

# Life Sciences Subject Matter Requirements

## Content Domains for Subject Matter Understanding and Skill in Life Sciences

### Domain 1. From Molecules to Organisms: Structures and Processes

#### 1.1 Understand the structure and function of cells.

- a. Apply knowledge of the process by which DNA (deoxyribonucleic acid) within cells is responsible for determining the structure of the proteins that carry out the work of cells.
- b. Analyze prokaryotic cells, eukaryotic cells, and viruses in terms of complexity, general structure (e.g., structure and function of cell organelles), and differentiation.
- c. Demonstrate knowledge of the role of the endoplasmic reticulum and Golgi apparatus/complex in the production, transport, and secretion of proteins.
- d. Apply knowledge of the structure of membranes (e.g., those found in chloroplasts, mitochondria, and cells) and analyze their role in cellular communication, transport, energy flow, and chemiosmosis.
- e. Analyze methods of transport across the membrane (e.g., diffusion, active transport, endocytosis, exocytosis).

(Next Generation Science Standards for California Public Schools, Kindergarten through Grade Twelve, Grades Nine through Twelve, Life Sciences: LS1.A)

#### 1.2 Understand the hierarchical organization and functioning of systems in multicellular organisms.

- a. Demonstrate knowledge of the hierarchical structure, functions, and interactions of major organ systems (e.g., nutrient uptake, water delivery, physical support, reproduction) in plants and fungi.
- b. Demonstrate knowledge of the hierarchical structure, functions, and interactions of major organ systems (e.g., circulatory, digestive, excretory, reproductive, respiratory) in animals, including humans.
- c. Analyze feedback mechanisms that maintain homeostasis in plants and animals, including humans (e.g., endocrine and nervous systems), and mediate behaviors under a range of external conditions.
- d. Analyze the various responses of the human immune system to infection, including the consequences of a compromised immune system as it relates to interactions with other systems.

(Next Generation Science Standards for California Public Schools, Kindergarten through Grade Twelve, Grades Nine through Twelve, Life Sciences: LS1.A, LS1.D)

#### 1.3 Understand growth and development of organisms.

- a. Demonstrate knowledge of the stages of the cell cycle.
- b. Distinguish between the processes of mitosis and meiosis, including their purposes.
- c. Demonstrate knowledge of the stages of mitosis; its significance in asexual reproduction; and its role in the growth, development, and maintenance of organisms.

- d. Explain how cell division and differentiation produce and maintain a complex organism composed of systems of tissues and organs that work together to meet the needs of the whole organism.

(Next Generation Science Standards for California Public Schools, Kindergarten through Grade Twelve, Grades Nine through Twelve, Life Sciences: LS1.B)

#### **1.4 Understand matter and energy flow in organisms.**

- a. Demonstrate knowledge of the process of photosynthesis, including the role of chloroplasts in obtaining and storing usable energy.
- b. Analyze the process of cellular respiration, including the role of mitochondria and how cellular respiration results in the net transfer of energy from one system of interacting molecules to another.
- c. Demonstrate knowledge of the anabolic and catabolic pathways involved in the metabolism of macromolecules (e.g., polysaccharides, nucleic acids, proteins, lipids).
- d. Analyze the role of enzymes in chemical reactions and analyze experiments designed to investigate the catalytic role of enzymes and factors that affect enzyme activity (e.g., levels of protein organization, temperature, ionic conditions, concentration of enzyme and substrate, pH).

(Next Generation Science Standards for California Public Schools, Kindergarten through Grade Twelve, Grades Nine through Twelve, Life Sciences: LS1.C)

### **Domain 2. Ecosystems: Interactions, Energy, and Dynamics**

#### **2.1 Understand interdependent relationships in ecosystems.**

- a. Analyze factors affecting the carrying capacity of an ecosystem (e.g., availability of abiotic and biotic resources).
- b. Apply knowledge of factors affecting population sizes of species within an ecosystem (e.g., carrying capacity, predation, disease, life history characteristics).
- c. Analyze the biotic interactions among organisms in ecosystems (e.g., competition, mutualism, pollination).
- d. Analyze how individual and group behavior (e.g., nest building, flocking, schooling, herding, hunting) influence the chances of survival and reproduction for individuals and species.

(Next Generation Science Standards for California Public Schools, Kindergarten through Grade Twelve, Grades Nine through Twelve, Life Sciences: LS2.A, LS4.D)

#### **2.2 Understand cycles of matter and energy transfer in ecosystems.**

- a. Analyze the roles of organisms in the flow of matter and energy in food webs (e.g., producers, consumers, decomposers).
- b. Analyze the flow of matter and energy through trophic levels of ecosystems.
- c. Demonstrate knowledge of how photosynthesis and cellular respiration (including anaerobic respiration) provide the energy for life processes.

- d. Analyze how chemical elements are transferred among biotic and abiotic components of ecosystems (e.g., biogeochemical cycles) and how changes in amount and distribution of chemical elements can impact ecosystems.

