NEW YORK STATE TEACHER CERTIFICATION EXAMINATIONS™

FIELD 06: BIOLOGY
TEST FRAMEWORK

June 2003
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New York State Teacher Certification Examinations™

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Foundations of Scientific Inquiry
Cell Biology and Biochemistry
Genetics and Evolution
Biological Unity and Diversity and Life Processes
Human Biology
Ecology
Foundations of Scientific Inquiry: Constructed-Response Assignment

The New York State biology educator has the knowledge and skills necessary to teach effectively in New York State public schools. The biology teacher is a skilled problem solver who understands the historical development of ideas in science and the connections among science, mathematics, and technology. The biology teacher knows how to access, generate, process, and transfer information using appropriate technologies and can apply knowledge and thinking skills of mathematics, science, and technology to address problems and make informed decisions. Most importantly, the biology teacher understands the process of scientific inquiry and applies biological concepts, principles, and theories to pose questions, seek answers, and communicate explanations of natural phenomena.

SUBAREA I—FOUNDATIONS OF SCIENTIFIC INQUIRY

0001 Understand the relationships and common themes that connect mathematics, science, and technology.

For example:

- analyzing similarities among systems in mathematics, science, and technology (e.g., stability, equilibrium)
- applying concepts and theories from mathematics and other sciences to a biological system
- analyzing the use of biology and other sciences in the design of a technological solution to a given problem
- using the Internet, a variety of software (e.g., spreadsheets, graphing utilities, statistical packages, simulations), and technologies (e.g., graphing calculators, computers) to model and solve problems in mathematics, science, and technology

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0002 Understand the historical and contemporary contexts of biological study and the applications of biology and biotechnology to society.

For example:

- recognizing the significance of key events in the history of biological study (e.g., development of the microscope, understanding the structure of DNA, use of animals in research, genomic research)
- recognizing the contributions of diverse cultures and individuals to biological study
- evaluating the impact of social factors on biological study (e.g., restrictions on the development of human cloning techniques, demand for genetically modified agricultural crops, bioethics)
- interpreting the implications for society of recent developments in biology and biotechnology (e.g., medical technology, genetic engineering, wastewater treatment, food safety)

0003 Understand the process of scientific inquiry and the role of observation, experimentation, and communication in explaining natural phenomena.

For example:

- analyzing processes by which new scientific knowledge and hypotheses are generated
- analyzing ethical issues related to the process of scientific research and reporting
- evaluating the appropriateness of a specified experimental design to test a hypothesis
- demonstrating an ability to design a hypothesis-testing inquiry experiment

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0004 Understand the processes of gathering, organizing, reporting, and interpreting scientific data, and apply this understanding in the context of biological investigations.

For example:

- evaluating the appropriateness of a given method or procedure for collecting data for a specified purpose
- selecting an appropriate and effective graphic representation (e.g., graph, table, diagram) for organizing, reporting, and analyzing given experimental data
- demonstrating the ability to appropriately set up and label graphs with dependent and independent variables
- applying procedures and criteria for reporting experimental protocols and data (e.g., use of statistical tests)
- analyzing relationships between factors (e.g., linear, exponential) as indicated by experimental data

0005 Understand and apply principles and procedures of measurement used in the biological sciences.

For example:

- demonstrating an ability to use the metric system
- evaluating the appropriateness and limitations of units of measurement, measuring devices, or methods of measurement for given situations
- applying methods of measuring microscopic organisms and structures
- analyzing likely sources of error in measurement and the consequences of such error on subsequent calculations and conclusions

0006 Understand the use of equipment, materials, chemicals, and living organisms in biological studies and the application of procedures for their proper, safe, and legal use.

For example:

- demonstrating knowledge of the appropriate use of given laboratory materials, instruments, and equipment (e.g., indicators, microscopes, centrifuges, spectrophotometers, chromatography equipment)
- applying proper methods for storing, identifying, dispensing, and disposing of chemicals and biological materials
- identifying sources of and interpreting information (e.g., material safety data sheets) regarding the proper, safe, and legal use of equipment, materials, and chemicals
- interpreting guidelines and regulations for the proper and humane procurement and treatment of living organisms in biological studies
- recognizing possible alternatives to dissection
- applying proper procedures for promoting laboratory safety (e.g., the use of safety goggles, universal health precautions) and responding to accidents and injuries in the biology laboratory

SUBAREA II—CELL BIOLOGY AND BIOCHEMISTRY

0007 Understand cell structure and function, the dynamic nature of cells, and the uniqueness of different types of cells.

