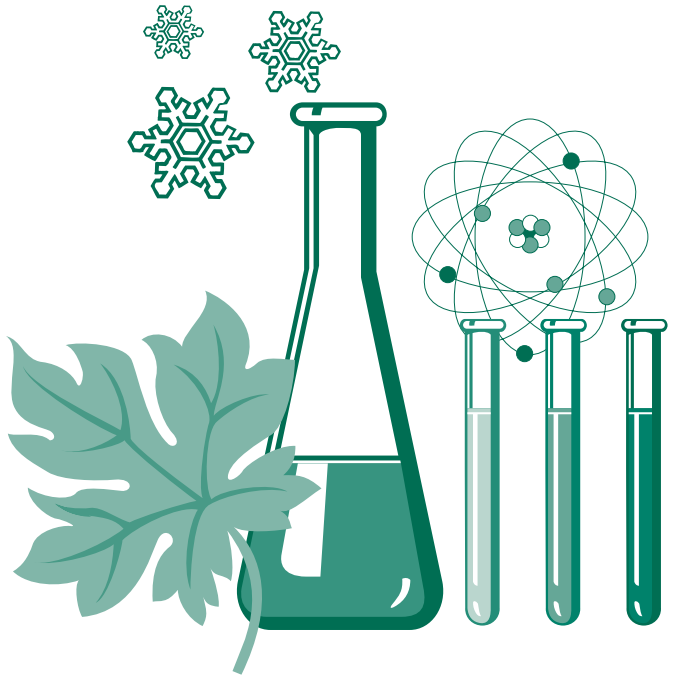

Science Standards of Learning Curriculum Framework

Life Science

Commonwealth of Virginia
Board of Education
Richmond, Virginia

Standard LS.1

The student will plan and conduct investigations in which

a) data are organized into tables showing repeated trials and means;
b) variables are defined;
c) metric units (SI — International System of Units) are used;
d) models are constructed to illustrate and explain phenomena;
e) sources of experimental error are identified;
f) dependent variables, independent variables, and constants are identified;
g) variables are controlled to test hypotheses, and trials are repeated;
h) continuous line graphs are constructed, interpreted, and used to make predictions;
i) interpretations from a set of data are evaluated and defended; and
j) an understanding of the nature of science is developed and reinforced.

Understanding the Standard

The skills described in standard LS.1 are intended to define the "investigate" component of all of the other Life Science standards (LS.2–LS.14). The intent of standard LS.1 is that students will continue to develop a range of inquiry skills and achieve proficiency with those skills in the context of the concepts developed in the Life Science course. This does not preclude explicit instruction on a particular inquiry skill or skills, but standard LS.1 does not require a discrete unit on scientific investigation. It is also intended that by developing these skills, students will achieve greater understanding of scientific inquiry and the nature of science, as well as more fully grasp the content-related concepts.

Across the grade levels, kindergarten through high school, the skills in the first standards form a nearly continuous sequence. (Please note Appendix, "Science Skills Scope & Sequence.") It is very important that the Life Science teacher be familiar with the skills in the sequence leading up to standard LS.1 (6.1, 5.1, 4.1).

Standard LS.1

Overview	Essential Knowledge, Skills, and Processes
The concepts developed in this standard include the following: • Expected results are reflected in the organization of the data table, which includes areas to record the number of repeated trials, levels of the independent variable, measured results for the dependent variable, and analysis of the results by calculation of the means. • Systematic investigations require a hypothesis stated in such a way that it identifies the independent variable (parameter that is deliberately changed), the dependent variable (the response that can be measured or observed because of changes in the independent variable), and the relationship between them. • Investigations will use International System of Units (metric units) of measurement. • Mental and physical models can be helpful in explaining events or sequences of events that occur. They can be used as part of scientific explanations to support data or represent phenomena, especially those that are not easily seen directly or must be inferred from data. • Potential sources of error in the experimental design must be identified. • To communicate the plan of an experiment accurately, the independent variable, dependent variable, and constants must be explicitly defined.	In order to meet this standard, it is expected that students should be able to • design a data table that includes space to organize all components of an investigation in a meaningful way, including levels of the independent variable, measured responses of the dependent variable, number of trials, and mathematical means. • identify what is deliberately changed in the experiment and what is to be measured as the dependent (responding) variable. • select appropriate tools for collecting qualitative and quantitative data and record measurements (volume, mass, and distance) in metric units.. • create physical and mental models as ways to visualize explanations of ideas and phenomena. • evaluate the design of an experiment and the events that occur during an investigation to determine which factors may affect the results of the experiment. This requires students to examine the experimental procedure and decide where or if they have made mistakes. • analyze the variables in an experiment and decide which ones must be held constant (not allowed to change) in order for the investigation to represent a fair test. This requires students to comprehend what “variables” are and to apply that idea in new situations related to the Life Science SOL concepts.

