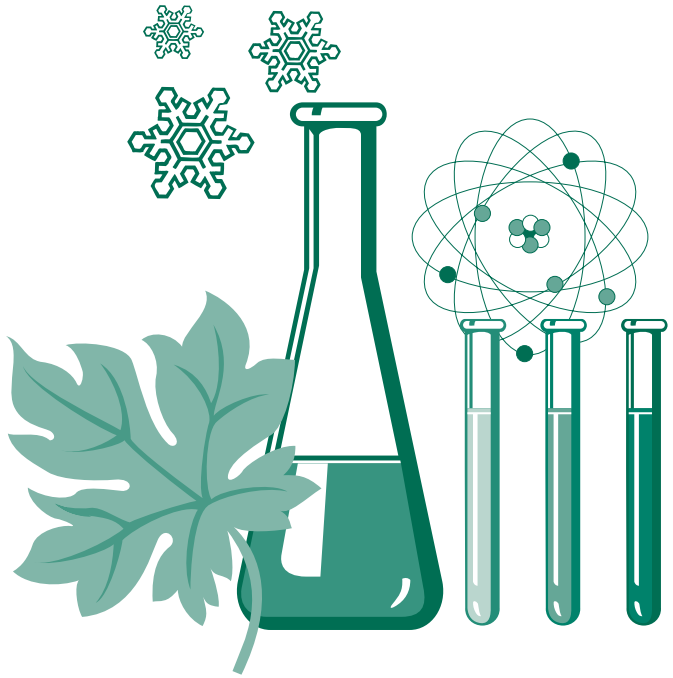

Science Standards of Learning Curriculum Framework

Biology

Commonwealth of Virginia
Board of Education
Richmond, Virginia

Standard BIO.1 a, b, c, i, j, m

The student will plan and conduct investigations in which

a) observations of living organisms are recorded in the lab and in the field;
b) hypotheses are formulated based on direct observations and information from scientific literature;
c) variables are defined and investigations are designed to test hypotheses;
i) appropriate technology including computers, graphing calculators, and probeware, is used for gathering and analyzing data and communicating results;
j) research utilizes scientific literature; and
m) a scientific viewpoint is constructed and defended (the nature of science).

Essential Understandings	Essential Knowledge and Skills
• Active participation in scientific investigations is necessary to develop an understanding of biology as an experimental science. • The continual use and development of cognitive and manipulative skills associated with the formulation of the scientific explanations is important. • The design of sound scientific experiments relies on systematic preliminary observations and data collected in the laboratory and in the field, as well as on a knowledge base gained from an examination of related scientific literature. Prior establishment of an adequate knowledge base is essential before hypotheses can be developed and tested.	<u>Skills</u> • Collect preliminary observations, both qualitative and quantitative. • Make clear distinctions among observations, inferences, and predictions. • Formulate hypotheses based on cause-and-effect relationships. • Justify hypotheses based on both preliminary observations and scientific literature. • Identify the independent variable (IV) and the values of the IV that will be used in the experiment. • Select dependent variables that allow collection of quantitative data.

Standard BIO.1 a, b, c, i, j, m (continued)

Essential Understandings	Essential Knowledge and Skills
• It is typical for scientists to disagree with one another about the interpretation of evidence or a theory being considered. This is partly a result of the unique background (social, educational, etc.) that individual scientists bring to their research. • Because of this inherent subjectivity, scientific inquiry involves evaluating the results and conclusions proposed by other scientists.	• Use appropriate technology for data collection, including probeware interfaced to a graphing calculator and/or computer, microscope, video microscope, or digital camera with image processing software. • Identify variables that must be held constant. • Establish controls as appropriate. • Write clear, replicable procedures. • Record quantitative data in clearly labeled tables with units. • Include labeled diagrams in the data record. • Critically examine and discuss the validity of results reported in scientific literature and databases. • Explain how competing scientific theories based on the same observations can be equally valid. • Recognize that in order to ensure the validity of scientific investigations, other members of the scientific community must evaluate the work.

Standard BIO.1 d, e, f, g

The student will plan and conduct investigations in which

d) graphing and arithmetic calculations are used as tools in data analysis;
e) conclusions are formed based on recorded quantitative and qualitative data;
f) sources of error inherent in experimental design are identified and discussed; and
g) validity of data is determined.

