RAMAKRISHNA MISSION VIVEKANANDA EDUCATIONAL AND RESEARCH INSTITUTE (RKMVERI)

(Deemed-to-be-University)

(Declared by Government of India under section 3 of UGC Act, 1956)

P.O. Belur Math, District- Howrah, West Bengal: 711202

SCHOOL OF BIOLOGICAL SCIENCES

FACULTY CENTRE FOR INTEGRATED RURAL DEVELOPMENT AND MANAGEMENT (IRDM)

Ramakrishna Mission Ashrama, Narendrapur

In Collaboration with

Ramakrishna Mission Seva Pratishthan Hospital, Kolkata

Two year M. Sc. in 'Medical Biotechnology'

PROPOSED COURSE CONTENT (with effect from academic year 2020-21)

Semester-I

Module	Title of the Course	Credits
MBT 101	Biochemistry	3+0=3
CBT 101	Molecular Biology	3+0=3
MBT 102	Genetics and Epigenetics	3+0=3
MBT 103	Cell and Developmental Biology	3+0=3
CBT 102	Biophysical Principles and Analytical Techniques	3+0=3
ARD 106	Spiritual and Cultural Heritage of India-I	2+0=2
MBT 104	Laboratory-I: Biochemistry	0+3=3
MBT 105	Laboratory-II: Cell Biology and Microscopy	0+3=3
	TOTAL	17+6=23

Semester-II

Module	Title of the Course	Credits
CBT 201	Genetic Engineering	3+0=3
CBT 202	OMICS: Genomics, Transcriptomics, Proteomics and Metabolomics	3+0=3
MBT 201	Basics of Microbiology and Immunology	3+0=3
CBT 203	Introduction to Bioinformatics	2+1=3
CBT 204	Basics of Mathematics and Statistics	2+1=3
ARD 207	Spiritual and Cultural Heritage of India-II	2+0=2
CBT 205	Laboratory-III: Microbiology	0+3=3
CBT 206	Laboratory-IV: Molecular Biology and Genetic Engineering	0+3=3
	TOTAL	15+8=23

Semester-III

Module	Title of the Course	Credits
MBT 301	Medical Microbiology and Infection Biology	3+0=3
MBT 302	Clinical Biochemistry and Disease Metabolism	3+0=3
MBT 303	Molecular Diagnostics and Medical Devices	3+0=3
MBT 304	Tissue Engineering and Stem Cell Therapy	3+0=3
MBT 305	Laboratory-V: Medical Microbiology	0+3=3
MBT 306	Laboratory-VI: Clinical Biochemistry	0+3=3
MBT 307	Laboratory-VII: Cell and Tissue Culture	0+3=3
MBT 308	Seminar-I: Journal Club Presentation	0+2=2
	Recommended Electives (Optional)	3*
	TOTAL	12+11=23*

Semester-IV

Module	Title of the Course	Credits
CBT 401	Intellectual Property Rights, Biosafety and Bioethics	2+0=2
MBT 401	Seminar-II: Dissertation Work	0+1=1
MBT 402	Dissertation Work	0+20=20
	TOTAL	2+21=23

Recommended Electives

Module	Title of the Course	Credits
MBT 309	Basics of Human Physiology	3+0=3
MBT 310	Sports Medicine	3+0=3
MBT 311	Stress and Cognitive Biology	3+0=3
MBT 312	Systems and Synthetic Biology	3+0=3
MBT 313	Medical Physics	3+0=3

Course Structure at a Glance

Core Courses:

Module	Title of the Course	Credits
MBT 101	Biochemistry	3+0=3
MBT 104	Laboratory-I: Biochemistry	0+3=3
CBT 101	Molecular Biology	3+0=3
MBT 102	Genetics and Epigenetics	3+0=3
MBT 103	Cell and Developmental Biology	3+0=3
CBT 102	Biophysical Principles and Analytical Techniques	3+0=3
CBT 201	Genetic Engineering	3+0=3
CBT 202	OMICS: Genomics, Transcriptomics, Proteomics and Metabolomics	3+0=3
MBT 201	Basics of Microbiology and Immunology	3+0=3
CBT 205	Laboratory-III: Microbiology	0+3=3
CBT 206	Laboratory-IV: Molecular Biology and Genetic Engineering	0+3=3

Discipline-specific Courses:

Module	Title of the Course	Credits
MBT 105	Laboratory-II: Cell Biology and Microscopy	0+3=3
MBT 301	Medical Microbiology and Infection Biology	3+0=3
MBT 302	Clinical Biochemistry and Disease Metabolism	3+0=3
MBT 303	Molecular Diagnostics and Medical Devices	3+0=3
MBT 304	Tissue Engineering and Stem Cell Therapy	3+0=3
MBT 305	Laboratory-V: Medical Microbiology	0+3=3
MBT 306	Laboratory-VI: Clinical Biochemistry	0+3=3
MBT 307	Laboratory-VII: Cell and Tissue Culture	0+3=3

Generic-elective Course:

Module	Title of the Course	Credits
CBT 204	Basics of Mathematics and Statistics	2+1=3

Ability Enhancement Courses:

Module	Title of the Course	Credits
ARD 106	Spiritual and Cultural Heritage of India-I	2+0=2
ARD 207	Spiritual and Cultural Heritage of India-II	2+0=2
CBT 401	Intellectual Property Rights, Biosafety and Bioethics	2+0=2

Skill Enhancement Courses:

Module	Title of the Course	Credits
MBT 104	Laboratory-I: Biochemistry	0+3=3
MBT 105	Laboratory-II: Cell Biology and Microscopy	0+3=3
CBT 203	Introduction to Bioinformatics	2+1=3
CBT 205	Laboratory-III: Microbiology	0+3=3
CBT 206	Laboratory-IV: Molecular Biology and Genetic Engineering	0+3=3
MBT 305	Laboratory-V: Medical Microbiology	0+3=3
MBT 306	Laboratory-VI: Clinical Biochemistry	0+3=3
MBT 307	Laboratory-VII: Cell and Tissue Culture	0+3=3
MBT 308	Seminar-I: Journal Club Presentation	0+2=2
MBT 401	Seminar-II: Dissertation Work	0+1=1

Bridging Course:

Module	Title of the Course	Credits
MBT 309	Basics of Human Physiology	3+0=3

Semester-I [Total: 17 (T) + 6 (P) = 23 Credits]

MBT 101: Biochemistry — 3 Credits Theory

Course Objectives: The objectives of this course are to build upon undergraduate level knowledge of biochemical principles with specific emphasis on different metabolic pathways. The course shall make the students aware of various disease pathologies within the context of each topic.

Student Learning Outcomes: On completion of this course, students should be able to:

- Gain fundamental knowledge in biochemistry;
- Understand the molecular basis of various pathological conditions and clinically important enzymes from the perspective of biochemical reactions.

Syllabus:

Unit-I **Chemical Basis of Life** **3 Lectures (6 hours)**	Chemical basis of life: Miller-Urey experiment, abiotic formation of amino acid oligomers, composition of living matter; Water: properties of water, essential role of water for life on earth pH, buffer, maintenance of blood pH and pH of gastric juice, pH optima of different enzymes (pepsin, trypsin and alkaline phosphatase), ionization and hydrophobicity, emergent properties of biomolecules in water, bio-molecular hierarchy, macromolecules, molecular assemblies.
Unit-II **Protein Structure** **6 Lectures (12 hours)**	Structure-function relationships: amino acids: structure and functional group properties, peptides and covalent structure of proteins, elucidation of primary and higher order structures, Ramachandran plot, evolution of protein structure, protein degradation and introduction to molecular pathways controlling protein degradation, structure-function relationships in model proteins like ribonuclease A, myoglobin, hemoglobin, chymotrypsin etc.; basic principles of protein purification; tools to characterize expressed proteins; Protein folding: Anfinsen's Dogma, Levinthal paradox, co-operativity in protein folding, free energy landscape of protein folding and pathways of protein folding, molten globule state, chaperons, diseases associated with protein folding, introduction to molecular dynamic simulation.
Unit-III **Enzyme Kinetics**	Enzyme catalysis: general principles of catalysis; quantitation of enzyme activity and efficiency; enzyme characterization and Michaelis-Menten kinetics; relevance of enzymes in metabolic regulation, activation, inhibition

5 Lectures (10 hours)	and covalent modification; single substrate enzymes; concept of catalytic antibodies; catalytic strategies with specific examples of proteases, carbonic anhydrases, restriction enzymes and nucleoside monophosphate kinase; regulatory strategies with specific example of hemoglobin; isozymes; role of covalent modification in enzymatic activity; zymogens.
Unit-IV **Glycobiology** **2 Lectures (4 hours)**	Sugars: mono, di, and polysaccharides with specific reference to glycogen, amylose and cellulose; glycosylation of other biomolecules: glycoproteins and glycolipids.
Unit-V **Lipid Structure** **1 Lecture (2 hours)**	Structure and properties of important members of storage and membrane lipids; lipoproteins Self-assembly of lipids, micelle, biomembrane organization.
Unit-VI **Bioenergetics & Metabolism** **6 Lectures (12 hours)**	Basic principles; equilibria and concept of free energy; coupled interconnecting reactions in metabolism; oxidation of carbon fuels; recurring motifs in metabolism; Glycolysis and gluconeogenesis; reciprocal regulations and non-carbohydrate sources of glucose; Citric acid cycle, entry to citric acid cycle, citric acid cycle as a source of biosynthetic precursors; Oxidative phosphorylation; importance of electron transfer in oxidative phosphorylation; Photosynthesis: chloroplasts and two photosystems; proton gradient across thylakoid membrane; Calvin cycle and pentose phosphate pathway; glycogen metabolism, reciprocal control of glycogen synthesis and breakdown, roles of epinephrine and glucagon and insulin in glycogen metabolism; Fatty acid metabolism; protein turnover and amino acid catabolism; nucleotide biosynthesis; biosynthesis of membrane lipids and sterols with specific emphasis on cholesterol metabolism and mevalonate pathway; elucidation of metabolic pathways; logic and integration of central metabolism; entry/ exit of various biomolecules from central pathways; principles of metabolic regulation; steps for regulation; target of rapamycin (TOR) & Autophagy regulation in relation to C & N metabolism, starvation responses.
Unit-VII **Pathophysiology & Clinically Important Enzymes**	Enzymes of clinical significance- Creatine Kinase, Lactate Dehydrogenase, Aspartate Aminotransferase, Alanine Aminotransferase, Alkaline Phosphatase, Acid Phosphatase, Glutamyl transferase, Amylase, Lipase, Glucose-6-

4 Lectures (8 hours)

Phosphate Dehydrogenase, Cholinesterase, Enolase. Drug-Metabolizing Enzymes, Tumour markers, Bone markers, Cardiac markers, liver markers, Enzymes as therapeutic agents, Enzymes used for diagnosis, immobilized enzymes. Inborn errors associated with carbohydrate metabolism; Inborn errors of metabolism- Glycogen storage diseases, Fructosuria, Fructose intolerance, Pentosuria, Galactosuria, Urine screening.

Recommended Textbooks:

1. Stryer, L. *Biochemistry*. New York: Freeman.
2. Lehninger, A. L. *Principles of Biochemistry* (4th ed.). New York, NY: Worth.
3. Voet, D., & Voet, J. G. *Biochemistry* (4th ed.). Hoboken, NJ: J. Wiley & Sons.
4. Segel, I. H. Biochemical Calculations (2nd ed.). J. Wiley & Sons.

CBT 101: Molecular Biology — 3 Credits Theory

Course Objectives:

The objectives of this course are to make students understand how molecular machines are constructed and regulated so that they can accurately copy, repair, and interpret genomic information in prokaryotes and eukaryotic cells. Further, to appreciate the subject of molecular biology as a dynamic and ever-changing experimental science.

Student Learning Outcomes:

On completion of this course, students should be able to:

- Gain fundamental knowledge on molecular architecture of prokaryotic and eukaryotic genomes;
- Understand the various molecular events that lead to duplication of DNA, recombination of genes, transcription and translation following a central dogma;
- Understand molecular mechanisms behind different modes of gene regulation in bacteria and eukaryotes.

Syllabus:

Unit-I

Structure of DNA and RNA

5 Lectures (10 hours)

Structure of DNA: A, B, Z and triplex DNA; Central dogma, DNA and RNA as genetic material; DNA contents and C-value paradox; melting and buoyant density; Tm; DNA reassociation kinetics (Cot curve analysis); Repetitive and unique sequences; Satellite DNA. RNA: Structure, and Function.

Unit-II

Replication: initiation, elongation and termination in prokaryotes and eukaryotes; Enzymes and accessory

DNA Replication, Repair and Recombination **6 Lectures (12 hours)**	proteins and mechanisms; Fidelity; Replication of single stranded circular DNA; link with cell cycle; DNA damaging agents: Physical, chemical and biological mutagens; types of damage caused by endogenous and exogenous agents; Mutations: nonsense, missense, silent and point mutations, frameshift mutations; Intragenic and Intergenic suppression. DNA repair mechanisms: direct reversal, photoreactivation, base excision repair, nucleotide excision repair, mismatch repair, double strand break repair, SOS repair; Recombination: Chi sequences in prokaryotes; Homologous, non-homologous and site specific recombination.
Unit-III **RNA Transcription, RNA Processing and Regulation in Prokaryotes** **6 Lectures (12 hours)**	Structure and function of prokaryotic mRNA, tRNA (including initiator tRNA) and rRNA (and ribosomes); Prokaryotic Transcription: RNA polymerase and sigma factors, Transcription unit, Promoters, Promoter recognition, Initiation, Elongation and Termination (intrinsic, Rho and Mfd dependent); Processing of mRNA, rRNA and tRNA transcripts; Gene regulation: Repressors, activators, positive and negative regulation, Constitutive and Inducible, small molecule regulators, operon concept: lac, trp, his operons, attenuation, anti-termination, stringent control, translational control, DNA re-arrangement, two component system; regulatory RNA: riboswitch, tmRNA, antisense RNA; transcriptional control in lambda phage.
Unit-IV **RNA Transcription, RNA Processing and Regulation in Eukaryotes** **6 Lectures (12 hours)**	Structure and function of eukaryotic mRNA, tRNA (including initiator tRNA) and rRNA (and ribosomes). Eukaryotic transcription: RNA polymerase I, II and III mediated transcription: RNA polymerase enzymes, eukaryotic promoters and enhancers, General Transcription factors; TATA binding proteins (TBP) and TBP associated factors (TAF); assembly of pre-initiation complex for nuclear enzymes, interaction of transcription factors with the basal transcription machinery and with other regulatory proteins, mediator, TAFs; Processing of hnRNA, tRNA, rRNA; 5'-Cap formation; 3'-end processing of RNAs and polyadenylation; loop model of translation; Splicing of tRNA and hnRNA; snRNPs and snoRNPs in RNA processing; Regulation of RNA processing: capping, splicing, polyadenylation; mRNA stability and degradation: degradation and surveillance pathways; RNA editing; Nuclear export of mRNA; Catalytic RNA: Group I and Group II introns splicing, Peptidyl transferase; Regulatory RNA and RNA interference mechanisms, miRNA, non-coding RNA; Silencers and insulators, enhancers, mechanism of silencing and activation; Families of DNA binding

transcription factors: Helix-turn-helix, helix-loop-helix, homeodomain; C2H2 zinc finger, multi cysteine zinc finger, basic DNA binding domains (leucine zipper, helix-loop-helix), nuclear receptors; Interaction of regulatory transcription factors with DNA: properties and mechanism of activation and repression including Ligand-mediated transcription regulation by nuclear receptors; Nuclear receptor; histone modifications and chromatin remodeling.

Unit-V

Protein Translation, Post-translational Modifications and Control in Prokaryotes and Eukaryotes

4 Lectures (8 hours)

Ribosomes; Composition and assembly; universal genetic code; Genetic code in mitochondria; Degeneracy of codons; Termination codons; Wobble hypothesis; Isoaccepting tRNA; Translational machinery; Mechanism of Translation in prokaryotes and eukaryotes; Co- and Post-translational modifications of proteins; Translational control; Protein stability; Protein turnover and degradation.

Recommended Textbooks:

1. Watson, J. D. (2008). *Molecular Biology of the Gene* (5th ed.). Menlo Park, CA: Benjamin/Cummings.
2. Alberts, B., Johnson, A., Lewis, J., Raff, M., Roberts, K., & Walter, P. (2008). *Molecular Biology of the Cell* (5th Ed.). New York: Garland Science.
3. Lodish, H. F. (2016). *Molecular Cell Biology* (8th Ed.). New York: W.H. Freeman.

MBT 102: Genetics and Epigenetics — 3 Credits Theory

Course Objectives:

The objectives of this course are to take the students through the basics of genetics and classical genetics encompassing prokaryotic/phage genetics to yeast and higher eukaryotic domains and will cover all classical concepts of Mendelian genetics. It will also cover epigenetic phenomena: heritable alternate states of gene activity that do not result from an alteration in nucleotide composition (mutations).

Student Learning Outcomes:

On completion of this course, students should be able to:

- Describe the fundamental molecular principles of genetics;
- Understand the relationship between phenotype and genotype in human genetic traits;
- Describe the basics of genetic mapping;
- Evaluate the genetic code and the role epigenetic modification plays in common complex disease.

Syllabus:

Unit-I **Mendelian Genetics** **3 Lectures (6 hours)**	History of Genetics (Pre and post Mendelian era), Mendelism, Monohybrid & dihybrid crosses, back-crosses, test-crosses, Law of Segregation in plant crosses, Multiple alleles, Epistasis, Heterosis, Heritability and genetic advance, genotype-environment interaction, types of gene actions.
Unit-II **Drosophila Genetics** **3 Lectures (6 hours)**	Chromosomal theory of inheritance; analyses of autosomal and sex linkages, Linkage Detection, Linkage estimation by various methods, recombination and genetic mapping; mutation mapping based on phenotypes, hypomorphy, genetic mosaics, Testing gene mutations for allelism: complementation test, intragenic complementation, pleiotropy; Sex determination.
Unit-III **Genetics of Bacteria and Bacteriophages** **3 Lectures (6 hours)**	Concept of a gene in pre-DNA era; mapping of genes in bacterial and phage chromosomes by classical genetic crosses; fine structure analysis of a gene; genetic complementation and other genetic crosses using phenotypic markers; phenotype to genotype connectivity prior to DNA-based understanding of gene.
Unit-IV **Yeast Genetics** **2 Lectures (4 hours)**	Meiotic crosses, tetrad analyses, non-Mendelian and Mendelian ratios, gene conversion, models of genetic recombination, yeast mating type switch; dominant and recessive genes/mutations, suppressor or modifier screens, synthetic lethality, genetic epistasis.
Unit-V **Quantitative Genetics** **2 Lectures (4 hours)**	Continuous variation, Complex traits, mapping QTLs, yeast genomics to understand biology of QTLs.
Unit-VI **Population Genetics and Evolution** **2 Lectures (4 hours)**	Introduction to the elements of population genetics: genetic variation, genetic drift, neutral evolution; mutation selection, balancing selection, Fishers theorem, Hardy-Weinberg equilibrium, linkage disequilibrium; in-breeding depression & mating systems; population bottlenecks, migrations.
Unit-VII **Human Genetics**	History of human genetics; Pedigrees: gathering family history, pedigree symbols, construction of pedigrees, presentation of molecular genetic data in pedigrees, Monogenic traits; Autosomal inheritance: dominant, recessive Sex-linked

3 Lectures (6 hours)	inheritance, Sex-limited and sex-influenced traits, Mitochondrial inheritance, OMIM number, Complications to the basic pedigree patterns: nonpenetrance, variable, expressivity, pleiotropy, late onset, dominance problems, anticipation, genetic heterogeneity, genomic imprinting and uniparental disomy, spontaneous mutations, mosaicism and chimerism, male lethality, X-inactivation.
Unit-VIII **Genetics of Complex Traits in Humans** **4 Lectures (8 hours)**	Approaches to analysis of complex traits: 'Nature-nurture' concept, role of Family and shared environment, monozygotic and dizygotic twins and adoption studies, Polygenic inheritance of continuous (quantitative) traits, normal growth charts, Polygenic inheritance of discontinuous (dichotomous) traits: threshold model, liability and recurrence risk, Genetic susceptibility in multifactorial disorders (alcoholism, diabetes mellitus, obesity), Estimation of genetic components of multifactorial traits: empiric risk, heritability, coefficient of relationship; Gene mapping, Physical mapping, Linkage and Association.
Unit-IX **Epigenetics** **5 Lectures (10 hours)**	Chromatin architecture; modifying chromatin structure, architectural proteins, DNA methylation, post-translational histone, histone modification machinery, histone variants, DNA methylation/imprinting, RNA-directed DNA methylation, RNA-based silencing, polycomb repression, epigenetic inheritance, preservation of epigenetic marks during DNA replication, reprogramming DNA methylation, chromatin states, stem cells and pluripotency, genomic imprinting in mammals, dosage compensation, epigenetic regulation and disease, drugs used in diseases (HDAC inhibitors).

Recommended Textbooks:

1. Gardner *et. al* (1991). *Principles of Genetics*. John Wiley.
2. Snustad *et. al* (1998). *Principles of Genetics*. Wiley and sons.
3. Strickberger (1985). *Genetics*. McMillan.
4. Pierce, B. A. (2005). *Genetics: A Conceptual Approach*. New York: W.H. Freeman.

MBT 103: Cell and Developmental Biology — 3 Credits Theory

Course Objectives: The cells are "the fundamental building blocks of all organisms". Therefore, a comprehensive understanding of the cell and cellular function is essential for all biologists. The objectives of this course are to sensitize the students to the fact that as we go down the scale of magnitude from cells to organelles, the understanding of various

biological processes becomes deeper and inclusive. Subsequently, it is equally important to understand how a single cell, develop into an embryo, grow, into an adult, sexually matures, and ages with special emphasis in animal tissue development.

Student Learning Outcomes:

On completion of this course, students should be able to:

- Understand major ideas in cell biology and developmental biology;
- Familiarize with experimental approaches, and how they are applied to specific problems in cell and developmental biology;
- Carry out and interpret experiments in cell and developmental biology.

Syllabus:

Unit-I **Cell Ultrastructure** **1 Lecture (2 hours)**	Cell theory; diversity of cell size and shape; Prokaryotic and Eukaryotic cell ultrastructure; Similarities and differences; cell wall composition.
Unit-II **Structure and Function of Biological Membranes** **6 Lectures (12 hours)**	Membrane structure and function: Structural models; Composition and dynamics; Transport of ions and macromolecules; Pumps, carriers and channels; Endo and Exocytosis; Cellular junctions and adhesions; Membrane carbohydrates and their significance in cellular recognition; Structure and functional significance of plasmodesmata; Mechanism of cellular recognition and communication.
Unit-III **Cell Organelles** **5 Lectures (10 hours)**	Nucleus: structure and function of nuclear envelope, lamina and nucleolus; Nuclear matrix in chromosome organization and function; Macromolecular trafficking; Mitochondria: structure, origin and evolution, organization of respiratory chain complexes, Structure-function relationship; structure and function of peroxisome; mitochondrial genome; Chloroplast: chloroplast biogenesis; structure-function relationship; chloroplast genome; origin and evolution.
Unit-IV **Endo-membrane System, Cytoskeleton, Motility and Cellular Signalling** **6 Lectures (12 hours)**	Structure and function of microbodies, Golgi apparatus, lysosomes and endoplasmic reticulum; Protein processing, sorting; vesicle transport, secretion; Overview of cellular cytoskeleton, Organization and role of microtubules and microfilaments; Intermediate filaments; Muscle organization and function; Cellular motility; Molecular motors; Extracellular matrix in plants and animals; Signal transduction: Intracellular receptor and cell surface

	receptors; Signalling via G-protein linked receptors (PKA, PKC, CaM kinase); Overview of various cellular signalling cascades with examples such as EGFR, Notch, Wingless, JAK-STAT etc.
Unit-V **Cell Division** **3 Lectures (6 hours)**	Cell division: mitosis, and meiosis; Cell cycle and its regulation: Molecular events at G1, S, G2 and M phase, Cytokinesis; Extracellular and Intracellular control of cell division; Types and regulation of cyclins; sister chromatid cohesion, differential regulation of cohesion complex during mitosis and meiosis; abnormal cell division; Cancer and role of oncogenes and tumour suppressor genes in cancer development; Programmed cell death (Apoptosis).
Unit-VI **Cell Differentiation & Animal Tissue Development** **4 Lectures (8 hours)**	Cellular differentiation; Cellular movements and Pattern Formation: Laying of body axis planes; Differentiation of germ layers; Cellular polarity; Maternal gene effects; Zygotic gene effects; Homeotic gene effects in Drosophila; Cell lineages and developmental control genes in Caenorhabditis; Stem cell differentiation; Blood cell formation; Differentiation of cancerous cells and role of proto-oncogenes.
Unit-VII **Chromosome Structure** **2 Lectures (4 hours)**	Organization of bacterial genome; Chromatin structure: Histones, DNA, nucleosome and higher level organization, functional state of chromatin; Heterochromatin and Euchromatin; Position Effect Variegation (PEV); Chromosome organization: Metaphase chromosome, centromere, kinetochore, telomere and its maintenance; Chromosome banding and karyotyping.

Recommended Textbooks:

1. Watson, J. D. (2008). *Molecular Biology of the Gene* (5th ed.). Menlo Park, CA: Benjamin/Cummings.
2. Alberts, B., Johnson, A., Lewis, J., Raff, M., Roberts, K., & Walter, P. (2008). *Molecular Biology of the Cell* (5th Ed.). New York: Garland Science.
3. Lodish, H. F. (2016). *Molecular Cell Biology* (8th Ed.). New York: W.H. Freeman.
4. Alberts, B., Bray, D., Hopkin, K., Johnson, A., Lewis, J., Raff, M., Roberts, K., & Walter, P. Essentials in Cell Biology (4th Ed.). New York: Garland Science.
5. Cooper, G. M., & Hausman, R. E. (2009). *The Cell: A Molecular Approach*. Washington: ASM ; Sunderland.
6. Gilbert SF., Barresi MJF. (2010). D*evelopmental Biology*; (9th Ed).; Sinauer Associates Inc.

CBT 102: Biophysical Principles and Analytical Techniques 3 Credits Theory

Course Objectives: The course is designed to provide a broad exposure to all basic techniques (Biochemical & Biophysical) used in current Modern Biology research. The goal is to impart basic conceptual understanding of principles of these techniques and emphasize on Biochemical utility of same & underlying Biophysics. At the end of the course, student is expected to have enough understanding of all the analytical techniques such that the barrier to implement the same is abated to a great extent.

Student Learning Outcomes: On completion of this course, students should be able to:

- Understand the principles and basic theory behind several popular Biophysical techniques;
- Learn how to combine previously acquired knowledge of physical chemistry and biochemistry in order to understand biochemical processes at molecular level;
- Apply these techniques successfully in practical situations.

Syllabus:

Unit-I **Basics** **2 Lectures (4 hours)**	Units of measurement of solutes in solution; Normality, molality, molarity, millimol and ppm; Length scales in biological systems: proteins, multiprotein complexes, organelles & cells; Basic thermodynamics; Basic chemical kinetics & reaction rates: Theory of chemical reactions.
Unit-II **Electromagnetic Radiation & Spectroscopic Techniques** **4 Lectures (8 hours)**	Energy, wavelength, wave number and frequency; Absorption and emission spectra, Beer-Lambert's law, light absorption and its transmittance; UV and visible spectrophotometry-principles, instrumentation and applications on enzyme assay and kinetic assays, protein structural studies, nucleic acid structural studies; Basic principles, instrumentation and applications of UV-visible, IR, fluorimetry, atomic absorption and emission spectrophotometry; Basic principles, instrumentation and applications of ESR, NMR; Biochemical applications of fluorescence, emission, Fluorescence life-times, Anisotropy, time-resolved fluorescence methods and their applications, IR-Raman Spectroscopic applications in biology.
Unit-III **Radioactivity & Radioisotopic Techniques**	Radioactivity, stable and radioactive isotopes, concepts of half-life and decay, principles of scintillation counting, GM counters, applications of isotopes, Isotope dilution technique, autoradiography, turnover studies, precursor-product relationship, production of radio-labelled

4 Lectures (8 hours)	biomolecules, calculations involving isotopes, radiation hazards and methods for contaminant prevention; Nature of radioactivity, properties of α, β and γ-rays, measurement of radioactivity, use of radioisotopes in research, *In vivo* and *in vitro* labelling techniques, double labelling, quenching, internal standard, channel ratio, external standard ratio, emulsion counting, radioactive decay; Application of radioactive isotopes in biochemical reaction mechanisms.
Unit-IV **Electrophoresis** **2 Lectures (4 hours)**	Principles of electrophoretic separation, zonal and continuous electrophoresis, paper, cellulose acetate/nitrate, gel and capillary electrophoresis, use of native and denaturating gels, Protein subunit molecular weight determination using SDS-PAGE, Anomalous protein migration of some proteins in SDS-PAGE, Acid-urea PAGE and their physical basis, Isoelectric focussing and two dimensional gel electrophoresis, electroporation, pulse field gel electrophoresis, gradient gels.
Unit-V **Hydrodynamic Methods** **2 Lectures (4 hours)**	Basic principles and types of centrifugation-rotors, boundary, differential, density gradient, zonal isopycnic centrifugation, equilibrium; Sedimentation–sedimentation velocity, preparative and analytical ultracentrifugation techniques: principles & applications in biochemical fractionation methods.
Unit-VI **Chromatography and X-ray Crystallography** **3 Lectures (6 hours)**	Chromatography, principles of adsorption, partition and ion-exchange chromatography, gel permeation chromatography, GC, GC-MS and HPLC; X-ray Crystallography: protein crystals, Bragg's law, unit cell, isomorphous replacement, fiber pattern of DNA; Small-angle X-ray diffraction methods: Principles & applications; Basic protein structure prediction methods.
Unit-VII **Optical Tweezers** **3 Lectures (6 hours)**	Principles & applications; single-molecule measurements, Atomic Force microscopy, Near-field Microscopy: Principles & applications. Force measurements at single molecule to cell level using optical tweezers, mechanobiology.
Unit-VIII **Optical Microscopy Methods** **4 Lectures (8 hours)**	Light Microscopy: lenses and microscopes, resolution: Rayleigh's Approach, Dark field; Phase Contrast; Differential Interference Contrast; fluorescence and fluorescence microscopy; Confocal microscope: confocal principle, resolution and point spread function; nonlinear microscopy: multiphoton microscopy; principles of two-photon fluorescence, advantages of two-photon excitation, tandem scanning (spinning disk) microscopes,

	deconvolving confocal images; image processing, three-dimensional reconstruction; Total Internal reflection microscopy, STED microscopy.
Unit-IX **Mass Spectroscopy** **3 Lectures (6 hours)**	Ionization techniques; mass analyzers/overview MS; FT-ICR and Orbitrap, fragmentation of peptides; proteomics, nano LC-MS; Phospho proteomics; interaction proteomics, mass spectroscopy in structural biology; imaging mass spectrometry.

Recommended Textbooks:

1. Atkins, de Paula. (2011). *Physical Chemistry for the Life Sciences* (2nd Edition). W.H. Freeman.
2. C. R. Cantor and P. R. Schimmel, *Biophysical Chemistry* (Part 1-3), 2nd Edn.
3. Branden C and Tooze J, *Introduction to Protein Structure*, Garland Science.
4. K. E. van Holde, C. Johnson, P. S. Ho (2005). *Principles of Physical Biochemistry*, 2nd Edn., Prentice Hall.
5. Tinoco, Sauer, Wang, and Puglisi. (2013). *Physical Chemistry: Principles and Applications in the Biological Sciences*. Prentice Hall, Inc.

ARD 106: Spiritual and Cultural Heritage of India-I — 2 Credits Theory

Course Objectives:

This course is designed to familiarize the student with Swami Vivekananda's comprehensive philosophy of education and its scope in its individual and social dimensions. The student will be exposed to the high ideals of education through selected hymns and be guided to understand and approach their role as a student with the right attitude. The student would be given a clear picture of the challenges faced by the society and the effective method for addressing them. The course would cover in detail the idea of education in all its aspects– the effective method for acquiring and transferring knowledge, the way to apply education to solve the problems of the individual, and the role of education in addressing the short-term and long-term needs of the society.

Student Learning Outcomes:

On completion of this course, students should be able to:

- Embrace their role as a student and an individual-in-the-making holding immense promise to the society;
- Understand the problems faced by the society/nation

and the effective approach for solving them;
- Develop a comprehensive idea of education in all its aspects in light of Swami Vivekananda's teachings;
- Understand how to apply education to solve the challenges faced in life;
- Develop an understanding of the effective method of acquiring and transferring knowledge.

Syllabus:

Unit-I **Introduction** **1 Lecture (2 hours)**	Shanti Mantras and Selected Vedic Hymns: Shraddha Suktam, Sangha Mantra etc.
Unit-II **Message to Youth by Swami Vivekananda** **5 Lectures (10 hours)**	It is youth who will transform this nation; take up an ideal and give your whole life to it; stand your own feet; awaken the spirit of 'Rajas' within you; believe in yourself; be bold and fearless; expand your heart; be open to learning from anyone; develop a gigantic will.
Unit-III **Message to Reformers by Swami Vivekananda** **6 Lectures (12 hours)**	Liberty is the first condition for growth, affirm; do not condemn; don't lead but serve; act with unselfish motives; create 'sanction' from the people; the Indian Nation will rise only when the self-esteem of the masses is raised; real social reform will happen when the people learn to help themselves.
Unit-IV **Message to Educationists by Swami Vivekananda** **6 Lectures (12 hours)**	Manifestation of infinite knowledge within; man-making education; strengthen faith and pride in ourselves as a nation; focus on character-building assimilation of ideas, enable the student to learn; enable individuals to find solutions to the challenges of life; give ideas and culture; develop the power of concentration; condition necessary for the teacher, the teaching and for effective transfer of learning.

Recommended Textbooks:

1. Swami Tejasananda. (1995). *A Short Life of Swami Vivekananda*. Advaita Ashrama.
2. Swami Vivekananda. (2008). *My Idea of Education*. Advaita Ashrama.
3. Swami Vivekananda. (1918). *Lectures from Colombo to Almora*. Advaita Ashrama.

MBT 104: Laboratory-I Biochemistry 3 Credits Practical

Course Objectives: The objective of this laboratory course is to introduce students to experiments in biochemistry. The course is designed to teach utility of experimental methods in biochemistry in a problem oriented manner.

Student Learning Outcomes: On completion of this course, students should be able to:

- Elaborate concepts of biochemistry with easy to run experiments;
- Familiarize with basic laboratory instruments and understand principle of measurements using those instruments with experiments in biochemistry.

Syllabus

1. Preparing various stock solutions and working solutions that will be needed for the course.

2. To prepare an Acetic-Na Acetate Buffer and validate the Henderson-Hasselbach equation.

3. To determine an unknown protein concentration by plotting a standard graph of BSA using UV-Vis Spectrophotometer and validating the Beer-Lambert's Law.

4. Titration of Amino Acids and separation of aliphatic, aromatic and polar amino acids by thin layer chromatography.

5. Purification and characterization of an enzyme from a recombinant source.

a) Preparation of cell-free lysates

b) Ammonium Sulfate precipitation

c) Ion-exchange Chromatography

d) Gel Filtration

e) Affinity Chromatography

f) Dialysis of the purified protein solution against 60% glycerol as a demonstration of storage method

g) Generating a Purification Table (protein concentration, amount of total protein; Computing specific activity of the enzyme preparation at each stage of purification)

h) Assessing purity of samples from each step of purification by SDS-PAGE Gel Electrophoresis

i) Enzyme Kinetic Parameters: Km, Vmax and Kcat.

6. Experimental verification that absorption at OD260 is more for denatured DNA as compared to native double stranded DNA.

MBT 105: Laboratory-II Cell Biology and Microscopy 3 Credits Practical

Course Objectives: The major objective of this course is to understand of fundamental cell biological research in relation to human diseases.

Student Learning Outcomes: On completion of this course, students should be able to:

- Acquire basic concepts of structure and functionality of the animal cell along with basics of microscopy.

Syllabus

1. Principles of microscopy and optics; Observation of suitable specimen under bright field, phase contrast, dark field and DIC microscope.
2. Observation of animal cell cultures under microscope. Measurement of cell size by oculometer and stage micrometre.
3. To quantify the number of cells present in given sample and assessment of cell viability.
4. Observation of Mitosis, and the Cell Cycle in a given cell lines.
5. Histology: Low speed separation of cells from animal blood.
6. Chromosome preparation from human blood cells- G banding and karyotyping.
7. Isolation of lysosomes, nuclei and ER membranes from animal samples by isotonic sucrose method.
8. Isolation of mitochondria from animal tissue samples.
9. Lecture demonstration of live cell image and dynamics of cellular organelles in relation to a function by using web-tutorials and online movies.

Semester-II [Total: 15 (T) + 8 (P) = 23 Credits]

CBT 201: Genetic Engineering — 3 Credits Theory

Course Objectives: The objectives of this course are to teach various approaches to genetic engineering that students can apply in their future career in biological research as well as in biotechnology industry. Genetic engineering is a technology that has been developed based on our fundamental understanding of the principles of molecular biology and this is reflected in the contents of this course. This technology has revolutionized the way modern biological research is done and has impacted mankind with a number of biological products and processes.

Student Learning Outcomes: On completion of this course, students should be able to:

- Endow themselves with strong theoretical knowledge of this technology;
- Gain working knowledge of gene silencing and editing tools and methods and appreciate their relevance for investigating specific contemporary biological questions;
- Take up biological research as well as find placement in the relevant biotech industry.

