PONDICHERY UNIVERSITY
SCHOOL OF LIFE SCIENCES

DEPARTMENT OF BIOCHEMISTRY & MOLECULAR BIOLOGY

COURSE OF STUDIES FOR M.Sc. PROGRAMME

In

Biochemistry & Molecular Biology

2019-20 onwards
PONDICHERRY UNIVERSITY
SCHOOL OF LIFE SCIENCES
DEPARTMENT OF BIOCHEMISTRY AND MOLECULAR BIOLOGY
MASTER OF SCIENCE
IN
BIOCHEMISTRY AND MOLECULAR BIOLOGY

PROGRAMME OBJECTIVES

The M.Sc. programme in Biochemistry and Molecular Biology will:

(1) provide training and understanding of basic concepts as well as cutting edge advancement in the field of Biochemistry and Molecular Biology,

(2) impart practical skills through laboratory courses and understanding of modern scientific techniques,

(3) enhance analytical, statistical and validation skills through hands on training,

(4) expose students to various aspects of research through dissertation, and

(5) introduce applications of Biochemistry and Molecular Biology in order to prepare highly trained and skilled workforce for teaching, research and entrepreneurship.

PROGRAMME OUTCOMES

By the end of the programme students will:

(1) have an in-depth understanding of the basic and recent developments in the field of Biochemistry and Molecular Biology,

(2) acquire skills of critical, analytical and problem solving in order to enable them to be successful in various national and international examinations,

(3) possess skills for independent thinking and in writing scientific proposal and presentations, and

(4) capable of becoming successful academicians/researchers and/or entrepreneurs.
## PONDICHERRY UNIVERSITY
### SCHOOL OF LIFE SCIENCES
#### DEPARTMENT OF BIOCHEMISTRY AND MOLECULAR BIOLOGY

**SYLLABUS FOR M.Sc. BIOCHEMISTRY AND MOLECULAR BIOLOGY**

*2019-20 onwards*

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*Online Courses recognized by UGC can be opted for with the approval of the Department.

Total credit requirements 72
BCMB 430 - ANALYTICAL BIOCHEMISTRY AND BIOPHYSICS

3 Credits

COURSE OBJECTIVES: To understand the principles of physical sciences that form the basis of the techniques and instrumentation used in biological science.

Pre-requisite: Bachelor’s level course in Life Sciences.

UNIT- I - Electrochemical techniques & Photometry 11h

UNIT- II – Microscopy 7h

UNIT- III – Centrifugation 6h
Basic principles of Centrifugation – instrumentation, centrifugation units - Types of centrifuges – rotors, accessories - centrifugation methods - sedimentation velocity - sedimentation equilibrium – colloids - cell fractionation methods.

UNIT- IV – Chromatography 10h
Types of chromatography - column, thin layer, paper, adsorption, partition, gas liquid ion exchange, affinity, High Performance Liquid Chromatography -principles of each type- instrumentation and accessories- detection methods & systems – qualitative and quantitative aspects – applications;

UNIT- V – Electrophoresis 6h

Text Books

Suggested Reading

COURSE OUTCOME: Students will know the physical basis of appropriate strategies and instrumentation for analysis of different biological sample types.
BMB 431 - BIOMOLECULES AND BIOENERGETICS

3 Credits

COURSE OBJECTIVES: To provide basic understanding of physical & chemical properties of macromolecules and principles of bioenergetics

Pre-requisite: Bachelor’s level course in Life Sciences.

UNIT- I – Biomolecules concepts and Bioenergetics 8h

UNIT- II – Carbohydrates 8h

UNIT- III – Proteins and Amino acids 9h

UNIT- IV– Lipids 8h

UNIT- V– Nucleic acids 7h
Nucleic acids types (A, B and Z forms) – Chemistry and structural organization – supercoiling – triple helix of DNA. Denaturation and renaturation of DNA – hyper and hypochromicity – Tm. Structure and functions of t-RNA – hnRNA – and non-coding regulatory RNAs (siRNA– miRNA, etc.).

Text Books

Suggested Reading

COURSE OUTCOME
The course will ensure basic understanding of physical, chemical and functional properties of macromolecules and principles of bioenergetics.
**BCMB 432 - CELL BIOLOGY**

**3 Credits**

**COURSE OBJECTIVES:** To understand structural and functional aspects of cells and basic mechanisms underlying cell signaling and cell division.

**Pre-requisite:** Bachelor’s level course in Life Sciences.

**UNIT-I - Cellular evolution**

Assembly of macromolecules and origin of life, endosymbiotic theory, RNA world hypothesis - structural organization of prokaryotic and eukaryotic cells - different cell types in tissues.

**UNIT-II – Bio-membranes and cell signaling**


**UNIT-III - Mitochondria**

Molecular organization and function - components of respiratory chain- chemiosmotic theory- ATP formation- uncouplers of oxidative phosphorylation- mitochondrial DNA and semiautonomy; autophagy and necrosis. **Ribosomes**- biogenesis, structural organization and functions.

**UNIT-IV - Endomembrane system**

Structure and function of endoplasmic reticulum and Golgi complex- post translational modifications, protein sorting, targeting and secretion; importance of proteasomes. Microbodies-peroxisomes, glyoxyysomes, lysosomes, and their functions; **Nucleus** - internal organization- nuclear pore complex and transport- nucleosomes and chromatin organization.

**UNIT-V – Cell division**

Stages of mitosis and meiosis- cohesins and condensins in chromosomes segregation, structure and functions of kinetochore, centrosomes and its functions, regulation of cell cycle- cyclin, CDKs, check points in cell cycle.

**Text Books:**


**Suggested Reading:**


**COURSE OUTCOME:** Students will understand the fundamentals of cell biology and cell signaling.
**BCMB 433 - ENZYMEOLOGY**

**COURSE OBJECTIVES:** To understand the principles of physical sciences in the techniques and instrumentation used in biological science

**Pre-requisite:** Bachelor’s level course in Life Sciences.

**UNIT - I - Introduction to Enzymes**

10h


**UNIT - II – Bisubstrate reactions and enzyme inhibition**

7h


**UNIT - III – Enzyme Catalysis**

10h


**UNIT - IV – Regulation of enzyme activity**

7h

Regulation by availability, importance of compartmentalization. Isoenzymes – Isoenzymes of clinical importance. Regulation by reversible covalent modification - proteolytic activation.


