



9th Grade Honors Biology

Approved by KSD Board of Education: 3-30-2026

Course Description:

Honors Biology is an advanced study of living organisms with an emphasis on the molecular and mechanistic foundations of life. Students investigate biological systems from cells to ecosystems through laboratory inquiry, modeling, and data analysis. In addition to the core topics of modern biochemistry, cell structure and function, energetics, genetics, evolution, and ecology, honors students will extend learning by examining the mechanisms that generate biological processes, applying quantitative and probabilistic reasoning, and evaluating multiple lines of scientific evidence.

Students are expected to construct and defend explanations using empirical data, connect molecular events to observable outcomes, and engage in advanced applications of biological principles. This course prepares students for further study in advanced science by developing analytical thinking, scientific literacy, and evidence-based reasoning. These topics will not only provide a comprehensive foundation in biological science but will also cultivate analytical skills, critical thinking, and a deeper appreciation for the diversity and complexity of life on Earth.

Grade Level: 9th Grade

Unit Scope and Sequence

Unit 1: How do living organisms sustain the balance that defines life?

Unit 2: How do chemical processes use energy flow and the cycling of matter to power life?

Unit 3: How do cells store life's genetic code and replicate?

Unit 4: How is life genetic's code expressed?

Unit 5: How is information for life varied and inherited?

Unit 6: How is the information for life changed over time?

Unit 7: How do organisms interact with each other and their environment?

Course Enduring Understandings:

- Living organisms are highly organized systems built from organic macromolecules, whose structure and function at molecular, cellular, and systemic levels work together to maintain internal stability through feedback mechanisms and homeostasis.
- Energy and matter move through Earth's systems as organisms and the environment interact through various interconnected biological and chemical processes
- The processes of DNA replication and cell division ensure the accurate transmission of genetic information, while different modes of reproduction influence genetic stability and variation across generations.

- DNA stores the genetic code that directs the production of proteins through transcription and translation; these proteins perform essential life functions and determine an organism's traits. Mutations in DNA, influenced by environmental factors, can change protein structure and function, leading to variations in traits that may be harmful, beneficial, or neutral.
- Genetic information is transmitted from parents to offspring through meiosis and fertilization, and the processes of meiosis, mutation, and environmental influence create genetic variation that follows predictable patterns of inheritance.
- Life on Earth has changed over time through interactions among organisms, their environments, and natural processes, with evidence showing ongoing adaptation and human influence on these patterns.
- Ecosystems are dynamic systems where living and nonliving components interact, with energy flow, matter cycling, and human influence shaping their balance and diversity over time.

Course Essential Questions:

- How do living organisms sustain the balance that defines life?
- How do chemical processes use energy flow and the cycling of matter to power life?
- How do cells store life's genetic code and replicate?
- How is life genetic's code expressed?
- How is information for life varied and inherited?
- How is the information for life changed over time?
- How do organisms interact with each other and their environment?

9th Grade Honors Biology

Unit 1: How do living organisms sustain the balance that defines life?

This unit introduces students to the fundamental characteristics and building blocks of living organisms. It explores how structures and interactions of macromolecules, cells, and body systems work together to maintain homeostasis. Students will explore the chemical basis of life, examining how six key elements combine to form the organic macromolecules essential for biological functions. They will investigate the hierarchical organization of living systems: from molecules to cells to tissues to organs to organ systems, homeostasis and to analyze how these interconnected levels work together to maintain life. Through hands-on investigations, students will discover how processes such as feedback mechanisms and cell transport maintain homeostasis, allowing organisms to respond to internal and external changes while preserving stability. By the end of this unit, students will understand the unique properties that define living things, the molecular components that comprise them, and the regulatory processes that sustain life.

Unit Essential Learning Targets	
<i>Enduring Understandings</i>	<i>Essential Questions</i>
- Living organisms maintain internal stability through feedback mechanisms and homeostasis both positive and negative - Organic macromolecules (proteins, carbohydrates, lipids, and nucleic acids) form the building blocks of life - Living organisms exhibit hierarchical organization from molecules to cells to tissues to organs to organ systems	- What makes a factor biotic or abiotic? - How do feedback mechanisms help living organisms maintain homeostasis in changing environments? - Why are organic macromolecules essential for the structure and function of living organisms? - How does the hierarchical organization of biological structures contribute to the overall function of living organisms?
<i>Students must know:</i>	<i>Students must be able to:</i>
Terminology: Homeostasis, positive/negative feedback, stimuli, metabolism, DNA, ribosomes, cell, cell theory, prokaryotic, eukaryotic, unicellular, multicellular, nucleus, cytoplasm, cell membrane, organelle, tissue, organ, organ system, organism, biotic, abiotic, nucleic acids, lipids, carbohydrates, proteins, amino acids, nucleotides, Lysosome, Golgi Apparatus, Endoplasmic Reticulum, and Vesicles, catalyst, enzyme, activation energy, denature, semi-permeable, passive transport, active transport, simple diffusion, facilitated diffusion, osmosis, hypotonic, hypertonic, isotonic, channel protein, endocytosis and	- Describe the three tenets of cell theory - Differentiate cells as prokaryotic and eukaryotic based on their similarities and differences focusing on the following cellular components: DNA, Nucleus, Cytoplasm, Cell Membrane, Cell Wall, (Central) Vacuole, Ribosome, Chloroplast, and Mitochondria, Lysosome, Golgi Apparatus, Endoplasmic Reticulum, and Vesicles - Compare and contrast bacteria, plant and animal cells - Develop and use a model to illustrate the hierarchical levels of organization and evaluate how each level contributes to the greater organism.

