

Revised

after Syllabus/ Curriculum Subcommittee Meeting
Faculty of Biological Sciences, University of Dhaka
Dated 17 Nov 2025



Faculty of Biological Sciences

University of Dhaka

**Outcome Based Education (OBE) Curriculum
Bachelor of Science (BS) Honours in Microbiology
Department of Microbiology, University of Dhaka
Dhaka 1000, Bangladesh**

Sessions: 2025-2026 and onward



Faculty Approval Date:

Academic Council Approval Date:

Outcome Based Education (OBE) Curriculum

Bachelor of Science (BS) Honours in Microbiology



Preface

Since its establishment in 1979 with the launch of the Master of Science (MSc) program under the Faculty of Biological Sciences, the Department of Microbiology at the University of Dhaka has grown into a center of excellence in Microbiology, Molecular Biology, and Biotechnology. Through sustained collaboration with national and international organizations, the Department has earned a strong reputation both in Bangladesh and abroad.

To meet the increasing demand for skilled microbiologists in academia, research, and industry, the Department introduced the Bachelor of Science (BS) Honours program in 1989. Since then, the curriculum has been regularly revised to remain aligned with global standards and national priorities.

The Department has now adopted and updated an **Outcome Based Education (OBE)** curriculum for the BS Honours in Microbiology, following the guidelines set by the University Grants Commission (UGC) of Bangladesh, Bangladesh Accreditation Council (BAC), Institutional Quality Assurance Cell (IQAC), and the University of Dhaka. The Curriculum Committee conducted a comprehensive review process, incorporating feedback from stakeholders and insights from the Self-Assessment Report (SAR) through online consultations and surveys. This updated curriculum follows the UGC's prescribed format (2021) and adheres to the Bangladesh National Qualification Framework (BNQF, 2021).

The OBE curriculum aims to deliver high-quality education and foster research excellence by equipping students with the intellectual and technological competencies needed for academic, professional, and social success. Key features of the OBE curriculum include clearly defined graduate profiles, level descriptors, and Programme Learning Outcomes (PLOs), which are systematically mapped to Course Learning Outcomes (CLOs). The four-year BS Honours program offers:

- Broad and in-depth knowledge in Microbiology,
- Strong analytical and technological skills, and
- Capacity to contribute to public health, economic development, and environmental sustainability through expertise in microbial technologies.

In addition to the undergraduate program, the Department also offers postgraduate studies and research opportunities through its MS, MPhil, and PhD programs. Finally, the Curriculum Committee gratefully acknowledges the support and contributions of the University of Dhaka, the UGC of Bangladesh, and all stakeholders who assisted in the development of this OBE curriculum.

Syllabus and Curriculum Committee

12 November 2025

Department of Microbiology

University of Dhaka, Dhaka 1000, Bangladesh



Table of Contents

Outcome-based Curriculum		Pages
Part A	Title of the Academic Program	4-10
	Name of the University	
	Vision of the University	
	Mission of the University	
	Name of the Program Offering Entity	
	Vision of the Program Offering Entity	
	Mission of the Program Offering Entity	
	Objectives of the Program Offering Entity	
	Name of the Degree	
	Description of the Program	
	Graduate Attributes	
	Program Educational Objectives (PEOs)	
	Program Learning Outcomes (PLOs)	
	Mapping the Mission of the university with PEOs	
	Mapping PLOs with the PEOs	
	Mapping courses with the PLOs	
Part B	Structure of the Curriculum	11-16
	Distribution of Courses	
Part C	Description of Courses (following BNQF)	17-135
Part D	Grading Evaluation	136-139
	General Regulations and Guidelines	140-144

Part A

Introduction of the Program

Part A



1. Title of the Academic Program:

Bachelor of Science (BS) Honours in Microbiology

2. Name of the University: University of Dhaka

3. Vision of the University:

Create a world-class educational ecosystem that enables individuals to act as dynamic human capital and ethical leaders for a sustainable future

4. Mission of the University:

UM1	Transformative Education
	Provide transformative education by enabling students to embrace lifelong learning and fostering a sustainable knowledge-based society through the continuous pursuit of scholarship, humanistic values, and technological innovation.
UM2	Collaborative Research and Innovation
	Pursue collaborative research and innovation, leveraging partnerships to expand the boundaries of knowledge.
UM3	Educational Ecology
	Develop an educational ecosystem that fosters excellence, transparency, inclusivity, and accountability.
UM4	Community Engagement
	Engage with stakeholders and communities to build a just, fair, diverse, and sustainable world.
UM5	Ethical Responsibility
	Encourage students to become ethically responsible global citizens with a positive societal impact.
UM6	National Heritage
	Instill a deep sense of national heritage and pride in students, upholding historical roots and global connectivity.

5. Name of the Program Offering Entity (Department/Faculty/Institute):

Department of Microbiology

6. Vision of the Program Offering Entity:

Evolving as a national center of excellence for microbiology education and research at graduate and postgraduate levels to enhance the intellectual foundation equipped with in-depth knowledge and skills for a professional career in microbiology and disseminating the knowledge imperative for the national and global interests for sustainable development.

7. Mission of the Program Offering Entity:

Codes	Description
M1	To provide an outstanding academic, infrastructural, and moral environment that promotes quality education and excellence in teaching, learning, and research in the field of Microbiology.
M2	To create, expand, and enhance knowledge and training in microbiological sciences to address national, regional, and global interests.
M3	To cultivate critical thinking and spark creativity in science, technology, and innovation, while nurturing talent with excellent skills to foster leadership, self-confidence, and self-reliance.
M4	To address and cater to the growing global demand for skilled microbiologists worldwide and prepare students to become responsible, contributing citizens and members of society.

8. Objectives of the Program Offering Entity:

The program is designed to equip undergraduate students with the knowledge, skills, and attributes necessary to meet employer expectations or to pursue postgraduate studies and research in applied microbiology. Graduates will be prepared to contribute to national economic development, support the Sustainable Development Goals (SDGs), and respond to the evolving challenges of the Fourth Industrial Revolution.

Upon completing the program, students will be able to demonstrate:

- **Knowledge Acquisition:** The ability to comprehend, articulate, and apply specialized terminology and core conceptual frameworks in microbiological sciences.
- **Laboratory Competency:** Proficiency in laboratory safety protocols and the execution of both fundamental and advanced microbiological techniques with precision. This includes the integration of artificial intelligence (AI) tools for data analysis, alongside the application of essential soft skills. Students will be able to accurately document and interpret experimental observations and results.
- **Effective Communication:** The capacity to communicate scientific principles, experimental findings, and analytical interpretations clearly and confidently, in both written and oral formats, tailored to academic, professional, and public audiences.
- **Engagement and Application:** Active participation in research projects, internships, or fieldwork; meaningful contribution to microbiology-focused clubs or associations; and involvement in outreach or peer mentoring activities that promote the practical application and societal relevance of microbiology.

9. Name of the Degree: Bachelor of Science (BS) Honours in Microbiology

10. Description of the Program:

The four-year Bachelor of Science (Honours) program in Microbiology is designed to equip students with a comprehensive and in-depth understanding of the microbial world and its relevance to health, environment, agriculture, and industry. The curriculum is thoughtfully structured to foster both theoretical knowledge and practical competencies, enabling students to pursue advanced studies, research, or professional careers in diverse fields of microbiology.

11. Graduate Attributes (based on need assessment):

The program is designed to develop a set of graduate attributes that reflect the competencies, values, and mindsets expected of future microbiologists. Upon completion of the BS (Honours) in Microbiology, graduates will demonstrate the following attributes:

GA code	Graduate Attribute	Description
GA 1	Foundational Knowledge and Skills	Demonstrate a comprehensive and coherent understanding of microbiological sciences essential for professional practice.
GA 2	Research and Innovation	Exhibit moderately high research aptitude, creativity, and capacity for innovation in microbiological inquiry.
GA 3	Independent and Collaborative Research	Capable of conducting research both independently and collaboratively under appropriate supervision.
GA 4	Professionalism and Ethics	Display resilience, responsibility, and ethical conduct in all microbiological professional engagements.
GA 5	Cultural Sensitivity and Environmental Stewardship	Recognize and value cultural diversity and sustainability imperatives in scientific and societal contexts.
GA 6	National Responsibility and Global Citizenship	Be aware of national priorities and global challenges, and act with a sense of civic duty and global awareness.

12. Program Educational Objectives (PEOs):

The BS (Honours) program in Microbiology is designed to prepare graduates for academic, professional, and societal excellence. Within a few years of graduation, alumni are expected to demonstrate the following attributes:

PEOs	Description
PEO 1	Gain applied knowledge, practical skills, and professional attitudes that ensure their competency and recognition in the microbiology profession.
PEO 2	Appreciate, adopt, and contribute to cutting-edge technologies and research innovations in microbiological sciences.

PEO 3	Apply essential professional and interpersonal skills to engage effectively with healthcare sectors, food and pharmaceutical industries, environmental services, and biotechnology enterprises.
PEO 4	Contribute to the advancement of microbiology through active collaboration with national and international academic, research, and professional organizations.

13. Program Learning Outcomes (PLOs):

Upon successful completion of the BS (Honours) program in Microbiology, graduates will be able to:

Statement	
PLO1	Demonstrate knowledge and a critical understanding of foundational and advanced principles in Microbiology, including their historical and contemporary development.
PLO2	Critically evaluate the suitability of various scientific approaches and methodologies to solve microbiological problems.
PLO3	Apply theoretical knowledge and technical skills to address microbiological issues and solve problems with minimal supervision.
PLO4	Design, plan, and execute microbiological experiments using appropriate techniques, methodologies, and tools.
PLO5	Exhibit competence in applying microbiological knowledge and laboratory skills in academic, industrial, and unfamiliar or evolving professional contexts.
PLO6	Demonstrate leadership capabilities and the ability to work independently as well as collaboratively in diverse team settings.
PLO7	Uphold ethical standards and exhibit a strong sense of social responsibility in professional and community contexts.

14. Mapping missions of the university with PEOs:

	UM1	UM2	UM3	UM4	UM5	UM6
PEOs	<i>Transformative Education</i>	<i>Collaborative Research and Innovation</i>	<i>Educational Ecology</i>	<i>Community Engagement</i>	<i>Ethical Responsibility</i>	<i>National Heritage</i>
PEO 1	√		√			
PEO 2	√	√				
PEO 3				√	√	
PEO 4		√				√

15. Mapping PLOs with the PEOs:

PLOs	PEO1	PEO2	PEO3	PEO4
PLO 1	✓	✓		
PLO 2	✓	✓		
PLO 3	✓		✓	
PLO 4	✓	✓	✓	
PLO 5	✓		✓	
PLO 6			✓	✓
PLO 7			✓	✓

16. Mapping courses with the PLOs:

Course codes	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7
MBG 101C	✓	✓	✓	✓	✓	✓	
MBG 102C	✓	✓	✓	✓	✓	✓	
MBG 103C	✓	✓	✓	✓	✓		
MBG 104C	✓	✓	✓	✓	✓	✓	
MBG 105C	✓	✓	✓	✓	✓		
MBG 106C	✓	✓	✓	✓	✓	✓	✓
MBG 107C	✓	✓	✓	✓	✓		
MBG 108G	✓	✓	✓	✓	✓	✓	
MBG 109G	✓	✓	✓	✓	✓	✓	✓
CM 100F	✓	✓	✓	✓	✓	✓	
MBG 110K	✓	✓	✓	✓	✓	✓	✓
MBG 201C	✓	✓	✓	✓	✓	✓	
MBG 202C	✓	✓	✓	✓	✓	✓	
MBG 203C	✓	✓	✓	✓	✓	✓	
MBG 204C	✓	✓	✓	✓	✓	✓	
MBG 205C	✓	✓	✓	✓	✓	✓	✓
MBG 206C	✓	✓	✓	✓	✓	✓	
MBG 207C	✓	✓	✓	✓	✓	✓	
MBG 208C	✓	✓	✓	✓	✓	✓	
MBG 209C	✓	✓	✓	✓	✓	✓	✓
MBG 210C	✓	✓	✓	✓	✓	✓	
MBG 211G	✓	✓	✓	✓	✓	✓	✓

Course codes	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7
CM 222H	√	√	√	√	√	√	
CMGL101H	√	√	√	√	√	√	√
MBG 301C	√	√	√	√	√	√	√
MBG 302C	√	√	√	√	√	√	√
MBG 303C	√	√	√	√	√	√	
MBG 304C	√	√	√	√	√	√	
MBG 305C	√	√	√	√	√	√	√
MBG 306C	√	√	√	√	√	√	
MBG 307C	√	√	√	√	√	√	
MBG 308C	√	√	√	√	√	√	√
MBG 309C	√	√	√	√	√	√	√
MBG 310C	√	√	√	√	√	√	√
MBG 311C	√	√	√	√	√	√	√
MBG 312C	√	√	√	√	√	√	√
MBG 313E	√	√	√	√	√	√	
MBG 314E	√	√	√	√	√	√	
MBG 401C	√	√	√	√	√	√	
MBG 402C	√	√	√	√	√	√	
MBG 403C	√	√	√	√	√	√	√
MBG 404C	√	√	√	√	√	√	√
MBG 405C	√	√	√	√	√	√	√
MBG 406C	√	√	√	√	√	√	√
MBG 407C	√	√	√	√	√	√	√
MBG 408C	√	√	√	√	√	√	√
MBG 409C	√	√	√	√	√	√	√
MBG 410C	√	√	√	√	√	√	√
MBG 411K	√	√	√	√	√	√	√
MBG 412E	√	√	√	√	√	√	√
MBG 413E	√	√	√	√	√	√	√
MBG 414E	√	√	√	√	√	√	√
MBG 415E	√	√	√	√	√	√	√

Part B

Structure of the Curriculum

&

Distribution of Courses

Part B

17. Structure of the Curriculum

a) Duration of the programme: Four Years

b) Admission Requirements:

To be eligible for admission into the four-year BS Honours program in Microbiology, candidates must have studied Biology, Chemistry, and Physics in their Higher Secondary Certificate (HSC) or equivalent examinations under the Science group or any other recognized equivalent qualification. Admission eligibility, selection criteria, and procedures shall be determined following the prevailing rules and regulations set by the University of Dhaka.

c) Total minimum credit requirement to complete the program: 140 Credits.

d) Total class weeks in a Year/ Semester: 28 weeks in a year

e) Minimum CGPA requirements for graduation: To be eligible for the award of the Bachelor's degree, a student must obtain a minimum Cumulative Grade Point Average (CGPA) of 2.00 on a 4.00 scale, with no 'F' grade in any course.

f) Maximum academic years of completion: Students must fulfill all academic requirements for the Bachelor's degree within a maximum period of 6 (six) academic years, starting from the year of initial registration.

g) Category of Courses: To ensure holistic and multidisciplinary training, the academic program comprises four distinct categories of courses:

- I. **General Courses:** Interdisciplinary in scope, these courses, comprising theoretical and/or practical components, broaden the students' academic perspective and contextual understanding beyond the core discipline. They are intended to enhance critical thinking and foster cross-disciplinary learning.
- II. **Core Courses:** These courses constitute the foundational framework of microbiological education, integrating theoretical lectures, laboratory experiments, and viva-voce examinations. They provide essential knowledge and technical skills across key areas of microbiology.
- III. **Elective Courses:** Designed to deepen specialization, elective courses offer students the opportunity to explore advanced and emerging topics within microbiology. These courses include both classroom instruction and practical/laboratory training to reinforce applied learning.
- IV. **Capstone Courses:** These culminating experiences include capstone projects, internships, fieldwork, portfolios, or equivalent activities. They are intended to enhance students' applied skills and professional readiness and are periodically updated by the Department to maintain curricular relevance and ensure balanced assessment.

h) Credit Hour distribution: One credit hour equals -

- 15 contact hours for theoretical courses,

- 20 contact hours for laboratory work,
- 28 contact hours for internships, fieldwork, or other skill-enhancement activities, as determined by the Department.

i) Assignment of Credits:

Academic Year	Core Course (credits)			General Course (credits)		Elective Course (credits)	Capstone Course (credits)	Total Credits	Total Marks
	Theoretical course	Laboratory works	Viva-voce	Theoretical course	Laboratory works				
First Year	15	4	2	9	0	0	2	32	800
Second Year	18	6	2	6	2	0	0	34	850
Third Year	24	8	2	0	0	2	0	36	900
Fourth Year	24	6	2	0	0	4	2	38	950
Total	81	24	8	15	2	6	4	140	3500

18. Distribution of Courses (year-wise):

1st year BS Honours

Course	Marks	Credits
7 Core courses	525	21
3 General courses	225	9
0 Elective Course	0	0
1 Capstone course	50	2
Total	800	32

Course code	Course name	Marks	Credit	Obligation
Core courses				
MBG 101C	Introductory Microbiology	75	3	Mandatory
MBG 102C	Microbial Diversity and Ecology	50	2	Mandatory
MBG 103C	Human Physiology	75	3	Mandatory
MBG 104C	Basic Techniques in Microbiology	75	3	Mandatory

MBG 105C	Basic Biochemistry	100	4	Mandatory
MBG 106C	Laboratory Works I	100	4	Mandatory
MBG 107C	Viva-Voce	50	2	Mandatory
General courses				
MBG 108G	Computer Applications for Life Sciences	75	3	Mandatory
MBG 109G	Communicative English	50	2	Mandatory
CM 100F	Fundamentals of Chemistry	100	4	Mandatory
Capstone course				
MBG 110K	Science Communication	50	2	Mandatory

2nd year BS Honours

Course	Marks	Credits
10 Core courses	650	26
3 General courses	200	8
0 Elective course	0	0
0 Capstone course	0	0
Total	850	34

Course code	Course name	Marks	Credit	Obligation
Core courses				
MBG 201C	Environmental Microbiology	50	2	Mandatory
MBG 202C	Bacterial Metabolism	50	2	Mandatory
MBG 203C	Genetics	75	3	Mandatory
MBG 204C	Medical Microbiology	50	2	Mandatory
MBG 205C	Food Microbiology	50	2	Mandatory
MBG 206C	Fundamentals of Enzymology	75	3	Mandatory
MBG 207C	Fundamentals of Cell Biology	50	2	Mandatory
MBG 208C	Applied Mycology	50	2	Mandatory
MBG 209C	Laboratory Works II	150	6	Mandatory
MBG 210C	Viva-Voce	50	2	Mandatory

General courses				
MBG 211G	Biostatistics and Calculus	100	4	Mandatory
CM 222H	Biologically Important Organic Compounds	50	2	Mandatory
CMGL101H	General Chemistry Laboratory	50	2	Mandatory

3rd year BS Honours

Course	Marks	Credits
12 Core courses	850	34
0 General Course	0	0
1 Elective course	50	2
0 Capstone course	0	0
Total	900	36

Course code	Course name	Marks	Credit	Obligation
Core courses				
MBG 301C	Biosynthetic Metabolism	50	2	Mandatory
MBG 302C	Microbial Molecular Genetics	75	3	Mandatory
MBG 303C	Microbial Pathogenesis	75	3	Mandatory
MBG 304C	Virology	50	2	Mandatory
MBG 305C	Basic Immunology	100	4	Mandatory
MBG 306C	Cell Biology	50	2	Mandatory
MBG 307C	Agricultural Microbiology	50	2	Mandatory
MBG 308C	Fermentation Technology	50	2	Mandatory
MBG 309C	Food Safety and Quality Control	50	2	Mandatory
MBG 310C	Pharmaceutical Microbiology	50	2	Mandatory
MBG 311C	Laboratory Works III	200	8	Mandatory
MBG 312C	Viva-Voce	50	2	Mandatory
Elective courses				
MBG 313E	Marine Microbiology	50	2	Optional
MBG 314E	Biophysics	50	2	Optional

4th year BS Honours

Course	Marks	Credits
10 Core courses	800	32
0 General Course	0	0
2 Elective courses	100	4
1 Capstone course	50	2
Total	950	38

Course code	Course name	Marks	Credit	Obligation
Core courses				
MBG 401C	Advanced Virology	100	4	Mandatory
MBG 402C	Advanced Immunology	50	2	Mandatory
MBG 403C	Genomics, Proteomics and Bioinformatics	100	4	Mandatory
MBG 404C	Genetic Engineering	75	3	Mandatory
MBG 405C	Microbial Biotechnology	75	3	Mandatory
MBG 406C	Analytical Techniques in Life Sciences	75	3	Mandatory
MBG 407C	Microbial Diagnosis in Health Clinics	75	3	Mandatory
MBG 408C	Research Methodology	50	2	Mandatory
MBG 409C	Laboratory Works IV	150	6	Mandatory
MBG 410C	Viva-Voce	50	2	Mandatory
Capstone course				
MBG 411K	Research Projects	50	2	Mandatory
Elective courses				
MBG 412E	Industrial Microbiology	50	2	Optional
MBG 413E	Epidemiology, Public Health, and Bioethics	50	2	Optional
MBG 414E	Advances in Food Fermentation Techniques	50	2	Optional
MBG 415E	Environmental Pollution and Bioremediation	50	2	Optional

Part C

Description of Courses

Template used at the onset of course introduction

Course code	Title of the Course	Credits	Class: Contact hours
-------------	---------------------	---------	----------------------

19. Part C

Courses for 1st year BS Honours

First Year foundation courses provide a broad introduction to biological sciences with supporting courses, covering key concepts and introduction to the essential data handling, strengthen skills in communication, laboratory works and academic integrity required for all the microbiological scientists. The course unit details given below are subject to change and are the latest example of the curriculum available on this course of study.

MBG 101C Introductory Microbiology

Credits: 3

Class: 45 hours

The course is designed for undergraduate beginners in microbiology and is intended to cover all the basic concepts and principles that a student should know the different aspects of microbiology, including recent developments in the area. It provides a comprehensive account of the microbial world, including both general and applied aspects. The course lies in its clearly defined targets and concisely in its frequent references to microbiological concepts, characteristics of different groups of microorganisms, and their applications to various fields for human welfare.

Course Objectives:

1. To recognize and apply concepts and theories of basic microbiological sciences.
2. To demonstrate the science of microbiology contributing various fields for human welfare.
3. To apply the knowledge on functions of various microorganisms in everyday interactions.

Course Learning Outcomes (CLOs):

1. Understand the aspects of microbiological sciences and its impacts on human society, environment and health.
2. Demonstrate the historical development with concepts and theories of science of microbiology.
3. Familiar with the morphological, molecular and functional characteristic features of prokaryotic and eukaryotic cells.
4. Explain basic structures and characteristics of bacteria including morphology, growth and growth requirements, and cultural properties.
5. Understand the nature, habitats, classification and economic importance of atypical bacteria, archaea, algae, fungi, protozoa and viruses.

Unit	Course Content	Class hours
1	Introduction to Science of Microbiology: Basic science of microbiology; Development of microscopes; Branches microbiology; Application of microbiology in human welfare, environment and health; Classification of microorganisms; Study of phylogenetic relationships.	6

2	Historical Development of Microbiology: Discovery of microorganisms; Origin of life; Spontaneous generation vs biogenesis; Germ theory of disease; Development of laboratory techniques, fermentation, vaccination, antisepsis and chemotherapy; The golden age of and contributions in historical development of microbiology.	6
3	Prokaryotic Cells: Introduction to cells; Morphological characterization, ultra-structure and chemical composition of prokaryotic cells; Functions of different sub-cellular elements; Endosymbiotic concept.	5
4	Introduction to Bacteria: Structure, size, shape and arrangements; Characteristics of Gram-negative and Gram-positive bacteria; Morphological, nutritional and cultural characteristics.	5
5	Eukaryotic Cell Structure: Structure and sub-cellular organelles; Rough and smooth endoplasmic reticulum (ER); Role of the vacuole in plant cells; Tonoplast; Cytoskeleton, nucleoid, nuclear envelope, nuclear pore complex and nuclear lamina; Chromatin, nucleolus.	8
6	Atypical Bacteria: General characteristics and importance of actinomyces, cyanobacteria, mycoplasmas, rickettsia, chlamydia and spirochetes; gliding, sheathed, budding and appendaged bacteria	7
7	Introduction to Microbes other than Bacteria: General characteristics, morphological and physiological properties, classification, distribution in nature and economic importance of archaea, viruses, fungi, algae and protozoa.	8

Recommended Books::

1. Microbiology - M.J. Pelczar Jr., E.C.S. Chan and N.R. Krieg; McGraw-Hill Inc. New York
2. Microbiology: An Introduction - G.J. Tortora, B.R. Funke and C.L. Case; Pearson, Boston
3. Introductory Microbiology – T Gross, J Faull, S Ketteridge, D Springham, Chapman & Hall, 1995
4. Brock Biology of Microorganisms - M.T. Madigan, K.S. Bender, D.H. Buckley, D.A Stahl and W.A. Sattley; Pearson Prentice Hall
5. Introduction to Microbiology - A.S. Rao; PHI Learning Pvt. Ltd.

Mapping Course Learning Outcomes (CLOs) with the Program Learning Outcomes (PLOs)

CLO	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7
CLO-1	√						√
CLO-2		√	√	√	√	√	
CLO-3	√		√		√		
CLO-4	√	√	√	√	√	√	
CLO-5	√		√		√		

Mapping CLOs with the Teaching-Learning and Assessment Strategy

CLO	Teaching-Learning Strategy	Assessment Strategy
CLO-1	Deliver lectures using PowerPoint slides, videos, images and chalk-talk.	- Class participation through attendance. - Continuous assessment through quizzes. - In-course exams, assignments, and oral presentations. - Final evaluation through a written examination.
CLO-2	Seek immediate feedback during the lecture through short questions.	
CLO-3	Respond to students' queries.	
CLO-4	- Conduct assessments to gauge understanding. - Assign tasks that encourage creativity and deeper exploration of specific topics.	
CLO-5	- Provide opportunities for practicing problem-solving. - Promote group discussions. - Arrange review classes when needed.	

MBG 102C**Microbial Diversity and Ecology****Credits: 2****Class: 30 hours**

This course provides an overview of microbial ecology, including the interactions between microorganisms and the environment and the functions and stability of the complex microbial communities of natural systems. A parallel goal of this course is to explore ways of new findings in microbial ecology to enable environmental and public health protection. It will also cover microbial diversity and their functions, the effect of factors on the growth and survival of microorganisms in various natural ecosystems, microbial community assembly and patterns, succession, adaptation, population dynamics, and other modes of microbial life in ecosystems.

Course Objectives:

1. To obtain an overview of the diversity of the microbial world and place it into an ecological context.
2. To learn the food dependency of organisms in an ecosystem and the essential roles microorganisms play in various natural ecosystems of the Earth.
3. To understand the physical and chemical characteristics of natural environments that interact with microbial life and influence its activities.

Course Learning Outcomes (CLOs):

1. Understand the basic concepts and historical development of ecology.
2. Explain the meaning of developing microbial communities in contextual parts of the ecosystem.
3. Become familiar with the scope and levels of organization of the characteristics of different natural habitats.
4. Define the key concepts of ecology, including abiotic and biotic factors, with their impacts on microbial communities of ecosystems.
5. To understand the nature and interactions of extremophiles in extreme environments.

Unit	Course Content	Class hours
1	Basic Concept of Microbial Ecology: Scope of microbial ecology; Relation of microbial ecology to general ecology; Historical overview of microbial ecology; Basic concepts, characteristics, and components of ecosystems.	3
2	Microbial Communities and Ecosystems: Development of microbial communities; Structure of microbial communities; Ecosystems; Microbial communities in nature	3
3	Microorganisms in Natural Habitats: Atmosphere—characteristics and stratification, atmosphere as habitat and medium for microbial dispersal, microorganisms in atmo-ecosphere; Hydrosphere—ecology, composition and activity of freshwater microbial communities; physical and chemical factors; estuaries and marine environments; characteristics and stratification of ocean; Composition and activity of marine microbial communities; role of microbes in the aquatic environment; Lithosphere—introduction to soil, rocks, and minerals; soil horizon; texture; matter; chemical properties; and microbial communities.	12
4	Effect of Abiotic Factors on Microorganisms: Abiotic limitations to microbial growth; Liebig's law of minimum and Shelford's law of tolerance; Effect of temperature, radiation, pressure, salinity, water activity, movement, hydrogen ion concentration, redox potential, and organic and inorganic compounds on microorganisms.	10
5	Adaptation and Interactions of Microbes in Extreme Environments: Hot springs, acid springs and lakes, salt lakes, deep sea, and extraterrestrial systems.	2

Recommended Books::

1. Microbial Ecology: Fundamentals and Applications -R.M. Atlas and R. Bartha; Addison Wesley Longman, New York
2. Current Perspectives in Microbial Ecology - M.J. Klug and C.A. Reddy; ASM, Washington
3. Ecological Systems and the Environment - T.C. Foin; Houghton Mifflin, London
4. Microbial Ecology: A Conceptual Approach-J.M. Lynch and N.J. Poole; John Wiley & Sons, New York
5. Microbial Ecology: Organisms Habitats Activities -H. Stolp; Cambridge University Press, England.
6. Microbial Ecology - L.L. Barton and D.E. Northup; Wiley Blackwell, USA

Mapping Course Learning Outcomes (CLOs) with the Program Learning Outcomes (PLOs)

CLO	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7
CLO-1	√	√				√	√
CLO-2			√	√			
CLO-3	√	√					

CLO-4	✓	✓		✓			
CLO-5	✓	✓		✓			

Mapping CLOs with the Teaching-Learning and Assessment Strategy

CLO	Teaching-Learning Strategy	Assessment Strategy
CLO-1	- Deliver lectures using PowerPoint slides, videos, images and chalk-talk. - Seek immediate feedback during the lecture through short questions. - Respond to students' queries. - Conduct assessments to gauge understanding. - Assign tasks that encourage creativity and deeper exploration of specific topics. - Provide opportunities for practicing problem-solving. - Promote group discussions. - Arrange review classes when needed.	- Class participation through attendance. - Continuous assessment through quizzes. - In-course exams, assignments, and oral presentations. - Final evaluation through a written examination.
CLO-2		
CLO-3		
CLO-4		
CLO-5		

MBG 103C Human Physiology**Credits: 3****Class: 45 hours**

This course particularly imparts the concepts and mechanisms of integration in the different functional systems of humans. It covers the physiology of humans, with emphasis on the major organs and the processes they govern, including heart function and circulation, muscle function and movement and the kidney and osmoregulation. It also includes the energetic and temperature regulation, respiration and digestion systems of humans. This helps a student of microbiology to correlate any disease process with specific parts and systems of the affected human body.

Course Objectives:

1. To provide a foundation of physiological principles and their application in real-life situations
2. To Familiarize with the different physiological systems of the human body and their functions with emphasis on clinical relevance
3. To acquaint students with different biosynthetic, secretory, and regulatory aspects of coordination.

Course Learning Outcomes (CLOs):

1. Demonstrate different physiological systems of the human body.
2. Demonstrate the ability to integrate physiology from the cellular and molecular level to the organ system and level of organization.
3. Explain the role of each system for the proper functioning of human body.
4. Describe the significance of a system in maintaining a balanced environment in the body.
5. Understand the effect of microbiological infection on each system.

Unit	Course Content	Class hours
1	Brief introduction on human Body: Different systems and their respective functions: organs, tissues and cells.	4
2	Digestion and Digestive System: Mechanisms and control of secretion; Composition of digestive juices; Digestion and absorption of foodstuffs in humans; secretions of GIT hormones; function of liver, bile salt, gall bladder, saliva; formation of gallbladder stone; liver, pancreas, spleen	6
3	Blood and Circulatory System: Composition, formation, destruction and function of blood; Blood coagulation; Blood groups; Tissue fluid; hemoglobin; plasma protein; blood transfusion; blood related diseases, cardiovascular system	6
4	Respiratory System and Respiratory Stimulants: Structures and functions of lungs breathing, lung compliance; lung volume; respiratory diseases; vital capacity,	6
5	Urinary system: Structure and function of the kidneys, regulation of water and electrolyte levels by hormonal action The Excretory System: The structure of the kidney. Ultrafiltration and Selective Reabsorption. Regulation of water loss by antidiuretic hormones (ADH). Fluid, electrolyte, and pH balance	7
6	Lymphoid and lymphatic system: Structures and functions of lymphoid and lymphatic systems; Lymphatic diseases.	6
7	Nervous system: Central and peripheral nervous systems, components, general mechanism, neuron; nerve disease and disorder	6
8	Reproductive System: Structure and function of testis, ovary, uterus and placenta. structure and function of the male and female reproductive systems	4

Recommended Books:

1. Vander's Human Physiology- E. Widmaier, H. Raff, and K.T. Strang; McGraw-Hill Education.
2. Martini Fundamentals of Physiology and Anatomy- F.H. Martini, J.L. Nath and E.F. Bartholomew; Pearson Publications.
3. Introduction to Human Physiology - M. Griffiths; MacMillan, New York
4. Human Physiology - R.F. Schmidt and G. Thews, Springer Verlag
5. Human Physiology - S.R. Fox; McGraw-Hill

Mapping Course Learning Outcomes (CLOs) with the Program Learning Outcomes (PLOs)

CLO	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7
CLO1	√		√				
CLO2	√	√	√				
CLO3	√		√				
CLO4	√	√					
CLO5	√	√	√		√		

Mapping CLOs with the Teaching-Learning and Assessment Strategy

CLO	Teaching-Learning Strategy	Assessment Strategy
CLO-1	- Deliver lectures using PowerPoint slides, videos, images and chalk-talk. - Seek immediate feedback during the lecture through short questions. - Respond to students' queries. - Conduct assessments to gauge understanding. - Assign tasks that encourage creativity and deeper exploration of specific topics. - Provide opportunities for practicing problem-solving. - Promote group discussions. - Arrange review classes when needed.	- Class participation through attendance. - Continuous assessment through quizzes. - In-course exams, assignments, and oral presentations. - Final evaluation through a written examination.
CLO-2		
CLO-3		
CLO-4		
CLO-5		

MBG 104C Basic Techniques in Microbiology**Credits: 3****Class: 45 hours**

This course introduces undergraduate students to the fundamental principles and techniques of microbiology, focusing on the observation, cultivation, growth, control, and preservation of microorganisms. Through both theoretical learning and practical applications, students will explore the structure and function of microscopes, staining methods, microbial nutrition and growth, and strategies for microbial control. Emphasis will be placed on developing essential laboratory skills, understanding microbial diversity, and recognizing the role of microbiology in research, industry, medicine, and public health.