**UNIT - V – Applications of Enzymology**

6h

Enzyme purification – methods and strategies. Test for catalytic activity – active site titrations – Overview of enzyme engineering - Immobilized enzymes- methods and applications in industry-medicine - enzyme electrodes in biosensors.

**Text Books**


**Suggested Reading**


**COURSE OUTCOME:** Basic understanding of enzyme kinetics, inhibition, mechanisms of action, enzyme regulation and applications.
BCMB 434 – MOLECULAR BIOLOGY

COURSE OBJECTIVES: To demonstrate knowledge and understanding of the molecular machinery of living cells. This course will introduce the principles that govern the synthesis of macromolecules: DNA, RNA and protein and chromatin organization.

Pre-requisite: Bachelor’s level course in Life Sciences.

UNIT- I - Introduction
Discovery of DNA - The genomes of bacteria, viruses, plasmids, mitochondria and chloroplast.
Gene transfer in microorganisms - conjugation- transformation, transduction – protoplasmic fusion.

UNIT- II – Organization of genome
Components of eukaryotic chromatin - chromatin and chromosome structure- DNA-supercoiling - linking number- Cot curve, C- value paradox - satellite DNA - possible functions - repetitive sequences – transposons.

UNIT- III – DNA replication
Prokaryotic and eukaryotic DNA replication – mechanism of replication, enzymes and necessary proteins in DNA replication, telomeres, telomerase and end replication, role of telomerase in aging and cancer. DNA Mutation and Repair - mutation subtypes, mismatch, base-excision, nucleotide-excision and direct repair. DNA recombination - homologous, non - homologous and site-specific. DNA transposition.

UNIT- IV – Transcription
Prokaryotic and eukaryotic transcription - RNA polymerases - general and specific transcription factors- regulatory elements. Mechanism of transcription regulation and transcription termination. Post-transcriptional modification - 5’ cap formation- 3’end processing and polyadenylation- splicing-editing- nuclear export of mRNA- mRNA stability. Inhibitors of transcription

UNIT- V – Translation

Text Books

Suggested Reading

COURSE OUTCOME: Students will be able to understand the central dogma of molecular biology and fundamentals of biogenesis of macromolecules.
BMB 480 - ANALYTICAL BIOCHEMISTRY LAB

1 Credit

1. **Buffers:** Basic principles, Concept of pH, buffering capacity and pKa, Preparation of different biological buffers in the laboratory, Calculations based on Henderson- Hassel Balch equation Use of pH meters. Handling of buffers and storage concerns.

2. **UV- Visible Spectroscopy:** Basic Principles, Concept of extinction coefficient, absorption spectra of nucleic acids, amino acids and proteins.

3. Separation of biomolecules by precipitation techniques

4. Separation of biomolecules by extraction techniques - Partition chromatography, adsorption chromatography

5. Biomolecule separation by ion exchange chromatography

6. Separation of Biomolecules by Size exclusion chromatography

7. Determination isoelectric point of proteins

8. Electrophoretic separation of proteins

9. Subcellular fractionation by centrifugation

**Reference:**
BCMB 481- BIOMOLECULES LAB

1 Credit

2. Comparative of protein quantification methods – Biuret & Lowry – sensitivity, specificity and interference
5. Estimation of cholesterol.
7. Estimation of free proline.
8. Isolation and estimation of casein in milk.
9. Isolation of cholesterol and lecithin from egg.

Reference:

BCMB 482 - CELL BIOLOGY LAB

1 Credit

1. Observation of eukaryotic cells with the help of light microscope.
2. Permanent slide preparation and preparation of slide for dicot leaf section.
5. Isolation of mitochondria and assay for function.
6. Isolation of peroxisomes and assay for function.
7. Determination of osmotic fragility of cell (goat erythrocyte).
9. Karyotyping
10. Mammalian Cell culture (demonstration and report only)

Reference:
BCMB 483 - ENZYMEOLOGY LAB

1 Credit

1. Estimation of enzyme activity (serum alkaline phosphatase) by endpoint assay.
2. Estimation of enzyme activity (serum alkaline phosphatase/lactate dehydrogenase/horse radish peroxidase) by continuous monitoring assay.
4. Effect of pH on enzyme (horse gram urease/alkaline phosphatase) activity.
5. Effect of Temperature on enzyme (horse gram urease/alkaline phosphatase) activity.
6. Effect of substrate concentration on enzyme (serum alkaline phosphatase/urease) activity.
7. Determination of $K_m$ & $V_{max}$ of an enzyme (horse gram urease/alkaline phosphatase).
8. Partial purification of enzyme and determination of specific activity.
10. Enzyme inhibition studies and determination of Ki (cadmium chloride on alkaline phosphatase).

Reference:

BCMB 484 - MOLECULAR BIOLOGY LAB

1 Credit

1. Extraction of genomic DNA
2. Extraction of plasmid DNA
3. Spectrophotometric analysis of purity of isolated DNA
4. Agarose gel electrophoresis of genomic and plasmid DNA
5. Restriction digestion of chromosomal DNA
6. Restriction digestion of plasmid DNA
7. Isolation of DNA fragment from agarose gel
8. Isolation of RNA

Reference:
BCMB 435 - BIOSTATISTICS AND SCIENTIFIC WRITING

COURSE OBJECTIVES: The objective of the course is to learn basic statistics and scientific communication.

Pre-requisite: Bachelor’s level course in Life Sciences

UNIT- I – Central Tendency and Dispersion of Data
Introduction- definition of statistics-population and universe- the sample and population- statistical inference- parameter and statistics
Handling of bulky data- construction a histogram- interpretation of histogram- the normal distribution- the mean-mode-and standard deviation- uncertainties in estimating a mean.

UNIT- II – Chi Square and Poisson’s Distribution
Proportion data- Examples of Proportion data- MPM- sterility testing of medicines- animal toxicity- infection and immunization studies e.g., LD50, ED50, PD50 statistical treatment to proportion data-
Chi-square test- goodness of fit to normal distribution.
Count data- Examples of count data (bacterial cell count, radioactivity count, colony and plaque count, etc.). Statistical treatment to count data- Poisson’s distribution- standard error- confidence limits of counts.

