# MICROBIOLOGY

## M.Sc. Syllabus(Effective from academic year 2017-2018)

**First Semester**

| Course name | Title | Credit |
|---|---|---|
| 101 | Basic math, stats and computers for Biologists | 3 |
| 102 | Biochemistry and Biophysics | 3 |
| 103 | Fundamentals of Molecular Biology & Microbiology | 3 |
| 104 | Cell Biology | 3 |
| 105 | General Microbiology | 3 |
| 106 | Lab course | 6 |
| Total credit | | 21 |

**Second Semester**

| Course Number | Title | Credit |
|---|---|---|
| 201 | Recombinant DNA Technology | 3 |
| 202 | Genomics and Proteomics | 3 |
| 203 | Immunology | 3 |
| 204 | Ecology and Environmental Microbiology | 3 |
| 205 | Medical Microbiology | 3 |
| 206 | Lab course | 12 |
| Total credit | | 27 |

**Third Semester**

| Course Number | Title | Credit |
|---|---|---|
| 301 | Microbial Genetics | 3 |
| 302 | Bioenergetics and Metabolism | 3 |
| 303 | Virology and Cancer | 3 |
| 304 | Industrial Microbiology | 3 |

| | | |
|---|---|---|
| 305 | Lab course | 6 |
| Total credit | | 18 |

**Fourth Semester**

| Course Number | Title | Credit |
|---|---|---|
| 401 | Microbial Biotechnology | 3 |
| 402 | Bioethics and IPR | 3 |
| 403 | Journal Club | 3 |
| 404 | Industrial tour | 3 |
| 405 | Project + Dissertation + Seminar | 9 |
| 406 | Grand Viva | 3 |
| Total Credit | | 24 |

| Course | Credit marks | Total marks |
|---|---|---|
| Theory total | 48 credit marks | 800 |
| Practical total | 42 credit marks | 700 |
| Total credit | 90 credit marks | 1500 |

**Detailed Content of M.Sc. Courses Microbiology (PG syllabus effective from academic year 2017-2018)**

## Program Specific Outcome (PSO):

Program Purpose:

Microbiology is a broad discipline and students have a wide range of options for the study of microbiology including: microbial physiology, microbial genetics, microbial ecology, pathogenesis, immunology, virology, parasitology, epidemiology, evolution and diversity. Students of this program commonly pursue careers in academics, industry, and medicine. Microbiology major program guidelines are to be used for "assessment, maintenance, and formation of strong programs in microbiology." Microbiology is a laboratory-based science, and as such, our curriculum supports laboratory components in most of the courses taught in the program.

Consequently, the program educational objectives are:

1. To prepare a new generation of microbiologists that are capable of excelling in careers of their choosing.
2. To provide an educational environment that fosters the development of appropriate scientific vocabulary, reasoning skills, and effective oral and written communication abilities.
3. To provide opportunities for students to engage in productive scholarly research projects that complement their classroom training and instruction.

Outcomes:

**Microbiology Fundamentals**

Exhibit mastery of variousareas of the discipline like microbial physiology, microbial genetics, microbial ecology, medical microbiology, virology, and immunology.

**Experiment Design**

Devise experiments with appropriate hypotheses and controls.

**Data and Research Interpretation**

Interpret experiments from primary scientific (biological) literature, analyzing the use of the scientific method, critiquing the rationale, methods, and conclusions in light of relevant scientific principles.

**Effective Communication**

Effectively communicate scientific information using both oral and written methods

**Semester I**

**101 Basic Mathematics, Biostatics and Computers for Biologists**

## Course Outcome:

**Course objectives: Biostatistics course for those students will aquaint students to enable them to continue learning more advanced techniques in future statistical and biostatistical course work.**

**It can also serve as the necessary base course in biostatistics for those who will go no further in acquiring advanced skills in biostatistics but who can use the knowledge they acquire to intelligently read journal articles that use biostatistical methods, interact effectively with professional biostatisticians in collaborative endeavors and understand the terminology of one of the core disciplines of public health.**
**The objective of Bioinformatics course is learning and understanding basic concepts of Bioinformatics.**

**Learning outcomes:**
**For the Biostatistics course:**

- **be able to discuss and explain what biostatistics is and how it is used in the field of public health**
- **be able to understand the common statistical techniques and terminology used in studies that are presented in the popular press and health related journals**
- **be able to use and understand the principal numeric and graphical techniques to display and summarize medical and health related data**
- **be able to understand the basic principles of probability and how they relate to biostatistics**
- **be familiar with the common probability distributions that are used in statistical inference**
- **be able to know what drawing a random sample from a population means and why it is important**
- **be familiar with the most common sampling distributions used in biostatistics**
- **be familiar with the concept of statistical inference**
- **be able to estimate the value of various population parameters from a sample of data**
- **be able to test the hypothesis that the value of a population parameter equals a certain value**
- **be familiar with the sources of vital statistics data, how to interpret such data and how to perform basic tests to evaluate them**

**By the end of the course in Bioinformatics the student will be able to: • Gain an understanding of the basic concepts of Bioinformatics. • Understand the tools used in Bioinformatics.**

**Course:**

Basic Mathematics

Elements of Algebra

Theory of Equations: Polynomials, Descartes's rule of signs, extraction of roots of quadratic, cubic and biquadratic equatons, Relation between roots and coefficients, Transformation. Simple problems only.

Matrix Theory: Matrix Operations, Symmetric and skew –symmetric matrices, orthogonal matrix, Determinants, Application to solution of system of equations, Cramer's rule, Eigen values and eigen vectors, Diagonalization of matrices, Quadratic form.

Set Theory: Sets and set operations, Relations, Functions, Injective, surjective and bijective functions, inverse of a function, composition of functions, Cardinality of a set, Cardinality theorem, Cartesian product of sets.

Elements of Calculus:

Differential Calculus: Integers, Real numbers-simple properties, complex numbers –simple properties, functions and their graphs and their interpretations, Study of the functions: xn, ex, ax, log x, sin x, cos x, tan x, sinh x, cosh x, tanh x, Boundedness, monotonicity and periodicity of functions, continuity and differentiability of functions, Higher order derivatives, Leibnitz's theorem, Physical, geometric and functional interpretations of derivative, maxima and minima, series expansions of functions.

Integral Calculus: Indefinite integral, Properties of Definite integral, Improper integral, Gamma and Beta functions, Reduction formulas only for ∫sinnx dx, ∫cosnx dx and ∫tannx dx. Evaluation of area – simple problems. Fourier Analysis.

Differential Equations: Definitions of ordinary and partial differential equations, Evolution of differential equations from biological processes, Methods of solving ordinary equations- separation of variables, exact, homogeneous equations, First order linear equations, equations of first order but not of first degree –simple equations only, Clairaut's equation for singular solution, Linear equations of second and higher orders with constant coefficients, Systems of equations – simple examples.

Biostatistics

Biostatistics and Biometry

Elements of Probability theory: Random experiment, sample space, events, Laplace's definition, Theorems of Total and Compound Probability, Bayes's theorem, Independence of events, Random variable, Probability function, Distribution function, Mathematical Expectation, Moment generating function,

Theoretical distributions- Binomial, Poisson, normal, uniform, exponential, and hypergeometric.

Elements of Statistics: Population, Sample, Methods of sampling, Sampling distributions, Measures of central tendency, dispersion, Moments Skewness and Kurtosis. Correlation and regression, Curve-fitting – linear, quadratic and exponential, Least-square method.

Biometry: Hypothesis testing, Parametric and nonparametric tests, z, t and $\chi^2$-tests.

