St. Xavier's College (Autonomous), Ahmedabad

Syllabus of Semester – II of the following departments under Faculty of Science based on Post Graduate Curriculum Framework - 2024 to be implemented from the Academic Year 2024-25.

FACULTY OF SCIENCE

DEPARTMENT OF MICROBIOLOGY

MSc. Microbiology

CORE PAPER: MICROBIAL GENETICS

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course Title & Code	Credit Distribution of The Course			Eligibility Criteria	Pre-requisite(s) of the Course (if any)
	Lecture	Tutorial	Practical / Practice		
Microbial Genetics (PMB 2801)	4	0	2	Life Science Graduate from a UGC recognized University	Basic Knowledge of Molecular Biology

LEARNING OBJECTIVES (LO)	
LO-1	Understanding of fundamental concepts in microbial genetics.
LO-2	Understanding of how microbial genetics has advanced science and society.
LO-3	Insight into genetic methods used to investigate interesting biological problems.
COURSE OUTCOMES (CO)	
On Completion of this course, the student will be able to	

CO-1	Describe the types of mutations, mode of action of different mutagens, molecular basis of spontaneous mutations and the pathways existing in cells to safe guard its DNA against such damages.
CO-2	Describe the different modes of gene exchange in bacteria and perform mapping using these methods.
CO-3	Explain the biology of *Agrobacterium tumefaciens* and describe the interkingdom gene transfer in detail.

Unit-1: Mutation & its repair (15 L)

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

Unit-2: Plasmid biology, recombination, phage and fungal genetics (15 L)

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

Unit-3: Gene transfer among prokaryotes (15 L)

1. Transformation (Natural transformation in *Bacillus subtilis*, *Streptococcus pneumonia* and *Haemophilus influenza*). Transformation by inducing artificial competence, Gene linkage, mapping and fine structure analysis of transformation.
2. Transduction (Generalized transduction in P22, P1, T4 and Mu bacteriophages, homologous recombination with recipient's chromosome, measuring transduction (co-

transduction of markers, marker effects, abortive transduction, transduction of plasmids). Applications of generalized transduction, Specialized transduction and its applications.

3. Conjugation (F-factor mediated Conjugation in *E. coli*, Hfr conjugation and chromosomal transfer, F-prime conjugation and merodiploids, Conjugation of fertility inhibited F-like plasmids, non-conjugative mobilizable plasmids, chromosomal mobilization of non-F plasmids, Plasmid based conjugation in other bacteria (*Salmonella*, *Pseudomonas*, *Streptomyces* and *Streptococcus*, Interrupted mating, conjugational mapping and fine structure analysis).

Unit-4: Restriction enzymes, transposable elements & *Agrobacterium* genetics (15 L)

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

Suggestive Readings:

- Watson, J. D., Tania, A. B., Stephen, P., B., Alexander, G., Michael, L., Richard, L., (2017). Molecular Biology of the Gene. 7th Edn. Pearson Education, United Kingdom.
- Henkin, T. M., Peters, J., E., (2020). Snyder and Champness Molecular Genetics of Bacteria. 5th Edn. ASM Press, Washington, DC.
- Tropp, B. E., (2012). Molecular Biology: Genes to Proteins. 4th Edn. Laxmi Publication, New Delhi.

CORE PAPER: ENZYMOLOGY

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course Title & Code	Credit Distribution of The Course			Eligibility Criteria	Pre-requisite(s) of the Course (if any)
	Lecture	Tutorial	Practical / Practice		
Enzymology (PMB 2802)	4	0	2	Life Science Graduate from a UGC recognized University	Basic Knowledge of Enzymes

LEARNING OBJECTIVES (LO)	
LO-1	The course will introduce students to the applications of enzymes in research and medicine as well as in industry, which will bolster their foray into industrial and biomedical research.
LO-2	Students will gain insight into the thermodynamic and molecular basis of catalysis by enzymes and the underlying basis of their specificity.
LO-3	Students will understand the mechanisms of enzyme action, kinetics of enzyme catalyzed reactions and clinical importance of enzyme inhibitors.
COURSE OUTCOMES (CO)	
On Completion of this course, the student will be able to	
CO-1	Imparting the knowledge on working of enzyme along with portraying their clinical, analytical and industrial applications.
CO-2	Apply appropriate methods for determination of catalytic parameters and activity of enzymes and resolve problems considering kinetics and thermodynamics of enzymatic reactions.
CO-3	Interpret and explain significant mechanisms of regulation of enzymatic action and specifies importance of enzymes in regulation of metabolism.

