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No. HEC/CD/NCRC/BIOLOGY/2025/**7510**

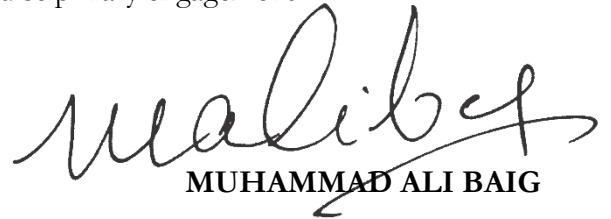
May 12, 2025

SUBJECT: REVISED CURRICULA FOR BIOLOGY DEGREE PROGRAMS

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 Biology degree programs at NQF levels 5 and 6. These updated standards are intricately aligned with HEC's Undergraduate Education Policy V 1.1 (2023) ensuring coherence with national priorities and adherence to international benchmarks.

2. The revised curricula for Biology degree programs are hereby notified. Universities offering these programs are advised to align their Biology curricula with these updated standards as a minimum requirement. The respective departments must also develop course contents in accordance with the prescribed framework, ensuring that the programs address evolving scholarly, and professional needs to enhance employability potential of Biology graduates. Subsequently, the finalized course contents 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. With the support of universities in implementing these standards, HEC envisions a future where Biology graduates contribute meaningfully to scientific advancement, sustainable development, and societal well-being through evidence-based knowledge and interdisciplinary engagement.



MUHAMMAD ALI BAIG

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CURRICULUM FOR

BIOLOGY DEGREE PROGRAMS

Associate Degree | Bachelor of Science

2025

**Academics Division
Higher Education Commission, Islamabad
Government of Pakistan**

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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 Biology at levels 5 and 6 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 Biology are designed to equip students with comprehensive knowledge and practical skills across key domains of the biological sciences, encompassing molecular biology, ecology, physiology, genetics, and organismal diversity. These programs emphasize a balance between theoretical understanding and applied scientific inquiry, enabling graduates to address contemporary challenges in health, environment, agriculture, and biotechnology. The curricular standards, developed by subject experts from across the country, aim to enhance the academic rigor and professional relevance of Biology education by fostering innovation, analytical thinking, and ethically grounded scientific practice. Graduates are prepared for diverse career pathways in research, healthcare, education, environmental management, and emerging bio-industries.

With the support of universities in implementing these standards, HEC envisions a future where Biology graduates contribute meaningfully to scientific advancement, sustainable development, and societal well-being through evidence-based knowledge and interdisciplinary engagement.

Dr. Amjad Hussain

Director General
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GUIDING PRINCIPLES

Minimum Standards

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

Course Sequence, Titles & Credits

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

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 major and interdisciplinary courses and whereas for electives, the departments concerned are 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" and "Understanding of Holy Quran I & II", the departments may adopt the CLOs as prescribed in the HEC developed model courses.

Course Syllabus

This document serves as a comprehensive guideline delineating the CLOs for each course as prescribed for the AD and BS Biology as minimum standards. The department concerned is required to prepare, modify, and tailor the syllabus of each course, ensuring alignment with the stipulated learning outcomes and scholarly demands. It is in this regard imperative that the department concerned utilizes instructional, reference, and reading materials that it deems appropriate to effectively meet the CLOs.

General Education

For AD and BS Biology, the courses for General Education component including the courses of "Pakistan Studies" and "Understanding of Holy Quran I & II" must mandatorily be offered with the same titles and credit hours as prescribed in the HEC Undergraduate Education Policy V 1.1., and subsequent notifications. The department concerned may adopt and follow the learning outcomes and study contents developed by HEC for these courses as available on its website.

Requirement of Internship

A supervised internship of 3 credit hours in accordance with HEC Undergraduate Education Policy V.1.1. is a mandatory degree award requirement for BS. This requirement must be graded and supervised under a faculty member in collaboration with a supervisor in the field, protocols of which will be determined by the concerned department subject to approval of the same by the university's relevant statutory body.

Requirement of Capstone

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

Associate Degree

The eligibility criteria and the courses in the first-four semesters of the BS Biology as prescribed in this document guide the admission requirement and the structure of AD in Biology, respectively. Field experience / internship is not a mandatory requirement for the AD in Biology.

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., Biology comprised of 87 credit hours, to meet the criteria of nomenclature with specialization. Where the department increases the range of major beyond 87, 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 Biology in its generic form and without any specialization. Example: **Bachelor of Science in Biology**.
- c) Where the electives are opted from within a single specialization domain, the degree will be offered as Bachelor of Science in Biology (with name of specialization) in accordance with the National Qualifications Framework (2015). Example: **Bachelor of Science in Biology (Marine Biology)**.
- 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.

Equivalence of Qualifications

- a) All the graduates having degrees of BS Biology with or without specialization will be considered at par in terms of their knowledge, skills and abilities acquired through the course of the degree program, for the purpose of employment and further education. Therefore, all graduates having BS Biology with any specialization are considered equivalent to BS Biology.
- b) Where specific specialization is required by employment agencies such as Biology (Computational Biology), the same **cannot** be considered at par with any other specialization such as Biology (Environmental Biology). The titles given here are only examples for clarification.