Essential Understandings	Essential Knowledge and Skills
• The analysis of evidence and data is essential in order to make sense of the content of science. • Multiple data manipulation and analysis strategies are available to help explain results of quantitative investigations. • Data and evidence should come from a variety of sources, including student investigation, peer investigation, and databases.	Skills • Determine the range, mean, and values for data, using a graphing calculator and/or computer spreadsheet software. • Plot data graphically, showing independent and dependent variables. • Describe linear mathematical functions from the data where appropriate, using a graphing calculator and/or computer spreadsheet. • Discuss accuracy, confidence, and sources of experimental error based on number of trials and variance in the data. • Recognize and discuss contradictory or unusual data.

Standard BIO.1 h, k, l

The student will plan and conduct investigations in which

h) chemicals and equipment are used in a safe manner;
k) differentiation is made between a scientific hypothesis and theory; and
l) alternative scientific explanations and models are recognized and analyzed.

Essential Understandings	Essential Knowledge and Skills
	Knowledge • A hypothesis can be supported, modified, or rejected based on collected data. A *hypothesis* is a tentative explanation that accounts for a set of facts and that can be tested by further investigation. A *theory* is an explanation of a large body of information, experimental and inferential, and serves as an overarching framework for numerous concepts. It is subject to change as new evidence becomes available. Skills • Use evidence, apply logic, and construct an argument for conclusions based on reported data. • Determine the extent to which data supports/does not support a hypothesis, and propose further hypotheses and directions for continued research.

Standard BIO.2 a, b, c, d

The student will investigate and understand the history of biological concepts. Key concepts include

a) evidence supporting the cell theory;
b) scientific explanations of the development of organisms through time (biological evolution);
c) evidence supporting the germ theory of infectious disease; and
d) the development of the structural model of DNA.

Essential Understandings	Essential Knowledge and Skills
• In order to develop an understanding of biology as an experimental science, there must be knowledge of how scientific discoveries are made and how these discoveries have led to the accumulation of knowledge that is presented in textbooks. A historical perspective encourages the examination of concrete examples in the context from which they were developed.	<u>Knowledge</u> • The development and refinement of magnifying lenses and light microscopes made the observation and description of microscopic organisms and living cells possible. • The development of the cell theory was accelerated by the ability to make observations on a microscopic level. • The *cell theory* states that all living things are composed of cells and that cells come from other cells by the process of cell reproduction. • Continued advances in microscopy allowed observation of cell organelles and ultrastructure. Current technology allows the observation of cellular processes underlying both cell structure and function. • Scientists have developed hypotheses about conditions on early Earth that could have led to the formation of the first organic molecules, early self-replicating molecules, the source of free oxygen in Earth's atmosphere, and the appearance of prokaryotic and later eukaryotic cells.

Standard BIO.2 a, b, c, d (continued)

Essential Understandings	Essential Knowledge and Skills
	• *Natural selection* is a process by which organisms with traits well suited to an environment survive and reproduce at a greater rate than organisms less suited to that environment. • Throughout history, people have created explanations for disease. • Pasteur's and Koch's experimentation and hypotheses led to an understanding of the presence of microorganisms and their relationship to diseases. • The introduction of the germ theory led to the understanding that many diseases are caused by microorganisms. • Changes in health practices have resulted from the acceptance of the germ theory of disease. • Modern health practices emphasize sanitation, the safe handling of food and water, aseptic techniques to keep germs out of the body, and the development of vaccinations and other chemicals and processes to destroy microorganisms. • Once DNA was shown to be the genetic material, a race among scientists took place to work out its structure. • Studies of the amounts of each DNA base in different organisms led to the concept of complementary base-paring.

Standard BIO.2 a, b, c, d (continued)

Essential Understandings	Essential Knowledge and Skills
	• Interpretations of X-ray photographs of DNA were used to describe the shape and dimensions of the molecule. An analysis of this and other available data led to a structural model for the DNA double helix. • The double helix model explained how heredity information is transmitted and provided the basis for an explosion of scientific research in molecular genetics.

Standard BIO.2 e

The student will investigate and understand the history of biological concepts. Key concepts include

e) the collaborative efforts of scientists, past and present.

Essential Understandings	Essential Knowledge and Skills
• The scientific establishment sometimes rejects new ideas, and new discoveries often spring from unexpected findings. • Scientific knowledge usually grows slowly through contributions from many different investigators from diverse cultures.	<u>Knowledge</u> • Science depends on experimental and observational confirmation and is subject to change as new evidence becomes available.

Standard BIO.3 a

The student will investigate and understand the chemical and biochemical principles essential for life. Key concepts include

a) water chemistry and its impact on life processes.