Unit-1: Introduction to Enzymology (15 L)

1. Introduction and historical developments in enzymology.
2. Protein Structure: Primary, secondary, tertiary and quaternary structure, techniques used in enzyme characterization.

3. Enzyme nomenclature and classification, characteristics, chemical nature and properties of enzymes, enzyme specificity and rate enhancement.
4. Enzyme Activity, assay methods, factors affecting enzyme activity, progress curve, enzyme activators, coenzyme and cofactors.

Unit-2: Enzyme Kinetics (15 L)

1. Chemical reaction kinetics and catalysis.
2. Single substrate kinetics: Equilibrium and Steady state kinetics, significance of Km, Vmax & Kcat, enzyme efficiency.
3. Multi substrate kinetics: General rate equation, compulsory order, random order and ping-pong mechanisms and their primary and secondary plots.
4. Enzyme inhibition and its kinetics: Reversible and irreversible inhibition, competitive, non-competitive and uncompetitive, mixed, partial, substrate inhibition.
5. Thermal kinetics: Effect of temperature on reaction rate, enzyme stability, Arrhenius equation and activation energy.

Unit-3: Enzyme catalytic mechanisms and control of enzyme activity (15 L)

1. Enzyme catalytic mechanisms: Factors affecting catalytic efficiency, Mechanism of Lysozyme, Chymotrypsin, Carboxypeptidase, Aspartate transcarbomylase.
2. Oligomeric enzymes: Sigmoidal kinetics and regulation, Protein ligand binding, Co-operativity, MWC & KNF models.
3. Experimental approaches to understand enzyme mechanisms.
4. Control of single enzyme activities by changes in covalent structure, ligand induced conformational changes and feedback inhibition.

Unit-4: Enzymes Technology and Applications (15 L)

1. Enzyme engineering: Structure function relationship, Methods of enzyme alterations, examples of engineered proteins.
2. Enzyme Immoblization, enzyme sensors, analytical and industrial applications of enzymes.
3. Enzymes in non-conventional media.
4. Isoenzymes and its physiological significance, Ribozymes and Abzymes.

Suggestive Readings:

- Enzyme Kinetics and Mechanism by P. F. Cook, W.W. Cleland. Garland Science Publishing, London, England and New York, USA, 2007.
- Biocatalysts and Enzyme Technology by K. Buchholz, V. Kasche, U.T. Bornscheuer., Wiley-VCH, Weinheim, Germany, 2005.
- Enzymes: Biochemistry, Biotechnology, Clinical Chemistry by Trevor Palmer Horwood Publishing House, Chichester, England, 2001.

CORE PAPER: FERMENTATION TECHNOLOGY

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course Title & Code	Credit Distribution of The Course			Eligibility Criteria	Pre-requisite(s) of the Course (if any)
	Lecture	Tutorial	Practical / Practice		
Fermentation Technology (PMB 2803)	4	0	2	Life Science Graduate from a UGC recognized University	Basic Knowledge of Fermentation

LEARNING OBJECTIVES (LO)	
LO-1	Understanding of upstream and downstream processing.
LO-2	To understand Isolation, preservation, improvement, handling of organisms and optimization of media.
LO-3	Understand basic concepts of growth, cultivation and product recovery.
COURSE OUTCOMES (CO)	
On Completion of this course, the student will be able to	
CO-1	Explain the concept of large-scale production of industrially essential metabolites.
CO-2	Evaluate selection of microorganisms used in various industries i.e. Pharmaceutical, Food and Dairy sector.
CO-3	Analyse a variety of fermentation and subsequent processing approaches for biological products.

Unit-1: Basic principle of Biochemical engineering (15 L)

1. Isolation, screening and maintenance of industrially important microbes.
2. Microbial growth kinetics (an example from each group, particularly with reference to industrially useful microorganisms).
3. Strain improvement for increased yield and other desirable characteristics.

Unit-2: Concepts of basic mode of fermentation processes (15 L)

1. Types of fermentation.

2. Fermenter design: mechanically agitated; Pneumatic and hydrodynamic fermenters; Large scale animal and plant cell cultivation and air sterilization.
3. Upstream processing: Media formulation, Sterilization, Aeration and agitation.
4. Measurement and control of bioprocess parameters, scale up and scale down process
5. Fermentation economics.

