Test Specifications: Biology

**General Description of the Biology Summative Examination**

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 examination that aligns to the new standards and model curriculum is mandated by Ohio Revised Code3301.079.The examination will be administered as a two-part summative test, in a computer-delivered format, to measure progress toward the standards and to provide information to teachers and administrators.

**Test Design: Two-Part Summative Exam**

The structure of the Biology Summative Exam follows the general outline of the summative assessments developed by the Partnership for Assessment of Readiness for College and Careers (PARCC) Consortium for measuring progress toward the Common Core standards in English language arts and mathematics. The Biology examination will consist of two parts: a performance-based assessment (PBA) that will be administered approximately three-quarters of the way through the course and an end-of-year examination (EOY) that will be given near the end of the course. Both the PBA and the EOY are fixed forms that are administered in an online format. The PBA is different in that, in addition to technology-enhanced items (graphic-response and short-answer items), it also contains constructed-response items that require the student to type a response into the computer interface. These items are scored by human scorers rather than by computer. The lead time needed to score the items means that the PBA must be administered approximately three-quarters of the way through the course. Outcomes are reported back to schools by the end of the year. After the student has completed both parts of the examination, his or her scores will be combined to yield a comprehensive view of the student’s progress.

The two parts of the examination are described in more detail below.

 **Part I: Performance-Based Assessment**

The Performance-Based Assessment (PBA) will assess the student’s knowledge of material from approximately the first three quarters of the course, as specified in this document. The assessment will consist of approximately 8-12 items worth 20 points overall. It will require students to engage with course content at a significant cognitive depth and a meaningful level of analysis. Following the PARCC model, the PBA will present a combination of discrete items and tasks,or sets of items linked to stimuli that engage significant content aligned to the model curriculum. An example of a task stimulus might be a set of data tables or charts, a simulation, or a set of passages or maps, linked around a central theme. The sequence of items associated with the stimulus draws the student into deeper analysis and interpretation of the source materials than might ordinarily be possible in a single item. Each task might consist of one or more hand-scored constructed response items or technology-enhanced graphic-response items that require the student to construct, rather than select, a response.

**Part II: End-of-Year Examination**

The End-of-Year Examination will cover the entire content of the course as specified in this document. It will be administered as close as possible to the end of the course (after approximately 90% of the course has been completed). All EOY assessment items will be scored by computer, making possible a very quick return of scores. Like the PBA, the EOY assessment will contain a combination of item types, but approximately 50% of the points on the examination will come from selected-response (multiple-choice) items. The remainder will be a combination of technology-enhanced items (short-answer and graphic-response items).

**Biology Summative Exam Blueprint**

The test blueprint tables below display the distribution of item types across the examination. Table 1 displays the two parts of the examination separately. Table 2 lists the biology topics covered in each reporting category. Table 3 displays the Content Statements that may be included on the Performance-Based Assessment.

**Table 1**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Subject** | **Format** | **Points per Item** | **Min Points** | **Max Points** | **Total Points** |
| **Performance-Based** | MC | MC items will not be on the PBA | 20 |
| Graphic-response or Short-answer\* | 1\*\*, 2, 3 | 8 | 12 |
| Hand-scored | 2 or 4 | 8 | 12 |
| **End of Year** | MC | 1 | 18 | 22 | 36 |
| Graphic-response or Short-answer\* | 1, 2, 3 | 14 | 18 |
| Hand-scored | Hand-scored items will not be on the EOY assessment |

\* Each form will have a distribution of both Graphic-response and Short-answer Items.

\*\*1 point Graphic-response/Short-answer items will be on the PBA only as a part of a cluster of items.