Essential Understandings	Essential Knowledge and Skills
• Water is essential for life on Earth. • About two thirds of the mass of a cell is made up of water, and most of the biochemical processes of life occur in water solutions.	<u>Knowledge</u> • Water molecules are both cohesive and adhesive due to the nature of bonding (polar covalent and hydrogen bonding). • Water is able to absorb large amounts of heat. As a result, lakes and oceans stabilize air and land temperatures. • Water absorbs heat when it evaporates, allowing organisms to release excess heat. • The solid form of water, ice, floats, preventing lakes and oceans from freezing solid. • Water is able to dissolve many substances; therefore, the water inside and outside of cells is able to carry nutrients into and around cells and wastes away from cells. • The pH scale ranges from 0 to 14. The pH of pure water is 7. Substances added to water can lower or raise the pH. A solution with a pH below 7 is acidic. A solution with a pH above 7 is basic. • Organisms can tolerate only small changes in pH because every cell has a particular pH at which it functions best. For example, changes in pH cause changes in enzyme conformation, resulting in a change in activity.

Standard BIO.3 b, c

The student will investigate and understand the chemical and biochemical principles essential for life. Key concepts include

b) the structure and function of macromolecules; and
c) the nature of enzymes.

Essential Understandings	Essential Knowledge and Skills
• Most life processes are a series of chemical reactions influenced by environmental and genetic factors. • Inside every cell is a concentrated mixture of thousands of different macromolecules forming a variety of specialized structures that carry out cell functions, such as energy production, transport, waste disposal, synthesis of new molecules, and storage of genetic material. • Protein molecules that are assembled in cells carry out most of the cells' work. The function of each protein molecule depends on its specific conformation. The chemical reactions that occur inside cells are directly controlled by a large set of protein molecules called enzymes, whose functions depend on their specific shapes.	<u>Knowledge</u> • The main components of a living cell are carbon, hydrogen, nitrogen, oxygen, phosphorus, and sulfur. • Carbon atoms can easily bond to several other carbon atoms in chains and rings to form large complex molecules. • Cells can make a variety of macromolecules from a relatively small set of monomers. • The primary functions of carbohydrate macromolecules are to provide and store energy. The primary functions of lipid macromolecules are to insulate, store energy, and make up cell membranes. • Nucleic acids (DNA and RNA) control cell activities by directing protein synthesis. • Some proteins are structural (hair, nails). Others function in transport (hemoglobin), movement (muscle fibers and cytoskeletal elements), defense (antibodies), and regulation of cell functions (hormones and enzymes).

Standard BIO.3 b, c (continued)

Essential Understandings	Essential Knowledge and Skills
	• *Proteins* are polymers made by linking together amino acid monomers. • A protein's structure depends on its specific conformation. The sequence of amino acids and the shape of the chain are a consequence of attractions between the chain's parts. • Each enzyme has a definite three-dimensional shape that allows it to recognize and bind with its substrate. In living cells, enzymes control the rate of metabolic reaction by acting as catalysts. • Most cells function best within a narrow range of temperature and pH. At very low temperatures, reaction rates are too slow. High temperatures or extremes of pH can irreversibly change the structure of proteins and alter their function.

Standard BIO.3 d

The student will investigate and understand the chemical and biochemical principles essential for life. Key concepts include

d) the capture, storage, transformation, and flow of energy through the processes of photosynthesis and respiration.

Essential Understandings	Essential Knowledge and Skills
• Plant cells and many microorganisms use solar energy to combine molecules of carbon dioxide and water into complex, energy-rich organic compounds and release oxygen into the environment. • The process of photosynthesis provides a vital connection between the sun and the energy needs of living systems. • The breakdown of nutrient molecules enables all cells to store energy in specific chemicals that are used to carry out the life functions of the cell.	<u>Knowledge</u> • Photosynthesis and cell respiration are complementary processes for cycling carbon dioxide and oxygen as well as transferring energy in ecosystems. • During photosynthesis, cells trap energy from sunlight with chlorophyll and use the energy, carbon dioxide and water to produce energy-rich organic molecules (glucose) and oxygen. • During cell respiration, eukaryotic cells "burn" organic molecules with oxygen, which produces energy, carbon dioxide, and water. • Light is the initial source of energy for most communities. • Photosynthesis involves an energy conversion in which light energy is converted to chemical energy in specialized cells. These cells are found in autotrophs such as plants and some protists. • Cells release the chemical energy stored in the products of photosynthesis. This energy is transported within the cell in the form of ATP.