Lab Requirements

Departments offering degree programs in Biology are required to adhere to the discipline / course relevant state-of-the-art lab requirements as minimum standards. Departments are expected to enhance the lab standards as and when required and maintain / upgrade the same to ensure quality education in Biology.

Entry & Exit Provisions at Undergraduate Level

Pathway for Graduates with Associate Degree

- a) Candidates who have completed AD in Biology are allowed admission in the fifth semester of the BS Biology with or without any deficiency course up to a maximum of 18 credit hours as determined by the concerned university / department. In case the deficiency courses are of more than 18 credit hours, the university concerned may decide not to offer admission in accordance with its screening, admission and merit calculation criteria approved by its statutory bodies.
- b) Candidates who have completed AD in any discipline other than but related to the field of Biology shall be required to complete deficiency courses up to a maximum 18 credit hours in a bridging semester as determined by the concerned university / department on case-to-case basis. Relevance of prior qualification in this regard may also be determined by the concerned university / department. In case the deficiency courses are or more than 18 credit hours, the university concerned may decide not to 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 the above cases is 2.00 / 4.00 CGPA in the prior qualification i.e., AD. The university concerned may, however, set higher eligibility and admission criteria for admission in the fifth semester of BS Biology.

Pathway for Graduates with Conventional BSc / Equivalent Degree Programs

- a) Candidates having completed two-year conventional BSc / equivalent degree programs are allowed admission in the fifth semester of BS Biology in which case, such students shall be required to complete deficiency courses up to a maximum of 21 credit hours through a bridging semester as determined by the concerned university. In case the deficiency courses are of more than 21 credit hours, the university concerned may decide not offer admission, in accordance with its screening, admission and merit calculation criteria approved by its statutory bodies.
- b) 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 university concerned may, however, set higher eligibility and admission criteria for admission in the fifth semester of BS Biology.

Exiting from Bachelor of Science in Biology with the Associate Degree

Students enrolled in BS Biology are allowed to exit the program provided they have completed the requirements of the first-four semesters of the BS degree program as prescribed in this document, and subject to approval of the university's relevant statutory body.

BACHELOR OF SCIENCE (BS)

Program Description

The program of BS Biology is structured in accordance with the HEC Undergraduate Education Policy V 1.1 (2023) and subsequent notifications, to offer a comprehensive and balanced foundation in the biological sciences, with equal emphasis on both plant and animal life. The program is designed to develop a thorough understanding of the structure, function, diversity, and evolution of living organisms across all levels of biological organization—from molecular and cellular processes to ecosystems and biospheres. Students will study a wide range of interrelated subjects including botany, zoology, physiology, microbiology, genetics, ecology, and biotechnology. The curriculum integrates theoretical instruction with hands-on laboratory and fieldwork, enabling students to explore the complexities of life in both flora and fauna. This balanced approach ensures that graduates are well-versed in the biological principles and research methodologies relevant to both the plant and animal domains. In addition to foundational and specialized coursework, the program offers opportunities for interdisciplinary learning and application, equipping students to critically examine biological phenomena, conduct experiments, analyze data, and propose evidence-based solutions to biological and ecological problems. As a policy requirement, the program culminates in a capstone research project through which students apply their knowledge to investigate real-world biological questions or conduct original research in their area of interest. The BS Biology program prepares graduates for diverse career paths in research, education, healthcare, agriculture, biotechnology, conservation, and public policy. It fosters scientific thinking, ethical responsibility, and a deep appreciation of life's diversity, aiming to produce professionals who contribute meaningfully to science and society through a well-rounded understanding of both plant and animal biology.

Standard Nomenclature

The scheme of study prescribed for the four-year undergraduate degree in Biology is based on a total of 7 electives. Where these courses are opted from the general pool of electives, the degree will be titled **Bachelor of Science in Biology** in its generic form and without any specialization. Whereas, if all the electives are opted from within a single specialization domain, the degree will be titled Bachelor of Science in Biology with the name of specialization in parenthesis in accordance with the National Qualifications Framework (2015).

Program Learning Outcomes

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

- a) Understand the fundamental concepts within the core domains of biological sciences, including both plant and animal biology.
- b) Apply biological knowledge and scientific reasoning to investigate, analyze, and interpret biological phenomena at molecular, cellular, organismal, and ecological levels.
- c) Demonstrate proficiency in basic laboratory techniques and modern biological tools used in the study and research of living organisms.
- d) Analyze the interrelationships among living organisms and between organisms and their environments, with a balanced understanding of both botanical and zoological systems.

Eligibility & Admission 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 BS Biology. Further, the university concerned may set minimum eligibility scores and may conduct entry /

admission test through its own testing body 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 Biology is structured in accordance with the provisions of the HEC Undergraduate Education Policy V 1.1. and comprises of minimum **142** credit hours spread over 8 regular semesters. Universities may offer courses up to a 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 an undue burden on students.