Standard LS.1 (continued)

Overview	Essential Knowledge, Skills, and Processes
• To establish that the events of an experiment are the result of manipulating the independent variable, the experiment must be controlled by observing the effects without the application of the independent variable. The results can be compared with this standard or control. Not all experiments have a control. • Multiple trials of an experiment must be conducted to verify the results. • Analysis of observed results of systematic investigations includes construction and interpretation of graphs. Such interpretation can be used to make predictions about the behavior of the dependent variable in other situations and to explore potential sources of error in the experiment. This analysis can be used to support conclusions about the results of the investigation. • Investigations can be classified as *observational* (descriptive) *studies* (intended to generate hypotheses), or *experimental studies* (intended to test hypotheses). • Experimental studies sometimes follow a sequence of steps known as the Scientific Method: stating the problem, forming a hypothesis, testing the hypothesis, recording and analyzing data, stating a conclusion. However, there is no single scientific method. Science requires different abilities and procedures depending on such factors as the field of study and type of investigation.	• determine the specific component of an experiment to be changed as an independent variable and control the experiment by conducting trials for the experiment in which the independent variable is *not* applied. This requires the student to set up a standard to which the experimental results can be compared. The student must use the results of the controlled trials to determine whether the hypothesized results were indeed due to the independent variable. • construct appropriate graphs, using data sets from experiments. This requires the student to recognize that a line graph is most appropriate for reporting continuous or real-time data. This also requires a student to comprehend that points along the line that are not actual data points can be used to make predictions. Students should be able to interpret and analyze these graphs. • develop conclusions based on a data set and verify whether the data set truly supports the conclusion. This requires students to cite references to the data that specifically support their conclusions. • distinguish between observational and experimental investigations. • identify, describe, and apply the generalized steps of experimental (scientific) methodology.

Standard LS.2

The student will investigate and understand that all living things are composed of cells. Key concepts include

a) cell structure and organelles (cell membrane, cell wall, cytoplasm, vacuole, mitochondrion, endoplasmic reticulum, nucleus, and chloroplast);
b) similarities and differences between plant and animal cells;
c) development of cell theory; and
d) cell division (mitosis and meiosis).

Understanding the Standard

This standard builds on the general concept in science standard 5.5 that states that living things are made of cells that have different parts. The emphasis here is on the concept that cells are the unit of structure and function of living things and on the concept of subcellular components, or organelles, each with a particular structure and function. The historical contributions of many scientists to the establishment of the cell theory are also important for students to understand. This standard also introduces students to the concept of cell division. It is intended that students will actively develop scientific investigation, reasoning, and logic skills (LS.1) in the context of the key concepts presented in this standard.

Standard LS.2

Overview	Essential Knowledge, Skills, and Processes
The concepts developed in this standard include the following: • The cell theory includes the following components: all living things are composed of cells, cells are the smallest unit (structure) of living things that can perform the processes (functions) necessary for life, living cells come only from other living cells. • The development of the cell theory can be attributed to the major discoveries of many notable scientists. The development of the cell theory has been dependent upon improvements in the microscope and microscopic techniques throughout the last four centuries. • Continuing advances in microscopes and instrumentation have increased the understanding of cell organelles and their functions. The structure of a cell organelle reflects the job or function carried out by that organelle. Division of labor within a cell is essential to the overall successful function of the cell. • Many of these organelles can be observed with a compound light microscope. • Similarities and differences in plants and animals are evident at the cellular level. Plant and animal cells contain some of the same organelles and some that differ.	In order to meet this standard, it is expected that students should be able to • describe and sequence the major points in the development of the cell theory. • identify the three components of the cell theory. • distinguish among the following: cell membrane, cytoplasm, nucleus, cell wall, vacuole, mitochondrion, endoplasmic reticulum, and chloroplast. • correlate the structures of cell organelles with their jobs and analyze how organelles perform particular jobs. • compare and contrast examples of plant and animal cells, using the light microscope and images obtained from microscopes. • differentiate between mitosis and meiosis. • design an investigation from a testable question related to animal and plant cells. The investigation may be a complete experimental design or may focus on systematic observation, description, measurement, and/or data collection and analysis. An example of such a question is: "Do onion cells vary in shape or structure depending on where they are found in the plant?"

Standard LS.2 (continued)

Overview	Essential Knowledge, Skills, and Processes
• Cells go through a life cycle known as the cell cycle. The phases of the cell cycle are interphase, mitosis, and cytokinesis. (Although it is appropriate for students at this level to learn to recognize the stages of the cell cycle, an exploration of the individual stages of meiosis may be reserved for high school Biology.)	• analyze and critique the experimental design of basic investigations related to animal and plant cells. This analysis and critique should focus on the skills developed in LS.1. Major emphases should include the following: the clarity of predictions and hypotheses, the organization of data tables, the use of metric measures, adequacy of trials and samples, the identification and use of variables, the identification of constants, the use of controls, displays of graphical data, and the support for conclusions.

