WEST BENGAL STATE UNIVERSITY

Draft Syllabus for M.Sc in Microbiology (CBCS)

Effective : Session 2019-2020

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 various areas 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

The proposed structure of PG Course Content in Microbiology as per CBCS guideline

Semester	Paper	Theory/ Practical	Title of the Paper	Paper Full marks	Semester Full marks	Paper Credit	Semester credit
Semester 1	Paper 1	Theory	Biomolecules and Enzymology	50		4	
	Paper 2	Theory	Basic Microbiology and Microbial Diversity	50		4	
	Paper 3	Theory	Basic Cell Biology	50		4	
	Paper 4	Practical	Biomolecules and Enzymology	50		4	
	Paper 5	Practical	Microbiology and Molecular Biology	50		4	
		AECC	Laboratory Safety Measures	25		2	
Total					**275**		**22**
Semester 2	Paper 6	Theory	Metabolism and Bioenergetics	50		4	
	Paper 7	Theory	Biophysical Techniques	50		4	
	Paper 8	Theory	Fundamentals of Molecular Biology	50		4	
	Paper 9	Practical	Biophysical Techniques and Immunology	50		4	
	Paper 10	Theory	Environmental Microbiology	50		4	
		SEC	Diagnostic Microbiology	25		2	
Total					**275**		**22**
Semester 3	Paper 11	Theory	Immunology	50		4	
	Paper 12	Theory	Microbial Genetics	50		4	
	Paper 13	Theory	Recombinant DNA Technology	50		4	
	Paper 14	DSE 1 Theory	Bioethics and Intellectual Property Rights Or Bioprocess Technology	50		4	
	Paper 15	Practical	Biostatistics and Bioinformatics	50		4	
		GEC	Microbes in Sustainable Development	50		4	
Total					**300**		**24**
Semester 4	Paper 16	Theory	Medical Microbiology	50		4	
	Paper 17	Theory	Food and Industrial Microbiology	50		4	
	Paper 18	Theory	Virology	50		4	
	Paper 19	DSE 2 Theory	Agricultural Microbiology Or Application of Microbial Technology	50		4	
	Paper 20	Project Work and Review Work	To be opted by the student	100		8	
Total					**300**		**24**
	Total				**1150**		**92**

Semester 1

Paper 1:
Biomolecules & Enzymology

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.

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.

Biomolecules:

Carbohydrates:
Families of monosaccharides. Stereoisomerism of monosaccharides, epimers, Mutarotation and anomers of glucose. Furanose and pyranose forms of glucose and fructose. Disaccharides; concept of reducing and non-reducing sugars, Haworth projections of maltose, lactose, and sucrose, Polysaccharides: storage polysaccharides (starch and glycogen). Structural Polysaccharides(cellulose and chitin), Glycoproteins

Amino Acids and Proteins:
General structure and classification of Amino Acids. Chemical reactions and modifications. Acid-Base properties, Biphasic Titration Curve and Isoelectric point. Reactions of carboxyl and amino groups, formation of Peptide bond, Determination of N-terminal amino acid (Edman's method) and C–terminal amino acid (hydrazinolysis). Structural organization of proteins (primary, secondary, tertiary & quaternary), Covalent and Non-covalent interactions that stabilize the three-dimensional structures of proteins. Forces stabilising protein structure. Structure function relationship of proteins. Protein folding and chaperones: Protein splicing, unfolding of protein structure, effect of heat, pH and chemicals denaturation and renaturation of proteins, diseases related to protein misfolding

Lipids: Classification of lipids, Nomenclature and structure of Saturated and Unsaturated Fatty acids, delta and omega-system; Essential fatty acids. Saponification number, Iodine number, Acetyl number of fats. Structure and Biological importance of triglycerides, phospholipids, glycolipids, and steroids (cholesterol). Role in biological membranes. Lipoproteins

Nucleic acids: Nucleosides and nucleotides; Structure of Nucleotides, Nucleotides as source of energy, component of coenzymes, second messengers. DNA structure – Watson-Crick model. A, B & Z forms of DNA, Supercoiled and relaxed DNA, quardruplex DNA, denaturation and renaturation of DNA, melting temperature (Tm), UV absorption and hyperchromic effect. Nucleosome structure and Genome organization. Structure of major types of RNA. DNA bending and supercoiling and their significance. Denaturation kinetics of DNA and Cot curves. Nucleic acid hybridization and its applications. Folding of RNA into higher order structures. Purification and separation of nucleic acids.

Enzymes:
IUB classification, active site, cofactors, coenzymes and prosthetic groups, activation energy and transition state, catalytic efficiency, activity, specific activity and turnover no. Principles of Enzyme kinetics: Michaelis-Menten Equation, Significance of K_m and V_{max}, Determination of K_m and V_{max}, Double reciprocal Plot, Eadie- Hofstee plot, two substrate kinetics- single and double displacement reaction (Ping Pong, Bi-Bi reaction), three substrate kinetics, Ligand binding studies, Effect of temperature, pH and Inhibitors (Reversible Inhibition: competitive, un-competitive and non-competitive and Irreversible Inhibition), Allosteric Enzymes and Feedback Inhibition, Isozymes, Abzymes. Regulation of enzymes. Industrial application of several enzymes. Ribozyme

Books: Adams, Voet and Voet, Van Holde, Stryer, Lehninger, Benjamin and Lewin.

Paper 2:
Basic Microbiology and Microbial Diversity

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.

Unit I History, Introduction and scope of Microbiology.

Unit II 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. Brief history and development of Microbiology as a separate discipline

Unit III Methods of studying microorganisms

Unit IV Biodiversity- levels of biodiversity, alpha, beta and gamma diversity, Values and ethics of biodiversity; Global patterns of biodiversity, hotspots of biodiversity and megadiversity country; Biogeographic zones in India; factors influencing local and regional biodiversity, Biodiversity documentation. Perception on Bioresource; Legal binding of biological materials- concept of Biopatents

Unit V Microbial Organisation: Structure and Organisation of microbes

Unit VI Microbial growth: definition of growth and its mathematical expression, growth curve, measurement 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 nutrient

Microbial Diversity

Unit I Origin of life: A brief history of the physical origin of the Earth and prebiotic conditions; Hypotheses; Chemical and Cellular evolution; Microbial Diversification: Consequences for Earth's Biosphere; Endosymbiotic origin of eukaryotes

Unit II Microbial Systematics: General account of systematics, Classification and nomenclature; Classification systems-artificial

or phonetic, natural and phylogenetic; Species concept; monophyletic, paraphyletic, polyphyletic; Molecular taxonomy, Molecular phylogeny, Molecular chronometers; Polyphasic taxonomy, Describing a new Prokaryotic species, Valid publication of names of bacterial taxa, Culture collection.

