

Biology

Biology is an inquiry-based course focused on providing all high school students with foundational life science content about the patterns, processes, and interactions among living organisms. It emphasizes depth and detail in a limited number of core ideas rather than memorization of broad factual content.

Each standard's foundational knowledge is integrated with the science and engineering practices to provide students with opportunities to engage in scientific inquiry. Students use both new and prior knowledge to build conceptual understandings based on evidence from their own and others' investigations. They use their own learning and experiences to support claims and engage in argument from evidence and to produce innovative solutions that reflect how scientists formulate explanations.

The standards provide opportunities to create deeper conceptual understanding and foster scientific literacy for college, career, and citizenship. Resources specific to the local area, scholarly resources (including evidenced-based literature from scientific journals, real-world data, industry studies, and scientific reports), and laboratory investigations should be used to extend and increase the complexity of the core ideas.

The Biology course incorporates safe laboratory investigations where students can actively explore the aspects of living things. Students are encouraged to apply evidence-based reasoning to investigate various structures, processes, and interactions in organisms. Hands-on experiences in the lab spark curiosity and build interest in learning about living things and are especially valuable for students interested in biology-related science, technology, engineering, and mathematics (STEM) careers.

Content standards within this course are organized according to the disciplinary core ideas for the life sciences domain. The first core idea, "From Molecules to Organisms: Structures and Processes," emphasizes the structure of cells and how their functions are necessary for supporting life, growth, behavior, and reproduction. The second core idea, "Ecosystems: Interactions, Energy, and Dynamics," investigates the positive and negative interactions between living organisms and other biotic and abiotic factors, as well as investigating and celebrating Alabama's biodiversity.

The third core idea, "Heredity: Inheritance and Variation of Traits," centers on the formation of proteins that affect trait expression (also known as the central dogma of molecular biology); the passing of genetic information through generations; and how environmental factors and errors in DNA replication can contribute to genetic variation. The fourth core idea, "Unity and Diversity," examines the variation of traits within a population that results in diversity among organisms over a long period of time. This core idea also focuses on analyzing the relatedness between organisms and groups of organisms using phylogenetic trees and cladograms. This approach moves away from the shifting nomenclature in hierarchical taxonomies toward the use of technologies to determine species relatedness.

Each content standard completes the stem “*Students will...*”

From Molecules to Organisms: Structures and Processes		
Cells	<ol style="list-style-type: none"> Engage in evidence-based argument to relate a cell’s function to the structure, function, and diversity of its components. <i>Examples: Muscle cells have a large number of mitochondria, which create energy for contraction in the form of ATP. Some plant cells have a large vacuole which is used for storage and transport of excess nutrients in changing environments.</i> 	Structure and Function
DNA and Protein Synthesis	<ol style="list-style-type: none"> Obtain and evaluate information to explain the role of DNA and RNA in transcription and translation leading to protein synthesis and cellular function. <ol style="list-style-type: none"> Use a model to describe the structure and sequence of DNA, including nucleotide structure, base pairing, and the structure of the helix. Obtain and evaluate information to explore additional functions and regulatory roles of RNA, DNA, and protein, including their roles in gene expression and cellular differentiation. <i>Examples: RNA contributing to ribosome structure, histone modification altering chromatin structure, and transcription factors and non-coding DNA involved in nuclear regulatory functions</i> Clarification: Discussion should include proteins that regulate and carry out essential functions of life including enzymes, structural proteins, hormones, and receptors. Obtain, evaluate, and communicate information regarding how DNA and genetic technology apply to daily life. <i>Examples: CRISPR can be used to develop species-specific pest control tools. GMO technology is used to produce drought-resistant plants to increase food supplies. Genetic screening is used in neonatal healthcare.</i> 	

<p>Growth and Development</p>	<p>3. Develop and use models to explain how events during the cell cycle lead to the formation of new cells and repair of multicellular organisms, including cell growth, DNA replication, separation of chromosomes, and separation of cell contents.</p> <ul style="list-style-type: none"> a. Construct an explanation of the process of DNA replication during cellular division (S-phase). b. Using observations of cell growth, construct an explanation of how the cell cycle leads to differentiation in tissue development. <i>Examples: stages of cellular differentiation that lead to formation of tissues in embryological development, dysfunction in the cell cycle that leads to uncontrolled cell growth (cancers and tumor growth), exposure to external stimuli that leads to changes in plant tissue growth or plant tropisms (phototropism, gravitropism)</i> 	<p>Systems and System Models</p>
<p>Cellular Homeostasis</p>	<p>4. Engage in argument from evidence to explain the regulation of cellular processes that maintain homeostasis, including active and passive transport. <i>Examples: evidence from a laboratory exercise investigating the effects of various factors such as temperature and concentration gradient on diffusion; viewing simulations of active transport and arguing its role in urine formation.</i></p> <ul style="list-style-type: none"> a. Use models to illustrate how the structural characteristics of lipids and proteins in the cell membrane regulate cellular processes. b. Construct an explanation of how the unique properties of water are vital to maintaining homeostasis in organisms. <i>Examples: Explain how cohesive properties contribute to capillary action and the movement of water in plants, how water is the universal solvent, and that the heat capacity of water contributes to survival in extreme habitats.</i> 	<p>Structure and Function</p>

Photosynthesis and Respiration	<p>5. Plan and carry out investigations and utilize results to explain the role and cycling of products and reactants involved in the cellular conversion of energy.</p> <ul style="list-style-type: none"> a. Construct an explanation of how the structural characteristics of carbohydrates and lipids store energy. b. Use models of the reactants and products of photosynthesis to illustrate the conversion of light energy into stored chemical energy within cells. <i>Examples: diagrams, flow charts, chemical equations, interactive games, concept maps</i> Clarification: Steps of light reactions, the Calvin cycle, or chemical structures of molecules are not required. c. Use models of the reactants and products of cellular respiration (both aerobic and anaerobic) to illustrate how chemical energy is stored in the bonds of carbohydrates and lipids and converted to ATP and heat when the bonds are broken. <i>Examples: diagrams, chemical equations, conceptual models</i> Clarification: Identification of the steps or specific process involved in cellular respiration or specific types of fermentation is not required. 	Energy and Matter
Ecosystems: Interactions, Energy, and Dynamics		
Interdependent Relationships	<p>6. Develop and use models to illustrate interactions between ecological hierarchy levels, including biosphere, biome, ecosystem, community, population, and organism.</p>	
Matter and Energy Flow	<p>7. Develop and use models to illustrate the flow of matter and energy between abiotic and biotic factors in ecosystems, including loss of heat, 10% rule, and the conservation of matter. <i>Examples: Diagram biogeochemical cycles (C, N, P, S), food chains, food webs, or biomass pyramids to illustrate the movement of energy and the conservation of matter.</i> Clarification: Steps of the biogeochemical cycles are not required. The focus of the standard is to create awareness of the importance of the exchange of elements between the subsystems.</p>	Systems and System Models

Population Dynamics	<p>8. Construct an evidence-based explanation of how density-dependent and density-independent factors affect population growth. <i>Examples: Utilize calculated averages, trends, or graphical comparisons of multiple sets of data detailing exponential, linear, or logistic growth to explain how food shortage decreases the population of animals in a particular habitat.</i></p>	Scale, Proportion, and Quantity
Biodiversity	<p>9. Obtain, evaluate, and communicate data to explain how the biodiversity of Alabama contributes to ecosystem services in the state. <i>Examples: Alabama has many species of freshwater fish, which support a robust fishery. Alabama's extensive, diverse forests support the timber industry.</i></p> <p>a. Obtain and evaluate data to describe human impact on various Alabama ecosystems. <i>Examples: Explain how nitrogen runoff from farms affects algal growth in Mobile Bay. Explain how invasive species (such as kudzu or cogon grass) affect Alabama ecosystems. Explain the impact of building on top of sand dunes on barrier islands along the Gulf Coast. Explain how humans have introduced white nose syndrome into bat cave habitat.</i></p>	
	<p>10. Engage in argument from evidence to support the claim that characteristics of an ecosystem contribute to its resilience and stability, including ecological succession and recovery from disturbance. <i>Examples: Gather evidence that fire suppression impacts seed germination in fire-dependent ecosystems. Using evidence from biodiversity indices, support the claim that biodiversity contributes to functional redundancy in tropical rainforests.</i></p>	Stability and Change

Heredity: Inheritance and Variation of Traits

Inherited Traits and Environmental Impact	<p>11. Use probability and statistical models to explain the variation of expressed traits within a population. <i>Examples: pedigree charts, family and population studies</i></p>	Patterns
	<p>a. Use mathematics and computational thinking to predict patterns of inheritance, including dominance, recessiveness, codominance, and incomplete dominance. <i>Examples: Use a Punnett square to illustrate codominance in genes for blood types. Use probability rules to predict the phenotypes of offspring from different parental combinations.</i></p> <p>b. Obtain, evaluate, and communicate information about how the interplay of heritable risk factors, somatic mutations, and environment influences human disease. <i>Examples: Because heart disease has heritable and environmental risk factors, a person's total risk needs to include both factors. Cancers have both heritable (breast, lung, colorectal, skin, cervical cancer) and environmental risk factors (smoking, diet, sun exposure, HPV exposure).</i> Clarification: Epigenetics could be an extension of this standard.</p>	Systems and System Models
Heredity and Meiosis	<p>12. Develop and use an evidence-based model to illustrate the formation of reproductive cells through the process of meiosis. <i>Example: Use karyotype cutouts to illustrate independent assortment into reproductive cells.</i></p>	Systems and System Models
	<p>a. Construct an explanation of how new genetic combinations and variations occur during crossover.</p> <p>b. Obtain, evaluate, and communicate information about how errors during meiosis and environmental factors affect the expression of traits. <i>Examples: Translocation between chromosomes 8 and 11 can cause myeloproliferative disorder and lymphoma. Smoking and exposure to teratogenic chemicals can alter genes in reproductive cells that can be passed on to offspring.</i></p>	Cause and Effect

Unity and Diversity

Phylogenetics	<p>13. Analyze and interpret data to support hypotheses of common ancestry and biological evolution illustrated by cladograms and phylogenetic trees.</p> <p><i>Examples: Use cladograms and phylogenetic trees developed from evidence (such as fossil records, comparative anatomy, comparative embryology, biogeography, or DNA/RNA/amino acids sequences) to discuss common ancestry and biological evolution.</i></p> <p>Clarification: Emphasis is on students' conceptual understanding of how lines of evidence relate to common ancestry and biological evolution, and is not extended to the lines of evidence for specific species.</p> <p>a. Evaluate evidence supporting claims that viruses should be placed in a separate category from living things.</p>	Patterns
Natural Selection	<p>14. Analyze and interpret data pertaining to adaptations resulting from natural and artificial selection to explain the evolution of populations.</p> <p><i>Examples: number of antibiotic-resistant bacteria present after incremental exposure to antibiotics, frequency distribution of different colored moths before and after the Industrial Revolution, population counts of tuskless elephants before and after poaching, frequency distribution of mutations resulting from errors in DNA replication leading to new alleles present in the population</i></p> <p>Clarification: This standard should focus on using evidence to explain how types of selection influences the number of organisms and behaviors, morphology, or physiology of species. Other mechanisms of evolution, such as genetic drift, gene flow through migration, and co-evolution, are not required.</p>	Stability and Change
	<p>15. Engage in argument from evidence to explain how populations respond to changes in the environment that can lead to speciation or extinction.</p> <p><i>Examples: emergence of geographic barriers over time leading to speciation; large-scale climate change shifting weather patterns and driving speciation or extinction; global disasters such as asteroids and volcanos leading to mass extinction events; anthropogenic shifts in climate or habitat causing extinction</i></p> <p>Clarification: Discussion of allele frequency calculations is not required.</p>	Cause and Effect