Course Objectives:

1. To introduce students to the types of microscopes and microscopy techniques used for studying microorganisms.
2. To familiarize students with the basic techniques for culturing, controlling, and preserving microorganisms.
3. To enable students to determine and analyze the growth characteristics of microorganisms for their identification and application.

Course Learning Outcomes (CLOs):

1. Understand principles of different microscopic techniques and explain how they work.
2. Learn different staining techniques for morphological characterization of microbes.
3. Select and prepare appropriate culture media for the growth of different microorganisms.
4. Learn the fundamentals of bacterial growth phases and analyze microbial growth using direct and indirect methods.
5. Apply physical and chemical methods to control microbial growth effectively.
6. Understand and explain the principles of preservation of microbes.

Unit	Course Content	Class hours
1.	Microscopes and Microscopy: Light spectrum, resolving power and magnification power; Microscopes- light and electron microscopes; Microscopy- bright-field, dark-field, fluorescence, phase-contrast, differential interference contrast, transmission electron, scanning, scanning tunnelling and atomic force microscopy.	8
2.	Microscopic Observation of Microorganisms: Wet-mount and hanging-drop techniques; Preparation of microorganisms for staining, chemical properties of stains, staining mechanisms, positive and negative staining, simple, differential and special staining techniques.	6
3.	Cultivation of Microorganisms: Nutritional requirements and categories of bacteria in response to nutrition and energy; Criteria for an ideal culture medium; Media used for cultivation microbes-chemically defined media, complex media, anaerobic growth media, selective and differential media; Cultural characteristics of bacteria, Culture techniques- enriched culture, anaerobic culture, and pure culture techniques; Special purpose media for eukaryotic microorganisms	8
4.	Microbial Growth and Growth Measurement: Growth and types of reproduction; growth measurements; growth phases; generation time; mathematical expression of growth; synchronous growth. Growth measurement: Direct methods- counting chamber, electronic count, membrane filtration and standard plate count (spread-plate and pour-plate); Indirect methods- turbidity, metabolic activity, dry weight and genetic probing.	8
5.	Control of Microbial Growth: Principles of microbial control; the rate of microbial death; conditions (factors) influencing microbial control; physical and chemical methods of control.	8
6.	Culture Preservation: Long-term and short-term techniques for preservation of microbial culture; Type culture collections.	4
7	Biochemical characterization of bacteria: Identification of bacteria by biochemical characteristics.	3

Recommended Books:

1. Brock Biology of Microorganisms – M.T. Madigan, K.S. Bender, D.H. Buckley, D.A Stahl and W.A. Satttley; Pearson Prentice Hall
2. Microbiology- M.J. Pelczer Jr, E.C.S. Chan and N.R. Krieg; McGraw-Hill Book Company
3. Microbiology: An Introduction- G.J. Tortora, B.R. Funke and C.L. Case; Pearson, Boston
4. General Microbiology- H.G. Schlegel, C. Zaborosch and M. Kogut; Cambridge University Press
5. Basic Techniques in Microbiology - S. Paniker, S.S. Patil and S. Agnihotri; Success Publications, Mumbai.

Mapping Course Learning Outcomes (CLOs) with the Program Learning Outcomes (PLOs)

CLO	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7
CLO-1	✓	✓	✓	✓	✓		
CLO-2		✓	✓	✓	✓	✓	
CLO-3	✓		✓		✓		
CLO-4		✓	✓		✓		✓
CLO-5	✓	✓	✓	✓	✓	✓	
CLO-6	✓	✓	✓	✓	✓	✓	

Mapping CLOs with the Teaching-Learning and Assessment Strategy

CLO	Teaching-Learning Strategy	Assessment Strategy
CLO-1	• Deliver lectures using PowerPoint slides, videos, images and chalk-talk. • Seek immediate feedback during the lecture through short questions. • Respond to students' queries. • Conduct assessments to gauge understanding. • Assign tasks that encourage creativity and deeper exploration of specific topics. • Provide opportunities for practicing problem-solving. • Promote group discussions. • Arrange review classes when needed.	• Class participation through attendance. • Continuous assessment through quizzes. • In-course exams, assignments, and oral presentations. • Final evaluation through a written examination.
CLO-2		
CLO-3		
CLO-4		
CLO-5		
CLO-6		

MBG 105C Basic Biochemistry**Credits: 4****Class: 60 hours**

The course is designed to provide elementary knowledge on the structure and function of biological molecules, including carbohydrates, lipids, nucleic acids, proteins and vitamins. It also includes the dynamism of life that proceeds with inter-conversion of the chemicals from feeding to the liberation

of energy for work. In this course the concepts of the chemical basis of life and the mechanisms involved in harvesting energy for growth, duplication etc., are deliberated.

Course Objectives:

1. To learn about the molecular structures of cells, biopolymers, building blocks and other biomolecules.
2. To explain the biological functional properties of the important biomolecules.
3. To explain the methods for isolation and detection of the bioactive metabolites of living body.

Course Learning Outcomes (CLOs):

1. Familiar with the biological functions of bioelements, acids, base and buffers.
2. Characterize and identify the five classes of biopolymers and their monomeric building blocks.
3. Explain the metabolism of glucose for the generation of ATP.
4. Understand the basic nature of carbohydrates and their biological functions.
5. Describe the metabolism of fats and their utilization for fuel.
6. Describe the structure and replication of DNA with genetic information in its base sequence.
7. Describe basic mechanisms of RNA and protein synthesis.
8. Explain how protein synthesis can be controlled at the level of transcription and translation.
9. Summarize the role of vitamins in biological systems.

Unit	Course Content	Class hours
1	Acid, Base, and Buffer: Ion product of water; acid; base; pH; pH indicator, buffer solution and buffer capacity	7
2	Essential Bioelements and Biomolecules: Major and minor bioelements; Available and non-available forms, sources and biological functions of bioelements; Cellular composition of biomolecules.	5
3	Bioenergetics: Membrane bioenergetics- the Chemiosmotic Theory; electrochemical energy, use of the Δp , exergonic reactions that generate a Δp . Bioenergetics in the Cytosol: high-energy molecules and group transfer potential, the central role of group transfer reactions in biosynthesis, ATP generation by different processes; free energy; energy coupling.	8
4	Carbohydrates: Nomenclature, classification and functions; Optical properties; General reactions; Method of estimation; Selection from natural sources and representative examples of each class with characteristics.	6
5	Lipids: Nomenclature, classification and reactions of fatty acids; Sterols and methods of estimation; Structure and biological functions of different classes of lipids.	5

6	Amino Acids and Peptides: Structural features, optical activity and classification of amino acids ionization of solution; Behaviour; Isolation of amino acids from protein hydrolysates; Peptide bonds and biologically important peptides.	8
7	Proteins: General introduction; classification based on shape, structure and biological properties; isolation from natural sources; different levels of structural organization; properties and classification of enzymes; enzyme inhibition; digestive enzymes.	10
8	Nucleic Acids: Basic chemistry of nucleosides and nucleotides; polynucleotide and their biological functions; the chemical nature of gene.	5
9	Vitamins: classification; occurrence; deficiency symptoms; biological functions; vitamins as coenzymes	6

Recommended Books:

1. Lehninger Principles of Biochemistry - D.L. Nelson and M.M. Cox, W.H. Freeman and Company
2. Biochemistry - M.K. Campbell; Cengage Learning
3. Biochemistry Illustrated - P.N. Campbell and A.D. Smith, Published by Churchill Livingstone
4. Biochemistry: A short course. J.L. Tymoczko, J.M. Berg, L. Stryer. WH Freeman and Company
5. Biochemistry - J.M. Berg, J.L. Tymoczko and L. Stryer, W.H. Freeman and Company

Mapping Course Learning Outcomes (CLOs) with the Program Learning Outcomes (PLOs)

CLO	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7
CLO1	✓				✓		
CLO2	✓	✓	✓			✓	
CLO3	✓	✓	✓		✓	✓	
CLO4	✓		✓				
CLO5	✓	✓	✓			✓	✓
CLO6	✓		✓		✓	✓	✓
CLO7	✓		✓			✓	
CLO8	✓	✓	✓		✓	✓	
CLO9	✓				✓		✓

Mapping CLOs with the Teaching-Learning and Assessment Strategy

CLO	Teaching-Learning Strategy	Assessment Strategy
CLO-1	- Deliver lectures using PowerPoint slides, videos, images and chalk-talk. - Seek immediate feedback during the lecture through short questions. - Respond to students' queries. - Conduct assessments to gauge understanding. - Assign tasks that encourage creativity and deeper exploration of specific topics. - Provide opportunities for practicing problem-solving. - Promote group discussions. - Arrange review classes when needed.	- Class participation through attendance. - Continuous assessment through quizzes. - In-course exams, assignments, and oral presentations. - Final evaluation through a written examination.
CLO-2		
CLO-3		
CLO-4		
CLO-5		
CLO-6		
CLO-7		
CLO-8		
CLO-9		

MBG 106C Laboratory Works I**Credits: 4****Class: 80 hours**

First Year laboratory course is designed to focus on the students and the tangible world around them and to observe and render in different ways using a range of techniques for beginners in microbiology. This Laboratory core curriculum described below represents topics and themes considered essential to teach in every microbiology laboratory, regardless of its emphasis. These core themes and topics are meant to frame objectives to be met somewhere within the introductory microbiology laboratory. Laboratory works typically supplement and integrate closely with the lecture content in a way that is unique to each instructor. Development of laboratory techniques and exercises designed to reinforce concepts covered in this course.

Course Objectives:

The main objective of the course is to achieve basic laboratory skills in microbiological sciences for beginners. The other specific objectives include the introduction of the basic techniques used for morphological and cultural characterization of different microbes/cells, determination of biomolecules, and developing analytical skills along with data processing for laboratory reports.

Course Learning Outcomes (CLOs):

1. Viewing and interpreting slides of microbiological specimens stained with appropriate dyes for morphological characterization using bright field microscope.
2. Using appropriate methods for the determination of different biomolecules relevant to microbiology.
3. Employing proper equipment and methods for isolation and preservation of microbes in culture media.
4. Determining hematobiochemical parameters from clinical human samples.
5. Estimating the number of cells and other properties of clinical samples using appropriate aseptic techniques for the transfer and handling of microorganisms and instruments.

Course Content	Class hours
1. Introduction to the operations, use and function of bright-field and other microscopes. 2. Microscopic observation of some common prokaryotic and eukaryotic microorganisms. 3. Hanging drop slide preparation to visualize microbes in their living state and to study motility. 4. The micrometric measurement of microbial cell 5. Preparation of solutions- molar, molal, normal and buffer solutions 6. Determination of HCl/citric acid by titrimetric method 7. Quantitative test for soluble protein and reducing sugar 8. Determination of ascorbic acid contents of biological samples 9. Determination of lactose contents of milk samples 10. Media preparation and sterilization 11. Techniques for isolation, observation and preservation of pure cultures of bacteria 12. Techniques for isolation and observation of fungi 13. Techniques of enumeration of microorganisms: serial dilution, spread plate and pour plate, Improved Neubauer counting chamber; Miles and Misra technique 14. Staining of Bacterial Cells: Simple staining and Negative staining; Gram staining; Acid-fast staining; Capsule staining; Spore staining; Flagella staining 15. Determination of Blood group 16. Identification and counting of different formed elements in blood by using microscope 17. Identification of histological sections of different human organ systems 18. Measurement of human blood pressure by using Palpatory/ Auscultatory method 19. Determination of total leukocytes count (TLC) & differential leukocytes count (DLC).	80

Recommended Books:

1. Microbiology: A Laboratory Manual- J. Cappucino & N. Sherman; Pearson Education Limited
2. Principles of Microbiology - R.M. Atlas, WM.T. Brown Publishers.
3. Practical Workbook of Human Physiology - K.S. Nageswari & R. Sharma, Jaypee Brothers Ltd.
4. Laboratory Protocols in Applied Life Sciences - P.S. Bisen, CRC Press
5. Laboratory Safety: Principles and Practices- D.O. Flaming, J.H. Richardson & J.I. Tulis, ASM Washington D.C.

Mapping Course Learning Outcomes (CLOs) with the Program Learning Outcomes (PLOs)

CLO	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7
CLO-1	√	√					
CLO-2	√		√				
CLO-3		√			√		
CLO-4			√	√			
CLO-5				√	√		

Mapping CLOs with the Teaching-Learning and Assessment Strategy

CLO	Teaching-Learning Strategy	Assessment Strategy
CLO-1	- Conduct interactive lectures covering the principles, methods, procedures, and applications of each experiment using PowerPoint/ videos/ pictures/ chalk-talk. - Obtain immediate feedback by asking questions. - Address students' queries promptly. - Facilitate problem-solving practice. - Provide hands-on laboratory training. - Encourage collaborative discussion among students.	- Class participation through attendance. - Continuous assessment through in-course exams, and assignments. - Evaluation of practical notebooks. - Final assessment through practical experiments and a written test. - Viva voce.
CLO-2		
CLO-3		
CLO-4		
CLO-5		

MBG 107C Viva-Voce**Credits: 2**

A viva-voce or oral examination is an opportunity where students demonstrate their knowledge, expertise, and understanding of both theoretical and practical courses. It also allows the examiners to assess the students' academic abilities and determine whether they have met the requirements for promotion to the next academic level.

Course Objectives:

1. Demonstrate comprehensive knowledge in their broader field of study.
2. Enhance their ability to effectively communicate scientific information with confidence, skills, and expertise.
3. Evaluate and reflect on their understanding and mastery of the program's content.

Course Learning Outcomes (CLOs):

1. To evaluate their knowledge and thinking capacity as well as pressure handling capacity.
2. Ability to describe the process of science.
3. Ability to communicate and collaborate with other disciplines.

Course Content: All the courses attended in the 1st academic year.

Mapping Course Learning Outcomes (CLOs) with the Program Learning Outcomes (PLOs)

CLO	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7
CLO-1	√	√	√			√	
CLO-2		√		√	√		
CLO-3						√	√

Mapping CLOs with the Teaching-Learning and Assessment Strategy

CLO	Teaching-Learning Strategy	Assessment Strategy
CLO-1	- Problem solving and discussion. - Respond to students' queries. - Encourage collaborative discussion among students.	Final evaluation through questions and performance.
CLO-2		
CLO-3		

MBG 108G Computer Applications for Life Sciences**Credits: 3****Class: 45 hours**

This course is designed as general course to cover the basic knowledge and skills required in the field of life sciences to solve biological problems with computation technology and for individual students to use computer hardware and software as tools to create documents, file managements, gather information and solve problems. Students learn basic programming skills on different avenues of biology and apply these skills in building projects for life sciences.

Course Objectives:

1. To present a basic understanding of computer operating systems useful for life sciences.
2. To provide students the exposure to modern computation to study life sciences in a smarter way.
3. To create an environment of basic programming and other applications to deal with life science problems.

Course Learning Outcomes (CLOs):

1. Familiar with the basic systems, data storage, input-output devices of a microcomputer.
2. Identify and categorize operating systems and applications of system software.
3. Demonstrate the basic skill level in applications of computer to create documents, file managements, gather information and solve problems.
4. Familiar with the data management systems with their number systems and codes.
5. Learn the basic applications of computers to deal with the avenue of life sciences in an efficient way.
6. Learning basic programming language necessary for life sciences.

Unit	Course Content	Class hours
1	Microcomputer System: Basic microcomputer system, microprocessor organization, machine cycle; Computer memory- memory types, primary and secondary memory, latches, flipflops, registers, flash memories; BUS organization; Input and output devices.	4
2	Computer Software: Software, classification of software, commercial software, Freeware; Advantages of package programs, popular package programs; Programming language.	5

3	System Software and Operating System: System software, role of BIOS language translators, text editor, the tasks of an OS, OS characteristics, types of OS, Linux, UNIX, MS DOS, and WINDOWS.	5
4	Database Concepts and Basic applications: Basic concepts, database software, database structure, biological databases (GenBank, ENA, PDB), database management system and its merits and demerits.	8
5	Programming for life sciences: Fundamentals of programming, Common programming languages in biology (Python, R, PERL), Core programming concepts (Variables and data types, operators, control flow, functions, data structures and others), Use of libraries (Biopython)	11
6	Hands on: (a) Simple exercises on installing and using basic commands in Windows and LINUX operating systems (b) Applications of MS word, MS excel, MS access and exploration of biological databases (c) Python exercises: simple variables, string operators, flow control, functions, data manipulation and others (d) Working with biological data in Python: Basic functions for biological tasks, file handling, Biopython, basic data analysis and visualisation, problem solving exercises	12

Recommended Books:

1. Computer Fundamentals - M.L. Rahman and M.A. Hossain; Systech, Dhaka
2. Introduction to Computer Science - P.W. Murrill and C.L. Smith; Harper and Row, New York
3. Computer Fundamentals: Concepts, Systems and Applications - P.K. Sinha & P. Sinha; BPB Publications, New Delhi
4. Computer fundamentals - A. Goel; Pearson New Delhi
5. Fundamentals of computer- A. Saxena, S. Chauhan & K. Gupta; Laxmi Publications
6. Python for Biologists – M.O. Jones; Greatespace Ind Pub Platform

Mapping Course Learning Outcomes (CLOs) with the Program Learning Outcomes (PLOs)

CLO	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7
CLO1	√		√				
CLO2	√	√	√				
CLO3			√		√	√	√
CLO4	√	√	√		√		
CLO5	√	√	√		√	√	
CLO6	√	√	√		√	√	

Mapping CLOs with the Teaching-Learning and Assessment Strategy

CLO	Teaching-Learning Strategy	Assessment Strategy
CLO-1	- Deliver lectures using PowerPoint slides, videos, images and chalk-talk. - Seek immediate feedback during the lecture through short questions. - Respond to students' queries. - Conduct assessments to gauge understanding. - Provide opportunities for developing problem-solving skills. - Provide hands-on laboratory training. - Encourage collaborative discussion among students. - Arrange review classes when needed.	- Class participation through attendance. - Continuous assessment through in-course exams, practical exams and assignments. - Final evaluation through a written examination.
CLO-2		
CLO-3		
CLO-4		
CLO-5		
CLO-6		

MBG 109G Communicative English**Credits: 2****Class: 30 hours**

This general course is designed to introduce technical writing and communication skills in reading, writing, speaking, and listening in English that enables the students to meet their real-life communication needs and their role in the world. It also gives scope to develop proficiency in the language and will help increase the usage of better vocabulary.

Course Objectives:

1. To interact with academic content: reading, writing, listening, speaking
2. To demonstrate the ability to think critically utilizing information and digital literacy skills
3. To demonstrate behavior and attitudes appropriate to a university environment

Course Learning Outcomes (CLOs):

1. Develop proficiency in the language and help increase the usage of better vocabulary.
2. Understand and apply the conventions of academic writing in English with confidence.
3. Enhance reading abilities and apply the skills with better understanding.
4. Apply the skills and strategies of a successful speaker.
5. Apply the skills and strategies of a successful listener.

Unit	Course Content	Class hours
1	Fundamentals: Parts of speech and its exercise; sentence structure- active & passive voice; use of adjectives & verbs; gerund- forms & uses; vocabulary building; comprehension.	5

2	Reading: Strategies of reading - predicting, skimming, scanning, intensive & extensive; speed reading; inferencing and analyzing selected texts- texts reflecting common interests, special texts related to major courses of Microbiology.	4
3	Writing: Writing process- brainstorming, outlining, drafting, editing and proofreading; Paragraph development- structure& types of paragraphs; Letter writing- apology, request for leave, acknowledgement, permission, information & friendly letters; Essay writing- structure and types, thesis statement, introduction and conclusion; Technical report writing- academic and lab reports, summary/paraphrase writing; Writing research papers- planning, method, organizing extracted information, drafting, and revising, ethical issue of writing.	8
4	Speaking: Introducing self and others; Expressing like and dislikes, personal experiences, apologies and excuses, comparison and contrast; Describing people/place/events, saying times; Giving and following instruction, reporting, complaining; Seminar presentation and interviews.	8
5	Listening: Listening comprehensions focusing on varying elements of vocabulary and structures will be practiced. Student will be taught how to be an active listener to obtain information and key ideas.	5

Recommended Books::

1. Guide to Writing- J.D. Ramage, J.C. Bean, J.J. Allyn and B. Longman
2. The Heinmann ELT English Grammar- D. Beaumont and C. Granger; McMillan
3. Advanced English Comprehensive Texts for Science Students - M. Smithies; Collier- Macmillan
4. Reading and Study Skill - J. Longman

Mapping Course Learning Outcomes (CLOs) with the Program Learning Outcomes (PLOs)

CLO	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7
CLO1	√				√		
CLO2	√	√	√		√		√
CLO3	√	√	√		√		
CLO4			√		√	√	
CLO5			√		√	√	

Mapping CLOs with the Teaching-Learning and Assessment Strategy

CLO	Teaching-Learning Strategy	Assessment Strategy
CLO-1	Deliver lectures using PowerPoint slides, videos, images and chalk-talk.	- Class participation through attendance. - Continuous assessment through quizzes. - In-course exams, assignments, and oral presentations. - Final evaluation through a written examination.
CLO-2	Seek immediate feedback during the lecture through short questions.	
CLO-3	Respond to students' queries.	
CLO-4	- Conduct assessments to gauge understanding. - Assign tasks that encourage creativity and deeper exploration of specific topics.	
CLO-5	- Provide opportunities for practicing problem-solving. - Promote group discussions. - Arrange review classes when needed.	

CM 100F Fundamentals of Chemistry**Credits: 4****Class: 60 hours**

This General course is designed for the graduate students of Microbiology. Development of fundamental principles of chemistry and their applications, chemical nomenclature, bonding theories, thermo-chemistry, periodic properties, solution calculations, gas laws and the properties of solids and liquids are among the topics discussed. It will also provide the student with the opportunity to establish and develop genetic skills including ability to use conceptual models and gather and rationalize data, problem-solving and critical thinking.

Course Objectives:

The aim of the subject is to provide students with an understanding of the nature of matter, solutions and gases, the chemical change related to equilibrium, energy and kinetics, and the nature of redox processes, and structures and functional groups in organic molecules.

Course Learning Outcomes (CLOs):

1. Demonstrate a clear understanding of the structure of atoms, atomic models, isotopes, and electronic configurations.
2. Explain the principles of radioactivity, nuclear reactions, and binding energy, including fission and fusion processes.
3. Apply the periodic classification of elements to predict chemical properties and trends.
4. Understand and explain different types of chemical bonds, molecular structures, VSEPR theory, hybridization, and intermolecular interactions.
5. Analyze oxidation-reduction processes and determine oxidation numbers in reactions.
6. Describe the states of aggregation of matter, phase changes, and kinetic theory.
7. Apply gas laws, molecular velocities, and critical constants to explain gaseous behavior.
8. Explain solution behavior, colligative properties, Raoult's law, and fractional distillation.
9. Understand chemical equilibrium, equilibrium constants, and Le Chatelier's principle.

10. Calculate and interpret energy changes in chemical reactions, including enthalpy, entropy, and spontaneity.
11. Explain the concepts of acids, bases, buffers, neutralization curves, and pH measurement.
12. Describe electrochemical processes, galvanic cells, electrode reactions, and measurement of reduction potentials.
13. Analyze rates of chemical reactions, reaction orders, half-lives, and temperature dependence.
14. Understand the structure, nomenclature, reactions, and mechanisms of organic compounds, including alkanes, alkenes, alkynes, alkynes, alkynes, aromatic compounds, functional groups, and organic macromolecules.
15. Apply organic chemistry concepts such as nucleophiles, electrophiles, carbocations, carbanions, and free radicals in reaction mechanisms.

Unit	Course Content	Class hours
1	Structure of Atoms: the discovery of electron proton and neutron; cathode rays; radioactivity; α -particles; scattering Rutherford model; fraction of atomic masses; isotopes; mass spectroscopy spectrum of atomic hydrogen; Bohr models; dual nature of matter; wave nature of electrons; atomic orbital; electron configuration of atom.	3
2	Radioactivity and Nuclear Reactions: nuclear binding energy: fission and fusion reactions	3
3	Periodic Classification of Elements: ionization potential; electro negativity; electron affinity; atomic radius; variation of properties along a period and a group; diagonal relationship; representative elements; transition elements; chemical properties of s-, p- and d-block elements.	4
4	Chemical Bonds: electronic theory; valence bonds theory; molecular orbital theory; sigma (δ)- and pi (π) bonds; C-C bonds; catenation; polar molecules electro negativity and electron affinity; hydrogen bond; shapes of molecules; VSEPR theory; hybridization.	3
5	Oxidation and Reduction: oxidation number; analytical reagents.	3
6	States of Aggregation of Matter: kinetic theory of matter; nature of heat; changes of states.	3
7	The Gaseous State: the gas laws; the perfect gas equation; the kinetic theory of gases; the distribution of molecular velocities; intermolecular attraction; liquefaction of gases; the critical state; the critical constants.	3
8	Vapour Pressure of Liquids: temperature dependent mixtures of liquids; Raoult's law; fractional distillation; solutions of non-volatile solids; colligate properties of solutions; Henry's law; Nernst distribution law.	3
9	Energy Changes in Chemical Reactions: the first law of thermodynamics F; the concept of internal energy and enthalpy; measurement of enthalpy changes;	3

	enthalpy of formation; Hess's law; lattice enthalpy; Born-Haber cycle; spontaneous process; concept of entropy.	
10	Chemical Equilibrium: the equilibrium law; the equilibrium constant; homogeneous and heterogeneous equilibrium; the principle of Le Chatelier and Brown; the dependence of K on temperature.	3
11	Acids and Bases: the Lewis concept; the Bronsted concepts in strong and weak acids; acid-base equilibrium in aqueous solutions; Ostwald dilution law; pH; buffer solutions; neutralisation curves; indicators for acid-base titration.	3
12	Electrolysis: galvanic cells; electrodes and electrode reactions; reduction potential; the electrochemical series the standard hydrogen electrode; measurement of pH	3
13	Rates of Chemical Reactions: order and molecularity; zero and first order reactions; half-life; carbon dating; temperature dependence of rates of reaction.	3
14	The Organic Compounds and Organic Chemistry: hydrocarbons; aliphatic hydrocarbons; standard and unsaturated hydrocarbon; alkanes, alkenes and alkynes; the aromatic hydrocarbons; delocalization in the benzene ring; nomenclature of organic compounds; the IUPAC system; petroleum; natural gas; refining of petroleum; petrochemicals.	4
15	The Concept of: Acid Bases, Nucleophiles, Electrophiles, Carbocations and Carboanions and Free Radicals.	3
16	Reactions of Alkanes, Alkenes, and Alkynes: substitution and hydrogen abstraction reactions in alkanes; hydrogenation; hydrohalogenation; ozonolysis of alkenes and alkynes; homolytic addition of hydrogen halides; geometrical isomers.	3
17	Functional groups: alcohols, aldehydes, ketones, ethers, epoxides, amines, amides; typical reactions of the functional groups.	4
18	Some Important Reactions of the Aromatic Compounds: substitution at the benzene ring; Friedel-Craft's reaction; diazotization and coupling; sulphonation and nitration.	3
19	Organic Macromolecules: polythene; teflon; plastic; resin; nylon; peptides; proteins; cellulose and starch.	3

Recommended Books:

1. General Chemistry - D.D. Ebbing and M.S. Wrighton, A.I.T.B.S publishers, Delhi
2. General Chemistry – L. Pauling; Dover Publications
3. Chemistry - J.M. Coxon, J.E. Gergusson and I.F. Philips
4. A-Level Chemistry – E.N. Ramsden

Mapping Course Learning Outcomes (CLOs) with the Program Learning Outcomes (PLOs)

CLO	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7
CLO1	✓		✓				
CLO2	✓	✓	✓				
CLO3	✓	✓	✓				
CLO4	✓	✓	✓	✓	✓		
CLO5	✓	✓	✓	✓	✓		
CLO6	✓		✓				
CLO7	✓	✓	✓	✓	✓		
CLO8	✓	✓	✓	✓	✓		
CLO9	✓	✓	✓	✓	✓		
CLO10	✓	✓	✓	✓	✓		
CLO11	✓	✓	✓	✓	✓		✓
CLO12	✓	✓	✓	✓	✓		✓
CLO13	✓	✓	✓	✓	✓		
CLO14	✓	✓	✓	✓	✓	✓	
CLO15	✓	✓	✓	✓	✓	✓	

Mapping CLOs with the Teaching-Learning and Assessment Strategy

CLO	Teaching-Learning Strategy	Assessment Strategy
CLO-1	- Deliver lectures using PowerPoint slides, videos, images and chalk-talk. - Seek immediate feedback during the lecture through short questions. - Respond to students' queries. - Conduct assessments to gauge understanding. - Assign tasks that encourage creativity and deeper exploration of specific topics. - Provide opportunities for practicing problem-solving. - Promote group discussions. - Arrange review classes when needed.	- Class participation through attendance. - Continuous assessment through quizzes. - In-course exams, assignments, and oral presentations. - Final evaluation through a written examination.
CLO-2		
CLO-3		
CLO-4		
CLO-5		
CLO-6		
CLO-7		
CLO-8		
CLO-9		
CLO-10		
CLO-11		
CLO-12		
CLO-13		
CLO-14		
CLO-15		

MBG 110K Science Communication**Credits: 2****Class: 30 hours**

This capstone course is designed to provide an opportunity for the newly admitted students to introduce with the facilities, services, academic curriculum of the department, career opportunities in microbiology, lab safety regulations and practices, etc. The course will give clear ideas about all necessary activities required for a student which will help them to understand what to do during different situations and where to seek advice on different issues. It also helps to develop the skills in presentation on selected assignment/seminars and good moral values in academic integrity during their studentship. The Department will update the tasks and determine marks distribution in assessment for the sessional activities.

Course Objectives:

1. To provide an opportunity for newly admitted students to become acquainted with the art of science communication.
2. To demonstrate the safety rules for good microbiology laboratory practices.
3. To develop academic integrity, behavior and attitudes appropriate to a university environment

Course Learning Outcomes (CLOs):

1. Define science communication and explain its goals, benefits, and motivations.
2. develop the academic integrity, behavior and attitudes appropriate to a university environment.
3. demonstrate the safe handling of pathogens, instruments and chemical reagents in Microbiology labs.
4. identify potential career paths in microbiology and required levels of education.
5. apply the skills and strategies of a successful presentation of assignments and seminar.

Unit	Course Content	Class hours
1	Scientific writing and communication: (a) Introduction to science communication; (b) goals, benefits, and motivation to science communication; (c) various forms and formats of science communication; (d) connecting with your audiences and building a presentation; (e) guidelines on preparing an assignment; students will prepare their own assignment independently according to the given instructions and format including basic key points and rules for writing an assignment and submit the well-documented assignments within a stipulated time; (f) finally, the assignment will be evaluated based on the quality of the assignment paper and oral presentation skills.	5
2	Ethics in Science Communication: (a) Basic components of student's code of conduct; common knowledge, writing code, time management, collaboration; (b) Academic integrity- basic principles, (c) violations of academic integrity- cheating, working under pressure, plagiarism, academic dishonesty, and (d) consequences of violating academic integrity; (e) developing good work ethics- study, research, and	5

	writing.	
3	Safety Regulations and GMLP: (a) Basic aspects microbiology lab and general lab safety regulations; (b) Biosafety guidelines for basic microbiology lab and code of practices; (c) Biosafety levels and practices; (d) Basic techniques for good microbiology laboratory practices, (e) Guidelines for safe handling of pathogenic microbes and hazardous chemicals in lab; (f) Guidelines for accidental hazards in microbiology labs.	5
4	Fieldworks and Specimen Collection: (a) Demonstration on standard field work protocols for microbiology students; (b) Demonstration on the standard procedures for collection of clinical, environmental or industrial samples/specimens; (c) Guidelines for data collection from the fields.	5
5	Visit to Research Organizations: infrastructure, research facilities, environment and management of a reputed research organization; understanding the scope and advancement of research projects in microbiology discipline. The individual student will submit a written report on visiting experience and learning for evaluation.	5
6	Career Development Plan and Job Opportunity: (a) Career in microbiology- level of education, applied fields, institutions, career path; (b) Opportunity- Skill, interests and qualities; searching for job opportunity, preparation of curriculum vitae, preemployment test preparation, specific training, career development process.	5

Recommended Books:

1. Basic Practical Microbiology: A Manual- D. Burdass, J. Grainger & J. Hurst, Society for General Microbiology, UK
2. A Student's Guide to Presentation- B. Chivers & M Shoolbred, SAGE Publications Ltd, London.
3. Handbook of Academic Integrity- T. Bretag, Springer Science + Business Media Singapore Pvt Ltd.

Mapping Course Learning Outcomes (CLOs) with the Program Learning Outcomes (PLOs)

CLO	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7
CLO-1	✓						
CLO-2	✓	✓					
CLO-3				✓		✓	
CLO-4					✓		✓
CLO-5	✓			✓			✓

Mapping CLOs with the Teaching-Learning and Assessment Strategy

CLO	Teaching-Learning Strategy	Assessment Strategy
CLO-1	- Conduct an interactive, student-centered approach combining lectures, demonstrations, field visits, and hands-on training. - Develop scientific communication skills through guided assignments, structured report writing, independent tasks, and oral presentations. - Conduct assessments to gauge understanding. - Promote case-based learning on ethics and biosafety. - Encourage group discussions. - Arrange visit to research facilities; organize career-focused workshops. - Journal Clubs: Assign tasks that encourage creativity and deeper exploration of specific topics.	- Continuous assessment through class participation. - In-course assessment through assignments and field work/ data/ specimen collection/ seminar report submission/ written tests. - Final evaluation through an oral presentation, report submission and/or written tests.
CLO-2		
CLO-3		
CLO-4		
CLO-5		

Courses for 2nd year BS Honours

The students will continue their studies on other basic courses in greater depth. The students will have the opportunity to gain basic knowledge and techniques that are widely used in current microbiological sciences. The course unit details given below are subject to change and are the latest example of the curriculum available on this course of study.

