

## SCIENCE – UNIFYING STANDARDS

THE NATURE OF SCIENCE

- 1.0 **Research and Investigation:** Students understand that science is a way of learning about the natural world. They use scientific inquiry and develop ideas based on data collected from investigations they design.
- 2.0 **Communication:** Students understand that the universe can be described by principles derived through scientific inquiry. They effectively communicate their understanding of ideas developed in scientific investigation through a variety of media.
- 3.0 **Connections and Implications:** Students review the consequences of the process and products of scientific inquiry. They understand the role that scientific advances have had throughout history.

EARTH SCIENCE

- 1.0 **Characteristics of the Universe:** Students understand Earth-based and space-based astronomy reveals the structure, scale, and dynamic nature of the solar system, stars, galaxies, and the universe.
- 2.0 **The Dynamic Earth:** Students understand that the Earth is constantly changing and being shaped due to a variety of natural events, processes, and human activity. The Earth is a collection of interacting cycles, structures, and processes that can be described in terms of space, time, energy, and matter.

LIFE SCIENCE

- 1.0 **Diversity and Interdependence:** Students understand that living things are diverse and interdependent. They recognize the relationship between cooperation and competition among organisms in ecosystems.
- 2.0 **Cellular Structures and Functions:** Students understand that cells are the basic structures of all living systems. They understand the complementary relationship between the structure and function of cells, organs, organ systems, whole organisms, and ecosystems.
- 3.0 **Change and Evolution:** Students understand that living things grow, develop, change, and evolve through time, depending on environmental influences. They know that traits of species can change through generations and that instruction of traits is contained in the genetic material of organisms.

PHYSICAL SCIENCE

- 1.0 **Forces and Motion:** Students understand the nature of forces and the relationship between forces and motion. They recognize that the relationship is described by one set of laws. They understand that all matter is in motion and that motion changes as a result of forces between matter. They realize that these forces affect everyday life, and that the effects can be identified, measured, and predicted.
- 2.0 **Energy, Momentum and Transformation:** Students understand that when matter interacts with matter, energy and momentum can be transferred or distributed, and that energy may be transformed. When matter interacts the total amount of matter, energy, and momentum remain the same.
- 3.0 **Structure and Properties of Matter:** Students understand that all matter is made up of particles. They understand the relationship between the structure and properties of matter. They know that a finite number of basic elements combine in various ways which determine all properties, characteristics, and behaviors of matter.

**LIFE SCIENCE**  
**Focus Goals Levels 9 - 12**

**1.0 Diversity and Interdependence:** Students understand that living things are diverse and interdependent. They recognize the relationship between cooperation and competition among organisms in ecosystems.

- 1.1 Describe how living things depend on one another and the environment for survival.
- 1.2 Explain how living things are parts of larger systems of interaction.
- 1.3 Summarize how organisms are linked to one another and to their physical setting by the transfer and transformation of matter and energy.

**2.0 Cellular Structures and Functions:** Students understand that cells are the basic structures of all living systems. They understand the complimentary relationship between the structure and function of cells, organs, organ systems, whole organisms, and ecosystems.

- 2.1 Recognize that all living things are made up of cells.
- 2.2 Know and describe that within the cell are specialized parts that are analogous to multicellular organisms.
- 2.3 Understand that fundamental life processes of plants and animals depend on a variety of chemical reactions.
- 2.4 Recognize that multicellular organisms are composed of specialized cells grouped to perform specific functions.
- 2.5 Know and explain that all living organisms have essential requirements for life: obtaining food and deriving energy from it, internal coordination and stability, and reproduction.
- 2.6 Understand that organisms have a variety of mechanisms to combat disease.

**3.0 Change and Evolution:** Students understand that living things grow, develop, change and evolve through time, depending on environmental influences. They know that traits of species can change through generations and that instruction of traits is contained in the genetic material of organisms.

- 3.1 Illustrate how DNA is the code of life.
- 3.2 Support how genes passed from parents determine the traits of the offspring.
- 3.3 Show how DNA provides for genetic variation through sexual reproduction and mutation.
- 3.4 Understand and describe the implications of genetic engineering.
- 3.5 Explain the basic idea of biological evolution that species have changed over time and developed from earlier distinctly different species.
- 3.6 Express how natural selection is a mechanism for change in living things.