Standard LS.3

The student will investigate and understand that living things show patterns of cellular organization. Key concepts include

a) cells, tissues, organs, and systems; and
b) life functions and processes of cells, tissues, organs, and systems (respiration, removal of wastes, growth, reproduction, digestion, and cellular transport).

Understanding the Standard

This standard emphasizes the fact that among living organisms, there is a universality of the functions that maintain life. This standard continues to build upon students' knowledge of these functions and introduces students to the process of cellular transport. With the exception of the structures associated with plant reproduction, which are highlighted in 4.4, this is the students' introduction to the specific structures of plants and animals that enable them to perform life functions. Students are introduced to the concepts of unicellular and multicellular organisms and division of labor. This standard is not intended to require student understanding of the details of human body systems. It is intended that students will actively develop scientific investigation, reasoning, and logic skills (LS.1) in the context of the key concepts presented in this standard.

Standard LS.3

Overview	Essential Knowledge, Skills, and Processes
The concepts developed in this standard include the following: • Unicellular organisms are made of only one cell. Multicellular organisms are made of many cells. • Multicellular organisms exhibit a hierarchy of cellular organization. They are complex in that there is a division of labor among the levels of this hierarchy for carrying out necessary life processes. • Cells perform numerous functions and processes, including respiration, waste removal, growth, irritability, and reproduction. • Cells that have the same function group together to form tissues. Tissues that have the same function group together to form organs. Organs with similar functions group to work together in an organ system.	In order to meet this standard, it is expected that students should be able to • differentiate between unicellular organisms and multicellular organisms and name common examples of each. • compare and contrast how unicellular and multicellular organisms perform various life functions. This includes the application of knowledge about systems in organisms. • compare and contrast the various basic life functions of an organism, including respiration, waste removal, growth, irritability, and reproduction, and explain the role that each life function serves for an organism. • model how materials move into and out of cells in the processes of osmosis, diffusion, and active transport. This includes creating and interpreting three-dimensional models and/or illustrations demonstrating the processes involved. Students should be able to analyze the components of these models and diagrams and communicate their observations and conclusions. • differentiate among cells, tissue, organs, and organs systems.

Standard LS.3 (continued)

Overview	Essential Knowledge, Skills, and Processes
	• analyze and critique the experimental design of basic investigations related to understanding cellular organization, with emphasis on observations of cells and tissue. This analysis and critique should focus on the skills developed in LS.1. Major emphases should include the following: the clarity of predictions and hypotheses, the organization of data tables, the use of metric measures, adequacy of trials and samples, the identification and use of variables, the identification of constants, the use of controls, displays of graphical data, and the support for conclusions.

Standard LS.4

The student will investigate and understand that the basic needs of organisms must be met in order to carry out life processes. Key concepts include

a) plant needs (light, water, gases, nutrients);
b) animal needs (food, water, gases, shelter, space); and
c) factors that influence life processes.

Understanding the Standard

The needs of living things are a continuous theme throughout the K-6 standards. This concept is extended here to develop an understanding that when the specific *range* of requirements for these needs are not met, there are consequences in the functioning of an organism. For example, over-watering a plant can be as harmful as under-watering it. It is intended that students will actively develop scientific investigation, reasoning, and logic skills (LS.1) in the context of the key concepts presented in this standard.

Standard LS.4

Overview	Essential Knowledge, Skills, and Processes
The concepts developed in this standard include the following: • Plants exhibit needs for light and other energy sources, water, gases, and nutrients. These needs may often be met in a range of conditions. Too much may be as harmful as too little. • Animals exhibit needs for food, water, gases, shelter and space. These needs may often be met in a range of conditions. Too much may be as harmful as too little. • Numerous factors can strongly influence the life processes of organisms.	In order to meet this standard, it is expected that students should be able to • identify the basic needs of all living things. • distinguish between the needs of plants and animals. • explain that there is a specific range or continuum of conditions that will meet the needs of organisms. • explain how organisms obtain the materials that they need. • create plausible hypotheses about the effects that changes in available materials might have on particular life processes in plants and in animals. • design an investigation from a testable question related to animal and plant life needs. The investigation may be a complete experimental design or may focus on systematic observation, description, measurement, and/or data collection and analysis. • analyze and critique the experimental design of basic investigations related to animal and plant needs. This analysis and critique should focus on the skills developed in LS.1. Major emphases should include the following: the clarity of predictions and hypotheses, the organization of data tables, the use of metric measures, adequacy of trials and samples, the identification and use of variables, the identification of constants, the use of controls, displays of graphical data, and the support for conclusions.

Standard LS.5

The student will investigate and understand how organisms can be classified. Key concepts include

a) the distinguishing characteristics of kingdoms of organisms;
b) the distinguishing characteristics of major animal and plant phyla; and
c) the characteristics of the species.

