| | M. Sc. Microbiology | | | |
|---|---|---|---|---|
| Semester | **I** | **II** | **III** | **IV** |
| Core I (4 Credits) | Molecular Biology (PS01CMIC21) | Bioprocess and Biochemical Engineering (PS02CMIC21) | Microbial Biotechnology (PS03CMIC21) | R-DNA Technology (PS04CMIC21) |
| Core II (4 Credits) | Bioinstrumentation (PS01CMIC22) | Microbial Genetics (PS02CMIC22) | Environmental Microbiology (PS03CMIC22) | Environmental Biotechnology (PS04CMIC22) |
| Core III (4 Credits) | Cell Biology (PS01CMIC23) | Fundamentals of Immunology (PS02CMIC23) | Enzymology (PS03CMIC23) | Lab I (PS04CMIC23) Practicals based on PS04CMIC21 and PS04CMIC22 |
| Core IV (4 Credits) | Lab I (PS01CMIC24) Practicals based on PS01CMIC21 and PS01CMIC22 | Lab I (PS02CMIC24) Practicals based on PS02CMIC21 and PS02CMIC22 | Lab I (PS03CMIC24) Practicals based on PS03CMIC21 and PS03CMIC22 | |
| Core V (4 Credits) | Lab II (PS01CMIC25) Practicals based on PS01CMIC23 and PS01EMIC2X | Lab II (PS02CMIC25) Practicals based on PS02CMIC23 and PS02EMIC2X | Lab II (PS03CMIC25) Practicals based on PS03CMIC23 and PS03EMIC2X | |
| Elective I (4 Credits) | Biochemistry (PS01EMIC21) | Biostatistics (PS02EMIC21) | Advanced Immunology (PS03EMIC21) | Lab II (PS04EMIC21) Practicals based on PS04CMIC2X and PS04EMIC2X |
| Elective II (4 Credits) | Biomolecules and Bioenergetics (PS01EMIC22) | Medical Microbiology (PS02EMIC22) | Bioinformatics (PS03EMIC22) | Dissertation (PS04EMIC22) (12 Credits) |
| Elective III (4 Credits) | Phytoresource Utilization and Conservation (PS01EMIC23) | Microtechniques (PS02EMIC23) | Omics and Computational Biology (PS03EMIC23) | Microbial Physiology (PS04EMIC23) |
| Elective IV (4 Credits) | Human Physiology (PS01EMIC24) | Toxicology (PS02EMIC24) | Plant Biochemistry (PS03EMIC24) | Food and Dairy Microbiology (PS04EMIC24) |
| Elective V (4 | | | | IPR and Biosafety (PS04EMIC25) |

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|---|---|---|---|---|
| Credits) | | | | |
| Elective VI (4 Credits) | | | | Plant Biotechnology (PS04EMIC26) |

**PS01CMIC21: Molecular Biology**

**Unit I: DNA structure**

DNA structure: Chemistry of DNA, DNA structure, Different conformations of DNA (B, A and Z), Denaturation and Renaturation (Cot curves) of DNA.

DNA topology: Supercoiling, Biology of Supercoiled DNA, DNA topoisomerases and their mechanism of action.

DNA- protein interactions: General features, Sequence specific DNA binding protein motifs, ss DNA binding proteins.

**Unit II: Organization of genome and its replication**

Organization of DNA into chromosomes: Packaging of DNA and organization of chromosome in bacterial cells; Packaging of DNA in eukaryotic nucleosome and chromatin condensation, assembly of nucleosomes upon replication, chromatin modification.

DNA replication: Mechanism of DNA polymerase catalyzed synthesis of DNA, Types of DNA polymerases in bacteria, Initiation of DNA replication and its regulation in prokaryotes, assembly of replisome and progress of replication fork, termination of replication. DNA replication in eukaryotes and archaea. Inhibitors of DNA replication.

**Unit III: Gene expression in prokaryotes and eukaryotes**

Transcription: RNA polymerases, features of prokaryotic and eukaryotic promoters, assembly of transcription initiation complex in prokaryotes and eukaryotes, and its regulation; synthesis and processing of prokaryotic and eukaryotic transcripts.

Translation: structure and role of t-RNA in protein synthesis, ribosome structure, basic features of genetic code and its deciphering, translation (initiation, elongation and termination in detail in prokaryotes as well as eukaryotes).

**Unit IV: Regulation of gene expression**

Regulation of gene expression in prokaryotes: Operon concept, positive and negative regulation. Examples of lac (including mutational analysis), ara, and trp operon regulation; global regulatory responses.

Regulation of gene expression in eukaryotes: Transcriptional, translational and processing level control mechanisms.

**References**:


- Genes X: Lewin
- Molecular Biology of the Gene: Watson et al
- Molecular Genetic of Bacteria: Snyder and Champness
- Molecular Biology, 4th Edition: Burton E Tropp
- Principles of Genetics: Snustad and Simmons

**PS01CMIC22: Bioinstrumentation**

**Unit I**

**Visualization techniques:**

Principle of working and applications of bright field microscopy, phase contrast microscopy, fluorescence microscopy, confocal microscopy, scanning and transmission electron microscopy, scanning tunneling microscopy, atomic force microscopy. Principle and applications of cytophotometry and flow cytometry.

**Unit II**

**Separation techniques:**

Basic principle and application of Differential, density and ultracentrifugation

Principle and applications of Native-PAGE, SDS-PAGE, Agarose and 2D gel electrophoresis. Capillary electrophoresis and its applications.

Principle, methodology and applications of gel – filtration, ion –exchange and affinity chromatography; Thin layer and High Performance Thin Layer Chromatography. Gas chromatography, High performance liquid chromatography and FPLC.

**Unit III**

**Spectropscopy**

Principle, instrumentation and applications of UV, Visible, IR (including FTIR and ATR), AAS, NMR, fluorescence and CD spectroscopy.

**Unit IV**

**Principle and applications of tracer technique in biology:**

Radioactive Isotopes and half-life of isotopes; Effect of radiation on biological system; autoradiography; cerenkov radiation; radiation dosimetry; ionization and scintillation based detection and quantification of radioactivity.

Biosensors: Principle, types and applications.

Principle of biophysical methods used for analysis of biopolymer structure: X ray diffraction and mass spectrometry.

**References:**


1. Instrumental method of chemical analysis: Sharma B K
2. Instrumental methods of analysis: D A Skoog
3. An introduction to practical Biochemistry: Plummer
4. Instrumentation: Chatwal and Anand
5. Modern experimental Biology: Boyer

**PS01CMIC23: Cell Biology**

**Unit I**

- Evolution of cell: Cell as a unit of living organism, evolution and structure of prokaryotic cell, evolution of eukaryotic cell.
- Structure of Plasma membrane, Transport across plasma membrane.
- Endocytosis (Phagocytosis, Receptor mediated endocytosis)
- Cell walls and extracellular matrix
- Cell-Cell interactions (Cell adhesion protein, Tight junctions, gap junctions, plant cell adhesion and plasmodesmata).

**Unit II**

- Nucleus, Nuclear pore complex and transport across nuclear envelope.
- Structure and functions of Endoplasmic reticulum, Golgi complex and lysosomes (Protein sorting and transport, Types of vesicular transport and their functions).
- Structure and function of Mitochondria, Chloroplasts and Peroxisomes.

**Unit III**

- Cytoskeleton and cell movement (Structure and organization of actin filaments; Actin, myosin and cell movement; Intermediate filaments; Microtubules and microtubule motors and movements); cilia and flagella: structure and function.
- Cell signalling: Signalling molecules and their receptors, Functions of cell surface receptors, pathways of intracellular signal transduction, signal transduction and cytoskeleton, signalling in development and differentiation.

**Unit IV**

- Cell division cycle (phases of CDC; Regulation by cell growth and extracellular signals; cell cycle check points; regulators of cell cycle progression-MPF, cyclins and CDKs, Inhibitors of cell cycle progression; M-phase and cytokinesis.
- Programmed Cell Death: Difference between necrosis, apoptosis and necroptosis, Caspases, Central regulators of apoptosis (Bcl-2 family), signalling pathways that regulate apoptosis.
- Cancer: Types of cancer, development and causes of cancer, properties of transformed cells, oncogenes and tumor suppressor genes.

**References:**


- The cell: A molecular approach-Geoffrey M Cooper and Robert E. Hausman
- Cell Biology-Karp
- Molecular Biology of the cell- Alberts
- Molecular Cell Biology-Lodish et al.

**PS01CMIC24: Lab I Practicals based on PS01CMIC21 and PS01CMIC22**

**PS01CMIC25: Lab II Practicals based on PS01CMIC23 and PS01EMIC2X**

**PS01EMIC21: Biochemistry**

**Unit I**

- Chemical and physical foundations of biomolecules.
- Water, acid, base and buffers
- Carbohydrate metabolism: Glycolysis and alternate pathways of glucose utilization, TCA cycle, glyoxylate cycle, Gluconeogenesis, Glycogen synthesis and utilization.

