St. Xavier's College (Autonomous), Ahmedabad

Syllabus of Semester – I 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 DIVERSITY

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 Diversity (PMB 1801)	4	0	2	Life Science Graduate from a UGC recognized University	Basic Knowledge of Microorganisms

LEARNING OBJECTIVES (LO)	
LO-1	Explore, characterize, and quantify the microbial diversity with respect to virus, eubacteria, archaea, fungi, algae and protozoa.
LO-2	To generally describe important interactions within microbial communities and between microorganisms and plants and animals.
LO-3	To describe common groups of bacteria and archaea in different ecosystems, and their role in biogeochemical key processes in these environments.
COURSE OUTCOMES (CO)	
On Completion of this course, the student will be able to	

CO-1	Understand the rich diversity of virus, eubacteria, archaea, fungi, algae and protozoa.
CO-2	Recognize the economic importance of microorganisms.
CO-3	Understand the habitats and classification of various microorganisms.

Unit-1: Fundamentals of Microbial Diversity (15 L)

1. Origin of life on planet Earth and concepts of the tree of life.
2. Concept of microbial diversity and taxonomy: morphological, biochemical, chemical molecular and numerical.
3. Methods of studying microbial diversity: classical and molecular approaches, microbial phylogeny, methods of assessment of non-cultivable microbial diversity.
4. Threat to microbial diversity and conservation strategy.

Unit-2: Diversity of Acellular Organisms (15 L)

1. General characteristics of acellular microorganisms.
2. Characteristics and importance of viroids and prions.
3. Brief history of the discovery of viruses.
4. Properties of viruses: diversity in size, structure, nucleic acid of selected plant and animal viruses.
5. Bacteriophages (bacterial viruses): general property, and diversity of phages.
6. Economic importance of virus.

Unit-3: Diversity of prokaryotes (15 L)

1. General characteristics of prokaryotes.
2. Systematics occurrence, diversity, and classification of eubacteria.
3. Systematics occurrence, diversity, and classification of archaea.
4. Economic importance of prokaryotes.

Unit-4: Diversity of Yeast, Moulds, Algae and Protozoa (15 L)

1. General characteristics, structure, occurrence, classification and reproduction of moulds and yeast, life cycle of selected fungi (*Penicillium / Aspergillus* and *Saccharomyces*).
2. Trends in yeast and moulds diversity.
3. Enumeration of yeasts and moulds.
4. Fungal association: mycorrhiza and lichens.

5. General characteristics, structure, occurrence, and diversity of algae.
6. Structure, occurrence, and diversity of protozoa.
7. Pharmaceuticals and environmental importance of yeast, moulds, algae and protozoa.

Suggestive Readings:

- Madigan et al. Brock Biology of Microorganisms, 14th edition, Pearson Prentice Hall, 2015.
- James T. Staley and Anna-Louise Reysenbach Biodiversity of Microbial Life, Wiley, New York 2001.
- Johri B. N., Extremophiles. Springer Verlag, 2000.

CORE PAPER: MICROBIAL PHYSIOLOGY AND METABOLISM

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 Physiology and Metabolism (PMB 1802)	4	0	2	Life Science Graduate from a UGC recognized University	Basic Knowledge of Physiology and Metabolism

LEARNING OBJECTIVES (LO)	
LO-1	Imparting the in-depth knowledge in microbial growth and physiology.
LO-2	To acquire and apply knowledge of metabolic pathways.
LO-3	To analyse and explain regulation of metabolic pathways.
LO-4	To learn about microbial transport systems, modes and mechanisms of energy conservation in microbial metabolism.
COURSE OUTCOMES (CO)	
On Completion of this course, the student will be able to	
CO-1	Understand the transport of nutrients as well as waste products across the microbial membranes.
CO-2	Recognize the adaptation capacity of extremophiles.
CO-3	Understand the central metabolic pathways and nitrogen metabolism.