Understanding the Standard

Classifying and grouping is a key inquiry skill, as described in the K–12 "Investigate and Understand" section of the Introduction to the *Science Standards of Learning.* Classifying is an important skill in the K–6 "Scientific Investigation, Reasoning and Logic" strand. The use of a classification key is introduced in 5.1. A key concept of 5.5 is the idea of using characteristics to group organisms into the currently recognized kingdoms.

This standard focuses on students continuing to practice classification skills within a hierarchical biological classification system. This is accomplished by analyzing similarities and differences between the structures and functions of organisms. Students should understand that scientists use classification as a tool to organize information about organisms and to gain information about related organisms. This standard does not require a detailed survey of each kingdom or phylum, but rather a general overview of how organisms are grouped and a focus on a few key groups. It is intended that students will actively develop scientific investigation, reasoning, and logic skills (LS.1) in the context of the key concepts presented in this standard.

Standard LS.5

Overview	Essential Knowledge, Skills, and Processes
The concepts developed in this standard include the following: • Information about physical features and activities is arranged in a hierarchy of increasing specificity. The levels in the accepted hierarchy include kingdom, phylum, class, order, family, genus and species. • As living things are constantly being investigated, new attributes are revealed that affect how organisms are placed in a standard classification system. • This system is the basis for scientific nomenclature. • Any grouping of organisms into kingdoms is based on several factors, including the presence or absence of cellular structures such as the nucleus, mitochondria, or a cell wall; whether the organisms exist as single cells or are multi-cellular; and how the organisms get their food. For example, organisms that do not have a nucleus are believed to be fundamentally different from other organisms and may be classified in one or even two different kingdoms. Six different kingdoms of organisms are generally recognized by scientists today. • Some important animal groups (phyla) are the cnidarians, mollusks, annelids, arthropods, echinoderms, and chordates. • Four important plant groups are the mosses, ferns, conifers, and flowering plants. • A group of similar-looking organisms that can interbreed under natural conditions and produce offspring that are capable of reproduction defines a species.	In order to meet this standard, it is expected that students should be able to • compare and contrast key features and activities between organisms. • classify organisms based on physical features. • arrange organisms in a hierarchy according to similarities and differences in features. • categorize examples of organisms as representatives of the kingdoms and recognize that the number of kingdoms is subject to change. • recognize scientific names as part of a binomial nomenclature. • recognize examples of major animal phyla. • recognize examples of major plant phyla (divisions).

Standard LS.6

The student will investigate and understand the basic physical and chemical processes of photosynthesis and its importance to plant and animal life. Key concepts include

a) energy transfer between sunlight and chlorophyll;
b) transformation of water and carbon dioxide into sugar and oxygen; and
c) photosynthesis as the foundation of virtually all food webs.

Understanding the Standard

Students learn in 4.4 that photosynthesis is a basic life process of plants requiring chlorophyll and carbon dioxide. This standard pulls these ideas together to demonstrate the complexity and importance of photosynthesis. Energy enters food webs through photosynthesis and is then transferred throughout the food web. It is crucial that students understand the importance of plants (and other photosynthesizing organisms) in this role of providing energy to all other living things. It is intended that students will actively develop scientific investigation, reasoning, and logic skills (LS.1) in the context of the key concepts presented in this standard.

Standard LS.6

Overview	Essential Knowledge, Skills, and Processes
The concepts developed in this standard include the following: • *Chlorophyll* is a chemical in chloroplasts that can absorb or trap light energy. • *Photosynthesis* is the necessary life process that transforms light energy into chemical energy. It involves a series of chemical reactions in which the light energy is used to change raw materials (carbon dioxide and water) into products (sugar and oxygen). The energy is stored in the chemical bonds of the glucose (sugar) molecules. • Energy is a basic need of all living things. Photosynthesizing organisms obtain their energy from the sun. Plants and other photosynthesizing organisms are often called producers because of their ability to produce glucose (sugar). • Photosynthesizing organisms are at the base of the energy pyramid.	In order to meet this standard, it is expected that students should be able to • describe the process of photosynthesis in terms of raw materials and products generated. • identify and describe the organelles involved in the process of photosynthesis. • explain how organisms utilize the energy stored from the products of photosynthesis. • relate the importance of photosynthesis to the role of producers as the foundation of food webs. • design an investigation from a testable question related to photosynthesis. The investigation may be a complete experimental design or may focus on systematic observation, description, measurement, and/or data collection and analysis. • analyze and critique the experimental design of basic investigations related to photosynthesis. This analysis and critique should focus on the skills developed in LS.1. Major emphases should include the following: the clarity of predictions and hypotheses, the organization of data tables, the use of metric measures, adequacy of trials and samples, the identification and use of variables, the identification of constants, the use of controls, displays of graphical data, and the support for conclusions.

Standard LS.7

The student will investigate and understand that organisms within an ecosystem are dependent on one another and on nonliving components of the environment. Key concepts include

a) the carbon, water, and nitrogen cycles;
b) interactions resulting in a flow of energy and matter throughout the system;
c) complex relationships within terrestrial, freshwater, and marine ecosystems; and
d) energy flow in food webs and energy pyramids.