Minimum Credit Hours (including all program related requirements)		142
General Education		34 credit hours (15 courses)
Major	a) Compulsory	66 credit hours (22 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	87 credit hours (29 courses)
Interdisciplinary Courses		15 credit hours (5 courses)
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 (the upper limit is increased to 19 credits in some semesters by NCRC Biology in light of provisions contained in the HEC Undergraduate Education Policy V 1.1). Up-to 8 credit hours for summer semesters (for remedial / deficiency / failure / repeat 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 Hour (Lab/equivalent)		Practical / lab / field work of 1 credit hour requires 3 hours per week throughout the semester

The standard scheme of studies for the program of BS Biology (irrespective of the area of specialization) is given as under:

SEMESTER I			
S.N.	COURSE	CREDIT HOURS	CATEGORY
1	Principles of Biology	3 (2-1)	Major
2	Biodiversity & Conservation	3 (2-1)	Major
3	Quantitative Reasoning – I *	3 (3-0)	General Education
4	Natural Science **	3 (2-1)	General Education
5	Islamic Studies * (Religious Edu / Ethics for non-Muslim students)	2 (2-0)	General Education
6	Applications of Information & Communication Technologies *	3 (2-1)	General Education
7	Understanding of the Holy Quran – I *	1 (0-1)	General Education
Total Credits Hours = 18			

SEMESTER II			
S.N.	COURSE	CREDIT HOURS	CATEGORY
1	Introduction to Cell & Molecular Biology	3 (2-1)	Major
2	Fundamentals of Genetics & Evolution	3 (2-1)	Major
3	Quantitative Reasoning – II *	3 (3-0)	General Education
4	Social Sciences ***	2 (2-0)	General Education
5	Functional English *	3 (3-0)	General Education
6	Pakistan Studies *	2 (2-0)	General Education
7	Arts & Humanities ****	2 (2-0)	General Education
Total Credits Hours = 18			

SEMESTER III			
S.N.	COURSE	CREDIT HOURS	CATEGORY
1	Principles of Biochemistry	3 (2-1)	Major
2	Principles of Microbiology	3 (2-1)	Major
3	Diversity of Plants	3 (2-1)	Major
4	Diversity of Animals	3 (2-1)	Major
5	Expository Writing *	3 (3-0)	General Education
6	Civics & Community Engagement *	2 (2-0)	General Education
7	Ideology & Constitution of Pakistan *	2 (2-0)	General Education
Total Credit Hours = 19			

SEMESTER IV			
S.N.	COURSE	CREDIT HOURS	CATEGORY
1	Introduction to Plant Anatomy & Embryology	3 (2-1)	Major

2	Fundamentals of Plant Taxonomy	3 (2-1)	Major
3	Invertebrate Zoology	3 (2-1)	Major
4	Vertebrate Zoology	3 (2-1)	Major
5	Biophysics	3 (2-1)	Interdisciplinary
6	Understanding of the Holy Quran – II *	1 (0-1)	General Education
7	Entrepreneurship *	2 (2-0)	General Education
Total Credit Hours = 18			

SEMESTER V			
S.N.	COURSE	CREDIT HOURS	CATEGORY
1	Fundamentals of Phycology, Mycology & Bryology	3 (2-1)	Major
2	Pteridophytes & Gymnosperms	3 (2-1)	Major
3	Systematics of Angiosperms	3 (2-1)	Major
4	Animal Anatomy & Physiology	3 (2-1)	Major
5	Developmental Biology	3 (2-1)	Major
6	Principles of Animal Ecology	3 (2-1)	Major
Total Credit Hours = 18			

SEMESTER VI			
S.N.	COURSE	CREDIT HOURS	CATEGORY
1	Plant Physiology	3 (2-1)	Major
2	Plant Ecology	3 (2-1)	Major
3	Animal Behavior	3 (2-1)	Major
4	Economic Zoology	3 (2-1)	Major
5	Artificial Intelligence in Biological Sciences	3 (2-1)	Interdisciplinary
6	Research Methods & Biostatistics	3 (3-0)	Interdisciplinary
Total Credit Hours = 18			

SEMESTER VII			
S.N.	COURSE	CREDIT HOURS	CATEGORY
1	Elective – I *****	3	Major
2	Elective – II *****	3	Major
3	Elective – III *****	3	Major
4	Elective – IV *****	3	Major
5	Biosafety & Ethics	3 (3-0)	Interdisciplinary
Total Credit Hours = 15			

SEMESTER VIII			
S.N.	COURSE	CREDIT HOURS	CATEGORY
1	Elective – V *****	3	Major
2	Elective – VI *****	3	Major
3	Elective – VII *****	3	Major

4	Sustainable Development Goals	3 (3-0)	Interdisciplinary
5	Capstone Project	3	Capstone
Total Credit Hours = 15			

- * HEC designed **model courses** for general education may be used by the university.
- ** The university / concerned 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 may offer any course in the broader category of **“Social Sciences”** including but not limited to a course of Sociology, Social Work, Anthropology, Psychology, Education 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.
- ***** 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 within one of the specializations as **electives** keeping in view its available academic, human and infrastructural resources. **Credit combination** may be arranged in accordance with the nature of the course.