Standard BIO.3 d (continued)

Essential Understandings	Essential Knowledge and Skills
	• When cells need energy to do work, certain enzymes release the energy stored in the chemical bonds in ATP. Skills • Recognize the equations for photosynthesis and respiration and identify the reactants and products.

Standard BIO.4 a, b

The student will investigate and understand relationships between cell structure and function. Key concepts include

a) characteristics of prokaryotic and eukaryotic cells; and
b) explorations of the diversity and variation of eukaryotes.

Essential Understandings	Essential Knowledge and Skills
• The cell theory is the unifying theme in biology because it emphasizes the similarity of all living things. • The simplest life forms exhibiting cellular structure are the prokaryotes. • Cell structure is one of the ways in which organisms differ from each other. • The diversity that exists ranges from simple prokaryotic cells to complex multi-cellular organisms.	<u>Knowledge</u> • Earth's first cells were prokaryotes. • Prokaryotic cells exist in two major forms: eubacteria and archaebacteria. • Prokaryotes are the Earth's most abundant inhabitants. They can survive in a wide range of environments and obtain energy in a variety of ways. • Eukaryotes arose from prokaryotes and developed into larger more complex organisms, from single-celled protists to multi-cellular fungi, plants, and animals. • Several differences between eukaryotes and prokaryotes include size, genetic material surrounded by a nuclear membrane, and the addition of mitochondria and chloroplasts. • Cellular differences between plant and animal cells include the presence of a cell wall that gives the plant cell a defined shape, the presence of chloroplast, and the number of vacuoles.

Standard BIO.4 c, d

The student will investigate and understand relationships between cell structure and function. Key concepts include

c) similarities between the activities of a single cell and a whole organism; and
d) the cell membrane model (diffusion, osmosis, and active transport).

Essential Understandings	Essential Knowledge and Skills
• *Cells* are the basic units of structure and function of all living things. • Relationships between structure and function can be examined at each of the hierarchical levels of organization: molecular, cellular, organism, population, community, and ecosystem. • Cells contain specialized structures to perform functions necessary for life. • Cellular activities necessary for life include chemical reactions that facilitate acquiring energy, reproduction, and adaptation/maintaining homeostasis. • Homeostasis of a cell is maintained by a plasma membrane comprised of a variety of organic molecules that controls the movement of material in and out of the cell, communication between cells, and the recognition of cells to facilitate multiple metabolic functions.	<u>Knowledge</u> • Essential cell structures and their functions include - the nucleus (contains DNA; site where RNA is made) - ribosome (site of protein synthesis) - mitochondria (site of cell respiration) - chloroplast (site of photosynthesis) - endoplasmic reticulum (transports materials through the cell) - Golgi (site where cell products are packaged for export) - lysosome (contains digestive enzymes) - cell membrane (controls what enters and leaves the cell) - cell wall (provides support). • Some organisms exist as a single cell, while others are composed of many cells, each specialized to perform distinct metabolic functions. • The basic processes necessary for living things to survive are the same for a single cell as they are for a more complex organism.

Standard BIO.4 c, d (continued)

Essential Understandings	Essential Knowledge and Skills
	• A single-celled organism has to conduct all life processes by itself. A multicellular organism has groups of cells that specialize to perform specific functions. • Cell specialization occurs during the development of a multicellular organism. The genetic information necessary for all cellular functions remains in each cell but may not be used. • The fluid mosaic model of a membrane emphasizes the arrangement and function of a bilayer of phospholipids, transport proteins, and cholesterol. • *Diffusion* occurs in cells when substances (oxygen, carbon dioxide, salts, sugars, amino acids) that are dissolved in water move from an area of higher concentration to an area of lower concentration. • *Osmosis* refers to the movement of water molecules through a semi-permeable membrane from an area of greater water concentration or pressure to an area of lesser water concentration or pressure. • *Active transport* refers to the movement of solid and liquid particles into and out of a cell by endocytosis and exocytosis.

Standard BIO.5 a, b, c

The student will investigate and understand life functions of archaebacteria, monerans (eubacteria), protists, fungi, plants, and animals including humans. Key concepts include

a) how their structures and function vary between and within the kingdoms;
b) comparison of their metabolic activities; and
c) analyses of their responses to the environment.

Essential Understandings	Essential Knowledge and Skills
• The millions of different organisms that live on Earth today share many structural and metabolic features, including cellular organization, common molecular mechanisms for energy transformation and utilization and maintenance of homeostasis, common genetic code, and mechanisms for the transmission of traits from one generation to the next. • The diversity that is evident in the natural world can be studied in the local environment in the context of variations on a common theme.	<u>Skills</u> • Differentiate and give examples of the following from local ecosystems: - autotrophs and heterotrophs (producers, consumers, and decomposers) - multicellular and unicellular organisms - motile and non-motile organisms - organisms with and without cell walls - sexually and asexually reproducing organisms - aquatic and terrestrial organisms - behavioral responses to the environment.

Standard BIO.5 d, e

The student will investigate and understand life functions of archaebacteria, monerans (eubacteria), protists, fungi, plants, and animals including humans. Key concepts include

d) maintenance of homeostasis; and
e) human health issues, human anatomy, body systems, and life functions.

Essential Understandings	Essential Knowledge and Skills
• Like other organisms, human beings are composed of groups of cells (tissues, organs, and organ systems) that are specialized to provide the human organism with the basic requirements for life: obtaining food and deriving energy from it, maintaining homeostasis, coordinating body functions, and reproducing. • Organ systems function and interact to maintain a stable internal environment that can resist disturbance from within or without (homeostasis). • Understanding normal body functioning assists in understanding situations, both hereditary and environmental, in which functioning is impaired.	<u>Knowledge</u> • For the body to use food for energy, the food must first be digested into molecules that are absorbed and transported to cells, where the food is used for energy and for repair and growth. • To burn food for the release of energy, oxygen must be supplied to cells and carbon dioxide removed. The respiratory system responds to changing demands by increasing or decreasing breathing rate in order to maintain homeostasis. • The circulatory system, which moves all of these substances to or from cells, responds to changing demands by increasing or decreasing heart rate and blood flow in order to maintain homeostasis. • The urinary system disposes of dissolved waste molecules; the intestinal tract removes solid wastes; and the skin and lungs rid the body of heat energy.

Standard BIO.5 d, e (continued)

Essential Understandings	Essential Knowledge and Skills
	• Specialized cells of the immune system and the molecules they produce are designed to protect against organisms and substances that enter from outside the body and against some cancer cells that arise from within. • Communication between cells is required for coordination of body functions. The nerves communicate with electrochemical signals, hormones circulate through the blood, and some cells secrete substances that spread only to nearby cells. • Environmental factors that impact human health include diet, exercise, sleep, stress, toxic substances that enter the body, viruses, and other living organisms that infect the body. • Genetic predisposition towards diseases impacts human health. Awareness of genetic predisposition allows individuals to make lifestyle changes that can enhance quality of life.

Standard BIO.5 f

The student will investigate and understand life functions of archaebacteria, monerans (eubacteria), protists, fungi, plants, and animals including humans. Key concepts include

f) how viruses compare with organisms.

Essential Understandings	Essential Knowledge and Skills
• Viruses do not share many of the characteristics of living organisms.	<u>Knowledge</u> • Viruses are not cells. Basic viral structure consists of a nucleic acid core surrounded by a protein coat. • Viruses can reproduce only inside a living cell, the host cell. • The viral reproductive process includes the following steps: - A virus must insert its genetic material into the host cell. - The viral genetic material takes control of the host cell and uses it to produce viruses. - The newly formed viruses are released from the host cell.

Standard BIO.6 a, b, c

The student will investigate and understand common mechanisms of inheritance and protein synthesis. Key concepts include

a) cell growth and division;
b) gamete formation; and
c) cell specialization.

Essential Understandings	Essential Knowledge and Skills
• All living cells come from other living cells. During mitosis, the nucleus of the cell divides, forming two nuclei with identical genetic information. • Many organisms are capable of combining genetic information from two parents to produce offspring. Sex cells are produced through meiosis. This allows sexually reproducing organisms to produce genetically differing offspring. • The many body cells of an organism can be specialized to perform different functions, even though they are all descended from a single cell and contain essentially the same genetic information.	<u>Knowledge</u> • Mitosis produces two genetically identical cells. • Meiosis occurs in sexual reproduction when a diploid germ cell produces four haploid daughter cells that can mature to become gametes (sperm or egg). • A typical cell goes through a process of growth, development, and reproduction called the cell cycle. • Mitosis and meiosis refer to division of the nuclear material. Cytokinesis is the division of the cytoplasm and organelles. • Mitosis is referred to in the following stages: prophase, metaphase, anaphase, and telophase.

Standard BIO.6 d

The student will investigate and understand common mechanisms of inheritance and protein synthesis. Key concepts include

d) prediction of inheritance of traits based on the Mendelian laws of heredity.