**Unit II**

- Principles of Thermodynamics; Bioenergetics and energy metabolism in cells.
- Oxidative phosphorylation and Electron transport chain: Electron carriers, iron sulphur proteins, cytochromes, PMF, ATP synthetase complex. Uncouplers and inhibitors of energy transfer.

**Unit III**

- Lipids: Structure and properties of lipids, fatty acids, phospholipids, and other derived lipids; functions of lipoproteins, cholesterol, steroids and prostaglandins, membrane lipids.
- Lipid metabolism: synthesis and oxidation of fatty acids ($\alpha$, $\beta$ and $\omega$ oxidation of fatty acids).
- Ketone bodies: Formation and degradation
- Vitamins: structure and function.

**Unit IV**

- Protein structure: primary, secondary, tertiary and quaternary structure of proteins. Determination of protein structure and its analysis, Ramachandran plot, Hydropathy plot.
- Structure, properties and classification of amino acids, aminoacid metabolism , urea cycle and nitrogen balance. Disorders associated with amino acid metabolism
- Nucleotides: Structure and functions, Nucleotide metabolism.

**References:**


- Lehninger's Principles of Biochemistry: D L Nelson and M M Cox, Macmillan, Worth Pub. Inc., NY.
- Biochemistry : Lubert Stryer
- Harper's Biochemistry: R. K. Murray and others, Appleton and Lange, Stanford.
- Microbial Physiology: Moat, Foster and Spector.

**PS01EMIC22- Biomolecules and Bioenergetics**

**Unit I**

**Carbohydrates and glycobiology :** Monosaccharide - structure of aldoses and ketoses, ring structure of sugars, conformations of sugars, mutarotation, anomers, epimers and enantiomers, structure of biologically important sugar derivatives, oxidation of sugars. Formation of disaccharides, reducing and nonreducing disaccharides. Polysaccharides – homo- and heteropolysaccharides, structural and storage polysaccharides. Structure and role of proteoglycans, glycoproteins and glycolipids (gangliosides and lipopolysaccharides). Carbohydrates as informational molecules, working with carbohydrates, Industrial importance of carbohydrate.

**Unit II**

**Amino acids:** Structure and classification, physical, chemical and optical properties of amino acids, Classification of amino acids, Protein sequencing and alignment

**Building blocks of lipids -** fatty acids, glycerol, ceramide. Storage lipids - triacyl glycerol and waxes, Structural lipids in membranes – glycerophospholipids, galactolipids and sulpholipids, sphingolipids and sterols, structure, distribution and role of membrane lipids.Lipids as signals, cofactors and pigments

**Nucleic acids:** Structure of major species of RNA - mRNA, tRNA and rRNA.
Nucleic acid chemistry – UV absorption, effect of acid and alkali on DNA.

**Unit III**

**Acid-Base Equilibrium** & Henderson and Hassebach equation, Buffers and their importance, pKa of amino acid and their relevance, Importance of discontinuous buffer system used in SDS PAGE.

**Common reaction mechanism in biological reaction:** Peptide bond formation, oligonucleotide and oligosaccharide synthesis, disulphide bond, group-specific chemical modification for amino acid

**Unit IV**

**Bioenergetics:** The laws of thermodynamics, concept of entropy and free energy; ATP synthesis and hydrolysis, Biological oxidations-–oxygenases ,hydrolases ,dehydrogenases, free energy changes and redox potentials, Gibbs energy,

The mitochondrial respiratory chain, order and organization of carriers, proton gradient, iron sulphur proteins, cytochromes and their characterization (**Animals, Plants, and Bacteria**), ATP- synthetase complex, Chemiosmotic theory of Energy Coupling, Inhibitors of ETC, Regulation of body temperature

**References:**


- Chemistry of Biomolecules by S. P. Bhutani, Ane Books Pvt. Ltd. CRC Press
- Lehninger's Principles of Biochemistry: D. L. Nelson and M. M. Cox, Macmillan, Worth Pub. Inc., NY.

- Biochemistry: Lubert Stryer WH Freeman & Co., NY.
- Harper's Biochemistry: R. K. Murray and others. Appleton and Lange, Stanford.
- Text book of Biochemistry with clinical correlations by Delvin.

**PS01EMIC23: Phytoresource Utilization and Conservation**

**Unit - I**

Plant Biodiversity : Concept, status in India, utilization and concerns.
Origin, evolution, botany, cultivation and uses of (i) Food, forage and fodder crops, (ii) fibre crops (iii) medicinal and aromatic plants, and (iv) vegetable oil – yielding crops
Plants as sources of drugs, pharmaceauticals and pharmaceutical aids.

**Unit -II**

Ethnomedicobotany: Basic approaches to study traditional knowledge on herbal medicine; Scope and potential applications.
Collection methods of ethnomedicobotanical data: Field methods and scrutiny of Herbarium specimens and folklore; verification of data; collection of materials for voucher specimen and for phytochemical screening; application of ethnomedicobotany.
Creating indigenous knowledge base of traditional medicines of plant origin.

**Unit -III**

Forest products**:**
Important timber yielding planting.
Timber types, identification diagnostic features, structure & quality
Important fire wood plants
Non Timber forest products bamboos, rattans, fibers pulp; gums, resins, tanins, lotex, fruits & tubers.
Innovations for meeting world food demands.
Plants used as avenue trees for shade, pollution control and aesthetics.

**Unit –IV**

Principles of conservation; extincitons; environmental status of plants based on International Union for Conservation of Nature.
Strategies for conservation – *in situ* conservation : International efforts and Indian initiatives; protected areas in India – sanctuaries, national parks, biosphere reserves, wetlands, mangroves and coral reefs for conservation of wild biodiversity.
*Ex situ* conservation **:** Principles and practices; botanical gardens, fields gene banks, seed banks, *in vitro* repositories, cryobanks; general account of the activities of Botanical Survey of India (BSI), National Bureau of Plant Genetic Resources (NBPGR), Indian Council of Agricultural Research (ICAR), Council of Scientific & Industrial Research (CSIR), and the Department of Biotechnology (DBT) for conservation, non-formal conservation efforts.

**References:**


- Anonymous. National Gene Bank: Indian Heritage on Plant Genetic Resources (Booklet). National Bureau of Plant Genetic Resources, New Delhi.
- Arora, R. K. and Nayar, E. R. Wild Relatives of Crop Plants in India. NBPGR Science Monograph.
- Baker, H. G. Plants and Civilization. C. A. Wadsworth, Belmont.

- Bole, P. V. and Vaghani, Y. Field Guide to Common Indian Trees. Oxford University Press, Mumbai.
- Chandel, K. P. S., Shukla, G. and Sharma, N. Biodiversity in Medicinal and Aromatic Plants in India : Conservation and Utilization. National Bureau of Plant Genetic Resources, New Delhi.
- Cristi, B. R. CRC Handbook of Plant Sciences and Agriculture. Vol. I. In-situ conservation. CRC Press, Boca Raton, Florida, USA
- Council of Scientific & Industrial Research. The Useful Plants of India. Publications and Information Directorate, CSIR, New Delhi.
- Plant Wealth of India. Special Issue of Proceedings India National Science Academcy B – 63
- Rodgers, N. A. and Panwar, H. S. Planning a Wildlife Protected Area Network in India. Vol. 1. The Report Wildlife Institute of India, Dehradun.
- Sahni, K. C. The Book of India Trees, Oxford University Press, Mumbai.
- Sharma, O. P. Hill's Economic Botany. Tata McGraw Hill Co. Ltd., New Delhi.
- Swaminathan, M. S. and Kocchar, S. L. Plants and Society. Macmillan Publication Ltd., London.
- Thakur, R. S., Puri, H. S. and Husain, A Major Medicinal Plants of India. Central Institute of Medicinal and Aromatic Plants, CSIR, Lucknow. S.K. Jain: A Manual of Ethnobotany
- S.K. Jain: Glimpses of Indian Ethnobotany
- S.K.Jain, B.K. Sinha and R.C.Gupta: Notable plants in Ethnomedicine of India
- J.K. Maheswari: Dictionary of Indian Folk medicine and Ethnobotany
- S.K. Jain: Useful plants of India
- Wiley Chichester, CIBA Foundation Symposium 185: Ethnobotany and the search for new drugs

**PS01EMIC24: Human physiology**

**Unit I**

Homeostasis and the organization of body fluids, Control of Homeostasis, Positive and negative Feedback systems, Homeostatic Imbalances.

An overview of human circulatory system. Anatomy of heart, cardiac cycle, cardiac output, blood pressure and regulation, ECG. The arterial system, venous system, the microcirculation and mechanics of capillary fluid exchange. Control of blood flow to the tissues. Portal circulations. Arterial pressure and its regulation. Blood-components and functional significance. Blood buffer systems, Blood coagulation and factors involved in coagulation. Laboratory tests to measure coagulation and thrombolysis. Hemopoiesis and blood groups, Disorders of circulatory system: coagulation disorders, hypertension, thalassaemias and anemias.

**Unit II**

Digestive system – Composition, functions and regulation of saliva, gastric, pancreatic intestinal and bile secretions – digestion and absorption of carbohydrates, lipids, proteins nucleic acids, minerals and vitamins.