Computer Application in Biology: Information and Data. Hardware: CPU, Primary and Secondary storage, I/O devices, Bus structure Software: Systems & Application. Generation of Computers: Super, Mainframe, Mini & Personal Computer. Programming Languages: Machine Language, Assembly Language, High Level Language. Problem solving: Flow charts, Decision tables & Pseudo codes.

Basic Computer Organization: Arithmetic and Logic Unit, Control Unit, CPU Registers, Instruction Registers, Program Counter, Stack Pointer, System Bus. Instruction: Machine instruction and Assembly Language. Operation Code and Operand, Instruction types, Addressing modes, Instruction Cycle. Stack organization. Memory: Types of Memory, RAM, ROM, EPROM, DRAM, SRAM, Associative memory.

Introduction to Data Structures: Arrays, Linked Lists, Stacks, Queues, Trees, Graphs, Searching and Sorting.

Operating Systems: What is OS? Multiprogramming OS. Concepts of processes, Files, Shell, System Calls. Structures: Monolithic, Layered, Virtual, Client Server and Distributed Model.

Internet Technologies: Intranet and Internet; Servers and Clients; Ports; Domain Name Server (DNS); Accounts, Internet Service Providers; Connections : Dial up, ISDN, ADSN; Cable, Modem; Email : Account, Sending, Receiving, Mailing List, IRC, Voice and Video Conferencing, WWW,Browsers

**102 Biochemistry andBiophysics**

## Course Outcome (CO):

**Course objectives:- The objective of this course is to gain an insight into the Structure and Functions of Carbohydrates, Proteins, Lipds, Nucleic acids and a detailed discussion into the fundamentals of enzyme structure and function and kinetics of soluble and immobilized enzymes. Also it deals with current applications and future potential of enzymes.To acquaint students with principles, working and applications of Microscopic techniques, spectroscopy Chromatography**

**Learning outcomes:- By the end of the course the student will be able to discuss the Structure and function of Carbohydrates e.g. glycogen, cellulose etc. Describe structure, functions and the mechanisms of action of enzymes. The student will learn kinetics of enzyme catalyzed reactions and enzyme inhibitory and regulatory process. The student will be able to perform immobilization of enzymes. The student will get exposure of wide applications of enzymes and their future potential. By the end of the course the student will be able to: • Gain an understanding of the basic principles of Atomic force, Fluorescence, Confocal and Electron Microcopy. • Understand the principles and analysis using Spectrocopy including, fluorescence, CD, ORD, NMR and ESR. Also gaining insights in the applications of chromatography and immunotechniques such as FISH, CISH etc.**

**Course:**

Biophysics

Elementary Quantum Mechanics: with special reference to macromolecular structure and Dynamics, Concept of electromagnetic radiations, Idea of wave particle duality, de Broglie hypothesis, Heisenberg's Uncertainty Principle, Schrodinger equation (time independent), elementary concepts of operator, Eigenfunction and Eigenvalues, Schrodinger's equation, for hydrogen atom, separation of radial and angular parts, concept of orbitals and shapes of s, p, d orbitals.

Thermodynamics: Extensive and Intensive Variables, Mathematical Description of Thermodynamic System with two or more variables, Exact and Partial differential, First, Second and Third Law of Thermodynamics, isothermal process, Entropy, enthalpy, reversible and irreversible process, free energy and chemical potential, Gibb's free energy, osmotic pressure, Nernst Potential, Donnan Equilibrium, methods for determining free energy changes, coupled reaction, kinetics of reaction, principles, elementary and multi-step reactions, activation energy, Molar refraction and polarization, dipole moment, potentiometric determination of pKs of amino acidsDebye-Huckel Theory, Hydradtion and Solvation number.

Stereochemistry : Chirality, elements of symmetry, Plane of symmetry, center of symmetry and axis of symmetry, optical isomerism, enatiomerism and diastereomerism, D/L,R/S,E/Z,syn/anti, cis/trans,

meso/dl, threo/erythro, nomenclature, conformational nomenclature, eclipsed/staggered, gauche/anti, dihedral angle, energy barrier of rotation, relative stability of conformers on the basis of steric effect, dipole- dipole interactions, H- bonding, conformational analysis of ethane, n-butane,stereochemistry of cyclohexane- chair and boat conformations, conformational analysis of cyclohexane.

Elementary Optics and Microscopy: Dispersion by a prism, dispersive power, Laser-Stimulated absorption, spontaneous emission, stimulated emission, characteristics and uses of laser. Interference of light- Diffraction of light, grating element Polarization, polarization of transverse wave, - plane of polarization, unpolarized, linearly polarized, circularly polarized, elliptically polarized, polarization of reflection, Polaroid, Nicol's prism (as polarizer and analyser), optical activity. Microscope (compound)- Basic components, ray-diagram, magnifying power, resolving power; Stereo-microscope – stereo images; Optical microscope- Bright field, Dark field, Phase contrast, Fluorescence, Confocal laser scanning; Electron Microscope- Dicroism, Transmission (TEM), Scanning (SEM), Reflection (REM), Scanning Transmission(STEM),;Scanning Probe Microscope; Atomic force, FACS Analysis.

General properties of matter: Surface tension, Viscosity and Newtonian flow of liquids: Surface tension and surface energy, molecular theory, angle of contact, elevation and depression of liquid columns in a capillary tube, excess pressure in a spherical bubble or drop, Streamline and turbulent motion, Poiseuille's formula, critical velocity, Reynold's number, Stoke's law.

Biohysical Methods: Brownian movements, osmosis and diffusion in aqueous solutions; Centrifugation (Isopicnic and density gradient sedimentation); Hydrodynamic methods: Determination of the hydrodynamic radius; Relationship of retardation time and molecular weight of biological polymers.

Biochemistry

Acid, Bases, Buffers and life processes

Arrhenius's concepts, theory of solvent system, Bronsted and Lowry's concepts, relative strengths of acids, Lux- Flood concept, Lewis concept, Usanovich's concept, HSAB principle, ionization of water, ionic product of water pH, Concept of pH, buffer solutions in biological sytstems, polyprotic acids, acid base neutralization curves, solubility product principle, common ion effect and its applications in separation and identifications of common cations, solvent properties of water, ampholytes electrostatic and hydrophobic interaction.

Biomolecules

Amino acids, peptides and proteins: Structure of amino acids, Chemical reactions and modification, physical properties, sequencing, synthesis of peptides.Proteins: End group analysis, Sequencing, Purification, Protein structure: Hierarchy of structure, primary, secondary, tertiary and quaternary, torsion angle and Ramachandran plot, motifs and domains, Chemical nature of polypeptides, the polypeptide chain, amino acids and their side chains, covalent modifications of the polypeptide chains, forces that determine protein structure. Methods to determine macromolecular structures Forces stabilizing protein structure: H-bond, Electrostatic interaction, Hydrophobic interaction, Vander Waal's

interaction Structure function relationship of proteins : fibrous proteins (keratins and collagen), globular protein, (oxygen transport proteins hemoglobin and myoglobin).

Nucleic acid: Types and basic structure (DNA, RNA), Principles of sequencing and oligonucleotide synthesis. Double helical structure of DNA(Watson-Crick model), Sugar puckering and base stacking; B-,A- and Z-DNA, other nonperiodic structures (DNA bending, Supercoiling) and their significance. Denaturation kinetics of DNA, Cot curves. Nucleic acid hybridization its application. Folding of RNA into higher order structures (mRNA, tRNA, rRNA in ribosome), modified nucleotides in tRNA and rRNA and their importance, Purification and separation of nucleic acids. Protein Folding and Stability

Lipids: Classification, Structure-function, role in biological membranes. Lipoproteins

Carbohydrates: Classification and reactions. Polysaccharides: Types, Structural features, determination of composition. Glycoproteins

Introduction to examples of Macromolecular assemblies :Membranes, Ribosomes, DNA/RNA polymerases, Sliceosomes, Exosomes, Proteasomes etc.

