Test Specifications: Biology

Introduction

The Biology Test Specifications provide an overview of the structure and content of the test. This overview includes a description of the test design as well as information on the types of items that will appear on the test. A test blueprint is included, composed of a table identifying the range and distribution of items and points, grouped into various categories. The specifications also provide specific guidelines for the development of all items used for the Biology test. This document is intended to be a resource not only for item writers and test designers, but for Ohio educators and other stakeholders who are interested in a deeper understanding of the test.

General Description of the Biology Test

In 2010 Ohio adopted new rigorous academic content standards for Biology. A model curriculum based on these new standards was adopted in 2011.

An achievement assessment that aligns to the new standards and model curriculum is mandated by Ohio Revised Code 3301.079. The assessment will be administered as a two-part test, in an online format, to measure progress toward the standards and to provide information to teachers and administrators. Test results are reported back to schools by June 30th.

Test Design

The structure of the Biology Test will consist of two parts that will be given near the end of the year. There are two parts in order to provide flexibility in test administration for school districts. Both parts of the test are fixed forms that are administered in an online format. In addition to technology-enhanced items, the test will also contain constructed-response items that require the student to enter a response into the computer interface. The sequence and timing of the administration of Part 1 and Part 2 is determined by the district. After the student has completed both parts of the test, his or her scores will be combined to yield a comprehensive view of the student's progress.

Test Blueprint

The following test blueprint shows the content statements assessed in each reporting category and the distribution of points.

Biology Test Blueprint

Reporting Category	Topic	Points	Total Points on Form	Approximate Percent of Test
Heredity	Cellular genetics	13 - 15	54 - 56	23% - 28%
	Structure and function of DNA in cells			
	Genetic mechanisms and inheritance			
	Mutations			
	Modern genetics			
Evolution	Mechanisms of evolution	13 - 15		23% - 28%
	Diversity of life			
Diversity and Interdependence of Life	Classification systems are frameworks created by scientists for describing the vast diversity of organisms indicating the degree of relatedness between organisms.	13 - 15		23% - 28%
	Ecosystems			
Cells	Cell structure and function	13 - 15		23% - 28%
	Cellular processes			

Description of Item and Stimulus Types

Item Types

Item types are divided into four categories: multiple-choice, enhanced selected-response, machine-scored constructed response and human-scored.

A **multiple-choice** item may consist of the following:

- a brief statement that orients students to the context of the question;
- a stimulus (document, data table, graphic, etc.) on which the question is based;
- a question or prompt;
- a set of answer choices (most often four) that allows students to select one option in response to the question.

An **enhanced selected-response** item may consist of the following:

- a brief statement that orients students to the context of the question;
- a stimulus (document, data table, graphic, etc.) on which the question is based;
- a question or prompt;
- a set of answer choices that allows students to select multiple options in response to one question, matching options together to classify information, selecting evidence supporting an initial answer choice, or a very structured graphic-response interface.
- Enhanced selected-response items allow students to demonstrate deeper understanding than multiple-choice items by having multiple parts or multiple correct answers.

A **machine-scored constructed-response** item may consist of the following:

- a brief statement that orients students to the context of the question;
- a stimulus (document, data table, graphic, etc.) on which the question is based;
- a prompt;
- a graphic-response, text/numeric entry, or simulation interface.
    - A graphic-response interface allows students to manipulate objects to create a response to the question. The graphic-response interface may be a map, a chart or graph, a picture, a diagram, or an interactive simulation on which the students must draw or position objects correctly.
- Machine-scored constructed-response items offer the students a great degree of freedom to create their own response. These items allow students to demonstrate deeper understanding than multiple-choice or enhanced selected-response items by requiring students to construct their own response instead of selecting their answer from a given set of choices. These items are scored based on an item-specific rubric.

A **human-scored constructed-response** item may consist of the following:

- a brief statement that orients students to the context of the questions;
- one or more stimuli (documents, graphics, data displays, etc.) to which the questions refer;
- a question or set of questions that require a detailed written response or responses. The responses are scored by trained scorers according to a rubric or set of rubrics that address multiple dimensions in students' work.