Unit-1: Growth, Cell Division and Solute Transport (15 L)

1. Microbial nutrition: Classification of nutrients, uptake and transport of nutrients.
2. Measurements of growth, physiology of growth, cell division, growth yield and kinetics, Synchronous and Diauxic growth, steady-state and continuous growth.
3. Signal Transduction and Quorum sensing.

Unit-2: Physiological Adaption and Signalling (15 L)

1. Introduction to the two-component system, regulatory system during aerobic-anaerobic shift, response to phosphate supply.
2. Adaptation mechanism in extremophiles.
3. Homeostasis and Survival.
4. Sporulation and control of competence in *Bacillus subtilis*, heat-shock response.
5. Microbial toxins.

Unit-3: Central Metabolic Pathways and their Regulation (15 L)

1. Glycolysis and its regulation, gluconeogenesis, pentose-phosphate pathway, Entner-Doudoroff pathway, citric acid cycle, alternate TCA, glyoxylate pathway and its regulation.
2. Examples of pathway engineering of carbon metabolic pathways to develop industrial useful strains: co-metabolism of pentoses and hexoses, succinic and citric acid production, hydrocarbons utilisation, PHA synthesis and degradation.
3. Metabolism of lipids: biosynthesis of lipid, degradation / oxidation of lipids and its regulation in *E. coli*, lipid accumulation in yeast / *Bacillus.*

Unit-4: Nitrogen Metabolism (15 L)

1. Metabolism of nucleotides: purine and pyrimidine biosynthesis, deoxyribonucleotide synthesis, regulation of purine and pyrimidine biosynthesis, inhibitors of nucleotide biosynthesis.
2. Nitrogen metabolism: inorganic nitrogen assimilation - nitrate and ammonia assimilation, regulation of glutamate synthetase, and Stickland reaction. Amino acid metabolism.
3. Glutathione: distribution in bacteria, biosynthesis and role in redox regulation.

Suggestive Readings:

- Nelson and Cox, Lehninger - Principles of Biochemistry, 6th edition, W.H Freeman and Company, 2013.
- L. Stryer, Biochemistry, 5th edition, W.H. Freeman and Company, 2002.
- D. Voet and J. G. Voet, Biochemistry, 3rd edition, John Wiley, New York, 2004.
- Reddy S. R. and Reddy S. M., Microbial Physiology, 2nd Ed., Scientific Publishers, 2022.

CORE PAPER: IMMUNOLOGY AND MEDICAL 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		
Immunology and Medical Microbiology (PMB 1803)	4	0	2	Life Science Graduate from a UGC recognized University	Basic Knowledge of Immune System

LEARNING OBJECTIVES (LO)	
LO-1	To explain basic concept of immune response and its impact towards disease.
LO-2	Interactions of microbes with humans with knowledge in the field of immunology is provided.
LO-3	Learning the deficiencies and disorders of immune system.
COURSE OUTCOMES (CO)	
On Completion of this course, the student will be able to	
CO-1	Understand the recent development in the field of immunology.
CO-2	Get an insight regarding the autoimmune diseases and immune disorders.
CO-3	Understand the latest developments in various microbial diseases.

Unit-1: Recent Advances in Immunobiology (15 L)

1. Recent advances in innate immunity including receptors involved and the signalling system, physiological & immunological barriers.
2. The cellular players: phagocytic cells, lymphocytic cells, DCs.
3. The innate immune response: inflammation, acute phase reaction.
4. Molecular basis of diversity of immunoglobulin molecules.
5. Multigene organisation of Ig genes.
6. Variable-region gene rearrangements.
7. Mechanism of Variable-region DNA rearrangements.

