St. Xavier's College (Autonomous), Ahmedabad

Syllabus of Semester – II of the following departments under Faculty of Science based on Post Graduate Curriculum Framework – 2026 & NEP 2020 to be implemented from the Academic Year 2026-27.

FACULTY OF SCIENCE

DEPARTMENT OF MICROBIOLOGY

MSc. Microbiology

CORE PAPER 1: MOLECULAR GENETICS OF MICROORGANISMS

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		
Molecular Genetics of Microorganisms	4	0	2	Life Science Graduate from a UGC recognized University	Basic Knowledge of Molecular Genetics

LEARNING OBJECTIVES (LO)	
LO-1	To understand the molecular mechanisms of mutation, DNA damage and repair, plasmid biology, genetic recombination, and genetic analysis in bacteriophages and fungi.
LO-2	To study the mechanisms of horizontal gene transfer in prokaryotes, including transformation, transduction, and conjugation, and their applications in microbial genetics.

LO-3	To develop knowledge of restriction–modification systems, transposable elements, integrons, and *Agrobacterium*-mediated interkingdom gene transfer.
COURSE OUTCOMES (CO)	
On Completion of this course, the student will be able to	
CO-1	Explain the molecular mechanisms of mutation, DNA repair, plasmid replication and maintenance, genetic recombination, and phage and fungal genetics.
CO-2	Analyse the mechanisms of transformation, transduction, and conjugation and interpret their applications in gene transfer, genetic mapping, and molecular genetic analysis.
CO-3	Describe the structure, functions, and mechanisms of restriction–modification systems and transposable elements, and explain Ti plasmid-mediated DNA transfer in *Agrobacterium*.

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 λ 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 2: MICROBIAL 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		
Microbial Fermentation Technology	4	0	2	Life Science Graduate from a UGC recognized University	Basic Knowledge of Fermentation

LEARNING OBJECTIVES (LO)	
LO-1	To understand the principles of biochemical engineering, microbial growth kinetics, isolation and screening of industrially important microorganisms, and strain improvement for enhanced product yield.
LO-2	To develop knowledge of fermentation processes, fermenter design, upstream processing, bioprocess monitoring, scale-up, and fermentation economics.
LO-3	To study downstream processing techniques, effluent management, and quality assurance and quality control practices for the production of safe, high-quality microbial products.
COURSE OUTCOMES (CO)	
On Completion of this course, the student will be able to	
CO-1	Explain the principles of microbial growth kinetics, industrial strain selection and improvement, fermenter design, and upstream processing for industrial fermentation.
CO-2	Analyse and select appropriate downstream processing techniques for the separation, recovery, purification, drying, and storage of fermentation products, including the treatment of industrial effluents.
CO-3	Apply the principles of quality assurance, quality control, Good Manufacturing Practices (GMP), sterility testing, and microbiological assays to evaluate the quality and safety of fermentation 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. Basic principles of quality control and quality assurance.
3. QC of raw materials, in-process items, finished products, packaging materials, labels, Sterility assurance and testing.
4. QA process and its importance
5. 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 3: MICROBIOLOGY OF FOOD AND AGRICULTURE

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		
Microbiology of Food and Agriculture	4	0	2	Life Science Graduate from a UGC recognized University	Basic Knowledge of Microbiology

LEARNING OBJECTIVES (LO)	
LO-1	To understand foodborne infections, microbial food spoilage, fermented foods, and the applications of microorganisms as food, including mushrooms and *Spirulina*.
LO-2	To study conventional and novel food preservation techniques, microbial interactions in soil, nutrient cycling, biofertilizers, mycorrhiza, vermicomposting, and natural farming practices.
LO-3	To develop knowledge of microbial plant diseases and sustainable plant disease management strategies, including integrated pest management and the use of bacterial, viral, and fungal biocontrol agents.
COURSE OUTCOMES (CO)	
On Completion of this course, the student will be able to	
CO-1	Identify major foodborne pathogens, explain their modes of transmission, and describe microbial food spoilage, fermented food production, and the nutritional importance of microbial foods.
CO-2	Explain food preservation methods, microbial interactions, biogeochemical nutrient cycles, and the role of biofertilizers and beneficial microorganisms in sustainable agriculture.
CO-3	Differentiate major fungal, bacterial, and viral plant diseases and evaluate integrated pest management and microbial biocontrol strategies for sustainable plant disease management.

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, phyllo sphere 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.

SEC: BIOSTATISTICS

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		
Biostatistics	2	0	0	Life Science Graduate from a UGC recognized University	Basic Knowledge of Statistics

LEARNING OBJECTIVES (LO)	
LO-1	To understand the fundamental concepts and applications of biostatistics in microbial research, including sampling techniques, data collection, data representation, and experimental design.
LO-2	To develop skills in summarising and interpreting biological data using measures of central tendency, variability, coefficient of variation, probability, and statistical distributions.
LO-3	To acquire knowledge of statistical hypothesis testing, analysis of variance, correlation, and regression for analysing experimental data and drawing scientifically valid conclusions.
COURSE OUTCOMES (CO)	
On Completion of this course, the student will be able to	
CO-1	Apply appropriate sampling techniques, design of experiments, and data presentation methods to organise and summarise microbiological research data.
CO-2	Select and perform suitable statistical tests, including chi-square, t-test, F-test, and Z-test, and apply one-way and two-way ANOVA to interpret experimental results.

