هيئة تقويم التعليم والتدريب
Education & Training Evaluation Commission

اعتماد
NCAAA

Key Learning Outcomes for General Biology Programs

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Introduction

Based on the mandate of the Education and Training Evaluation Commission (ETEC), by virtue of Council of Ministers decision No. 108, dated 14/2/1440 AH, which included the Commission competencies amongst which is "building systems for evaluation and accreditation - including institutional and programmatic - in education and training, encompassing rules, standards, frameworks and indicators and related terms, procedures, approval, and application" and with the same concern to build and develop high-quality national academic programs, the ETEC worked on preparing specialized academic standards for General Biology Programs. This document aims to contribute to the establishment of minimum requirements for Bachelor's programs in General Biology specialization to achieve the academic quality of programs and to ensure that graduates are highly qualified in the field of General Biology, possessing the knowledge, skills, and values required by the labor market, and national trends, in line with the best practices required for the academic and professional of the field.

Goals

The purpose of this work is to develop the minimum of knowledge units (KUs) in the field of General Biology, specifying a set of Specialized Learning Outcomes (SLOs) students are expected to acquire after completing their studies. This document lays the foundations for the design of the academic program and the study plans. It facilitates selecting the appropriate teaching methods and the proper evaluation strategies and tools, which should contribute toward aligning the academic programs with the labor market.

Methodology

This document describes minimum General and Specific Knowledge Units (GKUs & SKUs) in the General Biology field. The Learning Outcomes (LOs) of each Knowledge Unit (KU) set the threshold for what the students are expected to learn and be able to do after successfully completing that Knowledge Unit. Educational institutions should take into account the depth and breadth of these Knowledge Units so that learning outcomes integrate communication skills and values into the curriculum. Institutions can also offer additional knowledge units that are consistent with their objectives. It should also be noted that the knowledge unit is not necessarily an independent course; one or more courses can cover a single knowledge unit. Likewise, one course could also cover one or more knowledge units entirely or partially.

The methodology follows the following phases:

I- Survey and benchmarking:

- Benchmarking with International learned society and professional body.
- Benchmarks with top-rated international and local Universities.
- Identification of national labor market requirements.
- Incorporating specialists and experts' input from different sectoral groups.

II - Preparation of the contents of the Specialized Standards document:

- Identifying Program Key Learning Outcomes (KLOs).
- Defining the general characteristics of the curriculum.
- Development of General Knowledge Units (GKUs) and Specific Knowledge Units (SKUs) for each GKU.
- Formulation of Specialized Learning Outcomes (SLOs) for each Specific Knowledge Unit (SKU).
- Determine the minimum topics required for each Specific Knowledge Unit (SKU).
- Describe the methodology for aligning academic content with the National Qualification Framework (NQF).

The Knowledge Units (KUs) are derived from analyzing several high-ranked QS Universities and international regularity bodies/associations (see Appendix A).

The ETEC developed this document in cooperation and coordination with different entities in the field of General Biology, such as the different Biology programs at local universities in Saudi Arabia.

Scope and Uses

This document covers the Bachelor's degree programs in General Biology. The document can be applied to General Biology programs offered by public and private higher education institutions in Saudi Arabia.

Terms

Education and Training Evaluation Commission (ETEC): competent and independent body aimed at evaluating, assessing, and accrediting qualifications in education and training in both public and private sectors, raising the quality and efficiency of those qualifications and ensuring they contribute to the national economy and development.

National Qualifications Framework (NQF): A comprehensive and uniform structure for building, organizing, and categorizing qualifications into levels based on learning outcomes.

Learning Outcomes (LOs): Description of what a learner is expected to know, understand, and be able to do, which is represented in his/her behavior at the end of a specific educational program.

Key Learning Outcomes (KLOs): The minimum required Learning Outcomes (LOs) in the discipline students are expected to obtain.

Knowledge Units (KUs): mandatory multiple related topics that must be included in an institution's degree program.

Essential Knowledge Units (EKUs): knowledge units necessary for future learning in a given discipline

General Knowledge Units (GKUs): Knowledge Units that should be introduced to students majoring in a discipline

Specific Knowledge Units (SKUs): Knowledge Units derived from a General Knowledge Unit (GKU)

Specialized Learning Outcomes (SLOs): Learning Outcomes (LOs) for a Specific Knowledge Unit (SKUs)

Key Learning Outcomes

Key Learning Outcomes (KLOs) describe the essential knowledge, skills, and values that graduates of the General Biology undergraduate program will be able to demonstrate once they complete the program.

On successful completion of a bachelor's degree in General Biology, graduates should be able to:

KLO1: Explain the structural bases and crucial processes of life within the wide scope of biology over the ascending levels of organization from molecules to ecosystems, with integration of the evolutionary and inheritance principles.

KLO2: Recognize the fact that cells are the basic structural and functional units of life with regard to their highly specialized molecular mechanisms and biochemical processes.

KLO3: Relate the quantitative reasoning and the basic principles derived from the physical sciences to build up critical thinking about biological issues.

KLO4: Apply the acquired biology knowledge and research skills in association with critical thinking skills to conduct field or laboratory research projects.

KLO5: Test the generated hypotheses and employ the science-based evidence to distinguish between the scientific claims presented in various sources.

KLO6: Evaluate critically, analyze data using the proper statistical methods and draw sound conclusions.

KLO7: Demonstrate the ability to work independently or in a team to perform a research activity.

KLO8: Communicate the scientific issues and convey ideas and opinions clearly through professional writing and oral skills.

KLO9: Adhere to the ethical principles and rules, and take into consideration that the practice of biology has ethical, social, and legal implications.

Curriculum General Criteria

Based on a benchmarking study of leading universities (Appendix A) and analyzing all knowledge units (KUs) and skills using Biology programs, it is found that these KUs are grouped into the following categories:

1. Essential knowledge units: 36 credit hours
2. General knowledge and skills units: 76 credit hours
3. Specialized knowledge units

Each group consists of different subgroups that are essential in any typical Biology. To show the importance of each of the subgroups, a range of allocated credit hours in a typical [Biology] is shown in the next section.

Knowledge Units

The following table provides an overall view of the curriculum distribution of Knowledge Units: essential, general, specialized and others. The tables also provide general recommendations on the acceptable range of credit hours for each knowledge unit.

Essential Knowledge Units (EKU)

Calculated based on a minimum of 36 credit hours for Chemistry, Physics, Mathematics, Biostatistics, English Language, Interpersonal and Communication Skills, and Graduation Research Project. This part of the knowledge units should not be used in standardized tests.

Table 1: Essential Knowledge Units of Biology Program

#	EKU	Description	Minimum Requirements (credit hours)
1	Chemistry	This knowledge unit introduces students to the principles of chemistry that are essential to Biology major.	8
2	Physics	This knowledge unit introduces students to the principles of physics that are essential to Biology major.	6
3	Mathematics	This unit introduces students to the principles of Mathematics that are essential to Biology major.	6
4	Statistics	This unit introduces students to the principles of Biostatistics that are essential to Biology major.	3
5	English Language	This unit introduces students to the principles of the English language that are essential to Biology major.	8
6	Interpersonal and Communication Skills	This unit introduces students to the relevant ethical principles and rules, work independency, collaborative laboratory and field research activities, and communication skills.	2
7	Graduation Research Project	This unit introduces students to the induction of a research work related to one of the topics in biology program. The assigned research projects allow students to explore areas of interest across the various biology disciplines	3

Program core Knowledge Units

Percentages are calculated based on a minimum of credits for the Biology program.

Table 2: Generalized and Specialized Knowledge Units of Biology Program

#	GKU	Weight%	SKU	Weight%
1	Animal and Plant Biology	24	1.1. General biology	9
			1.2. Cell biology	6
			1.3. Developmental biology	4
			1.4. Plant biology	5
2	Physiology	7	2.1. Animal physiology	7
3	Biology of Microbes	12	3.1. Bacteriology	4
			3.2. Virology	4
			3.3. Mycology	4
4	Ecology and Environmental Science	16	4.1. Environmental science	5
			4.2. Animal behavior	3
			4.3. Marine environment	4
			4.4. Biodiversity	4
5	Immunobiology	5	5.1. Immunology	5
6	Cell Chemistry	14	6.1. Biochemistry	8
			6.2. Molecular biology	6
7	Genetics	13	7.1. Genetics and genomics	9
			7.2 Molecular genetics	4
8	Evolution	9	8.1. Evolution	5
			8.2 Evolutionary biology	4

Appendix (A): International Practices analysis

The KUs are derived from the following sources:

1. University of Cambridge, UK
2. Cornell University, USA
3. University of Pennsylvania, USA
4. University of Melbourne, Australia
5. Duke University, Trinity of Arts & Sciences, USA
6. University of North Carolina at Chapel Hill, USA

Table A1: International and local universities considered in the analysis of Biology program requirements

#	University	Department name	US News Ranking 2023	QS University Ranking 2023
1	University of Cambridge, UK	School of the Biological Sciences	8	2
2	Cornell University, USA	College of Agriculture and Life Sciences and the College of Arts & Sciences	17	20
3	University of Pennsylvania, USA	Department of Biology in the School of Arts and Sciences	7	13
4	University of Melbourne, Australia	School of Biosciences	27	33
5	Duke University, Trinity of Arts & Sciences, USA	Department of Biology	10	50
6	University of North Carolina at Chapel Hill, USA	Department of Biology	29	102