8. Generation of antibody diversity.
9. Manipulations of the immune response.

Unit-2: Immune tolerance, autoimmunity and immune disorders (15 L)

1. Recent advances in immune tolerance: a) central tolerance, b) peripheral tolerance, c) tolerance induction, d) T-cell tolerance, e) B-cell tolerance, f) incomplete tolerance, g) duration of tolerance.
2. Recent advances in autoimmunity: a) interplaying factors, b) triggering factors, c) mechanisms of damage, d) organ-specific autoimmune diseases, e) -systemic autoimmune diseases, f) animal models for autoimmune diseases, g) proposed mechanisms for induction of autoimmunity, h) treatment of autoimmune diseases.
3. Transplantation & transfusion immunology: a) antigens involved in graft rejection, b) allorecognition, c) graft rejection - role of APC's & effector cells, d) graft v/s host diseases, e) immuno suppressive therapies, f) blood transfusion: i. ABO & Rh blood Groups, ii. potential transfusion hazards, iii. transfusion alternatives.
4. Cancer immunology: a) cancer: origin & terminology, b) malignant transformation of cells, c) oncogenes & cancer induction, d) tumors of the immune system.

Unit-3: Epidemiology and Pathogenicity (15 L)

1. Classification of infectious diseases.
2. Types of diseases: endemic, epidemic, pandemic and sporadic.
3. Reservoirs, sources and transmission of infectious diseases.
4. Mechanism and factors involved in establishing and spreading infection, adhesion, invasiveness and toxigenicity.
5. Prevention and control measures of the diseases.
6. Hospital-acquired infections and their prevention.

Unit-4: Recent Advances in Medical Microbiology (15 L)

1. Multidrug resistance organisms and biochemical mechanism of resistance developments.
2. Introduction to emerging diseases: dengue haemorrhagic fever, swine flu, chikungunya, ebola, SARS, covid.
3. Current status of HIV, Malaria, Tuberculosis and Covid treatment/vaccine.

Suggestive Readings:

- Owen et al., Kuby-Immunology, 7th Edition, W. H. Freeman and Co., 2013.
- Cruckshanak et al., Medical Microbiology Vol I & II, Churchill Livingstone.
- Ryan K. J. and Ray C. G., Sherris Medical Microbiology: An Introduction to Infectious Diseases, 4th Edition, McGraw-Hill, Medical Publishing Division, 2004.

CORE PAPER: BIOSTATISTICS AND BIOINSTRUMENTATION

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 and Bioinstrumentation (PMB 1804)	4	0	2	Life Science Graduate from a UGC recognized University	Basic Knowledge of Statistics and Bioscience Lab Instruments

LEARNING OBJECTIVES (LO)	
LO-1	To introduce basic biostatistical techniques useful for analysing data arising in Microbiology and other health science domains.
LO-2	To emphasize statistical reasoning through problem solving and applications.
LO-3	To have basic knowledge regarding instrumentation techniques in Biological Sciences.
LO-4	To learn and apply standard operating procedure of various biological laboratory instruments.
COURSE OUTCOMES (CO)	
On Completion of this course, the student will be able to	
CO-1	Use the statistics in interpretation of practical results.
CO-2	Understand the standard deviation and can use ANNOVA with practical data.
CO-3	Understand the working and principle of lab instruments.

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 ANNOVA (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 (ANNOVA), one-way and two-way classification.
4. Correlation and regression analysis.
5. Concept of probability and distributions.

Unit-3: Microscopy, spectrophotometry and spectroscopy (15 L)
(Principals, working and applications)

1. Microscopy: Compound, phase contrast, fluorescence, infra-red, electron, confocal, and atomic force microscopy.
2. Spectrophotometry and spectroscopy: absorption and emission spectroscopy, visible ultraviolet and infrared spectroscopy, fluorescence spectroscopy, electron spin resonance spectroscopy, nuclear magnetic resonance (NMR) spectroscopy, mass spectroscopy, MALDI-TOF and quadrupole spectroscopy.

Unit-4: Centrifugation, Chromatography, Electrophoresis and PCR techniques (15 L)
(Principals, working and applications)

1. Centrifugation and separation techniques: ultracentrifugation, density gradient centrifugation.
2. Chromatography: paper and thin layer chromatography, column chromatography – ion exchange, adsorption, affinity, hydrophobic interaction, size exclusion, gas chromatography, HPLC.
3. Electrophoresis: polyacrylamide gel electrophoresis (PAGE), native and gradient gel, DNA sequence gel, SDS-PAGE, isoelectric focusing gel, 2-D PAGE.
4. Agarose gel electrophoresis-DNA gel, Pulsed-field gel and capillary electrophoresis.
5. PCR: Different techniques, instruments used and their applications.