Stimulus Types

A **simulation** stimulus consists of the following:

- An interactive graphic interface that presents a set of interactive stimulus materials or simulates an investigative experiment, physical situation, or an aspect of the inquiry process. The graphics may be static or contain animation. Information is displayed in the form of dynamic illustrations or maps, statistical tables, texts, charts, or graphs. Data "inputs" can be adjusted by the students, depending on the requirements of the scenario or the associated items, and the graphics adjust themselves to account for the new inputs.
- When a simulation is used as part of a task, the simulation is accompanied by one or more items of various types. The simulation functions as an interactive stimulus that provides information for the student to reflect on, analyze or synthesize with other knowledge into a cognitively demanding set of answers. This can be used to simulate an aspect of scientific inquiry.

Other stimulus types associated with discrete items or tasks may include:

- Document excerpts and other texts
- Photographs and illustrations
- Graphs
- Charts
- Data tables
- Maps
- Timelines

Item Specifications: Biology

Course Description

The Ohio Revised Code (ORC) Section 3313.603 requires students graduating from every public and chartered nonpublic high school complete three science units with inquiry-based laboratory experience that engages students in asking valid scientific questions and gathering and analyzing information. Biology is a high school level course, which satisfies the Ohio Curriculum Graduation Requirements for life sciences in ORC Section 3313.603.

This course investigates the composition, diversity, complexity and interconnectedness of life on Earth. Fundamental concepts of heredity and evolution provide a framework through inquiry-based instruction to explore the living world, the physical environment and the interactions within and between them.

Students engage in investigations to understand and explain the behavior of living things in a variety of scenarios that incorporate scientific reasoning, analysis, communication skills and real-world applications.

Course Content

The following information may be taught in any order; there is no ODE-recommended sequence.

Heredity

- Cellular genetics
- Structure and function of DNA in cells
- Genetic mechanisms and inheritance
- Mutations
- Modern genetics

Evolution

- Mechanisms
    - Natural selection
    - Mutation
    - Genetic drift
    - Gene flow (immigration, emigration)
    - Sexual selection
    - History of life on Earth
- Diversity of Life
    - Speciation and biological classification based on molecular evidence
    - Variation of organisms within a species due to population genetics and gene frequency

Diversity and Interdependence of Life

- Classification systems are frameworks created by scientists for describing the vast diversity of organisms indicating the degree of relatedness between organisms.
- Ecosystems
    - Homeostasis
        - Carrying capacity
        - Equilibrium and disequilibrium

Cells

- Cell structure and function
    - Structure, function and interrelatedness of cell organelles
    - Eukaryotic cells and prokaryotic cells
- Cellular processes
    - Characteristics of life regulated by cellular processes
    - Photosynthesis, chemosynthesis, cellular respiration
    - Cell division and differentiation

Heredity

Sub-Topics:

- Cellular genetics
- Structure and function of DNA in cells
- Genetic mechanisms and inheritance
- Mutations
- Modern genetics

Content Elaboration:

Building on knowledge from elementary school (plants and animals have life cycles and offspring resemble their parents) and knowledge from middle school (reproduction, Mendelian Genetics, inherited traits and diversity of species), this topic focuses on the explanation of genetic patterns of inheritance. In middle school, students learn that living things are a result of one or two parents, and traits are passed on to the next generation through both asexual and sexual reproduction. In addition, they learn that traits are defined by instructions encoded in many discrete genes and that a gene may come in more than one form called alleles.

At the high school level, the explanation of genes is expanded to include the following concepts:

- Life is specified by genomes. Each organism has a genome that contains all of the biological information needed to build and maintain a living example of that organism. The biological information contained in a genome is encoded in its deoxyribonucleic acid (DNA) and is divided into discrete units called genes.
- Genes are segments of DNA molecules. The sequence of DNA bases in a chromosome determines the sequence of amino acids in a protein. Inserting, deleting or substituting segments of DNA molecules can alter genes.
- An altered gene may be passed on to every cell that develops from it. The resulting features may help, harm or have little or no effect on the offspring's success in its environments.
- Gene mutations (when they occur in gametes) can be passed on to offspring.
- Genes code for protein. The sequence of DNA bases in a chromosome determines the sequence of amino acids in a protein.
- "The many body cells in an individual can be very different from one another, even though they are all descended from a single cell and thus have essentially identical genetic instructions. Different genes are active in different types of cells, influenced by the cell's environment and past history." (AAAS)

In high school biology, Mendel's laws of inheritance (introduced in grade 8) are interwoven with current knowledge of DNA and chromosome structure and function to build toward basic knowledge of modern genetics. Sorting and recombination of genes

in sexual reproduction and meiosis specifically result in a variance in traits of the offspring of any two parents and explicitly connect the knowledge to evolution.