Required Subjects/Topics in Top International and Local Universities

Table A2: Biology program required Subjects/Topics in elite International and local Universities

GKUs	SKUs	U1	U2	U3	U4	U5	U6	Count	
								Total	Note
Animal and Plant Biology	General biology	Y	Y	Y	Y	Y	Y	100%	A
	Cell biology	Y	Y	Y	Y	Y	Y	100%	A
	Developmental biology	Y	Y	Y	Y	Y		83%	A
	Plant biology	Y	Y	Y	Y	Y	Y	100%	A
Physiology	Animal physiology	Y	Y	Y	Y	Y	Y	100%	A
Biology of Microbes	Bacteriology	Y	Y	Y	Y	Y	Y	100%	A
	Virology	Y	Y	Y	Y	Y	Y	100%	A
	Mycology	Y	Y	Y	Y	Y	Y	100%	A
Ecology and Environmental Science	Environmental science	Y	Y		Y	Y		66%	A
	Animal behavior			Y	Y	Y	Y	66%	A
	Marine environment		Y		Y	Y	Y	66%	A
	Biodiversity	Y	Y		Y		Y	66%	A
Immunobiology	Immunology		Y	Y	Y	Y		66%	A
Cell Chemistry	Biochemistry	Y	Y	Y	Y	Y		83%	A
	Molecular biology	Y	Y	Y	Y			66%	A
Genetics	Genetics and genomics	Y	Y	Y	Y	Y		83%	A
	Molecular genetics		Y	Y		Y	Y	66%	A
Evolution	Evolution	Y		Y	Y	Y	Y	83%	A
	Evolutionary biology		Y	Y	Y	Y	Y	83%	A

- Any specialized knowledge unit that was taught by 65 % or more of the universities should be considered an important SKU and should be recommended and Labeled "A."
- If the comparison showed that a particular SKU scored below 65% and was believed to be important, they should be further screened by applying another acceptance condition as defined in the FE exam by QIYAS and SCE. The SKUs that satisfy this condition are recommended and labeled by "B."
- SKUs not meeting the above conditions should not be recommended, labeled by "C," and eliminated from Specialized Learning Outcomes.
- The comparisons should be made based on the course descriptions. If no syllabus is available, a consensus should be made.

Appendix (B): Alignment of Key Learning Outcomes of Biology Program with NQF.

Alignment of the Key Learning Outcomes for Biology Program with the NQF.

Biology Program Key Learning Outcomes	NQF Learning Areas		
	Knowledge and understanding	Skills	Values, Autonomy, and Responsibility
1	✓		
2	✓		
3	✓		
4		✓	
5		✓	
6		✓	
7			✓
8			✓
9			✓

Appendix (C): Learning Outcomes and Topics for Knowledge Units

Essential Knowledge Unit (EKU 1): Chemistry

Description	This unit introduces students to the essential basic principles of inorganic and organic chemistry needed as a foundation for upper courses.
Topics	**The following topics must be included in this SKU:** 1. Atomic structure: the basic principles of atomic theory, including atomic structure, electron configurations, and periodic trends. 2. Chemical bonding: the different types of chemical bonding, including ionic, covalent, and metallic bonding. 3. Chemical reactions: the principles of chemical reactions, including stoichiometry, reaction rates, and equilibrium. 4. States of matter: the behavior of gases, liquids, and solids, including phase transitions, intermolecular forces, and properties of solutions. 5. Acids and bases: the principles of acid-base chemistry, including pH, buffers, and acid-base titrations. 6. Organic chemistry: the basic principles of organic chemistry, including functional groups, nomenclature, and reactions of organic compounds. 7. Thermochemistry: the principles of thermodynamics, including enthalpy, entropy, and free energy. 8. Electrochemistry: the principles of electrochemistry, including redox reactions, electrolysis, and electrochemical cells. 9. Kinetics: the study of reaction rates and mechanisms, including factors that affect reaction rate and the use of rate laws. 10. Nuclear chemistry: the basic principles of nuclear chemistry, including nuclear reactions, radioactivity, and the use of isotopes in medicine and industry.
Specialized Learning Outcome	**By completing this EKU, students should be able to:** 1. Compare the properties and behavior of gases, liquids, and solids, including phase transitions and intermolecular forces. 2. Explain the basic principles of organic chemistry, including functional groups, nomenclature, and reactions of organic compounds. 3. Apply the fundamental principles of atomic and molecular structure, chemical bonding, and chemical reactions to analyze and solve problems involving the behavior of matter and its interactions. 4. Examine acid-base chemistry, including pH, buffers, and acid-base titrations, and apply these principles to solve chemical problems. 5. Analyze the principles of thermodynamics, including enthalpy, entropy, and free energy, and apply these principles to chemical systems. 6. Outline the applications of electrochemistry principles, including redox reactions, electrolysis, and electrochemical cells, in the fields of industry and technology. 7. Apply mathematical and analytical reasoning to chemical experiments. **The table below maps the Specialized Learning Outcomes for the SKU to the KLOs**

SLOs	KLOs								
	KLO1	KLO2	KLO3	KLO4	KLO5	KLO6	KLO7	KLO8	KLO9
SLO1	✓								
SLO2	✓								
SLO3				✓					
SLO4				✓					
SLO5				✓					
SLO6				✓					
SLO7					✓				

Essential Knowledge Unit (EKU 2): Physics

Description	This unit introduces students to the essential basic principles of physics needed as a foundation for upper courses.
Topics	**The following topics must be included in this SKU:** 1. Kinematics: describing motion in one and two dimensions. 2. Newton's laws of motion: force, mass, and acceleration. 3. Work, energy, and power: the relationships between force, work, and energy. 4. Conservation of energy and momentum: the principles of conservation in physical systems. 5. Rotational motion: the motion of objects rotating around a fixed axis. 6. Oscillations and waves: the motion of systems that repeat themselves. 7. Thermodynamics: the study of heat, temperature, and energy transfer. 8. Electromagnetism: the study of electric and magnetic fields and their interactions. 9. Optics: the study of light and its behavior in various media and systems. 10. Modern physics: an introduction to relativity, quantum mechanics, and particle physics.
Specialized Learning Outcome	**By completing this EKU, students should be able to:** 1. Describe the principles of rotational motion, oscillations and waves, and thermodynamics. 2. Compare electric and magnetic fields and understand the behavior of charged particles in these fields. 3. Explain the behavior of light in various media and systems by using the basic principles of optics. 4. Analyze and solve physical problems involving motion, forces, energy, and momentum by using the fundamental principles of classical mechanics, including Newton's laws of motion. 5. Apply mathematical and analytical reasoning to explain physical phenomena. 6. Interpret the basic concepts of modern physics, including relativity, quantum mechanics, and particle physics. 7. Communicate scientific concepts and results effectively through written and oral presentations. **The table below maps the Specialized Learning Outcomes for the SKU to the KLOs**

SLOs	KLOs								
	KLO1	KLO2	KLO3	KLO4	KLO5	KLO6	KLO7	KLO8	KLO9
SLO1	✓								
SLO2	✓								
SLO3	✓								
SLO4				✓					
SLO5				✓					
SLO6							✓		
SLO7							✓		

Essential Knowledge Unit (EKU 3): Mathematics

Description	This unit introduces students to the essential basic principles of mathematics needed as a foundation for upper courses.
Topics	**The following topics must be included in this SKU:** 1. Arithmetic: Basic operations with whole numbers, fractions, decimals, and percentages. 2. Algebra: Solving linear equations and inequalities, graphing linear equations, and basic operations with polynomials. 3. Complex numbers. 4. Geometry: Properties of lines, angles, triangles, and basic 2D and 3D shapes. 5. Matrices: Understanding basic matrix operations, including addition, subtraction, multiplication, and inversion. 6. Hyperbolic functions. 7. Trigonometry: Understanding basic trigonometric functions, including sine, cosine, and tangent, and their use in solving problems involving right triangles. 8. Exponents and logarithms: Understanding the relationship between exponents and logarithms and using logarithmic functions to solve equations. 9. Calculus: Basic concepts of calculus, including limits, derivatives, and integrals. 10. Applications of mathematics: Understanding how mathematics is used in various fields, including science, engineering, and finance.
Specialized Learning Outcome	**By completing this EKU, students should be able to:** 1. Demonstrate understanding of fundamental mathematical concepts, including arithmetic, algebra, and geometry. 2. Use mathematical software proficiently, including calculators and computer programs, to solve problems and analyze data. 3. Apply algebraic concepts to solve equations, including linear and quadratic equations. 4. Use geometric concepts and techniques to solve problems related to area, perimeter, volume, and surface area. 5. Create and interpret graphs and charts to represent mathematical data and relationships. 6. Use mathematical terminology and symbols correctly and precisely to communicate mathematical ideas and solutions. 7. Apply mathematical concepts to real-world situations, including financial and scientific applications. **The table below shows maps the Specialized Learning Outcomes for the SKU to the KLOs**

SLOs	KLOs								
	KLO1	KLO2	KLO3	KLO4	KLO5	KLO6	KLO7	KLO8	KLO9
SLO1	✓								
SLO2				✓					
SLO3					✓				
SLO4					✓				
SLO5						✓			
SLO6							✓		
SLO7								✓	