Enzymology: Definition of Enzyme, Active Site, Substrate, co-enzyme, cofactor, Enzyme substrate Complimentarity, Km and Vmax, Micheaelis-Menten plot, Lineweaver-Burke Plot, Eadie-Hofstee, Hanes Plot, Enzyme Inhibition (Competitive and non-Competitive, uncompetitive inhibition, mixed, partial), Enzyme Kinetics, two and three substrate kinetics, deviation from linear kinetics, Ligand Binding sites, Hill Equation, Types of kinetics (acid-base, covalent, electrostatic, metal ion activated) Use of isotopes in enzyme kinetics mechanism analysis, Effect of temperature and pH on enzyme activity, Allosteric Regulation of Enzymes, Active site determination studies, Protease family of Enzymes.

Bioenergetics and Metabolism Principles of Bioenergetics, ATP Cycle, Concept of metabolism, Nutritional importance, digestion, absorption, transport, mechanism of activation of digestive enzymes.

Carbohydrate Metabolism: Carbohydrates Digestion, Absorption, Intestinal transport. Intra Cellular metabolism of glucose – Glycolysis, HMP Shunt, Citric acid cycle; Glycogenolysis, Glycogen synthesis, metabolism of sugar other than glucose. Regulation of blood glucose level. Gluconeogenesis, biosynthesis of disaccharides, glycoproteins, Glyoxalate cycle, Metabolic regulation.

Amino acid Metabolism: Dynamic Equilibrium of body protein, Nutritional and Metabolic importance of amino acids, General catabolism of amino acids, Metabolism of a few individual amino acids, one carbon fragment metabolism amino acid as biosynthetic precursors. Urea, Metabolic diseases.

Lipid metabolism: Biosynthesis and catabolism of simple and complex lipids. Metabolic regulation. Lipoproteins, lipid storage and transport. Cholesterol metabolism and regulation. Abnormal metabolism of lipids.

Nucleotides metabolism: Biosynthesis degradation of purines and Pyrimidines and their nucleotides, their interconversion & regulation. Salvage pathways. Regulation of biosynthesis of deoxyribonucleotides from ribonucleotides, abnormal metabolism of purines and pyrimidines .

Nitrogen metabolism: Nitrate and ammonium assimilation; amino acid biosynthesis.

Photosynthesis; Light harvesting complexes; mechanisms of electron transport; photoprotective mechanisms; CO2 fixation-C3, C4 and CAM pathways, photorespiratory pathway.

**103Fundamentals of Molecular Biology and Microbiology**

## Course Outcome (CO):

**Objectives**

**Molecular Biology gives in-depth knowledge of biological and/or medicinal processes through the investigation of the underlying molecular mechanisms.**

**Target knowledge and understanding**

**• will gain an understanding of chemical and molecular processes that occur in and between cells. The understanding will become such that students will be able to describe and explain processes and their meaning for the characteristics of living organisms.**
**• will gain insight into the most significant molecular and cell-based methods used today to expand our understanding of biology.**

- **Learns about microbial Diversity and their outcomes.**
- **Learns about the techniques for studying and identifying microbes and environment pathogen**
- **interactions.**
- **Studies the microbes associated with various habitats and their metabolism. Molecular identification**
- **of the microbes.**
- **Knows the classification of microbes associated with environment.**
- **Can identify environment associated molds, yeasts, yeast-like fungi and bacteria by phenotypic and biochemical methods.**
- **Is aware of microbial habitat of specific microbes.**

**Outcomes**

**Having completed a master's degree, students will be able to:**
**• Conduct independent work in a laboratory.**
**• Read scientific articles and gain a critical understanding of their contents.**
**• Give a spoken and written presentation of scientific topics and research results.**
**• Present hypotheses and select, adapt and conduct molecular and cell-based experiments to either confirm or reject the hypotheses.**

- **Student is able to describe the molecular structure of DNA and RNA**
- **Student is able to describe the organization of microbial genomes and eukaryotic genomes**
- **Student is able to describe chromatin arrangement and nucleosome formation**
- **Student is able to describe arrangement of replicons in genome**
- **Student is able to describe various modes of DNA replication**
- **Learns about sustainable development and Biosafety and IPR rules.**

**Course:**

Molecular Biology: Emegence of Molecular Biology as a new discipline, Demonstration of DNA as genetic material, Fundamentals of Molecular Processes, Adapter Hypothesis, Central Dogma

Fundamental Processes

Propagation and Maintenance of Genome

Genome Organization in prokaryote and Eukaryotes: Bacterial Nucleoid Structure, Chromosome Structure and Organization,Histones and non-histone proteins, Nucleosome Structure, and organization.

DNA replication in Prokaryotic and Eukaryotic Cells, Enzymology and general features, Detailed mechanisms of intiation, elongation and termination, experiments underlying each steps and role of individual factors, regulation and control of replication, Problem of linear DNA replication, Telomerases.

Recombination at the molecular Level: Homologous recombination, Rec A and BCD system, Chi-Sequence, Holliday junction and Ruv System, Site specific Recombination and Transposition.

DNA damage and Repair: Replication Errors, mutations and other kinds of damages, Enzymology, Genetics and mechanisms of DNA Repair, Photoreactivation, Base and Nucleotide excision repair system, Mismatch Repair System, SOS Repair System.

Flow of genetic information

Mechanism of Transcription: Prokaryotic Transcription: Promoters, Sigma Factors, Initiation, Elongation, Rho-dependent and independent termination, Eukaryotic Transcription: Eukaryotic Promoter, Enhancers: General Transcription factors, Activators, mediators. Transcription Termination.

RNA processing: Capping and Polyadenylation, mRNA splicing, cis- and trans splicing, Chemistry of Splicing, Spliceosome and SR proteins, Alternative Splicing and Exon Shuffling, Splicing of Group I and II introns, Tetrahymenaself splicing introns, Ribozyme, mRNA editing, folding, export.

Protein Synthesis and translation: Ribosome function, Genetic code, tRNA and Wobble hypothesis, Fidelity and control of translation, mRNA degradation, Protein Sorting and targeting to ER.

Regulation of prokaryotic and eukaryotic genes: Concept of regulation at different layers, negetive vs. positive regulations; regulations in prokaryotes, concepts of operons and regulatory molecules eg. inducers, repressors etc., model operons eg. lac and trp operons, lytic/lysogenic switches in bacteriophage lanbda, Positive regulation in eukaryotic cells at transcriptional and post-transcriptional levels, basic and accessory transcription factors, enhancers and alternative splicing and polyadenylation; NPCs are another control point of gene regulation, regulation of gene expression after export eg. at the levels of mRNA localization, translation and decay, Regulation of gene expression by micro RNAs, RNA

interference, Doing reverse genetics with RNAi. Concept of quality control of gene expresssion and coupling of different steps of gene expression.

Epigenetics: Chromosomal remodelling and regulation of gene expression by modification of DNAs, Fundamentals of Genomics and system biology with very basic concepts of genome analysis

Microbiology

Introduction: Brief history and development of Microbiology as a separate discipline

Methods in Microbiology: Methods of studying microorganisms 14

Microbial Organisation: Structure and Organisation of microbes

Microbial growth: definition of growth and its mathematical expression, growth curve, mesurement of growth: synchronous growth, continuous culture. Factors affecting growth (temperature, acidity, alkalinity, water availability and oxygen), maintenance of growth, pure culture and culture characteristics.

Microbial Metabolism: Elementary Microbial nutrition, mode of uptake of nutrients.

Control of Microorganisms: Physical and chemical agents to kill microorganism, brief history of antibiotics and chemotherapeutic agents.

Microorganisms of various habitats: Air, water, soil and extremophiles, beneficial and harmful microbes.

**104 Cell Biology**

## Course Outcome (CO):

**Objectives -**

**(A) Structure and function of Cell;**

**(B) Coordination between different cell- cell, cell matrix interactions;**

**(C) Understanding of Pathology of various disease conditions and understanding the effectiveness of the treatment modalities**

**Outcome-**

**Students will be taught about different types of cells in brief followed by emphasis on Eukaryotic cells. Also the course content includes structure and functions of plasma membrane and cytoplasmic organells such as Mitochondria, Endoplasmic reticulum, Golgi complex, peroxisomes, Lysosomes and nucleus. Cytoskeletal component giving shape to the cell is also included. In addition, the students will be taught about Cell Division and its regulation as well as cell signaling**

**Course:**

Cell Biology

Cell as basic unit of life, Cell Theory, Precellular Evolution of Cell, Evolution of Eukaryotes from Prokaryotes & single cell to multicellular organism, Common Structural Features of Living Cells, Prokaryotic and Eukaryotic Cells: Their chracteristics and differences, Structure of Model Procaryotic Cell.

Cell wall and membranes: Prokaryotic-peptidoglycan wall, Plant cell wall; Cell membrane: Membrane structure; Membrane constituents, phospholipids, glycolipids, cholesterol, membrane proteins, receptors and phospholipases, phospholipid bilayer, structure asymmetry, fluid mosaic model of random diffusion of membrane components; Domains in membrane, natural and artificial membranes, Modern methods to study the cell membrane, FRAP, Scanning colorimetry,Chemilumiscence, Freeze-etching, Freeze-fracturing, Hydrophobicity plot,

Complexities and compartmentalization of Eukaryotic Cells: Cell Organelles: their structures and functions, nucleus, other membrane bound organelles eg. Mitochondria and chloroplast, Ribosomes, Endoplsmic reticulum, golgi bodies and secretory vesicles, trafficking, targetting, sorting and localization of proteins and other macromolecules Perxisomes and Lysosomes; Cytoplasm.

Cytoskeleton: Microtubules and microfilaments, intermediate filaments, microtubule polymerization dynamics, actin polymerization dynamics, cell crawling, contractile structures, actomyosin complex, muscle contraction.

Other Granular bodies: Extracellular appendages eg. flagella, cillia and extracellular matrix. Cell Function: Dynamic movements, and signal transduction in the living cells.

Cell cycle: mitosis meiosis and cytokinesis, animal and yeast cell division, cdc mutants, cell cycle control, cell cycle checkpoint, metaphase-anaphase transition, antimitotic drugs, cytoskeletol diseases, microtubule dependent drugs and actin targeted drugs. Loss of cell cycle control and cancer, programmed cell death and apopotosis;

Cell junctions and cell-cell signaling: General characteristics, specificity, amplification, desensitization or adaptation and integration; non-receptor mediated cell signaling - gaseous messengers (NO and CO); receptor mediated, cell signaling – ligands (membrane diffusible, eg. steroid hormones and non-diffusible, e.g. peptide hormones and other peptide or protein ligands) and receptors (intracellular, e.g. steroid hormone receptors and cell surface); ion-channel-linked receptors – neurotransmitters; G protein coupled receptors - heterotrimeric G proteins and its effectors (second messengers like cAMP); desensitization process, bacterial toxins as tools in study of receptor signaling; calcium homeostasis - calcium signaling.

**105 General Microbiology**

## Course Outcome (CO):

### Objectives

- **Learns about microbial Diversity and their outcomes.**

- **Learns about the techniques for studying and identifying microbes and environment pathogen**
- **interactions.**
- **Studies the microbes associated with various habitats and their metabolism. Molecular identification**
- **of the microbes.**
- **Knows the classification of microbes associated with environment.**
- **Can identify environment associated molds, yeasts, yeast-like fungi and bacteria by phenotypic and**
  **biochemical methods.**
- **Is aware of microbial habitat of specific microbes.**

**Outcomes**

- **Student is able to describe the molecular structure of DNA and RNA**
- **Student is able to describe the organization of microbial genomes and eukaryotic genomes**
- **Student is able to describe chromatin arrangement and nucleosome formation**
- **Student is able to describe arrangement of replicons in genome**
- **Student is able to describe various modes of DNA replication**
- **Learns about sustainable development and Biosafety and IPR rules.**

**Course:**

**Methods in Microbiology**

Culture of microorganisms: Methods for isolating pure cultures, types of culture media, enrichment culture techniques, maintenance and preservation of pure cultures. Control of microorganisms: physical and chemical methods.Pure culture techniques; Theory and practice of sterilization, principles of Microbial nutrition: Construction of culture media, Enrichment culture techniques for isolation of chemoautotrophs, chemoheterotrophs and photosynthetic microorganisms.

**Microbial Diversity and Extremophilies**

Phototrophic bacteria; Chemolithotrophic bacteria; Spirochetes; Rickettsias; Chlamydias; Mycoplasmas; Myxobacteria and Extremophiles (thermophilic, halophilic, acidophilic and alkalophilic bacteria). Unculturable bacteria.

**Structural Variations in Bacteria**

Bacterial Cell wall: structures, diversities and biosynthesis, different cell wall hydrolyzing enzymes;bacterial endospores: structure, formation and germination; uncommon bacterial genera: Rickettsia,Chlamydia, Mycoplasma, sheathed bacteria, stalked and budding bacteria, gliding bacteria includingMyxobacteria.

**Growth and Differentiation**

Bacterial growth: definition, growth parameters, measurement of growth, synchronous growth, growth kinetics, factors affecting growth. Batch and continuous culture. Differentiation:

endospore formation-cytological, physiological and genetic aspects, germination; life cycle of *Caulobacter*.

**Microbial Metabolism**

Outlines of biosynthesis of peptidoglycan, major amino acids and proteins. Regulatory mechanisms in bacteria - induction, repression, feed back inhibition, catabolite repression and attenuation; Manipulation of biochemical regulatory mechanisms for overproduction of metabolites. Nitrogen metabolism: ammonification, nitrification, denitrification and nitrogen fixation.

**Microbial Evolution:**

Systemetics and Taxonomy: Evolution of earth and earliest life forms; primitive organisms and their metabolic strategies and molecular coding. New approaches to bacterial taxonomy classification including ribotyping; Ribosomal RNA sequencing; characteristics of primary domains; Taxonomy. Nomenclature and Bergery's Manual.

**106 Lab Course**

**Semester II**

**201 Recombinant DNA Technology**

## Course Outcome (CO):

**Objectives:**

**This course will cover isolation and purification of nucleic acids, mechanisms of gene cloning, practical aspects of recombinant DNA technology, model organisms in recombinant DNA technology, recombinant gene expression systems.**

**Outcomes:**

**At the end of the course, the students should be able to:**

- **isolate and purify nucleic acids for routine laboratory procedures,**
- **explain the underlying mechanisms of gene cloning,**
- **discuss the practical aspects of applying recombinant DNA technology,**
- **explain the significance of model organisms in recombinant DNA technology,**
- **describe recombinant gene expression systems**

**Course:**

Recombinant DNA Technology Isolation and purification of RNA , DNA (genomic and plasmid) and proteins, different separation methods; analysis of RNA, DNA and proteins by one and two dimensional gel electrophoresis, isoelectric focusing gels; molecular cloning of DNA or RNA fragments in bacterial and eukaryotic systems; expression of recombinant proteins using bacterial, animal and plant vectors; isolation of specific nucleic acid sequences; generation of genomic and cDNA libraries in plasmid, phage, cosmid, BAC and YAC vectors; in vitro mutagenesis and deletion techniques, gene knock out in bacterial and eukaryotic organisms; protein sequencing methods, detection of post-translation modification of proteins; DNA sequencing methods, strategies for genome sequencing; methods for analysis of gene

expression at RNA and protein level, large scale expression analysis, such as micro array based techniques; isolation, separation and analysis of carbohydrate and lipid molecules; RFLP, RAPD and AFLP techniques.