Essential Understandings	Essential Knowledge and Skills
• Geneticists apply mathematical principles of probability to Mendel's laws of heredity in order to predict the results of simple genetic crosses.	<u>Knowledge</u> • Mendel's laws of heredity are based on his mathematical analysis of observations of patterns of inheritance of traits. • The laws of probability govern simple genetic recombinations. • Genotype describes the genetic make-up of an organism and phenotype describes the organism's appearance based on its genes. • Homozygous individuals have two identical alleles for a particular trait, while heterozygous individuals have contrasting alleles. • When one allele masks the effect of another, that allele is called dominant and the other recessive. When an intermediate phenotype occurs and no allele dominates, incomplete dominance results.

Standard BIO.6 d (continued)

Essential Understandings	Essential Knowledge and Skills
	Skills • Predict possible gametes in a dihybrid cross, given parental genotypes. • Use a Punnett square to show all possible combinations of gametes and the likelihood that particular combinations will occur in monohybrid crosses.

Standard BIO.6 e

The student will investigate and understand common mechanisms of inheritance and protein synthesis. Key concepts include

e) genetic variation (mutation, recombination, deletions, additions to DNA).

Essential Understandings	Essential Knowledge and Skills
• Genetically diverse populations are more likely to survive changing environments. • Recombination and mutation provide for genetic diversity. • Some new gene combinations have little effect, some can produce organisms that are better suited to their environments, and others can be deleterious.	<u>Knowledge</u> • The sorting and recombination of genes in sexual reproduction results in a great variety of gene combinations in the offspring of any two parents. • Inserting, deleting, or substituting DNA bases can alter genes. An altered gene may be passed on to every cell that develops from it, causing an altered phenotype. • An altered phenotype may be beneficial or detrimental. • Sometimes entire chromosomes can be added or deleted, resulting in a genetic disorder such as Trisomy 21 (Down syndrome). <u>Skill</u> • Evaluate karyotype charts.

Standard BIO.6 f, g

The student will investigate and understand common mechanisms of inheritance and protein synthesis. Key concepts include

f) the structure, function, and replication of nucleic acids (DNA and RNA); and
g) events involved in the construction of proteins.

Essential Understandings	Essential Knowledge and Skills
• DNA stores the information for directing the construction of proteins within a cell. These proteins determine the phenotype of an organism. • The genetic information encoded in DNA molecules provides instructions for assembling protein molecules. The code is virtually the same for all life forms. • Before a cell divides, the instructions are duplicated so that each of the two new cells gets all the necessary information for carrying on life functions.	<u>Knowledge</u> • The genetic code is a sequence of DNA nucleotides in the nucleus of eukaryotic cells. • DNA is a polymer consisting of nucleotides. A DNA nucleotide is identified by the base it contains: adenine (A), guanine (G), and cytosine (C) or thymine (T). • DNA is a double-stranded molecule. The strands are connected by complementary nucleotide pairs (A-T and C-G) like rungs on a ladder. The ladder twists to form a double helix. • The genetic code is the sequence of DNA nucleotides. • In order for cells to make proteins, the DNA code must be transcribed (copied) to messenger RNA (mRNA). • The mRNA carries the code from the nucleus to the ribosomes in the cytoplasm.

Standard BIO.6 f, g (continued)

Essential Understandings	Essential Knowledge and Skills
	• RNA is a single-stranded polymer of four nucleotide monomers. A RNA nucleotide is identified by the base it contains: adenine (A), guanine (G), and cytosine (C) or uracil (U). • At the ribosome, amino acids are linked together to form specific proteins. The amino acid sequence is directed by the mRNA molecule. • Cells pass on their genetic code by replicating (copying) their DNA. • During DNA replication, enzymes unwind and unzip the double helix and each strand serves as a template for building a new DNA molecule. Free nucleotides bond to the template (A-T and C-G) forming a complementary strand. The final product of replication is two identical DNA molecules. <u>Skills</u> • Given a DNA sequence, write a complementary mRNA strand (A-U, T-A, C-G and G-C).

Standard BIO.6 h, i

The student will investigate and understand common mechanisms of inheritance and protein synthesis. Key concepts include

h) use, limitations, and misuse of genetic information; and
i) exploration of the impact of DNA technologies.