UNIT- III - Test of significance
Analysis of variance- Introduction –procedure-F and t test.

UNIT- IV – Correlation and Regression
Correlation regression and line fitting through graph points- standard curves- correlation- linear regression (fitting the best straight line through series of points)- standards curves and interpolations of unknown y-values thereon.

UNIT- V – Scientific Writing & Communication
Methodology for writing science report and oral presentation- compilation of experimental record-
program of writing- use of vocabulary- use of good english-art of illustration- report writing- editing and correcting- technique of oral presentation.

Text Book:

Suggested Reading:

COURSE OUTCOME: At the end of the course the students will be able to apply appropriate statistical test for their analysis and will be able to effectively communicate scientifically.
BCMB 436 - GENOMICS

3 Credits

**COURSE OBJECTIVES:** To get an overview of genomics, its functional aspects and understanding of genome analysis.

**Pre-requisite** – Master’s level course in Molecular Biology.

**UNIT- I - Overview of Genomics**
Introduction to Genomics, number of genes and complexity of genomes, Structural genomics, Comparative genomics, Organelle genome: nuclear genome, mitochondria and chloroplast, Concepts of Metagenomics, Conservation and diversity of genomes.

**UNIT- II – The Genome project**
History, organization and goals of human genome project, Strategies for sequencing genomes, Genetic and physical map, DNA segment nomenclature, Organization of human genome: Mitochondrial genome, Gene density, CpG islands, RNA-encoding genes, functionally identical/similar genes, Diversity in size and organization of genes, Annotation. Human genome diversity, Human Microbiome Project, 16S rRNA analysis.

**UNIT- III – Functional genomics**

**UNIT- IV – Molecular markers in genome analysis**
Tools for genome analysis- RFLP, RAPD, AFLP, SSLPs, STR, EST and SNPs, Disease monitoring, Linkage and Pedigree, disease prognosis, genetic counseling.

**UNIT- V – Pharmacogenomics**
Pharmacogenetics, cancer genomics, immunogenomics, somatic cell Genomics, biochemical genomics, single cell analysis, Genetics of globin triplet repeat Disorders, polygenic inheritance, Effects of drugs in individual and susceptibility, Personalized medicine, Synthetic Genomes. Ethics and issues of synthetic.

**Text Books**

**Suggested reading**

**COURSE OUTCOME:** The course will impart understanding of comparative genomics, construction of protein interaction maps and outline the various experimental methods used to identify transcribed parts of a genome.
COURSE OBJECTIVES: To provide an overview of cellular metabolism, organization of metabolic networks and regulatory mechanisms.

Pre-requisite – Master’s level course in Biomolecules and Enzymology.

UNIT- I - General Introduction
10h

UNIT- II - Metabolism of Lipids
8h

UNIT- III - Metabolism of Amino acids
7h
Overview of biosynthesis of non-essential amino acids from amphibolic intermediates – α-ketoglutarate, oxaloacetate, 3-phosphoglycerate. Glucose - alanine cycle, Urea cycle reactions.

UNIT-IV - Metabolism of Porphyrins
8h
Biosynthesis and catabolism of Porphyrins – heme, bile pigments. Metabolism of Purines and Pyrimidines: biosynthesis and catabolism of purines and pyrimidines, regulation of purine and pyrimidine biosynthesis.

UNIT- V - Dietary Minerals
7h
Biological roles of magnesium, sodium, potassium and phosphate trace elements. Metabolism of iron: absorption, storage, transport and excretion, iron deficiency and overload. Genetic errors of metabolism: representative examples– galactosemia, phenylketonuria, alkaptonuria, albinism.

Text Books

Suggested Reading

COURSE OUTCOME: Understanding of different regulatory mechanisms in metabolic pathways, the key regulatory points in metabolic pathways and molecular mechanisms underlying major inherited diseases of metabolism.
BMB 438 - MOLECULAR ENDOCRINOLOGY

**COURSE OBJECTIVES:**
To provide basic understanding of organization, physiology and regulation of endocrine glands along with biological functions and control mechanisms.

**Pre-requisite** – Bachelor’s level course in Life Sciences.

**UNIT- I – Introduction to Endocrinology**
Definition and scope of Endocrinology – historical and anatomical aspects of mammalian endocrine system. Definition of a hormone – chemical nature of mammalian hormones – types of hormone receptors. Secondary messenger systems – General mechanism of signaling by G protein coupled receptors, receptor tyrosine kinase and ion channels. General mechanism of peptide and non-peptide hormone action. Axis and feed-back regulation of endocrine system.

**UNIT - II – Brain and gut hormones**

**UNIT- III – Thyroid and Parathyroid gland hormones**

**UNIT - IV– Adrenal gland and Adipose tissue hormones**

**UNIT- V– Reproductive Endocrinology**

**Text Books:**
Suggested Reading:

COURSE OUTCOME
Development of understanding of organization and functions of endocrine glands, feedback regulations, mechanisms of actions of hormones and clinical importance.
BCMB 439 – MOLECULAR GENETICS

3 Credits

COURSE OBJECTIVES: The course will focus on the fundamental concepts in genetics and techniques used to predict genetic outcomes.

Pre-requisite: Bachelor’s level course in Life Sciences.

UNIT- I - Introduction to Genetics
Molecular Evolution: History of Genetics and Evolutionary biology, Neutral evolution, molecular divergence and molecular clocks; Molecular tools in phylogeny, classification and identification; origin of new genes and proteins; Gene duplication and divergence. Mendelian and non-Mendelian principles: Laws of Inheritance, autosomal inheritance, Chi square analysis, Phenocopy, Inheritance of mitochondrial and chloroplast genes, X- linked Inheritance, Maternal Effect - Sex influenced and sex determined traits.

UNIT- II – Genome Mapping
Mapping in Bacteria, bacteriophages and yeast: - Mapping genes by interrupted mating, deletion mapping Chromosomal Mapping in Eukaryotes: Linkage maps, - Physical Mapping- restriction mapping, mapping with molecular markers, somatic cell hybrids. Linkage mapping in haploid organisms - tetrad analysis, development of mapping population in plants.