MBG 201C Environmental Microbiology

Credits: 2

Class: 30 hours

The course introduces the basic and applied concepts of microbial environment and the factors steering the assembly and functioning of complex environmental microbial communities. It provides an overview of the biological interaction of microbes, techniques to study environmental microbes, pollution problems, waterborne indicator organisms, sewage treatment and sanitation, and stimulates students' interest in performing the research necessary for this course. The students will learn the principles for using complex microbial communities for environmental applications in light of microbial resource management.

Course Objectives:

1. To acquire knowledge on wide microbial diversity in different complex ecosystems
2. To learn the beneficial roles of microbes in the improvement of environmental health and the harmful effects in deteriorated environments.
3. To learn the principles and methods for the detection of microbial interaction with the environment

Course Learning Outcomes (CLOs):

1. Familiarize one with interaction among diverse microbial populations as well as with other life forms.
2. Use techniques to detect environmental microbes, sample collection, and processing.
3. Get acquainted with indicator organisms related to potable water.
4. Learn about the pollution problem and the potential role of microbes to remediate the problems.
5. Learn about sewage treatment systems, sanitation, and public health from Bangladeshi perspectives.

Unit	Course Content	Class hours
1	Biological Interactions: Microbial interaction within a single microbial population, positive and negative interactions, and interaction between diverse microbial populations; neutralism, commensalism, synergism, mutualism, competition, amensalism, parasitism, predation, microbe-plant interaction, and microbe-animal interaction.	8

2	Techniques for Studying Environmental Microbes: Sample collection and processing; detection of microbial populations; determination of microbial numbers; determination of microbial biomass; measurement of microbial metabolism	5
3	Microbiology of Potable Water: Introduction to indicator organisms; water-borne pathogens; isolation and identification of indicator bacteria; water-borne pathogens	5
4	Culturable & non-culturable Microbes: Recent advances in culturable & non-culturable approaches for the detection of indicators and pathogenic microorganisms from the environment.	4
5	Microorganisms and Pollution Problems: Persistence and biomagnification of xenobiotic molecules; recalcitrant halocarbons, polychlorinated biphenyls, alkyl benzyl sulfonates and synthetic polymers	4
6	Sewage Treatment: Primary treatment, secondary treatment, aerobic and anaerobic treatment, and tertiary treatment	4

Recommended Books:

1. Microbial Ecology: Fundamentals and Applications—by R.M. Atlas & R. Bartha; Addison Wesley Longman, New York
2. Microbial Ecology: A Conceptual Approach—by J.M. Lynch & N.J. Poole; John Wiley & Sons, New York
3. Microbiology- by M.J. Pelczar Jr., E.C.S. Chan & N.R. Krieg; McGraw-Hill Book Company
4. Environmental Microbiology of Aquatic & Waste Systems—by N. Okafor, Springer, New York
5. Environmental Microbiology—by R.M. Maier, I.L. Pepper & C.P. Gerba, Academic Press
6. Microbial Ecology: Organism, Habitats, Activitiesby H. Stolp; Cambridge University Press
7. An Introduction to Soil Microbiology—by A. Martin, John Wiley & Sons Inc., New York & London.

Mapping Course Learning Outcomes (CLOs) with the Program Learning Outcomes (PLOs)

CLO	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7
CLO-1	√		√				
CLO-2	√	√	√	√	√		
CLO-3		√	√	√			
CLO-4	√		√		√		
CLO-5	√		√		√		

Mapping CLOs with the Teaching-Learning and Assessment Strategy

CLO	Teaching-Learning Strategy	Assessment Strategy
CLO-1	Deliver lectures using PowerPoint slides, videos, images and chalk-talk.	Class participation through attendance.
CLO-2	Seek immediate feedback during the lecture through short questions.	Continuous assessment through quizzes.
CLO-3	Respond to students' queries.	In-course exams, assignments, and oral presentations.
CLO-4	- Conduct assessments to gauge understanding. - Assign tasks that encourage creativity and deeper exploration of specific topics.	Final evaluation through a written examination.
CLO-5	- Provide opportunities for practicing problem-solving. - Promote group discussions. - Arrange review classes when needed.	

MBG 202C Bacterial Metabolism**Credits: 2****Class: 30 hours**

This course is designed to introduce students to bacterial physiology and metabolism, particularly focusing on catabolic pathways. The course will summarize different metabolic pathways, centering on the central metabolic pathway as well as fermentation pathways. The supporting streams linked with the central metabolic pathways like brief introduction to metabolic pathway, electron transport chain and metabolic dynamics of aerobic heterotrophs will also be covered.

Course Objectives:

1. To understand the basic concept of metabolism and metabolic network in a bacterial cell
2. To learn the central metabolic pathway and electron transport chain of a bacterial cell
3. To familiar with the basic catabolic pathway of interest other than central metabolic pathway

Course Learning Outcomes (CLOs):

1. Familiar with the basic facts, principles, theories related to microbial physiology and metabolism.
2. Acquire, retain, and communicate complex conceptual ideas related to bacterial physiology and metabolism.
3. Describe the network involved in metabolic pathways including solute transport.
4. Understand the details of central metabolic pathway
5. Explain the mechanism of electron transport chain
6. Understand the catabolic pathway of interest other than central metabolic pathway focusing on fermentation pathways

Unit	Course Content	Class hours
1	Introduction to Metabolism: Important differences and relationships between anabolic and catabolic mechanisms in living organisms.	3
2	Electron Transport: Aerobic and anaerobic respirations, electron carriers, organization of the electron carriers in mitochondria, organization of the electron carriers in bacteria; coupling sites, proton pumps, electron flow patterns in bacteria.	5
3	Solute Transport: Kinetics of solute uptake, energy-dependent transport, and source of energy for transport.	5
4	Central Metabolic Pathways: Glycolysis, the fate of NADH, the pentose phosphate pathway, the Entner–Doudoroff pathway, TCA cycle; carboxylation to replenish oxaloacetate. the pyruvate and phosphoenolpyruvate carboxylases glyoxylate cycle, glyoxal bypass; inter linkages of pathways; Anaplerotic reactions, pathways for utilisation of sugars other than glucose,	9
5	Fermentations: Oxygen Toxicity, Energy Conservation by Anaerobic Bacteria, Propionate Fermentation: Acrylate Pathway, Succinate–Propionate Pathway, Acetate Fermentation, Lactate Fermentation, Mixed-Acid and Butanediol Fermentation, Butyrate Fermentation	3
6	Catabolic Activities of Aerobic Heterotrophs: Degradation of biopolymers; growth with amino acids, organic acids, aromatic compounds, aliphatic hydrocarbons and C ₁ compounds.	5

Recommended Books:

1. The Physiology and Biochemistry of Prokaryotes- D. White, J. Drummond and C. Fuqu; Oxford University Press
2. Microbial Physiology- A.G. Moat and J.W. Foster; John Wiley, New York
3. Bacterial Metabolism- G. Gottschalk; Springer-Verlag, New York
4. Microbiology- M.J. Pelczer Jr., E.C.S. Chan, and N.R. Krieg; McGraw-Hill Book Company
5. Microbiology: Concepts & Applications- M.J. Pelczer, E.C.S. Chan, N.R. Krieg; McGraw-Hill, NY
6. Lehninger Principles of Biochemistry- D.L. Nelson and M.M. Cox; W.H. Freeman and Company

Mapping Course Learning Outcomes (CLOs) with the Program Learning Outcomes (PLOs)

CLO	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7
CLO1	✓						
CLO2	✓	✓	✓				
CLO3	✓	✓	✓	✓	✓		
CLO4	✓	✓	✓	✓	✓		
CLO5	✓	✓	✓	✓	✓		
CLO6	✓	✓	✓	✓	✓		✓

Mapping CLOs with the Teaching-Learning and Assessment Strategy

CLO	Teaching-Learning Strategy	Assessment Strategy
CLO-1	Deliver lectures using PowerPoint slides, videos, images and chalk-talk.	- Class participation through attendance. - Continuous assessment through quizzes. - In-course exams, assignments, and oral presentations. - Final evaluation through a written examination.
CLO-2	Seek immediate feedback during the lecture through short questions.	
CLO-3	Respond to students' queries.	
CLO-4	Conduct assessments to gauge understanding.	
CLO-5	Assign tasks that encourage creativity and deeper exploration of specific topics.	
CLO-6	- Provide opportunities for practicing problem-solving. - Promote group discussions. - Arrange review classes when needed.	

MBG 203C Genetics**Credits: 3****Class: 45 hours**

The course presents the basic facts and concepts with basic knowledge to stimulate students to move on to more advanced aspects of the subject. The course includes the fundamental concepts structural and functional properties of genetic materials, the function of the gene as a unit of biological information. role of the gene as a unit of inheritance and exploration of the areas of research that are responsible for the high profile that genetics has in our modern world, from agriculture and industry to medicine and forensics, and the ethical challenges that genetic knowledge imparts.

Course Objectives:

1. To familiarize oneself with the concepts and the genetic mechanisms of heredity of eukaryotes.
2. To learn about the mechanisms of replication and transcription in prokaryotes and eukaryotes.
3. To understand the translation of the genetic code for protein synthesis in a living body.

Course Learning Outcomes (CLOs):

1. Describe the historical developments and concepts of genetics to acquire specialized language relevant to microbial molecular genetics.
2. Explain the chromosome basis of inheritance and integrate information on concepts relevant to sex determination.
3. Familiar with the key concepts and mechanisms of DNA replication including microbial molecular genetics.
4. Describes how genes are transcribed and the structural and functional features of the transcripts.
5. Understand the nature genetic code and the translation of the genetic message.

Unit	Course Content	Class hours
1	Principles of Heredity: Importance and fundamental concepts of genetics; Discovery of basic principle of heredity- monohybrid, dihybrid and trihybrid crosses; Mendel's experiments and his interpretation - the basic principles of dominance, segregation and independent assortment; misinterpretations of Mendelian principles; Extension of Mendelism and modification of basic principles.	6
2	Chromosomal Basis of Inheritance: Chromosome theory of heredity; sex chromosomes and sex determination; sex-linked genes in human beings; variation in chromosome number and structure; Chromosome variation- mutations including Rearrangements, Aneuploidy and Polyploidy.	5
3	Replication of DNA: Various models of DNA replication, Enzymes and Proteins involved in DNA replication, Mechanisms of replication of bacterial DNA, eukaryotic DNA, and replication in archaea ; Rolling circle DNA replication	5
4	Transcription in Prokaryotes and Eukaryotes: Different types of RNA molecules; Structure and Processing of Messenger RNA, Transfer RNA, and Ribosomal RNA, Small interfering RNAs and MicroRNAs. Prokaryotic and eukaryotic RNA polymerases; mechanism of transcription in prokaryotes and eukaryotes; post-transcriptional modification of RNA; interrupted genes in eukaryotes.	10
5	RNA Processing: Gene organization, introns, RNA splicing, Alternative processing pathways. RNA interference.	4
6	Translation and Genetic Code: polypeptides and proteins; synthesis of polypeptide chain; nonsense mutation and suppressor mutation; the genetic code; Wobble hypothesis; post-translation modification of protein. RNA-RNA interactions in translation, Polyribosomes, Nonstandard Protein synthesis.	5
7	Chromosome variation- Chromosome morphology, Types of chromosome mutations, Chromosome rearrangements, Aneuploidy and Polyploidy.	5
8	Organelle DNA: The Endosymbiotic theory. Mitochondrial DNA – Structure, organization, nonuniversal codons in mtDNA, the replication, transcription and translation of mtDNA, the Evolution of mtDNA. Chloroplast DNA – Structure, organization, the replication, transcription and translation, and the Evolution of cp DNA.	5

Recommended Books:

1. Principles of Genetics- E.J. Gardner, M.J. Simmons & D.P. Snustad; John Wiley and Sons
2. Genetics- D.P. Snustad and M.J. Simmons; John Wiley and Sons, Inc.
3. Genetics: Analysis of Genes and Genomes- D.L. Hartl & M. Ruvolo; Jones & Bartlett, New Delhi
4. Molecular Biology of the Gene- J.D. Watson, T.A. Baker, S.P. Bell, A. Gann, M. Levine and R. Losick; Pearson, San Francisco
5. Molecular Biology- D. Freifelder; Jones and Bartlett, Boston

Mapping Course Learning Outcomes (CLOs) with the Program Learning Outcomes (PLOs)

CLO	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7
CLO-1	√						
CLO-2	√	√					
CLO-3	√	√	√				
CLO-4	√	√	√				
CLO-5	√	√	√				

Mapping CLOs with the Teaching-Learning and Assessment Strategy

CLO	Teaching-Learning Strategy	Assessment Strategy
CLO-1	- Deliver lectures using PowerPoint slides, videos, images and chalk-talk. - Seek immediate feedback during the lecture through short questions. - Respond to students' queries. - Conduct assessments to gauge understanding. - Assign tasks that encourage creativity and deeper exploration of specific topics. - Provide opportunities for practicing problem-solving. - Promote group discussions. - Arrange review classes when needed.	- Class participation through attendance. - Continuous assessment through quizzes. - In-course exams, assignments, and oral presentations. - Final evaluation through a written examination.
CLO-2		
CLO-3		
CLO-4		
CLO-5		

MBG 204C Medical Microbiology**Credits: 2****Class: 30 hours**

This course is designed to provide learning opportunities in the basic principles of medical microbiology and infectious disease. It covers the role of the human body's normal microflora and mechanisms of infectious disease transmission. The course provides the conceptual basis for understanding pathogenic microorganisms, including clinical examples and the mechanisms by which they cause disease in the human body. It also provides opportunities to develop informatics and diagnostic skills, including the use and interpretation of laboratory diagnosis of infectious diseases.

Course Objectives:

1. To develop knowledge on the principles of microbial pathogenesis.
2. To learn basic interactions between microorganisms with the human host and the diseases they produce.
3. To have a brief understanding of the human immune system.
4. To familiarize oneself with the major types of pathogenic microorganisms and their related diseases.

Course Learning Outcomes (CLOs):

1. Explain the basic concept of infection and infectious diseases.
2. Describe the role of microbes in diseases, including the nature of disease-causing microbes and their route of transmission.
3. Acquire basic knowledge about the virulence factors for identifying specific pathogens.
4. Summarize the role of the host in infectious disease, including natural barriers to infection
5. Compare and contrast different microbial diseases, including the properties of different types of pathogens, and the mechanisms of pathogenesis.
6. Have an understanding about the spread of infectious diseases, comparing the role of transmission, population size and susceptibility, and virulence.

Unit	Course Content	Class hours
1	Infection and Infectious Diseases: Concept of infection and infectious diseases; pathogenesis of infectious diseases; virulence (ID_{50} , and LD_{50})	3
2	Host-Microbe Interaction: normal resident microflora of human body and their role; initial colonization of a newborn; introduction to resident flora of skin, mouth, upper respiratory tract, intestinal tract, urogenital tract, eye.	4
3	Progress of Infection: true and opportunistic pathogens; portal of entry; stages in the course of infections and diseases; mechanism of invasion and establishment of the pathogens; signs and symptoms of a disease; portal of exit	3
4	Major Reservoirs of Microbial Pathogens and transmission of disease: acquisition of and mode of transmission of diseases. Introduction to nosocomial infection.	2
5	Introduction to Virulence factors: adherence factors; invasion of host cells and tissues; toxins; enzymes	3
6	Non-Specific Host Defences against Microbial Pathogens: primary defences conferred by tissues and blood	3
7	Introduction to Microbiology of Major Infectious Diseases: Skin, respiratory system, nervous system, genitourinary tract, gastrointestinal tract, circulatory system	9
8	Common infectious diseases in Bangladesh: Common diarrhoeal, respiratory, and genitourinary tract infections in Bangladesh	3

Recommended Books:

1. Jawetz, Melnick and Adelberg's Medical Microbiology- K.C. Carroll, S.A. Morse, T. Mietzner, and S. Miller; McGraw Hill Education
2. Essential Clinical Microbiology: an introductory text- E. M Cooke and G.L. Gibson; Wiley and Sons, New York
3. Bacterial Pathogenesis: A Molecular Approach- A.A. Salyers and D.D. Whitt; ASM Press
4. Medical Microbiology- J.P. Duguld, B.P. Marinian and R.H.A. Swain
5. Medical Microbiology - C. Mims, J. Playfair and I. Roitt; Wakelin D and Williams R.

Mapping Course Learning Outcomes (CLOs) with the Program Learning Outcomes (PLOs)

CLO	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7
CLO-1	√	√	√	√	√		
CLO-2	√	√	√	√	√		√
CLO-3	√	√	√	√			√
CLO-4	√	√	√				
CLO-5			√	√	√		√
CLO-6			√		√		√

Mapping CLOs with the Teaching-Learning and Assessment Strategy

CLO	Teaching-Learning Strategy	Assessment Strategy
CLO-1	- Deliver lectures using PowerPoint slides, videos, images and chalk-talk. - Seek immediate feedback during the lecture through short questions. - Respond to students' queries. - Conduct assessments to gauge understanding. - Assign tasks that encourage creativity and deeper exploration of specific topics. - Provide opportunities for practicing problem-solving. - Promote group discussions. - Arrange review classes when needed.	- Class participation through attendance. - Continuous assessment through quizzes. - In-course exams, assignments, and oral presentations. - Final evaluation through a written examination.
CLO-2		
CLO-3		
CLO-4		
CLO-5		
CLO-6		

MBG 205C Food Microbiology**Credits: 2****Class: 30 hours**

This course is designed to give students an understanding of the principles of food microbiology, role of microorganisms in food processing and preservation; the relation of microorganisms to food spoilage, food-borne illness, and intoxication; general food processing and quality control. Students will be able to familiarize themselves with the techniques used to research, regulate, prevent and control microorganisms in food and understand the function of beneficial microorganisms during food manufacturing process.

Course Objectives:

1. To learn about the relevance of microorganisms with food processing industries
2. To learn about food related microorganism with their growth and spoilage
3. To learn about control of food spoilage and preservation of foods

Course Learning Outcomes (CLOs):

1. Acquire knowledge about food categories & their common microbial association.
2. Demonstrate detailed understanding about the factors influencing microbial growth in food.

3. Make predication, assess and articulate for a specific food microorganisms are important in quality, spoilage and disease.
4. Acquire basic skills needed to learn procedures for preservation of foods.
5. Demonstrate the ability to perform basic regulatory guidelines for manufacturing safe and quality foods for consumers.

Unit	Course Content	Class hours
1	Food and Food-Associated Microbes: General aspects of food-needs; Food categories and six human nutrition and major sources; Sources of microbial contaminants in food; Role of nutrition in health and disease prevention; Beneficial and harmful microbes in associated with food- bacteria, yeasts and viruses; Probiotics, prebiotics, synbiotics, postbiotics and psychobiotics; Genetically modified microbes in food;	4
2	Factors Affecting Microbial Growth in Food: Intrinsic factors- pH, water activity, redox potential, nutrient content, antimicrobial constituents, biological structures; Extrinsic factors- temperature, relative humidity, gases; Implicit factors- specific growth rate, mutualism, antagonism, commensalism; Process factors- slicing, washing, packing, irradiation, Pasteurization.	5
3	Microbial Food spoilages: Causes and types of spoilages; Microbial contamination, spoilages of food-- cereal, sugar, vegetables, fruits, meat, fish and sea-foods, poultry, milk and milk products, and canned food.	6
4	Food Preservation: General principles; Thermal and non-thermal processing methods; Chemical and biological preservation of foods; Food packaging (modified atmosphere, antimicrobial packaging); Space food Safety & preservation; Impact of processing and packaging on the nutritional and microbial quality of food.	5
5	Fermented Food products: Dahi, Yogurt, Buttermilk (Chach), Cheese and Dried fish - preparation of inoculums, types of microorganisms and production process.	3
6	Food Safety Indicators and Food-borne Pathogens: Concept and importance of quality control of food; Food safety and quality indicators; Microbiological and chemical indicators and their selection criteria; characteristics of indicator microbes in various food products; Detection methods: Conventional and rapid methods for bacteriological identification; Detecting food poisoning toxins; Novel techniques for real-time food safety monitoring; Predictive food microbiology.	7

Recommended Books:

1. Fundamental Food Microbiology - B. Ray; CRC Press, New York
2. Food Microbiology: An Introduction - T.J. Montville & K.R. Matthews; ASM Press, USA.
3. Microbiology - W.C. Frazier & D.C. Westhoff; McGraw-Hill
4. Modern Food Microbiology - J.M. Jay; Springer
5. Food Microbiology - M.R. Adams & M.O. Moss; Thomas Graham House Cambridge

6. Principles of Food Sanitation – Norman G. Marriott, Robert B. Gravani; Springer
7. Food Processing Technology: Principles & Practice– P.J. Fellows; 4th Edn. Woodhead Publishing

Mapping Course Learning Outcomes (CLOs) with the Program Learning Outcomes (PLOs)

CLO	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7
CLO-1	√		√		√		
CLO-2	√		√		√		
CLO-3		√	√	√	√		
CLO-4	√	√	√	√	√	√	
CLO-5					√	√	√

Mapping CLOs with the Teaching-Learning and Assessment Strategy

CLO	Teaching-Learning Strategy	Assessment Strategy
CLO-1	- Deliver lectures using PowerPoint slides, videos, images and chalk-talk. - Seek immediate feedback during the lecture through short questions. - Respond to students' queries. - Conduct assessments to gauge understanding. - Assign tasks that encourage creativity and deeper exploration of specific topics. - Provide opportunities for practicing problem-solving. - Promote group discussions. - Arrange review classes when needed.	- Class participation through attendance. - Continuous assessment through quizzes. - In-course exams, assignments, and oral presentations. - Final evaluation through a written examination.
CLO-2		
CLO-3		
CLO-4		
CLO-5		

MBG 206C Fundamentals of Enzymology**Credits: 3****Class: 45 hours**

This fundamental course is designed to give students an understanding of the physical, chemical and kinetic properties of enzymes. It includes the influence of concentrations of substrate and enzyme, pH, temperature, and inhibitors on activity of enzymes. Specificity and mechanism of action of enzymes are described by considering examples of selected important enzymes related to food science, nutrition, and biological sciences. Moreover, the kinetics of the enzymatic reaction and the regulation of the enzyme, along with their relation to each other, will be under the umbrella of the scope of this course.

Course Objectives:

1. To provide a solid foundation in the principles of enzyme structure, function, and classification, including their physical, chemical, and catalytic properties.

2. To develop an understanding of enzyme kinetics, regulation, inhibition, and stabilization, with the ability to analyze and interpret experimental data.
3. To integrate theoretical enzymology with practical and applied contexts in research, clinical diagnostics, therapeutics, and industrial biotechnology.

Course Learning Outcomes (CLOs):

1. Classify enzymes according to their composition, function, and systematic classification, including isoenzymes and multi-enzyme complexes.
2. Explain the structural organization of enzymes (primary, secondary, tertiary, and quaternary structures) and the role of folding, domains, and molecular chaperones in enzyme stability and function.
3. Describe the properties and catalytic functions of enzymes, including catalytic power, specificity, and the role of cofactors, coenzymes, and vitamins and analyze mechanisms of enzyme regulation.
4. Study of enzyme kinetics as well as the estimation of important parameters (K_m , V_{max} , K_{cat})
5. Understand, analyze and determine the mechanism of enzyme inhibition and propose strategies for enzyme stabilization.
6. Integrate theoretical knowledge with practical enzymology to solve problems related to enzyme function, regulation, and application in research, diagnostics, therapeutics, biotechnology and industry.

Unit	Course Content	Class hours
1	Introduction to Enzymes: Composition and classification of enzymes; Isoenzymes; Multi-enzymes; Enzymes in organized systems; Use of enzymes in research, disease diagnosis and treatment, industrial applications of enzymes.	4
2	Properties and Functions of Enzymes: Remarkable properties; catalytic power; specificity; different forms; cofactors, coenzymes and vitamins	5
3	Structure of Enzymes: Primary, secondary, tertiary and quaternary structure; folding and domains; molecular chaperones	5
4	Enzyme Regulation: General mechanism of enzyme regulation; Reversible and irreversible covalent modification of enzymes; Allosteric enzymes; structure, properties and regulations.	7
5	Mechanism of Enzyme Action: Active site; substrate binding; general acid-base catalysis; covalent catalysis; protein-ligand binding; non-protein catalytic groups and metal ions; Enzyme turnover.	6
6	Kinetics of Enzyme-Catalysed Reactions: Factors influencing catalytic activity; simple enzyme kinetics with single and multi-substrate; Michaelis-Menten kinetics; turnover number, K_m and V_{max} ; other influences on enzyme activity; pH, temperature, fluid forces, chemical agents and irradiation.	8

7	Enzyme Inhibition and Deactivation: Reversible inhibition includes competitive, noncompetitive, and uncompetitive mechanisms; irreversible inhibition; deactivation models; and strategies for enzyme stabilisation.	6
8	Single molecule enzymology: Hexokinase, Chymotrypsin, Alcohol dehydrogenase, Lysozyme etc.	4

Books Recommended

1. Lehninger Principles of Biochemistry – D.L. Nelson and M.M. Cox, W.H. Freeman and Company, New York
2. Biochemical Engineering Fundamental – J.E. Bailey and D.F. Ollis, McGraw-Hill, New York
3. Fundamentals of Enzymology: The Cell and Molecular Biology of Catalytic Proteins - N.C. Price and L. Stevens; Oxford Science Publications
4. Advances in Enzymology and Related Areas of Molecular Biology – F.F. Nord; John Wiley & Sons.

Mapping Course Learning Outcomes (CLOs) with the Program Learning Outcomes (PLOs)

CLO	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7
CLO-1	✓	✓	✓		✓		
CLO-2	✓	✓	✓		✓		
CLO-3	✓	✓	✓	✓	✓	✓	
CLO-4	✓	✓	✓	✓	✓	✓	
CLO-5	✓	✓	✓		✓		
CLO-6	✓	✓	✓	✓	✓	✓	✓

Mapping CLOs with the Teaching-Learning and Assessment Strategy

CLO	Teaching-Learning Strategy	Assessment Strategy
CLO-1	• Deliver lectures using PowerPoint slides, videos, images and chalk-talk. • Seek immediate feedback during the lecture through short questions. • Respond to students' queries. • Conduct assessments to gauge understanding. • Assign tasks that encourage creativity and deeper exploration of specific topics. • Provide opportunities for practicing problem-solving. • Promote group discussions. • Arrange review classes when needed.	• Class participation through attendance. • Continuous assessment through quizzes. • In-course exams, assignments, and oral presentations. • Final evaluation through a written examination.
CLO-2		
CLO-3		
CLO-4		
CLO-5		
CLO-6		

MBG 207C**Fundamentals of Cell Biology****Credits: 2****Class: 30 hours**

Cell biology is the scientific study of the structure, function, and behavior of cells, the fundamental units of life in all living organisms. Understanding how cells grow, divide, communicate, and respond to their environment is essential to comprehending how tissues, organs, and organisms are formed and sustained. This course lays the foundation for exploring the molecular architecture of cells and the intricate mechanisms that govern their life processes. It also introduces cutting-edge topics such as quorum sensing and microbial memory, which expand our understanding of how unicellular organisms interact, adapt, and retain information from their environment.

Course Objectives:

1. To familiarize students with the fundamental concepts of cell biology, including the development and organization of cells in living organisms.
2. To understand the functions and coordination of cellular components in sustaining life.
3. To explore mechanisms involved in cell cycle regulation, signal transduction, adaptation, and cellular responses.
4. To introduce key principles of quorum sensing and microbial memory as emerging aspects of cellular communication and adaptability.

Course Learning Outcomes (CLOs):

1. Develop a broad understanding of cell structure and molecular architecture, emphasizing the unified role cells play in sustaining life.
2. Identify key cellular processes relevant to multicellular organization and tissue formation.
3. Understand transport mechanisms across eukaryotic cell membranes and energy generation.
4. Describe key steps and signals involved in intracellular protein transport.
5. Describe the mechanisms of nuclear and cellular division and how these are regulated and coordinated.
6. Recognize the roles of cell surface molecules and the extracellular matrix in cellular interaction, organ development, function, and respond to external signals.
7. Understand cell to cell junction and communications.

Unit	Course Content	Class hours
1	Molecular Architecture of Cells: Cellular and chemical foundations of life; historical development of cell theory; Distinguishing traits of prokaryotic cells and eukaryotic cells.	4
2	Transporting of Molecules Across Cell Membrane: Functions of cell membrane- phospholipids, cholesterol, proteins; Nutrient transport process- active and passive transport; Passive transport- Simple diffusion, osmosis, and facilitated diffusion; Active transport- ATP-driven pumps, ion channels; Bulk transport- endocytosis- pinocytosis, and receptor mediated endocytosis; exocytosis; Specialized transport systems- aquaporins; glucose and mitochondrial transporter; nanoparticle uptake.	5

3	Intracellular trafficking: Protein trafficking; signal hypothesis; Protein synthesis in ribosome- protein translation, signal sequences; Protein transport to ER- import, folding, modification, ER stress, unfolded protein response; Protein processing and sorting in Golgi apparatus- protein modifications, sorting into vesicles for targeting to endosomes, lysosomes, plasma membrane, secretion; vesicular transport and fusion- coat proteins; Protein transport to mitochondria- TOM/TIM complex; nucleus- nuclear pore complex, nuclear localization signals (NLS), importins/exportins; Defects in trafficking- CFTR, lysosomal storage disorder.	6
4	Cell Division and Cell Cycle: Cell division by binary fission; Mitosis in eukaryotes, stages of mitosis and meiosis; Phases of eukaryotic cell cycle- G1, S, G2 and M phase, cell cycle.	4
5	Cell cycle regulation: Regulation of cell cycle by CDK and associated proteins, cell cycle check points, regulation of passage through check points, effects of cell cycle deregulation.	4
6	Interactions between Cell and its Environment: Extracellular space, ECM components and their functions; collagen, fibronectin, proteoglycan, and laminin. Interactions of Cells with Extracellular Materials (Integrins), Interactions of Cells with Other Cells; selectins, cadherin etc. Focal adhesion and hemidesmosome. Cell junctions; Tight Junction and gap junction. Plasmodesmata and plant cell wall.	7

Recommended Books:

1. Cell and Molecular Biology: concepts and experiments- G. Karp and Marshall; Wiley & Sons
2. Karp's Cell and Molecular biology: Concepts and Experiments – G. Karp, J. Iwasa and W. Marshal; Wiley and Sons Pub.
3. Molecular Biology of the Cell: Alberts, Johnson, Lewis, Raff, Roberts and Walter. Garland Science.
4. Microbiology: An Introduction – G.J Tortora, B.R. Funke and C.L. Case. Pearson Education Inc.
5. Principles of Cell Biology – J. Plopper; Lewin's CELL
6. Cell Biology – T.D. Pollard and W.C. Earnshaw; Elsevier, Philadelphia

Mapping Course Learning Outcomes (CLOs) with the Program Learning Outcomes (PLOs)

CLO	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7
CLO-1		✓	✓		✓	✓	✓
CLO-2	✓	✓	✓	✓	✓	✓	
CLO-3	✓	✓	✓		✓	✓	
CLO-4		✓	✓	✓	✓	✓	
CLO-5		✓	✓			✓	
CLO-6		✓	✓			✓	
CLO-7		✓	✓			✓	

Mapping CLOs with the Teaching-Learning and Assessment Strategy

CLO	Teaching-Learning Strategy	Assessment Strategy
CLO-1	• Deliver lectures using PowerPoint slides, videos, images and chalk-talk. • Seek immediate feedback during the lecture through short questions. • Respond to students' queries. • Conduct assessments to gauge understanding. • Assign tasks that encourage creativity and deeper exploration of specific topics. • Provide opportunities for practicing problem-solving. • Promote group discussions. • Arrange review classes when needed.	• Class participation through attendance. • Continuous assessment through quizzes. • In-course exams, assignments, and oral presentations. • Final evaluation through a written examination.
CLO-2		
CLO-3		
CLO-4		
CLO-5		
CLO-6		
CLO-7		

MBG 208C Applied Mycology**Credits: 2****Class: 30 hours**

The course is designed to review the importance and advances in applications of fungi in agriculture, medicine, food production and the environmental sciences. It includes discussions of fungal associations in the environment, agriculture and forestry, long established and novel applications of fungi in fermentation, the use of fungi in the pharmaceutical industry, the growing recognition of fungal infections, current interests in the use of fungal enzymes in biotechnology and the new and emerging field of myconanotechnology.

Course Objectives:

1. To introduce students with fungal families with their characteristics and reproduction.
2. To learn about nutrition and culture techniques
3. To familiarize with the vast economic impact of fungi in environment, agriculture, health, and industry.

Course Learning Outcomes (CLOs):

1. learn significance of fungi and their relationship with other forms of life and environment.
2. familiarize with fungal families with respect to their characteristics.
3. familiarize students with fungal physiology and metabolic processes.
4. introduce them with fungal diseases of human, plants and animals and antifungal therapeutic agents.
5. enable them to understand the huge economic implications of fungal species in flourishing biotechnological industries of the world, and their positive and negative impacts on agriculture.
6. acquaint students about fungal culture in laboratory settings.

