# CHOICE BASED CREDIT SYSTEM

## Scheme of Instruction & Syllabus

## for

## M.Sc. Biotechnology

### 2019-2020


**JIS UNIVERSITY,**
81, Nilgunj Road,Agarpara
Kolkata -700109

# SEMESTER-I

| Sl.No. | Course | Type | Paper Code | Title of the Paper | L | T | P | No. of Credits | No of Hrs./Week |
|---|---|---|---|---|---|---|---|---|---|
| 1 | CC1 | Theoretical | MBT-101 | Biomolecules and Biophysical Techniques | 3 | 1 | 0 | 4 | 4 |
| 2 | CC2 | Theoretical | MBT-102 | Enzymology and Metabolism | 3 | 1 | 0 | 4 | 4 |
| 3 | CC3 | Theoretical | MBT-103 | Microbiology | 3 | 1 | 0 | 4 | 4 |
| 4 | CC4 | Practical | MBT-191 | Biomolecules and Enzymology Lab | 0 | 0 | 2 | 2 | 3 |
| 5 | CC5 | Practical | MBT-192 | Instrumentation Lab | 0 | 0 | 2 | 2 | 3 |
| 6 | CC6 | Practical | MBT-193 | Microbiology Lab | 0 | 0 | 2 | 2 | 3 |
| 7 | CBCS | Theoretical | | CBCS-1 | 3 | 1 | 0 | 4 | 4 |
| **Total** | | | | | | | | **22** | 25 |
| **NON-CGPA** | | | | | | | | | |
| 8 | EXTRA CC | | MSD-181 | Seminar | 0 | 0 | 1 | 1 | 1 |
| 9 | EXTRA CC | | MSD-182 | SkillX | 0 | 0 | 1 | 1 | - |
| **TOTAL** | | | | | | | | **24** | **26** |

## SEMESTER-II

| Sl.No. | Course | Type | Paper Code | Title of the Paper | L | T | P | No. of Credits | No of Hrs./Week |
|---|---|---|---|---|---|---|---|---|---|
| 1 | CC7 | Theoretical | MBT-201 | Immunology | 3 | 1 | 0 | 4 | 4 |
| 2 | CC8 | Theoretical | MBT-202 | Molecular Biology | 3 | 1 | 0 | 4 | 4 |
| 3 | CC9 | Theoretical | MBT-203 | Genetics | 3 | 1 | 0 | 4 | 4 |
| 4 | CC10 | Practical | MBT-291 | Immunology Lab | 0 | 0 | 2 | 2 | 3 |
| 5 | CC11 | Practical | MBT-292 | Molecular Biology Lab | 0 | 0 | 2 | 2 | 3 |
| 6 | CC12 | Practical | MBT-293 | Genetics Lab | 0 | 0 | 2 | 2 | 3 |
| 7 | CBCS | Theoretical | | CBCS II | 3 | 1 | 0 | 4 | 4 |
| **Total** | | | | | | | | **22** | **25** |
| **NON-CGPA** | | | | | | | | | |
| 8 | EXTRA CC | | MSD-281 | Seminar | 0 | 0 | 1 | 1 | 1 |
| 9 | EXTRA CC | | MSD-282 | SkillX | 0 | 0 | 1 | 1 | - |
| **TOTAL** | | | | | | | | **24** | **26** |

## SEMESTER-III

| Sl.No. | Course | Type | Paper Code | Title of the Paper | L | T | P | No. of Credits | No of Hrs./Week |
|---|---|---|---|---|---|---|---|---|---|
| 1 | CC13 | Theoretical | MBT301 | Recombinant DNA Technology | 3 | 0 | 1 | 4 | 5 |
| 2 | CC14 | Theoretical | MBT302 | Cell Biology | 3 | 1 | 0 | 4 | 4 |
| 3 | CC15 | Theoretical | MBT303 | Bioinformatics | 2 | 0 | 2 | 4 | 5 |
| 4 | Elective 1 | Theoretical | MBT304/ MBT305 | Developmental Biology/ Metabolic Engineering | 3 | 1 | 0 | 4 | 4 |
| 5 | CC16 | Project | MBT-392 | Project | 0 | 0 | 2 | 2 | 3 |
| **Total** | | | | | | | | **18** | **21** |
| **NON-CGPA** | | | | | | | | | |
| 8 | EXTRA CC | | MSD-381 | Seminar | 0 | 0 | 1 | 1 | 1 |
| 9 | EXTRA CC | | MSD-382 | SkillX | 0 | 0 | 1 | 1 | - |
| **TOTAL** | | | | | | | | **20** | **22** |

