ہائیر ایجوکیشن کمیشن
HIGHER EDUCATION COMMISSION
Government of Pakistan, Islamabad

Sector H-9
Islamabad, Pakistan
Phone : +92-51-90402446
+92-51-90402100
www.hec.gov.pk
smirza@hec.gov.pk

Office of the
Assistant Director (Academics)
Academics Division

No. HEC/CURR/NCRC/Bioinformatics/2026/**8619**
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SUBJECT: **REVISED CURRICULUM FOR DEGREE PROGRAMS IN BIOINFORMATICS**

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 has revised the curricular standards for Geography degree programs at NQF levels 5, 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.

02. The revised curricula for Bioinformatics degree programs (attached), incorporating the option of various specializations with advanced electives, are hereby notified. Universities offering these programs are advised to align their Bioinformatics curricula with these updated standards at the earliest. The finalized course content should be developed according to the curriculum framework provided and be submitted electronically to this office. An electronic copy of this document can be found on HEC's official website.

03. Through effective implementation of these standards, HEC aims to equip Bioinformatics graduates possess a deep understanding of biological data, computational methods, and molecular systems, enabling them to excel in fields such as genomics, systems biology, drug discovery, and biomedical data analysis. This will empower them to drive innovation in life sciences, support evidence-based decision-making, and foster positive change in healthcare and biological research, contributing to a more resilient and equitable future locally and globally.

SAHER MIRZA

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

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CURRICULUM

FOR

BIOINFORMATICS DEGREE PROGRAMS

Associate Degree

Bachelor of Science

Master of Philosophy / Master of Science

2026

Academics Division
Higher Education Commission, Islamabad
Government of Pakistan

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MASTER OF PHILOSOPHY / MASTER OF SCIENCE

COURSE LEARNING OUTCOMES

(Master of Philosophy / Master of Science)

CONTRIBUTIONS

Prof. Dr. Sajid Rashid - **Convener**
Professor & Chairperson,
National Center for Bioinformatics,
Quaid-i-Azam University, Islamabad

Prof. Dr. Zaheer Ul-Haq – **Co-Convener**
Professor
International Center for Chemical and Biological Sciences,
University of Karachi
Karachi

Dr. Arslan Sehgal
Assistant Professor & HoD
Department of Genomics & Bioinformatics
Cholistan University of Veterinary and Animal Sciences
Bahawalpur

Prof. Dr. Asif Mir
Professor
Department of Biological Sciences,
International Islamic University
Islamabad

Dr. Asma Abro
Assistant Professor
Department of Biotechnology
Balochistan University of Information Technology, Engineering & Management Sciences
Quetta

Dr. Faisal Nouroz
Associate Professor & Chairperson
Department of Bioinformatics
Hazara University
Mansehra

Prof. Dr. Farhat Naureen Memon
Professor
Institute of Mathematics & Computer
Science
University of Sindh
Jamshoro

Dr. Kafeel Ahmad
Assistant Professor
Centre of Biotechnology & Microbiology
University of Peshawar
Peshawar

Prof. Dr. Muhammad Aamer Mehmood
Professor & Chairperson
Department of Bioinformatics & Biotechnology
Government College University
Faisalabad

Dr. Muhammad Ilyas
Assistant Professor
Center of Omic Sciences
Islamia College University
Peshawar

Prof. Dr. Muhammad Nauman Aftab
Professor & Director
Dr. Ikram-ul-Haq Institute of Industrial
Biotechnology
Government College University
Lahore

Prof. Dr. Muhammad Naveed
Professor,
Department of Biotechnology
University of Central Punjab
Lahore

Prof. Dr. Muhammad Qasim
Professor
Department of Bioinformatics & Biotechnology
Government College University
Faisalabad

Dr. Naeem Mahmood Ashraf
Assistant Professor
School of Bioinformatics & Biotechnology
University of the Punjab
Lahore

Dr. Siddiq ur Rahman
Assistant Professor
Department of Computer Sciences & Bioinformatics
Khushal Khan Khattak University
Karak

Dr. Sumra Wajid Abbasi
Associate Professor
Department of Biological Sciences
National University of Medical Sciences
Rawalpindi

Prof. Dr. Syed Aun Muhammad
Professor
Institute of Molecular Biology & Biotechnology
Bahauddin Zakariya University
Multan

Dr. Uzma Hameed
Assistant Professor
Dr. Ikram-ul-Haq Institute of Industrial
Biotechnology
Government College University

Lahore

Dr. Waseem Haider
Associate Professor
Department of Biosciences
COMSATS University
Islamabad

Dr. Farida Anjum
Director
Academics Division
Higher Education Commission, Islamabad.

Saher Mirza - Secretary
Assistant Director
Academics Division
Higher Education Commission, Islamabad.