Unit	Course Content	Class hours
1	Biology and Ecology of Fungi: Structure and characteristics of fungi; major fungal subdivisions; dispersal strategy of microfungi in the environment; microfungi in indoor environment.	5
2	Fungal Systematics: history of mycology; recent approaches to microfungal nomenclature; future perspectives of fungal systematics.	6
3	Fungal Physiology and Metabolism: nutrition in fungi; aerobic and anaerobic respiration in fungi.	5
4	Fungal Diseases in Man, Animals and Plants: Fungal Diseases in man-hypersensitivity, Mycotoxicoses and mycoses; general aspects of fungal immunology and pathology; Antifungal therapeutic agents; animal and plant pathogens.	5
5	Economic Importance of Fungi to Man and the Environment: fungal metabolites; Importance of fungi in agriculture; food industry, bioenergy; pharmaceuticals, environment, and biotechnology.	5
6	Laboratory Methods in Mycology: Collection and transportation of fungal samples; Storage and processing of samples for mycological studies; Culture media and growth requirements; Macroscopic characterization of Fungi; Microscopic examination and staining techniques; Laboratory identification of Fungi and Mycotoxin detection methods	4

Recommended Books:

1. Biology of Microfungi- D-W Lee; Springer
2. Introduction to Fungi - J. Webster & R. Weber, Cambridge University Press, Cambridge
3. Introductory Mycology - C. J. Alexopoulos, C.W. Mims & M.M. Blackwell, John Wiley & Sons
4. Fungi: Biology and Applications - Kevin Kavanagh – John Wiley & Sons, Inc.
5. Applied Mycology- M. Rai & P.D. Bridge; CABI

Mapping Course Learning Outcomes (CLOs) with the Program Learning Outcomes (PLOs)

CLO	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7
CLO 1	✓		✓		✓		
CLO 2	✓		✓		✓		
CLO 3	✓	✓	✓	✓	✓		
CLO 4	✓	✓	✓	✓	✓		✓
CLO 5	✓	✓	✓		✓	✓	✓
CLO 6			✓	✓	✓	✓	
CLO 7			✓	✓	✓	✓	✓

Mapping CLOs with the Teaching-Learning and Assessment Strategy

CLO	Teaching-Learning Strategy	Assessment Strategy
CLO-1	- Deliver lectures using PowerPoint slides, videos, images and chalk-talk. - Seek immediate feedback during the lecture through short questions. - Respond to students' queries. - Conduct assessments to gauge understanding. - Assign tasks that encourage creativity and deeper exploration of specific topics. - Provide opportunities for practicing problem-solving. - Promote group discussions. - Arrange review classes when needed.	- Class participation through attendance. - Continuous assessment through quizzes. - In-course exams, assignments, and oral presentations. - Final evaluation through a written examination.
CLO-2		
CLO-3		
CLO-4		
CLO-5		
CLO-6		
CLO-7		

MBG 209C Laboratory Works II**Credits: 6****Class: 120 hours**

The second-year laboratory course is designed to focus on the senses and basic techniques more insight into the range of processes related to the theoretical courses. This basic Laboratory curriculum described below represents topics and themes considered essential to the development of cognitive, analytical, communication, and interpersonal skills in microbiology laboratories. These themes and topics are meant to frame objectives to be met somewhere within the microbiology laboratory. Laboratory works typically supplement and integrate closely with the lecture contents of the theoretical courses in a way that is unique to each instructor. Development of laboratory techniques; exercises designed to reinforce concepts covered in this course.

Course Objectives:

The main objective of the course is to achieve basic laboratory skills in microbiological sciences. The specific objectives include developing laboratory skills in the demonstration of cell structures and division, growth measurement, the factors influencing microbial growth and their metabolic activities in foods, microbiological health hazards, microbial enzymes, etc., and developing analytical and communication skills along with data processing for laboratory reports.

Course Learning Outcomes (CLOs):

1. Identify and differentiate the structural features of eukaryotic cells, including plant, animal, and parasitic cells, using microscopy and photomicrographs.
2. Perform sample collection, transportation, processing, and preservation of environmental, food, and clinical specimens following standard laboratory protocols.
3. Assess microbiological quality and contamination levels of samples through appropriate physical, chemical, and microbiological tests.
4. Measure microbial growth and conduct biochemical tests to identify microorganisms and analyze physiological properties.
5. Isolate, assay, and characterize microbial enzymes to determine their activity, specificity, and kinetic parameters using both wet-lab and *in silico* approaches.

Course Content	Class hours
1. Study representative plant and animal cells by microscopy 2. Study of different stages of Meiosis and Mitosis by permanent slides 3. Identification and study of healthy cells, cell organelles, and cancer cells by microscopy/photomicrographs 4. Microscopic study of parasites 5. Comprehensive analysis of Environmental sample (water) a. Sample collection, transportation, processing and preservation, b. Determination of physicochemical parameters, c. Assessment of microbiological quality, d. Determination of microbial growth parameters. 6. Comprehensive analysis of Clinical sample (urine) a. Sample collection, transportation, processing and preservation, b. Analysis of clinical sample (Urine)- physical, chemical and microbiological, c. Antibiotic sensitivity pattern against pathogenic microorganisms. 7. Isolation of normal microflora from skin and respiratory tract. 8. Comprehensive analysis of Food samples (milk, meat etc.) a. Sample collection, transportation, processing and preservation, b. Isolation and identification of bacteria from different food samples. 9. Methylene Blue Reduction Test (MBRT) and Alkaline Phosphatase Test (APT) of milk samples and their standard plate count. 10. Study and plot the growth curve of bacteria by the turbidimetric method. 11. Demonstration of the thermal death time and decimal reduction time of <i>E. coli</i>. 12. Hydrolysis of biopolymers such as starch, lipid, casein, and gelatin. Carbohydrate fermentation 13. Biochemical tests: MIU, KIA, and IMViC tests, Nitrate reduction, oxidase, catalase, and litmus milk reaction tests 14. Demonstration of anaerobic culture techniques 15. Isolation of cellulolytic, proteolytic, lipolytic, and amylolytic microbes from different sources, and determination of their enzyme activity 16. Determination of kinetic properties of an enzyme 17. Determination of activators and inhibitors of the enzyme 18. Determination of molecule weight and substrate specificity of the enzyme 19. <i>In silico</i> study of enzymes and kinetics. 20. A visit to a sewage treatment plant.	120

Recommended Books:

1. Microbiology: A Laboratory Manual- J. Cappucino & N. Sherman; Pearson Education Limited
2. Cell and Molecular Biology – P.V. Chaitanya; Prentice-Hall of India Pvt. Ltd.
3. Environmental Microbiology – I. Pepper, C. Gebra and J. Brandecke; Academic Press
4. Principles of Microbiology - R.M. Atlas, WM.T. Brown Publishers.
5. Food Microbiology: A Laboratory Manual – A.E. Yousef and C. Carlstrom; Wiley and Sons Inc.

Mapping Course Learning Outcomes (CLOs) with the Program Learning Outcomes (PLOs)

CLO	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7
CLO1	√		√				
CLO2		√	√	√			
CLO3		√	√	√	√		
CLO4	√		√	√	√		
CLO5		√	√	√	√		

Mapping CLOs with the Teaching-Learning and Assessment Strategy

CLO	Teaching-Learning Strategy	Assessment Strategy
CLO-1	- Conduct interactive lectures covering the principles, methods, procedures, and applications of each experiment using PowerPoint/ videos/ pictures/ chalk-talk. - Obtain immediate feedback by asking questions. - Address students' queries promptly. - Facilitate problem-solving practice. - Provide hands-on laboratory training. - Visit to a sewage treatment plant to gain professional experience. - Encourage collaborative discussion among students.	- Class participation through attendance - Continuous assessment through in-course exams, and assignments. - Evaluation of practical notebooks. - Report from the visit to the sewage treatment plant. - Final assessment through practical experiments and a written test. - Viva voce.
CLO-2		
CLO-3		
CLO-4		
CLO-5		

MBG 210C Viva-Voce**Credits: 2**

A viva-voce or oral examination is an opportunity where students demonstrate their knowledge, expertise, and understanding of both theoretical and practical courses. It also allows the examiners to assess the students' academic abilities and determine whether they have met the requirements for promotion to the next academic level.

Course Objectives:

1. Demonstrate comprehensive knowledge in their broader field of study.
2. Enhance their ability to effectively communicate scientific information with confidence, skills, and expertise.
3. Evaluate and reflect on their understanding and mastery of the program's content.

Course Learning Outcomes (CLOs):

1. To evaluate their knowledge and thinking capacity as well as pressure handling capacity.
2. Ability to describe the process of science.
3. Ability to communicate and collaborate with other disciplines.

Course Content: All the courses attended in the 2nd academic year.

Mapping Course Learning Outcomes (CLOs) with the Program Learning Outcomes (PLOs)

CLO	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7
CLO-1	√	√	√			√	
CLO-2		√		√	√		
CLO-3						√	√

Mapping CLOs with the Teaching-Learning and Assessment Strategy

CLO	Teaching-Learning Strategy	Assessment Strategy
CLO-1	• Problem solving and discussion. • Respond to students' queries. • Encourage collaborative discussion among students.	Final evaluation through questions and performance.
CLO-2		
CLO-3		

MBG 211G**Biostatistics and Calculus****Credits: 4****Class: 60 hours**

This course is designed to introduce the basic sequence, calculus, serving as the foundation of advanced subjects in all areas of mathematics. The sequence, equally, emphasizes basic concepts and skills needed for mathematical manipulation. The calculus focuses on the study of functions of a single variable. Without statistical analysis research articles are not accepted for publication by scientific journals.

Course Objectives:

1. To help the students analyze data to their research work.
2. To assess the significance of their experimental designs.
3. To earn sound knowledge of statistical programs.

Course Learning Outcomes (CLOs):

1. Develop skills to demonstrate communicating quantitative information.
2. Demonstrate competence in statistical, mathematical, computational, and non-mathematical skills in statistical science.
3. Demonstrate the ability to analyze data by appropriately fitting, assessing, and interpreting a variety of statistical models
4. Write technical reports and make technical presentations containing statistical results, and work in teams to demonstrate the consulting skills of a professional statistician

5. Manipulate data, implement statistical methods, document, and debug code in one or more professional statistical software programs
6. Solve problems in basic probability theory, statistical inference, and calculus.

Unit	Course Content	Class hours
1	Organizing and Summarizing Data: some basic concepts; statistics, biostatistics, variables, population and sample, random samples, distribution; tabulation, processing and summarizing of numerical data; the frequency – distribution, graphical representation of frequency table measures of central tendency; measures of dispersion, skewness of kurtoses; measures or exploratory data analysis by plotting	6
2	Probability: introduction; some elementary probability; the binomial distribution; the normal distribution; the Chi-square distribution; the distribution of Student's	4
3	Estimation of the Mean and Proportion: Introduction to Estimation; Point and Interval Estimates; Estimation of a Population Mean; Estimation of a population proportion	4
3	Hypothesis Testing/ Statistical Inference: statistical hypothesis: simple and composite hypothesis; significance test; type-I and type-II errors; power of a test; p-value; testing hypothesis of a single population mean, proportion, variance; comparison between two population means and between two population variances	6
4	Analysis of Frequency using χ^2 Distributions: the χ^2 criterion; tests of goodness-of-fit; homogeneity of two-cell samples; tests of independence	4
5	Correlation, Simple Regression and Multiple Regression: correlation: linear regression model, evaluating the regression equation, the multiple regression model; evaluating multiple regression model; choosing independent variables for multiple regression model	6
6	Analysis of Variance: experiment; experimental unit; treatment; replication analysis of variance for the completely randomized design; the randomized complete block design; the Latin square design	5
7	Statistical Methods in Epidemiology: basic incidence measures; risk and rate; prevalence measures; measures of association; risk ratio or relative risk; exposure odds ratio; risk odds ratio; measures of potential impact; attributable risk	6
8	Survival Analysis: introduction; basic designs follow-up studies, cross-sectional studies and case control studies; survival function; hazard function; the product	5

	limit estimate of survival function; the life table analysis; the log rank test for comparing survival distributions	
9	Calculus for biology: Fundamental theorem of calculus, simple limit ideas, functions and continuity, differentiation and applications, simple integration and applications, matrices and vectors, linear equation systems, sample models: predator prey model, disease model, cancer model	4
10	Applications and analyses	10

Recommended Books:

1. Introduction to Biostatistics: a textbook of biometry – P.K. Banerjee; S. Chand and Com. Ltd.
2. Fundamentals of Biostatistics – B. Rosner.
3. Fundamentals of Calculus – C.C. Morris and R.M. Stark; Wiley
4. Introductory Statistics- Prem S. Mann

Mapping Course Learning Outcomes (CLOs) with the Program Learning Outcomes (PLOs)

CLO	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7
CLO-1	✓	✓	✓		✓	✓	
CLO-2	✓	✓	✓	✓	✓		
CLO-3	✓	✓	✓	✓	✓		
CLO-4		✓	✓		✓	✓	✓
CLO-5	✓	✓	✓	✓	✓		
CLO-6	✓	✓	✓		✓		

Mapping CLOs with the Teaching-Learning and Assessment Strategy

CLO	Teaching-Learning Strategy	Assessment Strategy
CLO-1	• Deliver lectures using PowerPoint slides, videos, images and chalk-talk.	• Class participation through attendance.
CLO-2	• Seek immediate feedback during the lecture through short questions.	• Continuous assessment through in-course exams, assignments including writing technical reports and oral presentations.
CLO-3	• Respond to students' queries.	
CLO-4	• Conduct assessments to gauge understanding. • Provide opportunities for developing problem-solving skills.	
CLO-5	• Provide training on statistical analysis software.	
CLO-6	• Encourage collaborative discussion among students. • Arrange review classes when needed.	• Final evaluation through a written examination.

CM 222H Biologically Important Organic Compounds**Credits: 2****Class: 30 hours**

This course is designed by the Department of Chemistry as supporting/allied course for the graduate students of Microbiology. A large class of organic compounds of biological and chemical origin, have attracted scientific interest since historical times because of their applications in various purposes. The synthesis of organic compounds and their derivatives occupy an important place in the realm of natural and synthetic organic chemistry due to their therapeutic and pharmacological properties. This course offers unique applications of biologically important natural compounds, which forms the crucial foundation to understand this contemporary subject.

Course Objectives:

1. To familiarize with the different classes of biologically important organic compounds with their sources and properties.
2. To acquire knowledge about the basic concept of synthetic organic compounds and their applications in drug development.
3. To understand the unique applications of natural organic compound in human welfare.

Course Learning Outcomes (CLOs):

1. Have an overview over biomolecules such as carbohydrates, polysaccharides, amino acids, proteins, nucleic acids, DNA/RNA and lipids with their structure and chemical properties.
2. Have an overview over the properties, composition and biosynthesis of the natural compound.
3. Have an overview over and understand reaction mechanisms with relevance to pharmacy and biology.
4. Have an overview over the structure and chemical properties of radicals, metals, enolates, heterocyclic compounds and their relevance to pharmacy and biology.
5. Understand the fundamental chemical properties that are of importance to drug effects in general.
6. Understand how fundamental chemical properties can affect drug receptor interaction, drug uptake, transport, metabolism and excretion from the body.

Unit	Course Content	Class hours
1	Fats and Oils: occurrence, composition of fats and oils; hydrolysis of fats and oils; various use of fats and oils; saponification of fats and oils; Tiodine value and saponification value of fats and oils; saturated and unsaturated fatty acids	3
2	Amino Acids, Peptides and Proteins: structure and configuration of amino acids; isoelectric point preparations; reactions of amino acids and peptides; C-terminal and N-terminal residue of peptides; proteins, their classifications and functions; basic structure of proteins	3
3	Carbohydrates: definition, classification and composition of monosaccharides; ring structure of monosaccharides and their conformations; action of acids and bases on sugars: epimers, anomers and anomeric configurations; reactions of	3

	monosaccharides, disaccharides and trisaccharides, their structure and compositions; polysaccharides: cellulose, starch and their constituents	
4	Vitamins: occurrence, symptoms due to deficiency of vitamins; chemistry of vitamin: A, B1, B2, B6, B12 and E their structures	3
5	Synthesis of Following Drugs and Their Actions in Biological Systems: sulpha drugs, sulphonamide sulphapyridine, sulphaguanidine, sulphamethazine and sulphathiazole	4
6	Antimaterials: plasmaquine, mepacrine, proguanil and quinine	3
7	Antibiotics: penicillin, amoxycillin, streptomycin, chloromycetin, etc.	3
8	Insecticides, Fungicides and Herbicides: organic compounds: DDT, gammexane, methoxychlor and heptachlor; organophosphorous compounds; malathion, parathion, dimecron and diazinon; carbamates; 2,4-D (2,4-dichloroacetic acid)	3
9	Organic Pollutants	2
10	Purines and Nucleic Acids: structure of uric acid, nucleosides and nucleotides: DNA and RNA	3

Recommended Books:

1. Chemistry of Organic Natural Products, Vol. I & II –Agarwal OP
2. Organic Chemistry – Morrison RT & Boyd RN
3. Organic Chemistry, Vol. I & II – Finer LL
4. Organic Chemistry – Handrickson JB & Pine SH
5. Applications of Biologically Important Natural Compounds – K. Cornwell

Mapping Course Learning Outcomes (CLOs) with the Program Learning Outcomes (PLOs)

CLO	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7
CLO-1	✓	✓	✓		✓		
CLO-2	✓	✓	✓	✓	✓		
CLO-3	✓	✓	✓		✓		
CLO-4	✓	✓	✓	✓	✓		✓
CLO-5	✓	✓	✓		✓	✓	
CLO-6	✓	✓	✓		✓	✓	✓

Mapping CLOs with the Teaching-Learning and Assessment Strategy

CLO	Teaching-Learning Strategy	Assessment Strategy
CLO-1	Deliver lectures using PowerPoint slides, videos, images and chalk-talk.	Class participation through attendance.

CLO-2	- Seek immediate feedback during the lecture through short questions. - Respond to students' queries. - Conduct assessments to gauge understanding. - Assign tasks that encourage creativity and deeper exploration of specific topics. - Provide opportunities for practicing problem-solving. - Promote group discussions. - Arrange review classes when needed.	- Continuous assessment through quizzes. - In-course exams, assignments, and oral presentations. - Final evaluation through a written examination.
CLO-3		
CLO-4		
CLO-5		
CLO-6		

CMGL 101H General Chemistry Laboratory**Credits: 2****Class: 36 hours**

This course is designed by the Department of Chemistry as supporting/allied course for the graduate students of Microbiology. The course covers the determination of molecular mass of an unknown compound, velocity constant of a base catalyzed hydrolysis of ethyl acetate. Determination of viscosity of chemicals/solutions. Identification of unknown inorganic sample by semi micro qualitative analysis.

Course Objectives:

In the practical component, students should develop basic laboratory skills (observation, analytical techniques, report writing) and an appreciation of the health and safety issues associated with the safe handling and disposal of laboratory chemicals.

Course Learning Outcomes (CLOs):

1. Demonstrate basic laboratory skills including accurate observation, measurement, and handling of chemical substances safely.
2. Perform experiments related to physical and organic chemistry such as determination of molecular mass, enthalpy, conductance, and identification of functional groups.
3. Analyze and interpret experimental data, apply scientific reasoning to draw valid conclusions, and present results in a clear written format.
4. Apply safety procedures, waste management principles, and ethical practices in laboratory work.
5. Work effectively in groups to perform laboratory experiments and communicate findings through organized lab reports.

Unit	Course Content	Class hours
1	Physical Chemistry: (a) Determination of the molar mass of carbon tetrachloride by Duma's method, (b) Determination of enthalpy of neutralization of acid calorimetrically, (c) Determination of partition coefficient between water and	18

	carbon tetrachloride, (d) Investigation of the variation of conductance of a weak electrolyte with concentration, (e) Investigation of the effect of reactant concentration on the rate of the reaction between thiosulphate ion and H ⁺ ion and determination of the reaction.	
2	Organic Chemistry: (a) Determination of the melting point of the organic compounds, (b) Determination of the presence of nitrogen, sulphur, and halogens in organic samples Identification of functional groups in organic compounds.	18

Recommended Books:

1. Green Chemistry Laboratory Manual – S. Henrie; CRC Press
2. Handbook of Green Chemistry and Technology – J.H. Clark and D. Macquarrie; Wiley Balckwell

Mapping Course Learning Outcomes (CLOs) with the Program Learning Outcomes (PLOs)

CLO	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7
CLO-1	✓	✓		✓		✓	✓
CLO-2	✓	✓	✓			✓	
CLO-3		✓	✓	✓			✓
CLO-4				✓	✓		✓
CLO-5				✓	✓	✓	✓

Mapping CLOs with the Teaching-Learning and Assessment Strategy

CLO	Teaching-Learning Strategy	Assessment Strategy
CLO-1	- Conduct interactive lectures covering the principles, methods, procedures, and applications of each experiment using PowerPoint/ videos/ pictures/ chalk-talk. - Obtain immediate feedback by asking questions. - Address students' queries promptly. - Facilitate problem-solving practice. - Provide hands-on laboratory training. - Encourage collaborative discussion among students.	- Class participation through attendance. - Continuous assessment: In-course examinations and assignments. - Evaluation of practical notebooks. - Final assessment through practical experiments and a written test. - Viva voce.
CLO-2		
CLO-3		
CLO-4		
CLO-5		

Courses for 3rd year BS Honours

The student will undertake an independent in-depth of interesting courses and begin to specialize. It may involve supervised practical work in a laboratory, or the students may choose to work on e-learning, educational, data analysis, bioinformatics or enterprise topics. The course unit details given below are subject to change and are the latest example of the curriculum available on this course of study.

MBG 301C Biosynthetic Metabolism

Credits: 2

Class: 30 hours

This course is designed to introduce students to bacterial metabolism particularly focusing on the anabolic or synthetic pathways. The course will summarize different metabolic pathways and their regulation such as microbial inorganic metabolism, phototrophic prokaryotes and their significant light harvesting metabolic reactions, the nitrogen fixation system of nitrogen fixing bacteria etc.

Course Objectives:

1. To learn basic concepts of biosynthetic pathways, their regulatory enzymes and kinetics.
2. To understand the mechanism of photosynthesis in different photosynthetic bacteria.
3. To learn the metabolism of different inorganic compounds and biosynthesis of carbohydrate, lipid, amino acid and nucleic acid.

Course Learning Outcomes (CLOs):

1. Acquire, retain, and communicate complex conceptual ideas related to bacterial physiology and metabolism.
2. Know about the regulatory enzymes and their kinetics during metabolic reactions.
3. Explain the biosynthetic pathways of carbohydrate, lipid, amino acid and nucleic acid and their maintenance.
4. Understand the mechanisms of autotrophic and phototrophic microbial cycles and nitrogen fixation.

Unit	Course Content	Class hours
1	Regulation of Metabolic Pathways: regulatory patterns of metabolic pathways; kinetics of regulatory and non-regulatory enzymes; conformational changes in regulatory enzymes; regulation by covalent modification.	5
2	Carbohydrate synthesis: gluconeogenesis pathway and regulation.	4
3	Metabolism of Lipids and Nucleotides, biosynthesis of fatty acids; role of cofactors in fatty acid biosynthesis; pathway to biosynthesis of mevalonate, squalene and sterols, biosynthesis of purines and pyrimidines; regulation of purine and pyrimidine biosynthesis	5
4	Biosynthesis of Amino Acids: the glutamate and ketoglutarate family; the aspartate and pyruvate families; the serine-glycine family; aromatic amino acids.	6

5	Photosynthesis: The Phototrophic Prokaryotes, The Purple Photosynthetic Bacteria, The Green Sulfur Bacteria (Chlorobiaceae), Cyanobacteria and their Chloroplasts, Efficiency of Photosynthesis, Photosynthetic Pigments, The Transfer of Energy from the Light Harvesting Pigments to the Reaction Center, The Structure of Photosynthetic Membranes in Bacteria.	6
6	Inorganic Metabolism: Assimilation of Nitrate and Sulfate, Dissimilation of Nitrate and Sulfate, Nitrogen Fixation, Lithotrophy (aerobic chemolithotroph; hydrogen and CO oxidizers; ammonia, sulphur and ferrous ion oxidizers; facultative obligate chemolithotrophs)	5

Recommended Books:

1. Bacterial Metabolism- G. Gottschalk; Springer-Verlag, New York
2. The Physiology and Biochemistry of Prokaryotes- D. White, J. Drummond and C. Fuqu, Oxford University Press
3. Microbial Physiology- A.G. Moat and J.W. Foster; John Wiley, New York
4. Microbiology- M.J. Pelczar Jr., E.C.S. Chan & N.R. Krieg, McGraw-Hill Book Company
5. Lehninger Principles of Biochemistry- D.L. Nelson & M.M. Cox; W.H. Freeman & Company, NY

Mapping Course Learning Outcomes (CLOs) with the Program Learning Outcomes (PLOs)

CLO	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7
CLO-1	✓	✓	✓				
CLO-2	✓	✓	✓		✓		
CLO-3	✓	✓	✓		✓		
CLO-4	✓	✓	✓	✓			✓

Mapping CLOs with the Teaching-Learning and Assessment Strategy

CLO	Teaching-Learning Strategy	Assessment Strategy
CLO-1	• Deliver lectures using PowerPoint slides, videos, images and chalk-talk. • Seek immediate feedback during the lecture through short questions. • Respond to students' queries. • Conduct assessments to gauge understanding. • Assign tasks that encourage creativity and deeper exploration of specific topics. • Provide opportunities for practicing problem-solving. • Promote group discussions. • Arrange review classes when needed.	• Class participation through attendance. • Continuous assessment through quizzes. • In-course exams, assignments, and oral presentations. • Final evaluation through a written examination.
CLO-2		
CLO-3		
CLO-4		

MBG 302C Microbial Molecular Genetics**Credits: 3****Class: 45 hours**

This course provides a comprehensive introduction to microbial genetics, focusing on how bacterial DNA can undergo changes in sequence and structure. It explores the agents responsible for such mutations, the mechanisms of DNA repair, and various modes of horizontal gene transfer. The course further examines the role and mechanism of mobile genetic elements such as transposons and explains how bacteria regulate gene expression in response to environmental cues.

Course Objectives:

1. Develop an understanding of bacterial DNA sequences, mechanisms of sequence alteration (mutations) and the cellular systems for DNA repair.
2. Introduce the mechanisms of gene transfer in bacteria and the role of transposons in facilitating genetic variation.
3. Explain bacterial gene regulation in response to environmental stimuli and the molecular basis of genetic recombination.

Course Learning Outcomes (CLOs):

1. Critically analyze and integrate core concepts in microbial molecular genetics.
2. Define and classify different types of mutations in bacterial genomes.
3. Describe the mechanisms of DNA repair and how they correct genetic changes.
4. Explain the various methods of horizontal gene transfer in bacteria.
5. Regulation of gene expression in bacteria under different environmental conditions.
6. Describe the mechanisms and outcomes of genetic recombination.
7. Define transposons and explain their roles and mechanisms in bacterial genetics
8. Describe the molecular mechanism and role of QS in bacterial physiology and pathogenicity.
9. Recognize the importance of microbial memory in health, environment, and biotechnology.

Unit	Course Content	Class hours
1	Mutation: Mutation rate; types of mutations, Detection of mutations; mutagenic agents, Screening chemicals for mutagenicity Molecular basis of mutagenesis, Mutation induced by chemical and physical agents, Effects of mutation on multicellular organisms and microorganisms.	8
2	DNA Repair Mechanisms: Nature of DNA damage, Light-dependent repair; excision repair, Mismatch repair; post-replication repair, Error-prone repair system; SOS repair.	5
3	Gene Transmission in Bacteria: Mutant phenotypes in bacteria; basic test for transformation, conjugation and transduction, Transformation and gene mapping, Conjugation and gene mapping, Transduction and gene mapping, the evolutionary significance of sexuality in bacteria. Plasmid biology: Structure and replication of plasmids. Transformation of plasmids into bacterial cells.	7

4	Regulation of Bacterial Gene Expression: Constitutive, inducible, and repressive gene expression; positive and negative control; lactose and histidine operon in <i>E. coli</i> , induction and catabolite repression; tryptophan operon in <i>E. coli</i> repression and attenuation, arabinose operon in <i>E. coli</i> ; transcriptional, translational and post-translational regulatory mechanisms.	6
5	Genetic Recombination: Types of recombination, Models of general recombination, Molecular basis of homologous recombination, Molecular basis of non-homologous recombination	5
6	Transposable Genetic Elements: Transposable elements in prokaryotes; IS elements, Composite transposons, Tn3 element, Mutagenic effects of bacterial transposable elements, the medical significance of bacterial transposons. Transposable elements in eukaryotes: Ac, Ds, and Dt elements in maize, P elements and hybrid dysgenesis in <i>Drosophila</i>	5
7	Quorum Sensing: Definition and Historical Background, Molecular Mechanism of Quorum Sensing, Role of Quorum Sensing in Bacterial Physiology, Inter-species and Inter-Kingdom Communication, Quorum Quenching, Biotechnological and Medical Applications	5
8	Microbial Memory: Introduction to Microbial Memory, Mechanisms of Microbial Memory, Examples of Microbial Memory, Tools and Techniques to Study Microbial Memory, Implications and Applications	4

Recommended Books:

1. Genetics - D.P. Snustad and M.J. Simmons, John Wiley and Sons, Inc.
2. Principles of Genetics –E.J. Gardner, M.J. Simmons and D.P. Snustad, John Wiley and Sons
3. Lewin's Genes XI – J.E. Krebs, E.S. Goldstein, and S.T. Kilpatrick. Jones and Bartlett Learning
4. Genetics: A conceptual approach – B.A. Pierce, W.H. Freeman and Company
5. Cell and Molecular Biology - Gerald Karp, John Wiley and Sons Inc.

Mapping Course Learning Outcomes (CLOs) with the Program Learning Outcomes (PLOs)

CLO	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7
CLO-1	✓	✓	✓				
CLO-2	✓	✓					
CLO-3	✓	✓	✓				
CLO-4	✓	✓	✓	✓			
CLO-5	✓	✓	✓				
CLO-6	✓	✓	✓	✓			
CLO-7	✓	✓	✓				
CLO-8	✓	✓	✓	✓	✓		✓
CLO-9	✓	✓	✓		✓		✓

Mapping CLOs with the Teaching-Learning and Assessment Strategy

CLO	Teaching-Learning Strategy	Assessment Strategy
CLO-1	- Deliver lectures using PowerPoint slides, videos, images and chalk-talk. - Seek immediate feedback during the lecture through short questions. - Respond to students' queries. - Conduct assessments to gauge understanding. - Assign tasks that encourage creativity and deeper exploration of specific topics. - Provide opportunities for practicing problem-solving. - Promote group discussions. - Arrange review classes when needed.	- Class participation through attendance. - Continuous assessment through quizzes. - In-course exams, assignments, and oral presentations. - Final evaluation through a written examination.
CLO-2		
CLO-3		
CLO-4		
CLO-5		
CLO-6		
CLO-7		
CLO-8		
CLO-9		

MBG 303C Microbial Pathogenesis**Credits: 3 Class: 45 hours**

This course will introduce students to the microbial species that cause human disease and the basic principles of bacterial pathogenesis before conducting a survey of the pathogens and their specific virulence factors. It also covers current topics including antibiotic resistance, public health threats, and global health. The course also provides cutting-edge information on selected topics in Medical Microbiology, including molecular mechanisms by which bacterial pathogens cause disease and emergent technologies. Bacterial infections will be considered as molecular interactions between hosts and their infecting microbes. The course will also include some aspects of bacterial genetics and physiology, immune response to infection, and the cell biology of host-parasite interactions.

Course Objectives:

1. To explore the general nature of relationships between human and microbial diseases
2. To identify the major factors determining virulence and their genetic basis
3. To explain how humans try to prevent or treat these diseases.

Course Learning Outcomes (CLOs):

1. Describe the most common diseases caused by pathogenic bacteria including their mechanisms for transmission, virulence and pathogenicity and resistant patterns.
2. Understand the tests used by microbiologists to identify and characterize organisms and their virulence factors
3. Explain the bacterial strategies for evading or surviving host defense systems.
4. Describe toxins and other toxic virulence factors.
5. Explain the genome plasticity, mobile genetic elements, intracellular signaling, membrane biogenesis.

Unit	Course Content	Class hours
1	Clinical Manifestation, Pathogenesis, Virulence Factors, and Control of the following Pathogenic Microbes: <i>Streptococcus</i> spp. <i>Staphylococcus</i> spp; <i>Corynebacterium diphtheriae</i> ; <i>Mycobacterium tuberculosis</i> ; <i>Vibrio cholerae</i> ; <i>Escherichia coli</i> ; <i>Salmonella enteric typhi</i> ; <i>Neisseria</i> spp.; <i>Treponema pallidum</i> .	10
2	Introduction to Clinically Important Parasites: <i>Giardia</i> ; <i>Entamoeba</i> , <i>Leishmania</i> , <i>Taenia</i> , <i>Plasmodium</i> spp.	7
3	Bacterial strategies for Evading or Surviving Host Defence Systems: Overview of bacterial defense strategies; Colonization of host surfaces, evading the host immune response.	10
4	Toxins and Other Toxic Virulence Factors: Transparent mechanisms, mysterious purposes; Characteristics and nomenclature of bacterial toxins; Nonprotein toxins; Protein exotoxins; Protein exoenzymes/effectors; Diseases mediated by toxins; Immunotoxins-toxin-based therapeutics and research tools.	8
5	Mechanisms of Genetic Modification and Exchange: Role in Pathogen Evolution- Adapt or Perish- Horizontal gene transfer (HGT) and acquiring new virulence traits by HGT; Mutational change and diversification; Phase variation; Antigenic variation; Horizontal gene transfer (HGT)- mobile genetic elements; Pathogenicity islands and pathogen evolution.	10

Recommended Books:

1. Bacterial Pathogenesis: A Molecular Approach- A.A. Salyers and D.D. Whitt–ASM Press,
2. Jawetz, Melnick and Adelberg's Medical Microbiology – K.C. Carroll, S.A. Morse, T. Mietzner, S. Miller; McGraw Hill Education
3. Medical Microbiology - R.F. Boyd and J.J. Marr; Little Brown and Company, Boston
4. Manual of Clinical Microbiology – P.R. Murray, E.J. Baron, M.A. Pfaller, F.C. Tenover and R.H. Tenover – ASM Press, Washington D.C.
5. Medical Microbiology - C. Mims, J. Playfair, I. Roitt, D. Wakelin and R. Williams.