The Muscular System – Types of muscles and their functions. Physiology of muscle contraction in striated and non-striated muscle.

**Unit III**

Excretory system – structure of nephron formulation of urine, glomerular filteration, GFR, tubular reabsorption of glucose. renal and pulmonary control of blood pH, renal clearance.

**Unit IV**

Nervous System- Structure of neuron, function and organization of nervous system, Blood-brain barrier, Neurotransmitters, Nerve impulse transmission.

Reproductive physiology – secretion and function of reproductive hormones, pregnancy and lactation. Hormonal disturbances.

**References:**

Text book of Medical Physiology by A. C. Guyton and J. E. Harcourt.
Text book of Medical Physiology by Ganong.
Principles of anatomy and physiology by Gerard Tortora and Bryan Derrickson, 12$^{th}$ edition

## Semester II

### PS02CMIC21: Bioprocess and Biochemical Engineering

**Unit I**

Introduction to bioprocess technology

Isolation, primary and secondary screening, preservation, maintenance and improvement of industrially important organisms.

Raw materials for fermentation processes

Medium optimization

**Unit II**

Bioreactor design: Laboratory, pilot and large scale reactors. mechanical, pneumatic and hydrodynamic systems. Plug flow reactors, Immobilization and immobilized enzyme reactors.

Sterilization of media and air.

Scale up and Scale down and containment

Mass transfer of oxygen: Agitation and aeration, Determination of $K_La$, factors affecting $K_La$, fluid rheology. Inoculum development, aseptic inoculation and sampling.

**Unit III**

Bioprocess kinetics: Kinetics of growth and substrate utilization in batch, fed batch and continuous systems.

Control of process parameters: Instrumentation for monitoring bioreactor and fermentation processes, Sensors, Controllers, fermentation control systems and architecture, Incubation and sequence control, advanced control.

**Unit IV**

Downstream processing:

Bioseparation: filtration, centrifugation, sedimentation, flocculation, cell disruption, liquid liquid extraction. purification by chromatographic techniques, reverse osmosis and ultrafiltration, drying, crystallization, storage and packaging.

Fermentation Economics

**References:**


- Principles of Fermentation Technology : Whitekar & Stanbury
- Comprehensive Biotechnology : Murray Moo Young
- Methods in Industrial Microbiology : Sikyta
- Fermentation Microbiology and Biotechnology, El Mansi and Bryc

**PS02CMIC22: Microbial Genetics**

**Unit I**: **Mutation, DNA damage and Repair**
Spontaneous mutations (Random v/s Adaptive nature of mutation; Mutation rate and its determination, Types of DNA damage and their consequences (spontaneous and chemical induced deamination, radiation induced DNA damage, loss of nitrogen bases, alkylation, intra and inter strand cross linking) , DNA repair pathways (Mis-match repair in prokaryotes and eukaryotes, Nucleotide excision repair in prokaryotes and in eukaryotes, base excision repair, recombinational repair, SOS pathway, specific repair of oxidative DNA damage, repair of pyrimidine dimers, repair of alkylation induced damage and adaptive response and other specific repair mechanisms).

**Unit II:**
**Plasmid Biology** (Types of plasmids, compatibility, regulation of plasmid copy number and plasmid segregation)
**Phage genetics** (T-series, complementation and Fine structure analysis, biology of lambda phages)
**Recombination** (Types, Models of homologous recombination, Molecular mechanism of homologous, Homologous recombination in eukaryotes, mating type switching, Site specific recombination and its biological significance)
**Fungal Genetics** (Tetrad analysis and Mitotic recombination)

**Unit III: Genetic exchange in prokaryotes**
**Transformation** (Natural transformation in Bacillus subtilis, Streptococcus pneumonia and Haemophilus influenza). Transformation by inducing artificial competence, Gene linkage and mapping by transformation.
**Transduction** (Generalized transduction in P22, P1, T4 and Mu bacteriophages, homologous recombination with recipient's chromosome, measuring transduction (co-transduction of markers, marker effects, abortive transduction, transduction of plasmids). Applications of generalized transduction, Specialized transduction and its applications.
**Conjugation** (F-factor mediated Conjugation in E. coli, Hfr conjugation and chromosomal transfer, F-prime conjugation and merodiploids, Conjugation of fertility inhibited F-like plasmids, Non conjugative mobilizable plasmids, chromosomal mobilization of non-F plasmids, Plasmid based conjugation in other bacteria (Salmonella, Pseudomonas, Streptomyces and streptococcus, Interrupted mating and conjugational mapping)

**Unit IV**
**Agrobacterium genetics**: Ti plasmid, Interkingdom gene transfer (Key early experiments, vir regulon, protein secretion apparatus, conjugation model of T-DNA transfer, Integration products)
**Restriction modification systems**: Types of RM systems, Role of RM systems, salient features and insights into evolution of diverse types of Restriction endonucleases and Methyl transferases, Regulation of RM systems.
**Transposable elements**: Types of bacterial transposable elements; Structure, genetic organization and mechanism of transposition of Tn5, Tn3, phage Mu, Tn7, IS911, Integrons, Retrotransposons, conjugative and mobilizable transposons, Assays of transposition.

**References:**


- Genes X: Lewin
- Molecular Biology of the Gene-Watson et al.
- Modern Microbial Genetics-Uldis Streips and Ronald Yasbin
- Microbial genetics-Stanley Molay, John Cronan and David Freifelder.
- Molecular Genetics of Bacteria-Snyder and Champness.
- Molecular Genetics-Stent and Calender
- Principles of Genetics- Snustad and Simmons
- Molecular Biology of the Cell-Alberts et al.

**PS02CMIC23: Fundamentals of Immunology**

**Unit I**

Introduction to immune system: mechanisms of barrier to entry of microbes / pathogens; Cells and organs of the immune system involved in innate and adaptive immunity: cells of the immune system, primary and secondary lymphoid organs, Hematopoiesis and its regulation

Innate immunity: receptors of the innate immunity (TLR and sensing of PAMPs, CLR,RLR and CLR); Inflammatory responses

Antigens: antigenicity, and immunogenicity. B and T cell epitopes

**Unit II**

Antibody: Structure of immunoglobulin; classes of immunoglobulins, Signal transduction pathways emanating
from the BCR,

The Organization and Expression of Lymphocyte Receptor Genes: Hozumi and Tonegawa's Experiment, Multigene organization of Ig Gene, Mechanism of VDJ recombination, B cell receptor expression, allelic exclusion,B cell isotype switching and somatic hypermutation; expression of membrane bound and soluble immunoglobulin; T cell receptor genes and expression

Complement system: Overview of classical, alternative and lectin complement pathways, functions of complement, regulation of complement, complement deficiencies, microbial complement evasion strategies

**Unit III**

The Major Histocompatibility Complex and Antigen Presentation: The structure and function of MHC molecules, general organization and inheritance of MHC, self – MHC restriction, endogenous and exogenous pathway of antigen processing and presentation; cross presentation of exogenous antigen, presentation of non peptide antigens

Cytokines: properties, receptors, associated diseases, therapeutic applications, cytokine signaling pathways: JAK-STAT and FAS-FASL signaling pathways

**Unit IV**

Basics of Antigen-antibody interactions: Agglutination, precipitation, RIA and ELISA

Cell and antibody mediated effector response: Antibody mediated effector response (Neutralization, opsonization/ phagocytosis, complement fixation, ADCC); Cell mediated effector response (Generation of effector CTL's, Granzyme and Perforin Mediated Cytolysis, Fas-FasL Mediated Cytolysis, NK cell mediated cytolysis

Immunity to infection: Immunity to viruses, Immunity to bacteria and fungi, Immunity to parasites (protozoa and worms).

**References:**


1. Owen, J. A., Punt, J., & Stranford, S. A. (2013). ***Kuby immunology*** (7th Edn). New York: WH Freeman.
2. Murphy, K., & Weaver, C. (2016). ***Janeway's immunobiology*** (9th Edn) Garland Science.
3. Male, D., Brostoff, J., Roth, D., & Roitt, I. (2012). ***Immunology*** (8th Edn) *With STUDENT CONSULT Online Access*. Elsevier Health Sciences.
4. Abbas, A. K., Lichtman, A. H., & Pillai, S. (2014). ***Cellular and molecular immunology*** (6th Edn) Elsevier Health Sciences.