Compiled & Edited By:
Ms. Saher Mirza
Assistant Director
Academics Division
Higher Education Commission, Islamabad.

Coordinated By:
Mr. Sajjad Haider
Academics Division
Higher Education Commission, Islamabad.

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. In response to the evolving needs, HEC has undertaken the task to develop robust standards for the curricula of degree programs in Bioinformatics at levels 5-7 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 Bioinformatics are designed to develop students' critical understanding of biological data analysis, genomic sequencing, computational modeling, and interdisciplinary applications in healthcare, agriculture, and environmental sciences. These programs offer a comprehensive foundation in molecular biology, algorithms, machine learning, and big data management, equipping graduates with analytical, interpretive, and research skills essential for academic inquiry, innovation, and addressing real-world biological challenges. The curricular standards, developed by academic experts and practitioners from across the country, aim to elevate the quality and relevance of Bioinformatics education by promoting scholarly excellence, critical thinking, and ethical academic practice. Through these programs, graduates will be prepared for diverse career pathways in research, pharmaceuticals, biotechnology, data science, academia, and other sectors where expertise in biological computation and genomic analysis is essential.

With the support of universities in implementing these standards, HEC envisions a future where Bioinformatics graduates contribute meaningfully to national development, scientific advancement, and global health challenges through critical engagement with biological data, computational tools, and their relevance to contemporary issues like personalized medicine and pandemic preparedness.

Dr. Amjad Hussain
Director General
Academics Division
Higher Education Commission

GUIDING PRINCIPLES

Minimum Standards

The curricular standards and guidelines prescribed under this policy 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 and Credits

For Bachelor of Science and Master of Philosophy / Master of Science, the sequence of courses prescribed under this policy document is logically arranged and is suggestive only. The offering department may rearrange the sequence and alter the course titles and credits provided that the essence of the courses prescribed in policy remains intact. The department may add more courses as and when required subject to approval of university's relevant statutory body.

Course Learning Outcomes (CLOs)

Course Learning Outcomes Course learning outcomes (CLOs) are the bare minimum standards of learning that students must achieve upon completing a specific course. 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 developed for the major courses only and whereas for interdisciplinary courses and electives, the concerned department is required to develop their CLOs considering the course's advanced nature. For General Education courses as prescribed in the HEC Undergraduate Education Policy V 1.1 including the courses of "Pakistan Studies", "Understanding of Holy Quran I" and "Understanding of Holy Quran II", the department may adopt the CLOs as prescribed in the HEC developed model courses.

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 Philosophy / Master of Science in Bioinformatics as minimum standards. The offering department is mandated 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 department utilizes instructional, reference, and reading materials that it deems appropriate to effectively meet the CLOs.

General Education

For Bachelor of Science Bioinformatics, the courses prescribed for General Education component must mandatorily be offered with the same titles and credits as prescribed under 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.

Requirement of Internship

It is a mandatory degree award requirement of three (03) credit hours for Bachelor of Science Bioinformatics. Internship of six (06) to eight (08) 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 Project

It is a mandatory degree award requirement of three (03) credit hours for Bachelor of Science Bioinformatics. 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

The eligibility criteria and the first-four semesters of the Bachelor of Science Bioinformatics as prescribed in this policy document guide the admission requirement and the structure of Associate Degree in Bioinformatics. Field experience / internship is not a mandatory requirement for the Associate Degree in Bioinformatics.

Electives

a) In accordance with the National Qualifications Framework, the department is required to offer at least 7 electives comprised of 21 credit hours i.e., minimum of 25% of the major i.e., Bioinformatics comprised of 84 credit hours, to meet the criteria of nomenclature with specialization. Where the department increases the range of major beyond 84, the number of electives will accordingly be adjusted.
b) Where the electives are opted from the general pool, the degree will be awarded as BS Bioinformatics in its generic form and without any specialization. Example: Bachelor of Science Bioinformatics.
c) Where the electives are opted from within a single specialization domain, the degree will be offered as Bachelor of Science Bioinformatics (with name of specialization) in accordance with the National Qualifications Framework (2015). Example: Bachelor of Science Bioinformatics (Artificial Intelligence), Bachelor of Science Bioinformatics (Genomics & Precision Medicine) etc.
d) Subject to approval of the relevant statutory body, the department may develop additional specializations other than those prescribed in this document. It should however be noted that offering of the degree program with specialization is prescribed in this document as an option only and not as a mandatory requirement or a binding on the offering department. In view of this, the department concerned may consider offering the degree program with specialization or not, in accordance with its available academic, human and infrastructural resources

Entry and Exit Provisions at Undergraduate Level

a. Pathway for Graduates with Associate Degree

a) Students having completed Associate Degree in Bioinformatics are allowed admission in the fifth semester of the Bachelor of Science Bioinformatics with or without any deficiency course up-to a maximum of 6 credit hours as determined by the admitting university / department.
b) Students having completed Associate Degree in any discipline related to the field of Bioinformatics shall be required to complete deficiency courses up-to a maximum of 18 credit hours as determined by the admitting university / department.
c) In case where the deficiency courses are 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.
d) The minimum eligibility for admission in the fifth semester in above cases is 2.00/4.00 CGPA in the prior qualification i.e., Associate Degree. The admitting university may, however, set higher eligibility criteria for admission in the fifth semester of Bachelor of Science Bioinformatics.

b. Pathway for Graduates with Conventional BSc/Equivalent Degree Programs

a) Students having completed two-year conventional BSc/equivalent degree programs are allowed admission in the fifth semester of Bachelor of Science Bioinformatics in which case, such students shall be required to complete deficiency courses up-to a maximum of 21 credit hours as determined by the admitting university.
b) In case where the deficiency courses are more than 21 credit hours, the concerned university may decide to not offer admission, in accordance with its screening, admission and merit calculation criteria approved by its statutory bodies.
c) The minimum eligibility for admission in the fifth semester in this case is 45% cumulative score in the prior qualification i.e., two-year conventional BSc/equivalent degree programs. The admitting university may however set higher eligibility criteria for admission in the fifth semester of Bachelor of Science Bioinformatics.

Exiting from Bachelor of Science Bioinformatics with the Associate Degree

Students enrolled in Bachelor of Science Bioinformatics are allowed to exit the program with the Associate Degree provided that the requirements specified in this policy document for the Associate Degree in Bioinformatics are met.

BACHELOR OF SCIENCE BIOINFORMATICS

PROGRAM DESCRIPTION

The Bachelor of Science in Bioinformatics program is structured in accordance with the HEC Undergraduate Education Policy V 1.1 to provide students with a comprehensive and interdisciplinary understanding of bioinformatics. The curriculum offers a balanced and robust educational experience through core courses, specialized subjects, and interdisciplinary studies. The program emphasizes experiential learning through practical assignments, case studies, internships, and research projects, allowing students to connect academic knowledge with real-world applications in diverse settings. This curriculum aims to cultivate problem-solving skills, ethical reasoning, sustainability awareness, and cultural sensitivity, enabling students to address contemporary challenges in genomics, drug discovery, personalized medicine, agricultural biotechnology, and public health informatics etc. Graduates of the BS Bioinformatics program will be well-equipped for careers in fields such as computational biology, data analysis in biotech/pharma, genomic research, bioinformatics software development, and precision agriculture. They will also be prepared for advanced studies in Bioinformatics and related interdisciplinary areas, both nationally and internationally.

STANDARD NOMENCLATURE

To ensure uniformity, the standard nomenclature of four-year undergraduate degree programs in Bioinformatics must be **"Bachelor of Science Bioinformatics"** with its short form as **"BS Bioinformatics"**.

PROGRAM LEARNING OUTCOMES

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

a) Demonstrate a comprehensive understanding of foundational and advanced Bioinformatics concepts, theories, and methodologies, encompassing various areas of the field of Bioinformatics to analyze and interpret biological data for solving complex biological problems.

b) Apply Bioinformatics theories and research methodologies to evaluate and address contemporary issues related to the field of Bioinformatics considering local, regional, and global perspectives on health, biotechnology, related fields and data-driven scientific discovery.

c) Communicate Bioinformatics knowledge and research findings effectively, with ethical considerations, to inform decision-making, contribute to scientific advancements, and foster interdisciplinary collaborations in academic, professional, and industry settings.

ELIGIBILITY CRITERIA

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

PROGRAM STRUCTURE

The Bachelor of Science in Bioinformatics is structured in accordance with the provisions of the HEC Undergraduate Education Policy V 1.1. and comprises of minimum **136** credit hours (including supervised internship) spread over eight (08) regular semesters. Universities may offer courses up-to maximum of 148 credit hours provided that the total number of credit hours are reasonably set to achieve the Program Learning Objectives (PLOs) without putting undue burden on students.

Minimum Credit Hours (including all program related requirements)		136
General Education		34 credit hours (14 courses)
Major	a) Compulsory	63 credit hours (28 courses) Mandatory courses as reflected in the scheme of study, irrespective of the area of specialization (where applicable).
	b) Mandatory Electives	21 credit hours (7 courses) (to be opted from either general pool of electives or from a particular specialization)
	Total Major Requirement	84 credit hours (28 courses)
Interdisciplinary Courses		12 credit hours (4 courses)
Supervised Internship		3 credit hours
Capstone Project		3 credit hours
Program Duration		Minimum: 4 Years Maximum: 6 Years (further extendable to another year subject to approval of university's statutory body)
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

SCHEME OF STUDIES

The standard scheme of studies for Bachelor of Science Bioinformatics is given below:

SEMESTER I			
S.N.	COURSE	CREDIT HOURS	CATEGORY
1	Introduction to Biology	3 (2-1)	Major
2	Introductory Bioinformatics	3 (2-1)	Major
3	Application of Information & Communication Technologies (ICT) *	3 (2-1)	GE
4	Quantitative Reasoning-I *	3 (3-0)	GE
5	Functional English *	3 (3-0)	GE
6	Pakistan Studies *	2 (2-0)	GE
Total Credits (17)			

SEMESTER II			
S.N.	COURSE	CREDIT HOURS	CATEGORY
1	Programming Fundamentals for Bioinformatics	3 (2-1)	Major
2	Cell Biology	3 (2-1)	Major
3	Biochemistry	3 (2-1)	Major
4	Quantitative Reasoning-II *	3 (3-0)	GE
5	Understanding of Holy Quran-I/ Religious Ed.*	1 (0-1)	GE
6	Civics & Community Engagement *	2 (2-0)	GE
7	Expository Writing *	3 (3-0)	GE
Total Credits (18)			
SEMESTER III			
S.N.	COURSE	CREDIT HOURS	CATEGORY
1	Genetics	3 (2-1)	Major
2	Data Structures	3 (2-1)	Major
3	Object Oriented Programming	3 (2-1)	Major
4	Arts & Humanities ***	2 (2-0)	GE
5	Social Sciences **	2 (2-0)	GE
6	Islamic Studies / Ethics *	2 (2-0)	GE
7	Ideology & Constitution of Pakistan *	2 (2-0)	GE
Total Credits (17)			
SEMESTER IV			
S.N.	COURSE	CREDIT HOURS	CATEGORY
1	Molecular Biology	3 (2-1)	Major
3	Database Management Systems	3 (2-1)	Major
4	Interdisciplinary – I *****	3	IDS
5	Natural Sciences ****	3 (2-1)	GE
6	Entrepreneurship *	2(2-0)	GE
7	Understanding of Holy Quran-II/Religious Ed*	1 (0-1)	GE
Total Credits (15)			
SEMESTER V			
S.N.	COURSE	CREDIT HOURS	CATEGORY
1	Epigenomics	3 (2-1)	Major
2	Computational Proteomics	3 (2-1)	Major
3	Introductory Data Science	3 (2-1)	Major
4	Bioinformatics Software Engineering	3 (3-0)	Major
5	Interdisciplinary – II *****	3	IDS
6	Elective – I ******	3	Major
Total Credits (18)			

SEMESTER VI			
S.N.	COURSE	CREDIT HOURS	CATEGORY
1	High-Throughput Sequence Data Analysis	3 (2-1)	Major
2	Microbiome & Metagenomics	3 (2-1)	Major
3	Computer-Aided Drug Design	3 (2-1)	Major
4	Elective – II ******	3	Major
5	Interdisciplinary – III *****	3	IDS
6	Interdisciplinary – IV *****	3	IDS
Total Credits (18)			

SEMESTER VII			
S.N.	COURSE	CREDIT HOURS	CATEGORY
1	Artificial Intelligence in Bioinformatics	3 (1-2)	Major
2	Research Methodology	3 (2-1)	Major
3	Clinical Bioinformatics	3 (2-1)	Major
4	Elective – III ******	3	Major
5	Elective – IV ******	3	Major
Total Credits (15)			

SEMESTER VIII			
S.N.	COURSE	CREDIT HOURS	CATEGORY
1	Ethical & Legal Issues in Bioinformatics	3 (3-0)	Major
2	Elective – V ******	3	Major
3	Elective – VI ******	3	Major
4	Elective – VII ******	3	Major
5	Capstone Project	3	Capstone
Total Credits (15)			

* HEC designed model courses for general education may be used by the university.

** HEC designed model course may be used by the university, OR the university / offering department may offer any course in the broader category of **"Social Sciences"** including but not limited to a course of Psychology, Sociology, Anthropology etc.

*** HEC designed model course may be used by the university, OR the university / offering 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.

**** HEC designed model course may be used by the university, OR the university / offering department may offer any course in the broader category of **"Natural Sciences"** which should have relevance to the purpose of the degree program.

***** The university / concerned department must offer at least 4 interdisciplinary courses from the recommended list provided in this document, or any other such course to enhance the interdisciplinary understanding of the students, keeping in view the available academic, human and infrastructural resources of the department.

****** Read in conjunction with guidance given on "Standard Nomenclature" in this document, the university/concerned department may offer any 7 advanced courses from either the general pool or from any one of the specializations as electives keeping in view its available academic, human and infrastructural resources.