**Table 2**

|  |  |  |  |
| --- | --- | --- | --- |
| **Subject** | **Format** | **Points per Item** | **Total Points** |
| Heredity | MC | 1 | 13 - 15 |
| Graphic-response or Short-answer\* | 1, 2, 3 |
| Hand-scored | 2 or 4 |
| Evolution | MC | 1 | 13 - 15 |
| Graphic-response or Short-answer\* | 1, 2, 3 |
| Hand-scored | 2 or 4 |
| Diversity and Interdependence of Life | MC | 1 | 13 - 15 |
| Graphic-response or Short-answer\* | 1, 2, 3 |
| Hand-scored | 2 or 4 |
| Cells | MC | 1 | 13 - 15 |
| Graphic-response or Short-answer\* | 1, 2, 3 |
| Hand-scored | 2 or 4 |

\* Each form will have a distribution of both Graphic-response and Short-answer Items.

 **Table 3**

|  |  |
| --- | --- |
| **Reporting Category** | **Sub-Topics Eligible for Use on the Performance-Based Assessment** |
|
|
| Heredity | Cellular genetics |
| Structure and function of DNA in cells |
| Genetic mechanisms and inheritance |
| Mutations |
| Modern genetics |
| Evolution | Mechanisms of evolution |
| Diversity of life |
| Diversity and Interdependence of Life | Classification systems  |
| Cells | Not assessed on PBA |

**Description of Item Types**

The several types of items on the examination fall into two categories: those scored by machine and those that require human scorers to evaluate the response.

 **Machine-scored:** Machine-scored items are scored automatically by the testing software to yield an immediate score. The Machine-scored items in this examination are multiple-choice, short-answer and graphic-response.

**A Multiple-choice** item consists of the following:

* a brief statement that orients the student to the context of the question (optional).
* a stimulus (document, data table, graphic, etc.) on which the question is based (optional).
* a question.
* four answer options.

**A Short-answer** item consists of the following:

* a brief statement that orients the student to the context of the question (optional).
* a stimulus (document, data table, graphic, etc.) to which the question refers (optional).
* a question or prompt.
* a response area. The student types a response to answer the question.

**A Graphic-response** item consists of the following:

* a brief statement that orients the student to the context of the question (optional).
* a stimulus (document, data table, graphic, etc.) to which the question refers (optional).
* a question or prompt.
* a graphic-response interface on which the student manipulates objects using a computer mouse to create a response to the question. The response interface may be a map, a chart or graph, a picture or a diagram on which the student must position objects correctly.

**A Simulation** consists of the following:

* an interactive animated graphic interface that simulates an investigative experiment or physical situation. Information is displayed in the form of dynamic maps or illustrations, statistical tables, or charts and graphs. Data inputs can be adjusted by the student to reflect changes in the experimental or situational inputs, and the graphics adjust themselves to account for the new information.
* When a simulation is used as part of a task, it will be accompanied by more than one of the other item types above. 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.

**Hand-scored:** Hand-scored items are scored against rubrics by trained scorers. The hand-scored tasks on this examination are the constructed response items.

**A Short Constructed Response item** **(SCR)** consists of the following:

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

**An Extended Constructed Response item (ECR)** contains the same components as the SCR but requires a more elaborated response.

**Item Specifications: Biology**

**Course Description**

Biology is a high school level course, which satisfies the Ohio Core science graduation requirements of Ohio Revised Code Section 3313.603. This section of Ohio law requires a three-unit course with inquiry-based laboratory experience that engages students in asking valid scientific questions and gathering and analyzing information.

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 which may be addressed on the PBA

**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:**

**Machine-scored**

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.

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.

**Hand-scored**

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

* 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.

**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 which may be addressed on the PBA

**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:**

**Machine-scored**

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.

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.

**Hand-scored**

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

* 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.

**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 which may be addressed on the PBA

**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:**

**Machine-scored**

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.

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.

**Hand-scored**

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

* Using cladograms to compare and contrast the degree of relatedness between organisms.

**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:**

**Machine-scored**

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 (CO2, H2O, ATP, O2, 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.”

**Hand-scored**

 This topic will not be assessed on the PBA.