Generation of gene targeting mice, Tissue specific promoter, target gene and chimeras, Genomic analysis of gene expression-methods and analysis, Gene expression analysis by Micro array and Real Time PCR (QPCR), Next generation Sequencing, CLIP technology, Chromatography, Genetic counseling; Ethics and Genetic disorders prevention. Introduction to synthetic biology: SLIC, Infusion, BioBRICK systems, Large genome assembly, bioengineering fundamentals.

TEXT BOOKS:

Quality Assurance in the Molecular Diagnostics Laboratory: Framework for Quality Assurance in Molecular Diagnostics, Verification of Molecular Assays, Standards and Standardization of Molecular Diagnostics, Laboratory-Developed Tests in Molecular Diagnostics.

Applications of Molecular Diagnostics for Genetic Diseases, Molecular diagnostics of Coagulation, Cystic Fibrosis; Prenatal Genotyping for Identification of Fetuses at Risk for Immune Cytopenic Disorders. Applications of Molecular Diagnostics for Human Cancers. Applications of Molecular Diagnostics for Infectious Diseases, for Identity-Based Testing: HLA Typing Using Molecular Methods. Molecular Analysis for Forensic Casework and Parentage Testing. Molecular Assessment of Bone Marrow Transplant Engraftment. Personalized Medicine, Genetic Counseling Considerations in Molecular Diagnosis, Ethical, Social, and Legal Issues Related to Molecular Genetic Testing.

TEXT BOOK:
Molecular Diagnostics: For the Clinical Laboratorian / Edition 2 William B. Coleman (Editor), Gregory J. Tsongalis (Editor) Publisher: Springer-Verlag New York, LLC.

REFERENCES:

18MM629 PHARMACOKINETICS AND PHARMACODYNAMICS 2-0-0-2

Nature of drugs, drug-body interactions, permeation of drugs, drug groups, macromolecular nature of drug receptors, drug concentration and response, drug distribution and elimination of single and multiple drugs in single and multi-compartment models, derivation of relationships between various pharmacokinetic parameters like clearance, volume of distribution, elimination rate constant, half-life etc. Fundamental principles guiding absorption, distribution, metabolism and elimination of drug molecules, basics of population pharmacokinetics, pharmacogenomics, and single-gene pharmacokinetic disorder. Pharmacodynamic concepts related to affinity and efficacy of drug molecules, drug binding, receptor actions, transport proteins, enzyme action, ion channel function and extrusion mechanisms using specific drugs – acetaminophen, warfarin, certain antibiotics, and anti-malignant drugs. Mechanism of action of selected drugs will be discussed.

TEXT BOOK
REFERENCE:

18MM630 BIOINFORMATICS AND STRUCTURE BASED DRUG DESIGN 2-0-1-3

Introduction to Concept of Genomics, Proteomics and Bioinformatics; Databases on web: Genome, Proteome and Molecular biology; Sequence alignment: Near-optimal sequence alignment; Global pair wise sequence alignment; Multiple sequence alignment; Genome rearrangement; Evolutionary Bioinformatics: Phylogenetic tree construction and analysis. Different methods used for protein evolution; Protein Modeling: Protein structure prediction and analysis, Protein visualization software, Protein dynamics and Protein structure validation tools.

Chemoinformatics: Basic idea of molecule design, Visualization and generation of 2D and 3D molecular structures, Chemical databases and its implications, Pharmacophore model, Virtual screening, Ligand based and structure-based molecular design; Commands and Languages: Basic Unix and Linux commands, Extensible markup language and its use in Bioinformatics; Sequence similarity and database search: Pattern recognition and matching; Quantitative and probabilistic pattern matching; Sequence pattern databases, Spectral pattern matching, String matching algorithm. Pharmacy Informatics: Medical databases and clinically relevant drug-drug interactions, Pharmacy information system, Telemedicine and Telehealth.

Lab course work:
Basic linux commands and linux editors, X-windows and linux environment used for learning different linux commands and text editors like vi, xedit etc. Exposure to different useful databases, virtual screening and Data mining, Different biologically important databases were explored. Structural similarity search of drug like molecules were mined from different small molecular databases. Sequence alignment studies of protein family using BLAST software.

TEXT BOOKS:

18MM631 CLINICAL MICROBIOLOGY 2-0-0-2

History of microbiology; general properties of bacteria, bacteriophages (lytic and lysogenic), fungus, virus and parasites, sterilization, disinfection, control of microbes by physical and chemical agents; culture media, culture methods and growth; mechanism of action of common antimicrobial agents, molecular mechanism of drug resistance, bacterial protein secretions systems; operons (lactose and tryptophan); Human diseases caused by bacteria, fungus, virus and parasites (Example pathogenesis of Staphylococcus, Pneumococcus, Pseudomonas, Chlamydiae, Clostridium, Mycobacterium, Salmonella, Streptococcus, Neisseria, Vibrio,
Helicobacter, Hepatitis, HIV, HPV, Dengue, filaria and Malaria etc); Currently available vaccines.

TEXT BOOK:

THIRD SEMESTER

18RM601 ETHICS IN RESEARCH AND RESEARCH METHODOLOGY 1-0-1-2

Plagiarism, regulatory principles, safety in research, ethics in stem cell research, ethics in clinical research, ethics in nanomaterials based research
Principles of data documentation, protocol development, research questions and hypothesis driven research.

TEXTBOOKS:

18MM632 STEM CELL BIOLOGY AND THERAPY 3-0-0-3

Introduction to stem cells, basic principles and methodologies, classification of stem cells, major developments in stem cell biology, clinical use of stem cells. History of the origin of stem cells. Molecular mechanisms controlling the cell cycle: stem cell self-renewal and maintenance. Cell proliferation versus cell differentiation. Normal stem cells: hematopoietic stem cells, mesenchymal stem cells, cardiac stem cells. Embryonic stem cells (ESC): difference between mouse and human ESCs, derivation of ESCs, scientific and ethical hindrance to ESC therapy. Tissue Stem Cells, Translational Stem Cell Medicine, Identification and characterization of pluripotent stem cells in animal and humans; sources of pluripotent cells – blastocysts, parthenogenesis, nuclear transfer, iPSCs. Stem cell microenvironment: Stem cell niche and signaling, Stem cells and Gene Therapy: Signaling pathway involved in self-renewal and differentiation of stem cells. Identifying and isolating stem cells. Cancer stem cells: Historical perspective, isolation and characterization of cancer stem cells. Solid cancer stem cells (Breast, Lung, prostate, liver, stomach, Glioma). Targeting cancer stem cells. Hematological malignancies and stem cells. Side population cells in flow cytometry, Induced pluripotent stem cells, its derivation and applications. Regulatory and ethical issues of stem cell research in India. Stem cell therapy for various diseases (neurodegenerative, retinal, leukemia, heart).

TEXT BOOK:

REFERENCE: