ہائیر ایجوکیشن کمیشن
HIGHER EDUCATION COMMISSION
Government of Pakistan, Islamabad

Sector H-9
Islamabad, Pakistan
Phone : +92-51-90402114
+92-51-90402121
www.hec.gov.pk
mabaig@hec.gov.pk

Office of the
Deputy Director (Curriculum)
Academics Division

No. HEC/CD/NCRC/MICROB/2025/7133
February 10, 2025

SUBJECT: REVISED CURRICULA FOR DEGREE PROGRAMS IN MICROBIOLOGY

The Higher Education Commission (HEC) of Pakistan, as mandated by its law, provides guidance to Higher Education Institutions (HEIs) on curricula for tertiary education levels in alignment with the National Qualifications Framework (NQF). To address evolving academic trends and market demands, HEC, in collaboration with the Pakistan Academy of Sciences (PAS), has revised the curricular standards for Microbiology degree programs at NQF levels 6 and 7. These updated standards are intricately aligned with HEC's Undergraduate Education Policy V 1.1 (2023) and Graduate Education Policy (2023), ensuring coherence with national priorities and adherence to international benchmarks.

2. The revised curricula for Microbiology degree programs, incorporating option for advanced electives, are hereby notified. Universities offering these programs are advised to align their Microbiology curricula with these updated standards as a minimum requirement. Additionally, the respective departments must develop course content in accordance with the prescribed framework, ensuring that the programs address both national and local industry needs. The finalized course content should be submitted electronically to this office at the earliest. An electronic copy of the revised curricula is available on HEC's official website.

3. Through effective implementation of these standards, HEC envisions a future where Pakistani graduates in Microbiology excel in scientific discovery and technological innovation, making substantial contributions to societal progress both nationally and globally.

MUHAMMAD ALI BAIG

Vice Chancellors/Rectors/Heads
All Public/Private Sector Universities/DAIs

Copy for information to:

i. PS to Secretary General, Pakistan Academy of Sciences, Islamabad
ii. ES to Chairman, Higher Education Commission, Islamabad
iii. Executive Director, Higher Education Commission, Islamabad
iv. PS to Consultant, Quality Assurance, Higher Education Commission, Islamabad
v. PS to Managing Director, NAHE, Higher Education Commission, Islamabad
vi. PS to Advisor, Human Resource Development Division, Higher Education Commission, Islamabad
vii. PS to Director General, Academics Division, Higher Education Commission, Islamabad
viii. PS to Director General, A&A Division, Higher Education Commission, Islamabad
ix. PS to Director General, Higher Education Commission, Regional Centers in Karachi, Lahore, Peshawar & Quetta
x. Director, Academics Division, Higher Education Commission, Islamabad
xi. Director / In-charge, Higher Education Data Repository, Higher Education Commission, Islamabad
xii. Director / In-charge, Quality Assurance Agency, Higher Education Commission, Islamabad

CURRICULUM FOR
MICROBIOLOGY

BACHELOR OF SCIENCE
MASTER OF SCIENCE

2025

A COLLABORATIVE VENTURE OF
HIGHER EDUCATION COMMISSION & PAKISTAN ACADEMY OF SCIENCES
GOVERNMENT OF PAKISTAN

CURRICULUM FOR
MICROBIOLOGY
DEGREE PROGRAMS

2025

Prepared by:
SUBJECT EXPERTS
Different Universities

Designed and Edited by:
MUHAMMAD ALI BAIG
Deputy Director (Curriculum) | Academics Division
Higher Education Commission, Islamabad

Coordinated by:
AMAD UD DIN
Assistant Director (Curriculum) | Academics Division
Higher Education Commission, Islamabad

Table of Contents

Contributions

DR. ANJUM NASIM SABRI Convener
Professor & Director
Institute of Microbiology & Molecular Genetics, University of the Punjab, Lahore
Phone: +92-300-4132950

DR. ABDUL RAUF SHAKOORI FPAS
Professor Emeritus
Director, School of Biological Sciences
University of the Punjab, Lahore
Phone: +92-333-4673255

DR. AGHA ASAD NOOR PATHAN
Professor
Institute of Microbiology
University of Sindh, Jamshoro
Phone: +92-331-2115558

DR. TANVEER ABBAS
Professor
Department of Microbiology
University of Karachi, Karachi
Phone: +92-333-3878651

DR. MALIK BADSHAH
Associate Professor
Department of Microbiology
Quaid-i-Azam University, Islamabad
Phone: +92-301-8055677

DR. YASIR REHMAN
Associate Professor, Department of Life Sciences, School of Science, University of Management & Technology, Lahore
Phone: +92-333-8636475

DR. SAIRA MALIK
Assistant Professor
Institute of Microbiology & Molecular Genetics, University of the Punjab, Lahore
Phone: +92-323-4086238

MS. ANAM AMIR
Lecturer, Department of Life Sciences
School of Science, University of Management & Technology, Lahore
Phone: +92-321-4922383

DR. NAEEM ALI Co-Convener
Professor & Chairperson
Department of Microbiology
Quaid-i-Azam University, Islamabad
Phone: +92-344-5000174

DR. SIKANDAR ALI
Professor & Chairperson, Department of Microbiology, Dr. Ikram-ul-Haq Institute of Industrial Biotechnology, Government College University, Lahore
Phone: +92-335-0415275

DR. MUHAMMAD HIDAYAT RASOOL
Professor & Director
Institute of Microbiology
Government College University, Faisalabad
Phone: +92-301-7102378

DR. MUHAMMAD QASIM
Associate Professor & Chairperson
Department of Microbiology
Kohat University of Science and Technology, Kohat
Phone: +92-313-6318868

DR. HAROON AHMED
Associate Professor
Department of Biosciences
COMSATS University Islamabad, Islamabad
Phone: +92-345-5162128

DR. MUHAMMAD ALI FPAS
Associate Professor
Department of Biotechnology
Quaid-i-Azam University, Islamabad
Phone: +92-316-5190460

MS. SAMIA PARVEEN
Assistant Professor & Chairperson, Department of Microbiology, Balochistan University of Information Technology, Engineering and Management Sciences, Quetta
Phone: +92-333-7944763

MR. MUHAMMAD ALI BAIG Secretary
Deputy Director (Curriculum)
Academics Division
Higher Education Commission, Islamabad
Phone: +92-51-90402114

Preface

The curriculum serves as a comprehensive blueprint for the teaching-learning process that students must navigate to achieve specific academic objectives. This encompasses clearly defined prior learning requirements, program objectives, scheme of studies, and course learning outcomes. As knowledge rapidly evolves and new fields emerge, it is crucial to continually develop and revise curricula to ensure they remain current, relevant, and impactful.

As mandated by its law through Clause 10-1 (a), (l), (s), and (v), the Higher Education Commission (HEC) of Pakistan has been developing and periodically updating curricula through its National Curriculum Revision Committees (NCRCs). These committees are generally composed of subject matter experts, researchers, and representatives from accreditation bodies, professional councils, and industry stakeholders. In response to the evolving needs, HEC, in collaboration with the Pakistan Academy of Sciences (PAS), has undertaken the task to develop robust standards for the curricula of degree programs in Microbiology at levels 6 and 7 of the National Qualifications Framework. These standards are meticulously structured in accordance with the HEC's Undergraduate Education Policy V 1.1 (2023) and Graduate Education Policy (2023), ensuring alignment with both national priorities and international educational standards.

The degree programs in Microbiology are designed to equip students with cutting-edge knowledge and practical skills, fostering innovation and research to address the emerging and unique challenges in the field of Microbiology. It is hoped that these curricular standards, prescribed by subject experts from across the country, will not only contribute towards meeting the national educational and economic requirements but will also elevate the competency levels of our graduates in the field of Microbiology.

With the support of universities in implementing these standards, HEC envisions a future where Pakistani graduates in Microbiology are at the forefront of scientific discovery and technological innovation, driving progress and contributing to the betterment of society both nationally and internationally.

Dr. Amjad Hussain
Director General
Academics Division

Guiding Principles

MINIMUM STANDARDS

The curricular standards and guidelines prescribed in this document are mandatory at minimum level. Universities or the concerned departments may however set higher standards provided that the standards prescribed herein are not reduced or compromised.

COURSE SEQUENCE, TITLES & CREDITS

For Bachelor of Science and Master of Science in Microbiology, the sequence of courses prescribed in document is logically arranged and is suggestive only. The concerned department may rearrange the sequence and alter the course titles and credit hours provided that the essence of the courses prescribed herein remains intact. The concerned department may also add more courses as and when required subject to approval of university's relevant statutory body.

COURSE LEARNING OUTCOMES

The course learning outcomes (CLOs) prescribed in this document represent the minimum level of competency and understanding expected from students. While these standards must not be compromised, departments are encouraged to enhance the rigor of the CLOs by incorporating additional learning outcomes, provided these do not alter the essence of the prescribed standards. In this document, CLOs are exclusively developed for major and interdisciplinary courses, whereas for electives, CLOs are not prescribed as these are advanced or specialized courses. The development of CLOs for electives is the responsibility of the concerned department, taking into account the course's advanced nature and relevance to the program. For general education courses as required under the HEC Undergraduate Education Policy V 1.1. including the course of Pakistan Studies, departments may adopt the CLOs prescribed in the HEC-developed model courses, as available on its website.

COURSE SYLLABUS

This document serves as a comprehensive guideline delineating the course learning outcomes (CLOs) for each course offered in the Bachelor of Science and Master of Science in Microbiology as minimum standards. The concerned department is required to meticulously prepare, modify, and tailor the syllabus of each course, ensuring alignment with the stipulated learning outcomes. It is in this regard imperative that the concerned department utilizes instructional, reference, and reading materials that it deems appropriate to effectively meet the CLOs.

GENERAL EDUCATION

For Bachelor of Science in Microbiology, the courses prescribed for General Education component including the course of "Pakistan Studies" must mandatorily be offered with the same titles and credit hours as prescribed in the HEC Undergraduate Education Policy V 1.1. The concerned departments may adopt and follow the learning outcomes and study contents developed by HEC for these courses as available on its website. The requirement of general education is not applicable to Master of Science in Microbiology.

REQUIREMENT OF INTERNSHIP

Internship of 3 credit hours is a mandatory degree award requirement for Bachelor of Science in Microbiology. Internship of 6 to 8 weeks (preferably undertaken during semester or summer break) must be graded by a faculty member in collaboration with the supervisor in the field. This requirement cannot be substituted with additional course work, capstone or project work.

REQUIREMENT OF CAPSTONE

Capstone of 3 credit hours is a mandatory degree award requirement for Bachelor of Science in Microbiology. A capstone project is multifaceted body of work that serves as a culminating academic and intellectual experience for students. The capstone project must be supervised and graded by a faculty member as per the protocols prescribed by the concerned department. This requirement cannot be substituted with additional course work or internship.

ASSOCIATE DEGREE IN MICROBIOLOGY

The specialized nature of microbiology requires advanced qualifications for meaningful employment. In view of the existing market conditions and recruitment rules of the relevant employers in academia and industry, the Associate Degree in Microbiology falls short of the qualifications necessary for most microbiology-related positions. Therefore, and in the best interest of students and the discipline, the National Curriculum Review Committee for the discipline of Microbiology has unanimously decided to not recommend launch of Associate Degree in Microbiology.

LABORATORY REQUIREMENTS

The departments offering degree programs in the discipline of Microbiology are required to adhere to the laboratory requirements as specified in this document, as minimum standards. The concerned department is expected to enhance the laboratory standards as and when required and maintain / upgrade the same from time to time in order to ensure quality education and research in the field of Microbiology.

ENTRY & EXIT PROVISIONS

Pathway for Graduates with Associate Degree

a) Candidates having Associate Degree in any discipline related to the field of Microbiology are allowed admission in the fifth semester of Bachelor of Science in Microbiology provided that they complete deficiency courses up-to a maximum of 18 credit hours as determined by the admitting university / department. In case where the deficiency courses are of more than 18 credit hours, the concerned university may decide not to offer admission in accordance with its screening, admission and merit calculation criteria approved by its statutory bodies.

b) The minimum eligibility score for admission in the fifth semester in this case is 2.00/4.00 CGPA obtained in the prior qualification i.e., Associate Degree. The admitting university may, however, set higher eligibility score for admission in the fifth semester of Bachelor of Science in Microbiology.

Pathway for Graduates with Conventional BSc / Equivalent Degree Programs

a) Candidates having two-year conventional BSc / equivalent degree programs are allowed admission in the fifth semester of Bachelor of Science in Microbiology provided that

they complete deficiency courses up-to a maximum of 21 credit hours as determined by the admitting university. In case where the deficiency courses are of more than 21 credit hours, the concerned university may decide not to offer admission in accordance with its screening, admission and merit calculation criteria approved by its statutory bodies.

b) The minimum eligibility score for admission in the fifth semester in this case is 45% cumulative score obtained in the prior qualification i.e., two-year conventional BSc/equivalent degree programs. The admitting university may however set higher eligibility score for admission in the fifth semester of Bachelor of Science in Microbiology.

Exiting from Bachelor of Science in Microbiology with the Associate Degree

Offering of Associate Degree in Microbiology is not recommended. However, exit from Bachelor of Science in Microbiology with Associate Degree in the same discipline is allowed in accordance with the provisions of HEC Undergraduate Education Policy V 1.1. and only in such circumstances where no other remedy is available to safeguard the academic career of the student.

CURRICULUM FOR
BACHELOR OF SCIENCE (BS)
MICROBIOLOGY

BS Microbiology

PROGRAM DESCRIPTION

The Bachelor of Science in Microbiology program is designed in accordance with the provisions of the HEC Undergraduate Education Policy V 1.1. to provide students with a comprehensive understanding of microbial sciences, addressing both local and global perspectives. The program integrates cellular, molecular, genetic, and ecological dimensions to equip students with the skills necessary for research, industry, and further academic pursuits in microbiology and related fields. Spanning eight semesters, the curriculum offers a balanced and progressive learning experience. Throughout the program, students will gain hands-on experience with modern laboratory techniques, including but not limited to bacteriology, virology, immunology, and genetic engineering. Emphasis is placed on practical and technical proficiency, with a focus on molecular biology and biotechnological applications relevant to Pakistan's healthcare and industrial sectors. This approach ensures that graduates are well-prepared for the real-world challenges and opportunities in microbial sciences. Through this program, students will learn to effectively convey scientific knowledge and research findings, preparing them for careers in academia, research institutions, healthcare organizations, and the biotechnology industry, both within Pakistan and internationally.

STANDARD NOMENCLATURE

For the purpose of standardization, the recommended nomenclature for the four-year undergraduate degree program in Microbiology is **"Bachelor of Science in Microbiology"**.

PROGRAM LEARNING OUTCOMES

By the completion of Bachelor of Science in Microbiology, the graduates will be able to:

- Demonstrate a comprehensive understanding of fundamental concepts in the field of Microbiology.
- Effectively apply microbiological methods and techniques as used in research and diagnostics at different industrial and environmental levels.
- Communicate scientific knowledge and research findings effectively, while demonstrating a commitment to continuous learning and professional development in the field of Microbiology.
- Apply ethical principles and biosafety / biosecurity regulations in microbiological research and practices.

ELIGIBILITY & ADMISSION CRITERIA

Higher Secondary School Certificate (involving 12 years of education) or an IBCC equivalent qualification in any science group with a subject of Biology or General Biology is the basic eligibility requirement for admission in the Bachelor of Science in Microbiology. The admitting university may set minimum eligibility scores and may conduct entry / admission test through its own testing body / system or an external testing services provider of repute as per the screening, admission and merit calculation criteria approved by its statutory bodies.

PROGRAM STRUCTURE

The Bachelor of Science in Microbiology is structured in accordance with the provisions of the HEC Undergraduate Education Policy V 1.1. and comprises of 134 credit hours spread over 8 regular semesters, at minimum. Universities may offer courses up-to a maximum of 144 credit hours provided that the total number of credit hours are reasonably set to effectively achieve the Program Learning Objectives (PLOs) without putting undue burden on students. Summary of the program including the model scheme of study is given below.

Minimum Credit Hours	134
General Education	32 credit hours (13 courses)
Discipline Related Courses / Major	72 credit hours (24 courses)
Interdisciplinary / Allied Courses	24 credit hours (8 courses)
Internship	3 credit hours
Capstone	3 credit hours
Program Duration	Minimum: 4 years (8 regular semesters) Maximum: 6 years (12 regular semesters) The maximum duration is further extendable in accordance with HEC semester rules.
Semester Duration	16-18 weeks for regular semesters (1-2 weeks for examination) 8-9 weeks for summer semesters (1 week for examination)
Course Load (per semester)	15-18 credit hours for regular semesters Up-to 8 credit hours for summer semesters (for remedial/deficiency/failure/repetition courses only)
3 Credit Hours (Theory)	3 classes (1 hour each) **OR** 2 classes (1.5 hour each) **OR** 1 class (3 hours) per week throughout the semester.
1 Credit Hours (Lab / Field Work)	1 credit hour in laboratory or practical work / project requires lab contact of 3 hours per week throughout the semester.

SEMESTER 1			
S.N.	**Course**	**Credit Hours**	**Category**
1	Cell Biology	3 (2-1)	Major
2	Introduction to Microbiology	3 (2-1)	Major
3	Quantitative Reasoning – I *	3 (3-0)	General Education
4	Natural Science **	3 (2-1)	General Education
5	Functional English *	3 (3-0)	General Education
6	Applications of Information & Communication Technologies (ICT) *	3 (2-1)	General Education
TOTAL CREDIT HOURS: 18			

SEMESTER 2			
S.N.	**Course**	**Credit Hours**	**Category**
1	Microbial Diversity & Systematics	3 (2-1)	Major
2	Microbial Physiology & Metabolism	3 (2-1)	Major
3	Principles of Biochemistry	3 (2-1)	Interdisciplinary
4	Quantitative Reasoning – II *	3 (3-0)	General Education
5	Social Sciences ***	2 (2-0)	General Education
6	Expository Writing *	3 (3-0)	General Education
TOTAL CREDIT HOURS: 17			

SEMESTER 3			
S.N.	**Course**	**Credit Hours**	**Category**
1	Virology	3 (2-1)	Major

2	Mycology	3 (2-1)	Major
3	Molecular Biology	3 (2-1)	Major
4	Arts & Humanities ****	2 (2-0)	General Education
5	Islamic Studies * (Ethics for non-Muslim students)	2 (2-0)	General Education
6	Pakistan Studies *	2 (2-0)	General Education
7	Entrepreneurship *	2 (2-0)	General Education
TOTAL CREDIT HOURS: 17			

SEMESTER 4			
S.N.	**Course**	**Credit Hours**	**Category**
1	Microbial Genetics	3 (2-1)	Major
2	Immunology	3 (2-1)	Major
3	Medical Microbiology	3 (2-1)	Major
4	Bioethics, Biosafety & Biosecurity	3 (3-0)	Major
5	Civics & Community Engagement *	2 (2-0)	General Education
6	Ideology & Constitution of Pakistan *	2 (2-0)	General Education
TOTAL CREDITS: 16			

SEMESTER 5			
S.N.	**Course**	**Credit Hours**	**Category**
1	Industrial Microbiology	3 (2-1)	Major
2	Environmental Microbiology	3 (2-1)	Major
3	Food Microbiology	3 (2-1)	Major

4	Soil & Agricultural Microbiology	3 (2-1)	Major
5	Bioinformatics	3 (1-2)	Interdisciplinary
6	Biostatistics	3 (3-0)	Interdisciplinary
TOTAL CREDIT HOURS: 18			

SEMESTER 6			
S.N.	**Course**	**Credit Hours**	**Category**
1	Aquatic Microbiology	3 (2-1)	Major
2	Clinical & Diagnostic Microbiology	3 (2-1)	Major
3	Elective – I *****	3	Major
4	Scientific Writing & Research Methods	3 (3-0)	Interdisciplinary
5	Sustainable Development Goals	3 (3-0)	Interdisciplinary
TOTAL CREDIT HOURS: 15			

SEMESTER 7			
S.N.	**Course**	**Credit Hours**	**Category**
1	Microbial Biotechnology	3 (2-1)	Major
2	Antimicrobial Agents & Resistance	3 (2-1)	Major
3	Elective – II *****	3	Major
4	Recombinant DNA Technology	3 (2-1)	Interdisciplinary
5	Epidemiology & Public Health	3 (3-0)	Interdisciplinary
TOTAL CREDIT HOURS: 15			

SEMESTER 8			
S.N.	**Course**	**Credit Hours**	**Category**
1	Vaccinology	3 (2-1)	Major
2	Elective – III *****	3	Major
3	Elective – IV *****	3	Major
4	Artificial Intelligence in Microbiology	3 (2-1)	Interdisciplinary
5	Capstone	3	Capstone
TOTAL CREDIT HOURS: 15			

* HEC designed model courses may be adopted.

** The university / concerned department may offer any course in the broader category of **"Natural Science"** which should have relevance to the nature of the degree program.

*** The university / concerned department may offer any course in the broader category of **"Social Science"** including but not limited to a course of Psychology, Sociology, Anthropology etc.

**** The university / concerned department may offer any course in the broader category of **"Arts & Humanities"** including but not limited to a course of regional or international language such as Chinese, Arabic, French, Spanish etc. or any other course such as Philosophy, History etc.

***** The university / concerned department may offer any advanced course in the field of Microbiology as an **elective**, where required in the above scheme as per available academic and faculty resources. **Credit combination** (reflecting balance of theory and lab / field work) must be arranged in accordance with the nature of the course.

DEGREE AWARD REQUIREMENTS

The following minimum requirements are prescribed for award of Bachelor of Science in Microbiology:

a) All courses in the General Education category with titles and credit hours as prescribed in the HEC Undergraduate Education Policy V 1.1. including the course of "Pakistan Studies" must be completed.

b) Minimum of 134 credit hours as prescribed in this policy document must be completed.

c) Capstone of 3 credit hours must be completed in accordance with HEC Undergraduate Education Policy V 1.1. This requirement cannot be substituted with additional coursework or internship.

d) Internship of 3 credit hours must be completed in accordance with HEC Undergraduate Education Policy V 1.1. This requirement cannot be substituted with additional coursework, capstone, research or project work.

e) CGPA must not be below 2.00/4.00 at the time of completion of the degree program. The university may however set higher standard in this regard.

f) The minimum duration to complete the degree is 8 regular semesters and the maximum duration is 12 regular semesters. The maximum duration may be extended in accordance with HEC semester guidelines. Summer semester is not considered as a regular semester.

CURRICULUM FOR

MASTER OF SCIENCE (MS)

MICROBIOLOGY

MS Microbiology

PROGRAM DESCRIPTION

The Master of Science in Microbiology is designed in alignment with the HEC Graduate Education Policy 2023, aiming to provide students with a robust foundation in advanced microbiological sciences. This program is designed to deepen students' understanding of microbial life, focusing on the latest research, technologies, and trends in the field. Through an interdisciplinary approach, students will critically analyze and synthesize complex microbiological concepts, preparing them for careers in research, academia, healthcare, and industry. The curriculum combines rigorous academic training with mandatory research, emphasizing the application of advanced experimental techniques and methodologies. Students will be equipped to conduct independent research, addressing complex problems in microbiology, such as antimicrobial resistance, environmental sustainability, and infectious diseases. Upon completion, graduates will be well-prepared to contribute to the advancement of microbiological sciences and develop innovative solutions to critical challenges facing Pakistan and the world.

STANDARD NOMENCLATURE

For the purpose of standardization, the recommended nomenclature for all graduate degree programs (NQF-7) in Microbiology is **"Master of Science in Microbiology"**.

PROGRAM LEARNING OUTCOMES

By the completion of Master of Science in Microbiology, the graduates will be able to:

- Critically analyze and synthesize advanced concepts and current research in various fields of Microbiology.
- Apply advanced experimental techniques and methodologies to conduct independent research and solve complex problems in microbial science, with a focus on innovation and practical applications.
- Demonstrate the ability to effectively communicate scientific findings and theoretical concepts in Microbiology to both specialized and general audiences, ensuring clarity and scientific rigor.

ELIGIBILITY & ADMISSION CRITERIA

a) An undergraduate degree (involving 16 years of education) in the field of Microbiology is the basic eligibility requirement for admission in the Master of Science in Microbiology.

b) Candidates having undergraduate degrees (involving 16 years of education) in any discipline other than but relevant to Microbiology are also eligible for admission in the Master of Science in Microbiology subject to completion of deficiency courses up-to 9 credit hours in accordance with the HEC Graduate Education Policy (2023).

c) In addition to the basic eligibility, the admitting university is further required to conduct a rigorous admission test as an eligibility condition for admission to the program, with a passing score of 50% (OR) accept the GRE/HAT General/equivalent tests, with a passing score of 50%. The admitting university / department may set minimum eligibility scores

(above 50%) as per the screening, admission and merit calculation criteria approved by its statutory bodies.

PROGRAM STRUCTURE

The standard program structure for Master of Science in Microbiology is given below.

Minimum Credit Hours	30
Minimum Coursework Requirement	24 credit hours (8 courses)
Thesis Requirement (madatory)	6 credit hours
Program Duration	Minimum: 1.5 years (3 regular semesters) Maximum: 4 years (8 regular semesters) **Note:** In accordance with the HEC Graduate Education Policy (2023), in case where a student is unable to secure the degree within the prescribed timeframe and claims for extension in duration, the university may constitute an appropriate authority and determine the causes of delay. In the event of force majeure (i.e., delay on account of circumstance beyond the control of student), the university may grant an extension in the period of award of degree in accordance with the duration limiting factor(s) and also take corrective measures in case the delay is caused by process or administrative reasons.
Semester Duration	16-18 weeks for regular semesters (1-2 weeks for examination) 8-9 weeks for summer semesters (1 week for examination)
Course Load (per semester)	09-12 credit hours for regular semesters Up-to 8 credit hours for summer semesters (for remedial / deficiency / failure / repetition courses only)
3 Credit Hours (Theory)	3 classes (1 hour each) **OR** 2 classes (1.5 hour each) **OR** 1 class (3 hours)
1 Credit Hours (Lab / Field Work)	1 credit hour in laboratory or practical work requires lab / field contact of 3 hours per week throughout the semester.

SEMESTER 1			
S.N.	**Course**	**Credit Hours**	**Category**
1	Advanced Techniques in Microbiology *	3 (3-0)	Core
2	Elective – I **	3	Elective
3	Elective – II **	3	Elective
4	Elective – III **	3	Elective
TOTAL CREDIT HOURS: 12			

SEMESTER 2			
S.N.	**Course**	**Credit Hours**	**Category**
1	Scientific Writing & Research Methods *	3 (3-0)	Core
2	Elective – IV **	3	Elective
3	Elective – V **	3	Elective
4	Elective – VI **	3	Elective
TOTAL CREDIT HOURS: 12			

SEMESTER 3			
S.N.	**Course**	**Credit Hours**	**Category**
	Thesis ***	6	Research
TOTAL CREDIT HOURS: 6			

* These are the **mandatory courses** for the program, irrespective of the area of specialization.

** The university / concerned department may offer any advanced course in the field of Microbiology as an **elective**, where required in the above scheme as per available academic and faculty resources. **Credit combination** (reflecting balance of theory and lab / field work) must be arranged in accordance with the nature of the course.

*** Research work for **thesis** must be conducted by students individually in accordance with the university's policy as approved through its statutory bodies provided that the same is in accordance with the HEC Graduate Education Policy (2023).

DEGREE AWARD REQUIREMENTS

The following minimum requirements are prescribed for award of Master of Science in Microbiology:

a) Minimum of 24 credit hours including 6 credit hours for core courses and 18 credit hours for electives as prescribed in this document must be completed.

b) In addition to coursework of 24 credit hours, thesis of 6 credit hours must also be completed individually. Requirement of thesis cannot be substituted with additional course work.

c) CGPA must not be below 2.50/4.00 at the time of completion of the degree program. The university may however set higher standard in this regard.

d) The minimum duration required to complete the degree program is 3 regular semesters whereas the maximum duration is 8 regular semesters. Summer semester is not considered as a regular semester.

