FIELD 316: BIOLOGY

TEST FRAMEWORK

April 2022

Content Domain		Range of Competencies	Approximate Percentage of Test Score
I.	Structures and Processes of Cells and Organisms	0001–0004	40%
II.	Ecosystem Interactions and Dynamics	0005–0007	30%
III.	Heredity and Evolution	0008–0009	30%

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TEST FRAMEWORK

STRUCTURES AND PROCESSES OF CELLS AND ORGANISMS

0001 Understand the characteristics and behavior of the atoms and molecules necessary for life.

- Demonstrate knowledge of the chemistry of major elements composing living things (e.g., carbon, nitrogen, sulfur) and the properties of chemical bonds that join these elements (e.g., covalent, ionic, hydrogen).
- Demonstrate knowledge of the physical and chemical properties of common molecules in living things (e.g., water, molecular oxygen, carbon dioxide).
- Apply knowledge of the structures and functions of biologically important macromolecules (i.e., carbohydrates, proteins, nucleic acids, and lipids), including their basic building blocks (e.g., monomers, peptides, lipid chains, nucleotides), and the processes of dehydration synthesis and hydrolysis.
- Demonstrate knowledge of the structures of various proteins, their subunits, and the impact of those structures on their functions; and of the structure and function of enzymes in cells, models of enzyme function, and factors that affect enzyme activity.
- Apply knowledge of the structures of DNA and RNA, the impact of those structures on their functions, and the relationship between DNA, alleles, genes, and chromosomes.
- Apply knowledge of DNA replication and protein synthesis, including the role of RNA, transcription, and translation.
- Demonstrate knowledge of scientific practices (e.g., asking questions, analyzing and interpreting data, using mathematics and computational thinking), safety procedures and the proper use of equipment, and the engineering design process (e.g., iterative design, solving problems) related to the characteristics and behavior of the atoms and molecules necessary for life.

0002 Understand the components of living things.

- Apply knowledge of the structure and function of a cell's organelles and parts (e.g., mitochondrion, chloroplast, flagellum, membrane).
- Apply knowledge of the structure of a cell's membrane and its role in passive and active transport and the maintenance of homeostasis in cells (e.g., osmosis, endocytosis, exocytosis).
- Apply knowledge of cell theory and the similarities and differences between various cells and nonliving cell-like structures (e.g., viruses, prokaryotic cells, eukaryotic plant cells, eukaryotic animal cells, protists).
- Demonstrate knowledge of the structures and life-sustaining functions of cells in multicellular organisms, including differentiation of specialized cells.
- Demonstrate knowledge of the mechanisms of cellular communication (e.g., endocrine, synaptic transmission, hormonal, pheromonal).
- Apply knowledge of the hierarchical organization of cells, tissues, organs, and organ systems of living things (e.g., lung tissue in the respiratory system of a mammal, xylem and phloem making up the transport system in a plant).
- Demonstrate knowledge of scientific practices (e.g., asking questions, analyzing and interpreting data, using mathematics and computational thinking), safety procedures and the proper use of equipment, and the engineering design process (e.g., iterative design, solving problems) related to the components of living things.

0003 Understand the flow of energy and cycling of matter in different organisms.

- Demonstrate knowledge of the processes within photosynthesis, including energy transfer and cycling of reactants and products.
- Demonstrate knowledge of the processes of cellular respiration and ATP production in anaerobic and aerobic conditions (e.g., electron transport chain, glycolysis, the citric acid cycle).
- Apply knowledge of the cycling of matter and the flow of energy to the maintenance of homeostasis within organisms, including their equilibria, feedback loops, and the laws of thermodynamics.
- Demonstrate knowledge of scientific practices (e.g., asking questions, analyzing and interpreting data, using mathematics and computational thinking), safety procedures and the proper use of equipment, and the engineering design process (e.g., iterative design, solving problems) related to the flow of energy and cycling of matter in different organisms.