## SEMESTER-IV

| Sl.No. | Course | Type | Paper Code | Title of the Paper | L | T | P | No. of Credits | No of Hrs./Week |
|---|---|---|---|---|---|---|---|---|---|
| 1 | CC17 | Project Dissertation and Viva | MBT-491 | Project and Viva | 0 | 0 | 4 | 4 | 8 |
| 2 | CC18 | Theoretical | MBT-401 | Proteomics and Genomics | 3 | 1 | 0 | 4 | 4 |
| 3 | CC19 | Theoretical | MBT-402 | Bioenergetics and Metabolism | 3 | 1 | 0 | 4 | 4 |
| 4 | Elective 2 | Theoretical | MBT403A/MBT403B | Cell Culture Technology and Tissue Engineering /Virology | 3 | 1 | 0 | 4 | 4 |
| 5 | CC20 | Industry Visit | MBT-492 | Industrial Visit | 0 | 0 | 2 | 2 | - |
| **Total** | | | | | | | | **18** | **20** |
| **NON-CGPA** | | | | | | | | | |
| 8 | EXTRA CC | | MSD-481 | Seminar | 0 | 0 | 1 | 1 | 1 |
| 9 | EXTRA CC | | MSD-482 | SkillX | 0 | 0 | 1 | 1 | - |
| **TOTAL** | | | | | | | | **20** | **21** |

## M.Sc. in Biotechnology Syllabus

# CORE COURSES

## CC1: Biomolecules and Biophysical Techniques 3-1-0=4

**Unit I**

Carbohydrates-Monosaccharides- disaccharides- oligosaccharides- sugar derivatives- amino sugar- phosphate esters- deoxysugar- sugar acidpolysaccharides- structure and biological functions of homo- and heteropolysaccharides- biosynthesis and degradation of glucose and glycogen.

Proteins-primary- secondary- tertiary and quaternary structure- Ramachandran plot- super secondary structures- helix loop helix- - biosynthesis of urea.

Lipids- Classification- structure and properties- phospholipids- glycoplipidssphingolipids- cholesterol. Fatty acids- saturated and unsaturated fatty acidsbiosynthesis and degradation- Structure and biological role of prostaglandins, thromboxanes and leukotrienes.

Nucleic acids- types and structural organization- triple helix of DNA- DNA denaturation and renaturation- hypochromicity- Tm.

**Unit II**

Basic Techniques - Buffers; Methods of cell disintegration; Enzyme assays and controls; Detergents and membrane proteins; Dialysis, Ultrafiltration and other membrane techniques; Spectroscopy Techniques - UV, Visible and Raman Spectroscopy; Theory and application of Circular Dichroism; Fluorescence; MS, NMR, PMR, ESR and Plasma Emission spectroscopy Infrared Spectroscopy – Principles of IR spectroscopy, vibrational spectra of biopolymers, Fourier transform of Infra Red spectroscopy, Instrumentation, factors influencing vibrational frequency (Vibronic coupling, H-bond, electronic factors, bond angles, etc) NMR Spectroscopy – Proton magnetic resonance spectra of proteins, 13C NMR spectra of proteins, 31P NMR studies, NMR spectra of nucleic acids, Fourier transform of NMR spectroscopy, Relaxation (ID spectra) X-Ray Crystallography – Instrumentation, Fourier transformation, Application.

**Unit III**

Chromatography Techniques - TLC and Paper chromatography; Chromatographic methods for macromolecule separation - Gel permeation, Ion exchange, Hydrophobic, Reverse-phase and Affinity chromatography; HPLC and FPLC; Criteria of protein purity; Electrophoretic techniques - Theory and application of Polyacrylamide and Agarose gel electrophoresis;

Capillary electrophoresis; 2D Electrophoresis; Disc gel electrophoresis; Gradient electrophoresis; Pulsed field gel electrophoresis

**Unit IV**

Centrifugation - Basic principles; Mathematics & theory (RCF, Sedimentation coefficient etc); Types of centrifuge - Microcentrifuge, High speed & Ultracentrifuges; Preparative centrifugation; Differential & density gradient centrifugation; Applications (Isolation of cell components); Analytical centrifugation; Determination of molecular weight by sedimentation velocity & sedimentation equilibrium methods.

**Unit V**

Radioactivity - Radioactive & stable isotopes; Pattern and rate of radioactive decay; Units of radioactivity; Measurement of radioactivity; Geiger-Muller counter; Solid & Liquid scintillation counters (Basic principle, instrumentation & technique); Brief idea of radiation dosimetry; Cerenkov radiation; Autoradiography; Measurement of stable isotopes; Falling drop method; Applications of isotopes in biochemistry; Radiotracer techniques; Distribution studies; Isotope dilution technique; Metabolic studies; Clinical application; Radioimmunoassay.

**Unit VI** Microscopy- Basic concept, Light, Dark-field, phase contrast, fluorescence, confocal, scanning and transmission electron microscopy, Scanning Probe microscopy (AFM, STM)

## CC2: Enzymology & Metabolism 3-1-0=4

**Unit I: Enzymes:** General properties, Nomenclature and classification; Co-factors definition and function with special reference to the representative substances - a) Co-enzymes (NAD+, NADP+, Co-enzyme-A, TPP, Pyridoxal phosphate); b) Prosthetic groups (FAD+ - Succinic dehydrogenase); c) Metal ions: Zn2+, Mg2+, Fe2+, Fe3+, Mn2+ - required for enzyme action. Michaelis-Menten equation; Enzyme Inhibition – Competitive, Non-competitive, Regulatory enzymes-Allosteric, Feedback inhibition, Ribozyme and Abzyme.

**Unit II: Carbohydrate metabolism:** Aerobic respiration-Glycolysis (EMP-pathway) with energy production: entry of galactose & fructose in EMP-path; TCA-cycle with energy production: pentose-phosphate pathway, Fermentation - Glucose metabolism in anaerobic condition.

**Unit III: Electron Transport Chain:** ETC & ATP generation sites; ATP & ADP cycle (oxidationreduction potential and electromotive force). Photophosphorylation, oxidative phosphorylation (chemiosmotic theory)

**Unit IV: Fatty acid metabolism:** Oxidation of fatty (ß) acids, Metabolism of ketone bodies - Formation, utilization, excretion and clinical significance. Biosynthesis of fatty acids.

Cholesterol-Biosynthesis, regulation, transport and excretion. Metabolism of lipoproteins. Eicosanoid metabolism.

**Unit V: Amino acid metabolism:** Overview of biosynthesis of nonessential amino acids. Catabolism of amino acid nitrogen - Transamination, deamination, ammonia formation and the urea cycle.Disorders of the urea cycle. Catabolism of carbon skeletons of amino acids. Conversion of amino acids to specialized products.

**Unit VI: Nucleic acid metabolism:** Metabolism of purines - De novo and salvage pathways for biosynthesis. Purine catabolism. Biosynthesis and catabolism of pyrimidines.

## CC3: Microbiology 3-1-0=4

**UNIT I:**

Methods of sterilization: Physical methods, chemical methods and their application. Microbial cultures: Concept of pure culture, Methods of pure culture isolation, Enrichment culturing techniques. Microscopic identification characteristics, staining methods. Microbiological media-Natural and synthetic; autotrophic, heterotrophic and phototropic media: basal, defined, complex, enrichment, selective, differential, maintenance and transport media. Preservation and Maintenance of Microbial cultures. Bacterial nutrition and growth kinetics

**Unit II: Food microbiology:** Microbes used in food fermentation, food preservatives of microbial origin, Microbes as food (SCP, organic acid, vitamins, neutraceuticals), enzymes of microbial origin and its use in food, contribution of microbes in food digestion, microbial food spoilage, microbial food borne diseases, control of microorganism in food, HACCP, biosensors in food.

**Unit III: Clinical microbiology:** Microbiome of human system, host pathogen interaction, medically important microbes, microbial diseases - sources, route of transmission. pathogenesis - adhesion, invasion, host cell damage, release of pathogens, signs and symptoms of microbial diseases. treatment, prevention and control of microbial infections. immunity of microbial diseases. diagnosis of microbial diseases modern methods of microbial diagnosis.
Treatment, prevention and control of diseases caused by bacteria,

**Unit IV: Enzyme in microbiology**: Enzymes of microbial origin and its analytical, therapeutic & industrial applications, immobilization- process, property and application

**Unit V: Industrial microbiology:** Production and application of microbial pigments, therapeutic compound, industrial production of organic acid, enzymes, amino acid, microbial production of biofuels, bioinsectices, biopolymer, biosurfactent, Biofertilizers.

**Unit VI: Microbial interaction study-** quorum sensing, different types of interaction

**Unit VII: Environment microbiology**

Eutrophication, bioremediation, biomonitoring, bioterrorism, biogeochemical cycle, biofertiliser, waste utilization to valuable product

## CC4: Biomolecules & Enzymology Lab 0-0-2=3

1. Making of Buffers
2. One dimensional TLC of amino acids and Carbohydrates
3. Two dimensional TLC of amino acids and Carbohydrates
4. Isolation and precipitation of proteins from natural sources and Wavelength scan of proteins
5. Estimation of proteins by Lowry and Brandford methods
6. Thermal unfolding of proteins and calculations of thermo-dynamic parameters from temperature scanning UV spectrophotometer, Effect of solvent conditions on thermal stability of proteins.
7. pH titrations of protein, calculation of net charge and total charge at a particular pH.
8. Reduction of disulphide bonds of proteins.
9. Estimation of DNA by chemical means and wavelength scan of DNA
10. Melting studies of calf thymus DNA
11. Effect of temperature, time and substrate concentration on salivary alpha amylase activity

## CC5: Instrumentation Lab 0-0-2=3

1. Native gel electrophoresis of proteins
2. SDS-polyacrylamide slab gel electrophoresis of proteins under reducing conditions.
3. Preparation of the sub-cellular fractions of rat liver cells.
4. Preparation of protoplasts from leaves.
5. Separation of amino acids by paper chromatography.
6. To identify lipids in a given sample by TLC.
7. To verify the validity of Beer's law and determine the molar extinction coefficient.

## CC6: Microbiology Lab 0-0-2=3

1. Laboratory rules, safety and regulation, First Aid and ethics.
2. Standardization of microscope, measurement of microbes and direct cell counting.
3. Staining technique

   i) simple staining

   ii) differential staining

   iii) endospore staining

   iv) capsule staining
4. Pure culture method – Enumerate the number of bacteria from air and soil.
5. Preparation of bacterial growth curve
6. Assay of antibiotics by agar cup method and dilution method
7. Biochemical tests
8. i) Indole tests

   ii) Methyl red test

   iii) Voges Proskaur tests

   iv) Starch hydrolysis tests

   v) Tests for catalase, lipase, protease, amylase and oxidase

   vi) Gelatin hydrosis test
9. Isolation of Rhizobium from legume root nodule
10. Water microbiology – Testing for quality of water (coliform test)

## CC7: Immunology 3-1-0=4

**Unit-I: Introduction:** Phylogeny of Immune system, innate and acquired immunity, Clonal nature of immune response. Organisation and structure of lymphoid organs. Nature and Biology of antigens and super antigens.

**Unit-II: Antibody diversity:** Antibody structure and function, antigen and antibody interactions, Major histocompatibility complex, HLA. Generation of antibody diversity and complement system.

**Unit-III: Cells of immune system:** Hematopoiesis and differentiation, lymphocyte trafficking, B-lymphocyte, T-lymphocytes, macrophages, Dentritic cells, natural killer and lymphokine activated killer cells. Eosinophils, neutrophils and mast cells. Activation of B and T- lymphocytes. Cell mediated cytotoxicity: mechanism of T cell and NK cell mediated lysis, antibody dependent cell mediated cytotoxicity and macrophage mediated cytotoxicity.

**Unit-IV: Antigen processing:** Antigen processing and presentation, generation of humoral and cell mediated immune responses, cytokines and their role in immune regulation, T- cell regulation, MHC- regulation, Immunological tolerance, Hypersensitivity Reactions, Different types of anaphylaxis reactions with examples, Autoimmunity, Immunosenesence.

**Unit-V: Immunological disorders:** Transplantation (Immunity and graft rejections), Immunity to infectious agents (intracellular parasites, helimenths & viruses,) Tumor Immunology, AIDS and other immunodeficiences, autoimmune diseases, Hybridoma Technology and Monoclonal Antibodies.

**Unit-VI: Antigen - Antibody interactions:** Precipitation reactions-Radial immunodiffusion, double immunodiffusion, immunoelectrophoresis; Agglutination reactions-Hemagglutination, passive agglutination, bacterial agglutination, agglutination inhibition.

**Unit-VII: Complement Systems:** The complement components, function, complement activation- (i) Classical, (ii) Alternate and (iii) lectin pathways.

## CC8: Molecular Biology 3-1-0=4

**Unit I: DNA Replication:** Models of DNA Replication, Origin and direction of replication, Semidiscontinuous replication, DNA polymerases of prokaryotes and their mechanism of action; Primase, Ligase, Single strand DNA binding protein, Helicase, Topoisomerases. Replication strategies for replicating circular DNA: φ mode replication, σ mode or rolling circle replication and D-loop replication. Eukaryotic DNA polymerases, Reverse transcriptase, Strategies for replicating linear DNA, Fidelity and processivity of replication, Inhibitors of replication.

**Unit II:** DNA Repair and Recombination: DNA Repair mechanisms, Photoreactivation, Excision repair mechanism, Post replication repair mechanisms - recombination repair, mismatch repair system, SOS response, transcription-repair coupling. Recombination - models of general recombination; Hollyday model, asymmetric strand transfer model, double strand break repair model, site-specific recombination. Transposition of DNA; Transposable elements, Prokaryotic transposons, Eukaryotic transposons, Retroposons.