Antibody generation, detection of molecules using ELISA, RIA, western blot, immunoprecipitation, floweytometry and immunofluorescence microscopy, detection of molecules in living cells, in situ localization by techniques such as FISH and GISH.

**202 Genomics and Proteomics**

**Course Outcome:**

**The aim of this course is to teach genomics, proteomics, metabolomics and phonemics using model organisms representing plants and animals. The course will cover recent developments in genetics, epigenetics, small RNAs, proteomics, gene expression, mutagenesis and mapping genes. An objective of the course will be to develop skills in experimental design within the context of learning about biology including: signal transduction, regulation of transcription and translation, cancer, aging, drought stress and metabolic pathways.**

**Outcome**

**Upon successful completion, students will have the knowledge and skills to:**

1. **Describe recent advances in genomics, transcriptomics, metabolomics and proteomics.**
   **2. Explain some of the current genomics technologies and illustrate how these can be used to study gene function.**
   **3. Obtain and analyse information and data relating to specific genes using a number of general and plant-specific databases, bioinformatics principles and tools.**
   **4. Locate and evaluate current scientific literature and discuss the important findings of these papers in writing.**
   **5. Perform a range of practical techniques including DNA sequencing, PCR and proteomics.**
   **6. Design a set of experiments to address a particular biological question**

**Course:**

Genomics Fundamentals of Genomics: The Content of the Genome, Different mapping methods, Variations amongst individual genome, RFLPs and SNPs, Nature of eukaryotic genomes, Repetitive and non-repetitive DNA sequences, Epigenetic and Transcriptional and Post-transcriptional control, Functional and Comparative Genomics, Conservations of exons and genome organizations, Genomes of Organelles and Endosymbiosis.

Genome Sequences, Gene Numbers, Clusters and Repeats: Gene Numbers in Bacteria and Eukaryotes, Fundamentals of Human genome, Distribution of genes and other sequences, Essential genes, Patterns of expression of Genes in the genome. Gene Clusters and their origin, Sequence divergence is the Basis for the evolutionary clock. Duplication, crossing over and other kinds of Rearrangements, Pseudogenes, Tandem Repeats of different clusters, Satellite DNA sequences.

The Interrupted Gene: Interrupted Gene consists of Exons and introns, Organizations of interrupted genes, Nature of Exon and intron sequences, Wide distribution of intron and exon sequences, Some DNA sequences code for more than one proteins, Evolution of interrupted genes, Members of a gene family have a common organization.

Regulation of gene expression by micro RNAs: RNA interference, Doing reverse genetics with RNAi. Concept of quality control of gene expresssion and coupling of different steps of gene expression.

Controlling Chromosome Structures and Epigenetics: Organizations of Viral, Prokaryotic and Eukaryotic Chromosomes, Loops and Domains, Banding Patterns of Chromosomes, Polytene and Lampbrush Chromosomes, Features and functions of Centrometers and Telomeres, Chromosomal remodelling and regulation of gene expression by modification of histones and chromatins, Epigenetic Effects are inherited, Nucleation and Other features of heterochromatin, Prions

Systems Biology - Graphs and networks in Systems Biology – Phylogeny UnderstandingDymamics and Function of Cellular Networks Example problems - SBML ( System biology markup language)- Gepasy - Cell Designer Oscillations in Biology . Comparing delayed negative feedback oscillators to those with interlinked positive and negative feedback- changing the amplitude and frequency of oscillations demonstration using circadian oscillator.

Genome projects : Creating the sequence map of a genome. Making sense of DNA sequence. DNA sequence variation and SNP, Application of SNP-technology-mapping genes underlying monogenic and multigenic disorder. Comparative genomics, transcriptomics, and Functional Genomics. Gross chromosome abnormalities and Cytogenetics.

Proteomics

Proteomics & the New Biology

Proteomics & the New Biology: Introduction to the the Proteomics Overview of Analytical Proteomics: Analytical Protein and Peptide Separations, Protein Digestion Techniques, Mass Spectrometers for Protein and Peptide Analysis, MALDI-TOF, ESI; 2-D Gel electrophoresis,, Protein Identification by Peptide Mass Fingerprinting, Protein Sequence Analysis by Tandem Mass Spectrometry, Protein Identification with Tandem Mass Spectrometry Data DIGE, PF-2D, SELDI-TOF. Softwares for analysis of proteomic data, Mining Proteomes: Mining Specific Features of Tandem MS Data Protein Expression Profiling: Identifying Protein-Protein Interactions and Protein Complexes, Mapping Protein Modifications, New Directions in Proteomics, Protein Chips and Array, The Application of Mass Spectrometry to Membrane Proteins Proteomics and Human DiseaseReferences

Aebersold and Mann Nature 422: 198-207, 2003 Taylor et al Nature Biotech. 21: 281-286, 2003 Kakhniashvili et al Mol. Cell Prot. 3:501-509, 2004 Low et al. Proteom. 2:1229-1239, 2002 Olsen et al. Mol. Cell Prot. 3:608-614, 2004 Anderson et al Mol. Cell Prot. 3:311-326, 2004 Krokhen et al Mol. Cell Prot. 2: 346-356, 2003 Baldwin Mol. Cell Prot. 3:1-9, 2004Peng and Gygi J. Mass Spec. 36:1083-1091, 2001 Medzihradszky et al Mol Cell Prot. 3:429-440, 2004 Durr et al Nature Biotech 22:985-992, 2004

Hansen et al Anal. Chem. 73:1676-1683, 2001 Washburn et al Nature Biotech. 19:242-247, 2001 Han et al Nature Biotech 19:946-951, 2001 Blagoev et al Nature Biotech 21:315-318, 2003 Peng et al Nature Biotech 21:921-926, 2003 Mann and Jensen Nature Biotech 21:255-261, 2003 Candas et al Mol. Cell Prot. 2:19-28, 2003 Coleman et al Proteom. 3:2101-2107, 2003 Luche et al Proteom. 3:249-253, 2003 Wu and Yates Nature Biotech. 21:262-267, 2003

**203 Immunology**

## Course Outcome (CO):

**Objectives of the course:**

1. **Demonstrate an understanding of key concepts in immunology.**
2. **Understand the overall organization of the immune system.**
3. **Understand pharmacological basis of immunology.**

**Outcome of the course:**

**After completing the Immunology course, students will be able to:**

- **Understand the salient features of antigen antibody reaction & its uses in diagnostics andvarious other studies.**
- **Learn about immunization and their preparation and its importance**
- **Demonstrate scientific quantitative skills, such as the ability to evaluate experimental design, read graphs,and understand and use information from scientific papers.**
- **Demonstrate skill in communication of scientificdata in standard format.**
- **Undertake teaching assignments in the subject of Medical Microbiology**

**Course:**

Introduction to Immunology: History & philosophy of Immunology, Specific & Non specific Immune system : Innate & acquired, Cells & Organs of Immune system.