Syllabus:

Unit-I **Introduction and Tools for Genetic Engineering** **5 Lectures (10 hours)**	Impact of genetic engineering in modern society; general requirements for performing a genetic engineering experiment; restriction endonucleases and methylases; DNA ligase, Klenow enzyme, T4 DNA polymerase, polynucleotide kinase, alkaline phosphatase; cohesive and blunt end ligation; linkers; adaptors; homopolymeric tailing; labeling of DNA: nick translation, random priming, radioactive and non-radioactive probes, hybridization techniques: northern, southern, south-western and far-western and colony hybridization, fluorescence in situ hybridization.
Unit-II **Different Types of Vectors** **5 Lectures (10 hours)**	Plasmids; Bacteriophages; M13mp vectors; pUC19 and Bluescript vectors, phagemids; Lambda vectors; Insertion and Replacement vectors; Cosmids; Artificial chromosome vectors (YACs; BACs); Principles for maximizing gene expression expression vectors; pMal; GST; pET-based vectors; Protein purification; His-tag; GST-tag; MBP-tag etc.; Intein-based vectors; Inclusion bodies; methodologies to reduce formation of inclusion bodies; mammalian expression and replicating vectors; Baculovirus and Pichia vectors system, plant based vectors, Ti and Ri as vectors, yeast vectors, shuttle vectors.

Unit-III **Different Types of PCR Techniques** **5 Lectures (10 hours)**	Principles of PCR: primer design; fidelity of thermostable enzymes; DNA polymerases; types of PCR: multiplex, nested; reverse-transcription PCR, real time PCR, touchdown PCR, hot start PCR, colony PCR, asymmetric PCR, cloning of PCR products; T-vectors; proof reading enzymes; PCR based site specific mutagenesis; PCR in molecular diagnostics; viral and bacterial detection; sequencing methods; enzymatic DNA sequencing; chemical sequencing of DNA; automated DNA sequencing; RNA sequencing; chemical synthesis of oligonucleotides; mutation detection: SSCP, DGGE, RFLP.
Unit-IV **Gene Manipulation and Protein-DNA Interaction** **6 Lectures (12 hours)**	Insertion of foreign DNA into host cells; transformation, electroporation, transfection; construction of libraries; isolation of mRNA and total RNA; reverse transcriptase and cDNA synthesis; cDNA and genomic libraries; construction of microarrays: genomic arrays, cDNA arrays and oligo arrays; study of protein-DNA interactions: electrophoretic mobility shift assay; DNase I footprinting; methyl interference assay, chromatin immunoprecipitation (ChIP); protein-protein interactions using yeast two-hybrid system; phage display.
Unit-V **Gene Silencing and Genome Editing Technologies** **6 Lectures (12 hours)**	Gene silencing techniques; introduction to siRNA; siRNA technology; Micro RNA; construction of siRNA vectors; principle and application of gene silencing; gene knockouts and gene therapy; creation of transgenic plants; debate over GM crops; introduction to methods of genetic manipulation in different model systems *e.g.* fruit flies (*Drosophila*), worms (*C. elegans*), frogs (*Xenopus*), fish (zebra fish) and chick; Transgenics: gene replacement; gene targeting; creation of transgenic and knock-out mice; disease model; introduction to genome editing by CRISPR-CAS.

Recommended Textbooks:

1. Brown, TA. (2006). *Genomes* (3rd ed.). New York: Garland Science Pub.
2. Old, R.W.; Primrose, S.B.; & Twyman, R.M.; (2001). *Principles of Gene Manipulation: An Introduction to Genetic Engineering*. Oxford: Blackwell Scientific Publications.
3. Green, MR., & Sambrook, J. (2012). Molecular Cloning: a Laboratory Manual. Cold Spring Harbor, NY: Cold Spring Harbor Laboratory Press.

CBT 202: OMICS: Genomics, Transcriptomics, Proteomics and Metabolomics
3 Credits Theory

Course Objectives: The objective of this course is to give an introduction to Genomics and other global OMICS technologies, the theory and practical aspects of these technologies and the applications of these technologies in biology. The student should be able to gain working knowledge of these technologies and appreciate their ability to impart a global understanding of biological systems and processes in health and disease.

Student Learning Outcomes: On completion of this course, students should be able to:

- Gain overview of genome variation in the population including technologies to detect these variations;
- Understand how High-throughput DNA sequencing (HTS) can be used to identify genetic variants;
- Understand how HTS technologies can be used to explore changes in gene expression;
- Endow with application of various OMICS technologies.

Syllabus:

Unit-I **Introduction to Genomics** **5 Lectures (10 hours)**	Structure and organization of prokaryotic and eukaryotic genomes: nuclear, mitochondrial and chloroplast genomes; Computational analysis, Databases, Finding genes and regulatory regions; Tools for genome analysis: PCR, RFLP, DNA fingerprinting, RAPD, SNP detection, SSCP, FISH to identify chromosome landmarks; Human Genome Project-landmarks on chromosomes generated by various mapping methods, BAC libraries and shotgun libraries preparation, Physical map, Cytogenetic map, Contig map, Restriction map, UCSC browser.
Unit-II **Microarray Technology** **3 Lectures (6 hours)**	Introduction, Basic principles and design, cDNA and oligonucleotide arrays, DNA microarray, Instrumentation and structure; Designing a microarray experiment: The basic steps, Types of microarray: expression arrays, protein arrays, Comparative Genomic Hybridization (CGH) arrays, Resequencing arrays; Different platforms (Affymetrix, Agilent *etc.*); Applications of Microarray technology; case studies.
Unit-III **Sequencing Technologies** **6 Lectures (12 hours)**	Introduction to sequencing, Maxam and Gilbert method, Sanger Sequencing techniques and applications; Next Generation sequencing (NGS), Introduction to NGS, Experimental protocol (Isolation of DNA/RNA), quality check, Library Preparations, Sequencing reaction; Platform overview and comparison: Illumina, 454 (Roche), SOLiD (Life

	technology), Specific Biosciences, Ion Torrent, Nanopore, PacBio; Types of NGS, DNA-sequencing: Whole genome sequencing, exome sequencing, Deep sequencing, ChIP sequencing, RNA-sequencing and the types (small RNA sequencing, non-coding RNA sequencing), Whole transcriptome sequencing; Data Processing and Analysis: Data Quality Check, filtering and Genome assembly and mapping to reference genomes, mapping tools (bowtie, maqetc), Sequence Alignment formats: Sequence Alignment/Map (SAM) format, Binary Alignment/Map (BAM) format, Functional Analysis: Pathway analysis, Gene Ontology analysis; Application of different sequencing technique, methylomics, *in vivo* protein binding, genome wide association studies (GWAS), Histone modification, microbial sequencing, Comparison of Microarray technology and High throughput sequencing technology.
Unit-IV **Proteomics** **7 Lectures (14 hours)**	Overview of protein structure-primary, secondary, tertiary and quarternary structure, Relationship between protein structure and function; Outline of a typical proteomics experiment, Identification and analysis of proteins by 2D analysis, Spot visualization and picking; Tryptic digestion of protein and peptide fingerprinting, Mass spectrometry: ion source (MALDI, spray sources), analyzer (ToF, quadrupole, quadruple ion trap) and detector; Post translational Modifications: Quantitative proteomics, clinical proteomics and disease biomarkers, mass spectral tissue imaging and profiling; Protein-protein interactions: Surfaceomes and Secretomes, Solid phase ELISA, pull-down assays (using GST-tagged protein) tandem affinity purification, far western analysis, by surface plasmon resonance technique; Yeast two hybrid system, Phage display, Protein interaction maps, Protein arrays-definition; Applications: diagnostics, expression profiling.
Unit-V **Pharmacogenomics** **3 Lectures (6 hours)**	Pharmacogenomics; Pharmacogenetics; Benefits; Practical applications of pharmacogenomics; The Promise of Pharmacogenomics today leading to personalized medicines; Human genetic variation: examples of CYP gene variations leading to variable metabolism of drugs.
Unit-VI **Metabolomics** **3 Lectures (6 hours)**	Introduction and overview of metabolites, sample collection and processing, Non tracer and tracer (radio labelled)-based techniques in metabolomics (HPLC, NMR, LC-MS and GC-MS); Metabolome data processing derived by various techniques, analysis of databases (MetaboLight, Meta Cyc, MMCD *etc.*), Analysis tools, Metabolic pathways and network analysis Metabolic flux analysis (TCA, Amino acids, fatty acids, intermediary metabolites), Stoichiometric metabolic flux analysis, ^{13}C metabolic flux analysis (MFA), Metabolic control

analysis (MCA); Applications of metabolomics; Integration of metabolomics data sets with other data (*eg.* Transcriptomics, enzyme activity, *etc.*).

Recommended Textbooks:

1. Brown, TA. (2006). *Genomes* (3rd ed.). New York: Garland Science Pub.
2. Old, R.W., Primrose, S.B., & Twyman, R.M. (2001). *Principles of Gene Manipulation: An Introduction to Genetic Engineering*. Oxford: Blackwell Scientific Publications.
3. Campbell A. M. & Heyer L. J. (2007). *Discovering Genomics, Proteomics and Bioinformatics*. Benjamin Cummings
4. Twyman RM. (2013). *Principles of Proteomics* Second Edition by Garland Science Taylor & Francis Group New York and London.

MBT 201: Basics of Microbiology and Immunology 3 Credits Theory

Course Objectives:

The objectives of this course are to introduce field of microbiology with special emphasis on microbial diversity, morphology, physiology and nutrition; methods for control of microbes and host-microbe interactions. The objectives of this course are also to learn about structural features of components of immune system as well as their function. This will be imperative for students as it will help them to predict about nature of immune response that develops against bacterial, viral or parasitic infection, and prove it by designing new experiments.

Student Learning Outcomes:

On completion of this course, students should be able to:

- Identify major categories of microorganisms and analyze their classification, diversity, and ubiquity;
- Identify and demonstrate structural, physiological, genetic similarities and differences of major categories of microorganisms;
- Identify and demonstrate how to control microbial growth;
- Demonstrate and evaluate interactions between microbes, hosts and environment;
- Evaluate usefulness of immunology in different pharmaceutical companies;
- Apply their knowledge and design immunological experiments to demonstrate innate, humoral or cytotoxic T lymphocyte responses and figure out kind of immune responses in the setting of infection (viral or bacterial).

Syllabus:

Unit-I **Microbial Characteristics** **4 Lectures (8 hours)**	Introduction to microbiology and microbes, history & scope of microbiology, morphology, structure, growth and nutrition of bacteria, bacterial growth curve, bacterial culture methods; bacterial genetics: transformation, transduction and conjugation; plasmids, antimicrobial resistance; microbial communication system; bacterial quorum sensing.
Unit-II **Microbial Diversity** **4 Lectures (8 hours)**	Microbial taxonomy and evolution of diversity, classification of microorganisms, criteria for classification; classification of bacteria; Cyanobacteria, acetic acid bacteria, Pseudomonads, lactic and propionic acid bacteria, endospore forming bacteria, Mycobacteria and Mycoplasma. Archaea: Halophiles, Methanogens, Hyperthermophilic archae, Thermoplasm; eukarya: algae, fungi, slime molds and protozoa; extremophiles and unculturable microbes.
Unit-III **Microbial Growth, Kinetics and Physiology** **3 Lectures (6 hours)**	Microbial growth: Batch, fed-batch, continuous kinetics, synchronous growth, yield constants, methods of growth estimation, stringent response, death of a bacterial cell. Microbial physiology: Physiological adoption and life style of Prokaryotes.
Unit-IV **Control of Microorganisms** **2 Lectures (4 hours)**	Sterilization, disinfection and antisepsis: physical and chemical methods for control of microorganisms, antibiotics, antiviral and antifungal drugs, biological control of microorganisms.
Unit-V **Virology** **2 Lectures (4 hours)**	Virus and bacteriophages, general properties of viruses, viral structure, taxonomy of virus, viral replication, cultivation and identification of viruses; sub-viral particles: viroids and prions.
Unit-VII **Fundamental Concepts and Overview of the Immune System** **4 Lectures (8 hours)**	Components of innate and acquired immunity; phagocytosis; complement and inflammatory responses; pathogen recognition receptors (PRR) and pathogen associated molecular pattern (PAMP); innate immune response; mucosal immunity; antigens: immunogens, haptens; Major Histocompatibility Complex: MHC genes, MHC and immune responsiveness and disease susceptibility, Organs of immune system, primary and secondary lymphoid organs.

Unit-VIII **Immune responses by T and B Lymphocytes** **5 Lectures (10 hours)**	Basic structure, classes and subclasses of immunoglobulins, antigenic determinants; multigene organization of immunoglobulin genes; B-cell receptor; Immunoglobulin superfamily; principles of cell signaling; basis of self & non-self discrimination; kinetics of immune response, memory; B cell maturation, activation and differentiation; generation of antibody diversity; T-cell maturation, activation and differentiation and T-cell receptors; functional T Cell subsets; cell-mediated immune responses, ADCC; cytokines: properties, receptors and therapeutic uses; antigen processing and presentation- endogenous antigens, exogenous antigens, non-peptide bacterial antigens and super-antigens; cell-cell co-operation, Hapten-carrier system.
Unit-IX **Antigen-Antibody Interactions** **3 Lectures (6 hours)**	Precipitation, agglutination and complement mediated immune reactions; advanced immunological techniques: RIA, ELISA, ELISPOT assay, flow cytometry and immunoelectron microscopy; surface plasmon resonance, biosensor assays for assessing ligand-receptor interaction; CMI techniques: lymphoproliferation assay, mixed lymphocyte reaction, cell cytotoxicity assays.

Recommended Textbooks:

1. Pelczar, M. J., Reid, R. D., & Chan, E. C. (2001). *Microbiology* (5th ed.). New York: McGraw-Hill.
2. Willey, J. M., Sherwood, L., Woolverton, C. J., Prescott, L. M., & Willey, J. M. (2011). *Prescott's Microbiology*. New York: McGraw-Hill.
3. Matthai, W., Berg, C. Y., & Black, J. G. (2005). *Microbiology, Principles and Explorations*. Boston, MA: John Wiley & Sons.
4. Madigan, T. M., Martinko, J. M, Stahl, D. A., & Clarke D. P. Brock Biology of Microorganisms (15th Ed.). Pearson Publisher.
5. Murphy, K., Travers, P., Walport, M., & Janeway, C. (2012). *Janeway's Immunobiology.* New York: Garland Science.
6. Kindt, T. J., Goldsby, R. A., Osborne, B. A., & Kuby, J. (2006). *Kuby Immunology*. New York: W.H. Freeman.

CBT 203: Introduction to Bioinformatics 2 Credits Theory & 1 Credit Practical

Course Objectives: This course covers all basic details of Bioinformatics starting from sequence comparison tools to genome annotation to protein structure prediction methods. The course also touches upon *in-silico*

methods of biological networks to artificial intelligence designs. Therefore, the course gives a comprehensive understanding of the entire gamut of bioinformatics and computational analyses. The instructor is expected to cover only the basic details of these topics.

Student Learning Outcomes:

On completion of this course, students should be able to:

- Develop an understanding of the basic theory of computational tools;
- Gain working knowledge of computational tools and methods;
- Appreciate their relevance for investigating specific contemporary biological questions;
- Critically analyse and interpret the results of their study.

Syllabus:

Unit-I **Basics** **4 Lectures (8 hours)**	Scope and importance of bioinformatics in biology and medicine; Introduction to Unix and Linux systems and basic commands; Database concepts; Protein and nucleic acid databases; Structural databases; Biological XML DTD's; pattern matching algorithm basics; databases and search tools: biological background for sequence analysis; NCBI; publicly available tools; resources at EBI; resources on web; database mining tools.
Unit-II **DNA Sequence Analysis** **4 Lectures (8 hours)**	DNA sequence analysis: gene bank sequence database; submitting DNA sequences to databases and database searching; sequence alignment; pairwise alignment techniques; BLAST: BLASTp, BLASTn, tBLASTn, BLASTx, tBLASTx, PHI-BLAST, and PSI-BLAST; motif discovery and gene prediction; assembly of data from genome sequencing; Comparative genomics; Gene prediction: Extrinsic and intrinsic methods, applications and limitations.
Unit-III **DNA Sequence Alignment** **3 Lectures (6 hours)**	Multiple sequence analysis; multiple sequence alignment; flexible sequence similarity searching with the FASTA3 program package; use of CLUSTALW and CLUSTALX for multiple sequence alignment; submitting protein sequence to databases: where and how to submit, SEQUIN; methods of phylogenetic analysis.
Unit-IV **Protein Structure Database** **4 Lectures (8 hours)**	PDB: Introduction, Database searching, PDB file retrieval, mmCIF file retrieval and links; MMDB: Introduction Structure file formats; Protein structure prediction: protein folding and model generation; secondary structure prediction; analyzing secondary structures; Protein function prediction: sequence and domain based.

Unit-V **Drug Discovery** **3 Lectures (6 hours)**	Structure based Drug design: Rationale for computer aided drug designing, deriving 3D pharmacophore and its application; Drug design: types- structure based, Virtual screening: ligand based, optimization methods.

Practical:

Syllabus

1. Introduction to Major Databases:
   a) Nucleic Acid Sequence Database: DDBJ, GenBank and NCBI
   b) Protein Sequence Database: UNIPROT and NCBI
   c) Structure Database: PDB and MMDB
2. Sequence Alignment: Use of FASTA format, BLAST tool for similarity searches
3. Multiple Sequence Alignment: Clustal X, Clustal W, and EMBOSS
4. Phylogenetic analysis of protein and nucleotide sequences.
5. Gene Prediction: EMBOSS, GENESCAN and ORF finder
6. Tools for Primer Designing: Primer3, and FastPCR
7. Function Annotation: Prosite and PFAM
8. Protein Modelling: SWISS Model
9. Case studies:
   a) Saccharomyces Genome Database (Fungus)
   b) Rice Genome Database (Plant)
   c) Human Genome Database (Metazoa)

Recommended Textbooks:

1. Mount, D. W. (2001). *Bioinformatics: Sequence and Genome Analysis*. Cold Spring Harbor, NY: Cold Spring Harbor Laboratory Press.
2. Lesk, A. M. (2002). *Introduction to Bioinformatics*. Oxford: Oxford University Press.
3. Campbell A. M. & Heyer L. J. (2007). *Discovering Genomics, Proteomics and Bioinformatics*. Benjamin Cummings.

CBT 204: Basics of Mathematics and Statistics
2 Credits Theory & 1 Credit Practical

Course Objectives: The objective of this course is to introduce the students to bio-statistical methods and to understand the underlying principles, as

well as practical guidelines of "how to do it" and "how to interpret it" as the role they can play in decision making.

Student Learning Outcomes:

On completion of this course, students should be able to:

- Understand how to summarise data;
- Apply appropriate statistical tests based on an understanding of the study question, type of study and type of data;
- Interpret the results of statistical tests and application in biological systems.

Syllabus:

Unit-I **Elementary Mathematics** **2 Lectures (4 hours)**	Set theory; Determinants, and Matrices.
Unit-II **Introduction to Statistics** **2 Lectures (4 hours)**	Types of biological data (ordinal scale, nominal scale, continuous and discrete logical systems data), frequency distribution and graphical representations (bar graph, histogram, box plot and frequency polygon), cumulative frequency distribution, populations, samples, simple random, stratified and systematic sampling.
Unit-III **Descriptive Statistics** **2 Lectures (4 hours)**	Measures of Location, Properties of Arithmetic Mean, median, mode, range, Properties of the Variance and Standard Deviation, Coefficient of Variation, Skewness, Kurtosis; Grouped Data, Graphic Methods, Obtaining Descriptive Statistics on the Computer, Case study.
Unit-IV **Probability & Distribution** **3 Lectures (6 hours)**	Introduction to probability and laws of probability, Random Events, Events-exhaustive, Mutually exclusive and equally likely (with simple exercises), Definition and properties of binomial distribution, Poisson distribution and normal distribution.
Unit-V **Correlation & Regression Analysis** **2 Lectures (4 hours)**	Correlation, Covariance, calculation of covariance and correlation, Correlation coefficient from ungrouped data Spearson's Rank Correlation Coefficient, scatter and dot diagram, General Concepts of regression, Fitting Regression Lines, regression coefficient, properties of Regression Coefficients, Standard error of estimate.
Unit-VI	Sampling theory; probability sampling and non-probability sampling methods; sampling distributions; standard error

Sampling Theory **2 Lectures (4 hours)**	and its uses.
Unit-VII **Statistical Hypothesis** **1 Lecture (2 hours)**	Making assumption, Null and alternate hypothesis, error in hypothesis testing, confidence interval, one-tailed and two-tailed testing, decision making.
Unit-VIII **Test of Significance** **4 Lectures (8 hours)**	Steps in testing statistical significance, selection and computation of test of significance and interpretation of results; Sampling distribution of mean and standard error, Large sample tests (test for an assumed mean and equality of two population means with known S.D.), z-test; Small sample tests (t-test for an assumed mean and equality of means of two populations when sample observations are independent); Parametric and Non parametric tests (Mann-Whitney test); paired and unpaired t-test, chi square test.

Practical:

Syllabus	**1.** Graphical presentation (Bar diagram, Histogram, Frequency Polygon, Ogive, Pie Chart etc.); Tabular presentation. **2.** Mean, Median and Mode **3.** Analysis of measures of Dispersion, Skewness and Kurtosis **4.** Analysis of Correlation and Regression **5.** Study on Z-test, t-test, F-test and chi-square test **6.** Use of Computer in Research: Entry; Data Presentation and Analysis; Statistical Packages.

Recommended Textbooks:

1. Mann P. S. (2006), *Introductory Statistics*, 6th Edition, Wiley.
2. Daniel W. W. (2004), *Biostatistics: A Foundation for Analysis in the Health Sciences*, (8th Edition), Wiley.

ARD 207: Spiritual and Cultural Heritage of India-II 2 Credits Theory

Course Objectives: This course is designed to impart to the student a comprehensive understanding of various social challenges faced by modern India and its way forward in light of Swami Vivekananda's insightful study of

these subjects. The course would familiarize the student with Swami Vivekananda's ideas on women empowerment combining ancient ideals of womanhood with scope for adapting to the needs of the modern society. The importance of improving the condition of the poorer classes, an essential feature of an enlightened society, will be discussed in detail. The greater role that an enlightened India would play in the modern world and the blueprint for its harmonious and beneficent relationship with the rest of the world will be discussed.

Student Learning Outcomes:

On completion of this course, students should be able to:

- Chant selected Vedic hymns that bring the student in touch with the ideas of traditional Indian knowledge;
- Understand the traditional Indian ideal of womanhood and the way to bring back a respectable position for women in the society compatible with both the ancient ideals and the modern needs;
- Recognize the importance of serving equally the whole society, especially the lower classes, and feel inspired to dedicate their knowledge and skills to this cause;
- Understand the great future role that India has to play in the world and her relationship with other nations involving both teaching and learning, to the mutual benefit of both.

Syllabus:

Unit-I

Introduction

1 Lecture (2 hours)

Selected Vedic Hymns: Medha Suktam, Durga Suktam, Acharyopadesha etc.

Unit-II

Swami Vivekananda's Message on Women's Empowerment

5 Lectures (10 hours)

The ideal of woman as mother; womanhood personified in Sita; as warrior; eligibility for the highest knowledge; common humanity grounds; respecting the women; all round education of women; develop their own solutions.

Unit-III

Swami Vivekananda's Message on the Uplift of the Masses

6 Lectures (12 hours)

Dedicate yourself; develop faith in equality and oneness of man; educate the masses, solution to the caste problem.

Unit-IV **Swami Vivekananda's Message on Restoring our National Glory**	India's ideal is spirituality, India's mission is spiritual regeneration of the world, India's solution to life's challenges, India must share the spiritual knowledge with the West and gain material knowledge from them, India is readying for its time under the sun.

6 Lectures (12 hours)

Recommended Textbooks:

1. Swami Vivekananda. (1946). *Swami Vivekananda on India and Her Problems*. Compiled by Swami Nirvedananda. Advaita Ashrama.
2. Swami Vivekananda. (1918). *Lectures from Colombo to Almora*. Advaita Ashrama.
3. Swami Chidananda. (2013). *Sankshipta Sasvara Veda Mantrah (Sanskrit)*. Sri Ramakrishna Ashrama.

CBT 205: Laboratory-III Microbiology 3 Credits Practical

Course Objectives: The objective of this laboratory course is to provide the students practical skills on basic microbiological techniques.

Student Learning Outcomes: On completion of this course, students should be able to:

- Ability to isolate, characterize and identify common bacterial organisms;
- Determine bacterial load of different samples;
- Perform antimicrobial sensitivity test;
- Preserve bacterial cultures.

Syllabus

Basic Techniques

1. Sterilization, disinfection and safety in Microbiology laboratory, good laboratory practices.
2. Preparation of media for cultivation of bacteria, liquid and solid.

Syllabus

Culture Techniques

1. Spread plate method
2. Pour plate method
3. Streaking
4. Bacterial growth curve
5. Bacterial plate count method
6. Maintenance of stock cultures: slants, stabs and glycerol stock cultures.

Syllabus

Staining Techniques

1. Preparation of bacterial smear and Gram's staining.
2. Acid fast staining
3. Endospore staining
4. Capsule staining
5. Negative staining
6. Flagellar staining

Syllabus

Antibiotic Resistance Assay

1. Determination of antibiotic sensitivity by Kirby-Bauer method and antibiotic resistance.

Syllabus

Mutagenesis Assay

1. Isolation of auxotrophs and Ames test using any chemical mutagen.
2. Replica plate assay.

CBT 206: Laboratory-IV Molecular Biology and Genetic Engineering
3 Credits Practical

Course Objectives: The objective of this laboratory course is to provide the students practical skills on basic molecular biology and genetic engineering techniques.

Student Learning Outcomes: On completion of this course, students should be able to:

- Acquire basic molecular biology techniques and principles;
- Get first-hand experience that will coincide with what is taught in the lecture portion of the class;
- Gain hands-on experience in gene cloning, PCR amplification, protein expression and purification.

Syllabus

1. Isolation of Genomic DNA from
   a) *E. coli* (Bacteria)
   b) *Candida* species (Fungus)
   c) Banana (Plant)
   d) Blood cells (Animal)
2. Plasmid DNA isolation and DNA quantitation
3. Restriction Enzyme digestion of plasmid DNA
4. Agarose gel electrophoresis
5. Polymerase chain reaction (PCR) and analysis by Agarose gel electrophoresis
6. Purification of DNA from Agarose gel
7. Vector and Insert ligation
8. Preparation of competent cells
9. Transformation of E. coli with standard plasmid, Calculation of Transformation efficiency
10. Confirmation of the Insert by Restriction mapping
11. SDS-PAGE gel electrophoresis
12. Expression of recombinant protein, concept of soluble proteins and inclusion bodies in *E. coli*.

Semester-III [Total: 12 (T) + 11 (P) = 23 Credits*]

MBT 301: Medical Microbiology and Infection Biology 3 Credits Theory

Course Objectives: This course will provide a perspective and exposure to medical aspects of bacteriology, virology, mycology, parasitology and infectious diseases along with concepts of symptoms, pathogenesis, transmission, prophylaxis and control, a conceptual understanding of host-pathogen interactions using well characterized systems as examples. The student should have a good grasp of disease causing microbes and their interactions with host.

Student Learning Outcomes: On completion of this course, students should be able to:

- Compare and contrast different microbial diseases, including properties of different types of pathogens, and mechanisms of pathogenesis;
- Summarize role of host in infectious disease, including natural barriers to infection, innate and acquired immune responses to infection, and inflammation;
- Compare and contrast experimental approaches for identifying virulence genes and advantages/ disadvantages of each approach for specific pathogens.

Syllabus:

Unit-I

Bacterial Diseases

7 Lectures (14 hours)

Normal microflora (microbiome) of human body and its role – Skin, mouth and respiratory tract, intestinal tract, urogenital tract; Pathogenesis and virulence factors- Koch's postulates, Adherence and invasion, Toxins, Enzymes, Antiphagocytic factors, Antigenic heterogeneity, Iron acquisition; *Bacillus anthracis, Clostridium* spp.*, Corynebacterium diptheriae; E. coli, Vibrio cholerae, Helicobacter pylori, Salmonella typhi and paratyphi, Shigella dysenteriae; Listeria monocytogenes, Mycobacterium* spp.*,* Rickettsial diseases; *Haemophilus influenzae, Bordetella pertussis*, Brucellosis, Streptococcal and Staphylococcal infections; Antibacterial chemotherapy (with examples of antibiotics)- Inhibition of cell wall synthesis, inhibition of cell membrane function, inhibition of protein and nucleic acid synthesis, antimetabolites; Drug resistance- origin (genetic and non-genetic), mechanisms, antimicrobial activity *in vitro* and *in vivo*, Multi-drug resistance and its mechanisms *e.g.* MDR-TB.

Unit-II

Viral Diseases

Viral Pathogenesis- Routes of entry, Viral spread (local and systemic infection), Viral persistence (chronic and latent infection); Polio, Chicken pox, Mumps, Measles, Rubella; Viral hemorrhagic fever, viral encephalitis, Dengue and Yellow fever;

6 Lectures (12 hours)	Influenza virus infection (emphasis on Avian and swine flu), Rabies and Prion diseases; Hepatitis and Human Cancer viruses; Emerging viral diseases– Ebola, Marburg, SARS, Hanta, Chikungunya, Zika, Chandipura; Antiviral chemotherapy and Viral vaccines; Nucleotide and nucleoside analogs, Reverse transcriptase inhibitor, protease inhibitor, fusion inhibitor *etc.*, Interferons, Killed and attenuated vaccines.
Unit-III **Fungal and Protozoan Infections** **6 Lectures (12 hours)**	Types of Mycoses (with specific example of causative fungi): Superficial, Cutaneous, Sub-cutaneous; Types of Mycoses (with specific example of causative fungi): Endemic and Opportunistic; Mycotoxins and Antifungal chemotherapy– Mycetismus, Aflatoxins, classes of currently available drugs and new inhibitors in the pipeline; Protozoan diseases: Giardiasis, Amoebiasis; Leishmaniasis, African sleeping sickness; Malaria, Cryptosporidiosis; Infection by Helminths– Nematodes, Trematodes, Cestodes.
Unit-IV **Congenital Infections & Sexually Transmitted Diseases** **4 Lectures (8 hours)**	Syphilis and Gonorrheal infections; AIDS and Lentiviral infection; Herpes infections; Chlamydial infections *(Chlamydia trachomatis)*; Mycoplasma and Ureaplasma infection; Toxoplasmosis; Congenital viral infections – Cytomegalovirus, Varicella zoster, HBV, Enterovirus, Parvovirus B19 *etc.*
Unit-V **Pathogenicity and Host-pathogen Interactions** **3 Lectures (6 hours)**	Intracellular and extracellular pathogens, Principles of microbial pathogenesis, host damage, inflammatory responses, adaptation strategies of pathogen- impact of host and pathogen metabolism on immunity and pathogen survival; Chronic pathogens and mechanisms of persistence; Evasion mechanisms of pathogens; Bacteria: host interaction- *Mycobacterium tuberculosis, Borrelia burgdorferi*; Viruses: host interaction: HIV, Influenza; Protozoan: host interaction: *Plasmodium* spp., *Leishmania* spp.
Unit-VI **Human Microbiome** **1 Lecture (2 hours)**	Role in health and disease; identification using bioinformatic tools; prebiotics and probiotics.

Recommended Textbooks:

1. KC Carroll, SA Morse, T Mietzner, S Miller. (2016) Jawetz, Melnick and Adelbergs's *Medical Microbiology* 27th edition, McGraw Hill.

MBT 302: Clinical Biochemistry and Disease Metabolism 3 Credits Theory

Course Objectives: The objectives of this course are to build upon previous knowledge of biochemical pathways and immunology to develop an appreciation of applications of this knowledge in clinical diagnostics and treatment. The course shall make students aware about various disease diagnostic techniques, disease pathologies and clinical case studies within the context of each topic.

Student Learning Outcomes: On completion of this course, students should be able to:

- Understand applications of clinical biochemistry in diagnostics;
- Understand the molecular basis of various pathological conditions from the perspective of biochemical reactions.

Syllabus:

Unit-I

Introduction to Clinical Biochemistry

5 Lectures (10 hours)

Clinical specimen Considerations- Types of Samples, Sample collection & Processing, Sample Variables, Venipuncture, pediatric and geriatric venipuncture, capillary specimen collection, capillary puncture procedures. Place and time of sample collection, Order of draw with multiple blood specimens; Infection control, the vascular system, Anticoagulants & preservatives for blood, Pre-analytical variables (influence of nutrition, drugs, posture, *etc*).; Care of the specimens, identification, transport, storage, influence of temperature, freezing/thawing; Laboratory safety and regulations– Safety awareness, safety equipment, biological, chemical, fire and radiation safety; Method evaluation and quality management, Basic concepts, Reference interval study, Diagnostic efficiency, Method evaluation, Quality assurance & quality control.

Unit-II

Amino Acids and Protein Biochemistry

5 Lectures (10 hours)

Amino acids- Metabolism, Essential Amino Acids, Non-essential Amino Acids, Body amino acid pool, Aminoacidopathies, Amino Acid Analysis, glutathione hyperglycinemias, formation of taurine, homocystinuria, cystinuria and cystinosis, phenyl ketonuria and alkaptonuria, albinism, tyrosinemia; Proteins– Importance, Molecular Size, Catabolism and Nitrogen Balance, Structure, Classification, Dynamic state of body proteins; Plasma proteins- Prealbumin (Transthyretin), Albumin, Globulins; Total Protein abnormalities– Hypoproteinemia, Hyperproteinemia; Methods of analysis– Total nitrogen, Total proteins, Fractionation, Identification and Quantification of specific proteins, Serum protein electrophoresis, High-resolution protein electrophoresis, Immunochemical methods; Proteins in other body fluids– Urinary proteins and Cerebrospinal fluid proteins; Non-protein nitrogen compounds (Physiology, clinical

	application, methods and pathophysiology)– Urea, Uric acid, Creatine, Creatinine, Ammonia, Synthesis of thyroid hormones.
Unit-III **Regulation of Blood Glucose, Insulin and Diabetes Mellitus** **5 Lectures (10 hours)**	Blood glucose regulation (fasting/pp/random)– hormones influencing carbohydrate utilization, Insulin, glucagon, glucocorticoids, epinephrine, growth hormone. Hyperglycemia, Diabetes Mellitus- Aetiology and pathophysiology of Diabetes Mellitus, Symptoms and complications, Criteria for Testing for Prediabetes diabetes, Criteria for the Diagnosis of Diabetes Mellitus, Glucose Tolerance Test, Impaired glucose tolerance test, Glycated hemoglobin, Alimentary glucosuria, Renal glucosuria, Reducing substances in urine, Criteria for the Testing and Diagnosis of Gestational Diabetes Mellitus, Hypoglycemia-Genetic Defects in Carbohydrate Metabolism.
Unit-IV **Transport Mechanism of Plasma Lipid and Lipoprotein Associated Disorders** **5 Lectures (10 hours)**	Transport of plasma lipids, lipoprotein metabolism, lipid profile and diet, PUFA and dietary fiber, Serum triglycerides; Diagnosis and treatment of lipid disorders: Arteriosclerosis, Hyperlipoproteinemia, Hypercholesterolemia, Hypertriglyceridemia, Combined Hyperlipoproteinemia, Lipoprotein(a) Elevation, Hypolipoproteinemia, Hypoalphalipoproteinemia; Lipid and lipoprotein analyses- Lipid Measurement, Cholesterol Measurement, Triglyceride Measurement, Lipoprotein Methods, High-Density Lipoprotein Methods, Low-Density Lipoprotein Methods, Compact Analyzers, Apolipoprotein Methods, Phospholipid Measurement, Fatty Acid Measurement.
Unit-V **Assessment of Organ System Function** **8 Lectures (16 hours)**	**1. Pituitary Function:** Introduction to Hormones and Pituitary Function- hypophysiotropic or hypothalamic hormones; Anterior pituitary hormones; Pituitary tumors; Growth hormone; Actions of growth hormone; Testing; Acromegaly; Growth hormone deficiency; Prolactin; Prolactinoma; Other causes of hyperprolactinemia; Clinical evaluation of hyperprolactinemia; Management of prolactinoma; Idiopathic galactorrhea; Hypopituitarism- Etiology of hypopituitarism; Treatment of panhypopituitarism; Posterior pituitary hormones– Oxytocin and Vasopressin. **2. Liver Function:** Anatomy- Gross Anatomy, Microscopic Anatomy, Biochemical functions- Excretory and Secretory, Synthetic, Detoxification and Drug Metabolism, Liver function alterations during disease– Causes & Classification of Jaundice, Cirrhosis, Tumors, Reye Syndrome, Markers of Hepatic dysfunction: Serum bilirubin, urinary bilirubin, urinary urobilinogen, Urine bile acids & salts. Tests based on serum enzymes, Markers of obstructive liver disease Tests Measuring Hepatic Synthetic Ability: Serum albumin, serum globulin, prothrombin time, Alphafetoprotein, ceruloplasmin, Transerythrin, alpha-1antitrypsin, haptoglobulin, protein

electrophoresis, Tests Measuring Nitrogen Metabolism, Hepatitis

3. Cardiac Function: Anatomy and function of the heart- Anatomy Function, Pathologic conditions of the heart, Cardiovascular Disease, Risk factors of cardiovascular disease, prevention & management, Congenital Cardiovascular Defects, Heart Failure, Acute Coronary Syndromes

4. Renal Function: Renal anatomy, Renal physiology- Formation of urine, Glomerular Filtration Rate, Tubular Function, Renal Threshold, Tubular Maxima, Reabsorbation of water, Osmolality: Water, Electrolyte, and Acid-Base Homeostasis, Endocrine Function, 1,25-Dihydroxy Vitamin D3, Markers for GFR: Clearance Tests; creatinine clearance test, Analytic procedures Urinalysis, abnormal constituents of urine: physical and chemical characteristics of urine, elimination of non-protein nitrogen compounds**,** Pathophysiology– Glomerular Diseases, Tubular Diseases, Urinary Tract Infection/Obstruction, Renal Calculi, Renal Failure. Urine Electrophoresis, 2-Microglobulin, Myoglobin, Microalbumin.