Essential Knowledge Unit (EKU 4): Statistics

Description	This unit introduces students to the essential basic principles of statistics needed as a foundation for upper courses.
Topics	**The following topics must be included in this SKU:** 1. Introduction to Statistics: Basic concepts, definitions, and the role of statistics in decision-making. 2. Data types: Categorical and numerical data, discrete and continuous data, and their graphical representations. 3. Definition and overview of biostatistics This includes the population sample, observational data, and data from designed experiments. 4. Measures of Central Tendency: Mean, median, and mode, and how they describe the center of a data set. 5. Measures of Dispersion: Range, variance, and standard deviation, and how they describe the spread of a data set. 6. Probability: The basic concepts of probability, including probability distributions, probability rules, and conditional probability. 7. Sampling and Sampling Distributions: Random sampling, sampling methods, and the Central Limit Theorem. 8. Confidence Intervals: How to construct and interpret confidence intervals and how to determine sample size. 9. Hypothesis Testing: How to set up and test hypotheses, including the null and alternative hypotheses, the p-value, and Type I and Type II errors. 10. Correlation and Regression: The concepts of correlation and regression analysis and how to interpret and use the results. 11. Analysis of Variance (ANOVA): One-way ANOVA, two-way ANOVA, and how to analyze variance between groups. 12. Nonparametric Methods: Nonparametric tests, including the Wilcoxon test and the Kruskal-Wallis test, and how to use them when parametric assumptions are not met. 13. Ethics and Statistics: The ethical considerations involved in designing, conducting, and reporting statistical research.
Specialized Learning Outcome	**By completing this EKU, students should be able to:** 2. Differentiate between various types of data and their graphical representations by using the basic concepts and terminology of statistics. 3. Demonstrate understanding of the principles of random sampling and sampling distributions, as well as the basic principles of nonparametric methods and when to use them. 4. Apply the use of relevant basic scientific facts, concepts, principles, and theories and their applications in biostatistics. 5. Describe how to construct and interpret confidence intervals. 6. Calculate and interpret measures of central tendency and measures of dispersion. 7. Use the principles of probability to solve basic problems. 8. Set up and test hypotheses, including the null and alternative hypotheses, the p-value, and Type I and II errors. 9. Perform and interpret basic correlation and regression analyses, as well as basic analyses of variance (ANOVA). 10. Apply statistical concepts and tools to solve real-world problems and draw meaningful conclusions from data. 11. Value the ethical considerations involved in designing, conducting, and reporting statistical research. **The table below maps the Specialized Learning Outcomes for the SKU to the KLOs**

SLOs	KLOs								
	KLO1	KLO2	KLO3	KLO4	KLO5	KLO6	KLO7	KLO8	KLO9
SLO1	✓								
SLO2	✓								
SLO3	✓								
SLO4					✓				
SLO5					✓				
SLO6						✓			
SLO7						✓			
SLO8						✓			
SLO9								✓	

Essential Knowledge Unit (EKU 5): English Language

Description	This EKU introduces the students to the different types of academic writing, such as descriptive, narrative and informative paragraphs. The development and enhancement of basic writing skills are targeted by including a variety of topics. The vocabulary knowledge, through discussion questions and reading segments, and grammar skills are also objectives.
Topics	**The following core topics must be included in this EKU:** 1. Reading: basic reading comprehension skills such as skimming, scanning, monitoring comprehension, answering questions, generating questions, recognizing story structure and summarizing. 2. Writing: basic skills needed to write English well, nature of the English sentence and paragraph with emphasis on transitions and subordination, and paraphrasing and summarizing as important tools in note-taking. 3. Listening and speaking: listening for details and inferring meaning from context, conversational skills in various topics by working in small groups for discussion, and developing oral skills through listening to different types of conversations and arguments. 4. Grammar: basic grammatical concepts and categories, review of the English tenses, modals, if clauses, passive voice, reported speech, questions, use of infinitive articles, countable and uncountable nouns, pronouns, adjectives and adverbs, conjunctions, and prepositions. 5. Translation: foundation in the theory, practice, and ethics of translation. 6. Essay and summary writing: writing an essay and extracting sentences to build a summary.
Specialized Learning Outcome	**By completing this EKU, the students should be able to:** 1. Demonstrate command of oral, written, and visual literacy skills. 2. Identify the essential linguistic issues that enable people to exchange messages appropriate to the subject, occasion, and audience. 3. Formulate the information required to prepare scientific reports and essays. 4. Perform assigned work independently and cooperate effectively while working in a team. 5. Share scientific ideas and issues through written, oral or visual communication. 6. Relate choices, actions, and consequences to ethical decision-making. **The table below maps the Specialized learning Outcomes for the SKU to the KLOs**

SLOs	KLOs								
	KLO1	KLO2	KLO3	KLO4	KLO5	KLO6	KLO7	KLO8	KLO9
SLO1	✓								
SLO2		✓							
SLO3				✓					
SLO4							✓		
SLO5								✓	
SLO6									✓

Essential Knowledge Unit (EKU 6): Interpersonal and Communication Skills

Description	This EKU introduces students to the basic skills that contribute to effective communication in various contexts and situations while working in the field or conducting research. This knowledge unit provides the solid foundations and indispensable skills that are necessary for dynamic and effective interpersonal relationships. Undoubtedly, such skills greatly facilitate communication in the workplace environment.
Topics	**The following core topics must be included in this EKU:** 1. Understanding interpersonal styles: to adapt techniques of communication and recognize communication differences between individuals in cultures that affect interpersonal interactions. 2. Conversation and assertiveness skills: to show a positive personal character. 3. Verbal and nonverbal communication: through oral presentations and written formats 4. Achievement of effective communications: to earn the positive impacts of communication. 5. Effective listening and perception: to better understand the other opinions, concepts and ideas. 6. Personal influencing skills: to help convey ideas and concepts. 7. Feedback strategies: to evaluate interpersonal responsiveness and to continuously improve skills of communication. 8. Dealing with different situations: to acquire the skill of reasonable response. 9. Strategies of conflict management: to avoid interpersonal problems. 10. Negotiation skills: to develop the ability to reach suitable solutions. 11. Communicating in the workplace: to work effectively in a team under field conditions or while conducting research work.

Specialized Learning Outcome

By completing this EKU, students should be able to:

1. Explain the interpersonal skills as part of effective communication.
2. Identify the significance of attitudes, values and perceptions in interpersonal relationships.
3. Recognize the effects of personal behavior on interpersonal relationships.
4. Apply a range of effective interpersonal communication skills while conducting research work.
5. Interpret and analyze the interpersonal relationships in the workplace and employ this analysis to formulate feedback strategies.
6. Perform work in a team using effective communication skills in the form of written formats or verbal presentations.
7. Adhere to the ethical rules in communicating with peers or nonspecialized individuals in the community.
8.

The table below maps the Specialized learning Outcomes for the SKU to the KLOs

SLOs	KLOs								
	KLO1	KLO2	KLO3	KLO4	KLO5	KLO6	KLO7	KLO8	KLO9
SLO1	✓								
SLO2		✓							
SLO3			✓						
SLO4				✓					
SLO5						✓			
SLO6								✓	
SLO7									✓

Essential Knowledge Unit (EKU 7): Graduation Research Project

Description	This EKU introduces students to the induction of research work related to one of the topics in the biology program. The assigned research projects allow the students to explore areas of interest across the various biology disciplines. The research work is done under the supervision of the academic staff members. The concerned research activity encourages students to employ and develop their skills.
Topics	**The following core topics must be included in this EKU:** 1. Cell biology: cell division and replication, and the main compartments of cellular metabolism. 2. Molecular biology: emphasis on genetics, biomolecules, protein structures, enzymes, metabolism bioenergy, transcription, translation, biotechnology and methods applied in molecular biology. 3. Plant Physiology: principles of plant biology, including the structural organization, classification, physiology, reproduction, heredity, and evolution of plants and photosynthetic organisms 4. Animal physiology: the principal physiological systems in animals, and the mechanisms of how these systems operate and how they are regulated. 1. Genetics: prokaryotic and eukaryotic cell genetics, Mendelian (or transmission) genetics, molecular genetics, evolutionary genetics, transmission and molecular genetics. 2. Environmental biology: basic concepts that clarify the relationship between organisms and their surrounding environments. 3. Bacteriology: occurrence of bacteria in the environment, structure of bacterial cells, and classification of the bacterial groups based on morphological, physiological and genetic characterization. 4. Virology: structure, genetic material, replication strategies of various animal and human viruses, and mechanisms of viral pathogenesis. 5. Parasitology: parasite morphology, parasitic stages, reproduction, life cycle, parasite-host relationship and modes of parasitic infections. 10. Biochemistry: structure, function and performance relationships of biochemical compounds, including amino acids, nucleic acids, proteins, vitamins, enzymes, carbohydrates, and lipids.

Specialized Learning Outcome

By completing this EKU, students should be able to:

1- Demonstrate the skills to write a research proposal and to plan for a research project.
2- Identify the research tools (instrument, equipment, and methods) that suit the various research topics.
3- Outline the steps to execute a research project effectively.
4- Apply the appropriate techniques and use the proper equipment to conduct research work.
5- Evaluate and analyze research data using the proper statistical and computational methods.
6- Perform work independently or in collaboration with a team.
7- Communicate scientific ideas clearly and present research results through written reports and oral presentations.

The table below maps the Specialized learning Outcomes for the SKU to the KLOs

SLOs	KLOs								
	KLO1	KLO2	KLO3	KLO4	KLO5	KLO6	KLO7	KLO8	KLO9
SLO1	✓								
SLO2		✓							
SLO3			✓						
SLO4				✓					
SLO5						✓			
SLO6							✓		
SLO7								✓	

General Knowledge Unit (GKU 1): Animal and Plant Biology

Description	This GKU introduces students to the fundamental biology of animals and plants. The characteristics of major taxa and their anatomical, physiological, and life-history features are elucidated. This GKU focuses on the mechanisms of evolution and the relationship of evolution to the diversity of life and organization of taxa. The introduced knowledge involves the ecological relationships at the population, community, and ecosystem levels. The flow of genetic information, genetic expression, classical and molecular genetics, and inheritance are covered.

Specialized Knowledge Unit (SKU1.1): General Biology

Description	This SKU provides the students with fundamentals of biological processes with a chemical foundation, including macromolecules, cellular structure, metabolism, and genetics in an evolutionary context. Emphasis is placed on exploration of the core concepts of structure and function; information flow, storage and exchange; pathways and transformations of energy and matter; evolution; and systems biology. The interdisciplinary approach and relevance of biology to society are also emphasized.
Topics	**The following Core topics must be included in this SKU:** 1- Chemical structure of living organism: starting from the level of atoms to the cell and tissue level, and how the biomolecules build the cell (the structural unit of a living organism). 2- Cell Structure and Function: basic structural components of the cell, including the nucleus and the cytoplasmic organelles and how these components integrate together to perform cellular functions. 3- Cell Division: mitotic and meiotic cell divisions, and the specified division type to various types of cells, i.e. somatic and sexual cells. 4- Tissues: types of tissues that compose the various organs, cell components of each type of tissue, and how these tissues compose the different organs. 5- Systematics: organ systems, how organs compose the various body systems, and the anatomical and physiological interrelations of these systems. 6- Nutrition: essential types of nutrients, dietary requirements, energy units in different nutrients, and correlation between nutrients and energy requirements of the organism. 7- Metabolism: Assimilation of different types of nutrients, metabolic pathways and metabolic mechanisms and reactions. 8- Osmoregulation and Excretion: osmotic regulations of intracellular and extracellular compartments, excretion of waste metabolic products, correlation between excretion and osmoregulation. 9- Reproduction: mechanisms and control of reproductive processes, gametogenesis, and hormonal control of reproduction. 10- Fertilization and Development: male and female gametes, fertilization, and the various sequential embryonic stages. 11- Genetics: Chromosome structure, chromosomal sets, chromosomal abnormalities, and gene structure and expression.

Specialized Learning Outcome

By completing this SKU, the students should be able to:

1- State the evolutionary events of plants and animals, as well as the characteristics of the major animal and plant phyla.
2- Demonstrate the adaptive mechanisms and organization and functions of the organ systems of animals.
3- Clarify the organization, functions, and adaptation of the principal plant structures.
4- Write a scientific proposal and accordingly conduct research work in the various biology disciplines.
5- Interpret and analyze biological research data using the appropriate analytical statistical methods.
6- Perform the assigned work independently and participate effectively in a research team.
7- Communicate scientific issues and convey research data professionally to varied audiences.
8- Follow the relevant ethical rules strictly while working in the field of biological research.

The table below maps the Specialized learning Outcomes for the SKU to the KLOs

SLOs	KLOs								
	KLO1	KLO2	KLO3	KLO4	KLO5	KLO6	KLO7	KLO8	KLO9
SLO1	✓								
SLO2		✓							
SLO3			✓						
SLO4				✓					
SLO5						✓			
SLO6							✓		
SLO7									✓

Specialized Knowledge Unit (SKU1.2): Cell Biology

Description	This SKU provides the students with fundamentals of the biology of cells (the basic units of life). This knowledge unit focuses on the essentials of cellular biology, including the evolution of cells, cell division and replication, and the main compartments of cellular metabolism. The specialized unit also emphasizes the practical aspects of cell biology to give the opportunity for students to acquire the necessary research experience.
Topics	**The following Core topics must be included in this SKU:** 1- Principles of cell chemistry: integration and interactions of the various cellular chemical components, i.e. the biomolecules, to perform their roles in the various biological processes. 2- Structure and functions of the cell: nucleus, cytoplasm, organelles, cytoskeleton, and cell membranes. 3- Cellular metabolic pathways: metabolic reactions involved in energy production and metabolism, as well as the transformation of energy. 4- Cellular transport mechanisms: transport of proteins and other macromolecules between the cellular compartments and across the cell membranes. 5- Cell differentiation: sequential processes of acquiring specific morphology and functions by the various undifferentiated stem cells, as well as signal transduction pathways. 6- Types of cell division: division of somatic and sexual cells and chromosomal architecture of the daughter cells. 7- Nuclear structures: nucleus, nucleolus, nuclear sap and nuclear membrane, and their integrated and complementary functions. 8- Nucleic acids: DNA and RNA; structure, replication, transcription and translation, and genetic coding.
Specialized Learning Outcome	**By completing this SKU, the students should be able to:** 1- Explain the evolution, diversity, and replication of different types of cells. 2- Classify the different cellular compartments and clarify the intracellular signaling. 3- Identify the key cellular biology techniques and their use in biological studies. 4- Write a research proposal and conduct experimental work by employing cell biology techniques. 5- Interpret and critically analyze experimental data using the appropriate statistical methods. 6- Perform work independently and cooperate effectively in a research team. 7- Communicate scientific information explicitly through both written formats and oral presentations.

The table below maps the Specialized learning Outcomes for the SKU to the KLOs

SLOs	KLOs								
	KLO1	KLO2	KLO3	KLO4	KLO5	KLO6	KLO7	KLO8	KLO9
SLO1	✓								
SLO2		✓							
SLO3			✓						
SLO4				✓					
SLO5						✓			
SLO6							✓		
SLO7								✓	

Specialized Knowledge Unit (SKU1.3): Developmental Biology

Description	This SKU provides the students with principles of the molecular, biochemical and other cellular mechanisms. These mechanisms regulate the development of specialized cells and their differentiation into the corresponding tissues and organs during embryonic development. This knowledge unit integrates the evolutionary, ecological and molecular perspectives to clarify the interaction of animals with their environment during various stages of development. Cell signaling pathways are also emphasized to clarify their role in the regulation of embryonic tissue interactions as well as the expression of regulatory genes.
Topics	**The following core topics must be included in this SKU:** 1- Multicellular organisms: development of the complex multicellular organism from a single undifferentiated stem cell. 2- Evolution of multicellular organisms: the genetic and genomic basis of evolution of multicellular organisms and body forms. 3- Regulation of development: genes and hormones that are responsible for the regulation of the various developmental stages, as well as the mechanism of genome editing. 4- The flow of genetic data: transcription factors and signaling pathways that account for the transfer of genetic data. 5- Morphogenesis: sequential morphological changes and maintenance of homeostasis (balanced internal environment) during development. 6- Embryogenesis: impact of interaction with biotic and abiotic environmental factors on embryonic development. 7- Identification of development: techniques that are used to identify molecular and cellular mechanisms of development.

Specialized Learning Outcome

By completing this SKU, students should be able to:

1- Describe the morphological transformation processes implicated in the development of multicellular organisms.
2- Clarify molecular and biochemical mechanisms involved in the differentiation of specialized cells during embryonic development.
3- Select the organisms that are used as a model to investigate issues in developmental biology.
4- Prepare a proposal and subsequently conduct experimental research work in the field of developmental biology.
5- Interpret and analyze the collected quantitative data using the proper statistical methods.
6- Perform work effectively in diverse research groups.
7- Communicate scientific issues professionally and present research data orally or in written formats.
8- Adhere to the relevant ethical rules while working in the field of developmental biology.

The table below maps the Specialized learning Outcomes for the SKU to the KLOs

SLOs	KLOs								
	KLO1	KLO2	KLO3	KLO4	KLO5	KLO6	KLO7	KLO8	KLO9
SLO1	✓								
SLO2		✓							
SLO3			✓						
SLO4				✓					
SLO5						✓			
SLO6							✓		
SLO7								✓	
SLO8									✓

Specialized Knowledge Unit (SKU1.4): Plant Biology

Description	This SKU provides the students with principles of plant biology, including the structural organization, classification, physiology, reproduction, heredity, and evolution of plants and photosynthetic organisms. Additionally, this SKU provides an overview of the plant kingdom and compares various plant groups within the kingdom. Evolution, plant metabolism, and external factors influencing plant growth are also addressed. Classification and diversity, flowering plants, plant morphology and anatomy are also included.
Topics	**The following core topics must be included in this SKU:** 1- Plant taxonomy: taxonomy of plants and levels of organization starting from the top level of kingdom to the level of plant species. 2- Plant structure (anatomy): different anatomical structures of plants and their differentiation in various species, morphology of plants and organ adaptation. 3- Plant functions (physiology): vital functional processes needed for plant survival, such as photosynthesis, respiration, water transport, nutrient assimilation, and the role of plant hormones. 4- Plant reproduction: different reproductive mechanisms of plants, and embryo development. 5- Plant ecology: the relationship between plants and the dynamics of ecosystems, and conservation. 6- Plant genetics: Mendelian genetics and interactions between plants and their environment. 7- Medicinal plants: an overview of medicinal plants, their bioactive compounds, and their beneficial uses. 8- Plant diversity: diversity and its immense importance both to the ecosystem and to human interests, evolution, symbiotic relationships, and adaptive morphology.
Specialized Learning Outcome	**By completing this SKU, students should be able to:** 1. Discuss the fundamentals of plant biology, including plant structures and their functions. 2. Outline the organization of the various topics in plant biology and distinguish the major plant groups. 3. Explain plant evolution and reproduction and how plants acquire energy and nutrients in their environment. 4. Propose a research plan and accordingly carry out research work in the field of plant biology. 5. Evaluate and analyze the characters that link plants to each other and their environment. 6. Perform laboratory or field research activities independently or as a member of a team. 7. Communicate research ideas and convey scientific data in a professional manner, either verbally or in written formats.