RECOMMENDED LIST OF INTERDISCIPLINARY COURSES

Student may opt interdisciplinary courses from the following list where required in the scheme of studies for Bachelor of Science Bioinformatics, or may opt from other departments to complement their holistic understanding of the major, provided that the same is allowed by the admitting department. The list provided here is a recommended one only, and the offering department may add more courses as and when needed, provided that the same is approved by the university's relevant statutory body.

1. Principles of Chemistry
2. Introduction to Biotechnology
3. Discrete Structures
4. Differential Equations
5. Calculus II/Linear Algebra
6. Biostatistics & Probability
7. Nanotechnology
8. Numerical Analysis
9. Biophysics
10. Theory of Automata
11. Organic Chemistry
12. Linear Algebra
13. Physical Chemistry
14. Analytical Chemistry & Instrumentation
15. Principles of Biochemical Engineering
16. Genetic Resources & Conservation
17. Computational Immunology
18. Molecular Dynamics & Simulation
19. Molecular Medicine
20. Computational Medicinal Chemistry

RECOMMENDED GENERAL POOL OF ELECTIVES

Students may opt for any 7 courses as electives from the following recommended general pool where required in the scheme of studies for Bioinformatics, provided that the same is offered and allowed by the department concerned. Where all 7 courses are opted from this pool, the degree will be titled "Bachelor of Science Bioinformatics" in its generic form and without any specialization. The list provided here is a recommended one only and the department concerned may add more courses as and when needed.

1. Cancer Bioinformatics
2. Structural Bioinformatics
3. Functional Genomics
4. Single Cell RNA Sequencing
5. Pharmacogenomics
6. Systems Biology
7. Nanoinformatics
8. R Programming for Bioinformatics
9. Big Data in Bioinformatics
10. Cloud Computing for Biology
11. Transcriptomics
12. Climate & Agricultural Bioinformatics
13. Synthetic Biology
14. Metabolomics

15. Evolutionary Bioinformatics
16. Immunoinformatics
17. Enzyme Kinetics
18. Protein Chemistry
19. Molecular Oncology
20. Forensic Sciences

DEGREE AWARD REQUIREMENTS

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

a) All courses in the General Education category with titles and credit hours as prescribed in HEC Undergraduate Education Policy V 1.1. must be completed.
b) Minimum of 136 credit hours (including internship and capstone project) as prescribed in this policy document must be completed.
c) Capstone / research project 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 (4 Years) and the maximum duration is 12 regular semesters (6 Years). The maximum duration may be extended to 2 more semesters (1 Year) in extraordinary circumstances subject to approval of the university's relevant statutory body. Summer semester is not considered as a regular semester.

MAJOR SPECIALIZATIONS FOR BIOINFORMATICS

The following are a few example specialization streams in case the BS Bioinformatics is offered with specialization (7 courses from any stream). Subject to approval of the relevant statutory body, the department may develop additional specializations other than those prescribed below or add more courses or edit the list in the given specializations. The department concerned may consider offering the degree program with specialization or otherwise, keeping in view availability of its academic, human and infrastructural resources.

Specialization 1: Genomics & Precision Medicine

Below is the recommended list of courses within the given specialization.

1. Human Genome Analysis
2. Cancer Genomics
3. Pharmacogenomics
4. Clinical Bioinformatics
5. Population Genetics Analysis
6. Single Cell RNA Sequencing
7. Epigenomics
8. Functional Genomics
9. Transcriptomics
10. ChIP-Seq Data Analysis
11. GWAS Analysis
12. Variant Calling Pipelines
13. Structural Variation Analysis
14. Personalized Medicine Bioinformatics
15. Clinical Trial Bioinformatics

Specialization 2: Artificial Intelligence

Below is the recommended list of courses within the given specialization.

1. Machine Learning in Biology
2. Neural Networking
3. Systems Biology
4. Algorithm Design in Bioinformatics
5. Network Biology
6. Big Data Analytics
7. Integrative Omics & Data Analytics
8. Natural Language Processing
9. Image Processing
10. Deep Learning Omics Data Analysis

Specialization 3: Plant & Agroinformatics

Below is the recommended list of courses within the given specialization.

1. Plant Genomics
2. Agricultural Metagenomics
3. Plant-Pathogen Interactions
4. Plant Breeding Informatics
5. Plant Stress Response Analysis
6. Climate Smart Agriculture
7. Pan-Genomics Crops
8. Transgenic Plant Analysis
9. Plant Metabolomics
10. Agricultural Microbiome
11. Data Visualization for Plant Omics
12. Climate-Resilient Crops

Specialization 4: Microbial & Environmental Sciences

Below is the recommended list of courses within the given specialization.