Unit III Diversity of prokaryotic and eukaryotic microbes

Bacteria: General classification of bacteria with salient features of major bacterial phyla according to Bergey's Manual of Systematic Bacteriology.

Archaea: Systematics, occurrence, diversity, characteristic features and significance of different groups of Archaea

Fungi: Modern trends of fungal classification and phylogeny. Growth, Environmental conditions for growth; nutrition and life cycle patterns, parasexuality and heterothallism.

Algae: Distribution; classification nutrition and culture; reproduction and life cycles; algal toxins, algal bloom & its control, Economic importance of algae

Protozoa: General account, structure, reproduction and classification of protozoa

Unit IV Acellular organisms (Viruses, Viroids, Prion)

General Virology: Discovery of viruses, morphology and ultrastructure, capsids & their arrangements, viral genome – types and structures; nomenclature and classification of virus (Animal, plant, bacterial viruses). Virus related agents – viroids, prions.

Bacteriophages: Structural organization; Life cycle – lytic & lysogenic. Importance in bacterial genetics and biotechnology.

Animal viruses: Life cycle and replication of SV-40, retrovirus.

Plant virus: Structure of plant viruses like TMV, potato virus X; Brief outline of cyanophages and mycophages.

Unit V Threat to species diversity, Extinction vortex, Causes of extinction; Population viability analysis; Red Data Book, Biodiversity conservation approaches: Local, National and International, In situ and ex situ conservation, Concept of protected area network, Selecting protected areas, criteria for measuring conservation value of areas, Sanctuary, National Park and Biosphere reserves; Design and management of protected areas; Threats to wildlife conservation and wildlife trade; Tools for wildlife research, Wildlife threat, Use of Radiotelemetry and Remote sensing in wildlife research.

Paper 3:

Basic 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 colntent includes structure and functions of plasma membrane and cytoplasmic organelles 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 signalling.

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 characteristics and differences, Structure of Model Prokaryotic 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, Chemiluminescence, 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, Endoplasmic reticulum, golgi bodies and secretory vesicles, trafficking, targeting, sorting and localization of proteins and other macromolecules Peroxisomes 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 apoptosis;

Cell junctions and cell-cell signalling: General characteristics, specificity, amplification, desensitization or adaptation and integration; non-receptor mediated cell signaling - gaseous messengers (NO and CO); receptor mediated, cell signalling – 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 signalling.

Books:

- Molecular Biology of the genes by James D. Watson.
- The Cell by Geoffrey M. Cooper.
- Cell and Molecular Biology by Gerald Karp.
- Molecular Cell Biology by Harvey Lodish.
- Molecular Biology of Cells by Bruce Alberts.
- Genes by Benjamin Lewin.
- The world of cells by Wayne and Levis.
- Molecular biology by David Clark

Paper 4:

Biomolecules and Enzymology Practical

Course Outcome (CO):

Course objectives:- The objective of this course is to gain an insight into the Structure and Functions of Carbohydrates, Proteins, Lipids, 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.

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 processes. The student will be able to perform immobilization of enzymes. The student will get exposure of wide applications of enzymes and their future potential.

1. Properties of water, Concept of pH and buffers, preparation of buffers and Numerical problems to explain the concept
2.Quantitative Estimation of protein (Lowry Method, Bradford method)
3.Determination of R_f value and separation of amino acids by paper chromatography.
4. To study activity of any enzyme under optimum conditions.
5. To study the effect of pH, temperature on the activity of amylase enzyme.
6. Determination of - pH optima, temperature optima, Km value, Vmax value, Effect of inhibitor (Inorganic phosphate) on the enzyme activity.
7. Determination of Km and Vmax by Lineweaver Burk Plot.
8. Study of enzyme kinetics – calculation of *V*max , Km, Kcat values.
9. Study effect of temperature, pH and Heavy metals on enzyme activity
Physico-chemical and biochemical principles involved to be discussed in detail where needed.

Paper 5:

Microbiology and Molecular Biology Practical

Course Outcome (CO):

Microbiology:

- Learns about microbial Diversity and their outcomes.
- Learns about the techniques for studying and identifying microbes and environment pathogen nteractions.
- 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.

Molecular Biology:

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.

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.

General laboratory practices and handling of instruments; training on centrifugation, microscopy and spectroscopy. Culture and purification of microbes esp bacteria. Preparation of general and selective media. Staining and biochemical identification of microorganisms from water (fresh, saline and polluted),soil and air. Growth curve analysis. Antibiotics assays. Isolation of molecular analysis of the genetic materials.

Plasmid DNA Isolation and agarose gel electrophoresis, Restriction digestion of DNA, Ligation of digested samples

AECC:

Laboratory Safety Measures

COURSE OUTCOME

Laboratory safety involves the development of skills and responsibility and must be an integral part of every biological science curriculum. This means that safety awareness must be integrated into each laboratory course including research with increasingly broader scope at more advanced levels. The creation of a culture of laboratory safety requires a broad commitment from all levels of the educational institution. At the department level, faculty need to assume responsibility for continuing review of safety issues with students in teaching and research laboratories, especially the persons responsible for undergraduate instruction, often graduate students or instructors. Faculty must lead by example in a coordinated departmental safety effort. At the administrative level, this will involve implementation of a biological as well as biochemical hygiene plan that is in agreement with any campus biological, human, animal and environmental hygiene/safety efforts and must address the safe handling, storage, and disposal of wastes. Eye wash and showers must be in operating condition, and fume hoods with proper sashes are essential. Anyone working or visiting in the lab must be wearing goggles, and consumption of food or drinks must not be permitted. A clean, uncluttered laboratory is more likely to encourage careful work.

Development of safety skills may be divided into four emphasis areas.

• Recognize Hazards

• Assess Risks

• Minimize Risks

• Prepare for Emergencies

We may consider following three useful resources that provide guidelines for biologicalsafety in academic institutions and help in the identification and evaluation of hazards in research laboratories.

Recognize Hazards

A hazard is a potential source of danger or harm and can result from working withpathogenic organism chemicals, equipment, and instrumentation. Introduction to this topic can start with an understanding of the terms describing biological as well as chemical hazards, such as “pathogenic”, “infectious”,“toxic”, “flammable”, or “corrosive”, and how to obtain information from monographs and Safety Data Sheets (SDS), and other reference sources. Hazards encountered in early undergraduate laboratories should be explained in more detail. At more advanced levels, more details of chemical, physical and biological hazards should be explained so that students are able to identify hazards themselves in experiments

Assess Risks

Once a hazard(s) is recognized, laboratory safety necessarily requires an assessment or evaluation of risk from potential exposure to the hazard. Identifying potential routes of exposure is followed by judging the relative risk posed by the hazards of the experiment. The hazardous biological, physical, chemical, and toxic properties of solvents, reactants, catalysts, products, and wastes should be considered as well as circumstances of the experiment

Minimize Risks

Based on a risk assessment, experiments should be designed to minimize potential risks. These steps may involve carrying out experiments in a fume hood with a protective shield and wearing protective gloves and goggles. The handling and storage of wastes is a critical component. It is often useful to consider case histories of incidents that have resulted in injury or damage.

Prepare for Emergencies

Since it is essential to react promptly and deliberately to emergencies, students should learn what to do in various emergencies and be prepared to act accordingly – for example, biological hazards, fires, injuries, and spills. Safety devices such as showers, eye washes, fire extinguishers, and spill kits, must be clearly labeled and their use and location known to all those working in a laboratory. Emergency phone numbers, alarms, and escape routes should be clear to everyone.

CHAPTER-1 PRINCIPLES OF SAFETY MANAGEMENT

UNIT I CONCEPTS AND TECHNIQUES

Evolution of modern safety concept- general concepts of management – planning for safety for optimization of quality and safety-line.

Importance of training-identification of training needs-training methods – programs, seminars, conferences, competitions – method of promoting safe practice - motivation

UNIT II ACCIDENT INVESTIGATION AND REPORTING

Concept of an accident, reporting to statutory authorities – principles of accident prevention – accident investigation and analysis, Accident and safety records, formats – implementation of audit indication, Philosophy of Disaster management-Introduction to Disaster mitigation-

UNIT III ENVIRONMENT ACT – 1986 STRANDARS AND CERTIFICATIONS

Environmental Pollution Act, 1986, General powers of the central government, prevention, control and abatement of environmental pollution- Biomedical waste (Management and handling Rules, 1989- hazardous wastes (management and handling) rules, 1989, with amendments in 2000, Gas cyclinder rules-Explosives Act 1983 No Objection certificate from statutory authorities like pollution control board.

Structure and features of OSHAS 18001 – Benefits of certification-certification procedure EMS, ISO 14001, specifications, objectives, Environmental Policy, Guidelines and Principles (ISO 14004)

CHAPTER-2 DIFFERENT LABORATORYHAZARDS

UNIT I PHYSICAL AND CHEMICAL HAZARDS

Ionizing radiation, types, effects, monitoring instruments, control programs, Determination of relative humidity, Recognition of chemical hazards-dust, fumes, mist, vapour, fog, gases, types, concentration, Exposure vs. dose, list of hazardous and toxic chemicals – safety reports and sheets, Air sampling instruments, Types, Measurement Procedures, Gas and Vapour monitors, dust sample collection devices, Methods and Control.

UNIT II BIOLOGICAL AND ERGONOMICAL HAZARDS

Classification of Biohazardous agents – examples, bacterial agents, rickettsial and chlamydial agents, viral agents, fungal, parasitic agents, infectious diseases - Biohazard control program, employee health program-laboratory safety program-animal care and handling-biological safety cabinets - building design. Work Related Musculoskeletal Disorders –carpal tunnel syndrome CTS- Tendon pain-disorders of the neck- back injuries.Concept and spectrum of health - functional units and activities of occupational health services, pre-employment and post-employment medical examinations

UNIT IIIFIRE AND EXPLOSION HAZARD

Fire properties of solid, liquid and gases - fire spread - toxicity of products of combustion - theory of combustion and explosion, Sources of ignition – fire triangle – principles of fire extinguishing – active and passive fire protection systems – various classes of fires – A, B, C, D, E – types of fire extinguishers – fire stoppers,Sprinkler-hydrants-stand pipes – alarm and detection systems. –first aid for burns.

UNIT IV ELECTRICAL HAZARDS

Primary and secondary hazards-shocks, burns, scalds,falls-human safety in the use of electricity. insulation-classes of insulation-excess energy-current surges--over current and short circuit current-heating effects of current,– earthing, specifications, earth resistance, earth pit maintenance. Fuse, circuit breakers and overload relays – protection against over voltage and under voltage – safe limits of amperage –protection of conductor-joints-and connections, overload and short circuit protection-

CHAPTER-3 HUMAN BEHAVOIR, ERGONOMICS AND OCCUPATIONAL HEALTH AND PHYSIOLOGY

UNIT I APPLICATION OF ERGONOMICS AND ARTIFICIAL INTELLIGENCE

Applications of ergonomic principles– work benches – seating arrangements, Posture and Body Mechanics: Some basic body mechanics, anatomy of the spine and pelvis related to posture, posture stability and posture adaptation, low back pain, risk factors for musculoskeletal disorders in the workplace, behavioural aspects of posture,layout of different equipment and components according to ergonomics, Artificial intelligence: Historical background, applications of AI, objections and myths,

UNIT II COGNITIVE PSYCHOLOGY

The mind – informative and cybernetics, components for thought, modes of perception – visual, auditory and other systems: memory mechanisms, problem solving – planning, search, Artificial Vision – picture processing – identifying real objects; Vision programs, factory vision systems.

UNIT III STRESS PSYCHOLOGY

Efficiency – occupational work capacity — evaluation of physiological requirements of jobs – stress – strain – fatigue – rest pauses – shift work – personal hygiene Individual differences, Factors contributing to personality, Fitting the man to the job and intelligence, Influence of difference on safety, Method of measuring characteristics, Accident Proneness. Motivation, Complexity of Motivation, Job satisfaction.Management theories of motivation, Frustration and Conflicts, Reaction to frustration, Emotion and Frustration.Attitudes-Determination of attitudes, Changing attitudes Learning, Principles of Learning, Forgetting, Motivational requirements.

CHAPTER-4 ACCIDENT MANAGEMENT SYSTEMS: PERSONAL PROTECTIVE EQUIPMENT AND PRECAUTIONS

UNIT I STORAGES

General consideration, storage tanks and vessel- storages layout- segregation, separating distance, secondary containment- venting and relief, atmospheric vent, pressure, vacuum valves, flame arrestors, fire relief- fire prevention and protection- LPG storages, pressure storages, layout, instrumentation, vapourizer, refrigerated storages-, toxic storages, chlorine storages, ammonia storages, other chemical storages

UNIT II PERSONAL PROTECTIVE EQUIPMENT

Respiratory and non-respiratory-demonstration- hand gloves, goggles, safety shoe, gum boots, ankle shoes, face shield, nose mask, anti-static and conducting plastics/rubber materials, apron and leg guard.

UNIT III ACCIDENT MANAGEMENT

Problems impeding safety in construction of Laboratory- causes of fatal accidents, types and causes of accidents related to various construction activities, human factors associated with these accident – construction regulations, design aids for safe construction – permits to work – quality assurance in construction - compensation – Recording of accidents and safety measures – Education and training

UNIT IV SIX SIGMA AND ITS IMPLEMENTATION

Introduction- definition-methodology- impact of implementation of six sigma-DMAIC method-roles and responsibilities –leaders, champion, black belt, green belts. Do’s and dont’s - readiness of organization – planning-management role- six sigma tools – sustaining six sigma.

Semester 2

Paper 6:

Metabolism & Bioenergetics

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);

Bioenergetics: Concept and Importance of Gibb's free energy in living System, High energy compounds: Basic mechanism of ATP synthesis, Energy currency of the cell, Electron Transport Chain (ETC), Idea of Redox Potential, Chemiosmotic Hypothesis and Oxidative Phosphorylation, Inhibitors and Uncouplers.

Carbohydrates Metabolism: Catabolism and Anabolism, Glycolysis: Fate of pyruvate under aerobic and anaerobic conditions. Pentose phosphate pathway and its significance, Gluconeogenesis, Glycogenolysis and glycogen synthesis.TCA cycle, Entner-Doudoroff pathaway, phosphoketolase pathway.

Catabolism of amino acids: Amino acids- Essential, non-essential, glucogenic and ketogenic, Transamination and oxidative deamination, Central role of Glutamic acid, Removal of nitrogen waste from the body, Urea cycle and excretion of Nitrogen.

Catabolism of fatty acids: Transport of fatty acids into Mitochondria, β-oxidation of saturated odd and even chain fatty acids (Reactions and Energetics), Ketogenesis, Biosynthesis of fatty acids and cholesterol (outline).

Nucleotide Metabolism: Biosynthesis of purine & pyrimidine (de novo & salvage pathways); degradation of purine & pyrimidine.

Books: Voet and Voet, L. Stryer, H.W Dolle, Nelson & Cox.

Paper 7:

Biophysical Techniques

Course Outcome (CO):

Course objectives: To acquaint students with principles, working and applications of Microscopic techniques, spectroscopy and Chromatography.

Learning outcomes: 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.

Microscopy
Optical microscopy: the nature of light—its particle and wave character. Ray diagrams and image formation. Simple and compound microscopes, Applications of optical microscopes, Numerical Aperture (NA), Resolution, Contrast, magnification, Spherical aberration, Chromatic aberration of optical system (definitions only). Mathematical expression for limit of resolution in terms of Rayleigh criteria. Empty magnification. Basic principles of oil immersion microscope. Limitations of optical microscopes. Confocal microscopy, Electron microscopy---TEM and SEM, sample preparation for EM. Advantages of electron microscope over optical microscope, Electrostatics and magnetostatics electron microscopes, characteristics and use of lasers, Relation between the applied voltage and wavelength of electrons.

Diffusion:
Diffusion in fluids, Fick's laws (Statement and explanation) Facilitated diffusion e.g. gas exchanges in lungs and regulating principle relating to partial pressure of O_2 and CO_2.

Osmosis:
Definition, contrast with diffusion, Tonicity and isotonic solutions. Effect of tonicity on R.B.C. Cell nutrition.

Viscosity:
Definition, Laminar and turbulent flow, Concept of Reynolds number, Newton's law of viscosity, Newtonian and non- Newtonian fluids, Coefficient of viscosity, Relative viscosity and fluidity. Measurement by Ostwald's viscometer. Dependence of viscosity on temperature and other factors e.g. size and shape of solutes (general idea), Viscosity of human blood (general idea).

Centrifugation:
Theory of ultracentrifugation, Relative centrifugal force (RCF), Sedimentation rate, sedimentation coefficient, Isopycnic (equilibrium) sedimentation (discussion with example e.g. Meselson and Stahl Experiment).

Spectrophotometry:
Electromagnetic spectrum, Introduction to concepts of absorption and emission spectroscopy, Absorption of light, Transmittance, Absorbance (Optical density), Lambert-Beer's law and its limitations, Concept of Molar extinction co-efficient, Study of absorption spectra of Proteins and Nucleic Acids, Analysis of Proteins and Nucleic Acids using UV and Visible spectroscopy, Raman spectroscopy, circular dichroism (CD), optical-rotatory dispersion (ORD) and their application in the study of macromolecules.
Nuclear magnetic resonance; principles behind splitting, spin-spin interaction, spin-lattice interactions, Nuclear Overhauser Effect, nuclear quadruple effects, spectral interpretations; Electron Spin Resonance (ESR), Zero Field Splitting

Chromatography:
Partition co-efficient, paper chromatography and its applications (including 2-D), Thin layer chromatography. Column packing and fraction collection, Gel filtration chromatography, Ion- exchange chromatography and affinity chromatography, GLC, HPLC.

Electrophoresis:
Principle and applications of native polyacrylamide gel electrophoresis, SDS- polyacrylamide gel electrophoresis and its application in determining molecular size of protein (principle only), difference between native and SDS-PAGE; 2D gel electrophoresis, Agarose gel electrophoresis.

Proteomics:
Proteome, nature of proteome, overview of the tools to study proteome, two-dimensional gel electrophoresis (2D-PAGE), Mass Spectrometry (MALDI/MALDI-TOF), Interpretation of Mass Spectra, MS/MS of peptide, Mass spectrometry search engines: Mascot, structural proteomics –protein-protein interactions, Yeast 2-hybrid, Co-immunopurification/Mass-spectrometry, application, Metabolomics (in brief)

Books: Biophysical Chemistry-Cantor and Shimmel, Physical Biochemistry- Van Holde, Physical Biochemistry-David Freifelder, Biochemistry-Voet and Voet, Fundamentals of Light microscopy and Electronic Imaging-Douglas B. Murphy

Paper 8:

Fundamentals of Molecular Biology

Course Outcomes (CO):

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.

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.

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, Telomere and Telomerases.

Recombination at the molecular Level: Homologous recombination, Rec A and RecBCD 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 and Mechanism of Transcription: Prokaryotic Transcription: Promoters, Sigma Factors, Initiation, Elongation, Rho-dependent and independent terminations, 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, Tetrahymena self splicing introns, Ribozyme, mRNA editing, folding, export.

Protein Synthesis and translation: Ribosome structure and 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, negative 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 lambda, Positive regulation in eukaryotic cells at transcriptional and post-transcriptional levels, basic and accessory transcription factors, enhancers and alternative splicing and polyadenylation; NPCs and 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

Books:

1. "Molecular Biology" by Friefelder David.
2. "Gene VIII" by Lewin Benjamin.
3. "Molecular Biology of the Gene" by Watson J D.
4. "Molecular Biology" by Weaver R F.

Paper 9:
Biophysical Techniques and Immunology Practical

Course Outcome (CO):

Course objectives:- The objective of this course is to familiarize students with advances in immunology, molecular immunology and clinical immunology. Also gives a detailed understanding of the effector mechanisms. To acquaint students with the concepts of Autoimmunity, Transplantation, Imaging techniques in immunology, cancer Immunology.

Learning outcomes:- By the end of the course the student will be able to: • Understand the role of different types of Cells, Effector Molecules and Effector Mechanisms in Immunology particularly role of T and B cells, Cytokines and Mucosal immunity. • Understand the experimental immunology regarding vaccine development and significance of antigen antibody interactions in diagnostics. • Gain an understanding of the basic concepts of mechanisms of autoimmunity. Transplantation immunology, animal models in immunological studies and cell imaging • Understand the role of immune system in cancer, their causes and cure, also psychological modulation of immune system.

1. Measurement of refractive index of a biological solution with the help of travelling microscope.
2. Measurement of viscosity of unknown sample by Ostwald viscometer.
3. Determination of R_f value and separation of amino acids by paper chromatography.

Immunology Practical
1. Antigen-Antibody reactions – Agglutination (Blood grouping testing).
2. Antibody titration (Ouchterlony Double Diffusion).
3. Antigen-Antibody reactions – Dot blot assay

Paper 10:
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 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.

Environmental Microbiology

Extremophile: anaerobes, halophiles, acidophile, alkalophile, tharmophile, barophile;Effect of heavy metal and xenobiotic substances on microbes; biological magnification of toxic substances.Microbial deterioration of paper, leather, wood, textile, stone and monument.

Aeromicrobiology: Microbes of indoor and outdoor environment, pathways, enumeration, Extramural and intramural, control, bioterrorism. Eutrophication,

Water microbiology: Microbes in marine and fresh water environment – Eutrophication – food chain, water borne pathogens – indicator organism – Microbiology of Domestic water – Microbial water Quality– water purifications Significance of microbes in water quality. Test for portability of water. Microbial treatment of sewage; application of wastewater in land; composting of biosolids and domestic solid waste. Microbes related to fish growth. Common microbial diseases of fish.

Microorganism and metal pollutants: biodegradation of TNT, PCB; Bioremediation: bioventing, biofiltration, bioaugmentation, problems and advantages.

Bioleaching: mineral extraction, oil recovery. Biodegradation and bioremediation,Landfills, Composting and Earthworm treatment. Biodegradation of Xenobiotic compounds. Organisms involved in degradation of chlorinated hydrocarbons, substituted simple aromatic compounds, polyaromatic hydrocarbons, pesticides and surfactants. Microbial treatment of oil pollution.

Waste Management: Biomass waste management of plant's residues: Lignocellulolytic microorganisms, enzymes and their biotechnological applications in: (i) biopulping, (ii) biobleaching, (iii) textiles

(iv) biofules, (v) animal feed production.

Liquid waste management: Treatment of sewage (Primary, Secondary and Tertiary treatments), Treatment of Industrial effluents (distillery, textile, pulp and paper), methods to detect various pollutants (metals, sediments, toxin and organic matters)

Solid waste management:Solid waste types, composting, landfill development, incineration methods, composting and sustainable agriculture,plastic degrading microorganisms as a tool for bioremediation, challenges in waste management

Bioremediation of environmental pollutants:
Petroleum Hydrocarbons and pesticides,
use of biosensors for their detection.
Microbes in oil and mineral recovery: Microbial enhanced oil recovery, Bioleaching of copper, gold and uranium, electronic waste management.

SEC:

Diagnostic Microbiology

Course Outcome (CO):

Objectives of the course:

To acquaint the students with various aspects of basic and applied medical microbiology like Medical Diagnostic Microbiology 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 Applied Medical Microbiology course, students will be able to:

1. Understand and practice the principle of prevention and control of health care associated infections and rational antibiotic policy.
2. 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.
3. Carry out fundamental or applied research involving microbiological work.
4. Undertake teaching assignments in the subject of Medical Microbiology

Understanding Infection: Host parasite relationship, Pathogenesis of viral diseases, bacterial pathogenesis. Toxigenicity, Host defence against microbial invasion, microbial mechanism for escaping host defences

Antimicrobials and Infection:Development of chemotherapy; Antibiotics - Definition, genera of antibiotics, mode of action of antibiotics, assay of antibiotics, Antibiotics vs probiotics (to give a concept of probiotics), Antibiotic resistance, Multiple Antibiotic Resistance (MAR , its significance), Methods of action of antibiotics and antibacterial agents; determining the level of antimicrobial activity, Antimicrobial/ bacterial drugs, General Drug Resistance, Antiviral, fungal, protozoan drugs.

Clinical Microbiology: Prevention, diagnosis and treatment of infectious diseases. Various clinical applications of microbes for the improvement of health.

Molecular Diagnostics: Enzyme-Linked Immunosorbent Assay (ELISA), Polyclonal and Monoclonal Antibodies; Molecular Diagnosis of Genetic Disease (RFLPs, SNP genotyping, genotyping by sequencing); PCR in microbial diagnosis; Sequencing in microbiology; DNA Fingerprinting & Forensics.

Semester 3

Paper 11:

Immunology

Course Outcome (CO):

Objectives of the course are to :

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 and various 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 scientific data in standard format.
- Undertake teaching assignments in the subject of Medical Microbiology

Overview of Immune System: General features of immune responses; Clonal selection hypothesis; cell, tissues & organs of immune system.

Innate, Adaptive & Humoral immunity: Anatomic barriers, Physiologic barriers, Phagocytic/endocytic barriers, inflammatory barriers. B lymphocytes, T lymphocytes, Antigen-Presenting Cells,

Antigen-Immunoglobulin, Generation of immune Diversity: Overview of Antibody structure, Antigem-Antibody interactions, antibody heterogeneity and hybridoma technology.

Antigen presentation, Major Histo-compatibilityComplex, T-Cell maturation etc.

Cytokines: Properties of Cytokines; Cytokine Receptors; Cytokine Antagonists; Cytokine Secretion by TH1 and TH2 Subsets; Cytokine-Related Diseases; Therapeutic Uses of Cytokines and Their Receptors; Cytokines in Hematopoiesis

Autoimmunity and immunodeficiency Syndromesetc.

Paper 12:

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.

Bacterial & Viral Genetics: The Genetic Organization of Bacteria and Viruses**,** Mutation and its different types**,** mutagens and mutagenesis, Bacterial Mutants**,** Bacterial Transformation**,** Conjugation – Plasmids; Hfr Cells; Time-of-Entry Mapping; F' Plasmids**,**Transduction**,** Bacteriophage Genetics - Plaque Formation and Phage Mutants; Genetic Recombination in Virulent Bacteriophages; Fine Structure of the rII Gene in Bacteriophage T4**,** Genetic Recombination in Temperate Bacteriophages – Lysogeny; Generalized and Specialized Transducing Phages and the mechanism of gene transduction**,**Transposable Elements - Transposons in Genetic Analysis

Yeast Genetics: History of yeast and yeast in history*,* What are yeasts? Yeast is a model eukaryote*,* Information on yeast*,* Yeast strains*,* Growth and life cycles - The vegetative cell cycle; Mating and homothally; Sporulation and meiosis; The yeast genome - Sequencing project overview; Overview of clustered duplications in the *Saccharomyces cerevisiae* genome; Example of the genetic and physical map of chromosome III; Genetic nomenclature; Chromosomal genes; Mitochondrial genes; Non-mendelian determinants; Genetic analyses - Overviews with examples; Mutagenesis and genetic screens; Tetrad analysis; Dominance and complementation tests; Complementation and its complications; Complementation groups as genes; Intragenic complementation as an indication of multiple domains; Non-mendelian inheritance; Suppression*,*Transformation - Yeast vector and DNA fragments; Synthetic oligonucleotides; Homologous recombination and integrative transformation*,* Cloning in yeast by complementation, Expression of Foreign Protein inYeast, Gene Knock out, Plasmid shuffle, One Hybrid, Two Hybrid System

Paper 13:

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
- To describe various tools and techniques of RDT, different enzymes and vectors

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, flowcytometry and immunofluorescence microscopy, detection of molecules in living cells, in situ localization by techniques such as FISH and GISH.

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 Lamp brush 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

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.

Books:

1. Principles of Gene Manipulation and Genomics by Twyman and Primrose
2. Gene Cloning and DNA Analysis by T.A Brown

Paper 14: DSE 1 Theory

Bioethics and Intellectual Property Rights

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.

Bioethics
Biotechnology And Risk Ethical implications of cloning: Reproductive cloning , therapeutic cloning ; Ethical, legal and socio-economic aspects of gene therapy, germ line, somatic, embryonic and adult stem cell research- GM crops and GMO's – biotechnology and bio piracy – ELSI of human genome project. Role of bioethics in research. Prevention and management of plagiarism, fabrication/manipulation of data,

Introduction to intellectual property and intellectual property rights – types: patents, copy rights, trade marks, design rights, geographical indications – importance of IPR – patentable and non patentable – patenting life – legal protection of biotechnological inventions – world intellectual property rights organization (WIPO) .

Establishment and functions of General Agreement on Trade and Tariff (GATT) and World Trade Organizations. WTO Summits.

Rules governing patents. Case studies on patents (Super bug, Basmati rice, Turmeric etc.). Indian Patent Act, 1970 and its amendments.

Biosafety
Introduction. Different levels of biosafety. Guidelines for recombinant DNA research activities in microorganisms. Good Laboratory Practices (GLP). Containments –Types. Basic Laboratory and Maximum Containment Laboratory microbiology research. IBSC and RCGM,GEAC. Food Safety and Standards Regulation, 2011 Regulation, 2011.

TEXT BOOKS:

1. **Recombinant DNA safety guidelines** (January1990), Department of Biotechnology, Ministry of Science & Technology, Government of India, New Delhi.

2. **Revised guidelines for research in Transgenic plants** (August 1998), Department of Biotechnology, Ministry of Science & Technology, Government of India, New Delhi.
3. **Patents** ,Subbaram N., (2003), , Pharma Book Syndicate, Hyderabad.

OR

Bioprocess Technology

Course Outcome (CO):

Course Objective:

- To obtain knowledge on reaction engineering systems with emphasis on bioreactor design and operation and analysis of kinetics in biochemical engineering reactions along with separation and purification of desired products.
- Further students will be able to handle fermenter, design media, optimize process parameters and differentiate between different separations techniques to design a combination of downstream techniques for a given process to provide bioprocess engineering solutions.
- This course is drawing to illustrate the applications of microorganisms in fermentation industry.

Course Outcomes:

- Students will be able to comprehend and apply the inoculum development and strain improvement techniques for a desired fermentation process.
- Apply the ideas of select a fermenter and formulate suitable media for a desired fermentation process.
- Apply regulatory downstream techniques for product isolation, separation and purification. techniques in real time scenarios.
- Conduct experiments for production, isolation and recovery of bio-products.

An overview of fermentation technology
General requirement of fermentation process, basic configuration of fermentor primary and secondary metabolites ,Industrial micro organisms: isolation, preservation, screening and strain improvement and maintenance. Formulation of industrial media: Medium requirements for fermentation processes, carbon, nitrogen, mineral sources, buffers, antifoam agents, medium optimization. Stoichiometry of cell growth and product formation, Sterilization of media and fementers, scale – up process and starter culture technology

Basic design of fermentor
Types of fermentation vessels. Aseptic operation, containment, Body construction (stirrer glands, bearing, valves, steam traps) baffles, spargers and impellors. Types of fermentations: batch, continuous, fed-batch, solid state, sub-merged. Aerobic and anaerobic, dual and multiple fermentations, their advantages and disadvantages.

Aeration and Agitation: Fick's law, theories of mass transfer, mass transfer between two phases, role of aeration and agitation in a bioprocess, oxygen transfer methodology in a fermentation process, significance of volumetric transfer coefficient (KLa) and its determination, factors affecting KLa values in a bioreactor, power requirements in gassed and ungassed bioreactors, rheological characteristics of fermentation fluid

Significance of downstream processing in industrial fermentation processes
Problems and requirements of bio product purification and recovery. Physico- chemical basis of bio separation processes. Fermentation economics - Market potential, some effects of maintenance legislation on production of antibiotics and recombinant proteins, plant and equipment

Brief outline for the production of the following commercially important products

a. Primary metabolites i. Organic acids: Citric acid, lactic acid, ii. Amino acids: Glutamic acid, L – lysine, iii. Solvents: Acetone, ethyl alcohol
b. Secondary metabolites i. Antibiotics: Streptomycin, penicillin ii. Vitamins: B12, Riboflavin, iii. Biofuels : Hydrogen, methane

TEXT BOOKS:

1. Bailey and oilis, Biochemical engineering fundamentals, McGraw-Hill(2nd Ed),1986
2. Shule and Kargi, Bioprocess Engineering, prentice hall,1992,
3.Bioprocess Technology: Fundamentals and Applications. Stockholm KTH.

Paper 15:

Biostatistics & Bioinformatics Practical

Course Outcome:

Course objectives: Biostatistics course for those students will acquaint 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 endeavours 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.

Theory
Idea of Computational Biology and it's need in biological study. Central dogma of bioinformatics. Concept of databases, characteristics and classification of database. Sequencs information sources, EMBL, GENBANK, Entrez, Unigene.
Nucleic acid and protein sequence database and information retrieval; sequence file formats - FASTA & GENBANK. Sequence alignment - pairwise and multiple sequence alignment. Pairwise alignment tool - BLAST and multiple sequence alignment tool - Crustal W. Protein and nucleic acid structure database: Protein information Sources,PDB,SWISSPROT,TREMBL. The Protein Database (PDB); information retrieval from structural database, Dendogram, Claudogram, Evolutionary relationship.

Introduction to Biostatistics
Keywords and terms used in biostatistics. Concept of frequency distribution (frequency distribution table, simple and group frequency distribution, data presentation), mean, median, mode, standard deviation; Simple problems on mean, median, mode and standard deviation.

Statistical Distribution
Normal, binomial, poisson's distribution.

Books: Zin Xiong, Mount, Das and Das, Misra

Practical

1. Sequence information resource
2. Understanding and use of various web resources: EMBL, Genbank, Entrez, Unigene, Protein information resource (PIR)
3. Understanding and using: PDB, Swissprot, TREMBL
4. Using various BLAST and interpretation of results.
5. Retrieval of information from structural database.
6. Sequence alignment using BLAST

GEC:

Microbes in sustainable development

Course Outcome (CO):

Course Objectives:

- This course aims to provide that sustainable development involves diverse and complex approaches.
- To learn how Microbes provide a wide range of services to humans, animals and plants.
- To teach the innovations and innovative solution of harnessing microbes for an large spectrum of biotechnological application

Course outcomes:

- To understand the role of Environment in human Health. The students will learn the principles for using complex microbial communities for environmental applications in the light of the Microbial Resource Management.
- To understand the basics of Environmental Economics systems and acquire skills to manage them sustainably.
- To equip students with the knowledge, attitudes and skills necessary for Environmental Entrepreneurship and to motivate them to venture into entrepreneurship as an alternative career option.

Unit I Definition and concepts of sustainable development, issues in Sustainable Development, Strategic Planning for Sustainable Development. Microbes and its suitability in sustainable development: Brief account of bacterial cell structure, metabolic diversity, different niche occupancy

Unit II Concept of antisepsis, disinfection, sterilization and chemotherapeutant. General idea on bacterial drug resistance Modern approach of bacterial classification

Unit III Microbial Growth characteristics, strategies of cell division, stress response
Genetic recombination in bacteria, transformation, conjugation, transduction, Signal transduction in bacteria, regulation of signaling pathways, bacterial and plant two-component systems, bacterial chemotaxis and quorum sensing.

Unit IV Host parasite interaction Recognition and entry processes of different pathogens like bacteria, viruses into animal and plant host cells, alteration of host cell behavior by pathogens, virus-induced cell transformation, pathogen-induced diseases in animals and plants,

Unit V Microbial fermentation and production of small and macro molecules.

Unit VI Microbes in environmental management: Bioremediation and phytoremediation, Biosensors, Microbes in healthcare: antibiotics and drug developments,Microbes in agriculture: crop improvement and protection,Microbes in food processing,Microbes in bio-hydrometallurgy and fuel industry.

Text Books
Environmental Biotechnology. Edited by C. F. Forster and D.A., John Wase. Ellis Horwood Ltd. Publication.
Advances in Waste Water Treatment Technologies. 1998. Volumes II and I by R. K. Trivedy. Global Science Publication.
Biocatalysis and Biodegradation: Microbial transformation of organic compounds. 2000 by Lawrence P. Wacekett, C. Douglas Hershberger. ASM Publications.
Biotechnology in the sustainable environment, Plenum Press, N.Y.

Semester 4

Paper 16:

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:

5. 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.
6. Carry out fundamental or applied research involving microbiological work.
7. Undertake teaching assignments in the subject of Medical Microbiology

Pathogenicity of microorganism*:* Host parasite relationship, Pathogenesis of viral diseases, bacterial pathogenesis. Toxigenicity, Host defence against microbial invasion, microbial mechanism for escaping host defences.

Antimicrobial chemotherapy*:* Development of chemotherapy, Determining the level of antimicrobial activity, Antimicrobial/ bacterial drugs, Drug Resistance, Antiviral, 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 pylori), 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

Paper 17:

Food & Industrial Microbiology

Course Outcome (CO):

Objectives of the course:

1. Understand the beneficial role of microorganisms in fermented foods and in food processing and the microbiology of different types of fermented food products – dairy, pickles, Legume and cereal based food products
2. Understand the significance and activities of microorganisms in food and role of intrinsic and extrinsic factors on growth and survival of microorganisms in foods
3. Know the spoilage mechanisms in foods and thus identify methods to control deterioration and spoilage
4. Recognize and describe the characteristics of important pathogens and spoilage microorganisms in foods.

Outcome of the course:

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

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

Food Microbiology

Unit I Antibiotic fermentations – production of β lactams (penicillins), semi-synthetic penicillins and cephalosporins, amino-glycosides (streptomycin), macrolids (erythromycin), quinines.