For example:

- comparing and contrasting the cellular structures and functions of archaea, prokaryotes, and eukaryotes
- analyzing the primary functions, processes, products, and interactions of various cellular structures (e.g., lysosomes, microtubules, cell membrane)
- analyzing the importance of active and passive transport processes in maintaining homeostasis in cells and the relationships between these processes and the cellular membranes

0008 Understand chemistry and biochemistry to analyze the role of biologically important elements and compounds in living organisms.

For example:

- comparing and contrasting hydrogen, ionic, and covalent bonds and the conditions under which these bonds form and break apart
- relating the structure and function of carbohydrates, lipids, proteins (e.g., level of structure), nucleic acids, and inorganic compounds to cellular activities
- analyzing the properties of water and the significance of these properties to living organisms
- demonstrating an understanding of pH chemistry in biological systems
- analyzing the structure and function of enzymes and factors that affect the rate of enzyme action

0009 Understand the raw materials, products, and significance of photosynthesis and cellular respiration and the relationships of these processes to cell structure and function.

For example:

- recognizing the significance of photosynthesis and respiration to living organisms
- identifying the overall chemical equations for the processes of respiration and photosynthesis
- demonstrating an understanding of ATP production through chemiosmosis in both photosynthesis and respiration
- analyzing factors that affect photosynthesis and respiration
- comparing aerobic and anaerobic respiration
- evaluating the significance of chloroplast structure in photosynthesis and mitochondrion structure in respiration

0010 Understand the structure and function of DNA and RNA.

For example:

- demonstrating an understanding of the mechanism of DNA replication, potential errors, and implications of these errors
- analyzing the roles of DNA and ribosomal, messenger, and transfer RNA in protein synthesis
- analyzing the implications of mutations in DNA molecules for protein structure and function (e.g., sickle-cell anemia, cystic fibrosis)
- analyzing the control of gene expression in cells (e.g., *lac* operon in *E. coli*)

0011 Understand the procedures involved in the isolation, manipulation, and expression of genetic material and the application of genetic engineering in basic and applied research.

For example:

- analyzing the role and applications of genetic engineering in the basic discoveries of molecular genetics (e.g., in medicine, agriculture)
- demonstrating an understanding of genetic engineering techniques (e.g., restriction enzymes, PCR, gel electrophoresis)
- analyzing the role of genetic engineering in the development of microbial cultures capable of producing valuable products (e.g., human insulin, growth hormone)
- recognizing the role of gene cloning in deriving nucleotide and amino acid sequences and the role of cloned genes as probes in determining the structure of more complex DNA molecules
- recognizing how genetic engineers design new biological products unavailable from natural sources and alter gene products by site-directed mutagenesis (e.g., transgenic plants and animals)
- recognizing the ethical, legal, and social implications of genetic engineering

0012 Understand the cell cycle, the stages and end products of meiosis and mitosis, and the role of cell division in unicellular and multicellular organisms.

For example:

- describing general events in the cell cycle and analyzing the significance of these events
- interpreting the results of experiments relating to the eukaryotic cell cycle (e.g., cloning, polyploidy, tissue cultures, pharming)
- comparing chromosomal changes during the stages of meiosis and mitosis
- analyzing the significance of meiosis and fertilization in relation to the genetic diversity and evolution of multicellular organisms
- recognizing the relationship between an unrestricted cell cycle and cancer
- demonstrating an understanding of the process of cell differentiation, including the role of stem cells

SUBAREA III—GENETICS AND EVOLUTION

0013 Understand concepts, principles, and applications of classical and molecular genetics.

For example:

- demonstrating an understanding of basic principles of heredity (e.g., dominance, codominance, incomplete dominance, segregation, independent assortment)
- analyzing techniques used to determine the presence of human genetic diseases (e.g., PKU, cystic fibrosis)
- analyzing genetic inheritance problems involving genotypic and phenotypic frequencies
- interpreting pedigree charts
- recognizing the role of nonnuclear inheritance (e.g., mitochondrial DNA) in phenotypic expression

0014 Understand the principles of population genetics and the interaction between heredity and the environment, and apply this knowledge to problems involving populations.

For example:

- evaluating conditions that affect allele frequency in a gene pool
- analyzing the relationship between an organism's phenotype for a particular trait and its selective advantage in a given environment (e.g., the human sickle-cell trait and malaria)

0015 Understand hypotheses about the origins of life, evidence supporting evolution, and evolution as a unifying theme in biology.