1. Metagenomics
2. Microbiome Data Analysis
3. Computational Virology
4. Microbial Ecology
5. Phage Bioinformatics
6. Microbial Dark Matter
7. Environmental Meta-transcriptomics
8. Biogeochemical Cycle Modeling
9. Pollution Monitoring Metagenomics
10. Marine Microbiology
11. Microbial Diversity

COURSE LEARNING OUTCOMES
(For Bachelor's Degree Program)

Introduction to Biology

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

- Explain the basic concepts of Life Sciences, including diversity of life, physical & chemical nature of living matter and the form and formation of living cells.
- Apply basic analytical skills pertaining to life sciences.
- Analyze the role of biomolecules like proteins and nucleic acids in biological processes.

Cell Biology

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

- Explain the principles of cell theory, levels of cellular organization and historical aspects of Cell Biology
- Describe the structure and function of eukaryotic organelles and their interactions.
- Analyze cell signaling pathways and their regulation in health and disease.
- Evaluate experimental techniques for studying cellular processes such as microscopy and flow cytometry.

Biochemistry

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

- Understand the chemistry of biological macromolecules, major metabolic pathways, enzyme kinetics, and bioenergetics.
- Apply knowledge of biochemistry to understand biological systems.
- Analyze biochemical principles to understand molecular mechanisms underlying protein structure-function relationships.

Genetics

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

- Describe the basic principles of inheritance, classical and fundamental genetics.
- Apply linkage mapping and recombination frequencies to construct genetic maps.
- Evaluate the impact of mutations and genomic imprinting

Molecular Biology

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

- Explain molecular basis of central dogma of life.
- Apply molecular biological techniques to study organization of genetic material.
- Analyze gene regulation and expression.

Programming Fundamentals for Bioinformatics

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

- Explain basic programming concepts, emphasizing on problem identification, basic algorithm design and program development.
- Implement basic algorithms in Python for sequence manipulation and data parsing.
- Apply control structures, functions, data types and file handling to process biological datasets.
- Debug and test Python programs.

Data Structures

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

- Explain arrays, linked lists, stacks, strings, queues, and trees for efficient data handling.
- Implement hash tables and graphs to model biological networks.
- Analyze time and space complexity of algorithms to select the suitable solution for biological problems.

Object Oriented Programming

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

- Explain concepts of object oriented programming including, classes, objects, encapsulation, inheritance and polymorphism for modelling biological entities.
- Apply object oriented programming concepts to design and develop modular programs.
- Evaluate design patterns for software scalability in large-scale Bioinformatics data analysis.

Database Management Systems

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

- Explain and design conceptual and logical database models.
- Implement and use relational database systems to create, store, retrieve and manipulate biological data.
- Apply routines to connect back-end with front-end databases.

Introductory Bioinformatics

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

- Explain core concepts of data representation, types of biological databases, sequence alignment, and scope of Bioinformatics.
- Apply bioinformatics tools and databases to retrieve biological data.
- Analyze data file formats, file structures and phylogenetics.

Epigenomics

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

- Describe epigenetic modifications like DNA methylation and histone modification.
- Analyze ChIP-seq data to identify regulatory elements and chromatin states.
- Evaluate computational models for predicting epigenetic landscapes in disease.

Computational Proteomics

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

- Describe the fundamental concepts of proteomics, including protein sequence, structure and function.
- Apply computational tools to analyze protein-protein interactions, pathways and PTM analysis.
- Analyze functional implications of protein complexes.

High-Throughput Sequence Data Analysis

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

- Understand sequence data types, data handling techniques, data analysis and data visualization.
- Apply computational pipelines to process raw sequence data including quality control, alignment and variant calling.
- Analyze gene differential expression, variant calling and gene identification.

Microbiome & Metagenomics

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

- Explain molecular marker profiling and shotgun metagenomics for microbial communities.
- Apply bioinformatics tools for taxonomic profiling and functional prediction.
- Analyze host-microbe interaction, environmental impacts and diversity for biological interpretation.

Computer-Aided Drug Design

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

- Describe role of computational tools involved in drug design.
- Apply CADD pipelines and stand-alone applications to interpret molecular interactions.
- Evaluation of scoring parameters, validation of binding modes, docking pose selection and lead optimization.

Artificial Intelligence in Bioinformatics

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

- Understand basic concepts of Artificial Intelligence, machine learning and their application in bioinformatics.
- Apply machine learning models, visualization using deep learning architectures (ANNs,CNNs, RNNs etc.) for biological data interpretation.
- Analyze neural network-based model validation.

Research Methodology

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

- Understand the execution of various experimental methods for bioinformatics studies.
- Apply research methods to formulate research questions, hypothesis and objectives.
- Evaluate research proposals using comparative outcomes.