UNIT- III – Developmental Genetics

UNIT- IV – Human Genetics

UNIT- V – Mutations and Genetics of Cancer

Text Books

Suggested Reading

COURSE OUTCOME: Basic understanding of Mendelian /transmission genetics and mechanisms of non-Mendelian inheritance of traits, population and quantitative genetics and basic understanding of the genetic basis of development and cancer.
BCMB 485 - GENERAL MICROBIOLOGY LAB

1 Credit

1. Introduction to sterilization techniques- sterilization of glass wares, autoclaving.
2. Preparation of liquid and solid media
3. Isolation of Bacteria and fungi from soil samples – serial dilution technique
4. Measurement of bacterial population
5. Pure culture techniques: spread plate, streak plate technique and pour plate
6. Determination of Bacterial growth curve
7. Identification of bacteria by morphological and Biochemical characteristics
8. Smear preparation and staining of bacteria: simple staining, Grams staining and spore staining
9. In vitro antibiotic sensitivity tests for selected bacterial cultures
10. Methods for preserving microbial cultures: slant, glycerol stock and lyophilization

Reference:

BCMB 486 - METABOLISM AND REGULATION LAB

1 Credit

1. Estimation of urea
2. Estimation of uric acid
3. Estimation of creatinine
4. Determination of bilirubin
5. Estimation of pyruvate
6. Precipitation of calcium and estimation of calcium
7. Assay of acid phosphatase enzyme activity
8. Determination of catalase activity from liver/serum
9. Assay of alcohol dehydrogenase/ glutamate dehydrogenase enzyme activity in liver/ serum
10. Determination of alanine transaminase enzyme activity

Reference:
COURSE OBJECTIVES: To provide understanding of genetic manipulation and gene transfer in addition to providing insights into its success in living systems.

Pre-requisite: Master’s level course in Molecular Biology.

UNIT- I - Introduction to Genetic Engineering
Enzymes used in rDNA technology (Restriction enzymes, nuclease, RNA polymerases, DNA polymerases, PNK, alkaline phosphatases, DNA ligases). Cloning Vectors for E. coli: Plasmids, Bacteriophage λ, Filamentous phage, Cosmids, Phagemids and other advanced vectors: BAC, YAC, P1-derived Artificial Chromosome, Shuttle vectors, Expression vectors.

UNIT- II – Gene Transfer Techniques

UNIT- III - Gene Cloning Strategies

UNIT- IV – Gene Manipulation Techniques

UNIT- V – Expression of Engineered Proteins

Text Books

Suggested Reading
**COURSE OUTCOME:** Understanding of basic cloning, gene transfer techniques and methods of identifying the successful clones and expression of the desired protein, concepts of knock-in, knock-out and gene therapy.
BCMB 537 - IMMUNOLOGY

3 Credits

Course Objectives: To understand the basic concepts in Immunology and techniques used in Immunology research

Pre-requisite: Master’s level course in Cell Biology and Molecular Biology.

UNIT- I -Historic perspectives and introduction to immunology - 8h
History and scope of immunology; Types of Immunity-Innate/basic immunity, Acquired immunity-natural, artificial, active and passive immunity; nature of antigens, immunogenicity, antigenicity, epitopes; PAMPs, DAMPs; PRRs-Toll like receptors, acute phase proteins; functions of cells of myeloid and lymphoid lineage- granulocytes, dendritic cells, macrophages, T and B lymphocytes; Inflammatory response; Pathways of complement activation and its regulation

UNIT- II -Functions of Lymphoid organs- 6h
Primary and Secondary lymphoid organs; development of T and B lymphocytes in Thymus and Bone marrow-positive and negative selection; MHC restriction- types and significance of MHC molecules; antigen processing and presentation to T cells- endogenous and exogenous pathways; Formation of effector T and B lymphocytes in the secondary lymphoid organs; Lymphocyte recirculation

UNIT- III – Humoral Immunity and Immunological Techniques- 8h
Immunoglobulins-structure, types and biological functions; Primary and Secondary immune response; Molecular basis of antibody diversity-multiple germ-line gene segments, somatic gene recombination, N and P nucleotide addition and somatic hypermutation; Mechanism of antigen-antibody interaction; principle and applications of precipitation, agglutination reactions, ELISA, RIA, Western Blotting, and immunofluorescence techniques; Hybridoma technique- principle and methodology for production of monoclonal antibodies; Biomedical applications of murine and humanized monoclonal antibodies

UNIT- IV – Cell Mediated Immunity- 8h
Functions of T cell subsets-Th1, Th2, Treg, CTLs, and NK cells; Mechanism of activation of T cells; Tolerance mechanisms-central and peripheral tolerance-clonal deletion, clonal anergy; Role of cytokines in immune regulation; T cell-B cell interaction-immunoglobulin class switching; Mechanism of target cell killing by CTLs and NK cells-death signaling-induction of apoptosis-intrinsic and extrinsic pathways

UNIT- IV – Immunopathology- 10h
Types and causes of hypersensitivity reactions, autoimmune diseases and immune deficiency diseases; Transplantation immunity-types of grafts and the mechanism of graft rejection; Applications of physical, chemical and biological immunosuppressive agents. Vaccines: conventional vaccines-attenuated, killed and subunit vaccines; Modern vaccines- recombinant vaccines, DNA vaccines and Edible vaccines

Text Books:

Suggested Reading:
COURSE OUTCOME: Students will learn the basics of immune-surveillance mechanisms by both humoral and cell mediated immunity at molecular and cellular level. Students will also acquire knowledge on immunological techniques, immuno prophylaxis and immunotherapy.
BCMB 538 - PROTEOMICS

3 Credits

**COURSE OBJECTIVES:** The course focuses on the detailed study of proteins which represent the major proportion of functional molecules of the cell. The course will familiarize students on the application of technologies for the analysis and quantification of proteins.

**Pre-requisite:** Master’s Level Course in Genetic Engineering.

UNIT- I – Introduction to Proteomics

Human genome - Genomes to Proteomes - HUPO –Human Proteome Project, Branches of proteomics - Protein extraction Methods: Subcellular fractionation, Density gradients, Ultrafiltration, - Protein fractionation - Affinity purification –Removal of interfering compounds, salts, DNA, lipids, Protein solubilization methods, chaotropes, detergents, etc - Sample handling and storage - Stable Isotope Labeling with Amino acids in Culture (SILAC)

UNIT- II – Structural Proteomics

Protein structure-function relationship – Disulfide bonds, Post translational modifications, Glycosylation, Phosphorylation, other modifications, Applications - methods for detection of protein-protein interactions - Yeast 1 and 2 hybrid systems – Phage display – Surface Plasmon Resonance (SPR) - Fluorescence Resonance Energy Transfer (FRET).