The table below maps the Specialized learning Outcomes for the SKU to the KLOs

SLOs	KLOs								
	KLO1	KLO2	KLO3	KLO4	KLO5	KLO6	KLO7	KLO8	KLO9
SLO1	✓								
SLO2		✓							
SLO3			✓						
SLO4				✓					
SLO5						✓			
SLO6							✓		
SLO7								✓	

General Knowledge Unit (GKU 2): Physiology

Description	This GKU introduces the students to animal anatomy and physiology. These are the most basic terms and areas of study in biology. Anatomy refers to the internal and external structures of the body and their physical relationships, whereas physiology refers to the study of the functions of those structures. The anatomical locations, structures and physiological functions of the main components of each major system of the animal body are covered in this GKU.

Specialized Knowledge Unit (SKU2.1): Animal Physiology

Description	This SKU provides the student with an introduction to the principal physiological systems in animals. The mechanisms of how these systems operate and how they are regulated are included. Comparative physiology of selected systems and how the individual parts fit together into a working animal are also introduced.
Topics	**The following core topics must be included in this SKU:** 1. Homeostasis: maintaining the internal environment of the organism against external environmental changes, thermoregulation and osmoregulation 2. Cell metabolism and respiration: biochemical reactions involved in cell metabolism, as well as energy production and metabolism. 3. Excretion physiology: organ systems and mechanisms important for excretion of waste products and regulation of water balance and acid-base balance. 4. Digestive system physiology: mechanical digestion of food ingredients, chemical digestion (enzymes), gastric and intestinal secretions, and absorption. 5. Nervous system physiology: coordination and integration between body organs and systems and higher control in the central nervous system. 6. Respiration physiology: gaseous exchange, chemoreceptors, the oxygen carrier in the blood, gaseous gradients, nervous control of respiration. 7. Cardiovascular physiology: cardio-pulmonary circulation, general circulation, cardiac rhythm, and vascular dynamics. 8. Endocrine physiology: endocrine glands, hormones, hypothalamus-pituitary association, and role of the releasing and stimulating hormones.

Specialized Learning Outcome

By completing this SKU, students should be able to:

1. Illustrate functions of the various tissues, organs, and organ systems of animals.
2. Explain the regulation and coordination of the functions of different body systems.
3. Clarify the process of homeostasis and the various body mechanisms to maintain this bioactivity.
4. Design and carry out research work in animal physiology by applying the proper techniques and methods.
5. Evaluate and analyze the data collected from the diverse research activities in animal physiology.
6. Demonstrate and communicate scientific data and research ideas using the various formats appropriate for different target audiences.

The table below maps the Specialized learning Outcomes for the SKU to the KLOs

SLOs	KLOs								
	KLO1	KLO2	KLO3	KLO4	KLO5	KLO6	KLO7	KLO8	KLO9
SLO1	✓								
SLO2		✓							
SLO3			✓						
SLO4				✓					
SLO5						✓			
SLO6								✓	

General Knowledge Unit (GKU 3): Biology of Microbes

Description	This GKU introduces the students to microbial biology, which encompasses the study of all types of unicellular microorganisms, including bacteria, fungi and viruses. This knowledge unit enables the students to recognize that these microbes reside essentially in all biological habitats on Earth. The essential roles of these microbes in maintaining a healthy ecology by supplying nutrients and chemicals to other organisms, such as animals and plants, are focused. The fact that these microbes also aid in the recycling of biological matter via the global cycles for carbon, nitrogen, phosphorous and other essential elements is also emphasized.

Specialized Knowledge Unit (SKU3.1): Bacteriology

Description	This SKU provides the students with the basic data focusing on the occurrence of bacteria in the environment, the structure of bacterial cells, and the classification of bacterial groups based on the morphological, physiological and genetic characterizations. The key characteristics, sources, and biology of commonly encountered and/or taxonomically interesting bacterial groups are also covered.
Topics	**The following core topics must be included in this SKU:** 1. An overview: the role of bacterial organisms and their distribution in the environment. 2. Eukaryotes and prokaryotes: differences between prokaryotes and eukaryotes, i.e. early and advanced forms of life. 3. Taxonomy and identification: classification of bacteria, common genera and species in the environment, and their morphological characteristics. 4. Bacterial biofunctions: main biological functions of bacteria including nutrition and reproduction. 5. Phenotyping and genotyping: morphological typing and genetic characterization of bacterial species (16s rRNA, DNA-DNA hybridization, fatty acids profile, Protein profile). 6. Growth of bacteria in a laboratory: growth media and other growth conditions for the diverse types of bacteria. 7. Bacterial staining: simple stains (positive and negative stains), acid-fast stains, and immunostaining. 8. Bacterial infections: main disease conditions caused by bacterial infections, bacterial toxins, bacterial immunity, and antibiotic resistance.
Specialized Learning Outcome	**By completing this SKU, students should be able to:** 1. State the general characteristics of bacteria and the taxonomy of the bacterial species. 2. Describe the morphology and basic structures of the different bacterial genera. 3. List the different animal and human diseases caused by the pathogenic bacteria. 4. Prepare a plan to carry out laboratory research work to test hypotheses in the field of bacteriology. 5. Evaluate and analyze data of a research work by applying the analytical statistical methods. 6. Perform the assigned work independently and participate in the activity of a research team.

7. Follow the relevant ethical rules while conducting research in the field of bacteriology.

The table below maps the Specialized learning Outcomes for the SKU to the KLOs

SLOs	KLOs								
	KLO1	KLO2	KLO3	KLO4	KLO5	KLO6	KLO7	KLO8	KLO9
SLO1	✓								
SLO2		✓							
SLO3			✓						
SLO4				✓					
SLO5						✓			
SLO6							✓		
SLO7									✓

Specialized Knowledge Unit (SKU3.2): Virology

Description	This SKU provides the student with the principles in the field of virology, with emphasis on the structure, genetic material, and replication strategies of various animal and human viruses. Additionally, mechanisms of viral pathogenesis, viral diagnostics, and prevention and treatment of viral infections are considered.
Topics	**The following core topics must be included in this SKU:** 1. Taxonomy: classification of viruses, DNA and RNA viruses, common genera and species of viruses. 2. Replication: attachment of viruses to host cells, cell entry of viruses, various strategies of virus replication, and cytoplasmic and intra-nuclear viral replication. 3. Virus-host cell interactions: viruses as obligatory intracellular organisms, interactions of viruses with the host cells, and virus receptors on the host cells. 4. Pathogenesis: step-by-step development of viral infections, including attachment, cell entry, replication, cytopathic effects, and viral release. 5. Viral immunity: innate and acquired immunity to viruses, elements of natural immunity, vaccines, evading immune system, and viral mutants. 6. Diagnosis: diagnostic methods of various viral infections, including the direct (viral antigen) and indirect (detection of viral antibodies) detection methods. 7. Prevention and control: measures applied to prevent or decrease the incidence of viral infections.
Specialized Learning Outcome	**By completing this SKU, the student will be able to:** 1. Clarify the general life cycle of viruses in the host cells. 2. Demonstrate the various replication strategies of viruses based on their genomic composition. 3. Explain the methods and techniques used in the diagnosis of viral infections. 4. Propose a research plan and accordingly conduct experimental work in virology. 5. Analyze and interpret scientific data by applying the appropriate analysis approaches. 6. Perform work independently and collaborate effectively in a team. 7. Communicate the scientific issues and research results professionally to different audiences. **The table below maps the Specialized learning Outcomes for the SKU to the KLOs**

SLOs	KLOs								
	KLO1	KLO2	KLO3	KLO4	KLO5	KLO6	KLO7	KLO8	KLO9
SLO1	✓								
SLO2		✓							
SLO3			✓						
SLO4				✓					
SLO5						✓			
SLO6							✓		
SLO7								✓	