Recommended Textbooks:

1. Michael L. Bishop, Edward P. Fody and Larry E. Schoeff; (2013). *Basic Principles and Practice of Clinical Chemistry*, (7th Ed). Lippincott Williams and Wilkins.
2. Sucheta Dandekar; (2010). *Concise Medical Biochemistry*, (3rd ed), Elsevier Health.
3. Vasudevan D. M. *Text book of Biochemistry* 6th Ed.
4. Tietz. *Fundamentals of Clinical Chemistry and Molecular Diagnostics*. 7th Ed.

MBT 303: Molecular Diagnostics and Medical Devices 3 Credits Theory

Course Objectives: The objectives of this course are to sensitize students about recent advances in molecular biology and various facets of molecular medicine which has potential to profoundly alter many aspects of modern medicine including pre- or post-natal analysis of genetic diseases and identification of individuals predisposed to disease ranging from common cold to cancer. In addition, The objective of the course is to familiarize students with emerging trends in medical devices for early detection, selection of appropriate treatment, monitoring treatment effectiveness and disease surveillance.

Student Learning Outcomes:

On completion of this course, students should be able to:

- Understand various facets of molecular procedures and basics of molecular diagnostics that could be employed in early diagnosis and prognosis of human diseases.
- Extend principles of engineering to the development of medical devices and design of sensors;
- Appreciate basic configuration and distinction among biosensor systems.

Syllabus:

Unit-I **Genome: Resolution, Detection and Analysis** **4 Lectures (8 hours)**	DNA polymorphism; human identity; clinical variability and genetically determined adverse reactions to drugs; PCR: Real-time; ARMS; Multiplex; ISH; FISH; ISA; RFLP; DHPLC; DGGE; CSCE; SSCP; Nucleic acid sequencing: new generations of automated sequencers; Microarray chips; EST; SAGE; microarray data normalization & analysis; molecular markers: 16S rRNA typing; Diagnostic proteomics: SELDI-TOF MS; Bioinformatics data acquisition & analysis.
Unit-II **Diagnostic Metabolomics** **2 Lectures (4 hours)**	Metabolite profile for biomarker detection in the body fluids/tissues under various metabolic disorders by making use of LCMS & NMR technological platforms.
Unit-III **Detection of Diseases** **3 Lectures (6 hours)**	Detection & identity of microbial diseases: Direct detection & identification of pathogenic-organisms that are slow growing or currently lacking a system of *in vitro* cultivation as well as genotypic markers of microbial resistance to specific antibiotics; Detection of inherited diseases: Exemplified by two inherited diseases for which molecular diagnosis has provided a dramatic improvement of quality of medical care: Fragile X Syndrome: Paradigm of the new mutational mechanism of the unstable triplet repeats, von-Hippel Lindau disease: recent acquisition in growing number of familial cancer syndromes.
Unit-IV **Molecular Oncology** **3 Lectures (6 hours)**	Detection of recognized genetic aberrations in clinical samples from cancer patients; types of cancer-causing alterations revealed by next-generation sequencing of clinical isolates; predictive biomarkers for personalized onco-therapy of human diseases such as chronic myeloid leukemia, colon, breast, lung cancer and melanoma as well as matching targeted therapies with patients and preventing toxicity of standard systemic therapies.

Unit-V **Sensors** **3 Lectures (6 hours)**	Rationale of electronic biosensors; Essence of three types of electronic biosensors (*i.e.*, potentiometric, amperometric, and cantilever-based sensors); Three essential metrics that define modern electronic sensors; detection time, sensitivity, and selectivity; Physics of detection time that allows one to organize every available sensor in a systematic way; Fundamental limits of detection of various classes of sensors; Opportunities and challenges of integrating sensors in a system platform.
Unit-VI **Transducers** **3 Lectures (6 hours)**	Principles and applications of Calorimetric, Piezoelectric, semiconductor, impedimetric based transducers; Biochemical Transducers: Electrode theory: electrode-tissue interface, metal-electrolyte interface, electrode-skin interface, electrode impedance, electrical conductivity of electrode jellies and creams.
Unit-VII **Optical Sensors** **2 Lectures (4 hours)**	Photo detectors, optical fiber sensors, indicator mediated transducers; General principles of optical sensing, optical fiber temperature sensors; Pulse sensor: photoelectric pulse transducer, strain gauge pulse transducer.
Unit-VIII **Bio Recognition Systems** **2 Lectures (4 hours)**	Enzymes; Oligonucleotides Nucleic Acids; Lipids (Langmuir-Blodgett bilayers, Phospholipids, Liposomes); Membrane receptors and transporters; Immunoreceptors; Chemoreceptors.
Unit-IX **Electrodes and Immobilization** **2 Lectures (4 hours)**	Microelectrodes, body surface electrodes, needle electrodes, pH electrode, specific ion electrodes/ Ion exchange membrane electrodes, enzyme electrodes; Reference electrodes: hydrogen electrodes, silver-silver chloride electrodes, Calomel electrodes; Enzyme immobilization; Peptide immobilization; Antibody immobilization; Oligonucleotides and Nucleic Acid immobilization; Cell immobilization; Mono-enzyme electrodes; Bi-enzyme electrodes: enzyme sequence electrodes and enzyme competition electrodes.
Unit-IX **Applications** **3 Lectures (6 hours)**	Biomarkers: Disease and pathogen specific information, availability by sample type (blood, serum, urine, sputum, saliva, stool, mucus); Specificity, sensitivity, shelf life, portability; Clinical chemistry; Test-strips for glucose monitoring; Urea determination; Implantable Sensors for long-term monitoring; Drug development and

detection; Environmental monitoring; Examples of various diseases (Cancer, HIV/AIDS, Tuberculosis, Malaria, Lymphatic Filariasis, Schistosomiasis, Dengue, Chikungunya).

Recommended Textbooks:

1. Campbell, A. M., & Heyer, L. J. (2006). *Discovering Genomics, Proteomics, and Bioinformatics*. San Francisco: Benjamin Cummings.
2. Pamela Greenwell, Michelle McCulley, (2008), *Molecular Therapeutics: 21st century Medicine*, 1st Edition, Springer.
3. J G. Webster, (1998), *Encyclopedia of Medical Devices and Instrumentation.* Vol I, II, III, IV, Wiley-Blackwell.

MBT 304: Tissue Engineering and Stem Cell Therapy 3 Credits Theory

Course Objectives: Tissue engineering is progressively being accepted as beneficial means for lessening global disease burden. This course would provide a combined overview of genetic engineering and molecular cell biology to develop fundamental understanding to manipulate cell and tissue properties rationally to alter, restore, maintain, or improve cell and tissue functions. Further, this course also describes strategies of tissue engineering, stem cells, diseases that tissue engineering can address, and also focuses on various ethical issues attached with tissue engineering and stem cell research. This understanding is expected to manipulate cell and tissue properties rationally to alter, restore, maintain, or improve cell and tissue functions as well as to design artificial tissue substitutes.

Student Learning Outcomes: On completion of this course, students should be able to:

- Explain significance, current status and future potential of tissue engineering;
- Identify key challenges in tissue engineering of different human tissues;
- Describe design, fabrication and biomaterials selection criteria for tissue engineering scaffolds;
- Describe sources, selection, potential manipulations and challenges of using stem cells for tissue engineering.

Syllabus:

Unit-I Historical overview and fundamentals of tissue engineering, tissue dynamics/ homeostasis,

Introduction to Bioengineering **3 Lectures (6 hours)**	Introduction to Biomaterials used in tissue engineering, Role of scaffolds and growth factors in tissue engineering; Importance and scope of tissue engineering.
Unit-II **Biomaterials and Scaffold** **4 Lectures (8 hours)**	Engineering scaffolds, Properties and types of scaffolds, Tissue specific scaffolds; Scaffold Preparation: Different methods employed in synthesis of scaffolds and ways to process them; Cell/Tissue-scaffold interaction: Animal cell culture on scaffolds, consequences, optimization strategies and important considerations.
Unit-III **Tissue Engineering Applications** **5 Lectures (10 hours)**	Skin tissue engineering, Liver tissue engineering, Bone and cartilage tissue engineering, Nerve tissue engineering, Vascular tissue engineering, Muscle tissue engineering, Kidney tissue engineering.
Unit-IV **Basic of Stem Cells and Molecular Manipulation Techniques** **8 Lectures (16 hours)**	Stem cells in tissue engineering, types of stem cells, cellular signalling and maintenance of stem cells, isolation, expansion, genetic manipulation, genomic reprogramming, and cloning of stem cells, clinical applications, adult and embryonic stem cells, germline stem cells, ethical issues. Gene silencing technology; Antisense therapy; miRNA, siRNA; Tissue and organ transplantation; Transgenics and their uses; Gene therapy; selection of the right gene, cloning vectors and strategies, intracellular barriers to gene delivery; overview of different vehicles for gene delivery, Retro and adeno virus mediated gene transfer; Liposome and nanoparticles mediated gene delivery; Overview of inherited and acquired diseases for gene, Cell and Tissue Culture, *Ex-vivo* and *in vivo* gene therapy, post therapy immune response, success rate, ethical issues.
Unit-V **Tissue and Animal Level Manipulation & Therapy** **5 Lectures (10 hours)**	Embryonic stem cells, pluripotency, blastocyst and inner cell mass cells; Organogenesis; Mammalian nuclear transfer technology; Stem cell differentiation; Stem cell cryopreservation, animal cloning and ethical considerations. Overview of embryonic and adult stem cells for therapy of human neurodegenerative diseases, Spinal cord Injuries and other Brain Syndromes; Tissue systems Failures; Diabetes; Cardiomyopathy; Kidney failure; Liver failure; infertility, Cancer; Haemophilia etc; Regenerative medicine using biomaterials, Cardiovascular tissue engineering, Connective tissue engineering,

	Musculoskeletal tissue engineering, Neural tissue engineering.
Unit-VI **Therapy and Ethical Issues** **2 Lectures (4 hours)**	Potential applications of human embryonic stem cells; Human embryonic stem cells and society, Ethical considerations in stem cells research; Stem cells and religion consideration; Pre-clinical regulatory consideration in stem cell based therapies and patient advocacy.

Recommended Textbooks:

1. Ed. Robert Lanza *et al.*; *Principles of Tissue Engineering*; Academic Press
2. Lanza R., Atala A.; *Essentials of Stem Cell Biology*; Academic Press

MBT 305: Laboratory-V Medical Microbiology 3 Credits Practical

Course Objectives: This course will provide a perspective and exposure to medical aspects of bacteriology, virology, and parasitology to develop an appreciation of applications of this knowledge in clinical diagnostics. The course shall equip students with basic skills in practicals for medical microbiology.

Student Learning Outcomes: On completion of this course, students should be able to:

- Learn basic hands-on skills for the detection and identification of clinically important microbes;
- Understand applications of medical microbiology in diagnostics.

Syllabus

1. Detection and identification of bacteria: *E. coli, Shigella* spp, *Vibrio cholerae*

a) Culture and staining methods

b) PCR

c) ELISA

2. Detection and identification of viruses: EBV, HPV

a) PCR and RT-PCR

b) ISH

3. Detection of malarial parasite.

a) Thick and thin blood smears

b) PCR

c) Drug resistance assay

4. VITEK

a) Identification of bacterial species

b) Determination of antibiotic resistance

5. Specimen handling and analysis (throat swab/saliva):

a) Collection and Preservation

b) Culture and plating

c) Identification of culturable bacteria

6. Microbiota profiling in body samples (saliva):

a) Total DNA extraction using Qiagen/ MoBio kits

b) 16S rDNA PCR using universal primers

c) NGS of metagenomics of 16S rDNA

d) Bioinformatic analysis for microbiota profiling at genus level

MBT 306: Laboratory-VI Clinical Biochemistry 3 Credits Practical

Course Objectives: The objectives of this course are to build upon previous knowledge of biochemical pathways and immunology to develop an appreciation of applications of this knowledge in clinical diagnostics and treatment. The course shall equip students with basic skills in practicals for clinical biochemistry.

Student Learning Outcomes: On completion of this course, students should be able to:

- Learn basic hands-on skills for blood and urine biochemistry practicals;
- Understand applications of clinical biochemistry in diagnostics;
- Understand the molecular basis of various pathological conditions from the perspective of biochemical reactions through practical case studies.