5. Relevant review articles / research papers / handouts of latest development in the subject.

**PS02CMIC24: Lab I Practicals based on PS02CMIC21 and PS02CMIC22**

**PS02CMIC25: Lab II Practicals based on PS02CMIC23 and PS02EMIC2X**

**PS02EMIC21: Biostatistics**

**Unit - I**

Definition of Biostatistics
Data Collection:
Types of Biological Data:
Qualitative (Categorical ) Data: Nominal and Ordinal Data
Quantitative (Numerical) Data: Discrete and Continuous Data
Methods of Collecting Data:
Survey Method: Concept of a statistical population and sample from a population; Methods of drawing sample from the population, Simple Random Sampling (SRS), Stratified Random Sampling, Cluster Sampling; Experimental Method
Presentation:
Construction of frequency distribution (Simple or Discrete and Grouped): Rules for constructing Grouped frequency distribution
Diagrammatic Presentation: Bar Diagram (Chart), Simple, Sub – divided (Component), Percentage, Multiple, Pie Chart
Graphical Presentation: Line Graph, Histogram (For uniform class width only), Frequency Polygon, Frequency Curve, Ogives or Cumulative Frequency Curves
Descriptive Statistics:
Measures of Central Tendency (Averages): Mean or Arithmetic Mean, Median, Mode, Partition Values (For Raw and Grouped Data),Quartiles, Deciles, Percentile, Partition values using graphs (Ogives).
Measures of Dispersion (Variation): Range, Quartile Deviation (Q.D), Inter Quartile Range (IQR), Standard Deviation (SD) and Variance, Coefficient of Variation (C.V), Box – and – Whisker Plot.
Measures of Skewness and Kurtosis: Karl – Pearson's Coeff. of Skewness, Bowley's Coeff. Of Skewness, Kurtosis (Definition Only).

**Unit - II**

Probability and Probability Distributions:
Elements of Probability theory: Concept, Classical definition of Probability, Laws of Probabilities (Statements Only), Conditional Probability, Examples
Probability Distributions: Binomial Distribution**.** Definition, Conditions for applicability of Binomial Distribution, Examples applicable in the field of Biosciences; **Normal Distribution,** Definition (Normal and Standard Normal Distribution), Properties of Normal Distribution, Examples applicable in the field of Biosciences

**Unit - III**

Correlation and Regression Analysis:
Correlation: Meaning, Types of Correlation, Positive, Negative, Non – Sense or Spurious, Methods of studying correlation, Scatter Plot (diagram) method, Karl-Pearson's Correlation Coefficient (Product Moment) Method; Properties of Correlation Coefficient
Coefficient of determination and its meaning: Spearman's Rank Correlation Coefficient; Properties of Rank Correlation Coefficient
Regression: Meaning, Properties of Regression Coefficients, Applications in the field of Biosciences
Testing Of Hypothesis: Contingency tables, Goodness of Fit

**Unit - IV**

Large Sample Test: Z - test for (Single) population proportion; Z - test for difference between two population proportions; Z - test for (Single) population mean; Z - test for difference between two population means

Small Sample Test: t – test for (Single) Population Mean, t – test for difference between two population means (Unpaired t-test), t – test for difference between two population means (Paired t-test)

Analysis Of Variance (ANOVA) : One – Way Classification , Two – Way Classification

**References:**


- Fundamentals of statistics by S.C. Gupta
- Principles of Biostatistics by Marcello Pagano and Kimberlee Gaurea
- Biostatistics : A Foundation For Analysis in the Health Sciences by Daniel, Wayne(Seventh Edition), Wiley India Pub.

**PS02EMIC22: Medical Microbiology**

**Unit-I Basics in Medical Microbiology**

- Sources of infection, Modes of transmission, Factors predisposing to microbial pathogenicity, Types of infectious diseases,
- Prevention and Control of Hospital acquired infections. Immunoprophylaxis: Types of vaccines and schedule of vaccination.
- Recent advances in diagnostic microbiology: Automation, Nucleic acid based detection methods.

**Unit-II Bacteriology**

Morphology, Cultural Characteristics, Antigenic structures, Pathogenesis, Laboratory Diagnosis of following bacteria: *Staphylococcus, Streptococcus including Pneumococcus, Bacillus, Corynebacterium, Clostridium, Mycobacteria, Vibrios, E. coli, Salmonella, Shighella, Spirochaetes, Neisseria,*

**Unit-III Virology**

- The Nature and classification of viruses, Morphology: virus structure and Virus replication.
- General properties, diseases caused, lab diagnosis and prevention of
  - Pox, Herpes (HSV), Hepatitis (HAV & HAB), Picorna (Polio virus), Orthomyxo (Influenza), Paramyxo (Mumps and Measles), Rabdo (Rabies), Ebola, Zika and HIV virus.
- Viral vaccines and antiviral agents.

**Unit-IV Parasitology & Mycology**

Parasitology: Laboratory techniques in parasitology.
Morphology, life cycle, laboratory diagnosis of following parasites
*Parasites: Entamoeba, Giardia, Leishmania, Plasmodium,*
*Helminths: Taenia, Ascaris, Wuchereria bancrofti, Schistosomes*
Mycology: Morphology, diseases caused and lab diagnosis of:-

- Opportunistic fungi - *Cryptococcus, Candida, Aspergillus.*
- Fungi causing Cutaneous mycoses- *Dermatophytes*
- Subcutaneous mycoses - *Mycetoma,*
- Systemic mycoses-*Histoplasma*

**References:**


1. Textbook of Microbiology by Surinder Kumar
2. Medical Parasitology by R. Karyakarte.
3. P. B. Godkar. Text Books of Medical Laboratory Technology
4. Anathanarayana & Panikar – A Text Book of Medical Microbiology
5. P. Chakraborthy- A Text Book of Microbiology
6. Chatterjee, KD – Parasitology
7. Danial Greenwood et al, Medical Microbiology, A guide to Microbial Infections, Pathogenesis, Immunity, Laboratory Diagnosis and control.
8. Jagdish Chander, Textbook of medical mycology.
9. Teri Shores- Understanding Viruses.
10. Biswas SB and Biswas A An Introduction to Viruses.

**PS02EMIC23: Microtechniques**

**Unit I**

Light microscopy

Properties of lenses, Optical corrections, Properties and types of objectives, Oculars and Illumination.

Light microscopes: Bright field, dark field, fluorescence, phase contrast, polarizing, differential interference contrast.

Micrometry and photomicrography

**Unit II**

Basic components of electron microscopes. Thermionic and field emission guns. Types of electron microscopes: TEM, SEM, STEM, ESEM and HVEM

**Unit III**

Maceration, squash and clearing techniques. Sample preparation for light microscopy. Classification of fixatives, formulas', (Plant and animal samples).

Sample preparation for light microscopy: Fixation, dehydration and infiltration procedures. Embedding media for light microscopy. Stains and staining procedures- negative and positive staining procedures. Microtomes: Rotary, sliding, cryostat. Histochemical localization of metabolites for light microscopy: Starch, proteins, lipids, total carbohydrates, lignins, polyphenols, nucleic acid, histones, cutin, suberin and waxes. Localization of enzymes: Peroxidase, acid phosphatase and succinic dehydrogenase.

**Unit IV**

Freeze etching and freeze fracturing.

Sample preparation for Electron microscope: Fixatives, double fixation, dehydration and infiltration procedures, embedding media for electron microscopy. Fixation and embedding of particulate samples like bacteria, virus etc. ultra-microtome and freezing ultramicrotome-semi thin sectioning, ultrathin sectioning, grids, formavar coating, Staining for electron microscopy.

Ultrastructural cytochemistry: Tannin, protein, cell wall polysaccharide, lignin and membrane.

Enzymes: Peroxidase and phosphatase.

Immunocytochemistry.

**References:**


- Microscopy and Microtechnique: R Marimuthu MJP Publisher, Chennai
- The study of plant structure: Principles and selected methods- T. P. O' Brien and M E McCully.
- Plant Microtechnique- Johansen, DA, McGraw Hill Book Co., New York.
- Botanical Microtechnique and Cytochemistry;Graeme P. Berlyn and Jerome P Micksche.

**PS02EMIC24 - Toxicology**

**Unit-1**

Definition and scope of toxicology: Eco-toxicology and its environmental significance. Toxic effects : Basic for general classification & nature. Dose-Response relationship: Synergism and Antagonism, Determination of ED50 & LD50. Acute and Chronic exposures. Factors influencing Toxicity. Pharmacodynamics & Chemodynamics, dose conversion between animals and human

Diagnosis of toxic changes in liver and kidneys : Metabolism of drugs: paracetamol and asprin with their toxic effects on tissues.

**Unit-2**

Xenobiotics Metabolism: Absorption & distribution. Phase I reactions. Oxidation, Reduction, Hydrolysis and Hydration. Phase II reaction/Conjugation : Methylation, Glutathione and amino acid conjugation. Detoxification.

Biochemical basis of toxicity : Metabolism of Toxicity : Disturbances of Exitable membrane function. Altered calcium Homeostasis. Covalent binding of cellular macromolecules & Genoatoxicity. Tissue specificity of Toxicity.

Toxicity testing : Test protocol, Genetic toxicity testing & Mutagenesis assays : In vitro Test systems – Bacterial Mutation Test, Ames Test, Fluctuation Tests, *In vivo* Mammalian Mutation tests –DNA repair assays, Chromosome damage test, Evaluation of Apoptosis and necrosis

**Unit-3**

Pesticide toxicity : Insecticides : Organochlorines, Anti cholinesterases – Organophosphates and Carbamates, Fungicides. Herbicides, Environmental consequences of pesticide toxicity. Biopesticides.

Food Toxicity : Role of diet in cardio-vascular disease and cancer. Toxicology of food additives.

**Unit-4**

Metal Toxicity: Toxicology of Arsenic, mercury, lead and cadmium. Environmental factors, affecting metal toxicity effect of light, temperature & pH.