Clinical Bioinformatics

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

- Understand clinical datasets and their evaluation through bioinformatics techniques.
- Apply bioinformatics pipelines to annotate, visualize and interpret clinical datasets.
- Evaluate clinical outcome, score, report and patterns through decision making strategies.

Ethical & Legal Issues in Bioinformatics

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

- Identify ethical and legal aspects related to bioinformatics practices, procedures and products.
- Apply policy guidelines to ensure ethical practices and protect intellectual property rights.
- Analyze ethical & legal issues related to implementation of policy guidelines and IP rights.

Introductory Data Science

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

- Understand basic data manipulation and visualization techniques to preprocess and explore biological datasets such as genomic sequences or protein structures.
- Apply statistical analysis and hypothesis testing on bioinformatics data (e.g., gene expression profiles) to identify patterns and draw biologically relevant inferences using tools.
- Utilize introductory machine learning algorithms (e.g., clustering, classification) on biological datasets to solve problems and demonstrate ethical data handling practices.

Bioinformatics Software Engineering

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

- Create modular software applications using object-oriented programming to process biological data, implementing encapsulation and inheritance principles.
- Apply software engineering practices to develop testable bioinformatics pipelines.
- Evaluate software quality through unit testing, debugging, and documentation standards to ensure reliable, reproducible bioinformatics tools.

MASTER OF PHILOSOPHY BIOINFORMATICS / MASTER OF SCIENCE BIOINFORMATICS

PROGRAM DESCRIPTION

The **Master of Science (MS) Bioinformatic**s or **Master of Philosophy Bioinformatics** program is structured in alignment with the HEC Graduate Education Policy 2023 to provide students with an advanced and interdisciplinary understanding of key areas within bioinformatics, including genomics, computational biology, proteomics, and systems biology. This program is designed to equip students with critical analytical skills, research expertise, and practical knowledge necessary to address complex challenges in genomic data analysis, drug discovery, precision medicine, and biotechnology in both local and global contexts. Spanning three semesters, the program integrates core courses and specialized electives, emphasizing rigorous academic training, practical application, and independent research. Students engage in advanced qualitative and quantitative research methods, preparing them to design and conduct original studies that contribute to evidence-based solutions for issues in areas such as genomic sequencing, protein structure prediction, algorithmic modeling, and health informatics. The program fosters a deep understanding of the interconnectedness of biological, computational, statistical, and ethical factors impacting biomedical research, with a focus on sustainable practices, data security, and innovation. Students also develop effective communication, ethical reasoning, and interdisciplinary collaboration skills, enabling them to present their research and expertise clearly and impactfully to academic, professional, and industry audiences. Graduates of the MS in Bioinformatics are prepared for leadership roles in academia, research, biotech/pharma R&D, software development, and related sectors. They are equipped to drive innovation by addressing critical issues in computational biology, genomic analysis, drug design, and bioinformatics infrastructure, contributing to the advancement of the field both locally and globally.

STANDARD NOMENCLATURE

To ensure uniformity, the standard nomenclature for all NQF level 7 qualifications in the field of Bioinformatics will be either "**Master of Philosophy Bioinformatics**" or "**Master of Science Bioinformatics"** subject to approval by relevant statutory bodies of the university.

PROGRAM LEARNING OUTCOMES

By the completion of Master of Philosophy Bioinformatics / Master of Science Bioinformatics, the graduates will be able to:

a) Demonstrate advanced understanding of the major theories, concepts, and methodologies within Bioinformatics, integrating interdisciplinary perspectives to critically analyze and address complex issues related to family, home, and community well-being across diverse societal and cultural contexts.
b) Apply advanced research methods and analytical tools to evaluate contemporary challenges in Bioinformatics, design innovative solutions, and contribute evidence-based interventions in areas around Bioinformatics.
c) Conduct independent, original research in Bioinformatics, engaging with existing literature, employing rigorous methodologies, and generating new insights that advance knowledge in the field and inform practice in both academic and professional settings.
d) Communicate research findings and professional expertise effectively, both orally and in writing, to academic, professional, and public audiences, demonstrating clarity, ethical considerations, and cultural sensitivity in addressing complex issues in Bioinformatics and related fields.

ELIGIBILITY CRITERIA

a) An undergraduate degree (involving 16 years of education) in Bioinformatics or relevant field is the basic eligibility requirement for admission in the Master of Science Bioinformatics/ Master of Philosophy Bioinformatics. In case the candidate has any deficiency, the admitting department may offer deficiency courses of 6-9 credit hours as determined by it on case-to-case basis. Relevance of the prior qualification in this regard will also be determined by the admitting university / department.
b) 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 may also set minimum eligibility scores (above 50%) as per the screening, admission and merit calculation criteria approved by its statutory bodies.