Understanding the Standard

This standard explores the *application* of the concept of interdependence between organisms and their physical environment. This concept is covered thoroughly in the K–6 standards of the Living Systems strand. The K–6 standards include the concept of interdependence (2.5), relationships in aquatic and terrestrial food chains, trophic levels (3.5 and 6.9), food webs, food pyramids and cycles (6.9), and interactions between the living and nonliving components of an ecosystem (4.5). Terminology used in previous standards includes *producer*, *consumer*, *decomposer* (3.5 and 6.9), *herbivore*, *omnivore*, *carnivore* (3.5), and *niche* (4.5). It is intended that students will actively develop scientific investigation, reasoning, and logic skills (LS.1) in the context of the key concepts presented in this standard.

Standard LS.7

Overview	Essential Knowledge, Skills, and Processes
The concepts developed in this standard include the following: • In order to understand how an ecosystem functions, one must understand the concept of a system and be able to envision models of systems. • To analyze the interactions resulting in a flow of energy and matter throughout the ecosystem, one must identify the elements of the system and interpret how energy and matter are used by each organism. • Many important elements and compounds cycle through the living and nonliving components of the environment as a chain of events that continuously repeats. • Energy enters an ecosystem through the process of photosynthesis and is passed through the system as one organism eats and is, in turn, eaten. This energy flow can be modeled through relationships expressed in food webs. • Materials are recycled and made available through the action of decomposers. • The amount of energy available to each successive trophic level (producer, first-order consumer, second-order consumer, third-order consumer) decreases. This can be modeled through an energy pyramid, in which the producers provide the broad base that supports the other interactions in the system.	In order to meet this standard, it is expected that students should be able to • observe and identify common organisms in ecosystems and collect, record, and chart data concerning the interactions of these organisms (from observations and print and electronic resources). • classify organisms found in local ecosystems as producers or first-, second-, or third-order consumers. Design and construct models of food webs with these organisms. • observe local ecosystems and identify, measure, and classify the living and nonliving components. • differentiate among key processes in the water, carbon, and nitrogen cycles and analyze how organisms, from bacteria and fungi to third-order consumers, function in these cycles. • determine the relationship between a population's position in a food web and its size. • identify examples of interdependence in terrestrial, freshwater, and marine ecosystems. • apply the concepts of food chains, food webs, and energy pyramids to analyze how energy and matter flow through an ecosystem.

Standard LS.7 (continued)

Overview	Essential Knowledge, Skills, and Processes
	• design an investigation from a testable question related to food webs. The investigation may be a complete experimental design or may focus on systematic observation, description, measurement, and/or data collection and analysis. • analyze and critique the experimental design of basic investigations related to food webs.

Standard LS.8

The student will investigate and understand that interactions exist among members of a population. Key concepts include

a) competition, cooperation, social hierarchy, territorial imperative; and
b) influence of behavior on a population.

Understanding the Standard

This standard applies the concept that each organism exists as a member of a population and interacts with other members of that population in a variety of ways. The term *population* is introduced in standard 3.6 ("Living Systems" strand). Individuals of a population demonstrate various behavioral adaptations (competition, cooperation, establishment of a social hierarchy, territorial imperative), which allow the population to survive. It is intended that students will actively develop scientific investigation, reasoning, and logic skills (LS.1) in the context of the key concepts presented in this standard.

Standard LS.8

Overview	Essential Knowledge, Skills, and Processes
The concepts developed in this standard include the following: • Individual members of a population interact with each other. These interactions include competing with each other for basic resources, mates, and territory and cooperating with each other to meet basic needs. • The establishment of a social order in a population may insure that labor and resources are adequately shared. • The establishment of a territory ensures that members of a population have adequate habitat to provide for basic resources. • Individual behaviors and group behaviors can influence a population.	In order to meet this standard, it is expected that students should be able to • differentiate between the needs of the individual and the needs of a population. • interpret, analyze, and evaluate data from systematic studies and experiments concerning the interactions among members of a population. • determine the relationship between a population's position in a food web and the types of interactions seen among the individuals of the population. • observe and identify populations in ecosystems and collect, record, chart, and interpret data concerning the interactions of these organisms (from observations and print and electronic resources). • analyze and critique the experimental design of basic investigations related to interactions within a population. This analysis and critique should focus on the skills developed in LS.1. Major emphases should include the following: the clarity of predictions and hypotheses, the organization of data tables, the use of metric measures, adequacy of trials and samples, the identification and use of variables, the identification of constants, the use of controls, displays of graphical data, and the support for conclusions.

Standard LS.9

The student will investigate and understand interactions among populations in a biological community. Key concepts include

a) the relationships among producers, consumers, and decomposers in food webs;
b) the relationship between predators and prey;
c) competition and cooperation;
d) symbiotic relationships; and
e) niches.