Specialized Knowledge Unit (SKU3.3): Mycology

Description	This SKU provides the students with the biological principles of true fungi and other groups of organisms traditionally classified with fungi. Taxonomy, life history traits, ecology, physiology, and evolutionary biology of the major classes and orders of fungi are considered in this SKU.
Topics	**The following core topics must be included in this SKU:** 1. Taxonomy: classification of fungi, common genera and species, definitions, and fungal terminologies. 2. Ecology and genetics: occurrence of fungi in various ecosystems, dissemination of fungi in the environment, fugal contaminants, and fungal genetic structures. 3. Reproduction: methods of reproduction and factors enhancing growth and reproduction of fungi. 4. Physiology: physiological and biochemical processes in fungal cells 5. Fungus-host interaction: interactions of fungi with the different hosts, mycotoxins (fungal toxins), host responses, and host immunity to fungi. 6. Mycoses: categorization of fungal infections according to the affected body site into superficial mycoses, cutaneous mycoses, subcutaneous mycoses and systemic mycoses. 7. Laboratory diagnosis: diagnostic laboratory techniques applied for diagnosis and identification of fungal infections. 8. Economic fungi: The economic importance of fungi as revealed in the fields of agriculture, food industry, medicine, and biotechnology.
Specialized Learning Outcome	**By completing this SKU, the student will be able to:** 1. Outline the taxonomy of fungi, their biological and ecological characteristics, and their role in different ecosystems 2. Describe the morphological features of various fungi and 3. Clarify the significance of each taxonomic group of fungi and their direct and indirect impact on humans. 4. Propose a research design and conduct experimental work in the field of mycology by applying the appropriate methods and techniques. 5. Interpret and analyze the data collected from the conducted research work. 6. Perform laboratory or field work independently and collaborate effectively with a research team. **The table below maps the Specialized learning Outcomes for the SKU to the KLOs**

SLOs	KLOs								
	KLO1	KLO2	KLO3	KLO4	KLO5	KLO6	KLO7	KLO8	KLO9
SLO1	✓								
SLO2		✓							
SLO3			✓						
SLO4				✓					
SLO5						✓			
SLO6							✓		

General Knowledge Unit (GKU 4): Ecology and Environmental Science

Description	This GKU introduces the students to the fields of ecology and environmental science since both fields imply the importance of protecting and preserving our planet and its organisms for future generations. The specific relationships between living organisms, including humans and animals, animals and plants, and plants and organisms are covered. This general knowledge unit also focuses on the impact of humans on ecosystems and the environment, and the protection of the environment from negative factors such as climate change and pollution.

Specialized Knowledge Unit (SKU4.1): Environmental Science

Description	This SKU provides the student with the basic concepts that clarify the relationship between organisms and their surrounding environments. This relationship determines the dynamics of life organizational levels, including the scale of individuals, populations, communities, and ecosystems. The knowledge presented in this unit enables the students to appreciate the perspectives on biological and physical factors that might disrupt this relationship. The students, through the informed fundamentals, get acquainted with the appropriate policies and practices to deal with the various environmental problems at the local, regional, and global levels. This knowledge unit also focuses on the strategies to preserve environmental resources for the welfare of human life.
Topics	**The following core topics must be included in this SKU:** 1- Organism-environment relationship: broad interdisciplinary relationships between organisms and their environments and impacts of evolution and ecology. 2- Environmental problems: perspectives on biological and physical processes relevant to the causation of the environmental problems. 3- Solving environmental issues: regulations, rules, and policies and procedures that contribute significantly to solving the environmental problems. 4- Human activities and environment: major natural systems of the Earth, and how these systems are affected by human activities. 5- Human societies and environment: sustainability of various interactions between human societies and the Earth's natural systems in terms of energy use and generation and resource consumption. 6- Protective rules: National and global rules, and legislations help protect the environmental resources. 7- Ethical implications: Ethical and social considerations implicated in the activities of environmental science.

Specialized Learning Outcome

By completing this SKU, students should be able to:

1. Clarify the interactions between organisms and their environments and the impacts of human activities on the ecosystems and natural resources.
2. Illustrate the interdisciplinary dynamics of individuals, populations and communities in the broad scale of ecosystems.
1. Explain how the Earth systems (land, water, sea, and atmosphere) support life on Earth.
2. Propose a research plan and carry out research work in the field of environmental science.
3. Evaluate and analyze the results of field studies as well as the experimental data using the proper statistical methods.
4. Perform the assigned tasks independently and work effectively with a research team.
5. Communicate scientific issues professionally through written reports or oral presentations.
6. Follow the ethical rules strictly when applied in the field of environmental science.

The table below maps the Specialized learning Outcomes for the SKU to the KLOs

SLOs	KLOs								
	KLO1	KLO2	KLO3	KLO4	KLO5	KLO6	KLO7	KLO8	KLO9
SLO1	✓								
SLO2		✓							
SLO3			✓						
SLO4				✓					
SLO5						✓			
SLO6							✓		
SLO7								✓	
SLO8									✓

Specialized Knowledge Unit (SKU4.2): Animal Behavior

Description	This SKU provides the student with the fundamentals of animal behavior involving the relevant ecological and evolutionary perspectives. This knowledge unit focuses on concepts, tools, and methods for the study of animal behavior. Among the major objectives are the ecological and evolutionary impacts that shape animal behavior as well as the conditions that may lead animals to live solitarily or in groups. The basic techniques used to measure animal behavior, through combined laboratory and field investigations are also emphasized. One of the objectives is to give the students the opportunity to design and conduct research projects.
Topics	**The following core topics must be included in this SKU:** 1- Evolutionary factors: evolutionary perspectives that have impacts on animal behavior. 2- Ecological effects: ecological forces that lead animals to live solitarily or in groups. 3- Foraging strategies: ways of avoiding predation and selfish and cooperative behavior. 4- Choosing mates: monogamous vs. polygamous mating systems, reproduction, and modes of offspring care. 5- Use of models: models are beneficial to understand and predict the behavior of animals under different environmental and social conditions. 6- Evaluation methods: methods and tools used to study animal behavior and evaluate the animal adaptive strategies to varied environments. 7- Basic measuring techniques: techniques used in both laboratory and field conditions, to code and measure the diverse animal behavior.

Specialized Learning Outcome

By completing this SKU, students should be able to:

1- List the animal traits that can be considered behaviors and the adaptation strategies.
2- Discuss the animal behavioral strategies such as escaping predation, acquiring and defending resources, finding mates, and reproduction.
3- Illustrate the mechanisms that shape animal behavior, including adaptive mechanisms and non-adaptive evolution.
4- Design a research proposal and accordingly conduct research work in the field of animal behavior.
5- Evaluate and analyze the collected behavioral data using a variety of statistical methods.
6- Perform work independently and participate effectively in the activity of a research team.
7- Communicate and present scientific issues in a professional manner, either verbally or through written formats.

The table below maps the Specialized learning Outcomes for the SKU to the KLOs

SLOs	KLOs								
	KLO1	KLO2	KLO3	KLO4	KLO5	KLO6	KLO7	KLO8	KLO9
SLO1	✓								
SLO2		✓							
SLO3			✓						
SLO4				✓					
SLO5						✓			
SLO6							✓		
SLO7								✓	

Specialized Knowledge Unit (SKU4.3): Marine Environment

Description	This SKU provides the student with the ecological and environmental processes that affect and shape the patterns of reproduction, behavior, population dynamics, and community structure in marine ecosystems. This knowledge unit focuses on the diversity patterns of marine plants and animals and the factors that modulate these patterns. The objectives of this knowledge unit include the use of proper procedures and the development of solutions to environmental and conservation problems in coastal habitats.
Topics	**The following core topics must be included in this SKU:** 1- Marine environment: fundamentals of marine environmental science including definitions and types of marine pollution such as pollution from the off-shore oil and gas sectors. 2- Management actions: global and regional marine pollution management actions. 3- International standards: standards related to marine environment protection and understanding of the international safety management (ISM) Code. 4- Legal management: management of marine hazards and polluting incidents. 5- Ship-source pollution: management plan for the ship-source marine pollution, i.e. management of chemical pollution, sewage and garbage. 6- Post-event strategies: proactive approaches and post- event strategies (international and regional conventions)
Specialized Learning Outcome	**By completing this SKU, students should be able to:** 1- Discuss the contemporary issues implicated in marine ecosystems such as conservation and climate changes. 2- Explain the similarity of ecological concepts in the varied marine environments in relation to terrestrial and freshwater ecosystems. 3- Demonstrate the biological and ecological aspects related to marine organisms and the effect of pollution on these organisms. 4- Write a well-organized proposal and accordingly conduct research work in the field of marine environments. 5- Evaluate and analyze the collected research data using the appropriate statistical analytical methods. 6- Perform the assigned work independently and participate effectively in a research group. 7- Communicate scientific data professionally through technical written formats and oral presentations. **The table below maps the Specialized learning Outcomes for the SKU to the KLOs**

SLOs	KLOs								
	KLO1	KLO2	KLO3	KLO4	KLO5	KLO6	KLO7	KLO8	KLO9
SLO1	✓								
SLO2		✓							
SLO3			✓						
SLO4				✓					
SLO5						✓			
SLO6							✓		
SLO7								✓	

Specialized Knowledge Unit (SKU4.4): Biodiversity

Description	This SKU provides the student with the principles of conservation and biodiversity at both the population and ecosystem levels. This knowledge unit focuses on the ecological and evolutionary processes and their interactions that contribute significantly to shape the status of biodiversity. The objectives include the relation between the concepts derived from behavioral ecology, population ecology, genetics and evolution on one side and conservation biology and biodiversity on the other side. The theoretical foundations of conservation biology are also emphasized in this knowledge unit.
Topics	**The following core topics must be included in this SKU:** 1- Conservation biology: application of evolutionary and ecological concepts and theories to issues related to the conservation of biodiversity on Earth. 2- Biodiversity associations: anatomical, physiological and behavioral associations between related groups of organisms inhabiting the planet. 3- Importance of biodiversity: contribution of the diverse groups of living organisms to ecological systems and human welfare, diversity and ecosystems thrive, and regulation of the climate. 4- Biodiversity policy and management: management of biodiversity is accomplished through conservation landscapes, conservation biogeography, conservation governance, species responses to climate changes, conservation and society, and biodiversity technologies. 5- Conservation of biodiversity: minimizing the key threats to biodiversity, e.g., deforestation, pollution, global climate and environmental changes, influences of human activity, and invasive species. 6- Assessment and monitoring of biodiversity: applying the appropriate indicators for biodiversity.