The gene interactions described in middle school were limited primarily to dominance and co-dominance traits. In high school genetic mechanisms, both classical and modern including incomplete dominance, sex-linked traits, goodness of fit test (Chi-square) and dihybrid crosses are investigated through real-world examples. Dihybrid crosses can be used to explore linkage groups. Gene interactions and phenotypic effects can be introduced using real-world examples (e.g., polygenic inheritance, epistasis, pleiotropy).

It is imperative that the technological developments that lead to the current knowledge of heredity be included in the study of heredity. For example, the development of the model for DNA structure was the result of the use of technology and the studies and ideas of many scientists. Watson and Crick developed the final model, but did not do the original studies.

Content Limits:

- Genes are segments of DNA and code for protein;
- Concept of differentiation – although all cells have identical genetic information, different genes are active in different types of cells;
- Cellular and molecular mechanisms for inheritance and the expression of genetic information (e.g., complementary base pairs in DNA and RNA, transcription/translation);
- Importance of crossing over, independent assortment, and recombination in producing variation in traits as a result of meiosis;
- Connect Mendel's laws of segregation and independent assortment to the movement of chromosomes (crossing over, sorting, and recombination) during meiosis;
- Gene mutations and their short-term and long-term implications;
- Mendelian and Non-Mendelian inheritance (e.g., dihybrid crosses, sex-linked traits, linkage, chi-square test);
- The goals of genetic engineering and the role of restriction enzymes.

Do Not Assess:

- Examples using human genetics;
- Mechanisms of differentiation;
- Monohybrid crosses (including co-dominance) except those beyond Grade 8 (incomplete dominance and sex-linked traits are appropriate for high school);
- Mitosis is considered in Grade 6, not assessed in high school;
- Specific molecular structure of nucleic acids or types of RNA (e.g., sugars, single vs. double strands);
- Labeling specific phases of meiosis;
- Details about the steps of replication, transcription/translation, and protein synthesis (e.g., identifying or naming enzymes, introns or exons);
- Details about genetic engineering procedures.

Stimulus Attributes:

- Diagrams of DNA to illustrate protein synthesis;
- Diagrams that illustrate crossing over;
- Real-world scenario in which chi-squared test data are given;
- Codon chart to build a protein;
- Parent and daughter cells before and after meiosis;
- Diagrams of a variety of genetic crosses;
- Diagrams of gene sequences showing a mutation;
- Scenarios involving applications of biotechnology and genetic engineering such as cloning, gene therapy, or gel electrophoresis;
- Historical data from DNA discoveries.

Response Attributes:

Response options may include, but are not limited to, the following:

- Demonstrating how the complementary DNA base pairing within genes determines the sequence of amino acids in a protein;
- Illustrating how non-Mendelian genetics affects inheritance (including Punnett squares);
- Predicting the probability of two traits in offspring given the parental genotypes;
- Comparing and contrasting the genetic makeup of two different types of cells in the same organism;
- Given chi-squared test data, making an inference about the inheritance of a set of genes;
- Demonstrating how sorting and recombination of genes in sexual reproduction and meiosis result in variation of traits in offspring;
- Explaining how gene mutations might impact organisms;
- Interpreting data from a real-world scenario involving biotechnology (e.g., gel electrophoresis, gene therapy, cloning);
- Explaining the importance of historical discoveries after Mendel to our understanding of the structure and function of DNA;
- Explaining the scientific implications of a biotechnology (e.g., oil-eating bacteria);
- Given a scenario, making and justifying conclusions about the type of inheritance involved;
- Designing or conducting an investigation involving genetics and inheritance (e.g., fruit flies, fast plants, matching genes to traits);
- Explaining the effect that a gene mutation can have on protein synthesis or traits.