Air pollution : Common air Pollutant & their sources. Air pollution & ozone. Air pollution due to chlorofluorocarbons (CFCS) and asbestos.

**References:**


1. Klaassen, C. D (8th Eds.). (2013). *Casarett and Doull's toxicology: the basic science of poisons* . New York: McGraw-Hill.
2. John A. Timbrell (4th Edn) (2008) Principles of biochemical toxicology. Taylor & Francis Ltd, London,.
3. Smart, R. C., & Hodgson, E. (4th Eds.). (2013). Molecular and biochemical toxicology. John Wiley & Sons.
4. Relevant review articles / research papers / handouts of latest development in the subject.

## Semester III

### PS03CMIC21: Microbial Biotechnology

**Unit 1**

- Scope of Microbial biotechnology.
- Microbial production and applications of primary metabolites: Citric acid, Ethanol, L Glutamic acid, L Lysine ,Vitamins $B_{12}$ and Vitamin $B_2$
- Industrially important microbial enzymes: Types, mode of action and industrial applications of microbial amylases and proteases

**Unit 2**

- Microbial production of therapeutically important products:.
    - Antibiotics: Penicillin, Streptomycin
    - Ergot alkaloids : Production by Saprophytic cultivation
- Biotransformations of steroids: Hydroxylations and dehydrogenation, Sterol biotransformations.
- Probiotics and prebiotics: Fundamental aspects and health benefits

**Unit 3**

- Production of single cell protein from bacteria, fungi and algae: Characteristics, nutritional value and safety, substrates used, process examples, applications.
- Cultivation of edible and medicinal mushrooms: Nutritional and medicinal properties
- Production and applications of microbial exopolysaccharides: Classification. Biological functions, structure and biosynthesis of Xanthan and Alginate, Factors affecting fermentative production of exopolysaccharides and downstream processing( recovery).
- Production of bioplastics

**Unit 4**

- Physiological characteristics, functions and production of starter cultures for dairy products and fermented foods.
- Microbiology and technology of fermented dairy products:
    - Cheese making: Cheese varieties, manufacture of cheddar cheese, Sources and properties of rennets.
    - Yoghurt making:
    - Beer brewing:

**Reference Books :**


- Biotechnology: Rehm and Reid.
- Comprehensive biotechnology: Murray Moo Young.
- Microbial Technology vol I and II by Pepler
- Microbiology and technology of fermented foods: R. W. Hutkins. Blackwell publishing.
- Topic related review papers

**PS03CMIC22: Environmental Microbiology**

**Unit 1**

- Global environmental problems: Global warming, Ozone depletion, Acid rain
    - Global warming and infectious diseases
- Water pollution: Sources and types, Physical, chemical and biological pollution .
- Eutrophication and its control.
- Microbial Indicators of water pollution
- Biodeterioration of wood and metals: Role of micro-organisms, mechanisms and control.

**Unit 2**

- Biogeochemical cycles: Carbon, Nitrogen , Sulphur, Iron and Phosphorous cycles.
    - Detrimental effects of diverted biogeochemical cycles: Acid mine drainage, nitrous oxide emission, nitrate pollution of ground water
- Biological Nitrogen Fixation in detail:
    - Asymbiotic, symbiotic and associative nitrogen fixation.
    - Structure, function and genetic regulation of nitrogenases.

**Unit 3**

- Microorganisms in extreme environments:
    - Characteristics of extreme environments
    - Microbial diversity, habitats and adaptive strategies of thermophiles and hyperthermophiles, psychrophiles and psychrotrophs, halophiles, acidophiles and alkalophiles.
    - Biotechnological applications of extremophiles
- Methods to study microorganisms in environment:
    - Detection of microbial populations: Phenotypic detection, Lipid profile analysis, molecular detection
    - Determination of microbial biomass: Biochemical assays, physiological approaches,
    - Physiological methods to study microbial activity

**Unit 4**

- Microbial communities and ecosystems:
    - Microbial community dynamics, Structure of microbial communities, Ecosystems., Structure and function of some microbial communities in nature.
- Interactions between microorganisms and plant:
    - Mycorrhyzae,
    - Symbiotic nitrogen fixing associations between rhizobia and legumes, *Anabaena and Azolla*
    - Plant growth promoting rhizobacteria:
- Transport / Mobility of microorganisms in soil and subsurface:
    - Factors affecting transport
    - Novel approaches to facilitate microbial transport

**Reference Books:**


- Environmental Microbiology. R. M. Maier, I. L. Pepper & G. P. Gerba.
- Comprehensive Biotechnology Vol-4, Murray Moo Young.
- Biotechnology- Rehm and Reid.

- Microbial Ecology: Fundamentals and Applications- Atlas & Bartha, fourth edition, Pearson Education.
- Environmental science, B. J. Nebel and R. T. Wright.
- The prokaryotes- 3 rd edition, volume 2
- Brock Biology of micro organisms by Madigan,Martinko, Dunlap, and Clark
- Physiology and biochemistry of Extremophiles by Charles Gerday
- Topic related review articles

**PS03CMIC23: Enzymology**

**Unit I**

Introduction to enzymology and historical developments in enzymology

Enzyme Structure and classification.

Practical Enzymology: Enzyme Activity, assay, factors affecting enzyme activity, progress curve, rate enhancement, enzyme activators, coenzyme and cofactors,

Enzyme specificity

Enzyme purification: Objectives and strategy, separation techniques, test of purity, case study

**Unit II**

Enzyme Kinetics:

Chemical reaction kinetics and catalysis

Single substrate kinetics: Equilibrium and Steady state kinetics, significance of Km, Vmax & Kcat, enzyme efficiency

Multisubstrate kinetics: General rate equation, compulsory order, random order and ping-pong mechanisms and their primary and secondary plots.

Enzyme inhibition and its kinetics: Reversible and irreversible inhibition, competitive, non-competitive and uncompetitive, mixed, partial, substrate and allosteric inhibition.

Thermal kinetics: Effect of temperature on reaction rate, enzyme stability, Arrhenius equation and activation energy.

**Unit III**

Mechanism of Enzyme Action:

Enzyme mechanisms: Factors affecting catalytic efficiency, Mechanism of Lysozyme, Chymotrypsin, Carboxypeptidase, Restriction endonuclease, Aspartate transcarbomylase. Allosteric enzymes and sigmoidal kinetics: Protein ligand binding, Co-operativity, MWC & KNF models,

Multienzyme enzyme complexes

**Unit IV**

Methods to study enzymes and its mechanisms

Enzyme engineering: Chemical modification of enzymes: methods of modification of primary structure, catalytic and allosteric properties, use of group specific reagents.

Enzymes in non conventional media, Enzymes as analytical reagents.

Isoenzymes and its physiological significance, Ribozymes and Abzymes

**Reference Books:**

- Fundamentals of Enzymologist : Nicholes C. Price and Lewis Stevens, Oxford Univ. Press.
- Enzyme Structure and mechanism: Alan Fersht, Reading, USA.
- Understanding Enzymes: Trevor Palmer

- The chemical kinetics of enzyme action: K. J. Laider and P. S. Bunting, Oxford University
- Press, London.
- Enzymes: M. Dixon, E. C. Webb, CJR Thorne and K. F. Tipton, Longmans, London.
- Proteins: Thomas Creighton
- Biochemistry: Lubert Stryer.

**PS03CMIC24: Laboratory I (Practicals based on PS03CMIC21 and PS03CMIC22)**

**PS03CMIC25: Laboratory II (Practicals based on PS03CMIC23 and PS03CMIC2X)**

**PS03EMIC21: Advanced Immunology**

**Unit I**

**Experimental systems and methods for diagnostics and therapy**: Antibody generation (polyclonal, monoclonal, modification of monoclonal antibodies), Methods to Determine the Affinity (*Equilibrium dialysis, surface Plasmon resonance*), Microscopic visualization of cells and sub cellular structures (*Immunocytochemistry, Immunohistochemistry, Immunoelectron microscopy*), Immunofluorescence-Based Imaging Techniques of Antigen-Antibody Interactions (*Flow cytometry, Magnetic activated cell sorting, cell cycle analysis, assays of cell death*)

**Antibody Engineering**: Chimeric and hybrid monoclonal antibodies, Construction of monoclonal antibodies from Ig-gene libraries

**Vaccines:** Active and passive immunization, conjugate or multivalent vaccines, DNA vaccines, vaccines under development – malaria and cancer

**Unit II**

**T cell Development:** Early Thymocyte Development, Positive and Negative Selection, Lineage Commitment, Exit from the Thymus and Final Maturation, Other Mechanisms That Maintain Self-Tolerance, Apoptosis
**B cell Development:** The Site of Hematopoiesis, B-Cell Development in the Bone Marrow, The Development of B-1 and Marginal-Zone B Cells, Comparison of B- and T-Cell Development
**T-Cell Activation,Differentiation,and Memory:** T-Cell Activation and the Two Signal Hypothesis, T-Cell Differentiation, T-Cell Memory
**B-Cell Activation,Differentiation,and Memory generation**: T-Dependent B-Cell Responses, T-Independent B Cell Responses, Negative Regulation of B Cells