**Unit III: Transcription and Transcriptional control:** Structure of bacterial RNA polymerase, Transcription events, and sigma factor cycle, Eukaryotic RNA polymerase, Promoter sequences, TATA box, Hogness Box, CAAT box, Enhancers, upstream activating sequences, Initiation and termination of transcription factor, RNA processing in Prokaryotes Vs Eukaryotes, Spliceosome.

**Unit IV: Translation:** Prokaryotic and Eukaryotic translation, the translation machinery, Mechanisms of initiation, elongation and termination, Regulation of translation. Post-translational modifications and intracellular proteins transport

**Unit V: Control of gene expression in prokaryotes and eukaryotes:** operon model- lac and trp operon, Autogenous regulation, Feedback inhibition, Lytic cascades and lysogenic repression. Molecular Biology of Cancer causes and Genetics of cancer, Tumor suppressor genes and onco genes, anticancer agent (p53 and pRB).

## CC9: Genetics 3-1-0=4

**Unit I: Mendelian principles:** Dominance, segregation, independent assortment.

**Unit II: Concept of gene:** Allele, multiple alleles, pseudoallele, complementation tests

**Unit III: Extensions of Mendelian principles:** Codominance, incomplete dominance, gene interactions, pleiotropy, genomic imprinting, penetrance and expressivity, phenocopy, linkage and crossing over, sex linkage, sex limited and sex influenced characters.

**Unit IV: Gene mapping methods:** Linkage maps, tetrad analysis, mapping with molecular markers, mapping by using somatic cell hybrids, development of mapping population in plants.

**Unit V: Extra chromosomal inheritance:** Inheritance of Mitochondrial and chloroplast genes, maternal inheritance.

**Unit VI: Microbial genetics:** Methods of genetic transfers – transformation, conjugation, transduction and sex-duction, mapping genes by interrupted mating, fine structure analysis of genes.

**Unit VII: Human genetics:** Pedigree analysis, lod score for linkage testing, karyotypes, genetic disorders.

**Unit VIII: Quantitative genetics:** Polygenic inheritance, heritability and its measurements, QTL mapping.

**Unit IX: Mutation:** Types, causes and detection, mutant types – lethal, conditional, biochemical, loss of function, gain of function, germinal verses somatic mutants, insertional mutagenesis.

**Unit X: Structural and numerical alterations of chromosomes:** Deletion, duplication, inversion, translocation, ploidy and their genetic implications

## CC10: Immunology Lab 0-0-2=3

1. Simple immunodiffusion
2. Radial immuodiffusion
3. Immuno-electrophoresis
4. Spot ELISA
5. Blood group and Rh typing
6. Rocket electrophoresis
7. Ag-Ab agglutination reaction

## CC11: Molecular Biology Lab 0-0-2=3

1. DNA isolation - from Plant cell, Animal cell (goat liver), Human Blood & Microbes
2. Plasmid DNA isolation
3. Gel electrophoresis
4. Making competent cells and transformation of *E. coli* with recombinant plasmids
5. PCR amplification of DNA from unknown bacteria

## CC12: Genetics Lab 0-0-2=3

1. Prepare and analyze microscope slides of cells undergoing mitosis and meiosis.
2. Conduct and analyze inheritance experiments utilizing Drosophila.
3. Apply chi-square to inheritance data.
4. Analyze the eye pigments of Drosophila mutants utilizing paper chromatography.
5. Prepare agarose gel for standard DNA electrophoresis
6. Perform serial dilutions
7. Design Basic PCR Primers
8. Conduct a plasmid transformation of E.coli.
9. Isolate plasmids from E. coli.
10. Determine the size of DNA fragments by electrophoresis.
11. Determine the restriction map of DNA using restriction endonucleases and gel electrophoresis
12. Amplify samples of DNA through Polymerase Chain Reaction.

## CC13: Recombinant DNA Technology 3-0-1=4

**Unit I: Vectors for cloning:** Plasmids, phages, ssDNA phages, cosmids,YACs. Enzymes used in gene manipulation-restriction enzymes, DNA polymerases, reverse transcriptase, ligases, polynucleotide kinase, alkaline phosphatase and nucleases.

**Unit II: Transfer of DNA into cells:** transformation, transduction, electroporation, microinjection. Agrobacterium mediated gene transfer.

**Unit III: Cloning strategies:** Genomic libraries, cDNA Cloning subcloning, shot gun cloning. Cloning in E. coli, Bacilli and yeast. Yeast two hybrid system. cDNA phage display library. Recombinant clones: Detection of recombinant DNA and its Products.