Understanding the Standard

Life Science standard LS.9 applies the concept of interactions between populations of different species. This standard extends the concepts of prior K–6 standards, including those concerning producers, consumers, and decomposers (3.5); predator and prey (3.6); and niches (4.5). This standard introduces the concept of symbiosis and focuses on the symbiotic relationship between parasite and host. It is intended that students will actively develop scientific investigation, reasoning, and logic skills (LS.1) in the context of the key concepts presented in this standard.

Standard LS.9

Overview	Essential Knowledge, Skills, and Processes
The concepts developed in this standard include the following: • In a community, populations interact with other populations by exhibiting a variety of behaviors that aid in the survival of the population. • Organisms or populations that rely on each other for basic needs form interdependent communities. • Energy resources of a community are shared through the interactions of producers, consumers, and decomposers. • The interaction between a consumer that hunts for another consumer for food is the predator-prey relationship. • Populations of one species may compete with populations of other species for resources. Populations of one species may also cooperate with populations of other species for resources. • A symbiotic relationship may exist between two or more organisms of different species when they live and work together. • Symbiotic relationships include mutualism (in which both organisms benefit), commensalism (in which one organism benefits and the other is unaffected), and parasitism (in which one organism benefits and the other is harmed). • Each organism fills a specific role or niche in its community.	In order to meet this standard, it is expected that students should be able to • identify the populations of producers, consumers, and decomposers and describe the roles they play in their communities. • interpret, analyze, and evaluate data from systematic studies and experiments concerning the interactions of populations in an ecosystem. • predict the effect of population changes on the food web of a community. • generate predictions based on graphically represented data of predator-prey populations. • generate predictions based on graphically represented data of competition and cooperation between populations. • differentiate between the types of symbiosis and explain examples of each. • infer the niche of organisms from their physical characteristics. • design an investigation from a testable question related to interactions among populations. The investigation may be a complete experimental design or may focus on systematic observation, description, measurement, and/or data collection and analysis.

Standard LS.10

The student will investigate and understand how organisms adapt to biotic and abiotic factors in an ecosystem. Key concepts include

a) differences between ecosystems and biomes;
b) characteristics of land, marine, and freshwater ecosystems; and
c) adaptations that enable organisms to survive within a specific ecosystem.

Understanding the Standard

In standard LS.10, students explore the scheme of the Earth as a group of living systems. Students are asked to distinguish between ecosystems and biomes. The teacher should be aware that in previous standards, students have explored environments as discrete units or have examined individual components. In standard 3.6 students are introduced to the concept of water environments (pond, marshland, swamp, stream, river, and ocean) and land environments (desert, grassland, rainforest, and forest). It is intended that students will actively develop scientific investigation, reasoning, and logic skills (LS.1) in the context of the key concepts presented in this standard.

Standard LS.10

Overview	Essential Knowledge, Skills, and Processes
The concepts developed in this standard include the following: • The living organisms within a specific area and their physical environment define an ecosystem. • The major terrestrial ecosystems are classified into units called biomes — large regions characterized by certain conditions, including a range of climate and ecological communities adapted to those conditions. • Organisms have specific structures, functions, and behaviors that enable them to survive the conditions of the particular ecosystem in which they live. • Organisms adapt to both biotic and abiotic factors in their ecosystem.	In order to meet this standard, it is expected that students should be able to • differentiate between ecosystems and biomes. • recognize and give examples of major biomes: desert, forest, grassland, and tundra. • compare and contrast the biotic and abiotic characteristics of land, marine, and freshwater ecosystems. • observe and describe examples of specific adaptations that organisms have which enable them to survive in a particular ecosystem. • analyze specific adaptations of organisms to determine how they help the species survive in its ecosystem. • design an investigation from a testable question related to how organisms adapt to biotic and abiotic factors in a ecosystems. The investigation may be a complete experimental design or may focus on systematic observation, description, measurement, and/or data collection and analysis. • analyze and critique the experimental design of basic investigations related to how organisms adapt to biotic and abiotic factors in ecosystems.

Standard LS.11

The student will investigate and understand that ecosystems, communities, populations, and organisms are dynamic and change over time (daily, seasonal, and long term). Key concepts include

a) phototropism, hibernation, and dormancy;
b) factors that increase or decrease population size; and
c) eutrophication, climate changes, and catastrophic disturbances.

Understanding the Standard

In standard LS.11, students apply the concept of change over time to several specific situations. As conditions change, organisms, populations, communities, and ecosystems respond to those changes in order to survive. The key concepts are given in a sequence from responses of individual organisms (phototropism, hibernation, and dormancy) to responses of populations (factors that increase or decrease population size) to responses of communities or ecosystems (eutrophication, climate change, and catastrophic disturbances).