**Unit III**

**Allergy, Hypersensitivity and Chronic inflammation:** Allergy: A Type I Hypersensitivity Reaction, Antibody-Mediated (Type II) Hypersensitivity Reactions, Immune Complex-Mediated (Type III) Hypersensitivity, Delayed-Type (Type IV) Hypersensitivity (DTH), Chronic Inflammation

**Transplantation immunology:** Immunological principles of graft rejection, Role of T cells in graft rejection, Role of Blood Group and MHC Antigens in Graft Tolerance, Predictable clinical course of graft rejection, General and target specific immunosuppressive therapy, Circumstances favoring

**Unit IV**

**Immunodeficiency disorders:** Primary and secondary immunodeficiencies

**Cancer and immune system:** Terminology and Common types of cancer, Malignant transformation of cells, Tumor antigens, The Immune Response to Cancer, Cancer immunotherapy

**Tolerance and autoimmunity:** Establishment and maintenance of tolerance (*antigen sequestration, central tolerance, peripheral tolerance*), Autoimmunity (*Organ specific autoimmune disease, systemic autoimmune disease, intrinsic and extrinsic factors that can favor susceptibility to autoimmune disease, proposed mechanisms for induction of autoimmunity, treatment of autoimmune diseases*)

**Basic Text and Reference Books:**


1. Owen, J. A., Punt, J., & Stranford, S. A. (2013). ***Kuby immunology*** ($7^{th}$ Edn). New York: WH Freeman.
2. Murphy, K., & Weaver, C. (2016). ***Janeway's immunobiology*** ($9^{th}$ Edn) Garland Science.
3. Male, D., Brostoff, J., Roth, D., & Roitt, I. (2012). ***Immunology*** ($8^{th}$ Edn) *With STUDENT CONSULT Online Access*. Elsevier Health Sciences.
4. Abbas, A. K., Lichtman, A. H., & Pillai, S. (2014). ***Cellular and molecular immunology*** ($6^{th}$ Edn) Elsevier Health Sciences.
5. Relevant review articles / research papers / handouts of latest development in the subject.

**PS03EMIC22: Bioinformatics**

**Unit 1:**

- Introduction to Bioinformatics:
  - Overview, Internet and bioinformatics, Applications.
  - Introduction and Bioinformatics Resources:
  - Knowledge of various databases and bioinformatics tools available at these resources, the major content of the databases, Literature databases:
  - Nucleic acid sequence databases: GenBank, EMBL, DDBJ
  - Protein sequence databases: SWISS-PROT, TrEMBL, PIR, PDB, SCOP, CATH
  - Genome Databases at NCBI, EBI, TIGR, SANGER
  - Other Databases of Patterns/Motifs/System Biology (Gene and protein network database and resources)
- Sequence analysis:
  - Various file formats for bio-molecular sequences: genbank, fasta, gcg, msf, nbrf-pir etc.
  - Basic concepts of sequence similarity, identity and homology, Definitions of homologues, orthologues, paralogues, xenologus.
  - Scoring matrices: basic concept of a scoring matrix, PAM and BLOSUM series.
  - Sequence-based Database Searches: what are sequence-based database searches, BLAST and FASTA algorithms, various versions of basic BLAST and FASTA.
  - Pairwise and Multiple sequence alignments: basic concepts of sequence alignment, Needleman & Wuncsh, Smith & Waterman algorithms for pairwise alignments, Progressive and hierarchical algorithms for MSA.
  - Use of pairwise alignments and Multiple sequence alignment for analysis of Nucleic acid and protein sequences and interpretation of results.

**Unit 2:**

- Gene prediction:
  - Gene structure in Prokaryotes and Eukaryotes, Gene prediction methods: Neural Networks, Pattern Discrimination methods, Signal sites Predictions, Evaluation of Gene Prediction methods.
- Computational RNA Structure analysis:
  - Secondary and tertiary structure of RNA. Various algorithms of RNA folding and their analysis. Energy minimization in RNA folding. RNA sequence alignment based on secondary structure and its applications in functional genomics and phylogeny.
- Transcriptomics:
  - Complete transcript cataloguing and gene discovery sequencing based approach, Microarray based technologies and computation based technologies

**Unit 3:**

- Genomics:
  - Concepts and tools for genomics and comparative Genomics
  - Ancient conserved regions
  - Horizontal gene transfer
  - Functional classification of genes
  - Gene order (synteny) is conserved on chromosomes of related organisms.
  - Prediction of gene function based on a composite analysis.

- Functional genomics.
- Putting together all of the information into a genome database.

❖ Phylogenetic analysis:
- Definition and description of phylogenetic trees and various types of trees, Molecular basis of evolution, Method of construction of Phylogenetic trees: Distance based method (UPGMA, NJ), Character Based Method (Maximum Parsimony and Maximum Likelihood method).

**Unit 4:**

❖ Proteomics and Protein Computational Biology:
- Tools for proteomics: Acquisition of protein structure information, databases and applications.
- Structural classification of proteins, Protein structure analysis structure alignment and comparison,
- Secondary structure and evaluation: algorithms of Chou Fasman, GOR methods.
- Tertiary Structure: basic principles and protocols, Methods to study 3D structure. prediction of specialized structures.
- Active site prediction, Protein folding, Protein modeling and drug design

❖ Protein structure comparison and classification:
- Classes, folds, motif, domain; the concepts in 3D structure comparison, purpose of structure comparison, algorithms such as FSSP, VAST and DALI. Principles of protein folding and methods to study protein folding.

**Basic Text & Reference Books:**


- Bioinformatics: A Beginners Guide, Clavarie and Notredame
- Bioinformatics: David Mount
- Bioinformatics: Rastogi
- Introduction to Bioinformatics:Arthur M. Lesk
- Bioinformatics: Principles and applications, Ghosh and Mallick
- Bioinformatics: Genes, Proteins and Computer, C A Orengo
- Protein Structure Prediction: Methods and Protocols, Webster, David (Southern Cross Molecular Ltd., Bath, UK)


**PS03EMIC23: Omics and Computational Biology**

**Unit I Genomics and methods in genomics**

Introduction to the proteome and the genome, codon bias, gene expression, Genome size-C value paradox, DNA sequencing: Maxam- Gilbert, Sanger, Pyrosequencing, automated DNA sequencing. Other features of nucleic acid sequencing. Analysis and Annotation-ORF Exon-intron boundaries, DNA Microarray technology:The generation of cDNA expression libraries, their robotic arraying, Complex hybridization on DNA chips.

**Transcriptomics**: Comparative transcriptomics, Differential gene expression; Genotyping/SNP detection; Detection technology; Computational analysis of microarray data.

**Unit II Proteomics and methods in proteomics**

Relationship between protein structure and function, Identification and analysis of proteins by 2D analysis; Spot visualization and picking; Tryptic digestion of protein and peptide fingerprinting; Common ionization methods for peptide/protein analysis; Introduction to Mass spectrometers; MALDI-TOF and LCMS analyses
**Protein-protein interactions:** Solid phase ELISA, pull-down assay (using GST-tagged protein), far western analysis, surface plasmon resonance technique, Yeast two hybrid system, Phage display; Protein interaction maps.
**Protein arrays**-definition, applications- diagnostics, expression profiling. Uses of automated technologies to generate protein arrays and chips.

**Unit III Introduction to computational biology basics and biological databases**

Computers in biology, Overview of biological databases, nucleic acid & protein databases, primary, secondary, functional, composite, structural classification database, Sequence formats & storage **Pairwise and multiple sequence alignments:** Local alignment, Global alignment, Scoring matrices - PAM, BLOSUM, Gaps and penalties, Dot plots. Dynamic programming approach: Needleman and Wunsch Algorithm, Smith and Waterman Algorithm, Hidden Markov Model: Viterbi Algorithm. Heuristic approach: BLAST, FASTA. Building Profiles, Profile based functional identification.

**Unit IV Genome analysis**

Polymorphisms in DNA sequence, Introduction to Next Generation Sequencing technologies, Whole Genome Assembly and challenges, Sequencing and analysis of large genomes, Gene prediction, Functional annotation, Comparative genomics, Probabilistic functional gene networks, Human genome project.**Structure visualization:** Retrieving and drawing structures, Macromolecule viewing platforms, Structure validation and correction, Structure optimization, Analysis of ligand-protein interactions; Tools such as PyMol or VMD.

**References:**


- Discovering Genomics, Proteomics and Bioinformatics, A,M, Campbell, C,S,H, Press,
- (2003).
- Essential of Genomics and Bioinformatics C,W, Sensen, Wiley (2003).

- Hand book of Comparative Genomics: Principle and Methodology by Cecilia Saccone,
- GrazianoPesole, Wiley-LISS publication (2003).
- Proteomics: From protein sequencing to function by S.R. Pennington and M.J. Dunn,
- Private Ltd (2001).
- Introduction to Proteomics by Daniel C, Liebler, Humana Press.
- Mount, D. W. (2001). Bioinformatics: Sequence and Genome Analysis. Cold Spring Harbor, NY: Cold Spring Harbor Laboratory Press.
- Bourne, P. E., & Gu, J. (2009). Structural Bioinformatics. Hoboken, NJ: Wiley-Liss.
- Lesk, A. M. (2004). Introduction to Protein Science: Architecture, Function, and Genomics. Oxford: Oxford University Press.
- Campbell, M &Heyer, L. J. (2006), Discovering Genomics, Proteomics and Bioinformatics, Pearson Education.