**Unit IV: Site-directed mutagenesis of cloned genes. DNA sequencing:** Oxy, deoxy chemical methods, Pyrosequencing, Nanosequencing. PCR: Design of PCR primers, RT-PCR, RACE, AP-PCR, PAF. Antisense and ribosome technology: siRNA, miRNA, Ras, Dicer. Applications of PCR.

**Unit V: Applications of genetic engineering:** In medicine, agriculture, veterinary and industry. Safety aspects of recombinant DNA technology; Bioethics and Bioissues for releasing GMOs. DNA forensics. Somatic cell gene therapy.

## Recombinant DNA Technology Lab

1. UV mutagenesis and percent survival
2. Photoreactivation of UV irradiated E. coli.
3. Development of auxotrophic mutants employing EMS
4. Screening of multiple antibiotic resistant mutants of E. coli
5. Plasmid curing in bacteria
6. Replica plating technique
7. Determination of purity and estimation of DNA
8. Transfection by single burst experiment
9. Blue and white colony selection employing X-gal-IPTG

## CC14: Cell Biology 3-1-0=4

**Unit I: Membrane structure and function:** Structure of model membrane, lipid bilayer and membrane protein diffusion, osmosis, ion channels, active transport, ion pumps, mechanism of sorting and regulation of intracellular transport, electrical properties of membranes.

**Unit II: Cytoskeleton** - Types, tubulin and microtubules, Kinesin, Dynein, and intracellular transport, Cilia and flagella – Structure and movement. Action and myosin. Mechanism of muscle contraction. Intermediate filaments, motor proteins.

**Unit III: Cell signalling:** Hormones and their receptors, cell surface receptor, signaling through G-protein coupled receptors, signal transduction pathways, second messengers, regulation of signaling pathways, bacterial and plant two-component signaling systems, bacterial chemotaxis and quorum sensing.

**Unit IV: Cellular communication:** Regulation of hematopoiesis, general principles of cell communication, cell adhesion and roles of different adhesion molecules, gap junctions, extracellular matrix, integrins, neurotransmission and its regulation.

**Unit V: Protein traffic in cells -** Protein sorting and signal sequences; protein translocation in ER and vesicular transport to Golgi, lysosmes and plasma membrane; protein import into nuclei, mitochondria, chloroplasts and peroxisomes.

**Unit VI: Cell cycle** - Phases of the cell cycle. Interphase, cytokinesis, Regulation of MPF activity, Cell cycle control in mammalian cells. Role of check points in cell cycle regulation. Cell cycle and cancer. Apoptosis.

## CC15: Bioinformatics 2-0-2=4

**Unit I: Basics of Computer:** Basic operations, architecture of computer. Introduction of digital computers. Organization, low level and high level languages, binary number system. The soft side of the computer – Different operating systems – Windows, Linux. Introduction of programming in C. Introduction to Internet and its applications. Use of statistical packages for data analysis i.e. SPSS etc.

**Unit II: Introduction to Bioinformatics:** Genomics and Proteomics. Bioinformatics – Online tools and offline tools. Biological databases. Types of data bases – Gene Bank, Swiss port, EMBL, NCBI, and PDB. Database searching using BLAST and FASTA.

**Unit III: Multiple sequence alignment and Dynamic programming:** Gene and Genome annotation – Tools used. Physical map of genomes. Molecular phylogeny - Concept methods of tree construction.

**Unit IV: Protein secondary structure prediction:** Protein 3D structure prediction. Molecular docking. Introduction to homology modeling, Computer Aided Drug Design (CADD) in Drug discovery.

## CC16: Review work for project 0-0-2=2

## CC17: Project, Dissertation and Viva 0-0-4=4

## CC18: Genomics and Proteomics 3-1-0=4

**Unit I: Introduction:** Structural organization of genome in Prokaryotes and Eukaryotes; Organelle DNA-mitochondrial, chloroplast; DNA sequencing-principles and translation to large scale projects; Recognition of coding and non-coding sequences and gene annotation; Tools for genome analysis-RFLP, DNA fingerprinting, RAPD, PCR, Linkage and Pedigree analysis-physical and genetic mapping.

**Unit II: Genome sequencing projects:** Microbes, plants and animals; Accessing and retrieving genome project information from web; Comparative genomics, Identification and classification using molecular markers-16S rRNA typing/sequencing, ESTs and SNPs.

**Unit III: Proteomics:** Protein analysis (includes measurement of concentration, amino-acid composition, N-terminal sequencing); 2-D electrophoresis of proteins; Microscale solution isoelectricfocusing; Peptide fingerprinting; LC/MS-MS for identification of proteins and modified proteins; MALDI-TOF; SAGE and Differential display proteomics, Protein-protein interactions, Yeast two hybrid system.