The concepts of standard LS.11 focus on the theme of change. Living units respond in various ways to change. A key concept is the understanding of the dynamic nature of living systems as they constantly respond to change. Change is referenced several times in the K–6 standards. In the "Earth Patterns, Cycles, and Change" strand, the following concepts are introduced: natural and human-made things may change over time (K.9); temperature, light, and precipitation bring about changes (1.7); and weather and seasonal changes affect plants, animals, and their surroundings (2.7). In the "Life Processes" strand, the following concepts are introduced: animals respond to life needs through hibernation, migration, camouflage, etc. (3.4); and basic plant processes include the responses of reproduction, photosynthesis, dormancy (4.4). It is intended that students will actively develop scientific investigation, reasoning, and logic skills (LS.1) in the context of the key concepts presented in this standard.

Standard LS.11

Overview	Essential Knowledge, Skills, and Processes
The concepts developed in this standard include the following: • Organisms may exist as members of a population; populations interact with other populations in a community; and communities together with the physical environment form ecosystems. • Changes that affect organisms over time may be daily, seasonal, or long-term. • Plants may respond to light by growing toward it or away from it, a behavior known as *phototropism*. • Animals may respond to cold conditions with a period of lowered metabolism, a behavior know as *hibernation*. • Organisms may respond to adverse conditions with a period of lowered or suspended metabolism, a behavior known as *dormancy*). • A variety of environmental factors may cause the size of a population to increase or decrease. (This requires students to brainstorm examples of factors and predict the possible effects.) • Large-scale changes may affect entire communities and ecosystems. Such large-scale changes include the addition of excess nutrients to the system (eutrophication), which alters environmental balance; dramatic changes in climate; and catastrophic events, such as fire, drought, flood, and earthquakes.	In order to meet this standard, it is expected that students should be able to • relate the responses of organisms to daily, seasonal, or long-term events. • differentiate between ecosystems, communities, populations, and organisms. • predict the effect of climate change on ecosystems, communities, populations, and organisms. • compare and contrast the factors that increase or decrease population size. • predict the effect of large scale changes on ecosystems, communities, populations, and organisms. • classify the various types of changes that occur over time in ecosystems, communities, populations, and organisms. • design an investigation from a testable question related to change over time in ecosystems, communities, populations, or organisms. The investigation may be a complete experimental design or may focus on systematic observation, description, measurement, and/or data collection and analysis. • analyze and critique the experimental design of basic investigations related to change over time in ecosystems, communities, populations, and organisms.

Standard LS.12

The student will investigate and understand the relationships between ecosystem dynamics and human activity. Key concepts include

a) food production and harvest;
b) change in habitat size, quality, or structure;
c) change in species competition;
d) population disturbances and factors that threaten or enhance species survival; and
e) environmental issues (water supply, air quality, energy production, and waste management).

Understanding the Standard

In this standard, students are called upon to apply their knowledge of human interactions to interpret how these interactions affect ecosystem dynamics. In prior standards in the "Resources" strand of the K–6 standards, students explore a variety of ways in which humans interact with the environment. These include the concepts of waste management (K.10, 1.8), limitations of natural resources and factors that affect environmental quality (1.8, 3.10), Virginia's natural resources (4.8), and public policy decisions relating to the environment (6.9). In this Life Science standard, the student must interpret how human populations can change the balance of nature in ecosystems. They must use their prior knowledge of resources as well as the concepts and skills learned in Life Science standards LS.7 – LS.11. It is intended that students will actively develop scientific investigation, reasoning, and logic skills (LS.1) in the context of the key concepts presented in this standard.

Standard LS.12

Overview	Essential Knowledge, Skills, and Processes
The concepts developed in this standard include the following: • Ecosystems are dynamic systems. • Humans are a natural part of the ecosystem. Humans use the ecosystem to meet their basic needs, such as to obtain food. • Human interaction can directly alter habitat size, the quality of available resources in a habitat, and the structure of habitat components. Such interactions can be positive and/or negative. • Human input can disturb the balance of populations that occur in a stable ecosystem. These disturbances may lead to a decrease or increase in a population. Since populations in an ecosystem are interdependent, these disturbances have a ripple effect throughout the ecosystem. • The interaction of humans with the dynamic ecosystem may lead to issues of concern for continued ecosystem health in areas such as water supply, air quality, energy production, and waste management.	In order to meet this standard, it is expected that students should be able to • identify examples of ecosystem dynamics. • describe the relationship between human food harvest and the ecosystem. • describe ways that human interaction has altered habitats positively and negatively. • debate the pros and cons of human land use versus ecosystem stability. • compare and contrast population disturbances that threaten and those that enhance species survival. • observe the effect of human interaction in local ecosystems and collect, record, chart, and interpret data concerning the effect of interaction (from observations and print and electronic resources). • design an investigation from a testable question related to the relationships between ecosystem dynamics and human activity. The investigation may be a complete experimental design or may focus on systematic observation, description, measurement, and/or data collection and analysis. • analyze and critique the experimental design of basic investigations related to the relationships between ecosystem dynamics and human activity.