Suggestive Readings:

- Wilson and Walker. Principles and Techniques of Practical Biochemistry, 8th Edition, Cambridge Uni. Press, 2018.
- Chatwal and Anand, Instrumental Methods of Chemical Analysis. HPH, 2011.
- Veer Bala Rastogi Fundamentals of Biostatistics, 2nd Edition, VB Publisher, 2009.

PRACTICAL: MICROBIAL DIVERSITY AND PHYSIOLOGY 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 Diversity and Physiology Practical (PMB 1805 L)	0	0	4	Life Science Graduate from a UGC recognized University	Basic Knowledge of Microorganisms and Physiology

LEARNING OBJECTIVES (LO)	
LO-1	To understand the significance of microbial diversity.
LO-2	To learn various different types of bacterial, fungal and bacteriophage diversity.
LO-3	To understand the significance of microbial measurement in learning diversity and physiology.
COURSE OUTCOMES (CO)	
On Completion of this course, the student will be able to	
CO-1	Identify bacterial, fungal and extremophiles diversity.
CO-2	Understand bacterial growth curve and its kinetics.
CO-3	Isolate bacteriophages and understand plaque forming units.

1. Diversity study of cultivable microorganisms from soil / water / air.

2. Isolation of bacteria from various samples by enrichment techniques and their identification. by conventional biochemical approach.

3. Measurement of microbial cell size using Micrometry.

4. Isolation and study of Molds, Yeast, Algae.

5. Isolation and characterisation of microorganisms from extreme environments.

6. Isolation and titration of bacteriophage.

7. Study of bacterial growth curve and its kinetics.

8. Determination of bacterial growth rate and factors influencing it.

9. Endospore formation in *Bacillus subtilis*: Requirements for germination and outgrowth of spores.

10. Study of dimorphism in yeast.

PRACTICAL: IMMUNOLOGY, BIOSTATISTICS AND BIOINSTRUMENTATION 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		
Immunology, Biostatistics and Bioinstrumentation Practical (PMB 1806 L)	0	0	4	Life Science Graduate from a UGC recognized University	Basic Knowledge of Immune System, Statistics and Bioscience Instruments

LEARNING OBJECTIVES (LO)	
LO-1	To understand the principle and working of various bioscience instruments.
LO-2	To learn how to prepare various solution in any bioscience lab.
LO-3	To understand the basics of biostatistics while doing bioscience practical.
LO-4	To learn the immunological aspects through practical.
COURSE OUTCOMES (CO)	
On Completion of this course, the student will be able to	
CO-1	The SOPs of all the bioscience lab basic instruments.
CO-2	Prepare various types of solutions for the lab use.
CO-3	Use statistics in analysing the practical results.
CO-4	Understand the immunological reactions like agglutination, precipitation etc.

1. Demonstration of basic laboratory instruments.

2. Preparation of standard solutions, buffers and their standardisation.

3. Determination of lambda max of the given sample.

4. Sterilisation of the samples by various methods and their evaluation.

5. Observation of the given microbial samples by special staining.

6. Statistical analysis of data: Measures of central tendency.

7. Calculation of standard deviation.

8. Data presentation.

9. Separation of biomolecules using paper and thin layer chromatography.

10. Separation of biomolecules using electrophoresis.

11. Immunological interaction between Ag and Ab: ▪Immunoprecipitation ▪Agglutination.

12. Immunoelectrophoresis.

13. Radial immunodiffusion assay.

14. Rocket immunoelectrophoresis.

15. Quantitative precipitation assay.

16. Dot-ELISA.

17. Latex agglutination test.

18. Determination of MIC of the given samples on selected bacteria.

19. Isolation and detection of possible pathogenic bacteria from the given infected sample (Urine / stool / sputum / blood).

20. Study of antibiotic resistance of the given bacterial sample (antibiotic paper disc method).