UNIT- III – Proteomic Techniques for Analysis


UNIT- IV – Protein expression

Expression Systems –, E. coli, Yeast, Pitchia pastoris, Bacculovirus - introduction, detection and purification of expressed transgenes - antibody capture – antibody generation and Engineering – Protein/peptide chemical synthesis — Protein-polynucleotide interactions Reconstitution of proteins in lipid vesicles, - Liposomes-Peptide and protein drugs.

UNIT- V – Proteomic approach for Clinical studies

Protein Biomarker Discovery and Validation - low abundance and hydrophobic proteins. High through put techniques to identify protein molecules in sample Body fluid profiles, blood disease profiles, diabetes profiles stroke and myocardial infarction, Alzheimer, Proteomics in Biotechnology.

Text Books

Suggested Reading

**COURSE OUTCOME:** The course will impart the knowledge of Structural Proteomics, advances in high throughput technologies, protein engineering approaches for protein structure-function research.
BCMB 560 - GENETIC ENGINEERING LAB

1 Credit

1. Culture of *E. coli* cells & plasmid isolation
2. Preparation of competent cells
3. Calcium chloride mediated transformation
4. Ligation of DNA
5. Polymerase chain reaction
6. Restriction fragment length polymorphism
7. Random amplified polymorphic DNA
8. Sub-cloning of GFP protein

Reference:

BCMB 561 - IMMUNOLOGY LAB

1 Credit

1. Agglutination reactions- Active agglutination- Widal Test, Blood group analysis
2. Passive agglutination reactions -Latex agglutination Test
3. Precipitation reactions on gel-double immuno diffusion
4. Single radial immunodiffusion (SRID)
5. Immunelectrophoresis (IEP)
6. ELISA technique
7. SDS-PAGE analysis
8. Immunoblotting technique

Reference:
BCMB 441 - GENERAL MICROBIOLOGY  

3 Credits

Course Objectives: To develop a lucid understanding of the microbial diversity, structural features of prokaryotes, culture conditions for bacteria and major microbial diseases.

Pre-requisite: Bachelor’s level course in Life Sciences.

UNIT- I - Introduction to Microbiology  
6h

UNIT- II - Microbial diversity: 8h
Carl Woese’s three domain system of classification. Major groups of bacteria- Archaeabacteria, Eubacteria- identification of bacteria based on phenetic, physiologic/metabolic characteristics and molecular phylogeny. General characteristics of major groups of Fungi, viruses and protozoa.

UNIT- III – Structural features of prokaryotic cells  
8h
Structure of Gram positive and Gram negative bacterial cell walls, periplasm, flagella, pili, capsule, cell membrane, nucleoid, plasmids, inclusion bodies and endospores; Life cycle of DNA and RNA viruses, bacteriophages - Lysogeny and Lytic cycle; Importance of virus like agents.

UNIT- IV – Culture techniques  
8h
Sterilization methods-physical and chemical methods-disinfectants, antiseptic agents; Culture media - composition and uses of solid, liquid, simple, complex, differential and selective media; continuous and synchronous culture; bacterial growth kinetics; Effect of pH, temperature and radiation on growth.

UNIT- V – Microbial diseases and antimicrobial agents  
10h
Respiratory diseases-diphtheria, tuberculosis, pneumonia and Influenza; Skin diseases-measles, chickenpox, human papilloma virus, and dermatophyte (tinea) infections; Diseases affecting GIT- Oral thrush, typhoid, cholera, pathogenic E. coli infections, amoebiasis, and hepatitis; Genitourinary infections – syphilis, candidiasis, HIV; Protozoan and helminthic diseases- malaria, trypanosomiasis and leishmaniasis, filariasis; Mode of action of antimicrobial agents - antibacterial, antiviral, antifungal, antihelminthic and antiprotozoan drugs; Mechanism of development of antibiotic resistance in microbes.

Text Books:

Suggested Reading:

COURSE OUTCOME: The course will impart knowledge on microbial diversity, structural features of different prokaryotes, growth characteristics of bacteria, major microbial diseases and their control.
BCMB 442 – HUMAN PHYSIOLOGY

3 Credits

COURSE OBJECTIVES: This course aims to introduce the students to the Physiological concepts of homeostasis and control mechanisms and to study the functions of body systems- with emphasis on clinical relevance.

Pre-requisite: Bachelor’s level course in Life Sciences.

UNIT- I – Introduction and the Digestive System 8h
Internal environment and homeostasis- coordinated body functions. Digestion- digestive processes at various regions of digestive system, regulation of -gastric secretion and motility- intestinal secretion and motility - role of gastrointestinal hormones.

UNIT- II – Cardiophysiology 8h
Functional anatomy of heart - genesis and spread of cardiac impulses - cardiac cycle- heart sound- cardiac output- cardiovascular regulatory mechanisms - basic E.C.G. (Lead-II).

UNIT- III – Respiratory physiology 8h

UNIT- IV – Renal physiology 8h

UNIT- V – Nerve and Muscle Physiology 8h
Nerve physiology - structure of neuron and synapses – excitability - action potential - conduction of never impulse-synaptic transmission - neurotransmitter systems. 
Muscle physiology- skeletal and smooth muscle - electrical properties and ionic properties - types of muscle contraction.

Text Books

Suggested Reading

COURSE OUTCOME
The course will impart understanding of the structure function association of the physiological systems.
BCMB 443 - PLANT BIOCHEMISTRY AND BIOTECHNOLOGY  

3 Credits

COURSE OBJECTIVES: To learn basic metabolic processes plants in addition to theoretical knowledge of various applications like tissue culture, transgenic crops and micro propagation.

Pre-requisite: Bachelor’s level course in Life Sciences.