COURSE LEARNING OUTCOMES

FOR BS & MS MICROBIOLOGY

Arranged in Alphabetical Order

Course Learning Outcomes

(Arranged in Alphabetical Order)

ADVANCED TECHNIQUES IN MICROBIOLOGY

By the end of this course, students will be able to:

- Demonstrate proficiency in using advanced analytical techniques and tools for the detection, quantification, and analysis of microorganisms and microbial processes.
- Evaluate the strengths, limitations, and applications of various analytical methods in microbiological research.
- Integrate advanced analytical tools to design and conduct complex experiments, interpret data, and draw conclusions in microbial research.

ANTIMICROBIAL AGENTS & RESISTANCE

By the end of this course, the students will be able to:

- Understand the mechanisms of action of various antimicrobial agents and their roles in treating microbial infections.
- Analyze the factors contributing to antimicrobial resistance and its impact on public health.
- Apply knowledge of antimicrobial resistance to develop strategies for the effective use of antimicrobial agents and to mitigate the spread of resistance.

AQUATIC MICROBIOLOGY

By the end of this course, the students will be able to:

- Analyze the diversity and ecological roles of microorganisms in aquatic ecosystems.
- Apply microbiological methods to assess water quality and microbial processes in aquatic environments.
- Evaluate the impact of microbial activities on the health and sustainability of aquatic ecosystems.

ARTIFICIAL INTELLIGENCE IN MICROBIOLOGY

By the end of this course, the students will be able to:

- Understand the basic concepts of artificial intelligence and its potential applications in microbiology.
- Recognize the ways in which artificial intelligence (AI) can be used to analyze microbiological data and improve research outcomes.
- Explore simple AI tools or platforms that can assist in microbiological studies, without needing to understand the underlying technical details.

BIOETHICS, BIOSAFETY & BIOSECURITY

By the end of this course, the students will be able to:

- Explain the ethical, biosafety and biosecurity principles governing microbiological research and practices.
- Analyze the importance of biosafety and biosecurity in handling microorganisms.
- Apply ethical, biosafety and biosecurity guidelines to ensure responsible conduct in microbiology-related activities.

BIOINFORMATICS

By the end of this course, the students will be able to:

- Understand the role and uses of major computing tools and techniques as used in biological sciences in analyzing biological data and microbial genomes.
- Apply bioinformatics techniques in data analysis of microbial processes.
- Analyze complex biological problems using bioinformatics approaches in microbiology.

BIOSTATISTICS

By the end of this course, the students will be able to:

- Understand basic statistical concepts and methods used in biological research.
- Apply statistical techniques to analyze and interpret biological data.
- Use software tools to perform statistical analyses for experimental results.

CELL BIOLOGY

By the end of this course, the students will be able to:

- Describe the structural and functional organization of cells.
- Explain cellular processes essential for microbial life and interactions.
- Apply knowledge of cell biology to understand microbial physiology and behavior.

CLINICAL & DIAGNOSTIC MICROBIOLOGY

By the end of this course, the students will be able to:

- Identify microbial pathogens and their role in human diseases.
- Apply diagnostic techniques to detect and characterize microbial infections.
- Evaluate treatment strategies and their effectiveness in controlling infectious diseases.

ENVIRONMENTAL MICROBIOLOGY

By the end of this course, the students will be able to:

- Analyze the roles of microorganisms in environmental processes and sustainability.
- Apply microbiological techniques to monitor and manage environmental health.
- Evaluate the impact of microbial activities on ecosystems and biogeochemical cycles.

EPIDEMIOLOGY & PUBLIC HEALTH

By the end of this course, the students will be able to:

- Explain the principles of epidemiology in relation to diseases.
- Analyze patterns of disease transmission and strategies for prevention and control.
- Apply epidemiological methods to public health challenges involving microorganisms.

FOOD MICROBIOLOGY

By the end of this course, the students will be able to:

- Explain the roles of microorganisms in food production, spoilage, preservation, and safety.
- Apply microbiological techniques to ensure food quality and prevent spoilage.
- Evaluate the impact of microbial activities on foodborne illnesses and public health.

IMMUNOLOGY

By the end of this course, the students will be able to:

- Explain the components and functions of the immune system in microbial defense.
- Analyze the immune responses to various pathogens and their implications for health.
- Apply immunological principles to develop and evaluate vaccines and therapies.

INDUSTRIAL MICROBIOLOGY

By the end of this course, the students will be able to:

- Describe the application of microorganisms in industrial processes and product development.
- Analyze the principles of microbial fermentation, bioprocessing, and biotechnology.
- Apply industrial microbiology techniques to optimize production and innovation in various sectors.

INTRODUCTION TO MICROBIOLOGY

By the end of this course, the students will be able to:

- Understand the fundamental characteristics and classifications of microorganisms.
- Explain the basic principles of microbial growth, reproduction, and control.
- Apply microbiological knowledge to understand the roles of microorganisms in health, industry, and the environment.

MEDICAL MICROBIOLOGY

By the end of this course, the students will be able to:

- Describe the major microbial pathogens that cause human diseases.
- Understand the mechanisms of microbial pathogenesis, diagnosis, and treatment.
- Apply medical microbiology knowledge to develop strategies for disease prevention and control.

MICROBIAL BIOTECHNOLOGY

By the end of this course, the students will be able to:

- Explain the principles and techniques of microbial biotechnology.
- Understand the applications of microbial biotechnology in the environment, industry, agriculture, and medicine.
- Apply microbial biotechnology to develop innovative solutions for global challenges.

MICROBIAL DIVERSITY & SYSTEMATICS

By the end of this course, the students will be able to:

- Classify microorganisms based on their taxonomy and evolutionary relationships.
- Analyze the diversity of microorganisms in various ecological niches.
- Apply systematic methods to identify and characterize microorganisms.

MICROBIAL GENETICS

By the end of this course, the students will be able to:

- Explain the principles of microbial inheritance and gene expression.
- Analyze the role of genetic mechanisms in microbial adaptation and evolution.
- Apply microbial genetics techniques to study and manipulate microbial genomes.