Cell Mediated Immunity: Concept of Antigens : APC, APC structure & Classification; MHC , MHC Structure & Gene Complex, Antigen Presentation, T cell Structure, T cell Receptor & Molecule, APC-T cell Interaction, Co-stimulation, Development of T cell in Thymus; Positive & Negative Selection, Generation of Th1/Th2 responses, Mechanism of prevention & terminating T cell responses, Cytokines & Chemokines in maturation of T cells

Humoral Immunity: B cell Structure, B cell Receptor & Molecule B Cell development, Maturation of B cell & expression of Immunoglobin Genes, B cell antigen Presentation, B Cell- T cell Interaction, Cytokines & Chemokines in maturation of B cells.

Effector Mechanisms: Effector mechanisms in Cell Mediated & Humoral Immunity, Effector Mechanism of IgE-initiated immune responses, Cytokines, The Complement Pathway.

Infection & Immunity: Basic Concepts on Immunity against Infectious disease- Virus, bacteria, Fungi, Protozoan parasite, helminthic Parasite, Hypersensivity, Basic concepts of Vaccination and Immunotherapy.

**204 Ecology and Environmental Microbiology**

## Course Outcome:

**Course Objectives:**

- **This course aims to provide the student with an understanding of the current views of microbial association in various environments (soil,water,air); to evaluate the significant functions played by microbes in the environment.**
- **To train students on soil microbiology and biogeochemical cycles, plant growth promoting rhizobacteria, microbial activities.**
- **To taught the role of Basic biochemistry engaged in the process of nitrogen fixation and other interactions. Students will be conscious of various plant diseases associated with microbes and the role of bio control agents along with their classification and mechanisms.**
- **To solving environmental problems – waste water treatment and bioremediation.**

**Course Outcomes:**

- **Students will be able to know about the diversity of microorganisms inhabiting a multitude of habitats and occupying a wide range of ecological habitats.**
- **To explain various aspects of a microbial ecology and to become familiar with current research in environmental microbiology.**
- **Comprehend various biogeochemical cycles – Carbon, Nitrogen, Phosphorus cycles etc. and microbes involved biofertilizers and biopesticides production.**
- **Comprehend the various methods to determine the Sanitary quality of water and sewage treatment methods employed in waste water treatment.**

**Course:**

Ecology

Environment: Physical environment; biotic environment; biotic and abiotic interactions.

Habitat and niche: Concept of habitat and niche; niche width and overlap; fundamental and realized niche; resource partitioning; character displacement.

Population ecology: Characteristics of a population; population growth curves; population regulation; life history strategies (r and K selection); concept of metapopulation – demes and dispersal, interdemic extinctions, age structured populations.

Species interactions: Types of interactions, interspecific competition, herbivory, carnivory, pollination, symbiosis.

Community ecology: Nature of communities; community structure and attributes; levels of species diversity and its measurement; edges and ecotones. Ecological succession: Types; mechanisms; changes involved in succession; concept of climax.

Ecosystem: Structure and function; energy flow and mineral cycling (CNP); primary production and decomposition; structure and function of some Indian ecosystems: terrestrial (forest, grassland) and aquatic (fresh water, marine, eustarine).

Biogeography: Major terrestrial biomes; theory of island biogeography; biogeographical zones of India.

Applied ecology: Environmental pollution; global environmental change; biodiversity-status, monitoring and documentation; major drivers of biodiversity change; biodiversity management approaches.

Conservation biology: Principles of conservation, major approaches to management, Indian case studies on conservation/management strategy (Project Tiger, Biosphere reserves).

Environmental Microbiology - II

Environmental Microbiology

Microbial Communities and Eco-systems

Distribution of microorganisms in the aquatic environment- Microbiology of fresh water, marine, esturine, lacustrine. Lotic and lentic systems

Ocean Microbiology: Limnological and oceanographic conditions w.r.t MO’s

Microbiology of Drinking water, purification and sources of pollution, Biomonitoring of harmful MOs in water, Wastewater recycling (types of filters)

Microbial Biofilms of Different Habitats

Control of Pollution by microbes

Biopesticides and Bioreactors

Microbial interaction: Plant-microbe and man-microbe interaction.

**205 Medical Microbiology**

## Course Outcome (CO):

**Objectives of the course:**

**To acquaint the students with various aspects of basic medical microbiology like Medical DiagnosticMicrobiology which includes theory of pathogenesis, infectious diseases, principles of antimicrobials and their applications and modern methods of diagnostic procedures.**

**Outcome of the course:**

**After completing the Medical Microbiology course, students will be able to:**

1. **State the recent advances in the field of Medical Microbiology and apply this knowledge in understanding aetiopathogenesis and diagnosis of diseases caused by micro-organisms.**
2. **Carry out fundamental or applied research involving microbiological work.**
3. **Undertake teaching assignments in the subject of Medical Microbiology**

**Course:**

Pathogenisity of micro organism: Host parasite relationship, Pathogenesis of viral diseases, bacterial pathogenesis. Toxigenisity, Host defence against microbial invasion, microbial mechanism for escaping host defences. Antimicrobial chemotherapy: Development of chemotherapy, Determining the level of anti microbial activity, Anti microbial/ bacterial drugs, Drug Resistance, Anti viral, fungal, protozoan drugs. Human diseases caused by bacteria: Staphylococcus, Streptococcus, Pneumococcus, Neisseria, Corynebacterium, Bacillus, Clostridium, Shigella, Salmonella, E.coli, Vibrio, Mycobacterium. Meningitis, Tuberculosis, Diptheria, Leprosy, Cystic fibrosis, Typhoid, Enteritis, Gastritis (Helicobacter pylorae), Cholera, Pneumonia.

Human diseases caused by viruses and prions

Human diseases caused by fungi and protists

Biology of obligate parasites: Rickettsia, Chlymadia, Trypanosomes, Spirochetes

Microbial production of therapeutic agents:

Structural variations in bacteria: Uncommon bacterial genera- Rickettsia, Chlamyda, Mycoplasma etc.

Antimicrobial Agents and Chemotherapy: Antibiotics - Definition, genera of antibiotics, mode of action of antibiotics, assay of antibiotics, Antibiotics vs probiotics, Antibiotic resistance, MAR(its significance), Methods of action of antibiotics and antibacterial agents

Bioterrorism and Bioweapons: Introduction to Bioterrorism and Bioweapons, Pathogenic microorganisms used for these purpose and their properties, Infectious agents and their epidemiology.

**206 Lab course**

**Semester III**

**301 Microbial Genetics**

## Course Outcome (CO):

**Objectives of the course:**

1. **Know the terms and terminologies related to microbial genetics and understand the properties, structure and function of genes in living organisms at the molecular level**
2. **Explain the concept of recombination, linkage mapping and elucidate the gene transfer mechanisms inprokaryotes and eukaryotes.**

**Outcome of the course:**

**After completing the Microbial Genetics course, students will be able to:**

1. **Handle and independently work on lab protocols involving molecular and genetic techniques.**
2. **Demonstrate scientific quantitative skills, such as the ability to evaluate experimental design, read graphs, and understand and use information from scientific papers.**
3. **Demonstrate skill in communication of scientific data in standard format**.

**Course:**

Bacterial Genetics

A Chemist's view of the bacterial cell: Characteristics of Bacterial Cells: A Typical Prokaryotic Cells-No nuclei, no well defined chromosomes and no compartmentalization.

E. coli is best understood organism at the molecular level, Bacterial DNA is Condensed into nucleoid body, Replication, Transcription and Translation occurs in the same compartment

Rapid Turnover of mRNA molecules allows speedy changes of gene expression pattern

Regulation of Protein function by feedback inhibition,Protein modification lead to the modulation in enzymatic activity, Bacterial Cell is finely and precisely tuned machine. (1 Class)

Genetic System Provided by E.coli and its Phages: Intrinsic advantage of using microorganisms for genetic research, Bacteria have genes that mutate spontaneously, Phages provide easy to study Chromosomes, Phages are parasite at the genetic level and form plaques, Phages also mutate, Phage Crosses. Mutations: Spontaneous Origin of mutation: Awesome Power of Replica Plating: Lederberg's Experiment, Mutations: Mechanism of origin of Spontaneous Mutations; Induced Mutations by mutagens, Forward, Reverse and Suppressor Mutations.