For example:

- evaluating evidence supporting various hypotheses about the origins of life
- analyzing the progression from simpler to more complex life forms (e.g., unicellular to colonial to multicellular) by various processes (e.g., endosymbiosis)
- assessing the significance of geological and fossil records in determining evolutionary histories and relationships of given organisms
- evaluating observations made in various areas of biology (e.g., embryology, biochemistry, anatomy) in terms of evolution

0016 Understand the mechanisms of evolution.

For example:

- recognizing sources of variation in a population
- analyzing relationships between changes in allele frequencies and evolution
- analyzing the implications of natural selection versus the inheritance of acquired traits in given situations
- comparing alternative mechanisms of evolution (e.g., gradualism, punctuated equilibrium)
- analyzing factors that lead to speciation (e.g., geographic and reproductive isolation, genetic drift)

0017 Understand the principles of taxonomy and the relationship between taxonomy and the history of evolution.

For example:

- analyzing criteria used to classify organisms (e.g., morphology, biochemical comparisons)
- interpreting a given phylogenetic tree or cladogram of related species
- demonstrating the ability to design and use taxonomic keys (e.g., dichotomous keys)
- relating changes in the structure and organization of the classification system to developments in biological thought (e.g., evolution, modern genetics)

SUBAREA IV—BIOLOGICAL UNITY AND DIVERSITY AND LIFE PROCESSES

0018 Understand the unity and diversity of life, including common structures and functions.

For example:

- analyzing characteristics of living organisms (e.g., differences between living organisms and nonliving things)
- recognizing levels of organization (e.g., cells, tissues, organs)
- comparing and analyzing the basic life functions carried out by living organisms (e.g., obtaining nutrients, excretion, reproduction)
- recognizing the role of physiological processes (e.g., active transport) that contribute to homeostasis and dynamic equilibrium
- recognizing the relationship of structure and function in all living things

0019 Understand the general characteristics, functions, and adaptations of prions, viruses, bacteria, protoctists (protists), and fungi.

For example:

- comparing the structure and processes of prions and viruses to cells
- comparing archaebacteria and eubacteria
- analyzing the processes of chromosome and plasmid replication and gene transfer in bacteria
- comparing the structure and function of protoctists (protists)
- recognizing the significance of prions, viruses, retroviruses, bacteria, protoctists (protists), and fungi in terms of their beneficial uses or deleterious effects

0020 Understand the general characteristics, life functions, and adaptations of plants.

For example:

- comparing structures and their functions in nonvascular and vascular plants (e.g., mosses, ferns, conifers)
- analyzing reproduction and development in the different divisions of plants
- analyzing the structures and forces involved in transport in plants
- evaluating the evolutionary and adaptive significance of plant structures (e.g., modified leaves, colorful flowers)

0021 Understand the general characteristics, life functions, and adaptations of animals.

For example:

- identifying general characteristics of the embryonic development of invertebrates and vertebrates
- comparing and contrasting the life cycles of invertebrates and vertebrates
- demonstrating an understanding of physiological processes (e.g., excretion, respiration, aging) of animals and their significance
- recognizing the relationship between structure and function in given animal species
- analyzing the adaptive and evolutionary significance of animal behaviors and structures

SUBAREA V—HUMAN BIOLOGY

0022 Understand the structures and functions of the human skeletal, muscular, and integumentary systems; common malfunctions of these systems; and their homeostatic relationships within the body.

For example:

- comparing the structures, locations, and functions of the three types of muscles
- demonstrating an understanding of the mechanism of skeletal muscle contraction
- demonstrating an understanding of the movements of body joints in terms of muscle and bone arrangement and action
- relating the structure of the skin to its functions
- demonstrating an understanding of possible causes, effects, prevention, and treatment of malfunctions of the skeletal, muscular, and integumentary systems (e.g., arthritis, skin cancer, scoliosis, osteoporosis)

0023 Understand the structures and functions of the human respiratory and excretory systems, common malfunctions of these systems, and their homeostatic relationships within the body.

For example:

- demonstrating an understanding of the relationship between surface area and volume and the role of that relationship in the function of the respiratory and excretory systems
- analyzing the mechanism of breathing and the process of gas exchange between the lungs and blood and between blood and tissues
- analyzing the role of the kidneys in osmoregulation and waste removal from the blood and the factors that influence nephron function
- demonstrating an understanding of possible causes, effects, prevention, and treatment of malfunctions of the respiratory and excretory systems (e.g., emphysema, nephritis)

0024 Understand the structures and functions of the human circulatory and immune systems, common malfunctions of these systems, and their homeostatic relationships within the body.