Mapping Course Learning Outcomes (CLOs) with the Program Learning Outcomes (PLOs)

CLO	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7
CLO-1	√	√	√				
CLO-2	√	√	√	√			
CLO-3	√	√	√	√			
CLO-4	√	√	√				
CLO-5	√	√	√	√		√	√

Mapping CLOs with the Teaching-Learning and Assessment Strategy

CLO	Teaching-Learning Strategy	Assessment Strategy
CLO-1	Deliver lectures using PowerPoint slides, videos, images and chalk-talk.	Class participation through attendance.
CLO-2	Seek immediate feedback during the lecture through short questions.	Continuous assessment through quizzes.
CLO-3	Respond to students' queries.	In-course exams, assignments, and oral presentations.
CLO-4	- Conduct assessments to gauge understanding. - Assign tasks that encourage creativity and deeper exploration of specific topics.	Final evaluation through a written examination.
CLO-5	- Provide opportunities for practicing problem-solving. - Promote group discussions. - Arrange review classes when needed.	

MBG 304C Virology**Credits: 2****Class: 30 hours**

This course introduces the students with basic concept of viruses, covers the fundamental principles related to the interaction of animal and bacterial viruses with their host cells and events during viral replication. General topics include chemical and physical properties of viruses, virus classification, cultivation of viruses, prevention and control of infection.

Course Objectives:

1. The students will be provided with a broad and general knowledge of modern Virology.
2. Learn how viruses enter target cells, amplify their genomes and exit from these target cells
3. Learn the relationship of viruses and host and the importance of host factors for virus survival.

Course Learning Outcomes (CLOs):

1. Student will learn the essential concepts of virology which include the structure of different viruses, properties, replication, and types of infection.
2. The students will understand the mechanisms that viruses employ to cause disease, common bacteriophages, and their mode of replication.
3. The students will learn about the treatment and the inhibitory action of the antiviral chemotherapy, and laboratory diagnosis.

Unit	Course Content	Class hours
1	Introduction to Virology: brief history and development of virology; Nomenclature and Classification of Animal and Plant Viruses.	3
2	Virus Cultivation: cultivation and quantification of animal and bacterial viruses, purification and identification of virus; one step growth curve; inclusion bodies	3

3	Genome Multiplication of animal viruses: Initiation of genome replication, Multiplication and gene expression of DNA and RNA viruses (ss RNA, ds RNA, ambisense RNA, ssDNA, dsDNA and retro viral genome).	5
5	Pathogenesis of Viral Diseases: infection initiation, entry, spread, organ invasion and tropism. Pattern of infection.	3
6	Bacteriophages: overview of bacteriophages; genome organization and multiplication of RNA and DNA bacteriophages; temperate bacteriophages; lytic and lysogenic cycle; transposable phages.	8
7	Prevention and Treatment of Viral Infections: viral vaccines (conventional, recombinant, NA based, VLPs); interferon: induction and action of interferons; antiviral chemotherapy.	5
8	Virion, Viroids and Prions: Morphology, physical properties and chemical composition of virions; general properties and diseases caused by viroids and prions.	3

Recommended Books:

1. Principles of Molecular Virology – A.J. Cann, Elsevier Academic Press., New York
2. Fields Virology (Vol. I and II) - Edited by D.M. Knipe, P.M. Howley, D.E. Griffin, Lippincott Williams, New York
3. Fundamental Virology – B.N. Fields and D.M. Knipe, Raven Press, New York
4. Jawetz, Melnick and Adelberg's Medical Microbiology – K.C. Carroll, S.A. Morse, T.Mietzner and S. Miller, McGraw Hill Education

Mapping Course Learning Outcomes (CLOs) with the Program Learning Outcomes (PLOs)

CLO	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7
CLO-1	√	√	√		√	√	√
CLO-2	√	√	√		√	√	√
CLO-3	√	√	√	√	√	√	√

Mapping CLOs with the Teaching-Learning and Assessment Strategy

CLO	Teaching-Learning Strategy	Assessment Strategy
CLO-1	• Deliver lectures using PowerPoint slides, videos, images and chalk-talk. • Seek immediate feedback during the lecture through short questions. • Respond to students' queries. • Conduct assessments to gauge understanding.	• Class participation through attendance. • Continuous assessment through quizzes.
CLO-2		

CLO-3	- Assign tasks that encourage creativity and deeper exploration of specific topics. - Provide opportunities for practicing problem-solving. - Promote group discussions. - Arrange review classes when needed.	- In-course exams, assignments, and oral presentations. - Final evaluation through a written examination.
--------------	---	--

MBG 305C Basic Immunology**Credits: 4****Class: 60 hours**

The course will cover major concepts of fundamentals of immunology, general properties of antigen and antibody, immune cells involving antigen recognition, humeral and cell-mediated immunity, immunity to infections, various immunological techniques for laboratory and research methodology.

Course Objectives:

1. To introduce the concepts, basis of immunity and cells and organs involved in acquired immunity.
2. To understand the properties of antigen & antibody, role of antibodies and induction of antibody response to antigens.
3. To know the response of immunity to infection and immunological techniques for assessment and research.

Course Learning Outcomes (CLOs):

1. The students will be trained in major concepts of immunology, general properties of antigen & antibody their knowledge reinforce and build upon important concepts in immunology studied in higher education will be reinforced.
2. Learn how the immune cells recognize antigen.
3. Gain knowledge on concepts of induction of humeral and cell mediated immunity.
4. Have a grasp on knowledge on immunity to infections, have a hand on training on methods of immunological techniques for laboratories and research methodology.

Unit	Course Content	Class hours
1	Introduction to Immunology: history and development of immunology; introduction to immune system; basic concept of innate and adaptive immunity; cellular and humoral immunity.	5
2	Cells Involved in Immune Response: general features and functions of lymphoid cells; mononuclear phagocytes; antigen presenting cells; polymorphs; mast cells; platelets	3
3	Lymphoid Systems: primary and secondary lymphoid tissue; primary lymphoid organs; secondary lymphoid organs and tissues	4

4	Innate Immunity: phagocytosis: process and evasion strategies, complement systems: activation, function and regulation of complements.	4
5	Inflammation: patterns of cell migration and inflammation and their control.	4
6	Antigens: general properties of antigen; antigenic determinants; haptens.	5
7	Immunoglobulins: basic structure and function of immunoglobulin; immunoglobulin classes and subclasses; physiochemical properties, distribution and functions of different classes and subclasses of immunoglobulin; memory B cell; genetic basis of antibody heterogeneity; antibody class switching.	6
8	Membrane Receptors for Antigens: B cell surface receptors for antigens; T cell receptors (TCR major histocompatibility complex (MHC); antigens structure; functions of MHC class I and class II molecules; gene map of MHC antigens; processing and presentation of peptides by MHC molecule, antigen recognition; antigen-antibody interaction; forces of antigen-antibody binding; haplotype restriction of T cell reactivity	5
9	Lymphocyte activation: interaction of T lymphocytes and APC; signals for T cell activation; B cell response to thymus dependent and -independent antigens; B cell activation by surface Ig and T cell	3
10	Cytokines and chemokines: General properties, Families of cytokines and associated receptor molecules, cytokine action and network interaction	2
11	Immune regulations: regulation of immune response by antigens, antibody, antigen presenting cells and lymphocytes; idiotypic regulation of immune response.	2
12	Immunity to Infections: immunity to extracellular and intracellular bacteria; bacterial survival strategies; immunity to viral infection; innate and specific immune response to viruses; strategies for evading immune defences by viruses; immunity to parasitic infection	5
13	Immunological Techniques: precipitation reactions; immunodiffusion; immuno-electrophoresis; agglutination; co-agglutination; haemagglutination; complement fixation; direct and indirect immunofluorescence; immunoassay; immunoblotting; immuno-precipitation; fluorescence-activated cell sorter (FACS), experimental animal models.	7
14	Monoclonal antibodies: production of hybridoma; screening, cloning and large-scale production of monoclonal antibodies.	5

Recommended Books:

1. Immunology- P.J. Delves, S.J. Martin, D.R. Burton and I.M. Roitt, Mosby Elsevier
2. Roitt's Essential Immunology- P.J. Delves, S.J. Martin, D.R. Burton and I.M. Roitt, Wiley Blackwell
3. Kuby's Immunology- J.A. Owen, J. Punt, and S.A. Stranford, W.H. Freeman and Company, NY
4. Advanced Immunology- D. Male et al – Gower Medical pub., New York
5. Textbook of Immunology: An Introduction to Immunochemistry and Immunobiology- J.T.

Barrett, Mosby, New York

Mapping Course Learning Outcomes (CLOs) with the Program Learning Outcomes (PLOs)

CLO	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7
CLO-1	✓	✓	✓			✓	
CLO-2	✓	✓	✓			✓	
CLO-3	✓	✓	✓	✓		✓	
CLO-4	✓	✓	✓	✓		✓	✓

Mapping CLOs with the Teaching-Learning and Assessment Strategy

CLO	Teaching-Learning Strategy	Assessment Strategy
CLO-1	- Deliver lectures using PowerPoint slides, videos, images and chalk-talk. - Seek immediate feedback during the lecture through short questions. - Respond to students' queries. - Conduct assessments to gauge understanding. - Assign tasks that encourage creativity and deeper exploration of specific topics. - Provide opportunities for practicing problem-solving. - Promote group discussions. - Arrange review classes when needed.	- Class participation through attendance. - Continuous assessment through quizzes. - In-course exams, assignments, and oral presentations. - Final evaluation through a written examination.
CLO-2		
CLO-3		
CLO-4		

MBG 306C Cell Biology**Credits: 2****Class: 30 hours**

The course focuses on eukaryotic cell biology that covers topics such as membrane structure and composition, transport, and trafficking, the cytoskeleton and cell movement, and the integration of cells into tissues. The course will also cover important cellular processes such as cell cycle regulation, signal transduction, apoptosis and cancer cell biology. We will attempt to relate defects in these various cellular processes to human diseases to help gain a better understanding of what happens when cells don't work as they should.

Course Objectives:

1. To describe basic mechanisms for interactions between cells, cell growth, cell death, cell motility
2. To explain how these together facilitate the development of a multicellular organism,
3. To describe structures of biomolecules, with an emphasis on proteins and their processing.

Course Learning Outcomes (CLOs):

1. Account for how cells can communicate and understand cell signaling and how it regulates cellular functions
2. Account for intracellular protein transport
3. Describe the cell cycle and the cell division, how cells die and how these important processes are regulated.
4. How dysregulation leads to cancer and other diseases.
5. Know the procedures of growing, maintaining and preserving human embryonic stem cells, potential applications of stem cells.
6. Understand the ethical views surrounding embryonic stem cell research.

Unit	Course Content	Class Hours
1	Chemical signaling between cells: Three different strategies of chemical signaling, local chemical mediators, hormones and neurotransmitters, signaling mediated by intracellular receptors, mechanism of steroid hormone action, signaling mediated by cell surfaces, cyclic AMP and calcium ions as second messengers, involvement of G-proteins in signal transduction, target cell adaptation.	8
2	Cell cycle regulation: Regulation of cell cycle by CDK and associated proteins, cell cycle check points, regulation of passage through check points, effects of cell cycle deregulation.	5
3	Apoptosis: Extrinsic and intrinsic pathways, excessive and insufficient apoptosis.	4
4	Protein turnover: proteasome, chaperon; protein degradation, ubiquitination, Posttranslational processing of proteins: folding, cleavage, chemical modification.	5
5	Stem cell transplantation: Embryonic and adult stem cells; unipotency and pluripotency; the isolation, expansion, genetic manipulation, genomic reprogramming, and cloning of stem cells; ethical views surrounding human embryonic stem cell research.	8

Recommended Books:

1. Cell Biology – G. Karp, Wiley
2. Molecular Biology of the Cell – B. Alberts, A. Johnson, J. Lewis, M. Raff, K. Roberts and P. Walter – Garland Science
3. Lewin's Genes XI – J.E. Krebs, E.S. Goldstein, S.T. Kilpatrick – Jones & Bartlett Learning
4. Molecular Cell Biology - H. Lodish et al. 2012., 7th Ed. W.H Freeman and Company
5. Derivation of human embryogenic Stem cell lined from verified Blastocysts, Human embryonic stem cells protocols – Kursadturksen

Mapping Course Learning Outcomes (CLOs) with the Program Learning Outcomes (PLOs)

CLO	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7
CLO-1	✓			✓			
CLO-2		✓		✓			
CLO-3			✓	✓			
CLO-4				✓			
CLO-5					✓		✓
CLO-6						✓	

Mapping CLOs with the Teaching-Learning and Assessment Strategy

CLO	Teaching-Learning Strategy	Assessment Strategy
CLO-1	- Deliver lectures using PowerPoint slides, videos, images and chalk-talk. - Seek immediate feedback during the lecture through short questions. - Respond to students' queries. - Conduct assessments to gauge understanding. - Assign tasks that encourage creativity and deeper exploration of specific topics. - Provide opportunities for practicing problem-solving. - Promote group discussions. - Arrange review classes when needed.	- Class participation through attendance. - Continuous assessment through quizzes. - In-course exams, assignments, and oral presentations. - Final evaluation through a written examination.
CLO-2		
CLO-3		
CLO-4		
CLO-5		
CLO-6		

MBG 307C Agricultural Microbiology**Credits: 2****Class: 30 hours**

This course introduces students to the soil microbial communities and how they govern the soil environment by performing enormous amounts of biochemical reactions, which are directly contributing in agricultural practices and also playing a vital role in our sustenance on this planet. It also discusses biofertilizers and biopesticides made of microorganisms, the use of which can reduce the environmental damage caused by chemical fertilizers and make an eco-friendly agricultural system. Plant pathogenic microorganisms and how to prevent plant diseases is also taught in this course.

Course Objectives:

1. To understand the soil microbial communities and their role in improvement of soil fertility.
2. To learn about role of microbes as biofertilizers and nutrient recycling agents in soil.
3. To demonstrate the nature of common phytopathogens and their controlling methods.

Course Learning Outcomes (CLOs):

1. Understand the basic groups of microorganisms and their living activities in soil
2. Knowledge of basic relationship between microbes and plant nutrition
3. Learn the vital role of microbes in biochemical cycling throughout the globe
4. Learn about the practical applications of biofertilizers and biopesticides for sustainable agriculture
5. Understand the nature of phytopathogens and ways to control them in the field of plant care.

Unit	Course Content	Class hours
1	Soil Microorganisms and Soil Fertility: soil microbes and their major activities; microbial decomposition of organic matter; improvement of soil fertility—physicochemical properties, microbial metabolites as nutrients and growth regulators, and conversion of nutrients from unavailable form to available for plant uptake.	6
2	Microbes in Rhizosphere, Root Surface and Phyllosphere: endophytic microbes—types and functional characteristics; mycorrhiza; Nitrogen-fixing symbiotic and non-symbiotic bacteria; formation of root nodules; decomposition of plant and animal residues; biodegradation of pesticides and pollutants in soil.	6
3	Biogeochemical Cycling of Nutrient Elements: carbon cycle, nitrogen cycle, sulphur cycle, phosphorus cycle and their effects on the availability of plant nutrients.	4
4	Biofertilizers and Compost: biofertilizers—plant growth-promoting rhizobacteria (PGPR); bioinoculant mass production using <i>Rhizobium</i> , <i>Azotobacter</i> and Cyanobacteria; compost—green manure, town compost, vermicompost, production and applications.	6
5	Biological Control of Microbial Pathogens and Nematodes: microbial pesticides; interactions of synthetic pesticides with soil microbes; entomopathogenic fungi and bacteria.	2
6	Plant Pathogens and Growth Inhibitory Microbes: Concept of plant disease; mode of entry of pathogens, disease symptoms, diagnosis and control; Algal, fungal, bacterial and viral diseases; Disease by mycoplasmas and nematodes; Diagnosis and control of plant diseases—blast of rice, rust of wheat, stem rot of jute, grey blight of tea, smut of sugarcane, leaf blight of potato; production of phytotoxic substances by saprophytes and parasites; competition of microorganisms with plants for essential nutrients.	6

Recommended Books:

1. An Introduction to Soil Microbiology—M. Alexander, John Wiley, New York
2. Principles and Applications of Soil Microbiology—D.M. Sylvia, J.J. Fuhrmann, P.J. Harteland D.A. Pearson, Prentice Hall

3. Plant Microbiology—R. Campbell, Edwards Arnold, London
4. Plant Pathology—G.N. Agrios, Academic Press, New York
5. Biological Indicators of Soil Health—C. Pankhurst, B. Doube and V. Gupta—CAB international, New York

Mapping Course Learning Outcomes (CLOs) with the Program Learning Outcomes (PLOs)

CLO	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7
CLO-1	✓		✓				✓
CLO-2	✓	✓	✓		✓		✓
CLO-3	✓	✓	✓	✓	✓		✓
CLO-4	✓	✓	✓	✓		✓	✓
CLO-5	✓		✓	✓			✓

Mapping CLOs with the Teaching-Learning and Assessment Strategy

CLO	Teaching-Learning Strategy	Assessment Strategy
CLO-1	Deliver lectures using PowerPoint slides, videos, images and chalk-talk.	Class participation through attendance.
CLO-2	Seek immediate feedback during the lecture through short questions.	Continuous assessment through quizzes.
CLO-3	Respond to students' queries.	In-course exams, assignments, and oral presentations.
CLO-4	- Conduct assessments to gauge understanding. - Assign tasks that encourage creativity and deeper exploration of specific topics.	Final evaluation through a written examination.
CLO-5	- Provide opportunities for practicing problem-solving. - Promote group discussions. - Arrange review classes when needed.	

MBG 308C Fermentation Technology**Credits: 2****Class: 30 hours**

The course emphasizes the art of fermentation techniques using biological and engineering principles. It aims to review fundamentals and provide an up-to-date knowledge in biological and biochemical technology. The lectures will emphasize and place perspectives on biological systems with industrial practices. The course covers the key component parts of a fermentation process including growth kinetics, strain isolation and improvement, inoculum development, fermentation media, fermenter design and operation, product recovery, and the environmental impact of processes.

Course Objectives:

1. To introduce the students to the various concepts of fermentation.
2. To introduce the students to the role of microorganisms, play in fermentation process.
3. To provide the student with the skills to design and ferment processes.

Course Learning Outcomes (CLOs):

1. To understand the various concepts of fermentation.
2. To design a simple containment system of bioreactor or fermenter.
3. To understand microbial growth and their role in producing commercial metabolites.
4. To isolate, identify and develop microbial inoculum for industrial processing.
5. To set and control bioreactors for producing maximal products under optimal conditions.

Unit	Course Content	Class hours
1	Introduction to Fermentation Processes: range of fermentation processes; chronological development of the fermentation industry; component parts of fermentation process.	3
2	Fermenter/ Bioreactor design: bioreactor types and configuration, impeller designs and baffles, agitation, aeration; fermenter/ bioreactor associated instrument and services.	5
3	Media for industrial fermentations: Energy and carbon sources, nitrogen, minerals, addition of precursors and metabolic regulators to media, oxygen requirements, antifoams, medium optimization; submerged, surface and solid-state fermentations.	5
4	Inoculum Development: Inoculum preparation and scale up for bacterial, yeast and fungal processes.	3
5	Sterilization of Fermenters and Media: medium sterilization, the design of batch sterilization processes; the design of continuous sterilization, processes; sterilization of the fermenter; sterilization of feed and air.	5
6	Microbial growth kinetics: rate equations for cell growth, substrate utilization and product formation, comparison amongst batch, fed batch and continuous culture processes	4
7	Instrumentation and Control: control systems: manual, automatic and combinations of methods of control. Methods of control of process variables: temperature, pH, flow measurement, pressure measurement and control, agitation and aeration, foam sensing, measurement and control of dissolved oxygen; exit-gas analysis; redox and carbon dioxide electrodes.	5

Recommended Books:

1. Principle of Fermentation Technology-P.F. Stanbury, A. Whitaker and S.J. Hall–Butterworth, New Delhi
2. Fermentation Microbiology and Biotechnology-E.M.T. El-Mansi, C.F.A. Bryce and A. Demain; Taylor and Francis, London
3. Modern Industrial Microbiology and Biotechnology- N. Okafor–CBC Press, New Hampshire
4. Practical Fermentation Technology - B. McNeil and L. Harvey; Wiley
5. Fermentation Technology- M.L. Srivashava; Alpha Science Intl Ltd.

Mapping Course Learning Outcomes (CLOs) with the Program Learning Outcomes (PLOs)

CLO	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7
CLO-1	✓						
CLO-2		✓	✓				
CLO-3			✓				
CLO-4		✓	✓				
CLO-5		✓	✓	✓	✓		

Mapping CLOs with the Teaching-Learning and Assessment Strategy

CLO	Teaching-Learning Strategy	Assessment Strategy
CLO-1	- Deliver lectures using PowerPoint slides, videos, images and chalk-talk. - Seek immediate feedback during the lecture through short questions. - Respond to students' queries. - Conduct assessments to gauge understanding. - Assign tasks that encourage creativity and deeper exploration of specific topics. - Provide opportunities for practicing problem-solving. - Promote group discussions. - Arrange review classes when needed.	- Class participation through attendance. - Continuous assessment through quizzes. - In-course exams, assignments, and oral presentations. - Final evaluation through a written examination.
CLO-2		
CLO-3		
CLO-4		
CLO-5		

MBG 309C Food Safety and Quality Control**Credits: 2****Class: 30 hours**

This course addresses fundamental concepts of food safety and quality control. It provides the foundational knowledge necessary to understand food hazards, particularly microbiological agents responsible for spoilage and disease as well as the mechanisms of food-borne illness transmission, risk assessment, and control strategies. The module also integrates current topics in food microbiology, including regulatory frameworks and emerging issues in food safety. Designed with industry personnel in mind, the course serves as an introduction to microbial food safety hazards and their management in practical contexts.

Course Objectives:

1. To understand the food hazards and their impacts of food spoilage and diseases.
2. To develop surveillance and investigation systems for food-borne disease outbreak.
3. To prevent microbiological food hazards and diseases.

Course Learning Outcomes (CLOs):

1. Update the knowledge about basic types of national, regional and global food hazards.
2. Ability to detect food safety and quality indicators and food-borne disease-causing agents.
3. Ability to investigate foodborne disease outbreak.
4. Ability to solve design surveillance to prevent future outbreaks of food-borne diseases.

Unit	Course Content	Class hours
1	Introduction to Food Safety and Quality Management: Concept, Basic principles and applications of quality control; Major areas of quality control – raw materials, process and finished product; Quality management system (QMS) and Total Quality Management (TQM); Major problems and techniques of quality control; Improvement of quality control.	4
2	Food Safety Hazards: Categories– physical, chemical, biological hazards and others; Control of Food Hazards: Preventive approaches; Standards for monitoring to assess compliance with good practices; Biological control of hazards- application of bacteriophages.	5
3	Foodborne Microbial Hazards: Sources, characteristics, transmission, symptoms and prevention of microbial food hazards– by <i>Salmonella</i> spp., <i>Cl. perfringens</i> , <i>Vibrio</i> sp. <i>E. coli</i> (EIEC and EHEC), <i>Campylobacter</i> spp., <i>Yersinia enterocolitica</i> , <i>Listeria monocytogenes</i> , viruses and parasites and food intoxication - by <i>Cl. botulinum</i> , <i>Bacillus cereus</i> ., <i>Staphylococcus</i> spp.; Mycotoxins; Emerging food-borne diseases, Antimicrobial resistance (AMR) genes in the food chain.	6
4	Quality Assurance: Concept of quality assurance; Sampling, testing panel-sensory assessments in quality control and quality assurance; Establishment of hazard analyses and critical control point (GMP/GHP, HACCP) systems- identification of potential hazards, monitoring system for critical control point (CCP), corrective actions and verifications; Microbiological risk Analysis- risk assessment, risk communication and risk management.	6
5	Food Hygiene, Safety and Inspection: Microbiology in food sanitation- Sanitation Practices: (Personal hygiene and cleanness, sanitation of receiving food, washing, storing, thawing, preparing and serving); Environmental management in food industries: water supply, waste treatment & disposal; pest control; Facility Sanitation: Sanitation and hygiene of processing plant, air and water(field investigation, laboratory tests, interpretation and preventive measures; development of surveillance systems for controlling food-borne diseases.; Cleaning vs. sanitizing (detergents, disinfectants), CIP (Clean-in-Place) systems; Inspection and monitoring system for sanitary quality.	6
6	Food Laws and Regulations: National and international food standards, laws, regulations, enforcing agencies and their functions; Mandatory and voluntary guidelines; Inspection- food, Transport and food premises.	3

Recommended Books:

1. Food Safety: Rapid Detection and Effective Prevention of Food-borne Hazards – L. Hu, Apple CRC Press
2. Bad Bug Book: Foodborne Pathogenic Microorganisms and Natural Toxins Handbook – Food and Drug Administration, USA
3. Advances in Microbial Food Safety, vol.2 – J. Sofos; Woodhead Publishing
4. The Microbiology of Safe Food – S.J Forsythe, Wiley Blackwell
5. Foodborne Infections and Intoxications- G. Moris, M.E. Potter, HP Riemann, DO Cliver. Elsevier
6. Quality Control of Food and Agricultural Products – J.-L. Multon; Wiley VCH, New York
7. Quality control in the food industry - S. M. Herschdoerfer, Academic press, London,
8. Quality Control for Value Addition in Food Processing – D.R.R. Sharma and V.K. Joshi; New India Publishing Agency
9. Food Quality Assurance: Principles and Practices – I. Alli; CRC Press

Mapping Course Learning Outcomes (CLOs) with the Program Learning Outcomes (PLOs)

CLO	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7
CLO-1	✓	✓	✓		✓	✓	
CLO-2	✓	✓	✓	✓	✓	✓	
CLO-3	✓	✓	✓	✓	✓	✓	✓
CLO-4	✓	✓	✓		✓	✓	✓

Mapping CLOs with the Teaching-Learning and Assessment Strategy

CLO	Teaching-Learning Strategy	Assessment Strategy
CLO-1	• Deliver lectures using PowerPoint slides, videos, images and chalk-talk. • Seek immediate feedback during the lecture through short questions. • Respond to students' queries. • Conduct assessments to gauge understanding. • Assign tasks that encourage creativity and deeper exploration of specific topics. • Provide opportunities for practicing problem-solving. • Promote group discussions. • Arrange review classes when needed.	• Class participation through attendance. • Continuous assessment through quizzes. • In-course exams, assignments, and oral presentations. • Final evaluation through a written examination.
CLO-2		
CLO-3		
CLO-4		

MBG 310C Pharmaceutical Microbiology**Credits: 2****Class: 30 hours**

This course is designed to introduce students to the environment in the pharmaceutical industry. It includes sources of microbiological contamination and deterioration of different pharmaceutical products, basic concepts and guidelines for maintaining environmental conditions to manufacture, storage and distribution of pharmaceuticals. It also demonstrates the principles and procedures of various tests for safety control for pharmaceutical environment, raw materials and products. The course also elaborates on the nature of different biopharmaceutical products including antibiotics, their mode of action and the ways to develop resistance in bacteria.

Course Objectives:

1. To familiarize students with the environment and important products of pharmaceutical industry.
2. To acquaint students with designing, processing and preserving of the products.
3. To develop skills in techniques for controlling quality and safety of pharmaceutical products.

Course Learning Outcomes (CLOs):

1. Describe the microbiological aspects of desirable pharmaceutical environments and the principles for their maintenance.
2. Explain the nature, types, and therapeutic applications of various biopharmaceuticals.
3. Illustrate the mechanisms of antibiotic action and analyze the processes leading to antibiotic resistance.
4. Explain the concept, design principles, and operational requirements of an aseptic area.
5. Identify and describe the processes through which pharmaceutical products may undergo microbial spoilage.
6. Perform and interpret basic microbiological tests for assessing the quality control and safety of pharmaceutical products.

Unit	Course Content	Class hours
1	Environment of Pharmaceutical industry: Environmental monitoring in aseptic areas (Non-viable and Viable monitoring like active and passive air sampling (settle plate), contact plate, swabbing); Aseptic process simulation, Personnel hygiene monitoring, Gowning qualification, HVAC and related utilities qualification like compressed air, Pure steam, Nitrogen gas. Identification of Environmental isolates, screening & root cause analysis for any Out of Trend (OOT) or atypical issues. Atmosphere, water, raw materials, packaging, personnel, building and its premises; Maintenance of clean and hygienic environment in pharmaceutical industry.	5
2	Biopharmaceutical Products: Biosimilar products, Nature and application-antibiotics, insulin, growth hormone, vaccines, interferon, human globulins, suture, etc.	4

3	Antibiotics and Synthetic Antimicrobial Agents: Antibiotics- sources, nature, and mode of action; Synthetic antimicrobial agents– properties and mode of actions; Mechanisms of microbial resistance to antibiotics.	3
4	Design and Maintenance of Aseptic Area: Basic concept and principles for designing aseptic area for processing sterile pharmaceuticals and quality testing laboratory; methods for sterilization and maintenance of aseptic conditions. Microbiological validation or qualification of Equipment's, Water, HVAC, process and method under risk-based concept through Contamination Control Strategy (CCS).	3
5	Microbial Spoilage and Preservation of Pharmaceuticals: Spoilage- chemical and physicochemical deterioration, factors affecting microbiological spoilage, health hazards, sources and control of contamination, outcome of medicament-borne infection; Preservation- effect of preservatives, product pH, packaging of sterile and non-sterile products. Microbiological quality of raw materials finished products, and packaging materials. Quality control and risk management. Root cause analysis for any Out of Trend (OOT), Out of Specifications (OOS) and any other deviations/atypical issues. Good Microbiology practices as per WHO. Good documentation practice.	5
6	Microbiological Quality Control and Quality Assurance: Good manufacturing practice; Quality control procedures; Quality assurance and control of microbiological risks in medicine; Laboratory evaluation aseptic condition of environments, raw materials and products; Principle of testing methods- antibiotic potency, concentration, preservatives and MIC and MBC, tests for sterility, Bacteria Endotoxin, Liquid particulate matter, Growth Promotion test, Water test, Microscopic identification, Disinfectant efficacy test Environment isolates identification ,pyrogen and toxicity.	5
7	Field work / industry visit: Monitoring microbiological status of the pharmaceutical environment, Assessment of raw materials and finished products (solids, ointments & suspension), Bioassay of antibiotics, vitamins and other pharmaceuticals, Tests for sterility, Bacteria Endotoxin, Liquid particulate matter, Growth Promotion test, Water test, Microscopic identification, Disinfectant efficacy test Environment isolates identification, pyrogen and toxins of pharmaceuticals, and Tests for spoilage and efficacy of pharmaceutical preservatives.	6

Recommended Books:

1. Hugo and Russell's Pharmaceutical Microbiology- S.P.Denyer, N.A. Hodges and S.P. German, Blackwell Scientific Pub., Oxford
2. Cooper and Gunn's Dispensing for Pharmaceutical Students-J.W. Cooper, G. Colin; C.S. James, Pitman Medical, London
3. Preservatives in the food pharmaceutical and environmental industries- R.G. Board, M.C. Allwood, J. G. Banks, Blackwell, London
4. Essays in Applied Microbiology- J.R. Norris; M.H. Richmond, Wiley, New York, 1981

5. WHO Good Microbiology Practices (Annex-1)
6. United States Pharmacopeia (USP)
7. EU GMP Annex-1

Mapping Course Learning Outcomes (CLOs) with the Program Learning Outcomes (PLOs)

CLO	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7
CLO-1	✓	✓	✓				
CLO-2	✓						
CLO-3	✓		✓				
CLO-4	✓	✓	✓				
CLO-5	✓		✓				
CLO-6	✓	✓	✓		✓	✓	

Mapping CLOs with the Teaching-Learning and Assessment Strategy

CLO	Teaching-Learning Strategy	Assessment Strategy
CLO-1	- Deliver lectures using PowerPoint slides, videos, images and chalk-talk. - Seek immediate feedback during the lecture through short questions. - Respond to students' queries. - Conduct assessments to gauge understanding. - Assign tasks that encourage creativity and deeper exploration of specific topics. - Provide opportunities for practicing problem-solving. - Promote group discussions. - Arrange review classes when needed.	- Class participation through attendance. - Continuous assessment through quizzes. - In-course exams, assignments, and oral presentations. - Final evaluation through a written examination.
CLO-2		
CLO-3		
CLO-4		
CLO-5		
CLO-6		

MBG 311C Laboratory Works III

Credits: 8

Class: 160 hours

The 3rd year laboratory course is designed to develop skills for applied microbiology. This applied laboratory curriculum described below represents topics and themes considered essential to the development of cognitive, analytical, communication, and interpersonal skills in advanced microbiology laboratories. Laboratory works typically supplement and integrate closely with the lecture contents of the theoretical courses in a way that is unique to each instructor. Development of laboratory techniques; exercises designed to reinforce concepts covered in this course.

Course Objectives:

It is desirable to achieve applied laboratory skills in microbiological sciences, including bacterial metabolic systems, molecular cell biology & genetics, clinical microbiology, immunology, and virology. The other special desires are developing advanced technical skills in determining the role of microbes in fermentation, agricultural, food safety, and marine environment, and its applications in humane welfare, and to develop analytical and communication skills along with data processing for laboratory reports. Development of laboratory techniques; exercises designed to reinforce concepts covered in this course.