Distractors may include, but are not limited to, the following:

- Common misconceptions:
    - Mutations are all bad;
    - Unrealistic idea of mutations;
    - All mutations have effects;

- “Cloning” refers to only the whole organism;
- Each type of cell has unique genetic material;
- Male genes are always dominant;
- Dominant genes are more frequent in a population;
- Chromosomes are totally dominant or recessive;
- All dominant genes are advantageous.

Evolution

Sub-Topics:

- Mechanisms
    - Natural selection
    - Mutation
    - Genetic drift
    - Gene flow (immigration, emigration)
    - Sexual selection
    - History of life on Earth
- Diversity of Life
    - Speciation and biological classification based on molecular evidence
    - Variation of organisms within a species due to population genetics and gene frequency

Content Elaboration:

At the elementary school level, evolution concepts include the relationship between organisms and the environment, parent and offspring, and an introduction to the fossil record and extinction. At the middle school level, concepts include biodiversity (as part of biomes) and speciation, further exploration of the fossil record and Earth history, changing environmental conditions (abiotic factors), natural selection and biological evolution.

Biological evolution explains the natural origins for the diversity of life. Emphasis shifts from thinking in terms of selection of individuals with a particular trait to changing proportions of a trait in populations. The study of evolution must include Modern Synthesis, the unification of genetics and evolution and historical perspectives of evolutionary theory. The study of evolution must include gene flow, mutation, speciation, natural selection, genetic drift, sexual selection and Hardy Weinberg's law.

The basic concept of biological evolution is that the Earth's present-day species descended from earlier, common ancestral species. At the high school level, the term natural selection is used to describe the process by which traits become more or less common in a population due to consistent environmental effects upon the survival or reproduction of the individual with the trait. Mathematical reasoning must be applied to solve problems, (e.g., use Hardy Weinberg's law to explain gene frequency patterns in a population).

Modern ideas about evolution provide a natural explanation for the diversity of life on Earth as represented in the fossil record, in the similarities of existing species and in modern molecular evidence. From a long-term perspective, evolution is the descent with modification of different lineages from common ancestors.

Different phenotypes result from new combinations of existing genes or from mutations of genes in reproductive cells. At the high school level, the expectation is to combine grade-8 knowledge with explanation of the internal structure and function of chromosomes. Natural selection works on the phenotype.

Populations evolve over time. Evolution is the consequence of the interactions of:

1. the potential for a population to increase its numbers;
2. the genetic variability of offspring due to mutation and recombination of genes;
3. a finite supply of the resources required for life; and
4. the differential survival and reproduction of individuals with the specific phenotype.

Mutations are described in the content elaboration for Heredity. Apply the knowledge of mutation and genetic drift to real-world examples.

Recent molecular-sequence data generally, but not always, support earlier hypotheses regarding lineages of organisms based upon morphological comparisons.

Heritable characteristics influence how likely an organism is to survive and reproduce in a particular environment. When an environment changes, the survival value of inherited characteristics may change. This may or may not cause a change in species that inhabit the environment. Formulate and revise explanations for gene flow and sexual selection based on real-world problems.

Content Limits:

- Evolution of a species (change in gene frequency in a population and the Hardy-Weinberg Law);
- Mechanisms of speciation (gene flow, mutation, speciation, natural selection, genetic drift, sexual selection);
- Evidence for evolution (e.g., fossil record, molecular and structural homology, biogeography).

Do Not Assess:

- Human evolution;
- Specific type of mutations;
- The fossil record as evidence for biodiversity, diversity within a species, and the fact that most species that have lived on Earth are now extinct (this assessed in Grade 8);
- Formation of fossils and/or geologic strata;
- Calculations using the Hardy-Weinberg Law;
- Genes as they relate to specific traits in individuals;
- Evolution using the examples of peppered moths and Darwin’s finches.

Stimulus Attributes:

- Evidence of evolutionary theory from real-world examples (e.g., antibiotic resistant bacteria, fossil record, molecular and structural homology);
- Cladograms showing relationships between species;
- Scenarios in which environmental changes influence selective pressure on a population;
- Examples of speciation between isolated populations (e.g., leopard frogs, anole lizard, Central American hummingbirds);
- Tables or data showing gene frequency changes over time (e.g., bottleneck cheetahs).