**Unit IV: Pharmacogenetics:** High throughput screening in genome for drug discovery-identification of gene targets, Pharmacogenetics and drug development.

**Unit V: Functional genomics and proteomics:** Analysis of microarray data; Protein and peptide microarray-based technology; PCR-directed protein in situ arrays; Structural proteomics

## CC19: Bioenergetics 3-1-0=4

**Unit I: Free energy concept:** Molecular basis of entropy, concept of free energy, standard free energy and measurement of free energy, significance in metabolism. Application of first and second law of thermodynamics to biological systems. Energy rich bonds - ATP and interconversions of nucleotide phosphates. Phosphorylation potential

**Unit II: Energy conversions - mitochondria:** Architecture, chemical activity of mitochondria. Sequence of electron carriers and sites of oxidative phosphorylation, ATP generation, heme and non- heme iron proteins. Thermodynamic considerations, oxidation - reduction electrodes, standard electrode potential, redox couples, phosphate group transfer potential. Respiratory controls. Theories of oxidative phosphorylation, uncouplers and inhibitors of energy transfer. ATP synthetase complex. ATP generation in bacterial system.

**Unit III: Chloroplast:** Architecture, - light harvesting complexes, bacteriorhodopsin, plastocyanin, carotenoids and other pigments. Hill reaction, photosystem I and II - location and mechanism of energy transfer, photophosphorylation and reduction of carbon dioxide. Calvin cycle , quantitative efficiency, photorespiration, C4 - metabolism.

**Unit IV: Chemiosmotic theory and evidence for its occurance:** ion transport through membranes, proton circuit and electrochemical gradient, ionophores, Q cycle and stoichiometry of proton extrusion and uptake, P/O and H/P ratios, reverse electron transfer.

Fractionation and reconstitution of respiratory chain complexes.

**Unit V: Nitrogen fixation:** Biological fixation of nitrogen, symbiotic and nonsymbiotic nitrogen fixation.

**Unit VI: Hormones :** General classification of hormones - synthesis, structure, secretion, transport, metabolism and mechanism of action of pancreatic, thyroid, parathyroid, hypothalamus, pituitary, adrenal and prostaglandins. Hormonal control of spermatogenesis, menstrual cycle, pregnancy and lactation . Cell membrane and intracellular receptors for hormones. Secondary messengers

Plant growth hormones - auxins, gibberllins, abscessic acid, cytokinins.

Pheromones

Bacterial hormones.

## CC20: Industrial Visit 0-0-2=2

# Discipline Centric Subjects

## Metabolic Engineering 3-1-0=4

**UNIT I:** SUCCESSFUL EXAMPLES OF METABOLIC ENGINEERING

Product over production examples: amino acids, polyhydroxyalkanoic acids, By-product minimization of acetate in recombinant E. coli, Extension of substrate utilization range for organisms such as S. cerevisae and Z. mobilis for ethanol production, Improvement of cellular properties, Altering transport of nutrients including carbon and nitrogen and xenobiotic degradation.

**UNIT II:** METABOLIC FLUX ANALYSIS

Comprehensive models of cellular reactions; stoichiometry of cellular reactions, reaction rates, dynamic mass balances, metabolic flux analysis. MFA of exactly determined systems, over determined systems.

**UNIT III:** CONSTRAINT BASED GENOMIC SCALE METABOLIC MODEL

Underdetermined systems- linear programming, sensitivity analysis, Development of Genomic scale metabolic model, Flux balance analysis, Regulatory on-off Minimization and Minimization of metabolic adjustments and Opt knock tool development, Elementary mode analysis, Extreme pathways.

**UNIT IV:** METABOLIC FLUX ANALYSIS BY ISOTOPIC LABELLING

Methods for the experimental determination of metabolic fluxes by isotope labeling metabolic fluxes using various separation-analytical techniques. Validation of flux estimates by 13C labeling studies in mammalian cell culture.

**UNIT V:** METABOLIC CONTROL ANALYSIS AND NETWORK ANALYSIS

Fundamental of Metabolic Control Analysis, control coefficients and the summation theorems, Determination of flux control coefficients, MCA of linear pathways, branched pathways, theory of large deviations. Control of flux distribution at a single branch point, grouping of reactions, optimization of flux amplification.

## Developmental Biology 3-1-0=4

**Unit I: Basic concepts of development:** Potency, commitment, specification, induction, competence, determination and differentiation; morphogenetic gradients; cell fate and cell lineages; stem cells; genomic equivalence and the cytoplasmic determinants; imprinting; mutants and transgenics in analysis of development

**Unit II: Gametogenesis, fertilization and early development:** Production of gametes, cell surface molecules in sperm-egg recognition in animals; embryo sac development and double fertilization in plants; zygote formation, cleavage, blastula formation, embryonic fields, gastrulation and formation of germ layers in animals; embryogenesis, establishment of symmetry in plants; seed formation and germination.