Essential Understandings	Essential Knowledge and Skills
• DNA technologies allow scientists to identify, study, and modify genes. • Genetic engineering techniques are used in a variety of industries, in agriculture, in basic research, and in medicine.	<u>Knowledge</u> • Forensic identification is an example of the application of DNA technology. • There is great potential for the development of useful products through genetic engineering (e.g., human growth hormone, insulin, and pest- and disease-resistant fruits and vegetables). • Eugenics, a pseudo-science of selective procreation, was a movement throughout the twentieth century, worldwide as well as in Virginia, that demonstrated a misuse of the principles of heredity. • The Human Genome Project is a collaborative effort to map the entire gene sequence of organisms. This information will be useful in detection, prevention, and treatment of many genetic diseases. • The potential for identifying and altering genomes raises practical and ethical questions. • *Cloning* is the production of genetically identical cells and/or organisms.

Standard BIO.7 a

The student will investigate and understand bases for modern classification systems. Key concepts include

a) structural similarities among organisms.

Essential Understandings	Essential Knowledge and Skills
• Biological classifications are based on how organisms are related. • Organisms are classified into a hierarchy of groups and subgroups based on similarities that reflect their relationships over a period of time. • *Species* is the basic unit of classification. • Investigations of local flora and fauna provide opportunities to enhance understanding and stimulate interest in local environmental issues by developing and applying classification systems in the field.	<u>Knowledge</u> • Binomial nomenclature is a standard way of identifying a species with a scientific two-word name. The first word is the genus name and the second the species name. • A *species* is defined as a group of organisms that has the ability to interbreed and produce fertile offspring. <u>Skills</u> • Construct and utilize dichotomous keys to classify groups of objects and organisms. • Describe relationships based on homologous structures.

Standard BIO.7 b, c, d, e

The student will investigate and understand bases for modern classification systems. Key concepts include

b) fossil record interpretation;
c) comparison of developmental stages in different organisms;
d) examination of biochemical similarities and differences among organisms; and
e) systems of classification that are adaptable to new scientific discoveries.

Essential Understandings	Essential Knowledge and Skills
• Information about relationships among living organisms and those that inhabited Earth in the past is gained by comparing developmental stages of organisms and by examining and interpreting the fossil record. This information is continually being gathered and used to modify and clarify existing classification systems. • Similarities among organisms on the structural and metabolic levels are reflected in the large degree of similarity in proteins and nucleic acids of different organisms. Diversity is the product of variations in these molecules.	<u>Skills</u> • Compare structural characteristics of an extinct organism, as evidenced by its fossil record, with present, familiar organisms. • Recognize similarities in embryonic stages in diverse organisms in the animal kingdom, from zygote through embryo. • Interpret a clad gram or phylogenic tree showing evolutionary relationships among organisms. • Describe relationships between organisms, given amino acid or nucleotide sequences.

Standard BIO.8 a

The student will investigate and understand how populations change through time. Key concepts include

a) evidence found in fossil records.

Essential Understandings	Essential Knowledge and Skills
• Although there is not a complete record of ancient life for the past 3.5 billion years, a great deal of modern knowledge about the history of life comes from the fossil record.	Knowledge • A *fossil* is any evidence of an organism that lived long ago. • Scientists have used the fossil record to construct a history of life on Earth. Skills • Determine the relative age of a fossil given information about its position in the rock and absolute dating by radioactive decay.

Standard BIO.8 b, c, d, e

The student will investigate and understand how populations change through time. Key concepts include

b) how genetic variation, reproductive strategies, and environmental pressures impact the survival of populations;
c) how natural selection leads to adaptations;
d) emergence of new species; and
e) scientific explanations for biological evolution.

Essential Understandings	Essential Knowledge and Skills
• Genetic mutations and variety produced by sexual reproduction allow for diversity within a given population. • Many factors can cause a change in a gene over time. • Depending on the rate of adaptation, the rate of reproduction, and the environmental factors present, structural adaptations may take millions of years to develop.	<u>Knowledge</u> • Populations are groups of interbreeding individuals that live in the same place at the same time and compete with each other for food, water, shelter, and mates. • Populations produce more offspring than the environment can support. • Organisms with certain genetic variations will be favored to survive and pass their variations on to the next generation. • The unequal ability of individuals to survive and reproduce leads to the gradual change in a population, generation after generation over many generations. • Through his observations made in the Galapagos Islands, Charles Darwin formulated a theory of how species change over time, called *natural selection*.