Response Attributes:

Response options may include, but are not limited to, the following:

- Using mathematical reasoning related to the Hardy-Weinberg Law to explain or predict changes in a population;
- Predicting how factors affect evolution of a population or populations;
- Given evidence, determining the relatedness of groups;
- Comparing the survivability of traits between populations in different environments;
- Comparing evolutionary mechanisms illustrated in a variety of populations;
- Using mathematical reasoning related to Hardy-Weinberg's Law to explain or predict changes in a population;
- Given data and/or a scenario, making and justifying a conclusion about evolutionary mechanisms in a population;
- Explaining how variations within populations in a changing environment can lead to evolution;
- Describing how speciation occurred in two related populations;
- Using examples to explain how evidence supports the theory of evolution;
- Given a real-world example, explaining and predict how a population has responded to environmental changes.

Distractors may include, but are not limited to, the following:

- Common misconceptions:
    - Evolution always results in new species;
    - Non-genetic traits can be passed to offspring;
    - Genetic traits can be acquired when needed or lost when not needed;
    - Evolution happens to an individual;
    - Individual organisms choose to evolve;
    - Variation is a response to selection pressure;
    - The "strongest" organisms survive.

Diversity and Interdependence of Life

Sub-Topics:

- Classification systems are frameworks created by scientists for describing the vast diversity of organisms indicating the degree of relatedness between organisms.
- Ecosystems
    - Homeostasis
        - Carrying capacity
        - Equilibrium and disequilibrium

Content Elaboration

Building on knowledge from elementary school (interactions of organisms within their environment and the law of conservation of matter and energy, food webs) and from middle school (flow of energy through organisms, biomes and biogeochemical cycles), this topic focuses on the study of diversity and similarity at the molecular level of organisms. Additionally, the effects of physical/chemical constraints on all biological relationships and systems are investigated.

The great diversity of organisms and ecological niches they occupy result from more than 3.5 billion years of evolution. Some ecosystems can be reasonably persistent over hundreds or thousands of years. Like many complex systems, ecosystems tend to have cyclic fluctuations around state of rough equilibrium. In the long run, however, ecosystems always change as geological or biological conditions vary. Misconceptions about population growth capacity, interspecies and intra-species competition for resources, and what occurs when a species immigrates to or emigrates from ecosystems are included in this topic. Technology must be used to access real-time/authentic data to study population changes and growth in specific locations.

Classification systems are frameworks developed by scientists for describing the diversity of organisms, indicating the degree of relatedness between organisms. Recent molecular-sequence data generally support earlier hypotheses regarding lineages of organisms based upon morphological comparisons. Both morphological comparisons and molecular evidence must be used to describe biodiversity (cladograms can be used to address this).

Organisms transform energy (flow of energy) and matter (cycles of matter) as they survive and reproduce. The cycling of matter and flow of energy occurs at all levels of biological organization, from molecules to ecosystems. At the high school level, the concept of energy flow as unidirectional in ecosystems is explored.

Mathematical graphing and algebraic knowledge (at the high school level) must be used to explain concepts of carrying capacity and homeostasis within biomes. Use real-time data to investigate population changes that occur locally or regionally. Mathematical

models can include exponential growth model and the logistic growth model. The simplest version of the logistic growth model is

$$Population\ Growth\ Rate\ = rN\ (K - N)/K;$$

the only new variable added to the exponential model is K for carrying capacity.

Note 1: Exponential growth equation in simplest form, change in population size *N* per unit time *t* is a product of *r* (the per capita reproductive rate) and *N* (population size).

Note 2: Carrying capacity is defined as the population equilibrium sized when births and deaths are equal; hence *Population Growth Rate* = 0.

Note 3: Constructing food webs/food chains to show interactions between organisms within ecosystems was covered in upper elementary school and middle school; constructing them as a way to demonstrate content knowledge is not appropriate for this grade. Students may use these diagrams to help explain real-world relationships or events within an ecosystem, but not to identify simple trophic levels, consumers, producers, predator-prey and symbiotic relations.