Degree Award Requirements

The following minimum requirements are prescribed for the award of BS Biology:

- a) All courses in the General Education category with titles and credit hours as prescribed in HEC Undergraduate Education Policy V 1.1. including the courses of “Pakistan Studies”, “Understanding of Holy Quran – I” and “Understanding of Holy Quran – II” must be completed.
- b) A minimum of **142** credit hours as prescribed in this document must be completed.
- c) A 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 / field experience.
- d) A supervised 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 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 a higher standard in this regard.
- f) The minimum duration to complete the degree is 8 regular semesters spread over 4 years whereas the maximum duration is 12 regular semesters spread over 6 years. The maximum duration may further be extended to 2 more semesters **(OR)** 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 BS

Major Specializations for BS Biology

The following are a few example specialization streams in case the BS Biology is offered with specialization. Subject to approval of the relevant statutory body, the department may develop additional specializations other than those prescribed below. 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: Biochemistry

Below is the recommended list of courses within the given specialization. The department concerned may offer courses from the following list or any other course as elective(s) relevant to the given specialization, keeping in view its available academic, human and infrastructural resources:

- a) Advanced Biochemistry
- b) Analytical Biochemistry
- c) Biochemical Genetics
- d) Biochemical Techniques
- e) Bioenergetics
- f) Bio-membrane System
- g) Clinical Biochemistry
- h) Enzymology
- i) Immunochemistry
- j) Lipid Biochemistry
- k) Metabolic Pathways
- l) Nutritional Biochemistry
- m) Pharmacological Biochemistry
- n) Protein Chemistry
- o) Signal Transduction

Specialization 2: Biophysics

Below is the recommended list of courses within the given specialization. The department concerned may offer courses from the following list or any other course as elective(s) relevant to the given specialization, keeping in view its available academic, human and infrastructural resources:

- a) Biomechanics
- b) Biophysical Chemistry
- c) Biophysical Instrumentation
- d) Cellular Biophysics
- e) Computational Biophysics
- f) Electrophysiology
- g) Imaging Techniques in Biology
- h) Molecular Biophysics
- i) Nano-biophysics
- j) Neuro-biophysics
- k) Photobiology
- l) Quantum Biology

- m) Radiation Biophysics
- n) Structural Biology
- o) Thermodynamics in Biology

Specialization 3: Biotechnology

Below is the recommended list of courses within the given specialization. The department concerned may offer courses from the following list or any other course as elective(s) relevant to the given specialization, keeping in view its available academic, human and infrastructural resources:

- a) Biofertilizers
- b) Bioprocess Engineering
- c) Biosensors & Biochips
- d) Biotech Regulations
- e) Cell & Tissue culture
- f) Gene Therapy
- g) Genetic Engineering
- h) Industrial Biotechnology
- i) Medical Biotechnology
- j) Molecular Diagnostics
- k) Nanobiotechnology
- l) Pharmaceutical Biotechnology
- m) Plant & Animal Biotechnology
- n) Recombinant DNA Technology
- o) Synthetic Biology

Specialization 4: Botany

Below is the recommended list of courses within the given specialization. The department concerned may offer courses from the following list or any other course as elective(s) relevant to the given specialization, keeping in view its available academic, human and infrastructural resources:

- a) Advanced Plant Physiology
- b) Advances in Plant Systematics
- c) Economic Botany
- d) Ethnobotany
- e) Forest Botany and dendrochronology
- f) Horticulture
- g) Medicinal Plants
- h) Paleobotany
- i) Phylogenomic
- j) Plant Hormones & Growth
- k) Plant Molecular Biology
- l) Plant Pathology
- m) Plant Tissue Culture
- n) Stress Physiology in Plants
- o) Weed Biology & Management

Specialization 5: Computational Biology

Below is the recommended list of courses within the given specialization. The department concerned may offer courses from the following list or any other course as elective(s) relevant to the given specialization, keeping in view its available academic, human and infrastructural resources:

- a) Algorithms in Bioinformatics
- b) Bioinformatics
- c) Biological Databases
- d) Computational Genomics
- e) Computational Neuroscience
- f) Data Visualization in Biology
- g) Genomic Data Analysis
- h) Machine Learning in Biology
- i) Molecular Modeling & Simulation
- j) Next-Gen Sequencing Analysis
- k) Protein Structure Prediction & Drug Design
- l) RNA-seq Data Analysis
- m) Statistical Genomics

Specialization 6: Environmental Biology

Below is the recommended list of courses within the given specialization. The department concerned may offer courses from the following list or any other course as elective(s) relevant to the given specialization, keeping in view its available academic, human and infrastructural resources:

- a) Aquatic Ecology
- b) Biodiversity & Ecosystem Services
- c) Climate Change
- d) Conservation Biology
- e) Ecological Modeling
- f) Environmental Impact Assessment
- g) Environmental Microbiology
- h) Environmental Toxicology
- i) Pollution Biology
- j) Restoration Ecology
- k) Sustainable Agriculture
- l) Urban Ecology
- m) Waste Management & Bioremediation
- n) Wetland Ecology
- o) Wildlife Conservation & Management