UNIT- I - Introduction to Plant cells  
9 h

UNIT- II- Nitrogen metabolism & Plant hormones  
9 h
Physical and biological nitrogen fixation - ammonification, nitrification, denitrification. Biochemistry and genetics of nitrogen fixation and ammonium assimilation.
Biosynthesis, physiological effects and mechanism of action of auxins, gibberellic acids, cytokinins, abscisic acid, ethylene, brassinosteroids and polyamines.
Photomorphogenesis – phytochrome, cryptochrome and photoperiodism.

UNIT- III - Plant Stress physiology & Secondary metabolites  
7 h
Plant stress, plant responses to abiotic and biotic stresses, water deficit and drought resistance, flooding, temperature stress, salt stress, ion toxicity, pollution stress and potential biotic stress (insects and diseases).

UNIT- IV- Introduction to plant tissue culture  
8 h

UNIT- V- Application of Plant Biotechnology  
7 h

Text Book:

Suggested Reading:

COURSE OUTCOME: Basic knowledge of plant physiology and various metabolic processes and applications for crop improvement and micro propagation.
BCMB 541 - CANCER BIOLOGY

3 Credits

COURSE OBJECTIVES:
To understand cancer and the complex mechanisms that underlie its development and progression and thus to identify ways to treat the disease.

Pre-requisite: Master’s level course in Cell Biology and Molecular Biology.

UNIT-I- Introduction to Cancer

UNIT-II- Cancer cell biology and biochemistry

UNIT-III- Carcinogenesis & Free radicals

UNIT-IV - Cancer cell regulation
Cell Cycle Regulation-Tumor suppressor genes p53, p21, Rb, BRCA1 and BRCA2. Telomeres and Immortality; cell- cell interactions, cell adhesion-invasion and metastasis - VEGF signaling, angiogenesis. Hypoxia; Epigenetics-Role of DNA methylation in gene silencing- epigenetic silencing; Apoptosis in cancer-cell death by apoptosis–role of caspases; Death signaling pathways-mitochondrial and death receptor pathways. Autophagy in cancer.

UNIT-V - Diagnosis and Cancer treatment

Text Book:

Recommended Reading:

**COURSE OUTCOME:**
On completion of this course, a student will get the basic biochemistry, development of cancer and regulation at cellular level. Strategies of anti-cancer drug therapy have also been introduced.
**BCMB 542 - CLINICAL BIOCHEMISTRY**  

**3 Credits**

**COURSE OBJECTIVES:** The course focuses on understanding the methodology and interpretation of biochemical tests performed on body fluids and tissues to support diagnosis, treatment and monitoring disease.

**Pre-requisite:** Master Level Course in Metabolism.

**UNIT- I - Clinical biochemistry and quality assurance**  
8h
Clinical biochemistry: concept, definition and scope; Biological samples: types, collection, processing, stability and storage; Phlebotomy tubes; Chemical composition of biological fluids: blood, urine and cerebrospinal fluid; Reference range; Quality assurance; Accuracy, precision and reliability; other factors in quality control Factors. Values in health and diseases.

**UNIT- II – Kidney and Liver function test**  
10h
Kidney function test: Assessment of renal function, creatinine clearance, renal calculi, uremia, Laboratory investigation of kidney disorders: acute and chronic renal failure.
Liver function tests: Clinical features and diagnosis of liver function tests. Bile pigments formation of bilirubin, urobilinogen, bile acids. Jaundice; pre-hepatic, hepatic and post hepatic, plasma changes, clinically important enzymes; alkaline phosphatase, AST, ALT and isoenzymes of creatinine kinase and LDH, prothrombin time.

**UNIT- III – Disorders of carbohydrate and lipid metabolism**  
6h
Diabetes mellitus, insulin receptors and c-peptide assay, proinsulin and insulin antibodies. Hemoglobin Alc; fructosamines, insulin tolerance test. Glycogen storage diseases, galactosemia, fructosuria, pentosuria. Obesity, Hypercholesterolemia, Metabolic syndrome.

**UNIT- IV – Prenatal Diagnosis**  
8h

**UNIT- V – Molecular diagnosis of genetic defects**  
8h
DNA probes; restriction fragment length polymorphism (RFLP); polymerase chain reaction (PCR); amplification of mRNA. Diagnosis of genetic diseases by molecular biology techniques (cystic fibrosis, Hemachromatosis, thalassemias, sickle cell diseases), Clinical diagnosis of AIDS.

**Text Books**

**Suggested Reading**

**COURSE OUTCOME:** The course will enable the students to clinically assess the laboratory indicators of diseases and the biochemical and molecular tools needed to accomplish preventive, diagnostic, and therapeutic intervention on hereditary and acquired disorders.
BCMB 543 – STEM CELL AND REGENERATIVE BIOLOGY

3 Credits

COURSE OBJECTIVES: The course will focus on the biology and mechanism involving stem cells, their applications in replacing, regenerating and engineering human cells for translational regenerative medicine and ethical issues associated with the same.

Pre-requisite: Master’s level course in Cell Biology.

UNIT- I – Introduction to Stem Cells
Definition and Criteria for Stem Cells; Pluripotent, Multipotent and Totipotent Stem cells; Primordial germ cells, Embryonic stem cells; Amniotic fluid derived stem cells; Cord blood stem cells.

UNIT- II – Stem Cell Biology and Mechanisms
Molecular Basis of Pluripotency, Mechanisms of Self Renewal, Role of LIF/JAK/STAT, Nodal/Activin/TFGβ, FGF/MAP kinase pathways, Chromatin signature of pluripotent cells, Cell cycle regulators in Stem cells; Stem cell niches, Change of phenotype and differentiation, Senescence of Dividing somatic cells, aging and stem cell renewal, Quiescent Stem Cells.

UNIT- III – Tissue and Organ Development
Differentiation in early development, Potency, Commitment, Polarity and the specification of asymmetric divisions, induction, competence determination and differentiation, morphogenetic gradients, cell fate and cell lineages, Epigenetic silencing and lineage commitment; Cellular differentiation of the nervous system, Progenitors in adult brain, Epithelial stem cells; Adult progenitor cells, Mesenchymal stem cells, Plasticity; De-differentiation, Cancer stem cells.