Content Limits:

- Cyclical fluctuations of ecosystems around a rough state of equilibrium;
- Energy flow at ecosystem and molecular levels;
- Classification using morphological and molecular evidence;
- Diversity of species and ecological niches resulting from billions of years of evolution;
- Models describing carrying capacity and homeostasis within ecosystems supported with mathematical evidence**.**

Do Not Assess:

- Identification of trophic levels, consumers, producers, predator-prey and symbiotic relationships;
- Construction of food chains and/or webs;
- Features or definition of biomes;
- Steps of biogeochemical cycles;
- Memorization of Linnaeus' classification of living things;
- Calculations involving logistic growth or other models.

Stimulus Attributes:

- Population graphs or charts containing authentic, real-world data;
- Diagrams of food chains and webs to explain real-world relationships or events within an ecosystem (e.g., biomagnification, invasive species, energy flow and nutrient cycle changes);

- Scenarios involving remediation and habitat restoration programs (e.g., fish populations in the Great Lakes);
- Scenarios involving niche partitioning, competition for resources, immigration/emigration from an ecosystem, or environmental change;
- Cladograms;
- Data tables showing genetic relatedness between organisms.

Response Attributes:

Response options may include, but are not limited to, the following:

- Using mathematical reasoning to interpret exponential or logistic growth models;
- Designing or simulating a population growth model by manipulating environmental conditions;
- Given population graphs or charts containing data, analyzing the history or predict the future of an ecosystem;
- Predicting the effect of geological, biological, or environmental changes on a population within an ecosystem (e.g., climate change, deforestation, human development);
- Completing cladograms to determine relationships among organisms;
- Predicting the effect of geological, biological, or environmental changes on a population within an ecosystem (e.g., climate change, deforestation, human development);
- Discussing the implications of technology or engineering on an ecosystem (e.g., power plant increasing water temperature);
- Using mathematical models to explain carrying capacity and homeostasis within ecosystems;
- Given a scenario, designing an experiment to predict the effect of several possible factors on the carrying capacity;
- Using cladograms to compare and contrast the degree of relatedness between organisms.

Distractors may include, but are not limited to, the following:

- Common misconceptions:
    - Carrying capacity never changes;
    - Environmental change is always responsible for genetic variation;
    - Environmental changes are always detrimental;
    - A stable ecosystem is graphically represented by a static horizontal line;
    - All usable energy is conserved and passed on in a usable form in an ecosystem.

Cells

Sub-Topics:

- Cell structure and function
    - Structure, function and interrelatedness of cell organelles
    - Eukaryotic cells and prokaryotic cells
- Cellular processes
    - Characteristics of life regulated by cellular processes
    - Photosynthesis, chemosynthesis, cellular respiration
    - Cell division and differentiation

Content Elaboration

Building on knowledge from middle school (cell theory), this topic focuses on the cell as a system itself (single-celled organism) and as part of larger systems (multicellular organism), sometimes as part of a multicellular organism, always as part of an ecosystem. The cell is a system that conducts a variety of functions associated with life. Details of cellular processes such as photosynthesis, chemosynthesis, cellular respiration, cell division and differentiation are studied at this grade level. Additionally, cellular organelles studied are cytoskeleton, Golgi complex and endoplasmic reticulum.

From about 4 billion years ago to about 2 billion years ago, only simple, single-celled microorganisms are found in the fossil record. Once cells with nuclei developed about a billion years ago, increasingly complex multicellular organisms evolved.

Every cell is covered by a membrane that controls what can enter and leave the cell. In all but quite primitive cells, a complex network of proteins provides organization and shape. Within the cell are specialized parts for the transport of materials, energy transformation, protein building, waste disposal, information feedback and movement. In addition to these basic cellular functions, most cells in multicellular organisms perform some specific functions that others do not.

A living cell is composed of a small number of elements, mainly carbon, hydrogen, nitrogen, oxygen, phosphorous and sulfur. Carbon, because of its small size and four available bonding electrons, can join to other carbon atoms in chains and rings to form large and complex molecules. The essential functions of cells involve chemical reactions that involve water and carbohydrates, proteins, lipids and nucleic acids. A special group of proteins, enzymes, enables chemical reactions to occur within living systems.