**Unit III: Morphogenesis and organogenesis in animals:** Cell aggregation and differentiation in Dictyostelium; axes and pattern formation in Drosophila, amphibia and chick; organogenesis – vulva formation in Caenorhabditis elegans, eye lens induction, limb development and regeneration in vertebrates; differentiation of neurons, post embryonic development- larval formation, metamorphosis; environmental regulation of normal development; sex determination.

**Unit IV: Morphogenesis and organogenesis in plants:** Organization of shoot and root apical meristem; shoot and root development; leaf development and phyllotaxy; transition to flowering, floral meristems and floral development in Arabidopsis and Antirrhinum

**Unit V: Cancer:** oncogenes, tumor suppressor genes, micro RNAs in cancer, Chromosomal rearrangements and cancer, Viruses and cancer, Chemical carcinogenesis, Cell Cycle Control, G1 and "Go" Signals, Stop Signals, Cell Cycle in Stem Cells, Growth factors and Cancer Signaling, Metastasis, Angiogenesis, Tumor microenvironments and Stroma, Inflammation and Cancer, Therapeutic strategies.

## Cell Culture Technology and Tissue Engineering 3-1-0=4

**Unit I: Plant tissue culture technology:** Culture media – composition and preparation. Factors governing in vitro behaviour, Somatic embryogenesis, organogenesis and plant regeneration. Culture types. Micro propagation, Haploids, somaclonal variations, metabolite production in cultures. Isolation of protoplasts, protoplast fusion and culture. Somatic hybridization.

**Unit II: Animal cell and tissue culture:** Primary culture, balanced salt solutions and simple growth medium. Serum and protein free defined media. Cell lines, primary and established cell line cultures. Basic techniques of mammalian cell culture in vitro. Tissue and organ culture. Production and use of artificial tissues and organs – Skin, liver and pancreas. Apoptosis - mechanism and significance.

**Unit III: The biology of stem cells:** Different types of stem cells – embryonic stem cells, fetal tissue stem cells, adult stem cells; stem cell differentiation, stem cell plasticity – Differentiation

versus stem cell renewal. Isolation and propagation of embryonic stem cells; chimeras; generation of knockout mice and knock-in technology.

**Unit IV: Hematopoietic stem cells and bone marrow transplantation:** Cells for hematopoietic reconstitution – Cord blood stem cells; cells for adoptive cellular immunotherapy; bone marrow transplantation - advantages and disadvantages. Allogenic, autologous, syngenic and congenic transplantation. Clinical applications of stem cell therapy; neurodegenerative diseases – Parkinson's disease, Alzheimers, spinal cord injury and other brain syndromes.

## Virology 3-1-0=4

**Unit I: Classification and Morphology of Viruses:** Cataloging the virus through virus classification schemes of ICTV / ICNV. Morphology and ultra-structure of viruses. Virus related agents, viroids and prions.

**Unit II: Cultivation and assay of viruses:** Cultivation of viruses using embryonated eggs, experimental animals and cell cultures (Cell-lines, cell strains and transgenic systems). Purification of viruses by adsorption, precipitation, enzymes, serological methods – haeme agglutination and ELISA.

**Unit III: Assay of viruses:** Physical and Chemical methods (Electron Microscopy and Protein and Nucleic acids studies.) Infectivity Assays (Plaque and end-point) Genetic analysis of viruses by classical genetic methods.

**Unit IV: Viral Multiplication:** Mechanism of virus adsorption and entry into the host cell including genome replication and mRNA production by animal viruses, mechanism of RNA synthesis, mechanism of DNA synthesis, transcription mechanism and post transcriptional processing, translation of viral proteins, assembly, exit and maturation of progeny virions, multiplication of bacteriophages.

**Unit V: Pathogenesis of Viruses:** Host and virus factors involved in pathogenesis, patterns of infection, pathogenesis of animal viruses Adenovirus, Herpes virus, Hepatitis virus, Picorna virus, Poxvirus and Orthomyxovirus, pathogenesis of plant [TMV] and insect viruses [NPV]. Host cell transformation by viruses and oncogenesis of DNA and RNA viruses.

**Unit VI: Control of Viruses and Emerging Viruses:** Control of viral infections through vaccines, interferons and chemotherapeutic agents. Structure, genomic organization, pathogenesis and control of Human immunodeficiency virus. Emerging viruses