**LIFE SCIENCE**  
**Levels 9 – 12**

**1.0 Diversity and Interdependence:** Students understand that living things are diverse and interdependent. They recognize the relationship between cooperation and competition among organisms in ecosystems.

**1.1 Describe how living things depend on each other and the environment for survival.** (p)

- Recognize that ecosystems tend to have cyclic fluctuations around a state of equilibrium, but that they can change when divergent physical (abiotic) or biological (biotic) factors are introduced. (p)
- Analyze changes in an ecosystem resulting from changes in climate, human activity, introduction of non-native species, or changes in population size.(c/LS6b)
- Recognize that fluctuations in population size in an ecosystem are determined by the relative rates of birth, immigration, emigration, and death. (c/LS6c)
- \*Distinguish between the accommodation of an individual organism to its environment and the gradual adaptation of a lineage of organisms through genetic change. (c/LS6g)

**1.2 Explain how living things are part of larger systems of interaction.** (p)

- Recognize that human activities can, deliberately or inadvertently, alter the equilibrium in ecosystems. (p)
- Recognize that biodiversity is the sum total of different kinds of organisms, and is affected by alterations of habitats. (c/LS6a)
- Recognize that a vital part of an ecosystem is the stability of its producers and decomposers. (c/LS6e)

**1.3 Summarize how organisms are linked to one another and to their physical setting by the transfer and transformation of matter and energy.** (p)

- Recognize that the chemical elements that make up the molecules of living things pass through food webs and are combined and recombined in different ways. At each line in a food web, some energy is stored in newly made structures but much is dissipated into the environment as heat. Continual input of energy from sunlight keeps the process going. (c/LS6f)
- Recognize how water, carbon, and nitrogen cycle between abiotic resources and organic matter in the ecosystem and how oxygen cycles via photosynthesis and respiration. (c/LS6d)

**2.0 Cellular Structures and Functions:** Students understand that cells are the basic structures of all living systems. They understand the complementary relationship between the structure and function of cells, organs, organ systems, whole organisms, and ecosystems.

**2.1 Recognize that all living things are made up of cells.** (p)

- Explain how prokaryotic cells, eukaryotic cells (including those from plants and animals), and viruses differ in complexity and general structure. (c/LS1c)

**2.2 Know and describe that within the cell are specialized parts that are analogous to multicellular organisms.** (p)

- Identify parts of cells that are used for growth, transport of materials, energy capture and release, protein building, waste disposal, information feedback, and even movement. (p)
- Explain that a living cell is composed of a small number of chemical elements mainly carbon, hydrogen, nitrogen, oxygen, phosphorus, and sulfur. Carbon, because of its structure can join to other carbon atoms in chains and rings to form large and complex molecules. (p)
- Recognize that cells are enclosed within semi-permeable membranes that regulate their interaction with their surroundings. (c/LS1a)
- Explain the role of the endoplasmic reticulum and Golgi apparatus in secretion of proteins. (c/LS1e)
- Recognize that usable energy is captured from sunlight by chloroplasts, and stored via the synthesis of sugar from carbon dioxide. Oxygen is another by-product of this synthesis. (c/LS1f)
- Explain the role of the mitochondria in making stored chemical bond energy available to cells by completing the breakdown of glucose to carbon dioxide. (c/LS6g)
- \*Explain how eukaryotic cells are given shape and internal organization by a cytoskeleton and/or cell wall. (c/LS1j)

**2.3 Understand that fundamental life processes of plants and animals depend on a variety of chemical reactions.** (c/LS1)

- Recognize that enzymes are proteins that catalyze biochemical reactions without altering the reaction equilibrium. The activity of enzymes depends on the temperature, ionic conditions and pH of the surroundings. (c/LS1b)
- Explain that the Central Dogma of molecular biology outlines the flow of information from transcription of RNA in the nucleus to translation of proteins on ribosomes in the cytoplasm. (c/LS1d)
- Recognize that most macromolecules (polysaccharides, nucleic acids, proteins, lipids) in cells and organisms are synthesized from a small collection of simple precursors. (c/LS1h)
- \*Explain how chemiosmotic gradients in the mitochondria and chloroplasts store energy for ATP production. (c/LS1i)

**2.4 Recognize that multicellular organisms are composed of specialized cells grouped to perform specific functions.** (p)