Specialization 7: Marine Biology

Below is the recommended list of courses within the given specialization. The department concerned may offer courses from the following list or any other course as elective(s) relevant to the given specialization, keeping in view its available academic, human and infrastructural resources:

- a) Aquaculture
- b) Blue Economy

- c) Coastal Zone Management
- d) Coral Reef Biology
- e) Fisheries Biology
- f) Marine Biodiversity
- g) Marine Biotechnology
- h) Marine Botany
- i) Marine Conservation
- j) Marine Ecology
- k) Marine Invertebrates
- l) Marine Microbiology
- m) Marine Pollution & Toxicology
- n) Marine Vertebrates
- o) Oceanography

Specialization 8: Microbiology

Below is the recommended list of courses within the given specialization. The department concerned may offer courses from the following list or any other course as elective(s) relevant to the given specialization, keeping in view its available academic, human and infrastructural resources:

- a) Antimicrobial Resistance
- b) Environmental Microbiology
- c) Food Microbiology
- d) Host-pathogen Interaction
- e) Immunology
- f) Industrial Microbiology
- g) Medical Microbiology
- h) Microbial Biotechnology
- i) Microbial Ecology
- j) Microbial Genetics
- k) Microbial Genomics
- l) Microbial Physiology
- m) Mycology
- n) Pathogenic Microorganisms
- o) Virology

Specialization 9: Zoology

Below is the recommended list of courses within the given specialization. The department concerned may offer courses from the following list or any other course as elective(s) relevant to the given specialization, keeping in view its available academic, human and infrastructural resources:

- a) Animal Histology
- b) Animal Pathology
- c) Aquatic Zoology
- d) Comparative Anatomy
- e) Endocrinology
- f) Entomology

- g) Ethology
- h) Herpetology
- i) Ichthyology
- j) Mammalogy
- k) Ornithology
- l) Paleontology
- m) Reproductive Biology
- n) Wildlife Biology
- o) Zoogeography

COURSE LEARNING OUTCOMES

AD & BS

(Arranged in Alphabetical Order)

Animal Anatomy & Physiology

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

- a) Understand the structural organization and functions of various organ systems in animals.
- b) Elaborate the physiological mechanisms.
- c) Analyze the relationship between anatomical structures and physiological processes.

Animal Behavior

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

- a) Understand the fundamental principles governing animal behavior.
- b) Identify environmental and genetic factors influencing behavioral patterns.
- c) Analyze the adaptive significance of behavioral traits.

Artificial Intelligence in Biological Sciences

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

- a) Understand the basic concept of artificial intelligence and its emerging role in biological sciences.
- b) Recognize common AI tools and their simple applications in areas such as genetics, ecology, and health sciences.
- c) Interpret basic outputs from AI-assisted tools used in biological problem-solving.

Biodiversity & Conservation

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

- a) Understand the concept, types, and importance of biodiversity.
- b) Identify threats to biodiversity and their underlying causes.
- c) Analyze strategies and policies for biodiversity conservation at various levels.

Biophysics

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

- a) Understand the basic physical principles underlying biological structure and function.
- b) Identify the role of biophysical techniques and instrumentation in studying biological systems.
- c) Interpret biological phenomena using quantitative and conceptual approaches from physics.

Biosafety & Ethics

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

- d) Understand the principles of biosafety, biosecurity, and risk assessment in biological research.
- e) Identify ethical issues and regulatory frameworks related to biological sciences.
- f) Analyze case studies to evaluate responsible conduct and compliance in biological research and applications.

Developmental Biology

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

- a) Understand the stages and mechanisms of development in multicellular organisms.
- b) Identify genetic and molecular pathways regulating differentiation.
- c) Analyze developmental abnormalities and their biological causes.

Diversity of Animals

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

- a) Understand the classification and characteristics of major animal phyla.
- b) Identify structural and functional diversity across invertebrate and vertebrate groups.
- c) Analyze evolutionary trends and ecological roles of animals.

Diversity of Plants

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

- a) Understand the classification and morphological diversity of plant groups.
- b) Identify major plant taxa and their evolutionary adaptations.
- c) Analyze the ecological significance and applications of plant diversity.

Economic Zoology

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

- a) Understand the economic importance of various animal groups in agriculture, industry, and public health.
- b) Identify beneficial and harmful animal species and their roles in the economy.
- c) Analyze strategies for sustainable utilization and management of economically significant animal resources.

Fundamentals of Genetics & Evolution

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

- a) Understand the basic principles of heredity and genetic variation.
- b) Describe the mechanisms of evolution and speciation.
- c) Analyze genetic data to explain patterns of inheritance and evolutionary change.

Fundamentals of Phycology, Mycology & Bryology

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

- a) Understand the taxonomy, structure, and reproduction of algae, fungi and bryophytes.
- b) Identify various genera and ecological role of thallophytes and bryophytes.
- c) Analyze their significance in ecosystems.