Bacterial Conjugation: Two sexes are found in bacteria Transformation: Griffith's, Avery-Mcleod and Hershey-Chase.

Transposable elements in E-coli, Plasmids, Genetic elements that invert, Insertion of the phage chromosomes into chromosomes of E.coli, Phage Mu is a transposable genetic element, Phages occasionally carry bacterial genes, Transduction via phages (1 Class).

Yeast Genetics: Yeast as a model organism, information on Yeast, Strains of S. cerevisiae, Growth and Life cycles of Yeast, Genomes of S. cerevisiae, and Genetic Nomenclature, Chromosomal and extrachromosomal inheritance.

Genetic Analyses: Tetrad Analysis, Transformation: Yeast Vectors and DNA fragments, Different type of Yeast Vectors, Genes important for genetic studies,Gene mapping, Techniques of Genetic Analysis, Replica Plating, Mating and Complementation, Random Spores.

Manipulating Genome in vitro with Plasmids: Cloning by complementation, In vitro mutagenesis,Two step genereplacement, Gene disruptions and one step replacement, Plasmid Shuffle, Recovering mutant alleles, Interactions of Genes: Heterozygosity and Dominant Negetive Mutations, Suppressors and Epistatic Relationships.

Analyses with Yeast Systems: Two-Hybrid Systems, Yeast Artificial Chromosomes (YACs) and Expression of heterologous Proteins in Yeasts.

**302 Bioenergetics and metabolism**

## Course Outcome (CO):

**Course objectives: To aquaint students with an understanding of: (1) the basic metabolic pathways; (2) inborn errors of metabolism and the application of DNA technology to their study; (3) the control and integration of metabolism.**

**Learning Outcomes**

**By the end of the course the student will be able to:**

- **describe the principles of metabolism and the differences between anabolism and catabolism;**
- **demonstrate an ability to handle simple mathematical treatments of biological processes.**
- **discuss the role of coenzymes, such as NAD+, FAD and ATP, in metabolism;**
- **outline the metabolic pathways involving glucose, fatty acids and amino acids;**
- **show how the energy released by catabolism is recouped by substrate level and oxidative phosphorylation;**
- **describe the various types of genetic mutation and inborn errors of metabolism**
- **describe the methods for detecting and correcting inborn errors of metabolism**
- **outline the hormonal regulation of metabolism and discuss the role of protein phosphorylation in this context;**
- **describe the regulation of metabolism in physiological and pathological situations (e.g. exercise, starvation and diabetes);**

**Course:**

Principles of Bioenergetics: Biological energy transformations and thermodynamics, Standard free energy change and equilibrium constant. Phosphoryl group transfer and ATP, ATP and other

phosphorylated compounds and thioethers w.r.t their free energies of hydrolysis. Free energy of ATP hydrolysis in context of cellular metabolism. ATP energized biological processes, High energy phosphate compounds as free energy sources in biological systems, Biological oxidation /reduction reactions.

Carbohydrate catabolism (glycolysis, TCA cycle, oxidative degradation of fatty acids and amino acids in animal tissue and the correlation between carbohydrate, amino acid and fatty acid degradation),gluconeogenesis, Cori cycle, Glycogen metabolism Aerobic respiration in mitochondria (electron transport, oxidative phosphorylation, regulation of ATP production); photosynthesis in chloroplast (Calvin cycle, C4 cycle, elementary idea of photosynthetic electron transport).

Metabolism of nitrogen compounds; protein turnover; flow of nitrogen into biosynthesis and catabolism of amino acids, central role of glutamine; metabolism of nucleotides (purines and pyrimidines); urea cycle and the excretion of nitrogen.

Oxidation of fatty acids, β oxidation; biosynthesis of fatty acids and cholesterol (outline); ketone bodies.

Integration of metabolism and metabolic regulation with reference to metabolic pool.

**303 Virology and Cancer**

## Course Outcome (CO):

**Objectives:**

**The aim is to promote the knowledge and expertise in microbiology with a particular focus on virology and cancer. Students will develop an understanding of the scientific basis of established and novel cancer and virology concepts, as well as the specialist knowledge, practical skills and critical awareness required to enable students to pursue a career in virology and cancer. The specific aims/objectives are to: Provide knowledge in cancer and virology; Develop understanding of processes at the molecular level; Provide a training in laboratory and research skills;**

**Learning outcomes:**

**1) Knowledge and Understanding fundamentals of molecular cancer and viral biology; the structure of viruses and their genomes; virus gene expression, modes of replication and transmission, the interaction of viruses with cells and pathogenesis of virus-induced diseases, the detection, treatment and prevention of virus infections; virus epidemiology and the genetics and evolution of viruses.**

**2) Intellectual Skills and other Attributes understand the nature of viruses and their role in disease pathogenesis; integrate and evaluate information and data from a variety of sources;**

**3) Knowledge on cancer tumorogenesis, oncogenes, protooncogenes, metastasis, tumor suppressor genes, and the factors causing cancer.**

**Course:**

Lytic and lysogenic cycles of bacteriophage λ - marvels of transcriptional control; spite-specific recombination in lambda (generalized and specialized transduction); problems in replication of the ends

of linear DNA and how viruses circumvent the problem with examples of T-4 (terminal redundancy and circular permutation), λ (rolling circle model of replication, concatemers, site-specific cleavage), adenovirus and retrovirus; viruses as vectors for recombinant DNA technology – M13, fd, TMV, Ti, Baculovirus, Adenovirus, Retrovirus; oncogenic viruses; oncolysis - VSV.

Basic properties of cancer cell, Causes of Cancer,The genetics of cancer Tumor Suppressor genes and oncogenes, DNA repair, and programmed cell, Cell Immortalization: Multi-step Tumorigenesis:. Heterotypic Interactions: angiogenesis, invasion and metastasis, New strategies for combating cancer, Immunotherapy, Inhibiting the activity of cancer promoting proteins, gene therapy

**304 Industrial Microbiology**

## Course Outcome (CO):

**Objectives of the course:**

1. **Get equipped with a theoretical and practical understanding of industrial microbiology.**
2. **Appreciate how microbiology is applied in manufacture of industrial products.**
3. **Know how to source for microorganisms of industrial importance from the environment**

**Outcome of the course:**

**After completing the Applied Industrial Microbiology course, students will be able to:**

- **Apply various methods for their isolation, detection and identification of microorganisms in industries.**
- **Practice the theories and principles of industrial microbiology in practical, real-world situations and problems.**

**Undertake technical assignments in various industries related to microbial technology**

**Course:**

Fermentation, Bioreactors: Design and working principle

Food Microbiology: Microbiology of food processing (vegetables, horticulture products, aquatic animals), Different methods of food processing (Canning, freezing, salting etc. )w.r .t Microorganisms. Analysis of food products like milk, dairy products etc.