Course Learning Outcomes (CLOs):

1. Explain the metabolic activities, diversity, and ecological significance of soil microflora, including rhizosphere and autotrophic microorganisms.
2. Isolate, culture, and characterize soil microorganisms involved in cellulose degradation and nitrogen cycling.
3. Isolate and analyze plasmid DNA using molecular biology techniques.
4. Familiarize with the experimental approaches in virology by cultivating, enumerating, and characterizing bacteriophages.
5. Demonstrate understanding of the principles, facilities, and safety measures required for cell culture techniques.
6. Describe the principles and operation of fermenters and apply fermentation techniques to produce microbial biomass, biofuels, and industrial products.
7. Perform quality control tests including bioassays, sterility, pyrogen, toxin, and preservative efficacy assessments for pharmaceutical products.
8. Familiarize with the subjective sensory and objective laboratory analysis of food quality control
9. Isolate, culture, and characterize various microorganisms involved in marine environment.

Course Content	Class hours
1. Study of microflora of soil, rhizosphere, and rhizoplane 2. Isolation of cellulose-degrading organisms, autotrophic and phototrophic bacteria 3. Denitrification, ammonification and nitrogen fixation test 4. Purification of bacterial plasmid 5. Preparation of competent cells 6. Transformation of <i>E. coli</i> by plasmid and calculation of transformation efficiency 7. Analysis of plasmid DNA by agarose gel electrophoresis 8. Study of gene expression by Catabolite Repression in <i>E. coli</i>. 9. Isolation, and enumeration of different bacteriophages from sewage sample and 10. Assessment of host range of bacteriophages 11. Effect of physicochemical parameters on phage viability 12. A visit to a laboratory facility for animal cell culture 13. Demonstration of cell culture procedures 14. Quorum sensing 15. Demonstration of a typical fermenter and fermentation process 16. Production of biomass, biofuel, and industrial alcohol. 17. Monitoring microbiological status of the pharmaceutical environment 18. Assessment of raw materials and finished products (solids, ointments & suspensions) 19. Bioassay of antibiotics, vitamins, and other pharmaceuticals 20. Tests for sterility, pyrogen, and toxins of pharmaceuticals 21. Tests for spoilage and efficacy of pharmaceutical preservatives 22. Assay of antibacterial activity of the antibiotic by macrodilution broth 23. Evaluating the organoleptic attributes in food quality control through subjective sensory methods including appearance, texture, color, odor, flavor, taste, and additional quality factors; Paired Preference Test (PPT), Ranking Test (RT), Hedonic Tests (HT). 24. Quantitative evaluation of food quality using objective laboratory-based methods including physical, chemical, and microbiological analysis. 25. Determination of sugar concentration by refractometer 26. Collection and preservation of marine water and sediment samples 27. Total Bacterial count (TBC) of the marine water and sediment samples 28. Isolation and identification of pathogenic bacterial species from marine samples 29. Isolation of halotolerant bacteria from seawater and their salt tolerance assay. 30. A visit to a pharmaceuticals industry.	160

Recommended Books:

1. Microbiology: A Laboratory Manual- J. Cappucino & N. Sherman; Pearson Education Limited
2. Cell and Molecular Biology – P.V. Chaitanya; Prentice-Hall of India Pvt. Ltd.
3. Environmental Microbiology – I. Pepper, C. Gebra and J. Brandecke; Academic Press
4. Principles of Microbiology - R.M. Atlas, W.M.T. Brown Publishers.
5. Food Microbiology: A Laboratory Manual – A.E. Yousef and C. Carlstrom; Wiley and Sons Inc.
6. Laboratory Protocols in Applied Life Sciences - P.S. Bisen, CRC Press
7. Food Safety: Rapid Detection and Effective Prevention of Food-borne Hazards – L. Hu, Apple CRC Press

Mapping Course Learning Outcomes (CLOs) with the Program Learning Outcomes (PLOs)

	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7
CLO-1	✓		✓				
CLO-2		✓	✓	✓			
CLO-3	✓		✓	✓			
CLO-4	✓		✓	✓	✓		
CLO-5			✓	✓			
CLO-6		✓		✓	✓		
CLO-7	✓		✓		✓		
CLO-8	✓				✓		✓
CLO-9			✓	✓			✓

Mapping CLOs with the Teaching-Learning and Assessment Strategy

CLO	Teaching-Learning Strategy	Assessment Strategy
CLO-1	- Conduct interactive lectures covering the principles, methods, procedures, and applications of each experiment using PowerPoint/videos/pictures/chalk-talk. - Obtain immediate feedback by asking questions. - Address students' queries promptly. - Facilitate problem-solving practice. - Provide hands-on laboratory training. - Encourage collaborative discussion among students. - Visit to an industry/ research laboratory to gain professional experience.	- Class participation through attendance - Continuous assessment through in-course exams, and assignments. - Evaluation of practical notebooks. - Report from the visit to industry/ research labs - Final assessment through practical experiments and a written test. - Viva voce.
CLO-2		
CLO-3		
CLO-4		
CLO-5		
CLO-6		
CLO-7		
CLO-8		
CLO-9		

MBG 312C Viva Voce**Credits: 2**

A viva-voce or oral examination is an opportunity where students demonstrate their knowledge, expertise, and understanding of both theoretical and practical courses. It also allows the examiners to assess the students' academic abilities and determine whether they have met the requirements for promotion to the next academic level.

Course Objectives:

1. Demonstrate comprehensive knowledge in their broader field of study.
2. Enhance their ability to effectively communicate scientific information with confidence, skills, and expertise.
3. Evaluate and reflect on their understanding and mastery of the program's content.

Course Learning Outcomes (CLOs):

1. To evaluate their knowledge and thinking capacity as well as pressure handling capacity.
2. Ability to describe the process of science.
3. Ability to communicate and collaborate with other disciplines.

Course Content: All the courses attended in the 3rd academic year.

Mapping Course Learning Outcomes (CLOs) with the Program Learning Outcomes (PLOs)

CLO	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7
CLO-1	√	√	√			√	
CLO-2		√		√	√		
CLO-3						√	√

Mapping CLOs with the Teaching-Learning and Assessment Strategy

CLO	Teaching-Learning Strategy	Assessment Strategy
CLO-1	• Problem solving and discussion. • Respond to students' queries. • Encourage collaborative discussion among students.	Final evaluation through questions and performance.
CLO-2		
CLO-3		

MBG 313E Marine Microbiology

Credits: 2

Class: 30 hours

This course introduces the students to the marine microbial biosphere, its diversity, habitats, ecology, and applications. It includes microbiological techniques, quantification of marine microbial population, taxonomy of marine prokaryotes and eukaryotic microorganisms, and microbial diseases of marine plants, vertebrates and invertebrates, and examines the exploitation of marine microorganisms for a range of biotechnological applications. The course will pay special attention to many new discoveries in the field, including the role of microbes in ocean processes and nutrient cycles, the beneficial role of marine microbes in biotechnology and biofuels, and new research on the impact of climate change.

Course Objectives:

1. To study marine environment and microbial life
2. To examine the role of microbes in marine ecology
3. To explore the beneficial role of marine microbes in biotechnology

Course Learning Outcomes (CLOs):

1. Explain the principal features of microbial diversity in the oceans
2. Describe marine microbes in terms of physiological capability and biogeochemical role.
3. Synthesize microbial ecosystem function in pelagic and benthic marine habitats
4. Gather knowledge for creating an integrated approach for environmental management and economic concerns.

Unit	Course Content	Class hours
1	Introduction to marine ecosystems: Different marine ecosystems, Open oceans, Mangroves, Coral reefs, Salt marshes Intertidal zone (rocky, sandy, muddy shores), ocean zonation based on light, depth and nutrients availability, chemical and physical composition of sea water.	3
2	Marine microbial Diversity: Marine Bacteria/Archaea, Cyanobacteria, Fungi, Algae (Microalgae), viruses, Specialized microorganisms: Extremophiles (barophiles, thermophiles, psychrophiles, halophiles), actinomycetes, polyextremophiles, anaerobes Diversity in the environment	4
3	Marine Ecology: Food chains and food webs in marine ecosystems, Assimilatory and dissimilatory food chain, Abiotic factors influencing marine microbes, Biogeochemical cycles (Carbon, Nitrogen, Sulphur, Phosphorus cycles), the effect of acidification on marine microorganisms, Biofilms.	4
4	Microbial Hazard in Marine Environment: Commensals and pathogens of sea plants, vertebrates and invertebrates; Human pathogens; Man-made hazards—coastal and marine hazards; Pollutant detection, monitoring and bioremediation.	4
5	Seafood Processing and Preservation: Microbes associated with the deterioration of seafood; general techniques for processing seafood; guidelines for safe processing and preserving seafood.	3
6	Biotechnological applications: Biomedical potentials of marine products—membrane receptor, antitumor, anti-analgesic, antiviral agents; Microalgal polysaccharides, proteins and vitamins; Bioactive metabolites—discovery of bioactive marine natural products—current research and references.	6
7	Assessment of microbes and microbial products: Specific growth requirements for cultivation of marine microbes, culture-based methods for isolation and identification of marine microbes, Bioprospecting, assessment of biodiversity, screening of bioactive compounds; visit a Marine habitat/ seafood processing industry/Handling of marine microorganisms.	6

Recommended Books:

1. Marine Microbiology—B. Austin. Book News, Inc., Portland.
2. Marine Microbiology - O. Akesson

3. Marine Microbiology : Ecology and Applications—C. Munn, Garland Science, Taylor & Francis Group, LLC
4. Marine Microbial Diversity—D. Karl and M. Buckley
5. Ocean and Health: pathogens of the marine environment—R. Colwell and S. Belkin
6. Marine Microbial Ecology - E.J. F. Wood

Mapping Course Learning Outcomes (CLOs) with the Program Learning Outcomes (PLOs)

CLO	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7
CLO-1	√			√	√		
CLO-2	√	√	√				√
CLO-3	√		√			√	√
CLO-4	√	√	√	√	√		√

Mapping CLOs with the Teaching-Learning and Assessment Strategy

CLO	Teaching-Learning Strategy	Assessment Strategy
CLO-1	- Deliver lectures using PowerPoint slides, videos, images and chalk-talk. - Seek immediate feedback during the lecture through short questions. - Respond to students' queries. - Conduct assessments to gauge understanding. - Assign tasks that encourage creativity and deeper exploration of specific topics. - Provide opportunities for practicing problem-solving. - Promote group discussions. - Arrange review classes when needed.	- Class participation through attendance. - Continuous assessment through quizzes. - In-course exams, assignments, and oral presentations. - Final evaluation through a written examination.
CLO-2		
CLO-3		
CLO-4		

MBG 314E**Biophysics****Credits: 2****Class: 30 hours**

Almost any scientific problem can be approached using the ideas and methods of physics. This course introduces the use of physical methods in the study of biological systems. Biophysics makes use of physical concepts and techniques to address problems in biology. Physics has been very successful at illuminating fundamental aspects of biological problems at the molecular level. This course will focus on exposing students to modern topics in biophysics, covering a broad spectrum of topics including aspects of biotechnology, bioengineering, nanotechnology, and biomedical physics.

Course Objectives:

1. To describe the basic principles behind physics relevant to biological systems.
2. To understand the use of biological examples of physical principles.
3. To comprehend the theoretical basis and practical use of laws and physical phenomena in medical diagnostics, prophylaxis, and therapy.

Course Learning Outcomes (CLOs):

1. Apply fundamental physical principles and concepts to biological phenomena.
2. Recognize the nature of biophysics from molecular to organism levels.
3. Appraise recent advances and technologies in biophysics.

Unit	Course Content	Class Hours
1	Fluid Mechanics: Nature of fluids, dimensions and units, force and kinematics, Poiseuille's equation, viscosity, laminar and turbulent flow, blood velocity.	5
2	Electricity and Magnetism: Electric charge, Coulomb's law, electric potential, Ohm's law, RC circuits, electromagnetic oscillations, electromagnetic spectrum, NMR.	4
3	Biophysical Phenomena of Light: Polarimeter, photochemistry, vision transmission, image formation, biological light, laser beam in diagnosis and therapy.	4
4	Basic Electronics and Biosensors: Solid-state devices, diodes, transistors, amplifiers, biosensors, optical and enzyme-sensitive electrodes, glucose and DNA biosensors.	4
5	Nucleonics and Nuclear Medicine: Radioactivity, isotopes, radiation hazard, positron emission tomography, X-ray and magnetic resonance imaging.	4
6	Biochemical Instruments: Phase contrast, fluorescence, confocal, scanning and transmission electron microscopes.	4
7	Acoustics: Sound propagation, biological significance, and medical applications.	5

Recommended Books:

1. Halliday D., Resnick R., Walker J. Fundamentals of Physics. John Wiley (2010).
2. Beiser A. Concepts of Modern Physics. McGraw-Hill (2003).
3. Biological Physics for Health and Life Sciences. John Wiley (2010).
4. Mathur D.S. Elements of Properties of Matter. S. Chand & Co. (2007).
5. Davidovits P. Physics in Biology and Medicine. Academic Press (2007).
6. Boylestad R.L., Nashelsky L. Electronic Devices and Circuit Theory. Pearson (2013).
7. Malhotra B.D., Pandey C.M. Biosensors: Fundamentals and Applications. Smithers Rapra (2017).
8. Roy R.N. A Textbook of Biophysics. New Central Book Agency Ltd. (2009).

Mapping Course Learning Outcomes (CLOs) with the Program Learning Outcomes (PLOs)

CLO	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7
CLO1	✓	✓		✓			
CLO2	✓			✓			
CLO3	✓	✓		✓			

Mapping CLOs with the Teaching-Learning and Assessment Strategy

CLO	Teaching-Learning Strategy	Assessment Strategy
CLO-1	- Deliver lectures using PowerPoint slides, videos, images and chalk-talk. - Seek immediate feedback during the lecture through short questions. - Respond to students' queries. - Conduct assessments to gauge understanding. - Assign tasks that encourage creativity and deeper exploration of specific topics. - Provide opportunities for practicing problem-solving. - Promote group discussions. - Arrange review classes when needed.	- Class participation through attendance. - Continuous assessment through quizzes. - In-course exams, assignments, and oral presentations. - Final evaluation through a written examination.
CLO-2		
CLO-3		

Courses for Fourth Year BS Honours

The final year topics reflect the current hotspots of bioscience endeavor and the research interests of the faculty members of the Department and are constantly being updated. The student will undertake an independent in-depth short research project/internship that may involve supervised practical work in a laboratory, or the students may choose to work on educational, industrial, data analysis, bioinformatics or enterprise topics. The course unit details given below are subject to change and are the latest example of the curriculum available on this course of study.

MBG 401C**Advanced Virology****Credits: 4****Class: 60 hours**

The virology course in 4th year level mainly includes the viruses commonly found in this country and around the world. This course is designed to describe the viral agents commonly found in respiratory and gastrointestinal tracts, and the detail study of few viruses having world wide distribution and epidemiological potentials. This course also provides the students with basic concepts on oncogenesis.

Course Objectives:

1. To know the common infectious human viruses and their life cycles
2. To know the virulence properties and associated diseases
3. Understand the epidemiology of infections
4. To be familiar with the therapeutic and preventive strategies of common human viruses
5. To have a basic concept of oncogenic viruses.

Course Learning Outcomes (CLOs):

1. After completing the course, students will have a comprehensive understanding of the commonly occurring human viruses in this country, as well as globally.
2. Students will have detailed knowledge of some viruses and will be able to describe replication strategies, along with disease and transmission characteristics, if applicable.
3. Students will learn the diagnosis and treatment of common viral diseases.

Unit	Course Content	Class hours
1	Animal Viruses: Brief introduction to different classes of viruses	2
2	Brief overview of the Life cycle of animal viruses: Mechanisms of attachment and entry; assembly and release	3
3	Viral Infections to the Respiratory System: pathogenesis of common cold; measles; mumps; rubella; chicken pox; shingles	4
3	Viral Infections to the Gastrointestinal Tract: Pathogenesis of viral diarrhoea	4
4	Arthropod-Borne Diseases: pathogenesis and diseases caused by dengue virus, yellow fever virus.	6
5	Herpes Viruses: general properties; pathogenesis; transmission; diseases by HSV-I, EBV	6

6	Hepatitis Viruses: general properties; pathogenesis; transmission; diseases caused by HAV, HBV, HCV, HDV, and HEV	4
7	Hepatitis B Virus: detail of virion structure; genome organization; replication; pathogenesis; epidemiology and transmission; prevention; clinical diagnosis and treatment.	6
8	Non-oncogenic Retroviruses: HIV: structure; genome organization; transmission; epidemiology; disease pathogenicity; diagnosis, treatment strategy; vaccine approaches.	7
9	Oncogenic viruses and tumor virology; Overview of cancer and tumors, oncogenic viruses; general features and genome organisation of retroviridae. Characteristics and of mechanisms of transformation of cancer cells, tumour suppressor genes.	5
10	Human Papilloma viruses: general properties; pathogenesis; transmission; oncogenic potential and vaccines.	5
11	Influenza Viruses: general properties and replication; antigenic shift and drift; vaccine approaches.	5
12	Pandemics by viruses: Risks, Impacts and Mitigation of pandemics by viruses.	2

Recommended Books:

1. Fields Virology (Vol. I & II)- D.M. Knipe, P.M. Howley, D.E. Griffin, Lippincott Williams, NY
2. Jawetz, Melnick and Adelberg's Medical Microbiology- K. C. Carroll, S.A. Morse, T. Mietzner, S. Miller, McGraw Hill Education
3. Viral Hepatitis- Howard C. Thomas, Anna S. F. Lok, S. A. Locarnini, A.J. Zuckerman, Wiley Blackwell
4. Principles of Virology, 4th edition (2 Vol)- S. J. Flint, L.W. Enquist, V.R. Racaniello, A.M. Skalka, ASM Press
5. Principles of Molecular Virology- A. J. Cann, Academic Press

Mapping Course Learning Outcomes (CLOs) with the Program Learning Outcomes (PLOs)

CLO	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7
CLO-1	✓		✓	✓	✓	✓	✓
CLO-2	✓	✓	✓	✓	✓	✓	✓
CLO-3	✓	✓	✓	✓	✓	✓	✓

Mapping CLOs with the Teaching-Learning and Assessment Strategy

CLO	Teaching-Learning Strategy	Assessment Strategy
CLO-1	• Deliver lectures using PowerPoint slides, videos, images and chalk-talk. • Seek immediate feedback during the lecture through short questions.	• Class participation through attendance. • Continuous assessment through quizzes. • In-course exams, assignments, and oral presentations. • Final evaluation through a written examination.
CLO-2	• Respond to students' queries. • Conduct assessments to gauge understanding. • Assign tasks that encourage creativity and deeper exploration of specific topics.	
CLO-3	• Provide opportunities for practicing problem-solving. • Promote group discussions. • Arrange review classes when needed.	

MBG 402C Advanced Immunology**Credits: 2****Class: 30 hours**

This course is a continuation of basic Immunology and provides an advanced knowledge of Immunology and Immunopathology. It discusses mechanisms of immune system that are key to controlling different pathogenic organisms. Students will be introduced to the general concepts concerning the development and mode of actions of different immuno-pathological diseases. Lectures will also focus on the prevention of diseases.

Course Objectives:

1. To understand how different mechanisms at molecular and cellular levels provide continuous surveillance to maintain good health.
2. To introduce the general concepts of Immunodeficiency, including primary T cell and secondary immunodeficiency and Tumour Immunology.
3. To understand the immuno-pathological mechanisms of Hypersensitivity, Autoimmune diseases including tolerance and Transplantation and rejection reactions.

Course Learning Outcomes (CLOs):

1. Students will learn the main mechanisms of immune tolerance and autoimmunity.
2. Students will have a basic idea about the importance of different components of immune system and how failure of these components can lead to severe health problems.
3. To understand the mode of actions of different types of Hypersensitivities, defense mechanisms against tumor/cancer formation as well as the preventive approaches to combat these health problems.

Unit	Course Content	Class hours
1	Immunological tolerance: T-and B-cell development: Early development in thymocyte and bone marrow; mechanism of tolerance; thymic tolerance to self-antigens; B cell tolerance; artificially induced tolerance	5
2	Immunodeficiency: primary immunodeficiency; deficiencies of innate immunity; primary B cell deficiency; primary T cell deficiency; combine immunodeficiency; secondary immunodeficiency	6
3	Hypersensitivity: hypersensitivity type-I, type-II, type-III and type-IV reactions	7
4	Transplantation: barriers of transplantation; law of transplantation; role of T lymphocytes in rejection; prevention of rejection	5
5	Tumour Immunology: Surface markers of tumour cell; immune response to tumour cells; lymphoproliferative disorders due to tumour growth.	4
6	Autoimmunity and Autoimmune Diseases: association of autoimmunity with diseases; genetic factors in pathogenesis; aetiology and treatment of autoimmune diseases. Diagnostic and Prognostic Value of Autoimmune Diseases	3

Recommended Books:

1. Immunology – P.J. Delves, S.J. Martin, D.R. Burton, I.M. Roitt – Mosby Elsevier
2. Roitt's Essential Immunology – P.J. Delves, S.J. Martin, D.R. Burton, I.M. Roitt – Wiley Blackwell
3. Kuby's Immunology – J.A. Owen, J. Punt, S.A. Stranford – W.H. Freeman and Company, NY

Mapping Course Learning Outcomes (CLOs) with the Program Learning Outcomes (PLOs)

CLO	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7
CLO1	✓	✓	✓				
CLO2	✓	✓	✓				
CLO3	✓	✓	✓		✓		✓

Mapping CLOs with the Teaching-Learning and Assessment Strategy

CLO	Teaching-Learning Strategy	Assessment Strategy
CLO-1	• Deliver lectures using PowerPoint slides, videos, images and chalk-talk. • Seek immediate feedback during the lecture through short questions. • Respond to students' queries. • Conduct assessments to gauge understanding.	• Class participation through attendance. • Continuous assessment through quizzes.
CLO-2		

CLO-3	- Assign tasks that encourage creativity and deeper exploration of specific topics. - Provide opportunities for practicing problem-solving. - Promote group discussions. - Arrange review classes when needed.	- In-course exams, assignments, and oral presentations. - Final evaluation through a written examination.
--------------	---	--

MBG 403C Genomics, Proteomics and Bioinformatics**Credits: 4****Class: 60 hours**

This course introduces students to the core principles and terminology of genomics, proteomics, and bioinformatics, emphasizing the interdisciplinary foundation involving biological, mathematical, statistical, and computational approaches. Students will explore key bioinformatics techniques and tools for the analysis and interpretation of high-throughput biological data. Topics include sequence alignment, gene and protein structure prediction, primer design, evolutionary genomics, structural bioinformatics, systems biology, and the application of AI in biological data analysis. Through lectures and hands-on case studies, students will gain practical skills in working with biological databases, conducting sequence-based analyses, and integrating multi-omics data for advanced biological research and discovery.

Course Objectives:

- To understand the key concepts and principles of genomics, proteomics, and bioinformatics
- To introduce the basics of genomics and post-genomics with the progress to databases, sequence alignments, analysis of genes, etc.
- To provide hands-on experiences to use bioinformatics tools and develop skills in the analysis of biological data.

Course Learning Outcomes (CLOs):

- Explain the basics of genomics and post-genomics with applications of different techniques of data analysis.
- Familiar with the basics of bioinformatics and its applications and limitations.
- Acquire knowledge for database searching and basic sequence analysis.
- Learn the techniques for analysis of complex data analysis in computer modelling of biological systems.
- Explain the basis of bioinformatics and computational biology to use its search tools on the interest for multiple sequence analysis to predict protein structure.

Unit	Course Content	Class hours
1	Introduction: Bioinformatics - definition, goal, history, scopes, resources, applications and limitations; Overview of 'Omics' Sciences; Fundamentals of genomics, metagenomics, metatranscriptomics, metabolomics, proteomics; Big data and cloud computing in Bioinformatics; High-Performance Computing (HPC)	3

	for bioinformatics, AWS (Amazon Web Services) and Google Cloud Platform (GCP) in bioinformatics.	
2	Biological databases: Definition, importance and limitations of databases in bioinformatics; Structure and organization of various bioinformatics databases; Types of biological databases- primary, secondary and specialized databases; File formats and tools- FASTA, GenBank, GFF, SAM/BAM; Ethics in bioinformatics- Data sharing, privacy, reproducibility; FAIR Data Principles (Findability, Accessibility, Interoperability, Reusability).	4
3	Primer designing for targeted gene amplification: Standard polymerase chain reaction (PCR) and real-time PCR; Primer designing for PCR and real-time qPCR- key parameters for efficient primer design, steps in primer design, Tools and software for primer design (Primer3, NCBI Primer-BLAST, OligoAnalyzer-IDT).	4
4	DNA sequencing technology: Principles, advantages and limitations of sequencing technologies of different generations; First generation- Sanger and Maxam-Gilbert Sequencing, Second generation or Next-Generation Sequencing (NGS) (454, Illumina, Ion Torrent), Third generation- Single-Molecule Real-Time (SMRT) Sequencing, Nanopore Sequencing; Future Trends in DNA Sequencing.	5
5	Basic commands and bioinformatics pipelines: Basic Linux commands, Anaconda (Miniconda), Programs installation and maintenance, Programs repository, Programs (Python, R etc.); GitHub basics; Applications of packages in statistical analysis and visualization; Bioinformatics pipelines and workflow management: Snakemake, Nextflow, Galaxy.	7
6	Sequence alignment: Basics of sequence alignment; Similarity and homology; Local and global alignment; Pairwise sequence alignment; alignment methods, scoring matrices, statistical significance of sequence alignment; Multiple Sequence Alignment (MSA); Tools for MSA (MEGA, UGENE, MAFFT); BLAST and FASTA tools; Clustal Omega, MUSCLE.	5
7	Evolutionary genomics: Fundamentals of phylogeny and phylogenetic tree; Tree construction models: Distance-based models- UPGMA (Unweighted pair group method), Neighbor Joining (NJ); Character-based methods- Maximum Parsimony, Maximum Likelihood; Model selection; Tools for phylogenetics; Tree construction, evaluation and interpretation; Bootstrapping.	5
8	Post-genomics: Locating genes in DNA sequence: Computational approaches- Comparative genomics, ORF scanning, Gene prediction in prokaryotes and eukaryotes; Experimental techniques- Northern hybridization, Exon trapping; Determining the functions of genes- Computer-aided homology searching, loss of function, gain of function.	5
9	Decoding microbial genomes: Microbial genomic structure, assembly, annotation and mapping; Genome submission to repository; Functional characterization of complete genome- MLSTs, resistance genes (CARD, ResFinder databases), virulence genes (VFDB), Bacteriophage (PHASTER) and beyond.	7

10	Structural bioinformatics: Structure-function relationships in biomolecules; Analyzing RNA secondary structures; Concepts of protein folding, forces, interactions, domains and functions; Prediction of protein 3-D structures- <i>Ab initio</i> , homology modelling and threading; Protein structure validation and quality estimation using Ramachandran Plot; Visualizing and aligning protein structures in PyMol.	6
11	Systems biology: Overview, history, aims and associated disciplines; Systems biology vs. traditional cell and molecular biology; Technologies to study systems at different levels, features of complex systems, data integration, computer modeling and simulations, cellular simulations; Network biology using Cytoscape.	4
12	Artificial Intelligence in Bioinformatics: Introduction to AI, machine learning, and deep learning; Traditional bioinformatics vs. AI-based approaches; Deep learning architectures (CNNs, RNNs, Transformers); AI applications in genomics, transcriptomics, proteomics, systems biology, and drug discovery; major tools and platforms (AlphaFold, RoseTTAFold/ OpenFold, DeepVariant, BioBERT, AutoML); Challenges and ethical issues in AI for Bioinformatics.	5

Recommended Books:

1. Essential Bioinformatics – Jin Xiong – Cambridge University Press
2. Bioinformatics for dummies – J.M. Claverie; Cedric Notredame–John Wiley, New York
3. Genomes 3 - T.A. Brown – Garland Science, New York
4. Biotechnology: Genomics and Bioinformatics – H.J.Rehm. and G. Reed – Wiley VCH.
5. Discovering Genomics, Proteomics and Bioinformatics - Campbell, A. Malcolm; Heyer, Laurie J. - Pearson Education, San Francisco

Mapping Course Learning Outcomes (CLOs) with the Program Learning Outcomes (PLOs)

CLO	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7
CLO1	✓	✓	✓				
CLO2	✓		✓				
CLO3	✓	✓	✓		✓		
CLO4	✓	✓	✓	✓	✓		
CLO5	✓	✓	✓		✓	✓	✓

Mapping CLOs with the Teaching-Learning and Assessment Strategy

CLO	Teaching-Learning Strategy	Assessment Strategy
CLO-1	Deliver lectures using PowerPoint slides, videos, images and chalk-talk.	Class participation through attendance.

CLO-2	• Seek immediate feedback during the lecture through short questions. • Respond to students' queries. • Conduct assessments to gauge understanding. • Provide opportunities for developing problem-solving skills. • Provide hands-on laboratory training. • Encourage collaborative discussion among students. • Case Studies & Research Paper Analysis. • Visit to advanced genomics laboratories. • Arrange review classes when needed.	• Continuous assessment through in-course exams, practical exams, assignments and oral presentations. • Final evaluation through a written examination.
CLO-3		
CLO-4		
CLO-5		

MBG 404C Genetic Engineering**Credits: 3****Class: 45 hours**

This course familiarizes students with the fundamental molecular techniques of recombinant DNA (rDNA) technology. It provides both theoretical knowledge and practical understanding of the essential steps in gene cloning, including the tools and strategies of genetic engineering. Students will explore DNA extraction, manipulation, and quantification, the use of enzymes and vectors in cloning, and the construction of recombinant DNA molecules. In addition, the course introduces methods for analyzing gene expression, studying protein interactions, and applying sequencing technologies. By integrating classical approaches with modern innovations, the course prepares students to apply rDNA technology in biotechnology, medicine, agriculture, and related fields.

Course Objectives:

1. Understand the fundamental principles, tools, and strategies of recombinant DNA technology.
2. Apply molecular techniques to construct, analyze, and screen recombinant DNA in prokaryotic and eukaryotic systems.
3. Demonstrate the use of sequencing, gene expression, and protein interaction studies for functional characterization of cloned genes.

Course Learning Outcomes (CLOs):

1. Extract, manipulate, and quantify DNA from prokaryotic and eukaryotic sources using standard molecular techniques.
2. Apply recombinant DNA methodologies such as PCR, blotting, and mutagenesis for molecular analysis and genetic manipulation.
3. Select and justify the use of appropriate enzymes, vectors, and cloning strategies for gene cloning in different host systems.
4. Perform transformation experiments in bacterial and non-bacterial systems and evaluate the selection of recombinant clones.
5. Employ sequencing technologies, including classical and next-generation approaches, for analyzing genetic material.

Unit	Course Content	Class hours
1	Extraction of DNA from different sources: Preparation of total DNA from bacteria, plant, and animal cells; preparation of plasmid DNA (Separation by size and separation by conformation), preparation of phage DNA (λ and M13) measuring concentration of DNA.	4
2	Techniques in Molecular Genetics: Production of recombinant DNA in vitro; Construction and screening (identification of a cloned gene) of DNA and cDNA libraries; Probe preparation and labelling techniques; Colony and Plaque hybridization techniques; Molecular analysis of DNA, RNA, and protein by blotting techniques (Southern, Northern, Western, Colony blots); Amplification of DNA by PCR; In vitro site-specific mutagenesis; Chromosome Walking and Chromosome Jumping.	10
3	DNA Manipulative Enzymes: Restriction endonucleases and other nucleases; ligases; polymerases; DNA-modifying enzymes; Ligation systems: blunt and sticky end ligation; putting sticky ends onto a blunt-ended molecule; use of linkers and adaptors.	4
4	Vectors and cloning strategies: Cloning vectors for prokaryotic organisms, plasmid, bacteriophage M13 and λ ; cosmids; phagemids; cloning vectors for eukaryotic organisms; yeast episomal plasmid (2 μ m circle); cloning vectors for higher plants and mammalian cells, BACs, YACs, expression vectors; Genomic and cDNA cloning approaches; TA cloning, Gateway cloning, Gibson assembly.	10
5	Introduction of Recombinant DNA into Living Cells: transformation of bacterial cells and selection of recombinants; introduction of phage DNA into bacterial cells and selection of recombinant phage; transformation of non-bacterial cells.	4
6	Sequencing of DNA: The Sanger-Coulson method; Maxam-Gilbert Method; Sequencing by PCR; Pyrosequencing and Next Generation sequencing	4
7	Studying Expression and Function of Cloned Gene: transcript analysis (Electron microscopy, DNA-RNA hybrids, primer extension; RT-PCR and RACE), Identifying controlling sequences of a cloned gene (deletion analysis); identifying protein binding sites on a DNA molecule (Gel retardation, Footprinting with DNase and Modification interference Assay); identifying and studying the translation product of cloned gene (HRT and HART); Studying protein-protein interaction (Phage display and Yeast two hybrid system).	9

Mapping Course Learning Outcomes (CLOs) with the Program Learning Outcomes (PLOs)

CLO	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7
CLO-1	✓		✓		✓		
CLO-2	✓	✓	✓		✓		
CLO-3	✓	✓			✓		
CLO-4		✓	✓	✓	✓		
CLO-5	✓	✓			✓		

Mapping CLOs with the Teaching-Learning and Assessment Strategy

CLO	Teaching-Learning Strategy	Assessment Strategy
CLO-1	- Deliver lectures using PowerPoint slides, videos, images and chalk-talk. - Seek immediate feedback during the lecture through short questions. - Respond to students' queries. - Conduct assessments to gauge understanding. - Assign tasks that encourage creativity and deeper exploration of specific topics. - Provide opportunities for practicing problem-solving. - Promote group discussions. - Arrange review classes when needed.	- Class participation through attendance. - Continuous assessment through quizzes. - In-course exams, assignments, and oral presentations. - Final evaluation through a written examination.
CLO-2		
CLO-3		
CLO-4		
CLO-5		

MBG 405C Microbial Biotechnology**Credits: 3****Class: 45 hours**

This course focuses on the biotechnological areas where microbes and their metabolic pathways and products can be used. The course will summarize how to improve industrially important microorganisms and their enzymes, exploiting microbes to overproduce metabolites of interest, exploitation of microbes and their products for energy generation, bio-mining, bioremediation etc. Students will also explore where biotechnology may offer an answer to contemporary problems by dealing with the past and evaluating the future of the biotechnology industry. The course will also help the students to develop their own interests in other aspects of biotechnology.