**PS03EMIC24: Plant Biochemistry**

**UNIT I**

**Structure and biochemical aspects of specialized plant cell organelles** – cell plate, primary and secondary cell walls, plasmodesmata, importance of vacuoles, Vacuole and tonoplast membrane, cell wall, plastids and peroxisomes, Characteristics of meristematic Cells.

**Water relations of plants:** transpiration, guttation, Water balance and Stress Physiology. Osmoprotectants

**UNIT II**

**Photosynthesis** - Light and pigments; Light dependent reactions of

Photosynthesis; Carbon metabolism – The Photosynthetic Carbon Reduction (PCR) cycle; Activation and regulation of the PCR cycle, The C4 syndrome, Crustacean Acid Metabolism (CAM), Regulation of C4 photosynthesis and CAM; Translocation and distribution of photo assimilates, Photorespiration, Factors affecting the rate of photosynthesis.

**Synthesis and storage of polysaccharide:** Starch, sucrose. Fructans and cellulose synthesis as photoassimilates produced by photosynthesis.

**UNIT III**

**Nitrogen metabolism:**
Biological Nitrogen fixation by free living and in symbiotic association, structure and function of enzyme Nitrogenase. Nitrate assimilation: Nitrate and Nitrite reductase. Primary and secondary ammonia assimilation in plants; ammonia assimilation by Glutamine synthetase-glutamine oxoglutarate amino transferase (GS-GOGAT) pathway.

**Sulfate assimilation** and synthesis of sulfur containing substance in plant

**Plant Hormones -** Growth regulating substances and their mode of action. Role of auxins, gibberelic acid, abscisic acid, cytokinins and brassinosteriods (synthesis and their role)

**UNIT IV**

**Secondary metabolism** - Special features, formation and functions of phenolic acids, tannins, lignins, flavonoid pigments, surface waxes, cutin and suberin – the plant protective waxes, terpenes.

**Defence system in plants against biotic stresses-** roles of phytoanticipins, NADPH oxidase, defense proteins, NO, phenolic compounds, jasmonic acid, ethylene and phytoalexins. Hypersensitive Reaction and Systemic Acquired Resistance (SAR); Induce Systemic Resistance (ISR); Resistance to virus by gene silencing. Genetic basis of pathogen resistance Pathogenesis Related (PR) Proteins.

**Reference Books:**

Plant Biochemistry by Hans- Walter Heldt; Elsevier Publication
Plant Physiology by Lincoln Taiz and Eduardo Zeiger; Sinauer Associates Inc Publishers
Introduction to Plant Physiology by William G. Hopkins and Norman P. A. Huner; Wiley

## Semester IV

**PS04CMIC21: R-DNA Technology**

**Unit-I**

Concept and importance of Genetic Engineering; General strategies and Steps involved in gene cloning: Extraction and purification of DNA and RNA from bacteria, virus, plant and animal cells; physical and enzymatic methods for cutting DNA; DNA ligase and other enzymes involved in gene cloning; Construction genomic and cDNA libraries; Introduction of DNA into host cells; screening and selection methods for recombinant clones.

**Unit-II**

Cloning vectors- Basic properties and cloning strategies for vectors derived from Plasmids, λ-bacteriophages, M-13 phage, Cosmids, Fosmids, Phagemids, Phasmids, YAC, BAC, HAC/MAC.

Salient features of expression vectors for heterologous expression in E. coli, Yeast, Insect and Mammalian system, factors influencing heterologous gene expression.

**Unit-III**

DNA sequencing and sequence assembly: Maxam-Gilbert's and Sanger's methods, Shot gun sequencing, Next generation sequencing strategies for large genomes. DNA mapping and DNA fingerprinting: Physical and molecular mapping, Hybridization and PCR based methods of fingerprinting. Site directed mutagenesis: Methods and applications.

Polymerase Chain Reaction: Principle and basic types of PCR; Reverse Transcription and Real Time PCRs.

**Unit-IV**

Applications of Genetic engineering in improvement of plants, animals and microbes; Gene editing and its applications; Metagenomics and Metabolic engineering; Gene therapy; Restriction and regulations for the release of GMOs; Biosafety and levels of Physical and Biological containment; The Indian Guidelines for release and use of GM organisms.

**Reference Books**


- Genome 3rd Edition – Brown
- Molecular Biotechnology – Glick
- Principles of Genetic Manipulation – Old and Primrose
- Applied Molecular Genetics – Roger Miesfeld
- Biotechnology – H. K. Das
- Recombinant DNA – Watson et. al.
- Molecular cloning – Sambrook and Russel
- From genes to clones – Ernst Whittaker

**PS04CMIC22: Environmental Biotechnology**

**Unit 1**

Waste water treatment- Waste water characterization and its significance: COD, BOD, TOC, TOD, Inorganic constituents, solids, biological components.

Principles and aims of biological wastewater treatment processes: Primary, secondary and tertiary treatment of waste water.

Biochemistry and microbiology of inorganic phosphorus and nitrogen removal from waste water.

Suspended growth processes:

Activated sludge process: Biology of activated sludge, flocculation and sludge settling, problems of sludge settling, modified processes for inorganic nitrogen and phosphorous removal

Oxidation ditches and Waste stabilization ponds.

Fixed film processes: Biofilm formation and slaughing, Trickling filters, Rotating biological contactors, fluidized bed and submerged aerated filters.

**Unit 2**

Anaerobic digestion: microbiological and biochemical fundamentals, factors influencing anaerobic digestion.

Anaerobic waste water treatment systems: Upflow anaerobic sludge blanket , rotating biological contactors, anaerobic filters. Merits and demerits of anaerobic treatment of waste.

Composting: Objectives, fundamentals, microbiology, factors influencing composting and composting systems, Compost quality and uses, Vermicomposting.

Toxicity testing in waste water treatment plants using microorganisms:

Monitoring environmental processes with biosensors: BOD biosensor, Pesticide biosensor

**Unit 3**

Biodegradation of organic pollutants: Xenobiotic and recalcitrant organic compounds, mechanisms of biodegradation, factors affecting biodegradation, Acclimation phase in biodegradation. Biodegradation of simple aliphatic, aromatic, polycyclic aromatic hydrocarbons, halogenated hydrocarbons, azo dyes and lignin.

Bioremediation approaches: Intrinsic bioremediation, Biostimulation, Bioaugmentation: Use of genetically modified organisms.. *In situ* and *ex situ* bioremediation technologies with examples.

Bioremediation of heavy metal pollution, Phytoremediation.

Biological treatment of waste gas (polluted air): biofilters, bioscrubbers, membrane bioreactors, biotrickling filters.

**Unit 4**

Bioleaching of metals: Characteristics of commercially important microbes, mechanisms of bioleaching, factors affecting bioleaching and current biomining processes. Biobeneficiation of gold ores.

Biodesulfurization of coal: Removal of organic and inorganic sulfur from coal.

Microbially enhanced oil recovery.

Microbial Insecticides: Bacterial, fungal and viral insecticides in pest management.

Biofertilizers: applications of nitrogen fixing and phosphate solubilising/ mobilizing biofertilizers.

**Reference Books:**


- Comprehensive Biotechnology Vol-4, Murray Moo Young.
- Biotechnology-Rehm and Reid.
- Waste water microbiology by G. Bitton

- Biodegradation and bioremediation by M.Alexander
- Waste water treatment for pollution control, 2nd edition. Arceivala
- Environmental Biotechnology by H. Jordening and Josef Winter
- Handbook of water and waste water Microbiology by Horan
- Topic related review articles

**PS04CMIC23: Lab I (Practicals based on PS04CMIC21 and PS04CMIC22)**

**PS04EMIC21: Lab II (Practicals based on PS04EMIC2X and PS04EMIC2X)**

**PS04EMIC22: Dissertation**

**PS04EMIC23: Microbial Physiology**

**Unit-I**

Bacterial Cell Structure and its type, Bacterial Cell surfaces, Bacterial Cell wall structure function and synthesis, Membrane transport in bacteria-simple, group translocation, ABC transporters, Protein export in bacteria–Type 1,2,3,4, Protein export pathways.

Bacterial capsules structure and importance.

Bacterial organs for locomotion: Flagella: structure, synthesis, function and mechanism of locomotion, Swarming motility, Motility in spirochetes, Gliding motility, Twitching.

Chemotaxis: Molecular mechanism and physiological significance.

Two component signal transduction in prokaryotes

**Unit-II**

Bacterial differentiation: endospore formation, physiological and genetic aspects of sporulation, Sporulation inducing signals & events in sporulation

Bacterial cell division: molecular mechanisms involved in formation of Z-ring, Cell division machinery.

Yeast cell division: Growth and cell division coordination, Cell division events, molecular basis of cell cycle and control.