Unit II Production of vitamins (B12, riboflavin, A), enzymes for pharmaceutical industries, vaccines, recombinant proteins (insulin, interleukins and interferons), biotransformations – hormones

Unit III Microbiology of foods: Vegetables, fruits, milk and non-fermented products, fresh meats, poultry and non-dairy products.

Unit IV Microbial spoilage of foods,. Food preservation: Physical, chemical and biological methods.

Unit V Industrial bioethics and IPR

Industrial Microbiology

Unit I Fermentation: an overview, isolation, screening and selection of industrially important microorganisms, strain improvement for industrial purposes, use of recombinant DNA technology, cloning vectors, role and applications of genetic engineering in development of industrial strains

Unit II Bioreactors, design and components of basic fermentor, specialized fermentors for specific purposes – continuous, anaerobic, for gaseous nutrients, for treatment of wastes, trickle flow reactors, cyclone reactors, submerged types, tube reactors, packed bed reactors, lab scale to pilot to industrial – scale up process, online monitoring.

Unit III Bioprocessing – downstream processing of industrial fermentation processes, product purification and recovery, physico-chemical basis of bio-separation processes, techniques for purification of end products – chromatography, electrophoresis, distillation, crystallization, filtration.

Unit IV Economics of a fermentation process, determination of cost and its recovery, cost cutting strategies, cell and enzyme immobilization, biological waste treatment, hygiene and safety in fermentation industries.

Unit V Microbes in food industry, fermented foods (breads, sauerkraut, pickles, tofu), dairy products from microbes (cheese, curd, yoghurt), microbes as food - single cell protein, mushrooms, probiotics.

Alcoholic beverages – brief history of development of industrial process, production of beer (brewing) – media (raw materials used), process, maturation, carbonation. Types of beer(lager, pilsner, bock, ale, stout, porter). Whiskeys – types and production, Production of wine – media and raw material used, different types (sparkling wine, burned wine, cider, wine vinegar), vinegar.

Paper 18:

Virology

Course Outcome (CO):

Objectives:

The aim is to promote the knowledge and expertise in microbiology with a particular focus on virology. Students will develop an understanding of the scientific basis of established virology concepts, as well as the specialist knowledge, practical skills and critical awareness required to enable students to pursue a career in virology. The specific aims/objectives are to: Provide knowledge in 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 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 to understand the nature of viruses and their role in disease pathogenesis; integrate and evaluate information and data from a variety of sources;

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. Incidence and etiology of cancer, genetics of cancer, hallmarks of cancer, metastasis, molecular and cellular events, such as regulation of gene expression, genome maintenance, cell growth and death, differentiation, cell-cell recognition, signaling, and homeostasis

Books:

- Molecular Biology of the genes by James D. Watson.
- The Cell by Geoffrey M. Cooper.
- Cell and Molecular Biology by Gerald Karp.
- Molecular Cell Biology by Harvey Lodish.
- Molecular Biology of Cells by Bruce Alberts.

Paper 19:

DSE 2 Theory

Agricultural Microbiology

Course Objectives

- To teach 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 create awareness about plant pathogen interactions, involvement of soil microbes and various biogeochemical cycles involving plants.
- To study about GMO's and ways to increase production using biotechnology and microbiology tools.

Course Outcomes

- Students will get knowledge about the various biotechnology tools involved in increasing plant production. This will help in field based research.
- Study the use of genetics in predicting and maintaining production and control pathogens by using various biotechnology tools.
- To maintain gene banks and related studies.

Plant-microbe interactions–Endophytic organisms, Common plant pathogenic bacteria, virus and fungus. **Plant diseases:** symptoms, disease cycle and control measures – Bacterial diseases, Blight of rice, Citrus canker and wilt of potato.Viral diseases, Vein clearing disease, Tungro disease of rice, TMV and CMV. Fugal diseases**,** rust of wheat, smut of sugarcane, wilt of cotton, tikka leaf spot in groundnut

Beneficial association between plant and microorganisms. Different symbiosis including rhizosphere and phyllosphere microorganisms and their effect.

Important roles of soil microbe: Role of microorganisms in the formation of soil – Role of microbes in soil fertility. Biogeochemical cycles – Carbon, Nitrogen,Phosphorous and Sulphur cycles.

Biofertilizer: Types, production and application (*Rhizobium*, *Azotobacter*, *Azolla*). Liquid biofertilizer.. **Biopesticides:** bacterial, fungal and viral. Recent advances in biological pest control.

Microbes in composting: Farmyard manure, Method of composting (aerobic, anaerobic), enrichment of compost with microbial inoculants. Super digested compost,biogas production. Vermiculture: Vermiculture process, Vermicomposting materials, Advantages of vermicompost.

Concept of plant tissue culture: micropropagation and protoplast technology. **Brief account of microbial interactions -**Symbiosis**,** neutralism, Commensalism, Competition, Ammensalism, Synergism, Parasitism.

Application of Recombinant Microorganisms in Agriculture Microorganisms and Agriculture – Functions of Microorganisms: Putrefaction, Fermentation, and Synthesis, Relationships Between Putrefaction, Fermentation, and Synthesis of biomolecules Classification of Soils Based on the Functions of Microorganisms (Disease-Inducing Soils, Disease-Suppressive Soils, Zymogenic Soils, Synthetic Soils), Controlling the Soil Microflora for Optimum Crop Production and Protection.

Text Books

1. **Environmental Microbiology,** Alan Scragg, (1999), Longman.
2. **Environmental Biotechnology – Theory& Application**, Gareth M.Evans & Judith C.Furlong John, (2003), wiley & Sons Ltd.
3. **Soil Microorganisms and plant growth**. Subba Rao, N.S., (1995). Oxford & IBH Publishing Co., Pvt. Ltd., New Delhi.
4. **Agricultural Microbiology**. Rangasami G. and D.J.Bagyarai (1993). Second Edition, Prentice-Hall of India Private Limited, New Delhi.

OR

Application of Microbial Technology

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.

UNIT- I

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

UNIT -II

Microorganisms in fermentation and probiotics-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 and Drug Discovery: Basics of Environmental Microbiology; Marine, Aquatic Microbiology. Bioinformatics, Genomics, and Antimicrobial Drug Discovery; DNA Microarray Technology & its application in Microbial Biotechnology. **Nanobiotechnology**: potential use in human health and environmental management

UNIT -V

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

Unit –VII

Biological warfare. Use of GMOs and Biotechnology tools for human development and sustainable environment. Bioremediation and bioaugmentation. Biosafety and biosecurity.

Paper 20:

Project Work & Review Work

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.

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.