Course Objectives:

1. Basic concept and spectrum of biotechnology as well as areas of application of biotechnology.
2. Production of different biotechnological products including recombinant products, use of genetically manipulated organisms and biotechnologically important enzymes.
3. Areas of application certain microbes used in biotechnology with detailed processes such as biotransformation, bioremediation, metal extraction etc.

Course Learning Outcomes (CLOs):

1. Understanding the concepts, essential features and applications of biotechnology.
2. Improvement of the potential of microorganisms and utilizations of beneficial microbes.
3. Application of biotechnology in mining industry and remediation of pollutants.
4. Specific processes and reactions in the biotransformation and bioremediation.
5. Application in production of biofuels from low-cost raw materials.
6. Application of enzymes for various purposes.

Unit	Course Content	Class hours
1	Introduction to Biotechnology: historical development, scope and essential features of microbial biotechnology; interdisciplinary nature and applications of biotechnology.	2
2	Improvement of industrially important microorganisms: conventional routes to strain improvement; isolation of mutants, auxotroph, resistant mutants, revertant mutants, use of recombinant systems. Application of system biology and bioinformatics for strain improvement.	5
3	Over production of metabolites of industrially important microorganisms: Derangement or bypassing of regulatory mechanisms for the over-production of primary metabolites, regulation of over-production in secondary metabolites, empirical methods employed to disorganize regulatory mechanisms in secondary metabolic production.	6
4	Energy and Biotechnology: Biomass fuel; Biogas-methane production, biogas plant, anaerobic digester for methane production; Fuel-ethanol and methanol; biodiesel; introduction to biofuel cells; genetic manipulation of yeast and bacteria for biofuel/ethanol production	6
5	Materials and Biotechnology: microbial leaching, metal transformation and immobilization; Next-generation bioplastics: production of PHA, PHB, and PLA biopolymers, Metabolic engineering for high-yield PHA/PHB production; Use of synthetic biology in fine-tuning biopolymer composition and properties; Advanced biohydrometallurgical techniques for extracting rare earth elements (REEs); Use of genetically engineered microbes for enhanced metal solubilization; Application of extremophiles in bioleaching of refractory ores	6
6	Immobilized Biocatalyst Technology: Principles, benefits, biocatalysts over chemical catalysts; Immobilization: Enzyme Vs Whole Cell; methods of immobilization of enzymes and cells; application of immobilized biocatalysts; recent advancements in immobilized biocatalyst technology	5
7	Biotransformation: Biotransformation and principles; Biocatalysis in organic solvents, enzyme reactors in biotransformation, steroid, aromatic compounds and metals etc.	5

8	Chemical Engineering and Biotechnology: Microbial factors and process engineering factors affecting process performance and economics; future development in industrial biotechnological processes.	5
9	Nanobiotechnology: Introduction to Nanobiotechnology, Types of Nanomaterials in Biology, Green Synthesis of Nanoparticles, Nanocarriers for Drug Delivery, Nanoparticles in Diagnostics, Nanosensors in Environmental Monitoring, Nanobiotech in Agriculture, AI in Nanobiotechnology, Toxicology of Nanomaterials, Regulatory Framework, Ethical Implications and Risk Assessment	5

Recommended Books:

1. Biotechnology Principles: Aspects of Microbiology- by J.E. Smith; Van Nostrand Reinhold (UK) Co Ltd.
2. Microbial Biotechnology: Principles and Applications – L.W. Kun and Y.K. Lee; World Scientific Publishing Company
3. Biotechnology: Principles and Applications- by Higgins I.J.; Best D.J.; Jones J. – Oxford U
4. Comprehensive biotechnology: Principles, applications and regulations of biotechnology in industry, agriculture and medicine- by Moo-Young, Murray – Elsevier, New Delhi
5. Introduction to biotechnology- by Brown C. M.; Brown C. B.; Campbell I.; Priest F. G – Blackwell, London

Mapping Course Learning Outcomes (CLOs) with the Program Learning Outcomes (PLOs)

CLOs	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7
CLO1	✓						✓
CLO2	✓	✓	✓				
CLO3	✓	✓	✓	✓			
CLO4	✓	✓	✓	✓			
CLO5	✓	✓	✓	✓	✓	✓	✓
CLO6	✓	✓	✓	✓		✓	

Mapping CLOs with the Teaching-Learning and Assessment Strategy

CLO	Teaching-Learning Strategy	Assessment Strategy
CLO-1	Deliver lectures using PowerPoint slides, videos, images and chalk-talk.	Class participation through attendance.
CLO-2	Seek immediate feedback during the lecture through short questions.	Continuous assessment through quizzes.
CLO-3	Respond to students' queries.	

CLO-4	- Conduct assessments to gauge understanding. - Assign tasks that encourage creativity and deeper exploration of specific topics. - Provide opportunities for practicing problem-solving. - Promote group discussions. - Arrange review classes when needed.	- In-course exams, assignments, and oral presentations. - Final evaluation through a written examination.
CLO-5		
CLO-6		

MBG 406C Analytical Techniques in Life Sciences**Credits: 3****Class: 45 hours**

This course is designed to provide students with a comprehensive understanding of the analytical techniques used in modern life sciences to isolate, purify, and identify macromolecules. It emphasizes both qualitative and quantitative methods for analyzing biomolecular interactions and activities.

Course Objectives:

1. Understand and apply electron and confocal microscopy techniques for the detection and analysis of cellular and sub-cellular structures.
2. Gain familiarity with electrophoretic, chromatographic, spectroscopic, and centrifugation techniques for the separation, purification, and quantification of macromolecules, both as individual isolates and in supramolecular complexes.
3. Learn the principles and practices of cell culture techniques, including initiation, cultivation, maintenance, passaging, and preservation of cell lines, with applications in biotechnology.
4. Understand the generation, application, and analysis of genetically modified model organisms (e.g., mice), including experimental design consultation and relevant technology development.

Course Learning Outcomes (CLOs):

1. Describe a range of analytical techniques used for the isolation, resolution, purification, identification, and sequencing of proteins and nucleic acids.
2. Explain various methodologies to study protein-protein interactions and their significance in biological systems.
3. Demonstrate an understanding of cell culture techniques employed in biotechnology and describe the application of animal models in life science research.

Unit	Course Content	Class hours
1	Advanced Microscopy: The Electron microscopy: Principles and methods; Image analysis and Archiving, The Confocal fluorescent: Principles and methods; Image analysis and Archiving.	3

2	Centrifugation Techniques: Principle of sedimentation; sedimentation coefficients, centrifuges and their use, Differential centrifugation; ultracentrifuge, Density-gradient centrifugation: rate zonal technique and isopycnic technique.	3
3	Electrophoresis Techniques: Principle; Factors affecting electrophoresis; Types and Methods, Native, Gradient, SDS-PAGE, Isotachopheresis; Isoelectric focusing and 2D gel electrophoresis, Analysis of protein-protein interaction by gel electrophoresis, Co-immunoprecipitation, Mobility shift assay.	7
4	Protein Characterization: Isolation and quantification of proteins, Preparation of whole cell extract, surface proteins, lipopolysaccharides, chemical and physical methods. Identification of amino acids, Primary structure, amino acid sequence of polypeptide Chains; Biochemical, immunological and molecular characterization of proteins; Sequence analysis and report writing.	9
5	Chromatographic Techniques: Principle of chromatography; definition, terminology, types of chromatography, Column, thin-layer and paper chromatography, Affinity chromatography: Principles, Tandem affinity chromatography; Exclusion/ gel filtration chromatography: procedure and applications, Molecular imprinting, Ion exchange chromatography; Adsorption chromatography: hydroxylapatite and hydrophobic interaction chromatography-salting in and salting out, Gas-liquid, high performance liquid chromatography, fast protein liquid chromatography.	9
6	Spectroscopic Techniques: Introduction, Light spectrum of electromagnetic radiation, electronic spectra, Visible, ultraviolet and infrared spectrophotometers, Fluorescence and Spectrofluorimetry; it's applications, Luminescence and luminometry; it's applications; NMR and mass spectrometry; Matrix-Assisted Laser Desorption Ionization Time-of-Flight (MALDI-TOF). X-ray crystallography.	4
7	Radioisotope Techniques: Nature, detection and measurement of radioactivity, Application of radioisotopes in the biological sciences, Safety aspects of the use of radioisotopes.	3
8	Cell culture techniques: Preparation and maintenance of cell culture, Primary cell cultures, Continuous cell-lines, Cell quantification, Cryopreservation of cells, Determination of cell viability, Assay of cell death: TUNEL assay.	4
9	Animal Model: Inbred strain; Transgenic animal, Knock-in and knock out technology.	3

Recommended Books::

1. Protein Purification: principles and practice – R.K. Scopes – Springer-Verlag, New York
2. An introduction to Practical Biochemistry – D.T. Plummer – McGraw-Hill, London
3. Basic biochemical methods – R.R. Alexander – John Wiley, New York
4. A Guide to Principle and Techniques of Practical Biochemistry - Wilson K and Goulding KH
5. Gel electrophoresis of Proteins: A practical approach – B.D. Hames – Oxford University press
6. The Protein Protocols Handbook – J.M. Walker, Humana Press

Mapping Course Learning Outcomes (CLOs) with the Program Learning Outcomes (PLOs)

CLO	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7
CLO-1	✓	✓	✓	✓	✓		
CLO-2	✓	✓	✓	✓			
CLO-3	✓		✓	✓	✓		✓

Mapping CLOs with the Teaching-Learning and Assessment Strategy

CLO	Teaching-Learning Strategy	Assessment Strategy
CLO-1	- Deliver lectures using PowerPoint slides, videos, images and chalk-talk. - Seek immediate feedback during the lecture through short questions. - Respond to students' queries. - Conduct assessments to gauge understanding. - Assign tasks that encourage creativity and deeper exploration of specific topics. - Provide opportunities for practicing problem-solving. - Promote group discussions. - Arrange review classes when needed.	- Class participation through attendance. - Continuous assessment through quizzes. - In-course exams, assignments, and oral presentations. - Final evaluation through a written examination.
CLO-2		
CLO-3		

MBG 407C Microbial Diagnosis in Health Clinics**Credits: 3****Class: 45 hours**

This course is designed to provide comprehensive knowledge of diagnostic microbiology, covering both classical and modern approaches to pathogen detection. Students will study the principles of clinical specimen collection, transport, and laboratory safety, as well as traditional, serological, immunological, and molecular diagnostic methods for bacterial, viral, fungal, and parasitic diseases. The course also highlights the role of advanced technologies such as automated systems, PCR-based assays, and next-generation diagnostics. In addition, students will gain insights into quality management and validation practices that ensure accuracy, reliability, and biosafety in diagnostic laboratories.

Course Objectives:

1. To provide students with theoretical knowledge of clinical specimen collection, transport, and biosafety measures essential for accurate diagnostic practices.
2. To develop an understanding of conventional, serological, immunological, and molecular methods for the detection of microbial pathogens.
3. To familiarize students with advanced diagnostic technologies and quality management principles in clinical microbiology.

Course Learning Outcomes (CLOs):

1. Demonstrate an in-depth understanding of principles and practices of clinical specimen collection, transport, biosafety, and laboratory management in healthcare settings.
2. Apply conventional, serological, immunological, and molecular diagnostic methods for the detection and identification of bacterial, viral, fungal, and parasitic pathogens.
3. Evaluate the role and applications of automated diagnostic platforms and advanced technologies in microbial identification and antimicrobial susceptibility testing.
4. Interpret and compare results obtained from traditional, serological, molecular, and next-generation diagnostic techniques.
5. Discuss the significance of quality assurance, quality control, and validation processes in ensuring accuracy and reliability of diagnostic microbiology results.
6. Perform selected laboratory techniques in bacteriology, virology, mycology, and parasitology for microbial diagnosis and reporting in healthcare facilities.

Unit	Course Content	Class hours
1	Specimen Collection and Transport: Types of clinical specimens, approaches to clinical specimen collection, transport, rejection criteria of different specimens, laboratory biosafety and biosecurity, biomedical waste and laboratory management.	5
2	Diagnostic procedures: Sample processing and traditional diagnostic methods for the detection of bacterial, viral, fungal and parasitic etiologic agents.	12
3	Advanced approaches for bacterial Identification: Automated systems: Automated blood culture system, VITEK, MALDI-TOF, API strips	3
4	Serological and Immunological Diagnostics: Principles of antigen-antibody reactions, ELISA, latex agglutination, lateral flow tests, Rapid diagnostic tests (RDTs) for dengue, typhoid, malaria, etc. Serodiagnosis of viral (HBV, HCV, HIV) and bacterial diseases (syphilis, brucellosis)	4
5	Molecular based diagnosis: Microarray, BioFire FilmArray RT-PCR, qPCR, Nucleic acid extraction and storage, Applications in detection of TB, COVID-19, HPV, etc., Point-of-care molecular tests and next-generation diagnostics	4
6	Overview of quality management and quality assurance: Concepts of validation and its applications in diagnostic assay.	2

Recommended Books:

1. Bailey and Scott's Diagnostic Microbiology– by P.M. Tille. Weissfeld, Mosby, St. Louise
2. Textbook of Diagnostic Microbiology- by C.R. Mahon, D.C. Lehman and G. Manuselis Jr., WB Saunders Co., New York
3. Laboratory Diagnosis of Infectious Diseases: Essentials of Diagnostic Microbiology - P.G. Engelkirk and J.D. Engelkirk; Wiliam and Wilkins
4. Essentials of Practical Microbiology-Apurba S Sastry, Sandhya Bhat; Jaypee brothers medical publishers Ltd, New Delhi.

Mapping Course Learning Outcomes (CLOs) with the Program Learning Outcomes (PLOs)

CLO	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7
CLO-1	✓						✓
CLO-2	✓	✓	✓		✓		
CLO-3	✓	✓			✓		
CLO-4	✓	✓	✓		✓		
CLO-5	✓	✓			✓		✓
CLO-6			✓	✓	✓	✓	

Mapping CLOs with the Teaching-Learning and Assessment Strategy

CLO	Teaching-Learning Strategy	Assessment Strategy
CLO-1	- Deliver lectures using PowerPoint slides, videos, images and chalk-talk. - Seek immediate feedback during the lecture through short questions. - Respond to students' queries. - Conduct assessments to gauge understanding. - Assign tasks that encourage creativity and deeper exploration of specific topics. - Provide opportunities for practicing problem-solving. - Promote group discussions. - Arrange review classes when needed.	- Class participation through attendance. - Continuous assessment through quizzes. - In-course exams, assignments, and oral presentations. - Final evaluation through a written examination.
CLO-2		
CLO-3		
CLO-4		
CLO-5		
CLO-6		

MBG 408C**Research Methodology****Credits: 2****Class: 30 hours**

This course aims to guide 4th year BS Honours students towards achieving competence and proficiency in the theory and practice of research. The course will help students develop their research topic, enhance intellectual ability, critical analysis, and independence of thought, and foster individual judgement and skills in applying research theory and methods. Students will also learn how to write research proposals, reports, and dissertations effectively.

Course Objectives:

1. To familiarize students with the fundamental principles behind research work.
2. To acquaint students with practical knowledge and processes of conducting research.
3. To enable students to design, perform, and present research work independently or collaboratively.

Course Learning Outcomes (CLOs):

1. Understand what research is and distinguish it from non-research activities.
2. Demonstrate awareness of the nature of scientific knowledge and the importance of the scientific method.
3. Formulate and justify research problems suitable for study.
4. Review and critically evaluate relevant literature from diverse sources.
5. Identify and justify the components of a research framework relevant to a given problem.
6. Select appropriate research methods and data collection techniques.
7. Prepare a credible research proposal following academic and ethical standards.

Unit	Course Content	Class Hours
1	Introduction to Research Methodology: Meaning, objectives, motivations, types, approaches, significance, methods vs methodology, criteria of good research.	2
2	Basic Types of Research: Fundamental/applied, descriptive/analytical, quantitative/qualitative, conceptual/empirical, diagnostic/hypothesis testing, theoretical/action research, longitudinal/cross-sectional.	4
3	Research Design: Exploratory, descriptive, and experimental research designs; concepts of independent and dependent variables.	6
4	Sampling: Statistical population, sample, sampling frame, sampling error, sample size, non-response, probability and non-probability sampling, and determining sample size.	6
5	Data Analysis and Synthesis: Data preparation, univariate and bivariate analyses, hypothesis testing (chi-square), and generalization methods.	5
6	Task of Writing in Research: Writing research proposals, academic and project proposals, thesis/dissertation structure, steps, and documentation.	3
7	Research Ethics: Ethical issues, plagiarism and self-plagiarism, intellectual property rights, and patent law.	4

Recommended Books:

1. Research Methodology – C. R. Kothari.
2. Research Methodology: A Step-by-Step Guide for Beginners – R. Kumar (2011). London: TJ International Ltd.
3. Fundamentals of Research Methodology and Statistics – YK Singh (2006). New Delhi Int'l Ltd.
4. Research Methodology in Education: A Practical Guide – Robert E. Slavin (1994). Prentice Hall.

Mapping Course Learning Outcomes (CLOs) with the Program Learning Outcomes (PLOs)

CLO	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7
CLO1	✓	✓					
CLO2	✓	✓					
CLO3	✓	✓	✓	✓			
CLO4	✓	✓	✓				
CLO5	✓	✓	✓	✓			
CLO6	✓	✓	✓	✓		✓	
CLO7	✓	✓	✓		✓	✓	✓

Mapping CLOs with the Teaching-Learning and Assessment Strategy

CLO	Teaching-Learning Strategy	Assessment Strategy
CLO-1	- Deliver lectures using PowerPoint slides, videos, images and chalk-talk. - Seek immediate feedback during the lecture through short questions. - Respond to students' queries. - Conduct assessments to gauge understanding. - Develop scientific writing skills through guided assignments, structured report writing. - Conduct assessments to gauge understanding. - Encourage group discussions; Assign tasks that encourage creativity and deeper exploration of specific topics.	- Continuous assessment through class participation. - In-course assessment through exam and assignments and report/ literature review submission. - Final evaluation through an oral presentation and report submission on a selected topic.
CLO-2		
CLO-3		
CLO-4		
CLO-5		
CLO-6		
CLO-7		

MBG 409C

Laboratory Works IV

Credits: 6

Class: 120 hours

This applied and professional Laboratory course represents the relevant topics and themes of the theoretical courses and is considered essential for the development of skills in service, teaching, and research in microbiology. The 4th year students integrate their knowledge and skills into a research project that sets out from an abstract theme. The students will have to conduct an in-depth study of the theme and to come up themselves or, often in teams with research questions, the instructor/supervisor will act as a 'hands-on' expert and motivator in this process. Development of laboratory techniques; exercises designed to reinforce concepts covered in this course.

Course Objectives:

The main objective of the course is to achieve specialized knowledge and intellectual skills in the Laboratory work in different fields of microbiological sciences. The specific objectives include integration of knowledge, exercising designed concepts, and developing laboratory skills for service, teaching, and research laboratories.

Course Learning Outcomes (CLOs):

1. Exercise their specialized laboratory skills in service, teaching and innovations in different field of microbiology including virology, immunology, genomics and genetic engineering, biotechnology and food industry, analytical and diagnostic microbiology, disease control and bioremediation of natural and man-made hazards in terrestrial and marine environments.
2. The students will also achieve the capability to complete a substantial research project related to microbiological sciences.
3. Seek and employ insights from others in implementing the project.
4. Evaluate a significant challenge or question faced in the project concerning core concepts, methods or assumptions in microbiology; and
5. Describe the effects of learning outside the classroom on his or her research or practical skills.

Course Content	Class hours
1. Study of fluorescent micrographs to visualize bacterial cell 2. Separation of components of a given mixture using a centrifuge 3. Separation of sugars by paper chromatography 4. Thin-layer chromatographic separation of amino acids 5. Preparation of bacterial whole cell extract and outer membrane protein. 6. Detection of antigen by SDS-PAGE and immunoblotting. 7. Immunization of animal with selective antigen and collection of serum and plasma. 8. Detection of antibody by gel immunodiffusion technique and crossed immune-electrophoresis technique 9. Estimation of total bilirubin concentration in blood serum 10. Detection of HBsAg from patients' serum by serological methods 11. Primer designing using in silico/ bioinformatics tools 12. DNA sequencing and analysis: Sanger sequencing (gene) and NGS (complete genome). 13. Multiple Sequence Analysis (MSA) and Phylogenetic analysis 14. Modeling and evaluation of RNA and Protein structures using structural bioinformatics tools 15. Replicate published bioinformatics analyses and apply these methods to address novel research questions. 16. Extraction of bacterial DNA 17. Isolation of plant DNA 18. Extraction of viral DNA 19. Measurement of DNA concentration 20. DNA manipulation by restriction enzymes and ligase 21. Polymerase Chain Reaction (PCR) in a thermocycler followed by Agarose Gel Electrophoresis 22. Detection of viral DNA by PCR amplification 23. Yeast cell immobilization in the Ca-alginate gel method 24. Demonstration on biotransformation of organic compounds 25. Isolation of biodegradative microbes from the environment 26. Determination of physiochemical parameters of the sewage sample by measuring conductivity, TDS, salinity, temperature, and dissolved oxygen 27. Enrichment and isolation of pathogenic bacteria from sewage sample 28. Remediation of metal ions through microbes 29. A visit to a forensic laboratory facility. 30. A visit to an industrial (food/beverages/pharmaceuticals/other) facility.	120

Recommended Books:

1. Microbiology: A Laboratory Manual- J. Cappucino & N. Sherman; Pearson Education Limited
2. Cell and Molecular Biology – P.V. Chaitanya; Prentice-Hall of India Pvt. Ltd.
3. Environmental Microbiology – I. Pepper, C. Gebra and J. Brandecke; Academic Press
4. Food Microbiology: A Laboratory Manual – A.E. Yousef and C. Carlstrom; Wiley and Sons Inc.
5. Laboratory Protocols in Applied Life Sciences - P.S. Bisen, CRC Press
6. Manual of Industrial Microbiology and Biotechnology – A.L. Demain & J.E. Davies; ASM Press.
7. Practical Immunology - C.H. Frank, M.R. Olwyn and Westwood; Blackwell Science Ltd.

Mapping Course Learning Outcomes (CLOs) with the Program Learning Outcomes (PLOs)

CLO	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7
CLO-1	√		√	√	√	√	√
CLO-2	√	√	√	√	√	√	√
CLO-3		√		√	√	√	
CLO-4	√	√	√	√	√	√	
CLO-5				√	√	√	√

Mapping CLOs with the Teaching-Learning and Assessment Strategy

CLO	Teaching-Learning Strategy	Assessment Strategy
CLO-1	- Conduct interactive lectures covering the principles, methods, procedures, and applications of each experiment using PowerPoint/ videos/ pictures/ chalk-talk. - Obtain immediate feedback by asking questions. - Address students' queries promptly. - Facilitate problem-solving practice. - Provide hands-on laboratory training. - Encourage collaborative discussion among students. - Visit to an industry/ research laboratory to gain professional experience.	- Class participation through attendance - Continuous assessment through in-course exams, and assignments. - Evaluation of practical notebooks. - Report from the visit to industry/ research labs - Final assessment through practical experiments and a written test. - Viva voce.
CLO-2		
CLO-3		
CLO-4		
CLO-5		

MBG 410C**Viva-voce****Credits: 2**

The fourth year, being the final year of the undergraduate program, culminates in a comprehensive viva-voce examination. This academic interview allows examiners to evaluate the students' mastery of the subject matter across all theoretical and laboratory courses completed during the year. It also serves as a final assessment of their academic competence and readiness to be awarded the degree.

Course Objectives:

1. Demonstrate comprehensive knowledge in their broader field of study.
2. Enhance their ability to effectively communicate scientific information with confidence, skills, and expertise.
3. Evaluate and reflect on their understanding and mastery of the program's content.

Course Learning Outcomes (CLOs):

1. To evaluate their knowledge and thinking capacity as well as pressure handling capacity.
2. Ability to describe the process of science.
3. Ability to communicate and collaborate with other disciplines.

Course Content: All the courses attended in the entire academic program.

Mapping Course Learning Outcomes (CLOs) with the Program Learning Outcomes (PLOs)

CLO	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7
CLO-1	√	√	√			√	
CLO-2		√		√	√		
CLO-3						√	√

Mapping CLOs with the Teaching-Learning and Assessment Strategy

CLO	Teaching-Learning Strategy	Assessment Strategy
CLO-1	• Problem solving and discussion. • Respond to students' queries. • Encourage collaborative discussion among students.	Final evaluation through questions and performance.
CLO-2		
CLO-3		

MBG 411K**Research Projects****Credits: 2**

In the fourth and final year of the undergraduate program, students integrate and apply the knowledge and skills acquired throughout their studies by undertaking an independent research project. Beginning with a broad thematic area, students develop focused research questions and conduct an in-depth investigation under the guidance of a faculty supervisor. The course emphasizes the development of laboratory techniques, critical thinking, and scientific inquiry. Students engage in hands-on experimental work, data analysis, and scholarly communication as they progress from conceptualization to completion of their research.

Course Objectives:

1. To enable students to design and execute a research project relevant to contemporary microbiology.
2. To strengthen students' competence in laboratory techniques, data analysis, and scientific methodology.
3. To cultivate independent thinking, problem-solving skills, and research ethics.
4. To develop students' ability to prepare scientific reports, present research findings, and engage with the broader scientific community.
5. To encourage professional growth by motivating students to present their work at scientific forums and prepare manuscripts for peer-reviewed journals.

Course Learning Outcomes (CLOs):

1. Formulate research questions and design a feasible study plan based on a given research theme.
2. Apply appropriate laboratory techniques and scientific methodologies to conduct independent research.
3. Analyze data, interpret results, and evaluate the scientific significance of their findings.
4. Prepare a well-structured written research report that adheres to academic standards.
5. Communicate research findings effectively through oral presentations and scholarly discussions.
6. Demonstrate professionalism, ethical conduct, and responsibility when working within institutional or external research laboratories.

Course Content

A supervised research project developed in consultation with the assigned faculty supervisor. Students will identify a research theme, review relevant literature from print and electronic sources, formulate research questions, and design an appropriate study plan. The course includes laboratory work, data collection, analysis, interpretation, and preparation of a written research report. Students will also prepare and deliver an oral presentation of their findings as part of the final evaluation.

Mapping Course Learning Outcomes (CLOs) with the Program Learning Outcomes (PLOs)

CLO	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7
CLO-1	√	√		√			
CLO-2			√	√	√		
CLO-3		√	√				
CLO-4					√		√
CLO-5						√	√
CLO-6					√		√

Mapping CLOs with the Teaching-Learning and Assessment Strategy

CLO	Teaching-Learning Strategy	Assessment Strategy
CLO-1	- One-on-one supervision and mentoring. - Guided literature review sessions. - Hands-on laboratory training. - Demonstrations by supervisor - Peer-assisted learning - Use of statistical and bioinformatics tools - Oral presentation practice sessions - Peer feedback on presentations - Workshops on laboratory safety and ethics	- Evaluation of project proposal - Laboratory performance assessment - Supervisor observation and checklist - Lab notebooks - Evaluation of the final written report - Oral defense (seminar)
CLO-2		
CLO-3		
CLO-4		
CLO-5		
CLO-6		

MBG 412E**Industrial Microbiology****Credits: 2****Class: 30 hours**

The course is designed to develop the student's ability to apply the techniques used in different phases of industrial microbiology such as discovery, production, bioprocessing and cell storage. It includes the principles and practices in the major applications of microorganisms (natural isolates, laboratory mutants or genetically engineered) to the industrial production of biomass, enzymes, primary and secondary metabolites, pure chemical and other useful products.

Course Objectives:

1. To understand and develop concepts in industrial processes which in turn resulted in action.
2. To acquaint the art of microbial action in commercial production of valued producers.
3. To enable graduates to enter industry with an appropriate level of understanding of the need for both the science and business aspects to be achievable to make a viable product.

Course Learning Outcomes (CLO)

1. Describe the main steps and processes used to produce biological products in industry.
2. Discover new useful microorganisms and store them reliably for later use.
3. Evaluate which molecular techniques are applicable to improve production including transfer of useful genes to microorganisms that are more amenable to large-scale production and the use of molecular techniques to block and enhance specific metabolism.
4. Understand ethical and commercial issues such as record keeping, confidentiality, patenting, and licensing.
5. Perform microbiological investigations, observe and evaluate the data obtained, and report the findings accurately and precisely.
6. Undertake an independent investigation to propose microbiological options for developing a new production on a large-scale commercial basis.

Unit	Course Content	Class hours
1	Scope of Industrial Microbiology: Historical development, scope and multidisciplinary nature of industrial microbiology; Applications of microbiology in commercial production; Optimization of industrial process and economic viability; Organization setup in industrial microbiology; Product development, safety regulation, patent and patent laws.	5
2	Industrial Microorganisms: microorganisms of industrial importance and their characteristics; Improvement, screening, selection and maintenance of industrially potent microorganisms; media formulation, culture systems & economics.	3
3	Production of Biomass & Beverages: Single cell protein (SCP) and microbial biomass protein (MBP); Yeast biomass; Technology for production of alcoholic beverages- beer, wine and distilled spirit; Vinegar.	4
4	Production of Industrial Chemicals and food additives: Organic acids- lactic acid, citric acid, alcohol, acetone, butanol, monosodium glutamate and vitamins.	5

5	Production of microbial enzymes and antibiotics: Microbial sources of commercial enzymes and their applications; biotechnological approaches for production of enzymes and antibiotics.	4
6	Industrial Waste Management: Utilization of domestic, agro-industrial and industrial waste for commercially valued products; Treatment of industrial wastes.	3
7	Bio business and Entrepreneurship: Business environment and stakeholders; Corporate strategies and economic principles (e.g. profit maximization, shareholder value); Business planning, decision-making processes, and analysis tools; Fundamentals of project management and project life cycle; Planning and problem-solving methods in project management; Marketing and sales of biotechnology products; Commercialization steps for industrial products; Introduction to intellectual property rights and patent claims; Patentability criteria, ownership, and public domain; Biotechnology-specific patent issues, disclosure, and collaborative research; Patent litigation and recent developments in biotech patent systems	6

Recommended Books:

1. Industrial Microbiology: an introduction- M.J. Waites, N.L. Morgan, J.S. Rockey & G.Higton, Blackwell Science, Oxford
2. Modern Industrial Microbiology and Biotechnology- N. Okafor, Science, New Hampshire.
3. Prescott and Dunn's Industrial Microbiology- G. Reed, CBS, New Delhi
4. Industrial Microbiology- B.M. Milier & W. Litsky, McGraw-Hill, New York.
5. Industrial Microbiology- L.E Casida, Wiley, New York.
6. Intellectual Property in Academia: A Practical Guide for Scientist and Engineers - N Reingand, CRC Press
7. BUSINESS for the 21st Century, Steven J. Skinner and John M. Ivancevich 2003, Richard D. Irwin, Inc.
8. Building Biotechnology: Biotechnology Business, Regulations, Patents, Law, Policy and Science, Yali Friedman, Logos Press (USA), 4th Edition 2014.
9. Projects- Planning, Analysis, Selection, Financing, Implementation, and Review, Prasanna Chandra, McGraw Hill Education (India) Private Limited. Eight edition 2014.

Mapping Course Learning Outcomes (CLOs) with the Program Learning Outcomes (PLOs)

CLOs	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7
CLO1	✓	✓				✓	
CLO2	✓	✓	✓			✓	
CLO3	✓	✓	✓	✓		✓	
CLO4	✓		✓	✓	✓		✓
CLO5	✓	✓	✓	✓		✓	
CLO6	✓	✓	✓	✓		✓	✓

Mapping CLOs with the Teaching-Learning and Assessment Strategy

CLO	Teaching-Learning Strategy	Assessment Strategy
CLO-1	- Deliver lectures using PowerPoint slides, videos, images and chalk-talk. - Seek immediate feedback during the lecture through short questions. - Respond to students' queries. - Conduct assessments to gauge understanding. - Arrange visit to an industrial facility. - Encourage collaborative discussion among students. - Arrange review classes when needed.	- Class participation through attendance. - Continuous assessment through in-course exams, industrial visit report submission and oral presentation. - Final evaluation through a written examination.
CLO-2		
CLO-3		
CLO-4		
CLO-5		
CLO-6		

MBG 413E Epidemiology, Public Health, and Bioethics**Credits: 2****Class: 30 hours**

In this course, students will learn and apply basic concepts of epidemiology to multiple domains of public health. The course will illustrate and practice using epidemiology to better understand, characterize, and promote health at a population level. The class will engage the students in active and collaborative learning through team activities, individual projects, case studies, group discussion, and individual projects.

Course Objectives:

1. To apply the basic concepts, principles, and tools of epidemiology for appropriate inferences from epidemiologic data.
2. To explain the importance of epidemiology for informing scientific, ethical, and economic discussion of health issues.
3. To acquire knowledge of major frameworks of ethics and the basic ethical concepts operative in public health ethics.

Course Learning Outcomes (CLOs):

1. Explain the importance, concept and applications of epidemiological approaches to control diseases.
2. Investigate outbreak of a disease and prevent future outbreak.
3. Evaluate the key data sources, basic epidemiology measures, strengths and limitations of epidemiological reports.
4. Understand the basic terms, disciplines and development of public health and family health.
5. Identify the principles and limitations of public health screening programs.
6. Apply concepts, methods, and tools of public health data collection, analysis and interpretation.
7. Comprehend basic ethical and legal principles pertaining to the collection, maintenance, use and dissemination of epidemiologic data.