0004 Understand the maintenance, growth, and reproduction of organisms.

- Demonstrate knowledge of the structures and functions of organs and organ systems in plants, including for growth and reproduction.
- Demonstrate knowledge of the structures and functions of organs and organ systems in animals for growth and reproduction, including humans.
- Apply knowledge of how the cell cycle relates to the life processes of growth, differentiation, maintenance, and repair in multicellular organisms.
- Apply knowledge of the major events of the cell cycle outside of mitosis (e.g., DNA replication, cytokinesis, cell cycle control).
- Demonstrate knowledge of the process of mitosis, including its major events, functions, and intermediate and final products.
- Demonstrate knowledge of the process of meiosis, including its major events, functions, and intermediate and final products.
- Apply knowledge of the forms of reproduction, including the similarity and differences between sexual and asexual reproduction.
- Demonstrate knowledge of scientific practices (e.g., asking questions, analyzing and interpreting data, using mathematics and computational thinking), safety procedures and the proper use of equipment, and the engineering design process (e.g., iterative design, solving problems) related to the maintenance, growth, and reproduction of organisms.

ECOSYSTEM INTERACTIONS AND DYNAMICS

0005 Understand the relationships between organisms within an ecosystem.

- Demonstrate knowledge of ecological concepts (e.g., niche, population, community, ecosystem, biome), types of biomes, and the characteristics of the flora and fauna of various biomes.
- Analyze the biotic and abiotic factors that influence population dynamics (e.g., carrying capacity, resource availability, limiting factors, competition), including the use of mathematical models.
- Apply knowledge of cause and effect to biodiversity, population sizes, density, and growth rates of species in an ecosystem (e.g., disease, predation, generation length).
- Analyze how individual and group behaviors (e.g., nest building, flocking, schooling, herding, hunting) influence the chances of survival and reproduction for individuals and species.
- Apply knowledge of symbiotic interactions between organisms in an ecosystem (e.g., competition, predation, commensalism, mutualism, parasitism).
- Demonstrate knowledge of scientific practices (e.g., asking questions, analyzing and interpreting data, using mathematics and computational thinking), safety procedures and the proper use of equipment, and the engineering design process (e.g., iterative design, solving problems) related to the relationships between organisms within an ecosystem.

0006 Understand how energy and matter pass through ecosystems.

- Apply knowledge of the ways in which matter moves through abiotic and biotic reservoirs in an ecosystem (e.g., carbon cycle, nitrogen cycle, water cycle, photosynthesis, cellular respiration), including through the use of models.
- Analyze energy transfer within ecosystems, including through food webs and mathematical models (e.g., pyramid of energy).
- Demonstrate knowledge of trophic levels and relationships in an ecosystem (e.g., primary producers, decomposers).
- Apply knowledge of factors affecting equilibrium, resistance, and resilience in an ecosystem (e.g., biodiversity, functional redundancy, genetic diversity, reproductive rates).
- Apply knowledge of feedback loops promoting stability and change within an ecosystem (e.g., introduction of species, melting of ice sheets, rise in sea level, ocean acidification).
- Demonstrate knowledge of scientific practices (e.g., asking questions, analyzing and interpreting data, using mathematics and computational thinking), safety procedures and the proper use of equipment, and the engineering design process (e.g., iterative design, solving problems) related to how energy and matter pass through ecosystems.

0007 Understand how humans impact ecosystems.

- Apply knowledge of the impacts of human activities on changes in climate and the impacts of climate change on species and ecosystems (e.g., ocean chemistry, changes in temperature and precipitation).
- Demonstrate knowledge of renewable resources (e.g., wind, solar) and nonrenewable resources (e.g., natural gas, coal) and their impact on the environment.
- Apply knowledge of the types and sources of environmental pollution; the effects of pollution on natural populations, communities, and ecosystems; and remediation methods.
- Apply knowledge of the ecological consequences of human activities and population growth that lead to a loss in biodiversity (e.g., habitat fragmentation, introduction of invasive species, overharvesting), including the use of models.
- Demonstrate knowledge of the concept of sustainability; its applications to human activities (e.g., agriculture, forestry management, fisheries management, recycling); and its potential for preventing, mitigating, and reversing environmental harm.
- Demonstrate knowledge of scientific practices (e.g., asking questions, analyzing and interpreting data, using mathematics and computational thinking), safety procedures and the proper use of equipment, and the engineering design process (e.g., iterative design, solving problems) related to how humans impact ecosystems.