MICROBIAL PHYSIOLOGY & METABOLISM

By the end of this course, the students will be able to:

- Describe the key physiological and metabolic processes that regulate microbial growth, energy production, and survival.
- Analyze the metabolic pathways utilized by microorganisms under different environmental conditions.
- Apply microbial physiology and metabolism knowledge to understand how microorganisms adapt to various ecological niches.

MOLECULAR BIOLOGY

By the end of this course, the students will be able to:

- Explain the molecular mechanisms of gene expression and regulation.
- Analyze the techniques used in molecular biology to study microbial genetics and processes.
- Apply molecular biology principles to research and develop applications in microbiology.

MYCOLOGY

By the end of this course, the students will be able to:

- Identify the major groups of fungi and their ecological roles.
- Explain the physiological and biochemical processes unique to fungi.
- Apply mycological knowledge to understand fungal interactions with other organisms and environments.

PRINCIPLES OF BIOCHEMISTRY

By the end of this course, the students will be able to:

- Explain the biochemical principles underlying various cellular processes.
- Analyze the role of biomolecules in metabolism and energy production.
- Apply techniques to study biochemical processes.

RECOMBINANT DNA TECHNOLOGY

By the end of this course, the students will be able to:

- Explain the principles and techniques of recombinant DNA technology.
- Analyze the applications of recombinant DNA technology in microbiology and biotechnology.
- Apply recombinant DNA technology to manipulate and study genes for industrial, Health, and environmental research

SCIENTIFIC WRITING & RESEARCH METHODS (NQF-6)

By the end of this course, the students will be able to:

- Explain the principles of scientific writing and research design in microbiology.
- Analyze and interpret data using appropriate research methodologies.
- Apply research methods to conduct independent studies and contribute to microbiological knowledge.

SCIENTIFIC WRITING & RESEARCH METHODS (NQF-7)

By the end of this course, students will be able to:

- Explain advanced principles of scientific writing and research methodologies specific to microbiology.
- Apply advanced statistical and computational tools to interpret complex microbiological data.
- Design and conduct independent research projects, producing manuscripts and proposals aligned with international standards in microbiology.

SOIL & AGRICULTURAL MICROBIOLOGY

By the end of this course, the students will be able to:

- Explain the roles of microorganisms in soil health, nutrient cycling, and plant growth.

- Analyze the interactions between microorganisms, plants, and the environment in agricultural systems.
- Apply soil and agricultural microbiology knowledge to enhance sustainable agricultural practices.

SUSTAINABLE DEVELOPMENT GOALS

By the end of this course, the students will be able to:

- Explain the role of microbiology in achieving the United Nations Sustainable Development Goals (SDGs).
- Analyze the impact of microorganisms on global challenges such as health, food security, and environmental sustainability.
- Apply microbiological knowledge to contribute to sustainable development initiatives and policies.

VACCINOLOGY

By the end of this course, the students will be able to:

- Understand the basic principles of vaccine development, including the biological mechanisms of immune response stimulation.
- Analyze the different types of vaccines, their components, and the methods used for their production and evaluation.
- Apply knowledge of vaccinology to assess the impact of vaccines on public health and to understand strategies for vaccine deployment and immunization programs.

VIROLOGY

By the end of this course, the students will be able to:

- Describe the structure, classification, and life cycles of viruses.
- Analyze the mechanisms of viral infection, replication, and host interactions.
- Apply knowledge to understand the prevalence, and control of viral infections.

LABORATORY REQUIREMENTS

FOR BS & MS MICROBIOLOGY

List of Essential Equipment and Apparatus

Laboratory Requirements

GENERAL EQUIPMENT / APPARATUS

The following common / general equipment and materials are **essentially required** for microbiology laboratories:

- Micropipettes
- Incubators, Shaking incubator
- Ovens
- Autoclave
- Distillation Unit
- Hot plate, Weighing Balance, pH meter, Vortex
- Centrifuge machine
- UV-Vis Spectrophotometer
- Water bath
- PCR
- Laminar flow and fume hood
- Compound microscope
- Gel electrophoresis and UV trans illuminator
- Cool cabinet 4°C
- Room temperature regulators
- Colony counter
- Safety equipment / PPE etc.
- Staining jars and trays

COURSE SPECIFIC EQUIPMENT / APPARATUS

Antimicrobial Agents and Resistance

- Antibiotic disc and e-strips

Aquatic Microbiology

- Water sampling equipment
- Filtration assembly

Artificial Intelligence in Microbiology

- High-performance computing systems or workstations
- AI platforms (e.g., TensorFlow, PyTorch), machine learning libraries (e.g., scikit-learn), data visualization tools (e.g., Matplotlib) etc.
- Access to large microbiological datasets and image datasets for microbial analysis.

Bioinformatics

- High-performance computers or cloud computing services
- Software for sequence analysis (e.g., BLAST, Clustal Omega), genomics software (e.g., Galaxy, GATK), molecular modeling tools (e.g., PyMOL), phylogenetic analysis software (e.g., MEGA)
- Databases such as NCBI, EMBL, Protein Data Bank (PDB), ENSEMBL etc.

Cell Biology

- Computing tools such as image analysis software (e.g., ImageJ)

Diagnostic Microbiology

- API Kit systems
- Anaerobic culturing system
- Computing tools such as Laboratory Information Management System (LIMS), diagnostic data analysis software

Environmental Microbiology

- Water and soil sampling equipment such as sterile bottles, augers, core samplers etc.
- Anaerobic culturing system

Food Microbiology

- Incubators for culturing food spoilage organisms and pathogens.
- Stomacher with bag
- Endotoxin testing kits

Immunology

- ELISA reader for detecting antibodies and antigens.
- Hemo-cytometer
- Diagnostic kits

Industrial Microbiology

- TLC System
- Endotoxin testing kits

Introduction to Microbiology

- As mentioned in general requirements

Medical Microbiology

- API Kit systems
- Anaerobic culturing system
- Computing tools such as Laboratory Information Management System (LIMS), diagnostic data analysis software

Microbial Biotechnology

- Centrifuges: for biomass separation and product concentration.
- Computing tools

Microbial Diversity and Systematics

- Anaerobic jars
- Bioinformatics software for phylogenetic analysis (e.g., MEGA).