For example:

- demonstrating an understanding of the structure, function, and regulation of the heart and the factors that influence cardiac output
- analyzing changes in the circulatory system (e.g., vessel structure and function) and their influence on blood composition and blood flow (e.g., blood cell diversity)
- demonstrating an understanding of the possible causes, effects, prevention, and treatment of malfunctions of the circulatory system (e.g., hypertension)
- demonstrating an understanding of the structure, function, and regulation of the immune system (e.g., cell-mediated and humoral responses)
- demonstrating an understanding of the possible causes, effects, prevention, and treatment of malfunctions of the immune system (e.g., autoimmune diseases, transplant rejection)

0025 Understand human nutrition and the structures and functions of the human digestive system and accessory organs, common malfunctions of the digestive system, and its homeostatic relationships within the body.

For example:

- demonstrating an understanding of the roles in the body of the basic nutrients found in foods (e.g., carbohydrates, vitamins, water)
- demonstrating an understanding of the processes of mechanical and chemical digestion in the digestive system, including contributions of accessory organs
- recognizing the process by which nutrients are transported from inside the small intestine to other parts of the body
- demonstrating an understanding of the possible causes, effects, prevention, and treatment of common malfunctions of the digestive system (e.g., ulcers, appendicitis, eating disorders)

0026 Understand the structures and functions of the human nervous and endocrine systems, common malfunctions of these systems, and their homeostatic relationships within the body.

For example:

- demonstrating an understanding of the structures and functions of the central and peripheral nervous systems
- demonstrating an understanding of the location and function of the major endocrine glands and the function of their associated hormones
- demonstrating an understanding of the transmission of nerve impulses within and between neurons and the influence of drugs and other chemicals on that transmission
- evaluating the role of feedback mechanisms in homeostasis (e.g., role of hormones, neurotransmitters)
- demonstrating an understanding of the possible causes, effects, prevention, and treatment of malfunctions of the nervous and endocrine systems (e.g., diabetes, brain disorders)

0027 Understand the structures and functions of the human reproductive systems, the processes of embryonic development, common malfunctions of the reproductive systems, and their homeostatic relationships within the body.

For example:

- recognizing the role of hormones in controlling the development and functions of the male and female reproductive systems
- demonstrating an understanding of gametogenesis, fertilization, and birth control
- demonstrating an understanding of embryonic and fetal development and the potential effects of drugs, alcohol, and nutrition on this process
- demonstrating an understanding of the possible causes, effects, prevention, and treatment of malfunctions of the reproductive systems (e.g., infertility, birth defects)

SUBAREA VI—ECOLOGY

0028 Understand the characteristics of populations and communities and use this knowledge to interpret population growth and interactions of organisms within an ecosystem.

For example:

- demonstrating an understanding of factors that affect population size and growth rate (e.g., carrying capacity, limiting factors)
- determining and interpreting population growth curves
- analyzing relationships among organisms in a community (e.g., competition, predation, symbiosis)
- evaluating the effects of population density on the environment

0029 Understand the development and structure of ecosystems and the characteristics of major biomes.

For example:

- demonstrating an understanding of the flow of energy through the trophic levels of an ecosystem
- comparing the strengths and limitations of various pyramid models (e.g., biomass, numbers, energy)
- recognizing the importance of the process of ecological succession and the role of biotic and abiotic factors in this process
- identifying the characteristics and geographic distribution of major biomes
- recognizing the effect of biome degradation and destruction on biosphere stability (e.g., climate changes, deforestation, reduction of species diversity)

0030 Understand the connections within and among the biogeochemical cycles and analyze their implications for living things.

For example:

- recognizing the importance of the processes involved in material cycles (e.g., water, carbon, nitrogen, phosphorus)
- demonstrating an understanding of the role of decomposers in nutrient cycling in ecosystems
- analyzing the role of respiration and photosynthesis in biogeochemical cycling
- evaluating the effects of limiting factors on ecosystem productivity (e.g., light intensity, gas concentrations, mineral availability)

0031 Understand concepts of human ecology and the impact of human decisions and activities on the physical and living environment.

For example:

- recognizing the importance and implications of various factors (e.g., nutrition, public health, geography, climate) for human population dynamics
- predicting the impact of the human use of natural resources (e.g., forests, rivers) on the stability of ecosystems
- analyzing types of resource misuse (e.g., deforestation, pollution, strip mining) and their long- and short-term effects
- recognizing the importance of maintaining biological diversity (e.g., pharmacological products, stability of ecosystems)
- evaluating methods and technologies that reduce or mitigate environmental degradation
- demonstrating an understanding of the concept of stewardship and ways in which it is applied to the environment

SUBAREA VII—FOUNDATIONS OF SCIENTIFIC INQUIRY: CONSTRUCTED-RESPONSE ASSIGNMENT

The content to be addressed by the constructed-response assignment is described in Subarea I, Objectives 01–06.