(Next Generation Science Standards for California Public Schools, Kindergarten through Grade Twelve, Grades Nine through Twelve, Life Sciences: LS2.B)

### **2.3 Understand ecosystem dynamics, functioning, and resilience.**

- a. Apply knowledge of the biodiversity (e.g., genetic diversity, species diversity, ecosystem diversity) present in different types of biomes.
- b. Demonstrate knowledge of how natural events and human activity (e.g., fire, flood, habitat destruction, introduction of invasive species) can adversely affect biodiversity and can disrupt an ecosystem.
- c. Apply knowledge of how ecosystems respond to modest and catastrophic change (e.g., resilience, ecological succession).
- d. Evaluate possible solutions for mitigating adverse impacts of human activity on biodiversity.

(Next Generation Science Standards for California Public Schools, Kindergarten through Grade Twelve, Grades Nine through Twelve, Life Sciences: LS2.C)

## **Domain 3. Heredity: Inheritance and Variation of Traits**

### **3.1 Understand inheritance of traits.**

- a. Analyze the structure of DNA and its relationship to genes.
- b. Apply knowledge of how genes expressed by a cell may be regulated in different ways and that specialization of cells in multicellular organisms is due to different patterns of gene expression.
- c. Analyze how DNA codes for proteins and DNA's regulatory or structural functions.
- d. Apply knowledge of the role of alleles and chromosomes in determining phenotypes (e.g., sex determination, chromosomal aberrations).
- e. Predict the probable outcome of phenotypes in a genetic cross from the genotypes of the parents and mode of inheritance (e.g., autosomal or X-linked, dominant or recessive, codominance).
- f. Apply knowledge of the genetic and cellular basis of Mendel's laws of dominance, segregation, and independent assortment.

(Next Generation Science Standards for California Public Schools, Kindergarten through Grade Twelve, Grades Nine through Twelve, Life Sciences: LS3.A)

### **3.2 Understand variation of traits and genetic engineering.**

- a. Recognize how sexual reproduction results in genetic variation as a result of chromosomal reorganization.
- b. Apply knowledge of how genetic variation may be the result of errors that occur during DNA replication or mutations caused by environmental factors, how these mutations are inherited, and the factors affecting whether or not these mutations are expressed.

- c. Relate the structure and function of DNA and RNA (ribonucleic acid) to the concept of variation in organisms.
- d. Apply knowledge of the genetic and environmental factors that affect variation and distribution of traits in a population, including how alleles that are lethal in a homozygous individual may be maintained in a gene pool.
- e. Demonstrate knowledge of how genetic engineering (i.e., biotechnology) produces biomedical and agricultural products.
- f. Demonstrate knowledge of issues of bioethics, including those related to genetic engineering, cloning, the Human Genome Project, and gene therapy and its medical implications.

(Next Generation Science Standards for California Public Schools, Kindergarten through Grade Twelve, Grades Nine through Twelve, Life Sciences: LS3.B)

#### **Domain 4. Biological Evolution: Unity and Diversity**

##### **4.1 Understand evidence of common ancestry and diversity.**

- a. Apply knowledge of how conditions on early Earth led to the evolution of life, as well as how the evolution of life altered Earth's conditions.
- b. Apply knowledge of anatomical, embryological, and genetic evidence to explain biological evolution and common ancestry.
- c. Analyze fossil evidence with regard to biological diversity, episodic speciation, and mass extinction.
- d. Analyze a branching diagram (cladogram) illustrating the phylogeny between organisms of currently identified taxonomic groups and demonstrate understanding that cladograms are hypotheses and can change with the discovery of new information (e.g., fossils, genetics).

(Next Generation Science Standards for California Public Schools, Kindergarten through Grade Twelve, Grades Nine through Twelve, Life Sciences: LS4.A)

##### **4.2 Understand natural selection.**

- a. Apply knowledge of how genetic variation and its expression leads to differences in reproductive success among individuals in a population.
- b. Analyze how natural selection acts on the phenotype rather than the genotype of an organism to alter genotypes in populations.
- c. Analyze the role of diversity in gene pools.
- d. Apply knowledge of Hardy-Weinberg equilibrium and its assumptions, and solve equations to predict the frequency of genotypes in a population.
- e. Demonstrate knowledge of evolutionary mechanisms (e.g., genetic drift, reproductive isolation, patterns of selection) and their effects on patterns of speciation (e.g., convergent evolution).

(Next Generation Science Standards for California Public Schools, Kindergarten through Grade Twelve, Grades Nine through Twelve, Life Sciences: LS4.B)

### **4.3 Understand adaptation.**

- a. Apply knowledge of factors affecting the adaptation of species (e.g., heritable genetic variation, competition, differential survival and reproduction of organisms).
- b. Distinguish between the accommodation of an individual organism to its environment and the gradual adaptation of a lineage of organisms through genetic change.
- c. Apply knowledge of how natural selection results in genetic change in populations.
- d. Analyze how changes in the physical environment may result in changes in the distribution of traits in a population and the emergence, decline, or extinction of species over time.

(Next Generation Science Standards for California Public Schools, Kindergarten through Grade Twelve, Grades Nine through Twelve, Life Sciences: LS4.C)

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