Sewage treatment, chemotherapeutants preparation, Preparation of alcohols, lipase etc

Endospores and Toxins

Hazardous Microorganisms in processing industry

Quality control measures

Microbial Mineral Leaching

**305 Lab course**

**Semester IV**

**401 Microbial Biotechnology**

**Course Outcome (CO):**

- **Learns biotechnological applications of lignin and cellulose degrading microbes and their enzymes in biopulping, biobleaching, textiles, biofuels and animal feed production.**
- **Gains knowledge about liquid waste management of sewage including primary, secondary and tertiary treatments methods.**
- **Learns about treatment of Industrial effluents generated from various industries such as distillery, textile, pulp and paper.**
- **Becomes well versed with methods to detect various pollutants in environment such as metals, sediments, toxins and organic matter.**
- **Is able to know different types of solid wastes.**
- **Gets knowledge of methods of solid waste management such as composting, landfills and incineration methods and challenges in waste management.**
- **Knows how to use compost for sustainable agriculture.**
- **Understands Bioremediation of environmental pollutants like petroleum hydrocarbons and pesticides.**
- **Becomes acquainted with the use of biosensors as detection tools of pollutants. Learns about plastic degrading microorganism as a tool for bioremediation.**
- **Gets familiar with microbes in enhanced oil recovery and mineral recovery.**
- **Gains knowledge of the use of microbes in bioleaching of copper, gold and uranium.**
- **Learns about various fermented products, preparation techniques and applications of Genetically Modified organisms. Drug discovery and related topics.**

**Course:**

**UNIT- I**

**Microbial Biotechnology: Scope and applications** -horizons of Microbial Technology.Agriculture, Soil, Forest Microbiology.Microbes: Living factories for macromolecules-Production of proteins in Bacteriaand yeast; recombinant and synthetic vaccines; microbial enzymes- application instarch processing, textile designing, detergents, cheese making, polysaccharidesand polyesters. – immobilization of cells and enzymes.

**UNIT -II**

**Microorganisms in fermentation**-Ethanol from feed stocks to fermentable sugars, from sugars to alcohols, Clostridial fermentation, lactic acid fermentation, acetic acid production and industrial production of various milk products.Probiotics.

**UNIT -III**

**Metabolites from microorganisms**-amino acids; antibiotics-antibacterial agents ((-lactams, tetracyclines, peptides, amino glycosides), antifungal agents, anti-tumor antibodies; Biotechnological potential of micro algae – food – fuel production – pharmaceutically valuable compounds of micro algae,Single-cell protein (SCP), Mycoprotein.

**UNIT –IV**

**Environmental Microbiology; Bioinformatics, Genomics, and Drug Discovery:**Basics of Environmental Microbiology; Marine, Aquatic Microbiology. Bioinformatics, Genomics, and Antimicrobial Drug Discovery; DNA Microarray Technology & its application in Microbial Biotechnology

**UNIT -V**

**Biopesticides;** Bio control of insects – microbial insecticides (*Bacillus.thuringiensis, B.spaerinus, B.papilliae*andBaculo-Viruses).
Biofertilizers (nitrogen fixing Bacteria, mycorrizha and phosphate solubilizing Bacteria)- genetically engineered organisms.

**UNIT -VI**

**Bioremediation, Biosorption, Environmental clean-up by microbes**: Application of microbial biotechnology in sewage and wastewater treatment, degradation of xenobiotics, mineral recovery, removal of heavy metals from aqueous effluents.
Public concerns about the microbial biotechnology and Economics of microbial biotechnology.

**402 Bioethics and IPR**

## Course Outcome (CO):

**Course objectives:**

**• To acquire knowledge about the Intellectual Property Rights**

**• To comprehend about criteria in applying and maintaining patents.**

**• To be familiarized with the law and enforcement in Intellectual Property Rights**

**• Developing a superior work ethics and laboratory working condition**

**• Understanding the significance of following and maintaining laboratory safety guidelines**

**Course Outcomes:**

- **On the completion of the above objectives student will be able to know about IPR and also the importance of protecting their innovation.**
- **They will be familiar with international and national law practiced and also recent issues on it.**

- **They will develop a thought about the importance of good laboratory practice in high quality research.**
- **They will also grow awareness about the basic fundamental safety measures that a researcher should follow in laboratory**.

**Course:**

**Biosafety**
Introduction; Historical background; Introduction to Biological safety cabinets; Primary containment for Biohazards; Biosafety Levels; Biosafety Levels of specific Microorganisms; Principles of Laboratory Biosecurity. Occupational Health Hazard and Immunoprophylaxis. Recommended Biosafety Levels for Infectious Agents and Infected Animals; Biosafety general guidelines; Definition of GMOs & LMOs; Roles of Institutional Biosafety Committee, RCGM, GEAC etc. for GMO applications in food and agriculture; Environmental release of GMOs; Risk Analysis; Risk Assessment; Risk Management and Communication; Overview of National Regulations and relevant International Agreements including Cartagena Protocol.

**Bioethics**
The importance and needs of bioethics; Bioethical business practices; Laws and bioethics; Environmental protection; Creating awareness and safeguarding health of consumers; Ethical issues relating to experiments on animal systems.

**Intellectual Property Rights**
Intellectual property rights (IPR): kinds of property, nature of IP, basic principle, major IP, moral rights & economic rights; Copy right, patent, industrial design, trade mark, geographical indication, farmers' right, IPR licensing & technology transfer; Reproduction of published material – plagiarism, citation and acknowledgement. Reproducibility of IP and accountability.

**403 Journal Club**

## Course Outcome (CO):

Students participate in journal clubs where they are encouraged to read scientific articles and present their review work. They enlighten themselves on a scientific topic of their interest and its recent advancements which keeps them updated with the ever changing science and technology.

**404 Industrial Tour**

**Course Outcome (CO)**

1. Industrial visit is a part of the Education, during which students visit industries and get insight of on the internal working environment of the industry.
   The industrial visit also provides an insight on how industries work and also useful information related to the practical aspects of the course which cannot be visualized in lectures.
2. Industry visits sensitize students to the practical challenges that organizations face in the business world. Industrial visits also give greater clarity about various management concepts for students as they can practically see how these concepts are put into action. Visits to manufacturing firms are useful for students. To understand the nuances and realities of the shop floor, this in itself is a rare exposure. By visiting the shop floor they get to understand the risky conditions in which workers work,

the people management challenges involved in managing workers apart from getting hands-on technical knowledge

**Outcome**

1. Research says that, there is a huge gap between today's educational system and industrial requirements. College outcomes do not reach the expectations of a company. The only way to bridge the gap is connecting students with the industries so that students will be able to know the needs of the industry and groom themselves accordingly. And, to do so, Industrial visits to students is a pathway.
2. The industrial visit also provides an insight on how industries work and also useful information related to the practical aspects of the course which cannot be visualized in lectures. With an aim to go beyond academics, these visits are arranged to develop the insights of the students – attaining practical knowledge and their theoretical applications thereof.
3. Industrial visit is considered as one of the most tactical methods of teaching. The main reason behind this – it lets students to know things practically through interaction, working methods and employment practices. Moreover, it gives exposure from academic point of view and provides exposure to practical working environment, increases practical awareness of various Industrial sectors; acquaint students with Interesting facts and breath-taking technologies. In addition to industrial exposure and knowledge, this will increase the internship and placement opportunities.
4. They get an opportunity to gain in-depth knowledge about the field of their interest, helping them make the correct career choice in future.
5. Interfacing with the industry gives them a chance to build networks and hone their business communication skills.
6. The program enables the students to apply their classroom learning to a real-life situation while being mentored by a variety of industry experts.

**405 Project Dissertation and Seminar**

## Course Outcome (CO):

- Students go for an intensive project of 2 months in various laboratories and research institutes to get hands on experience on various techniques and also learn to use various sophisticated instruments used in research. They get a flavor of research which motivates them to pursue their doctoral program.
- They also join microbiological R&D industries.

**406 Grand Viva**

**Course Outcome:**

Grand viva is organized at the end of the course where students are assessed on their overall learning of the course and how the course was fruitful to them.