HEREDITY AND EVOLUTION

0008 Understand inheritance.

- Demonstrate knowledge of how the different forms of reproduction affect the observed diversity in traits in a population.
- Apply knowledge of the role of DNA, RNA, genes, and chromosomal behavior (e.g., independent assortment, segregation, crossing over) on patterns in the inheritance of traits (e.g., codominance, sex linkage, multiple alleles, polygenic).
- Demonstrate knowledge of the Mendelian principles of genetics (e.g., unit factors, dominance, independent assortment).
- Apply knowledge of genetics to explain connections between genotype and phenotype, including models (e.g., Punnett squares, pedigree charts).
- Apply principles of probability to analyze possible genotype and phenotype combinations in offspring (e.g., complete dominance, codominance, incomplete dominance, sex linked, polygenic).
- Demonstrate knowledge of the sources and types of mutations and of genetic disorders and their causes (e.g., Down syndrome, sickle cell anemia).
- Apply knowledge of factors that affect gene expression (e.g., diet, chemical exposure, age) and gene regulation, including explanations of population-level diversity in traits.
- Demonstrate knowledge of the basic methods, processes, and tools used in molecular biology research (e.g., electrophoresis, polymerase chain reaction, plasmids); their applications (e.g., genetic engineering, forensic science); and the societal and ethical implications of their use.
- Apply knowledge of evidence of common ancestry and diversity among living things (e.g., anatomical, embryonic, amino acid sequences), including the use of models (e.g., taxonomic systems, binomial nomenclature, phylogenetic trees, cladograms).
- Demonstrate knowledge of scientific practices (e.g., asking questions, analyzing and interpreting data, using mathematics and computational thinking), safety procedures and the proper use of equipment, and the engineering design process (e.g., iterative design, solving problems) related to inheritance.

0009 Understand natural selection, adaptation, and the diversity of life.

- Demonstrate knowledge of the theory of natural selection (e.g., overproduction, competition, variation, survival of the fittest).
- Demonstrate knowledge of the types of evidence for natural selection (e.g., fossil record, comparative anatomy, biochemistry, molecular biology).
- Apply knowledge of the cause and effect relationship between natural selection and adaptation and of factors necessary for adaptation to occur (e.g., genetic variation, phenotypic variation, survival of the fittest).
- Demonstrate knowledge of the processes of speciation that maintain reproductive isolation and factors that affect the reproductive success of populations, including rates of speciation.
- Apply knowledge of the ways in which natural selection can influence the phenotypes in a population to affect the distribution of heritable traits (e.g., disruptive selection, stabilizing selection, directional selection) and the rate of these changes.
- Apply knowledge of the effects of gene flow and genetic drift on species diversity (e.g., population bottlenecks, founder effect), including the rate and extent of genetic change.
- Demonstrate knowledge of the conditions associated with Hardy–Weinberg equilibrium and solve probability problems related to the frequency of genotypes and phenotypes in specific populations.
- Demonstrate knowledge of basic taxonomy, criteria used to classify organisms, and biological systematics (e.g., binomial nomenclature, phylogenetic trees, cladograms).
- Demonstrate knowledge of scientific practices (e.g., asking questions, analyzing and interpreting data, using mathematics and computational thinking), safety procedures and the proper use of equipment, and the engineering design process (e.g., iterative design, solving problems) related to natural selection, adaptation, and the diversity of life.