UNIT- IV – Stem Cell Technology
Characteristics and characterization of Human Pluripotent Cells; Fluorescence and Magnetic bead assisted cell sorting, Derivation, characterization and maintenance of Murine and Human Embryonic Stem Cells, Differentiation of embryonic stem cells; Derivation of induced pluripotent stem cells; Derivation and differentiation of Human Embryonic Germ Cells; Genomic Reprogramming, Fate Mapping of Stem Cells.

UNIT- V – Stem Cells in Regenerative Therapeutics
Neural stem cells in Neurodegenerative diseases; Hematopoietic stem cell transplantation; Epithelial stem cells and burns; Stem cells and heart disease; Pancreatic stem cells and diabetes; Liver stem cells and cell therapy for liver disease; Embryonic stem cells in tissue engineering, Examples of stem cells in Clinical Trials and translational therapeutics, stem cell banking, Ethical concerns in stem cell research.

Text Books:

Suggested Reading:

COURSE OUTCOME: The course will provide the basic understanding of stem cell biology and their applications in translational therapeutics.
OBJECTIVES: This is a job oriented course which will introduce the basic principles of modern drug design, discovery and regulations of drug development. The course will impart knowledge on clinical trials management, regulatory affairs and patent rights.

Pre-requisite: Master’s Level Course in Genetic Engineering.

UNIT- I 8h
General Introduction to public health, drug design and drug discovery, Sources of drugs – Plants, Microbial and Animal origin, Recombinant therapeutic proteins – Use of transgenic models for therapeutic purpose, Drug delivery systems, Pre-clinical drug development strategies.

UNIT- II 6h
Clinical Trials – Fundamentals of clinical operations, Study design and methodology in clinical trials, Inclusion and Exclusion criteria, Informed Consent process, Clinical Trials Phase- I, II, III, IV; Monitoring treatment outcome and Termination of a trial, Clinical data management, Quality control; Ethical, Legal and Regulatory aspects of clinical trials.

UNIT- III 6h

UNIT- IV 9h
Regulatory Affairs - Regulatory aspects for drug product design, Drug and Cosmetics Act, Schedule-Y, Regulatory bodies in India and regulations in developed countries, Medical device registration; Preparation, review and submission of drug master files to regulatory bodies, Final approval procedures. Patent and Intellectual property rights – Importance and overview of IPR, The Indian Patents Act, Type of patents, Provisional applications and Patent infringement.

UNIT- V 7h
Guidelines: Guides to Good Manufacturing Practice (GMP), Good Laboratory Practice (GLP), Good Clinical Practice (GCP), Central Drugs Standard Control Organization (CDSCO) guidelines, International Council for Harmonization of Technical Requirement for Pharmaceuticals for Human Use (ICH) guidelines – Quality, Safety, Efficacy and Multidisciplinary guidelines; WHO and FDA guidelines; NABL and NABH.

Text books:

Suggested Reading:
from ADME to Toxicity Optimizatio, Elsevier Inc, Academic Press, California.


**COURSE OUTCOME**

*The students will get orientation towards the protocols followed in pharmaceutical industry.*
BCMB 545 - DEVELOPMENTAL BIOLOGY AND AGEING  
3 Credits

**COURSE OBJECTIVES:** The course offers a detailed understanding of the intricacies of developmental biology and how each step of development, patterning and ageing process takes place and how it is regulated at the molecular and cellular level.

**Course Pre-requisite:** Master Level Course in Cell Biology and Molecular Biology.

**UNIT - I – Introduction to Developmental Biology**  
6h  
History and basic concepts of development: Potency, commitment, specification, induction, competence, determination and differentiation. Morphogenetic gradients, cell fate and cell lineages, stem cells, genomic equivalence and the cytoplasmic determinants, imprinting, mutants and transgenics in analysis of development.

**UNIT - II – Early embryonic development**  
9h  

**UNIT - III – Cell-cell communication and signaling in development**  
6h  
Concepts of induction and competence, epithelial-mesenchymal interactions, role of FGF-RTK pathway, JAK-STAT, Hedgehog family, Wnt family, TGF-β superfamily, Notch pathway and developmental signals from extracellular matrix. Juxtacrine signaling and cell patterning.

**UNIT - IV – Model organisms, organogenesis and Sex determination**  
9h  

**UNIT - V – Postembryonic development and ageing**  
10h  

**Text Books:**

**Suggested reading:**

**COURSE OUTCOME:** The course will enable to gain a clear understanding of the stages of development, patterning and ageing process in various model organisms.
BCMB 546 – NEUROBIOLOGY

3 Credits

COURSE OBJECTIVES: The course focuses on the basic concepts Neurobiology and observing the interdisciplinary nature of the Neurosciences will encourage participation from students majoring in Physics, Chemistry, Psychology and Computer Science alongside the students of the School of Life Sciences. Pre-requisite: Bachelor’s level course in Basic Biology.

UNIT- I – Gross Neuroanatomy and Cellular Components of Nervous System 10h

UNIT- II – Developmental Neurobiology 7h
Induction and patterning of body axis and neural development – Homeotic induction, morphogenic gradients, role of sonic hedgehog, TGF β and Wnt signaling, generation and survival of neurons and glia – Role of Notch Signaling and JAK STAT pathway - Activity dependent maturation of synapses – plasticity of mature synapses and circuits. Regeneration and Repair: Regenerative repair in the CNS and PNS, Stem cells in regenerative therapy.

UNIT- III – Neurotransmitters 10h

UNIT- IV – Brain and Behavior: 7h
Approaches and methods in study of behavior; Proximate and ultimate causation; Development of behavior; Social communication; Habitat selection, Social dominance, Mating systems, Parental investment and Reproductive success; Aggressive behavior, Migration, orientation and navigation, Photo-periodism, Circadian Rhythm– Sleep and arousal. Neural basis of Complex Behaviors: Learning, memory, Emotions, Stress and Adaptation, Altruism and evolution.

UNIT- V – Neurodegenerative and Neurochemical Disorders 6h

Text Books

**Suggested Reading**

**COURSE OUTCOME:** The course will provide the basic understanding of anatomical organization of the central and peripheral nervous system and its development, how communication in neural circuits leads to sensory perceptions, movement, behavior, learning and memory. Mechanisms of neurodegenerative processes and cellular processes of regeneration and basic neuropharmacology.
BCMB 547 - INDUSTRIAL CONVERGENCE IN LIFE SCIENCES

2 Credits

**COURSE OBJECTIVES:**
Skill development geared towards trained manpower for employment & entrepreneurship
Understand the present trends in life science industry
Familiarization to role of microbiome & awareness
Responsibility towards environment & climate change
Initiate curiosity in entrepreneurship.