Specialized Learning Outcome

By completing this SKU, students should be able to:

1. Explain the theories of biodiversity, conservation strategies, and protected areas.
2. Distinguish the natural varieties of biodiversity around the globe at both small and large scales.
3. Identify the main factors (both natural and anthropogenic) that cause loss of biodiversity.
4. Prepare a proposal and conduct research work on biodiversity by applying the appropriate techniques.
5. Evaluate and critically analyze biodiversity data using the appropriate reasoning and statistical methods.
6. Perform qualified work independently and participate effectively in a research team.
7. Communicate scientific data professionally, either verbally or through written formats.
8.

The table below maps the Specialized learning Outcomes for the SKU to the KLOs

SLOs	KLOs								
	KLO1	KLO2	KLO3	KLO4	KLO5	KLO6	KLO7	KLO8	KLO9
SLO1	✓								
SLO2		✓							
SLO3			✓						
SLO4				✓					
SLO5						✓			
SLO6							✓		
SLO7								✓	

General Knowledge Unit (GKU 5): Immunobiology

Description	This GKU introduces the students to the components, principles and mechanisms of a healthy immune system and how these mechanisms co-ordinate to mount safe and appropriate protection against infection. The mechanisms by which the immune system distinguishes between healthy and damaged self and identifies dangerous non-self are also emphasized. The situations of inappropriate or insufficient immunity, such as allergy, autoimmunity and immune deficiency, are also addressed.

Specialized Knowledge Unit (SKU5.1): Immunology

Description	This SKU provides the student with principles of the immune system that govern defence against pathogens. The students are introduced to the organization of the immune system and the fundamentals of the various immunological responses. Molecular and cellular elements of the immune system are also emphasized.
Topics	**The following core topics must be included in this SKU:** 1. Fundamentals of immunology: cells and molecules contributing to the activities of the immune system. 2. Components of the immune system: immune cells, and tissues and organs related to immune functions. 3. Cellular and humoral immunity: cellular immune responses (natural killer cells, T- and B-lymphocytes) and humoral immune response (antibody production) 4. Immune reactive molecules: antigen and immunoglobulins (antibody diversity) 5. Innate immunity: properties, defensive barriers, cells, receptors, and inflammation. 6. Adaptive immunity: properties, cells, mechanisms of humoral and cell-mediated immunity. 7. Complement system: properties, functions, pathways of complement activation. 8. Antigen presentation: antigen-presenting cells and cell-mediated effector responses. 9. Mucosal immunity: natural components of mucosal immunity. 10. Immunodeficiency disorders: congenital and acquired immunodeficiency. 11. Hypersensitivity and autoimmune diseases: immediate, cytotoxic, and delayed-type hypersensitivity reactions and autoimmune reactions. 12. Transplantation Immunity: types of grafts, and mechanisms of graft rejection.

Specialized Learning Outcome

Upon successful completion of this SKU, students should be able to:

1. Discuss the basic immunological processes at both cellular and molecular levels.
2. Compare the key mechanisms and cellular components of innate and adaptive immunity.
3. Clarify the genetic basis of immunological diversity and the generation of adaptive immune responses.
4. Propose a research design and conduct an experimental work by applying the appropriate methods and techniques.
5. Interpret the basis of immunological tolerance, autoimmunity and transplantation.
6. Perform the assigned scientific tasks independently and cooperate effectively with a research team.
7. Communicate scientific issues professionally through oral presentations and written formats to varied audiences.

The table below maps the Specialized learning Outcomes for the SKU to the KLOs

SLOs	KLOs								
	KLO1	KLO2	KLO3	KLO4	KLO5	KLO6	KLO7	KLO8	KLO9
SLO1	✓								
SLO2		✓							
SLO3			✓						
SLO4				✓					
SLO5						✓			
SLO6							✓		
SLO7								✓	

General Knowledge Unit (GKU 6): Cell Chemistry

Description	This GKU introduces the students to the chemical reactions and biological processes that take place at the cellular level, such as metabolism and enzyme catalysis and regulation. This knowledge unit also focuses on the cellular events that are necessary to make energy available through certain pathways and how this energy is used to power other biochemical reactions.

Specialized Knowledge Unit (SKU6.1): Biochemistry

Description	This SKU provides the student with principles of the structure, function and performance relationships of biochemical compounds, including amino acids, nucleic acids, proteins, vitamins, enzymes, carbohydrates, and lipids, as well as pH buffer systems. Energy metabolism and reaction rate kinetics are also emphasized in the context of regulatory mechanisms of integrated cellular metabolism.
Topics	**The following core topics must be included in this SKU**: 1- Importance of water: the bonds formed between biomolecules, pH, and biological buffers. 2- Protein biosynthesis: polypeptides and synthesis of proteins biomolecules. 3- Enzymes: structure, properties and functions of enzymes, and co-enzymes and co-factors. 4- Carbohydrates: structure and metabolic reactions, including oxidative phosphorylation of biomolecules (electron transport system). 5- Lipids: structure and metabolism of lipids and steroids. 6- Amino acids: metabolism, transamination, and urea cycle. 7- Blood biochemistry: hemoglobin, plasma proteins and immunoglobulins. 8- Control and integration of metabolism: homeostasis of biochemical reactions.

Specialized Learning Outcome

Upon successful completion of this SKU, students should be able to:

1- Explain the chemical ionization behavior of weak acids and bases responsible for the pH buffer systems of cells and blood.
2- Relate the structure of biochemical compounds to their physicochemical properties and function within the cells, tissues and physiologic systems.
3- Demonstrate the fundamental kinetic properties of enzymes and their role in the regulation of biochemical reactions.
4- Write a research proposal and subsequently carry out a biochemical research work.
5- Analyze and interpret the collected research data using the proper statistical approaches.
6- Communicate scientific issues and present research data professionally via oral presentation and written formats.

The table below maps the Specialized learning Outcomes for the SKU to the KLOs

SLOs	KLOs								
	KLO1	KLO2	KLO3	KLO4	KLO5	KLO6	KLO7	KLO8	KLO9
SLO1	✓								
SLO2		✓							
SLO3			✓						
SLO4				✓					
SLO5						✓			
SLO6							✓		

Specialized Knowledge Unit (SKU6.2): Molecular Biology

Description	This SKU provides the students with an overview of modern molecular biology with an emphasis on genetics, biomolecules, protein structure, enzymology, metabolism, and bioenergy. Biotechnology and methods applied in molecular biology are covered. The key principles of molecular biology and processes shared by different organisms are also included.
Topics	**The following core topics must be included in this SKU:** 1- Molecular biological processes: study of proteins and nucleic acids and their role in the development, function, and replication of cells. 2- DNA structure and replication: nucleic acid structure, DNA topology and methodology, and nucleic-acid protein interactions. 3- RNA structure: types of RNA and regulatory mechanisms of transcription and translation. 4- Proteomics: covalent structure of proteins, protein secondary, tertiary and quaternary structure, physical forces influencing protein structure, protein surface areas, and protein folding. 5- Membrane proteins: structural features of integral membrane proteins. 6- Protein synthesis: synthesis of protein biomolecules as a sequence of the translation process.
Specialized Learning Outcome	**Upon successful completion of this SKU, students should be able to:** 1- State the key concepts and ideas in molecular biology, as well as the basic molecular processes in eukaryotic cells. 2- Describe the biosynthesis of proteins and the role of DNA and RNA in this bioactive process. 3- Explain the regulatory mechanisms of gene expression. 4- Prepare a research plan and accordingly conduct experimental work in molecular biology. 5- Interpret and analyze the results of a molecular research work. 6- Communicate the scientific issues and convey the research data in a professional manner. 7- Follow the ethical rules relevant to research activities in the field of molecular biology. **The table below maps the Specialized Learning Outcomes for the SKU to the KLOs**

SLOs	KLOs								
	KLO1	KLO2	KLO3	KLO4	KLO5	KLO6	KLO7	KLO8	KLO9
SLO1	✓								
SLO2		✓							
SLO3			✓						
SLO4				✓					
SLO5						✓			
SLO6								✓	
SLO7									✓

General Knowledge Unit (GKU 7): Genetics

Description	This GKU introduces the students to the principles of prokaryotic and eukaryotic cell genetics. Three areas of genetics, namely Mendelian (or transmission) genetics, molecular genetics, and population/evolutionary genetics, are presented. Transmission and molecular genetics are the main objectives. Emphasis is also placed on the molecular basis of heredity, chromosome structure, and patterns of Mendelian and non-Mendelian inheritance.