Unit-3: Downstream processing (15 L)

1. Bioseparation - filtration, centrifugation, sedimentation, flocculation.
2. Cell disruption.
3. Liquid-liquid extraction.
4. Purification by chromatographic techniques.
5. Reverse osmosis and ultra-filtration.
6. Drying, Crystallization and Storage and packaging.
7. Treatment of effluent and its disposal.

Unit-4: Quality Assurance and Control (15 L)

1. Definitions- GMP, QA, QC.
2. QC of raw materials, in-process items, finished products, packaging materials, labels, Sterility assurance and testing.
3. QA process and its importance
4. Microbiological Assays.

Suggestive Readings:

- Stanbury RF and Whitaker A., Principles of Fermentation Technology, Pergamon press, Oxford, 1997.
- Modi H. A., Fermentation technology. Pointer Publishers, 2009.
- Shuler ML and Kargi F., Bioprocess Engineering: Basic concepts, 2ndEdition, Prentice Hall, EngelwoodCliffs, 2002.

CORE PAPER: FOOD AND AGRICULTURAL MICROBIOLOGY

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course Title & Code	Credit Distribution of The Course			Eligibility Criteria	Pre-requisite(s) of the Course (if any)
	Lecture	Tutorial	Practical / Practice		
Food and Agricultural Microbiology (PMB 2804)	4	0	2	Life Science Graduate from a UGC recognized University	Basic Knowledge of Microbiology

LEARNING OBJECTIVES (LO)	
LO-1	To introduce students with respect to food borne infections.
LO-2	To make them understand how we can control the unwanted contamination of microbes in our food.
LO-3	To introduce the presence of microflora of soil.
LO-4	Introduction of plant diseases with respect to microbial agents.
COURSE OUTCOMES (CO)	
On Completion of this course, the student will be able to	
CO-1	Understand role of bacteria, virus and protozoa in causing food infections.
CO-2	Recognize fermented food products and microbes which we can consume as source of nutrition.
CO-3	Understand the role of soil microbes as biofertilizer agents.
CO-4	Recognize fungal, viral and bacterial diseases of plants.
CO-5	Cure plant diseases with the help of microorganisms.

Unit-1: Microbes in food infection, food spoilage and as food (15 L)

1. Food and milk borne infections: Microorganism involved, source of infection, Incubation period and characteristics in brief:

   A. Bacterial infections: *Salmonella* sp., *Shigella* sp., *E. coli*, *Vibrio* sp., *Campylobacter jejuni*, *Listeria monocytogenes.*

B. Viral infections: Rotavirus, Hepatitis A, Poliovirus.

C. Protozoal infections: *Entamoeba.*

2. Fermented dairy products.
3. Fermented food products.
4. Microbes as food: Mushroom & Spirulina.

Unit-2: Control of microbes in food (15 L)

1. Control of access of microbes in foods: Cleaning, sanitation and disinfection in food handling operations, removal of biofilm.
2. Control by physical agents: physical removal, thermal Processing, irradiation, reducing water activity and drying, low temperature.
3. Control by chemical agents: low pH and organic acids, antimicrobial preservatives and bacteriophages.
4. Control by novel processing technologies: microwave and infrared heating, ohmic and inductive heating, pulsed electric fields processing, high pressure processing, pulsed light technology, pulsed X-rays, plasma technology.

Unit-3: Microorganisms of soil (15 L)

1. Brief account of microbial interactions: Symbiosis, mutualism commensalisms, synergism and parasitism.
2. Rhizosphere, phyllosphere and endophytic microflora
3. Nutrient cycle: Carbon cycle, Nitrogen cycle, phosphorous cycle and sulphur cycle.
4. Biofertilizers: types and applications; Mycorrhiza & Vermicompost fertilizers.
5. Natural farming and its significance.