PROGRAM STRUCTURE

The Master of Philosophy Bioinformatics / Master of Science Bioinformatics is structured in accordance with the provisions of the HEC Graduate Education Policy (GEP) 2023. Standard structure of the program is as under:

Minimum Credit Hours		32
Course Work	a) Compulsory	11 credit hours (5 courses)
	b) Electives	15 credit hours (5 courses)
	Total Coursework Requirement	26 credit hours
Research Work / Thesis		6 credit hours
Program Duration		Minimum: 1.5 Years (3 regular semesters) Maximum: 4 Years (8 regular semesters) **Note:** In case a student is unable to secure an MS/MPhil within the prescribed timeframe and claims for extension in duration, the university may constitute 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 MS/MPhil degree in accordance with the duration limiting factor(s) and shall 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)

SCHEME OF STUDIES

The standard scheme of studies for Master of Philosophy Bioinformatics / Master of Science Bioinformatics is given below:

SEMESTER I			
S.N.	COURSE	CREDIT HOURS	CATEGORY
1	Advanced Data Analysis in Bioinformatics *	3 (3-0)	Core
2	Advanced Research Methods in Bioinformatics *	3 (3-0)	Core
3	Elective – I **	3	Elective
4	Elective – II **	3	Elective
Total Credits (12)			

SEMESTER II			
S.N.	COURSE	CREDIT HOURS	CATEGORY
1	Applications of Artificial Intelligence in Bioinformatics *	3 (2-1)	Core
2	Elective –III **	3	Elective
3	Elective –IV **	3	Elective
4	Elective – V **	3	Elective
Total Credits (12)			

SEMESTER III			
S.N.	COURSE	CREDIT HOURS	CATEGORY
1	Understanding of Holy Quran – I/ Religious Ed ***	1 (0-1)	GE
2	Understanding of Holy Quran – II/ Religious Ed ***	1 (0-1)	GE
3	Thesis ****	6	Research

SEMESTER IV			
S.N.	COURSE	CREDIT HOURS	CATEGORY
1	Thesis ****	Continued	Research

* 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 Bioinformatics as an elective, as per its available academic, human and infrastructural resources.

*** These are prescribed for all NQF level 5-8 qualifications as mandated vide HEC letter No.10- 01/2022/Coord(Acad)/HEC/235 dated March 28, 2025.

**** 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 Philosophy Bioinformatics / Master of Science Bioinformatics:

a) A minimum of 26 credit hours of course work including 09 credit hours for core courses, 15 credit hours for general or specialization-oriented electives and 2 credit hours for Quranic courses as prescribed in this document must be completed.

b) In addition, research thesis of 6 credit hours or course work of 2 courses of 6 credit hours must also be completed individually as partial fulfilment of the degree program.

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

d) The minimum duration required to complete the degree is 3 regular semesters which may be extended up to a maximum of 8 regular semesters. Summer semester is not considered as a regular semester.

COURSE LEARNING OUTCOMES

(Master of Philosophy / Master of Science)

1. Advanced Data Analysis in Bioinformatics

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

- Understand data types, retrieval, storage and various techniques implicated in biological data analysis.
- Apply advanced software/tools and techniques to analyze and interpret qualitative and quantitative data in Bioinformatics research.
- Evaluate research findings critically to support evidence-based decision-making in Bioinformatics.
- Communicate data analysis results effectively in academic and professional contexts.

2. Advanced Research Methods in Bioinformatics

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

- Understand research designs, data collection techniques, and statistical/computational tools for data analysis.
- Apply qualitative, quantitative and mixed research methods to investigate contemporary issues and trends in Bioinformatics.
- Evaluate published research critically to identify gaps and propose innovative research solutions.
- Develop a comprehensive research proposal while adhering to ethical research practices and academic integrity.

3. Applications of Artificial Intelligence in Bioinformatics

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

- Explain the fundamental concepts of AI, type of agents, machine learning, deep learning and their relevance to bioinformatics applications.
- Apply machine learning and deep learning methods to solve potential biological problems.
- Evaluate model efficiency, validation, optimization, visualization and interpretation of solutions.
- Develop problem-solving and integrated knowledge based automated AI models.

RECOMMENDATIONS OF NCRC BIOINFORMATICS

- Bioinformatics is a core discipline of Biology.
- Bioinformatics department needs to be separated from Computer Science department, where there are programs of Bioinformatics being operationalized at the level of BS, MS/MPhil and PhD.
- The Bioinformatics curriculum has been revised in accordance with the approved guidelines, and any future revisions shall be made strictly in line with the updated national curriculum.
- HEC should provide regular funding, publication charges & maintenance of laboratory equipment.
- Bioinformatics related research funding projects must be evaluated through relevant experts, faculty members.
- HEC must establish an independent computing/software, faculty for research purposes and share with all universities/HEls.