Cell functions are regulated. Complex interactions among the different kinds of molecules in the cell cause distinct cycles of activities, such as growth and division. Most cells function within a narrow range of temperature and pH. At very low temperatures, reaction rates are slow. High temperatures and/or extremes of pH can

irreversibly change the structure of most protein molecules. Even small changes in pH can alter how molecules interact.

The sequence of DNA bases on a chromosome determines the sequence of amino acids in a protein. Proteins catalyze most chemical reactions in cells. Protein molecules are long, usually folded chains made from combinations of the 20 typical amino-acid sub-units found in the cell. The function of each protein molecule depends on its specific sequence of amino acids and the shape the chain takes as a result of that sequence.

Note 1: The idea that protein molecules assembled by cells conduct the work that goes on inside and outside the cells in an organism can be learned without going into the biochemical details. It is sufficient for students to know that the molecules involved are different configurations of a few amino acids and that the different shapes of the molecules influence what they do.

Note 2: The concept of the cell and its parts as a functioning system is more important than memorizing part of the cell.

Content Limits:

- The cell is a functioning system (e.g., regulation, homeostasis, cell cycle, and transport);
- The cell has specialized parts for the transport of materials, energy transformation, protein building, waste disposal, and movement;
- Role of water and organic molecules in cells (lipids, carbohydrates, nucleic acids, proteins);
- Properties of the cellular environment that affect shape and function of enzymes (e.g., pH, temperature, concentration);
- Transformation of energy through ATP and cycling of carbon through cellular processes in cells (e.g., photosynthesis, cellular respiration).

Do Not Assess:

- Steps of protein synthesis;
- Names of specific enzymes;
- Memorization of formulas and detailed chemical reactions associated with cellular functions;
- Memorization of cell parts and their functions (basic cell parts and functions are assessed at Grade 6);
- Electron transport chains.

Stimulus Attributes:

- Investigative scenarios that explore abiotic effects on the cell cycle;
- Investigative scenarios that determine factors that affect the activity of enzymes on their substrates;

- Real-world applications of cells that play a foundational role in engineering and industry (e.g., fermentation, medicine);
- Diagrams of photosynthesis, cellular respiration, and/or chemosynthesis connected to a real-world scenario;
- Diagrams of cells from a variety of organisms connected to a real-world scenario. (e.g., plant vs. animal cells, prokaryotic vs. eukaryotic, cells with or without potassium pump);
- Diagrams of cellular transport.

Response Attributes:

Response options may include, but are not limited to, the following:

- Interpreting graphs or data (e.g., temperature, pH, light, concentration) to explain the rate of enzyme activity in a cell;
- Explaining how the structure of cellular parts facilitates their function;
- Describing regulation of the cellular environment (e.g., homeostasis);
- Comparing organic molecules and their role in cells;
- Describing how photosynthesis and cellular respiration impact the concentration of chemicals in a system;
- Using a diagram of the basic stages of photosynthesis (light and dark reactions) identify the major reactants/products (CO_2, H_2O, ATP, O_2, glucose) involved in each stage;
- Explaining how cell components work together to perform the functions of the cell;
- Analyzing graphs displaying data about enzyme activity and how that impacts a cell;
- Designing an experiment to determine the effect of external factors (e.g., pH, temperature, concentration) on the cellular function (e.g., transport, enzyme rate, photosynthesis, cellular respiration);
- Evaluating or improving the design of an industrial application of cellular processes (e.g., optimal environment for fermentation, genetically modified organisms).

Distractors may include, but are not limited to, the following:

- Common misconceptions:
    - Plant cells only produce oxygen;
    - Only animal cells perform cellular respiration;
    - Most of plants mass is from water or soil (gases have no mass);
    - Oxygen is produced from the carbon dioxide in photosynthesis;
    - Energy can be created by cellular processes;
    - Molecules can only move downward;
    - Equilibrium means no movement of molecules;
    - Prokaryotic cells lack membranes;
    - Only plant cells have cell walls;
    - Plants are prokaryotic and animals are eukaryotic;
    - All lipids are “bad.”