- Recognize that communication between cells is required to coordinate their diverse activities and that the communication can be electrical (via nerve cells) or chemical (via neurotransmitters or hormones). (p)
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- Explain how the nervous system mediates communication between different parts of the body and interactions with the environment. (c/LS9b)
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- List the functions of the nervous system, and the role of neurons in transmitting electrochemical impulses. (c/LS9d)
- Describe the roles of sensory neurons, interneurons, and motor neurons in sensation, thought, and response. (c/LS9e)
- Describe the reproductive adaptations and processes of plants. (p)
- \*Describe the individual functions and sites of secretion of digestive enzymes (amylases, proteases, nucleases, lipases), stomach acid, and bile salts. (c/LS9f)
- \*Explain the cellular and molecular basis of muscle contraction, including the roles of actin, myosin, Ca<sup>2+</sup>, and ATP. (c/LS9h)

**2.5 Know that all living organisms have essential requirements for life: obtaining food and deriving energy from it, internal coordination and stability, and reproduction.** (p)

- Recognize that all body systems are in dynamic equilibrium, utilize feedback loops to maintain homeostasis, and are affected by gradients and surface area to volume ratios. (p)
- List and describe the major organ systems in vertebrates. (p)
- Explain how the complementary activity of major body systems provides cells with oxygen and nutrients, and removes toxic waste products such as carbon dioxide. (c/LS9a)
- Explain how feedback loops in the nervous and endocrine systems regulate conditions within the body. (c/LS9c)
- \*Explain the homeostatic role of the kidneys in the removal of nitrogenous wastes, and of the liver in blood detoxification and glucose balance. (c/LS9g)
- \*Explain how hormones (including digestive, reproductive, osmoregulatory) provide internal feedback mechanisms for homeostasis at the cellular level and in whole organisms. (c/LS9i)

**2.6 Understand that organisms have a variety of mechanisms to combat disease.** (c/LS10)

- Recognize that the immune system is designed to protect against microscopic organisms and foreign substances that enter from outside the body and against some cancer cells that arise within. (p)
- Explain how vaccinations protect an individual from infectious diseases. (c/LS10c)
- Describe the role of the skin in providing nonspecific defenses against infection. (c/LS10a)
- Describe the role of antibodies in the body's response to infection. (c/LS10b)
- Recognize that there are important differences between bacteria and viruses, with respect to their requirements for growth and replication, the primary defense of the body against them, and effective treatment of infections they cause. (c/LS10d)
- Explain why an individual with a compromised immune system (for example, a person with AIDS) may be unable to fight off and survive infections of microorganisms that are usually benign. (c/LS10e)
- \*Describe the roles of phagocytes, B-lymphocytes, and T-lymphocytes in the immune system. (c/LS10f)

**3.0 Change and Evolution:** Students understand that living things grow, develop, change and evolve through time, depending on environmental influences. They know that traits of species can change through generations and that instruction of traits is contained in the genetic material of organisms.

**3.1 Illustrate how DNA is the code of life.** (p)

- Recognize that the information passed from parents to offspring is coded in DNA, a large molecule formed from nucleotides. (p)
- Describe the general pathway by which ribosomes synthesize proteins, using tRNAs to translate genetic information in mRNA. (c/LS4a)
- Explain how to apply the genetic coding rules to predict the sequence of amino acids from a sequence of codons in RNA. (c/LS4b)
- Recognize that proteins can differ from one another in the number and sequence of amino acids. (c/LS4e)
- Recognize the general structures and functions of DNA, RNA and protein. (c/LS5a)
- Apply base-pairing rules to explain precise copying of DNA during semi-conservative replication, and transcription of information from DNA into mRNA. (c/LS5b)
- \*Explain why proteins having different amino acid sequences typically have different shapes and chemical properties. (c/LS4f)

**3.2 Support how genes passed from parents determine the traits of the offspring.** (p)

- Recognize that genes are segments of DNA molecules and that each segment or combination of segments codes for a specific trait in an organism. (p)
- Predict the probable outcome of phenotypes in a genetic cross from the genotypes of the parents and mode of inheritance (autosomal or X-linked, dominant or recessive). (c/LS3a)
- \*Predict the probable mode of inheritance from a pedigree diagram showing phenotypes. (c/LS3c)
- \*Use data on frequency of recombination at meiosis to estimate genetic distances between loci, and to interpret genetic maps of chromosomes. (c/LS3d)

**3.3 Show how DNA provides for genetic variation through sexual reproduction and mutation.** (p)

- Recognize that the interaction between heredity and the environment determines the expression of a trait. (p)
- Recognize that the sorting and recombination of genes in sexual reproduction results in a great variety of possible gene combinations from the offspring of any two parents. (p)
- Recognize that inserting, deleting, or substituting DNA segments can alter genes. An altered gene may be passed on to every cell that develops from it. The resulting features may help, harm, or have little or no effect on the offspring's success in its environment. (p)
- Recognize that some new gene combinations make little difference, some can produce organisms with new and perhaps enhanced capabilities, and some can be deleterious. (p)

- Recognize that gene mutations occur naturally at low frequency but such things as radiation and chemicals can increase the frequency of mutations. When they occur in sex cells, the mutations can be passed to offspring. (p)
- Recognize that meiosis is an early step in sexual reproduction in which the pairs of chromosomes separate and segregate randomly during cell division to produce gametes containing one chromosome of each type. (c/LS2a)
- Explain why approximately half of an individual's DNA sequence comes from each parent. (c/LS2e)
- Explain the role of chromosomes in determining an individual's sex. (c/LS2f)
- Explain how to predict possible combinations of alleles in a zygote from the genetic makeup of the parents. (c/LS2g)
- Recognize the genetic basis for Mendel's laws of segregation and independent assortment. (c/LS3b)
- Explain how mutations in the DNA sequence of a gene may or may not affect the expression of the gene, or the sequence of amino acids in an encoded protein. (c/LS4c)
- Recognize that specialization of cells in multicellular organisms is usually due to different patterns of gene expression rather than to differences of the genes themselves. (c/LS4d)

#### 3.4 **Understand and describe the implications of genetic engineering.** (p)

- Recognize that genetic engineering (biotechnology) is used to produce novel biomedical and agricultural products. (c/LS5c)
- \*How basic DNA technology (restriction digestion by endonucleases, gel electrophoresis, ligation, and transformation) is used to construct recombinant DNA molecules. (c/LS5d)

#### 3.5 **Explain the basic idea of biological evolution, that species have changed over time and developed from earlier distinctly different species.** (p)

- Recognize that biochemical and anatomical evidence provides detail about the sequence in which various lines of descent branched off from one another. (p)
- Recognize that the degree of kinship between organisms or species can be estimated from the similarity of their DNA sequences, which often closely matches their classification based on anatomical similarities. (p)
- List effects of genetic drift on the diversity of organisms in a population. (c/LS8c)
- Describe reproductive or geographic isolation affects speciation. (c/LS8d)
- Analyze fossil evidence with regard to biological diversity, episodic speciation, and mass extinction. (c/LS8e)
- Recognize that biologists describe the diversity of life within a classification system derived from the evolutionary heritage of the organisms on earth.(p)
- Use the classification system to identify organisms and discuss their evolutionary heritage. (p)
- \*Recognize that several independent molecular clocks, calibrated against each other and using evidence from the fossil record, can help to estimate how long ago various groups of organisms diverged evolutionarily from each other. (c/LS8g)
- \*Recognize that comparative embryology, DNA or protein sequence comparisons, and other independent sources are used to create a branching diagram (cladogram) that shows probable evolutionary relationships. (c/LS8f)

**3.6 Express how natural selection is a mechanism for change in living things.** (p)

- Recognize that although differences exist concerning the details of the process and how rapidly evolution of species takes place, most scientists accept Darwin's basic idea. (p)
- Describe the mechanisms of natural selection (overproduction, variation in heritable characteristics, competitive advantage, transmission of traits in reproduction, and frequency of favorable traits in offspring). (p&c/LS8a)
- Recognize that chemistry, structure, and behavior are heritable characteristics, and that these characteristics strongly influence how likely an organism is to survive and reproduce. (p)
- Identify adaptations in plants and animals that provide a competitive advantage in given niches. (p)
- Recognize that alleles lethal in a homozygous individual may be carried in a heterozygote, and thus maintained in a gene pool. (p)
- Recognize that a great diversity of species increases the chance that at least some organisms survive large changes in the environment. (c/LS8b)
- \*List the conditions for Hardy-Weinberg equilibrium in a population, and why these conditions are not met in nature. (c/LS7e)
- \*Solve the Hardy-Weinberg equation to determine the predicted frequency of genotypes in a population, given the frequency of phenotypes. (c/LS7f)