Unit-4: Plant diseases and their control (15 L)

1. Fungal Diseases of plants: rust of wheat, green ear disease of bajra.
2. Bacterial diseases of plants: citrus canker, yellow rot of wheat.
3. Viral diseases of plants: leaf curl of papaya, leaf curl of tomato.
4. Integrated Pest Management.
5. Bacterial control of phytopathogens: *Bacillus thuringiensis* as bacterial insecticide.
6. Viral control of phytopathogens: nuclear polyhedrosis viruses (NPV) and cytoplasmic polyhedrosis viruses.
7. Fungal control of phytopathogens: Entromopathogenic fungi: *Metarhizium anisopliae*, *Beauveria bassiana*, *Lecanicillium lecanii*, *Hirsutella thompsonii.*

Suggestive Readings:

- Food Microbiology, Adams M. R. and Moss M. O., 3rd Ed., 2008, RSC Publishing, Cambridge, UK.
- Fundamental Food Microbiology, Bibek R. and Bhunia A., 5th Ed., 2014, CRC Press, USA.
- Chakraborty-Post harvest technology of cereals, pulses and oil seeds, 1995.
- Boumans, G., Grain Handlings and storage, Development in Agricultural Engg., 4. Elsevier, Tokyo, 1985.

PRACTICAL: MICROBIAL GENETICS AND ENZYMOLOGY PRACTICAL

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course Title & Code	Credit Distribution of The Course			Eligibility Criteria	Pre-requisite(s) of the Course (if any)
	Lecture	Tutorial	Practical / Practice		
Microbial Genetics & Enzymology Practical (PMB 2805 L)	0	0	4	Life Science Graduate from a UGC recognized University	Basic Knowledge of Molecular Biology & Enzymes

LEARNING OBJECTIVES (LO)	
LO-1	To observe bacterial mutants for a clearer concept.
LO-2	To understand the enzyme kinetics and the factors influencing it.
LO-3	To learn the isolation of DNA components from microbes.
COURSE OUTCOMES (CO)	
On Completion of this course, the student will be able to	
CO-1	Understand the agents used to induce mutations and its significance.
CO-2	Extract the chromosomal as well as plasmid DNA from microbes.
CO-3	Understand the activity and kinetics of enzymes.

1. Isolation of lac$^-$ mutant of *E. coli* mutant of using U. V. radiations / chemical as a mutagenic agent.
2. Isolation of streptomycin resistant mutant using gradient plate technique.
3. Isolation of chromosomal DNA and plasmid.
4. Enzymes assay.
5. Substrate specificity and efficiency of enzymatic catalysis.
6. Kinetics of enzyme catalyzed reactions.
7. Effect of pH and temperature on enzyme activity.
8. Immobilization of enzymes using calcium alginate beads.
9. To determine the enzyme activities from soil samples.

PRACTICAL: FERMENTATION TECHNOLOGY, FOOD AND AGRICUTURAL MICROBIOLOGY PRACTICAL

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course Title & Code	Credit Distribution of The Course			Eligibility Criteria	Pre-requisite(s) of the Course (if any)
	Lecture	Tutorial	Practical / Practice		
Fermentation Technology, Food and Agricultural Microbiology Practical (PMB 2806 L)	0	0	4	Life Science Graduate from a UGC recognized University	Basic Knowledge of Microbiology and Fermentation

LEARNING OBJECTIVES (LO)	
LO-1	To understand the practical aspects of fermentation industry.
LO-2	To study the microbes involved in food formation through fermentation.
LO-3	To understand the significance of microbes in agriculture.
COURSE OUTCOMES (CO)	
On Completion of this course, the student will be able to	
CO-1	Handle small scale to large scale fermentation parameters.
CO-2	Understand the preparation and nutritional value of fermented foods.
CO-3	Recognize the diversity of microbes involved in providing nutrients to plants and other crops.

1. Preparation of fermentation media.
2. Isolation, screening and selection of industrially important organisms.
3. Development of the strain.
4. Sterilization and aeration scale-up.
5. Separation and recovery of fermentation products.
6. Isolation of organisms from fermented food products.
7. Development of starter culture.

8. Detection and isolation of food spoiling organisms
9. Isolation of PGPR from root nodules.
10. Isolation of free-living nitrogen-fixing bacteria from soil.
11. Isolation of phosphate & potassium solubilizing bacteria from soil.
12. MPN.
13. Grading of milk.

Suggestive Readings:

- Experimental Microbiology Volume I by Rakesh J. Patel and Kiran R. Patel, Aditya Publications, 2006.
- Experimental Microbiology Volume II by Rakesh J. Patel and Kiran R. Patel, Aditya Publications, 2006.
- Laboratory Manual and Workbook in Microbiology. McGraw-Hill, 2003.