Specialized Knowledge Unit (SKU7.1): [Genetics and Genomics]

Description	This SKU provides the students with the basic principles of genetics and genomics. This knowledge involves the combination of classical Mendelian genetics with contemporary genomic analysis. The main principles of genetics and the different models of genetic inheritance are presented. Among the objectives are the basics of linkage and chromosome mapping and the mechanisms of chromosome and genome variation. The students are also provided information on gene interactions, inheritance of complex traits, and association mapping.
Topics	**The following core topics must be included in this SKU:** 1- Fundamentals of genetics: principles of genetic analysis and heredity, and the connections between cell biology and inheritance of genetic information. 2- Progeny ratios: interpretation of progeny ratios resulting from different inheritance patterns. 3- Chromosome mapping: analysis of linkage and chromosome mapping. 4- Chromosome variation: origin and effect of chromosome and genome variations. 5- Flow of genetic information: molecular processes that control the flow of genetic information. 6- Mutations: chemistry of DNA damage, types of mutations and mechanisms for their repair, and mutations leading to generation of genetic diversity and disease. 7- Mapping of genes: identification of which trait is affected by which gene. 8- Genome regulation: transcriptional regulation of the genome (genetically and epigeneyically) to yield genetic variations at the level of phenotype. 9- Genetic complexity: integration of epigenetics and gene interactions. 10- Functional Genomics: mechanisms of genome and plasmid segregation. 11- Genome projects: understanding the molecular basis of diseases and use of genetic manipulation in biotechnology.
Specialized Learning Outcome	**By completing this SKU, students should be able to:** 1. Explain the nature of inheritance and how the genetic material is eventually expressed as phenotypes. 2. Clarify the basics of genetic analysis at the gene, genome and populatio n level, as well as the relevant analytical techniques and methods. 3. Illustrate gene expression and the relevant regulation mechanisms. 4. Formulate a research plan and carry out research work in the field of genetics and genomics.

5. Analyze critically the data collected from genetic research work using the appropriate statistical methods.
6. Communicate scientific information clearly and explicitly, either in written formats or via oral presentations.
7. Follow the ethical rules applied in the field of genetics and genomics.

The table below maps the Specialized Learning Outcomes for the SKU to the KLOs

SLOs	KLOs								
	KLO1	KLO2	KLO3	KLO4	KLO5	KLO6	KLO7	KLO8	KLO9
SLO1	✓								
SLO2		✓							
SLO3			✓						
SLO4				✓					
SLO5						✓			
SLO6							✓		
SLO7									✓

Specialized Knowledge Unit (SKU7.2): Molecular Genetics

Description

This SKU provides the students with principles of modern techniques in molecular genetics. This knowledge unit places an emphasis on examples derived from various biological systems such as yeasts, plants and bacteria. The presented knowledge encompasses the molecular mechanisms of genetic information transfer. Description of recombinant DNA techniques, molecular biology of genes, molecular cloning, plasmid design, transfection, and protein expression systems are also involved. This specialized knowledge enables the students to acquire laboratory experience with plasmid isolation, transformation, electrophoresis, and PCR.

Topics

The following core topics must be included in this SKU:

1. Structure of genetic material: structure of DNA and RNA.
2. DNA replication: events of replication and involvement of DNA polymerases.
3. Genetic information: role of transcription initiation, elongation and termination processes in flow of the genetic information.
4. Genetic coding: basic features of the genetic coding.
5. Gene expression: regulation of gene expression at the transcriptional and post-transcriptional levels.
6. Gene transfer: mechanisms of gene transfer and processes of gene recombination.
7. Mutagenesis: mutagens and carcinogenesis, and mechanisms of DNA repair.
8. Genetic engineering: principals of genetic engineering.

Specialized Learning Outcome

By completing this SKU, students should be able to:

1. Illustrate the chemistry and full structure of nucleic acids as DNA replication, transcription, translation, and protein synthesis at the molecular level.
2. Report the different molecular genetic techniques that are used to isolate, separate, and quantify nucleic acids, as well as the modern approaches to genetic engineering.
3. Clarify the regulation of gene expression in prokaryotes and eukaryotes.

4. Plan for research work and conduct laboratory experiments by applying the appropriate techniques of molecular genetics.
5. Assess and analyze critically the collected research data from molecular genetic experiments using the appropriate statistical analytical methods.
6. Perform the assigned work independently to pursue a laboratory activity and to collaborate effectively in a research team.
7. Share research issues by applying professional communication skills and presenting scientific data through written formats or oral presentations.

The table below maps the Specialized Learning Outcomes for the SKU to the KLOs

SLOs	KLOs								
	KLO1	KLO2	KLO3	KLO4	KLO5	KLO6	KLO7	KLO8	KLO9
SLO1	✓								
SLO2		✓							
SLO3			✓						
SLO4				✓					
SLO5						✓			
SLO6							✓		
SLO7								✓	

General Knowledge Unit (GKU 8): Evolution

Description	This GKU introduces the students to the processes and patterns of evolution. The core concepts of evolution, including the geological, biological, phylogenetic and rational evidence of evolution, are emphasized. The origin of genetic and phenotypic variations, as well as micro- and macro-evolutionary processes and patterns, are addressed in this knowledge unit.

Specialized Knowledge Unit (SKU 8.1): Evolution

Description	This SKU provides the students with the principles of vertebrate evolution, with particular emphasis on the origin of major groups and the anatomical and functional evolutionary processes associated with their rise and diversification. This knowledge unit presents the vertebrate evolutionary history that has resulted in the diversity of vertebrates. The presented knowledge concentrates on the morphology reported in fossils and higher vertebrates as major evidence supporting the interpretations of evolutionary relationships. It is emphasized in this knowledge unit that the morphology of organisms is developed through a series of natural selection.
Topics	**The following core topics must be included in this SKU:** 1. Phylogeny: phylogeny, geologic time, and taxonomy. 2. Chordates: evolution of chordates and living fossils. 3. Vertebrate evolution: body plan and material properties of flesh and bone. 4. Paleozoic armoured fish: heterostracans and osteostracans. 5. Origin of gnathostomes: placoderms, acanthodians, chondrichthyes, and teleosts. 6. Radiation of teleosts: variations in aquatic feeding and locomotion. 7. Transition to land: Sarcopterygia, Tiktaalik, Acanthostega, and Ichthyostega; transformations in limbs, girdles, axial skeleton, respiration and senses. 8. Paleozoic anamniotic tetrapods: the origin of modern amphibians. 9. Origin of the amniotes: amniote egg, sauropsids and synapsids. 10. Archosaurs: dinosaurs and birds. 11. Synapsids: synapsids and fabulous furballs (aka Mammals) 12. End Mammals: evolutionary aspects of end mammals.

Specialized Learning Outcome

By completing this SKU, students should be able to:

1. Distinguish the anatomical features of various vertebrates and identify the major anatomical structures (skull, limbs/fins, axial skeleton, etc.)
2. Relate vertebrate history to geological history and trace the evolutionary changes in morphology from modern vertebrates back to early Paleozoic animals.
3. Clarify the phylogenic relations and the use of cladistic analysis of morphology to evaluate phylogenetic hypotheses.
4. Write a research proposal and consequently conduct evolutionary studies on phylogeny and other vertebrate evolutionary issues.
5. Interpret and analyze critically the scientific evolutionary data using the appropriate statistical methods.
6. Perform the assigned scientific tasks independently and cooperate effectively in a research team.
7. Communicate professionally to convey scientific data through written reports or oral presentations to varied audiences.

The table below maps the Specialized Learning Outcomes for the SKU to the KLOs

SLOs	KLOs								
	KLO1	KLO2	KLO3	KLO4	KLO5	KLO6	KLO7	KLO8	KLO9
SLO1	✓								
SLO2		✓							
SLO3			✓						
SLO4				✓					
SLO5						✓			
SLO6							✓		
SLO7								✓	

Specialized Knowledge Unit (SKU 8.2): Evolutionary Biology

Description	This SKU provides the students with modern evolutionary theories concerning the origin and dynamics of genetic diversity, reproductive isolation and evolutionary relationships among organismal groups. This knowledge unit places an emphasis on the interactions between the evolutionary forces (mutation, recombination, selection, migration and genetic drift), which drive the patterns and processes of biodiversity at different levels of biological organization.
Topics	**The following core topics must be included in this SKU:** 1- History of life: study of life history through investigation of genes and genomes. 2- Evolutionary processes: evolutionary processes and causes of genetic variations. 3- Natural selection: evolution by natural selection and adaptation. 4- Diversity: causes of diversification and novelty. 5- Environmental interaction: interaction of environmental and genetic factors. 6- Evolutionary perspectives: application of evolutionary perspectives to phenomena at all levels of biological organization starting from molecules to ecosystems.
Specialized Learning Outcome	**By completing this SKU, students should be able to:** 1- State the phylogenetic perspectives, causes of genetic variations, and various forms of selection. 2- Identify the genetic and environmental factors that act in concert to determine the evolutionary outcomes, including adaptation and diversification. 3- Explain how selection, mutation, migration (gene flow), and inbreeding affect the genetic structure of populations. 4- Plan for carrying out studies in the field of evolutionary biology. 5- Analyze critically the collected research data by employing the proper analytical approaches. 6- Communicate scientific issues in a professional manner to both peers and nonspecialized audiences. **The table below maps the Specialized Learning Outcomes for the SKU to the KLOs**

SLOs	KLOs								
	KLO1	KLO2	KLO3	KLO4	KLO5	KLO6	KLO7	KLO8	KLO9
SLO1	✓								
SLO2		✓							
SLO3			✓						
SLO4				✓					
SLO5						✓			
SLO6								✓	