Microbial Genetics

- Cloning equipment
- Primer design tools etc.

Microbial Physiology and Metabolism

- Small-scale bioreactors
- Kits
- Computing tools such as data analysis software (e.g., GraphPad Prism)

Molecular Biology

- Centrifuges / microcentrifuge for DNA / RNA extraction
- Computing tools such as sequence alignment and analysis software

Mycology

- Stereo microscope
- Fungal incubators
- Slide preparation kits for fungal spore staining and identification
- Computing tools such as fungal identification software, mycology databases etc.

Recombinant DNA Technology

- Same as for microbial genetics, molecular biology and microbial biotechnology

Soil & Agricultural Microbiology

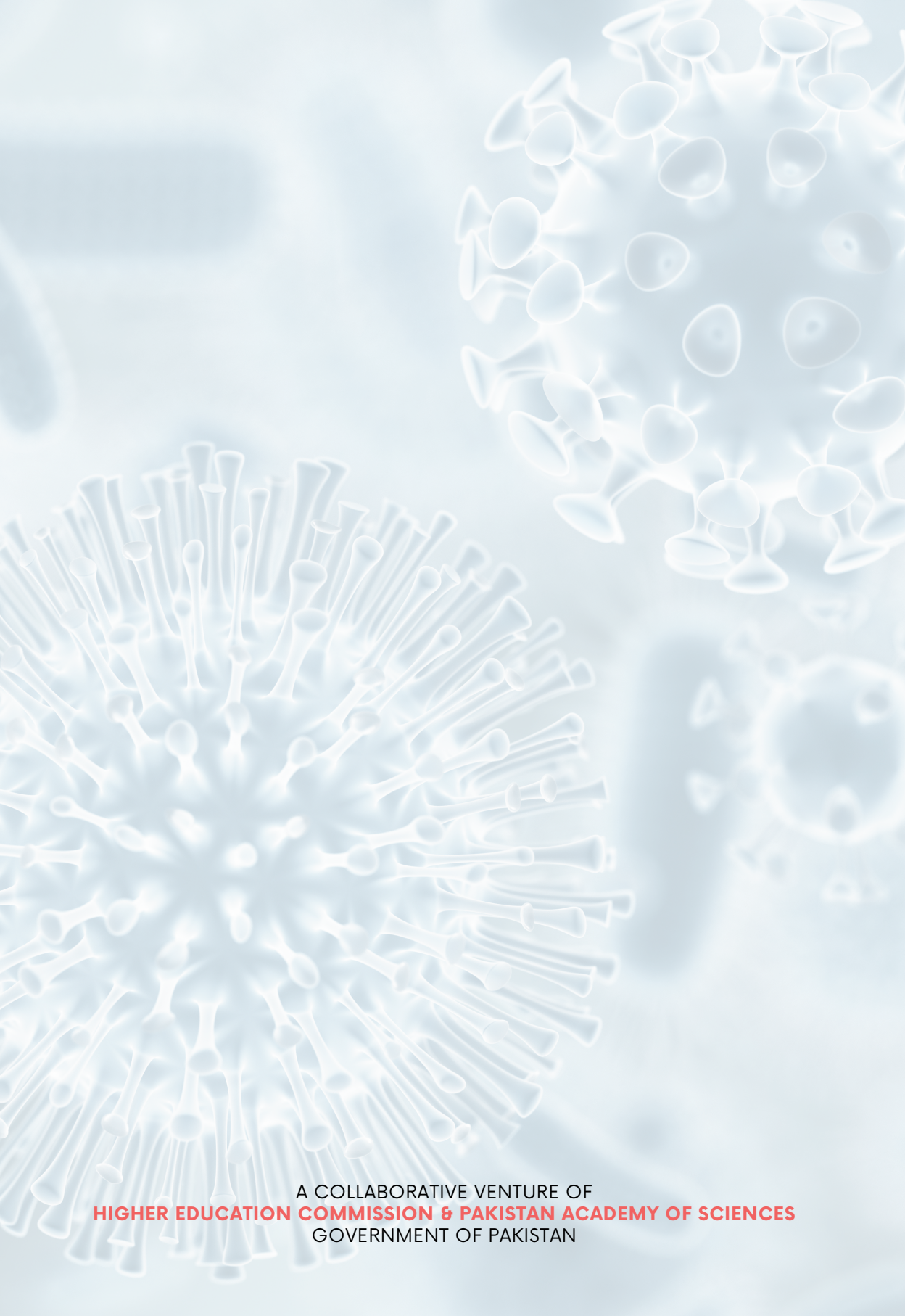
- Soil sampling equipment

Vaccinology

- Cell culture systems
- ELISA
- Adjuvant preparation equipment such as stirrer, ultrasonic homogenizer
- Animal house facility
- Computing tools such as immuno-informatics tools for vaccine design, protein modeling software etc.

Virology

- Cell culture facilities
- Virus culture media such as specialized viral media, host cell lines (e.g., Vero cells)
- PCR
- Computing tools such as sequence analysis software (e.g., BLAST), viral genome databases (e.g., ViPR) etc.



A COLLABORATIVE VENTURE OF
HIGHER EDUCATION COMMISSION & PAKISTAN ACADEMY OF SCIENCES
GOVERNMENT OF PAKISTAN