**Course Pre-requisite:** Master’s Level Course in Genetic Engineering.

**UNIT – I** 6h

**Introduction to biofoundries & biofactories** – Introduction to synthetic biology. Production of artemisinin as case study. Building the new bio-economy. Introduction to Biofoundries & circuits. Role of automation and robotics in biofactories; use of plants for engineering biologics & small molecules. Biosurfactants as an example of microbial cell factory based production.

**UNIT- II** 5h

**Contemporary techniques in industry** – Gene shuffling for large scale pathway assembly and engineering; Choices for microbial hosts for industrial applications– bacteria, yeast, insect. Gene editing methods – CRISPR/ Cas; Gene sequencing – Pyro sequencing, Nanopore sequencing.

**UNIT- III** 5 h

**Microbiome Communities** – Definition & role of microbiome on human health and wellbeing; Role of 16s rRNA based identification – metagenomics approaches for microbiome analysis; Human Microbiome project; Anti-microbial resistance and superbugs – methods to counter; specific case studies on its influence (positive & negative) on plants (soil microbiome), animals (poultry – minimize use of antibiotics) and aquaculture (viruses). Rapid responses to counter bio-terrorism.

**UNIT – IV:** 5h

**Conservation Biology & Climate Change** - Impact of climate change, Community response and Government policies, Ecological footprint, Clean Development Mechanism (CDM); Earth summit, Kyoto protocol, Framework convention on Climate change (UNFCCC); Genetic methods for conservation biology; Assessment of carbon and water footprint on processes. Biodiversity act & agencies regulating it (National & State biodiversity authorities). Potential biological methods to counter plastic & e-wastes.

**UNIT – V** 5h

**Introduction to Entrepreneurship in life sciences** – Need for entrepreneurship in life-sciences, Types of life-scientific companies in India (biopharma, bioagri, bioinformatics, bio services, biocatalysts, bioindustrial) and their growth; New startups & bio-medical device companies; Types of bio-incubators (Bioparks, Bioclusters, BioNests); Bio industry associations – BIO, ABLE,
AIBA: Funding avenues in India for entrepreneurship development – Government initiates (DBT - BIRAC), philanthropic (Gates, Wellcome, DNDi) & private funding; Types of companies and steps in company formation; Steps in compiling business plan. Introduction to regulatory agencies – DGCI, CIB, NBA, GEAC, FSSAI, CDSCO, ISO.

**Text Books:**

**Suggested Reading:**
1. Gene editing
   ii. https://www.addgene.org/crispr/guide/
7. CII report on biotech startups in India, 2017.
BCMB 548 - NANOBIO TECHNOLOGY  

3 Credits

**COURSE OBJECTIVES:** The aim of this course is to provide basic knowledge about applications of nanoscience in the field of Biotechnology and Medicine.

**Pre-requisite:** Bachelor’s level course in Life Sciences.

UNIT- I – Introduction  
Overview of Nanomaterials and nanoparticles in biological applications; Biomimetic nanostructures; Overview of DNA and protein based nanostructures; Inorganic nanoparticles; Applications of nanotechnology in bioseperations, enzymatic reactions and tissue/cell culture.

UNIT- II- Biological synthesis and characterization of nanomaterials  
Biosynthesis- microbial, plant mediated synthesis. biofunctionalization of nanosurfaces with peptides and proteins. Bacteriorhodopsin: structure and its potential applications in nanobiotechnology; S-layers: structure and its applications; Cell-nanomaterial interactions; Monitoring nano-bio interactions: Cell targeting and cell penetrating peptides; Atomic Force Microscopy.

UNIT -III -Implications of Nanobiotechnology  
Nanotoxicity: Absorption and distribution of Nanoparticles in vivo; Toxicological effects of nanoparticles in various target organs in vivo.

UNIT- IV -Nanostuctures for Analytics  
Nanoparticles for electrobiochemical assays; Quantum dots in biology; Nanoparticle based biosensors; Protein nanoarrays; DNA nanoarrays; Lab-on-a-chip; Microfluidics: Definition and history, Advantages of microfluidic devices and their potential for nanobiotechnology.

UNIT- V-Nanoparticles for Diagnostic and Therapeutics  
Introduction to drug delivery; Drug delivery systems based on nanotechnology; PLGA, lipid based nanoparticles, nanocrystals; Nanocarriers for applications in medicine; siRNA delivery using nanoparticles; Targeted drug delivery using nanocarriers; Nanoparticle contrast agents for magnetic resonance imaging; Nanodiamonds for bioimaging and therapeutic applications; Nanotherapeutics.

**Text Books:**

**Suggested Reading:**

**COURSE OUTCOME:** The course will enable to account for interaction of biomolecules with surfaces of different chemical and physical species, account for production and the applications of various types of nanostructured materials.
BCMB 580 - PRE- PROJECT & PRESENTATION

1 Credit

COURSE OBJECTIVES:

To enable the students to identify a research problem, perform review of literature, plan a study to address the same and frame a research proposal and defend the same.

Course Pre-requisite: Master Level Course on Biostatistics and Scientific Writing.

Course Plan –

This course will have the following components –

1. Identifying a Research Problem.
3. Planning a study to address the research question.

COURSE OUTCOME:

The students will learn to-

- Identify research gaps through study of scientific literature and device ways to address the same.
- Review Literature in their respective field of Research.
- Gain the experience of presenting a research proposal before an evaluating committee.
BCMB 581 - DISSERTATION

4 Credits

**COURSE OBJECTIVES:**
To enable the students to have hands-on research experience and write a comprehensive report, present, and defend the same.

**Course Pre-requisite:** BCMB 548: Pre-Project and Presentation

**Course Plan** -
This course will have the following components –

1. Executing the proposed Research Plan.
2. Designing and planning experiments.
3. Performing experiments or *in silico* studies based on the criteria.

**COURSE OUTCOME:**
The students will learn to execute a research proposal, prepare a project report and present, and defend the same.