Fundamentals of Plant Taxonomy

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

- a) Understand the principles and rules of plant classification and nomenclature.
- b) Identify key morphological characteristics used in plant identification.
- c) Apply taxonomic tools and techniques to classify and differentiate plant species.

Introduction to Cell & Molecular Biology

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

- a) Understand the structure and functions of cell and cellular components including cellular processes.
- b) Explain the structure and function of micro and macromolecules necessary for life.
- c) Analyze the role of cellular and molecular mechanisms in growth, development, and disease.

Introduction to Plant Anatomy & Embryology

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

- a) Understand the internal structure and organization of plant tissues and organs.
- b) Describe processes of plant reproduction and embryogenesis.
- c) Analyze structure–function relationships through microscopic examination.

Invertebrate Zoology

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

- d) Understand the diversity and classification of invertebrate phyla.
- e) Describe anatomical, physiological, and reproductive features of invertebrate groups.
- f) Analyze the ecological roles and evolutionary adaptations of invertebrates.

Plant Ecology

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

- a) Understand the ecological principles governing plant populations and communities.
- b) Describe plant responses to environmental factors and inter-species interactions.

- c) Analyze plant distribution and dynamics using ecological models.

Plant Physiology

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

- a) Understand major physiological processes including photosynthesis, respiration, transpiration and water transport.
- b) Describe the role of plant hormones in growth and development.
- c) Analyze physiological responses of plants to biotic and abiotic factors.

Principles of Animal Ecology

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

- a) Understand ecological interactions between animals and their environment.
- b) Describe concepts of population dynamics, competition, and predator-prey relationships.
- c) Analyze ecological data to interpret patterns of animal behavior and distribution.

Principles of Biochemistry

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

- a) Understand the structure and function of biomolecules.
- b) Describe metabolic pathways and energy transformations in biological systems.
- c) Analyze biochemical reactions and their regulation in living cells.

Principles of Biology

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

- a) Understand fundamental biological concepts across molecular, cellular, and ecological levels.
- b) Describe the organization and functioning of life from cells to ecosystems.
- c) Apply basic biological knowledge to explain natural phenomena.

Principles of Microbiology

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

- a) Understand the diversity, structure, and classification of microorganisms.
- b) Describe microbial metabolism, growth, and reproduction.
- c) Analyze the role of microbes in health, environment, and biotechnology.

Pteridophytes & Gymnosperms

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

- a) Understand the morphology, anatomy, and reproduction of pteridophytes and gymnosperms.
- b) Classify and compare life cycles of seedless and seed-bearing vascular plants.
- c) Analyze their evolutionary significance and ecological adaptations.

Research Methods & Biostatistics

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

- a) Understand fundamental concepts of biostatistics and research methodology in the context of biological sciences.
- b) Develop research questions, design experiments, and evaluate scientific literature using standardized research methods.
- c) Apply appropriate statistical tools to analyze biological data and interpret results.

Sustainable Development Goals

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

- a) Understand the United Nations Sustainable Development Goals and their relevance to biology.
- b) Discuss biological challenges linked to sustainability, such as health, climate and biodiversity.
- c) Analyze biological contributions and innovations supporting sustainable development.

Systematics of Angiosperms

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

- a) Understand classification systems and phylogenetic relationships among flowering plants.
- b) Identify diagnostic features of major angiosperm families.
- c) Apply systematic techniques for the identification and comparison of angiosperms.

Vertebrate Zoology

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

- a) Understand the diagnostic features of vertebrates and their classification.
- b) Identify structural and functional adaptations in vertebrates.
- c) Analyze evolutionary relationships among vertebrates.

STANDARDS FOR EQUIVALENCE & PATHWAYS FOR FURTHER EDUCATION

To facilitate academic progression and ensure subject-specific readiness, graduates of the BS Biology program may obtain equivalence with related disciplines by completing additional coursework in the relevant subject area. The following guidelines define the credit requirements necessary for equivalence with undergraduate degrees in different fields / specializations of Biology enabling graduates to pursue advanced studies in these specialized domains.

BIOCHEMISTRY

Standard for Equivalence – BS Biology to BS Biochemistry

To obtain equivalence with a BS Biochemistry degree, a graduate of the BS Biology program must fulfill the following additional academic requirements in the domain of Biochemistry:

- a) 21 credit hours of elective courses in Biochemistry
- b) 3 credit hours of capstone project in Biochemistry
- c) 3 credit hours of internship in Biochemistry
- d) 15 credit hours of minor coursework in Biochemistry

In addition to the above 42 credit hours specific to Biochemistry, a minimum of 18 credit hours of foundational biology courses will be considered toward the total 60 credit hours required in the major discipline. This meets 83% of the 72-credit hour major requirement, in accordance with HEC's equivalence standards. Students seeking equivalence will be required to complete the aforementioned requirements in accordance with the academic, operational, and assessment protocols set by the respective university, which may include an additional semester if necessary.

Eligibility for Admission to MS/MPhil in Biochemistry

A BS Biology graduate who has fulfilled the above equivalence criteria will be eligible to apply for admission to an MS/MPhil program in Biochemistry. However, if any subject-specific deficiencies remain, the admitting institution may require the student to complete up to 9 credit hours of deficiency courses, as permitted under the HEC Graduate Education Policy 2023.