Standard BIO.8 b, c, d, e (continued)

Essential Understandings	Essential Knowledge and Skills
	• Natural selection is governed by the principles of genetics. The change frequency of a gene in a given population leads to a change in a population and may result in the emergence of a new species. • Natural selection operates on populations over many generations. • Mutations are important in how populations change over time because they result in genetic changes to the gene pool. • Adaptations sometimes arise in response to environmental pressures, for example, the development of antibiotic resistance in bacterial populations, morphological changes in the peppered moth population, the development of pesticide resistance in insect populations. • Stephen Jay Gould's idea of *punctuated equilibrium* proposes that organisms may undergo rapid (in geologic time) bursts of speciation followed by long periods of time unchanged. This view is in contrast to the traditional evolutionary view of gradual and continuous change. <u>Skills</u> • Differentiate between relative and absolute dating based on fossils in biological evolution.

Standard BIO.9 a

The student will investigate and understand dynamic equilibria within populations, communities, and ecosystems. Key concepts include

a) interactions within and among populations including carrying capacities, limiting factors, and growth curves.

Essential Understandings	Essential Knowledge and Skills
• As any population of organisms grows, it is held in check by interactions among a variety of biotic and abiotic factors.	Knowledge • A *community* is a collection of interacting populations. • Population growth curves exhibit many characteristics, such as initial growth stage, exponential growth, steady state, decline, and extinction. • Limiting factors are the components of the environment that restrict the growth of populations. • Carrying capacity is the number of organisms that can be supported by the resources in an ecosystem. • Abiotic factors are the nonliving elements in an ecosystem, such as temperature, moisture, air, salinity, and pH. Biotic factors are all the living organisms that inhabit the environment, including predators, food sources, and competitors. • *Symbiosis* is a close and permanent relationship between organisms of two different species. Examples include mutualism, commensalism, and parasitism.

Standard BIO.9 a (continued)

Essential Understandings	Essential Knowledge and Skills
	Skills • Graph and interpret a population growth curve.

Standard BIO.9 b, c

The student will investigate and understand dynamic equilibria within populations, communities, and ecosystems. Key concepts include

b) nutrient cycling and energy flow through ecosystems; and
c) succession patterns in ecosystems.

Essential Understandings	Essential Knowledge and Skills
• Ecosystems demonstrate an exchange of energy and nutrients among inhabiting organisms. • The gradual change in an ecosystem that occurs as communities slowly replace one another is known as *ecological succession*.	<u>Knowledge</u> • An *ecosystem* consists of all the interacting species and the abiotic environment in a given geographic area. • Nutrients cycle through an ecosystem. The most common examples of such nutrients include carbon, oxygen, nitrogen, and water. • Flow of energy occurs between trophic levels in all ecosystems and can be depicted as follows: - food chain - food web - pyramid of energy - pyramid of biomass - pyramid of numbers. • *Ecological succession* is a series of changes in a community in which new populations of organisms gradually replace existing ones.

Standard BIO.9 b, c (continued)

Essential Understandings	Essential Knowledge and Skills
	• A *climax community* occurs when succession slows down and a stable community is established. The climax community is made up of organisms that are successful at competing for resources in a given environment. The climax community in most of Virginia is a deciduous oak-hickory (hardwood) forest. Skills • Given an illustration of a food chain and a food web, describe each organism as a producer (autotroph), consumer (primary/second order), or decomposer.

Standard BIO.9 d, e

The student will investigate and understand dynamic equilibria within populations, communities, and ecosystems. Key concepts include

d) the effects of natural events and human activities on ecosystems; and
e) analysis of the flora, fauna, and microorganisms of Virginia ecosystems including the Chesapeake Bay and its tributaries.

Essential Understandings	Essential Knowledge and Skills
• As the human population increases, so does human impact on the environment. • Investigations of local ecosystems provide opportunities for students to enhance their understanding and stimulate their interest in local environmental issues by applying ecological principles in the field.	<u>Knowledge</u> • Human activities, such as reducing the amount of forest cover, increasing the amount and variety of chemicals released into the atmosphere, and intensive farming, have changed the Earth's land, oceans, and atmosphere. • Some of these changes have decreased the capacity of the environment to support some life forms. <u>Skills</u> • Observe and identify flora and fauna in a local community, using field guides and dichotomous keys for identifying and describing organisms that characterize the local ecosystem.

Standard BIO.9 d, e (continued)

Essential Understandings	Essential Knowledge and Skills
	• Identify and describe an ecosystem in terms of the following: - effects of biotic and abiotic components - examples of interdependence - evidence of human influences - energy flow and nutrient cycling - diversity analysis - ecological succession.