Standard LS.13

The student will investigate and understand that organisms reproduce and transmit genetic information to new generations. Key concepts include

a) the role of DNA;
b) the function of genes and chromosomes;
c) genotypes and phenotypes;
d) factors affecting the expression of traits;
e) characteristics that can and cannot be inherited;
f) genetic engineering and its applications; and
g) historical contributions and significance of discoveries related to genetics.

Understanding the Standard

In science standard 2.7, students are introduced to the general notion that plants and animals resemble their parents. This Life Science standard is the students' introduction to genetics. It is important for the teacher to understand that the intent of this standard is to provide students with a general overview of the nature of DNA, genes, and chromosomes and the important role they play in the transmission of traits from one generation to another. Students are not expected to understand the specific chemical composition of DNA or the mechanics of transcription and translation. It is intended that students will actively develop scientific investigation, reasoning, and logic skills (LS.1) in the context of the key concepts presented in this standard.

Standard LS.13

Overview	Essential Knowledge, Skills, and Processes
The concepts developed in this standard include the following: • DNA is a double helix molecule. • DNA is a molecule that includes different components — sugars, nitrogenous bases, and phosphates. The arrangement of the nitrogenous bases within the double helix forms a chemical code. • Chromosomes are strands of tightly wound DNA. Genes are sections of a chromosome that carry the code for a particular trait. • The basic laws of Mendelian genetics explain the transmission of most traits that can be inherited from generation to generation. • Traits that are expressed through genes can be inherited. Characteristics that are acquired through environmental influences, such as injuries or practiced skills, cannot be inherited. • In genetic engineering, the genetic code is manipulated to obtain a desired product. • Genetic engineering has numerous practical applications in medicine, agriculture, and biology. • A series of contributions and discoveries led to the current level of genetic science.	In order to meet this standard, it is expected that students should be able to • recognize the appearance of DNA as double helix in shape. • explain that DNA contains coded instructions that store and pass on genetic information from one generation to the next. • demonstrate variation within a single genetic trait. • explain the necessity of DNA replication for the continuity of life. • differentiate between characteristics that can be inherited and those that cannot be inherited. • distinguish between dominant and recessive traits. • distinguish between genotype and phenotype. • use Punnett squares to predict the possible combinations of inherited factors resulting from single trait crosses. • identify aspects of genetic engineering and supply examples of applications. Evaluate the examples for possible controversial aspects. • describe the contributions of Mendel, Franklin, and Watson and Crick to our basic understanding of genetics.

Standard LS.14

The student will investigate and understand that organisms change over time. Key concepts include

a) the relationships of mutation, adaptation, natural selection, and extinction;
b) evidence of evolution of different species in the fossil record; and
c) how environmental influences, as well as genetic variation, can lead to diversity of organisms.

Understanding the Standard

Standard LS.14 explores the concept of evolution. Species respond to changes in their environments through adaptations. This is a gradual process that occurs over long periods of time. The progression of these long-term changes is well documented in the fossil record. Evolution, as a big organizing principle of the life sciences, establishes order among the great variety of living things.

There are many misconceptions about evolution; therefore teachers must be careful to be accurate in their presentation of this scientific theory. One common misconception among students is that they believe that environmental influences on an organism produce changes in that organism that can be passed on to offspring. However, selection can only work through the genetic variation that is already present in the population. It is intended that students will actively develop scientific investigation, reasoning, and logic skills (LS.1) in the context of the key concepts presented in this standard.

Standard LS.14

Overview	Essential Knowledge, Skills, and Processes
The concepts developed in this standard include the following: • The mechanisms through which evolution takes place are a related set of processes that include mutation, adaptation, natural selection, and extinction. • Mutations are inheritable changes because a mutation is a change in the DNA code. • Adaptations are structures, functions, or behaviors that enable a species to survive. • A mutation may result in a favorable change or adaptation in genetic information that improves a species' ability to exist in its environment, or a mutation may result in an unfavorable change that does not improve or impedes a species' ability to exist in its environment. • Individuals of a population exhibit a range of variations in a trait as a result of the variations in their genetic codes. • The evidence for evolution is drawn from a variety of sources of data, including the fossil record, radiometric dating, genetic information, the distribution of organisms, and anatomical and developmental similarities across species. • Natural selection is the survival and reproduction of the individuals in a population that exhibit the traits that best enable them to survive in their environment.	In order to meet this standard, it is expected that students should be able to • explain how genetic variations in offspring, which lead to variations in successive generations, can result from the same two parents.. • describe how changes in the environment can bring about changes in species through natural selection, adaptation, and extinction. • describe and explain how fossils are records of organisms and events in the Earth's history. • explain the evidence for evolution from a variety of sources of scientific data. • analyze and evaluate data from investigations on variations within a local population. • interpret data from simulations that demonstrate selection for a trait belonging to species in various environments.

Standard LS.14 (continued)

Overview	Essential Knowledge, Skills, and Processes
• If a species does not include traits that enable it to survive in its environment or to survive changes in the environment, then the species may become extinct.	