Syllabus

Blood Practicals

1. Sugar estimation (fasting/ post-pradial-random): Alkaline copper reduction method.
2. Total Lipid Profile and CBC.
3. Kidney Function Test: Urea- Diacetyl monoxime method; Creatine- Jaffe's Kinetic Method.
4. Protein estimation: Total protein- Biuret method, Albumin- BCG method.
5. Lipid; Cholesterol- by CHOD-POD method.
6. Body elements; Calcium- CPC method; Phosphorus- Ammonium phosphomolybdate method.
7. Liver Function Test; Bilirubin (total, direct and indirect)- Diazo method, SGPT, ALP.
8. Electrophoresis for Enzymes and activity staining of any clinically relevant enzyme from a patient sample: Activity measurements of Creatine Kinase, Lactate dehydrogenase from patient sample.

Syllabus

Urine Practicals

1. Sugar
2. Protein
3. Ketone bodies
4. Bile salts and Bile acids

Syllabus

Case Studies

1. **Case history-1: Diabetic Ketoacidosis**

A 32-year-old male with type 1 diabetes since the age of 14 years was taken to the emergency room because of drowsiness, fever, cough, diffuse abdominal pain, and vomiting.

Fever and cough started 2 days ago and the patient could not eat or drink water. On examination, he was tachypneic, his temperature was 39° C, pulse rate 104 beats per minute, respiratory rate 24 breaths per minute, supine blood pressure 100/70 mmHg. He was slightly confused. Perform suitable tests in the blood/urine sample provided and give probable diagnosis on the basis of your findings. Interpret the result accordingly.

2. Case history-2: Nephrotic Syndrome

A five year old child was brought in paediatric OPD with complaints of weakness and polyuria. On physical examination it was observed that he was having periorbital oedema and swelling over legs. Perform suitable tests in blood/urine sample provided and interpret your findings.

3. Case history-3: Chronic Renal Failure

A 70 years old man presented in nephro OPD with complaints of weakness, loss of appetite and breathlessness. He was diabetic and taking anti-diabetic drugs since last 15 years. His blood pressure was 140/100 and there was oedema over face. Perform suitable tests on blood sample provided and interpret your findings accordingly.

4. Case history-4:

Choose a case of a genetic disorder, describe the basics of disease biochemistry, study patient case history to assess the disease phenotype, discuss the available treatment modalities, study the patient case-history after the successful completion of prescribed treatment.

MBT 307: Laboratory- VII Cell and Tissue Culture 3 Credits Practical

Course Objectives: This course aims at providing hands-on experience of basic aspect of methods for handling animal cell culture. Online tools and resources are highly recommended, especially when infrastructure facility is limiting factor.

Student Learning Outcomes: On completion of this course, students should be able to:

- Gain hands on experience of handling and maintaining various animal cell lines;
- Learn materials and substances which cause toxicity in animal cells.

Syllabus

1. Culturing a given cell line (primary or transformed), maintaining the same using serial passaging, safety methods employed to minimise contaminations while culturing and maintaining the culture.

2. Various cell culture media, culturing methods for adherent and suspension cultures, counting cells, quantifying cell viability in the culture, freeze-storing the cultures.

3. Staining cells using nuclear stains such as DAPI/PI or membranes or mitochondria using specific dyes, followed by fluorescence imaging.

4. Detecting contamination (bacterial/fungal/micoplasma *etc.*) in animal cell cultures. Cross-contamination of cell-lines.

5. Trypsinizing cells: Trypsinization is a technique that uses the proteolytic enzyme trypsin to detach adherent cells from the surface of a cell culture vessel. This procedure is performed whenever the cells need to be harvested (*e.g.*, for passaging, counting, or for nucleic acid isolation).

6. Low speed centrifugation of cultured cells, followed by detergent lysis and fractionation of cell lysates into cytoplasmic, nuclear soluble and chromatin fractions. Assessing the purity of cell fractionation by staining with marker-specific Abs using Immunoflorescence or western blot methods.

7. Assessing culture instability: This is generally overlooked in busy labs, but is a very important facet of cell culturing. The growth rate of cells that have been repeatedly subcultured may sometimes unexpectedly decrease, and the cytotoxicity of, for example, a transfection process may unexpectedly increase. This instability can result from variations in cell culture conditions, genomic variation, and selective overgrowth of constituents of the cell population. Importance of using cells with a low passage number (<10 splitting cycles). To safeguard against instability in continuous cell lines, avoid senescence or transformation in finite cell lines, and maintain consistency in transfection experiments, and create cell banks by freezing aliquots of cells to recall into culture if and when necessary.

8. Also important to learn about procedures of sterilizing potentially bio-hazardous materials (*e.g.*, cells, culture medium, *etc.*) before disposal, and disposed of according to your institution's guidelines.

MBT 308: Seminar-I Journal Club Presentation 2 Credits Practical

Course Objectives: The objectives of this course are to train the students to evaluate research papers, to assess quality of the papers and how the papers are refereed and published as well as learn how to get the papers published.

Student Learning Outcomes:

On completion of this course, students should be able to:

- Critically analyse the research papers from different upcoming topics;
- Understand the weaknesses and strengths of the paper and what additional experiments could have been done to strengthen the research study;
- Understand the context of the paper and identify important questions;
- Acquire the skills in paper writing and getting it published.

Syllabus

1. Student Presentations:

Each student will need to present one paper during the term. They should select research papers, which deal with upcoming or most recent scientific findings/breakthrough and technologies developed.

2. Class Evaluations and Discussions:

Every week, each student will be asked to write a short review and evaluations of the paper presented in the class and then indulge in discussion with flaws of the paper, important questions and impact of the overall paper. Recent technologies, can be discussed, where it can be applied.

Semester-IV [Total: 2 (T) + 21 (P) = 23 Credits]

CBT 401: Intellectual Property Rights, Biosafety and Bioethics
2 Credits Theory

Course Objectives: The course concentrates on technology, knowledge and business management aspect of intellectual property, including patenting aspect so as to focus on use of IP to drive business models and value propositions. It also provides insights to align IP strategies with overall corporate strategies and Shares best practice models for IP valuation. This course further enables students to learn biosafety and risk assessment of products derived from biotechnology and regulation of such products. It also addresses ethical issues in biological research.

Student Learning Outcomes: On completion of this course, students should be able to:

- Understand the rationale for and against IPR and especially patents;
- Understand why India has adopted National IPR Policy and be familiar with broad outline of patent regulations;
- Understand different types of intellectual property rights in general and protection of products derived from biotechnology research and issues related to application and obtaining patents;
- Gain knowledge of biosafety and risk assessment of products derived from recombinant DNA research environment release of genetically modified organisms, national and international regulations;
- Understand ethical aspects related to biological, biomedical, health care and biotechnology research.

Syllabus:

Unit-I

Introduction to IPR

4 Lectures (8 hours)

Types of IP: patents, trademarks, copyright & related rights, industrial design, traditional knowledge, geographical indications, protection of new GMOs; International framework for the protection of IP; IP as a factor in R&D; IPs of relevance to biotechnology and few case studies; introduction to history of GATT, WTO, WIPO and TRIPS; plant variety protection and farmers rights act; concept of 'prior art': invention in context of "prior art"; patent databases- country-wise patent searches (USPTO, EPO, India); analysis and report formation.

Unit-II

Basics of patents: types of patents; Indian Patent Act 1970;

Patenting **3 Lectures (6 hours)**	recent amendments; WIPO Treaties; Budapest Treaty; Patent Cooperation Treaty (PCT) and implications; procedure for filing a PCT application; role of a Country Patent Office; filing of a patent application; precautions before patenting- disclosure/non-disclosure- patent application- forms and guidelines including those of National Bio-diversity Authority (NBA) and other regulatory bodies, fee structure, time frames; types of patent applications: provisional and complete specifications; PCT and conventional patent applications; international patenting-requirement, procedures and costs; financial assistance for patenting introduction to existing schemes; publication of patents-gazette of India, status in Europe and US; patent infringement- meaning, scope, litigation, case studies and examples; commercialization of patented innovations; licensing– outright sale, licensing, royalty; patenting by research students and scientists-university/organizational rules in India and abroad, collaborative research- backward and forward IP; benefit/credit sharing among parties/community, commercial (financial) and non-commercial incentives.
Unit-III **Biosafety** **3 Lectures (6 hours)**	Introduction; historical background; introduction to biological safety cabinets; primary containment for biohazards; biosafety levels; GRAS organisms, biosafety levels of specific microorganisms; recommended biosafety levels for infectious agents and infected animals; definition of GMOs & LMOs; principles of safety assessment of transgenic plants– sequential steps in risk assessment; concepts of familiarity and substantial equivalence; risk – environmental risk assessment and food and feed safety assessment; problem formulation– protection goals, compilation of relevant information, risk characterization and development of analysis plan; risk assessment of transgenic crops *vs* cisgenic plants or products derived from RNAi, genome editing tools.
Unit-IV **International and National Regulations** **3 Lectures (6 hours)**	International regulations: Cartagena protocol, OECD consensus documents and Codex Alimentarius; Indian regulations: EPA act and rules, guidance documents, regulatory framework: RCGM, GEAC, IBSC and other regulatory bodies; Draft bill of Biotechnology Regulatory authority of India- containments– biosafety levels and category of rDNA experiments; field trails– biosafety research trials– standard operating procedures- guidelines of state governments; GM labeling– Food Safety and Standards Authority of India (FSSAI).
Unit-V	Introduction, ethical conflicts in biological sciences-

Bioethics

5 Lectures (10 hours)

interference with nature, bioethics in health care- patient confidentiality, informed consent, euthanasia, artificial reproductive technologies, prenatal diagnosis, genetic screening, gene therapy, transplantation. Bioethics in research– cloning and stem cell research, Human and animal experimentation, animal rights/welfare, Agricultural biotechnology– Genetically engineered food, environmental risk, labeling and public opinion. Sharing benefits and protecting future generations- Protection of environment and biodiversity– biopiracy.

Recommended Textbooks:

1. *Biosafety in Microbiological and Biomedical Laboratories*, (2009) 5th Ed, www.cdc.gov/od/ohs/biosfty/bmbl5/bmbl5toc.html.
2. V. Shree Krishna, (2007), *Bioethics and Biosafety in Biotechnology*, New Age International Pvt. Ltd. Publishers.
3. Deepa Goel, Shomini Parashar. (2013). *IPR, Biosafety and Bioethics.* Pearson.

MBT 401: Seminar-II Dissertation Work — 1 Credit Practical

Course Objectives: The purpose of this course is to help students organize ideas, material and objectives for their dissertation and to begin development of communication skills and to prepare the students to present their topic of research and explain its importance to their fellow classmates and teachers.

Student Learning Outcomes: Students should be able to demonstrate the following abilities:

- Formulate a scientific question;
- Present scientific approach to solve the problem;
- Interpret, discuss and communicate scientific results in written form;
- Learn how to present and explain their research findings to the audience effectively.

Syllabus

1. Oral Presentation:

At the end of their project, presentation will have to be given by the students to explain work done by them in detail. Along with summarizing their findings they should also be able to discuss the future expected outcome of their work.

MBT 402: Dissertation Work — 20 Credits Practical

Course Objectives: The objectives of this course are to prepare the students to adapt to the research environment and understand how projects are executed in a research laboratory. It will also enable students to learn practical aspects of research and train students in the art of analysis and thesis writing.

Student Learning Outcomes: Students should be able to learn how to select and defend a topic of their research, how to effectively plan, execute, evaluate and discuss their experiments. Students should be able to demonstrate considerable improvement in the following areas:

- In-depth knowledge of the chosen area of research;
- Capability to critically and systematically integrate knowledge to identify issues that must be addressed within framework of specific thesis;
- Competence in research design and planning;
- Capability to create, analyse and critically evaluate different technical solutions;
- Ability to conduct research independently;
- Ability to perform analytical techniques/experimental methods;
- Project management skills;
- Report writing skills;
- Problem solving skills;
- Communication and interpersonal skills.

Syllabus

1. Planning and Performing Experiments:

Based on the project proposal submitted in earlier semester, students should be able to plan, and engage in, an independent and sustained critical investigation and evaluate a chosen research topic relevant to biological sciences and society. They should be able to systematically identify relevant theory and concepts, relate these to appropriate methodologies and evidence, apply appropriate techniques and draw appropriate conclusions. Senior researchers should be able to train the students such that they can work independently and are able to understand the aim of each experiment performed by them. They should also be able to understand the possible outcomes of each experiment.

2. Thesis Writing:

At the end of their project, thesis has to be written giving all the details such as aim, methodology, results, discussion and future work related to their project. Students may aim to get their research findings published in a peer-reviewed journal. If the research findings have application-oriented outcomes, the students may file patent application.