Unit	Course Content	Class hours
1	Introduction to Epidemiology: Definition of epidemiology, uses, and core epidemiologic functions; Epidemiologic approach- defining a case and using counts and rates; Concepts of disease occurrence, natural history and spectrum of disease, chain of infection, epidemic disease occurrence.	3
2	Investigating Disease Outbreak: Introduction to investigating an outbreak; Steps of an outbreak investigation; surveillance system to control disease outbreak.	3
3	Design of Epidemiological study: Observational studies; Experimental or intervention studies, descriptive epidemiology and analytic epidemiology; Intervention or experimental studies, randomized and non-randomized trials, controlled trials, clinical trials, field trials and community trials.	3
4	Health and Health Development: Public health- history and major disciplines in public health; Family health- family, family health, maternal health, family planning and child health; Health development. The role of health in development, health and the millennium development goal.	4
5	Health Care and Service: Primary Health Care (PHC)-components, principles, philosophy, strategy and development of PHC; Community-based health services- community responsibility, community health councils, community involvement in health (CIH) and team approach in health service.	4
6	Public Health Surveillance: Introduction, Purpose and characteristics of public health surveillance, identifying health problems for surveillance, Identifying or collecting data for surveillance, Analyzing and interpreting data, disseminating data and interpretations, Evaluating and improving surveillance.	4
7	Bioethics: Principles and concepts in bioethics debates, including autonomy, non-maleficence, beneficence and justice.	3
8	Hands on Training: (a) Demonstration and data analysis on epidemiologic description of a disease, (b) Demonstration on health surveillance systems and control of diseases, (c) Demonstration on control of personal hygiene in food and health care, and (d) Demonstration on bioethics in public health.	6

Recommended Books:

1. Essentials of Epidemiology in Public Health – A. Aschengrau and G.R. Seage; Jones and Bartlett Publishers, Massachusetts
2. Introduction to Public Health –M.L. Fleming and E. Parker– Churchill Livingstone Australia
3. Introduction to Public Health – R.L. Goldsteen, K. Goldsteen, and T. Dwelle, Springer Publishing Company, New York
4. Principles of Epidemiology in Public Health Practice: An Introduction to Applied Epidemiology and Biostatistics- R. Dicker, F. Coronado, D. Koo and R.G. Parrish, CDC
5. Dictionary of Epidemiology – J.M. Last, Oxford University Press, New York

Mapping Course Learning Outcomes (CLOs) with the Program Learning Outcomes (PLOs)

CLO	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7
CLO1	✓	✓		✓			
CLO2	✓	✓		✓			
CLO3	✓			✓		✓	
CLO4	✓	✓		✓			
CLO5	✓			✓	✓		
CLO6	✓			✓		✓	
CLO7							✓

Mapping CLOs with the Teaching-Learning and Assessment Strategy

CLO	Teaching-Learning Strategy	Assessment Strategy
CLO-1	- Deliver lectures using PowerPoint slides, videos, images and chalk-talk. - Seek immediate feedback during the lecture through short questions. - Respond to students' queries. - Conduct assessments to gauge understanding. - Assign tasks that encourage creativity and deeper exploration of specific topics. - Provide opportunities for practicing problem-solving. - Promote group discussions. - Arrange review classes when needed.	- Class participation through attendance. - Continuous assessment through quizzes. - In-course exams, assignments, and oral presentations. - Final evaluation through a written examination.
CLO-2		
CLO-3		
CLO-4		
CLO-5		
CLO-6		
CLO-7		

MBG 414E Advances in Food Fermentation Techniques**Credits: 2****Class: 30 hours**

The course is designed to review the modern art of fermentation techniques used in a wide range of food and beverage applications, and the technology for enhancing this process which is continually evolving. It presents the key aspects of fermented food production including potential microbes for fermentation, ways of controlling and monitoring the quality and safety of fermented foods, advances in fermentation technology, process of fermented food products and their health benefits.

Course Objectives:

1. To learn the concept, scope and health benefit fermented foods for human consumption.
2. To provide vital information on the traditional and modern art of fermentation of foods.
3. To present on the emerging trends in the production and marketing of fermented in the world.

Course Learning Outcomes (CLOs):

1. Understand the concept and advantages of microbial fermentation of foods with their health benefits.
2. Gain practical information on fermenting vegetables, fruits, grains, milk, beans, meats, and related more products
3. Develop potential microbes and their use in the processing of fermented foods.
4. Explain the advancement of modern art of fermentation techniques for different foods.
5. Learn about the health benefits, commercial production of probiotic foods and food supplements.

Unit	Course Content	Class hours
1	Fermented foods: The past, present and future of fermented foods; microbes involved in food fermentation, types of global fermented foods, advantages and health benefits.	4
2	Grain-based fermented foods: Soy sauce, Bread, Idli and Dosa and Tofu-microorganisms and production process.	5
3	Fruits and Vegetables based fermented foods: Pickles, Sauerkraut & Kimchi - microorganisms and production process; beverages.	5
4	Fermented meat and fish: Categories, potential microbes involved, and fermentation process of Sausage, Chapa	5
5	Probiotic foods: Types, potential microbes used in probiotic food; health benefits; prerequisite for commercial production; probiotics as super foods; probiotic food supplements.	5
6	Synthetic Biology & Functional Foods: Synthetic Biology & Functional Foods for Enhanced Fermented Foods; Use of synthetic biology to design starter cultures; fortification of fermented foods with functional compounds (e.g., vitamins, antioxidants), Microbiome engineering to produce nutraceuticals, Production and application of postbiotics	6

Recommended Books:

1. Handbook of Food and Fermentation Technology – Y.H. Hui, L. Meunier-Goddik, J. Josephsen, W.K. Nip and P.S. Stanfield; CRC Press.
2. Advances in Fermented Foods and Beverages –W. Holzapfel; Woodhead Publishing.
3. Microbiology and Technology of Fermented Foods- R.W. Hutkins, Blackwell Publishing
4. Probiotic Foods for Good Health – B.T. Hunter, Basic Health Publications Inc. USA
5. Fermented Food and Beverage of the World – J.P. Tamang and K. Kailasapathy; CRC Press

Mapping Course Learning Outcomes (CLOs) with the Program Learning Outcomes (PLOs)

CLOs	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7
CLO1	✓	✓				✓	
CLO2	✓	✓	✓			✓	
CLO3	✓	✓	✓	✓		✓	
CLO4	✓	✓	✓	✓	✓	✓	
CLO5	✓	✓	✓	✓	✓	✓	✓

Mapping CLOs with the Teaching-Learning and Assessment Strategy

CLO	Teaching-Learning Strategy	Assessment Strategy
CLO-1	- Deliver lectures using PowerPoint slides, videos, images and chalk-talk. - Seek immediate feedback during the lecture through short questions. - Respond to students' queries. - Conduct assessments to gauge understanding. - Assign tasks that encourage creativity and deeper exploration of specific topics. - Provide opportunities for practicing problem-solving. - Promote group discussions. - Arrange review classes when needed.	- Class participation through attendance. - Continuous assessment through quizzes. - In-course exams, assignments, and oral presentations. - Final evaluation through a written examination.
CLO-2		
CLO-3		
CLO-4		
CLO-5		

MBG 415E Environmental Pollution and Bioremediation Credits: 2 Class: 30 hours

This course deals with major problems of pollution of the atmosphere, water, the land surface and the food chain. It covers processes responsible for the occurrence and release of pollutants in the environment, dispersion mechanisms, the hazards associated with different types of pollutant, problems of accumulation of toxic substances, and procedures for the reduction of emissions and remediation of contaminated environments.

Course Objectives:

1. To understand the nature of pollutants and its impact in the environment
2. To determine the role of microbes in pollution and bioremediation in environment
3. To overview the recent pollution problems and potential biological remediation techniques

Course Learning Outcomes (CLO):

1. learn the basic principles of microbiology required for understanding the biodegradation of hazardous and toxic organic pollutants.
2. familiarize with and understand problems of pollution of the environment by potentially toxic elements and persistent organic pollutions.
3. learn procedures and prospects for reducing unwanted emissions to the environment and remediation of already polluted systems.

Unit	Course Content	Class hours
1	Biodeterioration of Materials: basic concepts, factors involved in biodeterioration; biodeterioration of leather, wool, fur, feather, stones, plastics and rubber; microbial production of bioplastics; Control of biodeterioration: physical, chemical and biological methods.	4
2	Biodegradation of Recalcitrant: Xenobiotic chemicals in the environment; bio-degradable, persistent and recalcitrant wastes; structure-recalcitrance relationship; concept on ring cleavage, factors affecting microorganisms to degrade xenobiotic, removal of substituent groups and ring opening in model molecules; chloro-organics; organic dyes; phenols; petroleum hydrocarbons.	5
3	Xenobiotic Degrading Bacteria and Their Catabolic Genes in Bioremediation: In situ analysis of microbial community and activity in bioremediation, DNA- and RNA-based methods of microbial community analysis in bioremediation, genetic finger printing techniques.	3
4	Enrichment and Isolation of pollutant degrading Microbes: Introduction to culture enrichment and enrichment media; Isolation of degradative microbes; recent approaches to enrich and isolate microbes having catabolic properties (metagenomic-guided enrichment strategies, Functional metatranscriptomics for enrichment optimization, Co-culture enrichment models mimicking environmental complexity etc.)	5
5	Bioremediation of organic pollutants: Biodegradation of organic pollutants-mechanisms and factors affecting biodegradation, and degradation of different organic pollutants; Bioremediation- In situ and ex situ bioremediation technologies; Bioremediation of oil spills, and phytoremediation; Use of GMO in bioremediation; In situ analysis of microbial community and activity in bioremediation, DNA- and RNA-based methods of microbial community analysis in bioremediation, genetic finger printing techniques; Biological treatment of waste gas- biofilters, bioscrubbers, membrane bioreactors, biotrickling filters.	4
6	Waste Treatment Technologies: physical, chemical and biological treatment; activated sludge; advanced treatments; biological removal of nitrogen and phosphorous; biotechnological processes for industrial wastes and effluent treatment; Future development in biotechnological processes of waste materials	3

	treatment; Resource recovery and circular bioeconomy approaches (Recovery of nutrients, energy, and water from waste streams for reuse in agriculture and industry); Integrated constructed wetlands with hybrid treatment systems.	
7	Biotechnological Aspects for Effluent Treatment: genetic manipulation, enzyme and specialized bacteria; biodegradability testing.	3
8	Toxicity Testing in Wastewater: impacts of toxicity on wastewater treatment; heavy metals organic toxicants; enzymatic assays and microbial bioassays.	3

Recommended Books:

1. Microbial Ecology: Fundamentals and Applications- R.M. Atlas & R. Bartha; Addison Wesley Longman, New York
2. Current Perspective in Microbial Ecology- M.J. Klug & C.A. Reddy; American Society for Microbiology, Washington
3. Ecological Systems and the Environment- T.C. Foin; Houghton Mifflin, London
4. Biotreatment Systems, Vol. II- by Wise Donald L – Boca Raton : CRC Press, Inc.
5. Wastewater Microbiology- G. Bitton; Wiley, Florida

Mapping Course Learning Outcomes (CLOs) with the Program Learning Outcomes (PLOs)

CLOs	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7
CLO1	✓			✓			
CLO2	✓	✓		✓			
CLO3	✓	✓		✓	✓		

Mapping CLOs with the Teaching-Learning and Assessment Strategy

CLO	Teaching-Learning Strategy	Assessment Strategy
CLO-1	• Deliver lectures using PowerPoint slides, videos, images and chalk-talk. • Seek immediate feedback during the lecture through short questions.	• Class participation through attendance. • Continuous assessment through quizzes.
CLO-2	• Respond to students' queries. • Conduct assessments to gauge understanding. • Assign tasks that encourage creativity and deeper exploration of specific topics.	• In-course exams, assignments, and oral presentations.
CLO-3	• Provide opportunities for practicing problem-solving. • Promote group discussions. • Arrange review classes when needed.	• Final evaluation through a written examination.

Course Offered by the Department of Microbiology for Other Departments**MBG 200G General Microbiology****Credits: 4****Class: 60 hours**

This course is designed to introduce a comprehensive account of the microbial world including both general and applied aspects. It provides a defined target to understand different groups of microorganisms and their applications to various fields for human welfare. This course also includes a brief introduction to microorganisms responsible for diseases of fish, birds and animals as well as aquatic microbiology.

Course Objectives:

1. To recognize and apply concepts and theories of basic microbiological sciences.
2. To acquaint the basic methods for bacterial isolation, their maintenance and microscopy imaging
3. To introduce characteristics of different microorganisms and their mode of transmission for diseases of plants and animals.

Course Learning Outcomes (CLOs):

1. Acquire an understanding of fundamental concepts of microbiology, including microbial growth and their nutritional requirement, pure culture techniques, and microscopy.
2. Demonstrate the ability to accurately measure microbial growth by several techniques.
3. Explain the principles and mechanism of different biochemical tests used in the microbiology laboratory.
4. Identify different microbes with their characteristic features and economic importance.
5. Understand the nature of common microbial diseases of birds, fish and other animals along with their controlling measures.
6. Familiar with the fundamentals of microbial genetics.
7. Understand the nature of aquatic microbes and their economic importance.

Unit	Course Content	Class Hours
1	Brief History of the Development of Microbiological Sciences: Discovery of microorganisms; Origin of life; Spontaneous generation vs biogenesis; Germ theory of disease; Development of laboratory techniques, fermentation, vaccination, antisepsis and chemotherapy; Contributions in historical development of microbiology; Branches of applied microbiology.	3
2	Microscopy: Basic concepts on microscope and microscopy; Different types of microscopes and their applications.	5
3	Prokaryotic and Eukaryotic Cells: Morphological characterization, ultra-structure and chemical composition of prokaryotic cells and eukaryotic cells; Functions of different sub cellular elements.	4

4	Microorganisms: General characteristics, morphological and physiological properties, classification, and economic importance of bacteria, cyanobacteria, fungi, algae, protozoa and archaea.	6
5	Virus, Virion and Prion: Morphology, classification and replication of viruses; Characteristics of viroid and prions.	3
6	Growth and Growth Requirements: Growth and growth curve; Growth measurement- direct and indirect methods; Environmental growth requirements- temperature, pH, salinity, hydrostatic pressure, oxygen; Nutrition of microbes- nutritional requirements; categorization of microbes based on nutritional and environmental growth factors.	5
7	Microbiological Culture: Culture types- pure, mixed and contaminated culture; Culture media- types, preparation and dispensation; Pure culture techniques- isolation, maintenance and preservation of pure culture; Type culture collections.	5
8	Identification of Bacteria: Microscopic observation, staining properties, cultural characteristics on solid and liquid media, different biochemical tests to identify bacteria.	3
9	Infectious Diseases and Disease Control: Disease causing microbes in fish, bird and animals; investigation and prevention of diseases.	5
10	Microbial Genetics: Basic Concepts & Gene Expression- the genome, gene organization, DNA replication; Genes, Maintenance & Exchange- mutation & repair, gene transfer.	4
11	Control of microbial Growth: Microbial control, microbial death rate and action of microbial controlling agents; Control of microbes by physical and chemical means.	4
12	Brief Introduction to Aquatic Microbiology: Aquatic environment; Microbes associated with fresh water, brackish water and marine environment.	3
13	Laboratory Works • Handling and use of the bright-field microscope • Staining techniques: simple staining, negative staining and Gram staining • Preparation and examination of bacteriological culture media • Transfer and maintenance of microbial pure culture • Techniques for isolation of pure cultures: pour plate, spread plate and streak plate methods • Enumeration of microbial cells using improved Neubauer counting chamber • Enumeration of microbial cells by standard plate count method • Demonstration of antimicrobial activities of antibiotics and antimicrobial agents.	10

Recommended Books:

1. Microbiology: An Introduction- G.J. Tortora, B.R. Funke and C.L. Case; Pearson, Boston
2. Brock Biology of Microorganisms- M.T. Madigan, J.M. Martinko, P.V. Dunlap, D.P. Clark, Pearson Prentice Hall
3. Microbiology–M.J. Pelczer Jr, E.C.S. Chan and N.R. Krieg; McGraw-Hill Book Company
4. Microbiology: Concepts and Applications–M.J. Pelczer Jr, E.C.S. Chan and N.R. Krieg; McGraw-Hill Inc., New York
5. Principles of Microbiology- R.M. Atlas and W.C. Brown Pub

Mapping Course Learning Outcomes (CLOs) with the Program Learning Outcomes (PLOs)

CLO	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7
CLO-1	✓	✓	✓				
CLO-2	✓		✓				
CLO-3	✓		✓	✓			
CLO-4	✓			✓		✓	
CLO-5	✓	✓			✓	✓	
CLO-6	✓			✓	✓	✓	
CLO-7	✓		✓		✓	✓	

Mapping CLOs with the Teaching-Learning and Assessment Strategy

CLO	Teaching-Learning Strategy	Assessment Strategy
CLO-1	• Deliver lectures using PowerPoint slides, videos, images and chalk-talk. • Seek immediate feedback during the lecture through short questions. • Respond to students' queries. • Conduct assessments to gauge understanding. • Assign tasks that encourage creativity and deeper exploration of specific topics. • Provide opportunities for practicing problem-solving. • Provide hands-on laboratory training. • Encourage collaborative discussion among students. • Arrange review classes when needed.	• Class participation through attendance. • Continuous assessment through quizzes. • In-course exams, assignments, and oral presentations. • Evaluation of practical notebooks. • Final evaluation through a written examination. • Final assessment through practical experiments and a written test.
CLO-2		
CLO-3		
CLO-4		
CLO-5		
CLO-6		
CLO-7		



Part D

Grading / Evaluation

Part D

20. Grading / Evaluation

1) Grading Scale: 4-point grading scale

2) Grades: Marks obtained for each course will be converted to grades. The following letter grades and corresponding grade-points will be used to determine the student's grade point average (GPA).

Grading System

Marks Obtained	Letter Grade	Grade point	Grade Description
80% or above	A+	4.00	Grade A: Exceptional performance; all Course Objectives: achieved; objectives met in a consistently outstanding manner.
75% to less than 80%	A	3.75	
70% to less than 75%	A-	3.50	
65% to less than 70%	B+	3.25	Grade B: Very good performance; significantly more than the majority (at least two-thirds) of the Course Objectives: achieved; objectives met in a consistently thorough manner.
60% to less than 65%	B	3.00	
55% to less than 60%	B-	2.75	
50% to less than 55%	C+	2.50	Grade C: Satisfactory performance; at least majority of the Course Objectives: achieved; objectives met satisfactorily
45% to less than 50%	C	2.25	
40% to less than 45%	D	2.00	Grade D: Minimally acceptable performance; less than majority but more than the minimum required Course Objectives: achieved; objectives achieved at a minimally acceptable level.
Less than 40%	F	0.00	Grade F: Failed in the course

Note: A course in which a student has obtained "D" or higher grade will be counted as credits earned by him/her and obtained "F" grade will not be counted towards his/her earned credits.

3) Grade Point Average (GPA) and Cumulative Grade Point Average (CGPA):

Grade Point Average (GPA) is the weighted average of the grade points obtained in all courses passed/completed by a student in an academic year. The GPA is computed in the following manner:

$$\text{GPA} = \sum \text{PE} / \sum \text{Cr}$$

Where *PE* means Points Earned (i.e. Grade Points x Credits) and *Cr* means Credits attempted in an academic year.

Cumulative Grade Point Average (CGPA) for the 1st, 2nd, 3rd, and 4th year results is calculated by dividing the total accumulated grade points earned to date by the total credit hours attempted. Courses in which a student has secured a grade of 'D' or higher will be counted as earned credit hours. However, any course in which a student receives an 'F' grade will not be included in the earned credits

for CGPA computation. In such cases, the student must reappear in the examination for that course to obtain a passing grade.

4) Grade Improvement

a) To improve their GPA or CGPA, a student may appear only once in the final examination (theory, practical, or viva-voce) of a course along with the following batch. This opportunity is limited to a maximum of 8 credit hours per academic year. The student must apply to the Chairman of the Department at least four weeks before the commencement of the Final Examination. The improved grade points will be used in calculating both the GPA and CGPA. The official transcript will bear the symbol 'I', indicating the improved course.

b) If a student wishes to improve the grade point of any 4th-year course, application for such an improvement must be submitted before the award of the degree (i.e., before the issuance of the certificate). No grade improvement shall be permitted once the degree has been awarded.

5) Incomplete (I) Courses: A grade of 'I' (Incomplete) shall be assigned to students who fail to appear in the mid-term or final examination of a course. To complete the course, the student must sit for the missed examination (mid-term or final, as applicable) within the next academic year. An *incomplete examination fee* will be applicable.

6) Retake Examination

a) A student placed on probation for failing in one or more final examination courses must sit for a Retake Examination of the failed course(s) within six (6) weeks of the publication of results. The Retake Examination shall be conducted by the original Examination Committee of that academic year.

All expenses associated with the Retake Examination, as determined by the University authority, must be borne by the student.

If the student earns the required credits in the Retake Examination, he/she shall be considered promoted, and the corresponding letter grade for that course will be preceded by the letter 'P' in the transcript. Failure to achieve the required credits will result in cancellation of the promotion on probation.

b) A student placed on probation for failing to achieve the requisite CGPA, but without any 'F' grade, may also appear in a Retake Examination for a maximum of 8 credits (including practical and viva-voce courses), under the same conditions prescribed above and as determined by the University. If the student attains the required CGPA after the Retake Examination, he/she shall be promoted, and the improved course grade(s) will be preceded by the letter 'P' in the transcript. Failure to achieve the required CGPA will result in cancellation of the promotion on probation.

c) A student who fails in a maximum of 8 credits during the 4th year must appear in the Retake Examination for those failed courses under the same conditions stipulated above and as determined by the University.

If the student earns the required credits in the Retake Examination, he/she will be considered eligible for graduation, and the corresponding course grade(s) will be preceded by the letter 'P' in the transcript.

7) Drop out: A student who fails to achieve the required minimum GPA/CGPA and/or to earn the requisite credits after the Retake Examination may be allowed to take readmission with the approval of the Academic Committee of the Department. Such a student will be permitted to appear in the final examination of the relevant course(s) with the next batch. If, after readmission, the student again fails to earn the required minimum GPA/CGPA and/or the necessary credits, he/she shall be dropped from the programme.

8) Readmission

a) A student who fails to earn the requisite credits and/or the minimum GPA/CGPA required for promotion or graduation may seek readmission with the next batch. The student must submit a written application for readmission within one (1) month of the publication of the results of the year concerned.

Readmission shall be granted only upon approval of the Departmental Academic Committee.

b) Upon readmission, a student may, subject to the approval of the Departmental Academic Committee, choose either to retain previously earned grades and credits or to reappear in all or selected courses. The student must clearly indicate this choice in the application for readmission.

c) If a student successfully completes the requirements after readmission, the corresponding letter grade(s) for the repeated course(s) shall be preceded by the letter 'R' in the official transcript.

21. General Regulations and Guidelines

The student admission, programme duration, credit assignment, evaluation of student performance, grading system and requirements for the degree of Bachelor of Science (BS) with Honours in Microbiology shall be conducted as per the Rules and Guidelines of the Faculty of Biological Sciences, University of Dhaka (Approved 23 August 2015).

- 1. Duration of the Programme:** The BS Honours degree spans four academic years (sessions), with a final examination conducted at the end of each year. Each session comprises 42 weeks, except for the fourth year, which extends to 44 weeks to provide an additional two weeks of preparatory leave before the Final Examination. The results of the Annual Examination will be published within six weeks of the last examination date. The week-wise distribution of the 42-week academic calendar is presented below:

Description	Period
Contact in the Class and In-course Assessment	30 weeks
Preparation time for the Course Final Examination	4 weeks
Course Final Examination (Theory and Practical)	8 weeks

- 2. Requirements for Graduation:** A student must fulfill the requirements for a Bachelor's degree within a maximum period of 6 (six) academic years, starting from the year of registration. To graduate with a Bachelor degree (BS Honours) a minimum total of 140 credits or more if approved by the University authorities, with no 'F' grade in any course must be earned by the student during the programme. He/she must also have earned the minimum required CGPA 2.5 on a 4.00 scale. After successful completion of the requirements the degree will be awarded and conferred by the University authorities.
- 3. Evaluation of Student's Performance:** The total performance of a student in each course will be evaluated based on a scheme of Continuous assessment, In-course examinations and Course Final examinations.
 - (a) Marks Distribution for Courses:** The distribution of marks for theoretical and practical courses will be as follows:

Description	Mark (%)
Class attendance/participation	5
In-course assessment	35
Course Final Examination	60

- (a) Continuous Assessment:** Continuous assessment for theory courses shall be conducted through a combination of in-course examinations and class attendance/participation. For practical courses (including laboratory work, fieldwork, or short projects), assessment shall be based on class attendance/participation, assignments, evaluation of interactive skills, laboratory or project reports, and other sessional activities as deemed appropriate. The

detailed scheme of continuous assessment shall be announced by the course teacher(s) at the beginning of the course.

- (b) Class Attendance/Participation:** A student must attend at least 75% of the total classes held in an academic year to be eligible to appear in the Course Final Examinations. A student attending at least 60% but less than 75% of the total classes shall be permitted to sit for the examination upon payment of a non-collegiate fee, as determined by the University authority. Students attending less than 60% of the total classes shall not be allowed to appear in the Final Examination for that year or session.

The distribution of marks for class attendance shall be made according to the following scale:

Attendance (% of the total class held)	Marks (%)
95 and above	5
90 to less than 95	4
85 to less than 90	3
80 to less than 85	2
75 to less than 80	1
Less than 75	0

- (c) In-course Assessment:** In-course tests of at least one hour shall be conducted and evaluated by the course teacher(s). There will be a minimum of two written tests for 3- or 4-credit courses, and at least one written test for 2-credit courses. Additional assessments may be administered with prior approval from the Academic Committee of the Department. The question patterns for in-course tests should preferably be objective in nature. The course teacher will return the evaluated scripts to the students and announce the results within two weeks from the date of the test.

A make-up test will be arranged for a student who is unable to appear in the scheduled in-course test(s) due to unavoidable circumstances—such as an accident, medical surgery, the death of a parent, or other comparable situations—with prior approval from the Academic Committee of the Department. The make-up test must be conducted within the course period. Absence from any in-course test will be recorded as zero when calculating the average marks for that test.

- (d) Course Final Examination:** The Course Final Examination for theoretical courses will be conducted centrally by the Controller of the Examinations in accordance with University rules. The duration of the examination will be 3 hours for a 4-credit course and 2 hours for a 2-credit course. The Department will define the question patterns for the Course Final examination.

For evaluation, each theoretical course will have two examiners. One internal examiner (the course teacher or teachers), and one external examiner (preferably from within the Department or University, provided he/she has not taught the course being examined). If there is a difference of more than 20% between the marks awarded by the two examiners

under this double-examiner system, the script will be evaluated by a third examiner. The average of the two closest marks will be considered the final score.

- (e) **Assessment of Seminar/Project/Internship:** The mode of assessment of Seminar/ Project/ Internship will be determined by the respective Departmental Examination Committee approved by the University.
- (f) **Viva-Voce:** A regular student must appear at the Viva-voce/Oral examination at the end of the Course Final examinations, and it will be conducted by the respective Departmental Examination Committee approved by the University.

(1) Promotion to Higher Class

- (a) **Promotion from 1st year to 2nd year:** A student must earn a minimum GPA of 2.00 and must pass all courses taken (with at least a 'D' grade) to be promoted. Students who have failed in courses totaling up to 8 credit hours but have earned a GPA of 2.00 will be promoted on probation. Students placed on probation must appear in the retake examination and must pass the failed course(s) to be allowed to continue their studies in the 2nd year.

- (b) **Promotion from 2nd year to 3rd year:** A student must earn a minimum CGPA of 2.25 and must pass all courses (with at least a 'D' grade) to be promoted. Students who have failed in courses totaling up to 8 credit hours but have a CGPA of 2.25, and students who have a CGPA of 2.00 to below 2.25 without any 'F' grade, will be promoted on probation.

Students placed on probation must appear in the retake examination and pass the failed course(s) to be allowed to continue their studies in the 3rd year.

- (c) **Promotion from 3rd year to 4th year:** A student must earn a minimum CGPA of 2.50 and must pass all courses (with at least a 'D' grade) to be promoted. Students who have failed in courses totaling up to 8 credit hours but have earned a CGPA of 2.50, and students who have a CGPA between 2.25 and below 2.50 without any 'F' grade, will be promoted on probation.

Students on probation must appear in the retake examination and must pass the failed course(s) to be allowed to continue their studies in the 4th year.

(9) Other regulations

The respective statutory authorities of the University shall design the curriculum, allocate courses for teaching, and constitute the examination committee and panel of examiners in accordance with university regulations. For any matters not covered in these general rules and guidelines, the existing rules and guidelines of the Faculty and the University of Dhaka shall apply.

Dean's Award

As a recognition of outstanding academic performance, students who obtain a CGPA of 3.75 or above upon successful completion of the 4-year graduation program will be eligible for the Dean's Award, with a maximum of five candidates from each department. Students who have received an 'F' grade, taken retake or improvement examinations in any course, taken readmission, or attended less than 80% of classes during the graduation program will not be eligible for the Dean's Award.

22. Other Information

Teaching and Learning Methods:

Teaching and learning are centered on lectures, supported by practical laboratory classes and skill-development sessional programs.

- **Integration of Theory and Practice:** Most theoretical concepts introduced in lectures are reinforced through laboratory sessions and group seminars. Lecture materials are complemented by Recommended Books: and e-resources. Multimedia systems are widely used to share summary slides, articles, recent research papers, and course-related information.
- **Development of Communication Skills:** Students will have many opportunities to strengthen their communication skills by writing reports in various formats and delivering oral presentations to their peers. Seminars provide a group learning environment—often driven by students' needs—to review, discuss, and reflect on topics covered in lectures or laboratory classes.
- **Laboratory-Based Learning:** Laboratory classes emphasize hands-on acquisition of practical skills relevant to key principles, concepts, and methods in Microbiology. These sessions involve problem-solving, data collection, and observation. Additional time is allocated for the analysis, interpretation, and evaluation of results both during and outside laboratory hours.
- **Independent Learning:** Students will gradually develop the ability to engage in self-directed study and become autonomous, independent learners.
- **Supplementary Study and Final Research:** Students are expected to undertake supplementary reading and research to reinforce taught material. These practices culminate in the final year, when students complete an individual research project, which may be laboratory-based, field-based, informatics-driven, or literature-based.

Organization and Teaching Methods

Each credit will include at least 15 class periods, with each period lasting 50 minutes, typically held once per week. Most of these periods will consist of lectures, with revision sessions scheduled at regular intervals.

Rationale for Teaching Methods

The core curriculum—comprising both major and supporting course content—will be introduced and explained through lectures. Revision classes help reinforce learned material and revisit difficult concepts. Students will not be allowed to make up missed examinations except in cases of genuine emergencies, as determined by the instructor on a case-by-case basis.

Policies

Students are expected to attend classes regularly, take careful notes, and study consistently to succeed. There is a clear correlation between attendance and performance in this course. Lectures will begin promptly at the scheduled time. A written record of attendance is maintained daily.

Students are responsible for obtaining and safeguarding all handout materials; replacement copies may not always be provided. It is not necessary to contact the instructor for an absence of one class period. All examination scripts will be retained as part of the official course record.

To contact the instructor outside scheduled class times, students should email or telephone to arrange an appointment.

Learner Expectations in Laboratory Work

1. Attend laboratory classes on time and remain for the entire period.
2. Read the assigned laboratory exercises before attending the session.
3. Bring the laboratory manual to every class.
4. Prepare adequately for the final examination; last-minute preparation is discouraged.
5. Participate fully in the learning activities and complete tasks punctually.
6. Work cooperatively and share responsibilities fairly within the team.

Assessment

A range of assessment methods is employed to accommodate students' diverse strengths and to evaluate their achievement of the course learning outcomes. Subject knowledge and understanding are assessed through written tests, examinations, assignments, laboratory reports, and oral presentations.

Laboratory investigations assess both intellectual and practical skills. Students' ability to formulate and test hypotheses, observe, record, present, interpret, and evaluate findings is measured through laboratory reports.

Communication skills both written and spoken are assessed throughout the course. Laboratory reports, presentations, assignments, and examinations offer opportunities for students to demonstrate their writing skills, while oral presentations and verbal defenses assess their speaking abilities.

The overall assessment structure follows the **Rules and Guidelines of the Faculty of Biological Sciences, University of Dhaka**.

References:

1. Bangladesh National Qualification Framework, Part B: Higher Education (level 7-10). 2021. Ministry of Education, Government of Peoples Republic of Bangladesh
2. Outcome Based Education (OBE) Curriculum (Revised). 2021. University Grants Commission of Bangladesh, Dhaka, Bangladesh
3. Strategic Plan for Higher Education in Bangladesh: 2018-2030. 2018. Higher Education Quality Enhancement Project (HEQEP), University Grants Commission of Bangladesh, Dhaka, Bangladesh
4. International Standard Classification of Education, Field of Education and Training 2013 (ISCED-F 2013)-Detailed field description. 2015. United Nations Educational, Scientific and Cultural Organization (UNESCO), Institute of Statistics, Montreal, Quebec, Canada
5. Development of Curricular Guidelines for Introductory Microbiology that focuses on understanding. 1012. Journal of Microbiology and Biology Education. American Society for Microbiology. DOI: <http://dx.doi.org/10.1128/jmbe.v13i1.363>.

6. Curriculum for Bachelor of Science (Honours) degree in Microbiology (2020-2021 and onward), Department of Microbiology, Faculty of Biological Sciences, University of Dhaka, Dhaka 1000.

The End