Microbial stress responses: Oxygen toxicity, pH, Heat shock, Osmotic pressure, Osmolarity regulation in *E.coli* (Omp system) Phosphate assimilation in *E.coli* (Pho system), Nitrogen fixation in *Klebsiella & Rhizobium* (Ntr system).

Metabolism in Autotrophs, Methylotrophs and Photoautotrophs

**Unit-III**

Bioluminescence: process, biochemistry, genetics and significance.

Mechanism of action of antibiotics and mechanisms of drug resistance.

Bacteriocins: Structure, Classification and physiological significance of it.

Microbial reserve compounds: Types, Synthesis and Applications

Siderophores; structure, function and significance

Bacterial biofilms formation steps, dispersion and control strategies

**Unit-IV**

Quorum sensing process in gram positive and gram negative bacteria.
Microbial fuel cells: Energy generation principle and application.
Microbial production of Hydrogen.
Host Parasite interactions: Structures and functions involved in Host-parasite interactions, Bacterial damages to host upon infection. Structure and Mechanism of Endotoxin, Exotoxin and Exoenzymes formed by bacteria.
The prokaryotic "immune system", CRISPR/Cas

**References:**


- Bacterial signalling, Kramar and Jung
- Microbial Physiology, Moat, Foster and Spector
- The Physiology and Biochemistry of prokaryotes, David White
- Bacterial physiology: A molecular approach, W. E. Sharoud
- Topic related review articles


**PS04EMIC24: Food and Dairy Microbiology**

**Unit I:**

Scope of food microbiology

Food as a substrate

a) Microorganisms important in food microbiology – Bacteria, yeasts and moulds.

b) Factors influencing microbial growth in food.

Food Spoilage

a) General principles underlying food spoilage and contamination.

b) Spoilage of canned food, sugar products, vegetables, fruits, meat and meat products, milk and milk products fish, seafood and poultry

**Unit II:**

Food poisoning

a) Indicator food borne pathogens

b) Bacterial food borne infections and intoxications-*Brucella, Campylobacter, Clostridium, Escherichia* (ETEC/EHEC/EPEC/EAEC), *Salmonella, Shigella, Listeria, Vibrio, and Yersinia.*

c) Non- bacterial food borne infections and intoxications- Nematodes, protozoa, algae, fungi, and viruses.

d) Culture and non-culture based detection of food pathogens and viruses

e) General methods for diagnosis of infections, intoxications and preventive measures.

**Unit III:**

Food preservation

Principles of food preservation – Physical and chemical preservation methods, Bio preservatives

Food fermentations

Starter cultures for fermented foods: Biochemical activities in fermentation of foods. Oriental fermented foods: Shoyu, Temph, Kimchi etc

Fermented milk products: Yogurt, Kefir, Koumiss etc.
Fermented vegetables – Sauerkraut
Bread manufacture

Application of microbial enzymes in food industry

**Unit IV:**

Genetically modified foods. Biosensors in food

Food research organizations/institutes in India

Recent foodborne outbreaks

Food sanitation – Microbiology of food plant sanitation, water and milk testing

Food laws and quality control – HACCP, Codex alimentarius, PFA, FPO, MFPO, BIS, AGMARK.

**Books recommended**

1. Food Microbiology, Frazier and Westhoff
2. Food microbiology, Adam and Moss
3. Dairy Microbiology by Robinson. Volume II and I.
4. Fundamental Food Microbiology, Bibek Ray and ArunBhuniya

**PS04EMIC25: IPR and Biosafety**

**UNIT-I**

**Biotechnology and society:** Biotechnology and social responsibility, public acceptance issues in biotechnology, issues of access, ownership, monopoly, traditional knowledge, biodiversity, benefit sharing, environmental sustainability, public vs private funding. Social and ethical issues in biotechnology. Principles of bioethics. Ethical conflicts in biotechnology- interference with nature, unequal distribution of risk and benefits of biotechnology, bioethics vs business ethics.

**UNIT-II**

**Bio- safety:** Definition of bio-safety, Biotechnology and bio-safety concerns at the level of individuals, institutions, society, region, country and world.

Bio-safety in laboratory institution: laboratory associated infection and other hazards, assessment of biological hazards and level of biosafety.

Bio safety regulation: handling of recombinant DNA products and process in industry and in institutions.

**UNIT-III**

**IPR I:** Introduction to IPR: Forms of IPR and Intellectual property protection. Concept of property with respect to intellectual creativity, Tangible and Intangible property.

WTO: agency controlling trade among nations, WTO with reference to biotechnological affairs, TRIPs. WIPO, EPO.

**UNIT-IV**

**IPR II:** Concept related to patents novelty, non-obviousness, utility, anticipation, prior art etc. Type of patents. Indian patent act and foreign patents.
Patentability, Patent application, Revocation of patent, Infringement and Litigation with case studies on patent, Commercialization and Licensing.

**References:**


1. Fleming, D.A., Hunt, D.L., (2000). Biotechnology and Safety Assessment (3rd Ed) Academic press.ISBN-1555811804,9781555811808.
2. Thomas, J.A., Fuch, R.L. (1999). Biotechnology and safety assessment (3rd Ed). CRC press, Washington. ISBN: 1560327219, 9781560327219
3. Law and Strategy of biotechnological patents by Sibley. Butterworth publication.(2007) ISBN: 075069440, 9780750694445.
4. Intellectual property rights- Ganguli-Tat McGrawhill. (2001) ISBN-10: 0074638602,
5. Intellectual Property Right- Wattal- Oxford Publicatiopn House.(1997) ISBN:0195905024.
6. Biotechnology - A comprehensive treatise (Vol. 12). Legal economic and ethical dimensions VCH. (2nd ed) ISBN-10 3527304320.
7. Encyclopedia of Bioethics 5 vol set, (2003) ISBN-10: 0028657748.
8. Thomas, J.A., Fuch, R.L. (2002). Biotechnology and safety Assessment (3rd Ed) Academic press.
9. B.D. Singh. Biotechnology expanding horizons.
10. H.K.Das. Text book of biotechnology 3rd edition.


**PS04EMIC26: Plant Biotechnology**

**Unit I**

Historical review and scope of plant tissue culture; Plant cell-totipotency. Aseptic techniques; Culture media: preparation and composition. Methods of sterilization, inoculation, incubation and hardening. Cell and organ differentiation; Clonal propagation or micropropagation (artificial seeds, virus free plants); Somaclonal variation; Overcoming crossing barriers : Pre fertilization and post fertilization barriers including in-vitro pollination/fertilization and embryo rescue); Endosperm, nucellus culture, anther culture and ovule culture. Germplasm storage including cryopreservation.

**Unit II**

Isolation of protoplasts; Purification of protoplasts; Visibility and plating density of protoplasts; Protoplast culture and regeneration of plants; Protoplast fusion and somatic hybridization (techniques of fusion, selection of fused protoplasts, chromosome status of fused protoplasts, uses of somatic hybrids); Cytoplasmic hybrids or Cybrids; Genetic modification of protoplasts.

**Unit III**

Vectors for gene transfer (based on Ti and Ri plasmids; co integrate, intermediate and helper plasmids; binary vectors; viruses as vectors); gene transfer techniques using Agrobacterium; selectable and scorable markers (genes); Agroinfection and gene transfer; Physical delivery methods: Biolistics and electroporation.

**Unit IV**

Transgenic plants for crop improvement (dicots and monocots including maize, rice, wheat, oats, etc.; resistance to herbicide, insecticide, virus and other diseases; transgenic plants for molecular farming; transgenic plants to regulated gene expression, Chloroplast and Mitochondrion engineering.

**Reference Books :**


- Plant biotechnology – J Hammond, *et. al.*, Springer Verlag.
- Plant cell and tissue culture for production of food ingredients – T J Fu, G Singh, *et. al.*
- Biotechnology in crop improvement – H S Chawla.
- Practical application of plant molecular biology – R J Henry, Chapman & Hall.
- Elements of biotechnology – P K Gupta.
- An introduction to plant tissue culture – M K Razdan.
- Plant propagation by tissue culture : The technology (Vols. 1 & 2) – Edwin George.
- Handbook of plant cell culture (Vols. 1 to 4) – Evans *et. al.*, Macmillan.
- Plant tissue and cell culture – H E Street, Blackwell Scientific.
- Cell culture and somatic cell genetics of plants (Vols. 1 to 3) – A K Vasil, A. Press.
- Plant cell culture technology – M M Yeoman.
- Plant tissue culture and its biotechnological applications – W Bary, *et. al.*, Springer Verlag.
- Principles of plant biotechnology : An introduction to genetic engineering in plants – S H Mantell, *et. al.*
- Advances in biochemical engineering / Biotechnology – Anderson, *et. al.*
- Applied and fundamental aspects of plant cell tissue and organ culture edited by Reinert& Bajaj Y P S, Springer Verlag.
- Plant cell and tissue culture – S Narayanswamy, Tata Mc Graw Hill Co.
- Text Books: 2.Ignacimuthu, S.J. 1997. Plant Biotechnology. Oxford and IBH Publ