CO-3	Analyse relationships between biological variables using correlation and regression and interpret probability distributions and statistical results to draw evidence-based conclusions in microbiological research.

Unit-1: Introduction to Biostatistics and design of experiments (15 L)

1. Basic definition and applications of statistics in microbial research.
2. Sampling techniques and bias.
3. Design of experiments: objectives, strategies components and basic principles of experiments.
4. Types of data, data collection methods and representation.
5. Measures of central tendency.
6. Measures of variability and coefficient of variation.

Unit-2: Test for Significance and ANOVA (15 L)

1. Test for significance: small sample test (Chi-square, t-test and F test), test for large sample (Z test).
2. One factor at a time and factorial experiments.
3. Analysis of variance (ANOVA), one-way and two-way classification.
4. Correlation and regression analysis.
5. Concept of probability and distributions.

Suggestive Readings:

- Veer Bala Rastogi Fundamentals of Biostatistics, 2nd Edition, VB Publisher, 2009.
- Antonisamy, Premkumar and Christopher Principles and Practices of Biostatistics, Elsevier Publication, 2017.
- Rao and Richard Introduction to Biostatistics and Research Methodology. PHI Learning Pvt. Ltd., 2012.

MAJOR COURSE LAB 1: MOLECULAR GENETICS OF MICROORGANISMS & MICROBIAL FERMENTATION TECHNOLOGY 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		
Molecular Genetics of Microorganisms & Microbial Fermentation Technology Practical	0	0	4	Life Science Graduate from a UGC recognized University	Basic Knowledge of Molecular Genetics & Fermentation

LEARNING OBJECTIVES (LO)	
LO-1	To develop practical skills in microbial mutagenesis, mutant selection, isolation of chromosomal and plasmid DNA, and quantitative analysis of gene expression using the lac operon system.
LO-2	To acquire practical knowledge of fermentation media preparation, isolation and screening of industrially important microorganisms, and strain development for enhanced production of useful metabolites.
LO-3	To understand the practical aspects of fermentation scale-up, sterilisation, aeration, downstream processing, product recovery, and isolation of microorganisms from fermented food products.
COURSE OUTCOMES (CO)	
On Completion of this course, the student will be able to	
CO-1	Perform microbial mutagenesis and mutant selection, isolate chromosomal and plasmid DNA, and estimate enzyme induction using the ONPG assay.
CO-2	Prepare fermentation media and apply appropriate techniques for the isolation, screening, selection, and improvement of industrially important microorganisms.

CO-3	Demonstrate an understanding of fermentation scale-up, sterilisation, aeration, product separation and recovery, and the isolation of microorganisms from fermented food products.

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. ONPG test for quantitative estimation of enzyme induction in lac operon.
5. Preparation of fermentation media.
6. Isolation, screening and selection of industrially important organisms.
7. Development of the strain.
8. Sterilization and aeration scale-up.
9. Separation and recovery of fermentation products.
10. Isolation of organisms from fermented food products.

MAJOR COURSE LAB 2: MICROBIOLOGY OF FOOD AND AGRICULTURE 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		
Microbiology of Food and Agriculture Practical	0	0	4	Life Science Graduate from a UGC recognized University	Basic Knowledge of Microbiology

LEARNING OBJECTIVES (LO)	
LO-1	To develop practical skills in the preparation of starter cultures and probiotics and in the detection, isolation, and study of microorganisms associated with food spoilage and fermentation.
LO-2	To understand and apply microbiological techniques for the isolation of plant growth-promoting rhizobacteria (PGPR), endophytes, free-living nitrogen-fixing bacteria, and phosphate- and potassium-solubilising bacteria.
LO-3	To acquire practical knowledge of milk quality assessment using the Most Probable Number (MPN) method and milk grading techniques.
COURSE OUTCOMES (CO)	
On Completion of this course, the student will be able to	
CO-1	Prepare starter cultures and probiotics and isolate and identify microorganisms associated with food spoilage and fermentation.
CO-2	Isolate and characterise beneficial agricultural microorganisms, including PGPR, endophytes, nitrogen-fixing bacteria, and phosphate- and potassium-solubilising bacteria.
CO-3	Assess the microbiological quality of milk using the MPN method and apply appropriate milk grading techniques to evaluate its quality.

1. Development of starter culture.
2. Detection and isolation of food spoiling organisms
3. Isolation of PGPR from root nodules.
4. Isolation of endophytes from medicinal plants.
5. Isolation of free-living nitrogen-fixing bacteria from soil.
6. Isolation of phosphate & potassium solubilizing bacteria from soil.
7. Preparation of probiotics.
8. MPN of milk.
9. 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.