BIOPHYSICS

Standard for Equivalence – BS Biology to BS Biophysics

To obtain equivalence with a BS Biophysics degree, a graduate of the BS Biology program must fulfill the following additional academic requirements in the domain of Biophysics:

- a) 21 credit hours of elective courses in Biophysics
- b) 3 credit hours of capstone project in Biophysics
- c) 3 credit hours of internship in Biophysics
- d) 15 credit hours of minor coursework in Biophysics

In addition to the above 42 credit hours specific to Biophysics, a minimum of 18 credit hours of foundational biology courses will be considered toward the total 60 credit hours required in the major discipline. This meets 83% of the 72-credit hour major requirement, in accordance with HEC's equivalence standards. Students seeking equivalence will be required to complete the aforementioned

requirements in accordance with the academic, operational, and assessment protocols set by the respective university, which may include an additional semester if necessary.

Eligibility for Admission to MS/MPhil in Biophysics

A BS Biology graduate who has fulfilled the above equivalence criteria will be eligible to apply for admission to an MS/MPhil program in Biophysics. However, if any subject-specific deficiencies remain, the admitting institution may require the student to complete up to 9 credit hours of deficiency courses, as permitted under the HEC Graduate Education Policy 2023.

BIOTECHNOLOGY

Standard for Equivalence – BS Biology to BS Biotechnology

To obtain equivalence with a BS Biotechnology degree, a graduate of the BS Biology program must fulfill the following additional academic requirements in the domain of Biotechnology:

- a) 21 credit hours of elective courses in Biotechnology
- b) 3 credit hours of capstone project in Biotechnology
- c) 3 credit hours of internship in Biotechnology
- d) 15 credit hours of minor coursework in Biotechnology

In addition to the above 42 credit hours specific to Biotechnology, a minimum of 18 credit hours of foundational biology courses will be considered toward the total 60 credit hours required in the major discipline. This meets 83% of the 72-credit hour major requirement, in accordance with HEC's equivalence standards. Students seeking equivalence will be required to complete the aforementioned requirements in accordance with the academic, operational, and assessment protocols set by the respective university, which may include an additional semester if necessary.

Eligibility for Admission to MS/MPhil in Biotechnology

A BS Biology graduate who has fulfilled the above equivalence criteria will be eligible to apply for admission to an MS/MPhil program in Biotechnology. However, if any subject-specific deficiencies remain, the admitting institution may require the student to complete up to 9 credit hours of deficiency courses, as permitted under the HEC Graduate Education Policy 2023.

BOTANY

Standard for Equivalence – BS Biology to BS Botany

To obtain equivalence with a BS Botany degree, a graduate of the BS Biology program must fulfill the following additional academic requirements in the domain of Botany:

- a) 21 credit hours of elective courses in Botany
- b) 3 credit hours of capstone project in Botany
- c) 3 credit hours of internship in Botany
- d) 15 credit hours of minor coursework in Botany

In addition to the above 42 credit hours specific to Botany, a minimum of 18 credit hours of foundational biology courses will be considered toward the total 60 credit hours required in the major discipline. This meets 83% of the 72-credit hour major requirement, in accordance with HEC's equivalence standards. Students seeking equivalence will be required to complete the aforementioned

requirements in accordance with the academic, operational, and assessment protocols set by the respective university, which may include an additional semester if necessary.

Eligibility for Admission to MS/MPhil in Botany

A BS Biology graduate who has fulfilled the above equivalence criteria will be eligible to apply for admission to an MS/MPhil program in Botany. However, if any subject-specific deficiencies remain, the admitting institution may require the student to complete up to 9 credit hours of deficiency courses, as permitted under the HEC Graduate Education Policy 2023.

COMPUTATIONAL BIOLOGY

Standard for Equivalence – BS Biology to BS Computational Biology

To obtain equivalence with a BS Computational Biology degree, a graduate of the BS Biology program must fulfill the following additional academic requirements in the domain of Computational Biology:

- a) 21 credit hours of elective courses in Computational Biology
- b) 3 credit hours of capstone project in Computational Biology
- c) 3 credit hours of internship in Computational Biology
- d) 15 credit hours of minor coursework in Computational Biology

In addition to the above 42 credit hours specific to Computational Biology, a minimum of 18 credit hours of foundational biology courses will be considered toward the total 60 credit hours required in the major discipline. This meets 83% of the 72-credit hour major requirement, in accordance with HEC's equivalence standards. Students seeking equivalence will be required to complete the aforementioned requirements in accordance with the academic, operational, and assessment protocols set by the respective university, which may include an additional semester if necessary.

Eligibility for Admission to MS/MPhil in Computational Biology

A BS Biology graduate who has fulfilled the above equivalence criteria will be eligible to apply for admission to an MS/MPhil program in Computational Biology. However, if any subject-specific deficiencies remain, the admitting institution may require the student to complete up to 9 credit hours of deficiency courses, as permitted under the HEC Graduate Education Policy 2023.

ENVIRONMENTAL BIOLOGY

Standard for Equivalence – BS Biology to BS Environmental Biology

To obtain equivalence with a BS Environmental Biology degree, a graduate of the BS Biology program must fulfill the following additional academic requirements in the domain of Environmental Biology:

- a) 21 credit hours of elective courses in Environmental Biology
- b) 3 credit hours of capstone project in Environmental Biology
- c) 3 credit hours of internship in Environmental Biology
- d) 15 credit hours of minor coursework in Environmental Biology

In addition to the above 42 credit hours specific to Environmental Biology, a minimum of 18 credit hours of foundational biology courses will be considered toward the total 60 credit hours required in the major discipline. This meets 83% of the 72-credit hour major requirement, in accordance with HEC's equivalence standards. Students seeking equivalence will be required to complete the

aforementioned requirements in accordance with the academic, operational, and assessment protocols set by the respective university, which may include an additional semester if necessary.

Eligibility for Admission to MS/MPhil in Environmental Biology

A BS Biology graduate who has fulfilled the above equivalence criteria will be eligible to apply for admission to an MS/MPhil program in Environmental Biology. However, if any subject-specific deficiencies remain, the admitting institution may require the student to complete up to 9 credit hours of deficiency courses, as permitted under the HEC Graduate Education Policy 2023.

MARINE BIOLOGY

Standard for Equivalence – BS Biology to BS Marine Biology

To obtain equivalence with a BS Marine Biology degree, a graduate of the BS Biology program must fulfill the following additional academic requirements in the domain of Marine Biology:

- a) 21 credit hours of elective courses in Marine Biology
- b) 3 credit hours of capstone project in Marine Biology
- c) 3 credit hours of internship in Marine Biology
- d) 15 credit hours of minor coursework in Marine Biology

In addition to the above 42 credit hours specific to Marine Biology, a minimum of 18 credit hours of foundational biology courses will be considered toward the total 60 credit hours required in the major discipline. This meets 83% of the 72-credit hour major requirement, in accordance with HEC's equivalence standards. Students seeking equivalence will be required to complete the aforementioned requirements in accordance with the academic, operational, and assessment protocols set by the respective university, which may include an additional semester if necessary.

Eligibility for Admission to MS/MPhil in Marine Biology

A BS Biology graduate who has fulfilled the above equivalence criteria will be eligible to apply for admission to an MS/MPhil program in Marine Biology. However, if any subject-specific deficiencies remain, the admitting institution may require the student to complete up to 9 credit hours of deficiency courses, as permitted under the HEC Graduate Education Policy 2023.

MICROBIOLOGY

Standard for Equivalence – BS Biology to BS Microbiology

To obtain equivalence with a BS Microbiology degree, a graduate of the BS Biology program must fulfill the following additional academic requirements in the domain of Microbiology:

- a) 21 credit hours of elective courses in Microbiology
- b) 3 credit hours of capstone project in Microbiology
- c) 3 credit hours of internship in Microbiology
- d) 15 credit hours of minor coursework in Microbiology

In addition to the above 42 credit hours specific to Microbiology, a minimum of 18 credit hours of foundational biology courses will be considered toward the total 60 credit hours required in the major discipline. This meets 83% of the 72-credit hour major requirement, in accordance with HEC's equivalence standards. Students seeking equivalence will be required to complete the aforementioned

requirements in accordance with the academic, operational, and assessment protocols set by the respective university, which may include an additional semester if necessary.

Eligibility for Admission to MS/MPhil in Microbiology

A BS Biology graduate who has fulfilled the above equivalence criteria will be eligible to apply for admission to an MS/MPhil program in Microbiology. However, if any subject-specific deficiencies remain, the admitting institution may require the student to complete up to 9 credit hours of deficiency courses, as permitted under the HEC Graduate Education Policy 2023.

ZOOLOGY

Standard for Equivalence – BS Biology to BS Zoology

To obtain equivalence with a BS Zoology degree, a graduate of the BS Biology program must fulfill the following additional academic requirements in the domain of Zoology:

- a) 21 credit hours of elective courses in Zoology
- b) 3 credit hours of capstone project in Zoology
- c) 3 credit hours of internship in Zoology
- d) 15 credit hours of minor coursework in Zoology

In addition to the above 42 credit hours specific to Zoology, a minimum of 18 credit hours of foundational biology courses will be considered toward the total 60 credit hours required in the major discipline. This meets 83% of the 72-credit hour major requirement, in accordance with HEC's equivalence standards. Students seeking equivalence will be required to complete the aforementioned requirements in accordance with the academic, operational, and assessment protocols set by the respective university, which may include an additional semester if necessary.

Eligibility for Admission to MS/MPhil in Zoology

A BS Biology graduate who has fulfilled the above equivalence criteria will be eligible to apply for admission to an MS/MPhil program in Zoology. However, if any subject-specific deficiencies remain, the admitting institution may require the student to complete up to 9 credit hours of deficiency courses, as permitted under the HEC Graduate Education Policy 2023.