9th Grade Honors Biology

Unit 1: How do living organisms sustain the balance that defines life?

- exocytosis, phospholipid, solute, solvent, concentration gradient, solution
- The six primary elements (C, H, O, N, P, S) that compose organic macromolecules
 - The structure and function of the four major macromolecules (proteins, carbohydrates, lipids, nucleic acids)
 - Examples of positive and negative feedback mechanisms that maintain homeostasis
 - The hierarchical organization of living systems (molecules to cells to tissues to organs to organ systems to organisms)
 - How structure relates to function at various levels of organization (macromolecules, cell membrane, cells, organ systems, and organisms)
 - How systems interact to maintain homeostasis through nutrient uptake and water delivery

- Describe the difference between positive and negative feedback.
- Plan and conduct an investigation to provide evidence that feedback mechanisms maintain homeostasis
- Properly use a microscope to view life at a cellular level.
- Construct and revise an explanation based on evidence to describe the structure and function of the four macromolecules (proteins, lipids, carbohydrates, and nucleic acids)
- Use evidence to justify what distinguishes biotic from abiotic factors using the seven characteristics of life (homeostasis, growth, stimuli, reproduction, evolution, cell, metabolism)
- Predict the rate of enzyme activity based on environment
- Identify the structures of the cell membrane and describe their functions involved in the semi-permeability of the cell membrane
- Compare and contrast passive and active transport (simple diffusion, facilitated diffusion, osmosis, protein pumps, endocytosis and exocytosis)
- Predict the movement of particles across the cell membrane based on environment

9th Grade Honors Biology
Unit 1: How do living organisms sustain the balance that defines life?

Missouri Learning Standards

Priority Standard: Develop and use a model to illustrate the hierarchical organization of interacting systems that provide specific functions within multicellular organisms. **[Clarification Statement: Emphasis is on functions at the organism system level such as nutrient uptake, water delivery, and organism movement in response to stimuli.]** (9-12.LS1.A.2).

Priority Standard: Plan and conduct an investigation to provide evidence that feedback mechanisms maintain homeostasis **[Clarification Statement: Examples of investigations could include heart rate response to exercise, stomata response to moisture and temperature, and root development in response to water levels.]** (9-12.LS1.A.3).

Priority Standard: Construct and revise an explanation based on evidence that organic macromolecules are primarily composed of six elements, where carbon, hydrogen, and oxygen atoms may combine with nitrogen, sulfur, and phosphorus to form large carbon-based molecules **[Clarification Statement: Large carbon-based molecules included are proteins, carbohydrates, nucleic acids, and lipids.]** (9-12.LS1.C.3).

9th Grade Honors Biology

Unit 2: How do chemical processes use energy flow and the cycling of matter to power life?

This unit explores the essential energy processes that sustain all living organisms. Students will investigate the pathways of energy transformation, examining how light energy is converted to chemical energy through the process of photosynthesis and how that energy is later released and utilized during cellular respiration. They will analyze the molecular details of these complementary processes: from carbon dioxide and water to glucose and oxygen, and back again. Through guided investigations and data analysis, students will construct and revise explanations showing how and when photosynthesis, cellular respiration (both aerobic and anaerobic), and chemosynthesis drive the cycling of matter and the flow of energy in ecosystems. By the end of this unit, students will understand the critical relationship between photosynthesis and cellular respiration, the cycling of carbon, nitrogen, and phosphorus through Earth's systems, and how energy transformations underpin all biological functions.

Unit Essential Learning Targets	
<i>Enduring Understandings</i>	<i>Essential Questions</i>
• Photosynthesis converts light energy into chemical energy stored in organic molecules • Cellular respiration releases stored chemical energy in organic molecules to power life processes • The biogeochemical cycles connect all living and non-living components of Earth's systems • Energy flows and matter cycles through ecosystems via photosynthesis, chemosynthesis, and aerobic and anaerobic respiration, with environmental conditions determining which processes occur.	• How does photosynthesis transform light energy into chemical energy, and what are the key inputs and outputs of this process? • How does the process of cellular respiration convert stored energy from glucose into usable energy for cellular functions through the breaking and forming of molecular bonds? • How do environmental conditions, such as sunlight and oxygen availability, influence the processes of photosynthesis and cellular respiration? • How do biological and physical processes like photosynthesis, respiration, decomposition, and combustion drive the movement of carbon through Earth's systems? • How do biological and physical processes move nitrogen and phosphorus through Earth's system?
<i>Students must know:</i>	<i>Students must be able to:</i>
• Terminology: photosynthesis, ATP, cellular respiration, aerobic respiration, anaerobic respiration, mitochondria, chloroplast, carbon cycle, autotroph, heterotroph, chemosynthesis, combustion, decomposition, glucose, hydrocarbons, biomass, ADP, Nitrogen Fixation	• List the inputs and outputs of photosynthesis (Light-Dependent Reaction and Calvin Cycle) and cellular respiration. • Model the flow of energy focusing on the transformation of light energy into stored chemical energy (glucose, ADP, and ATP) • Determine how environmental factors

9th Grade Honors Biology

Unit 2: How do chemical processes use energy flow and the cycling of matter to power life?

• The differences between aerobic and anaerobic respiration • Chemosynthesis provides an alternative energy source for some organisms • How carbon, nitrogen, and phosphorus, cycle through the biosphere, atmosphere, hydrosphere, and geosphere • How environmental conditions restrict energy transformation processes • The inputs and outputs of photosynthesis and how light energy is converted into chemical energy. • The inputs and outputs of cellular respiration and how chemical energy is converted into ATP to power life's processes.	will impact photosynthesis, chemosynthesis, and anaerobic and aerobic respiration • Illustrate the roles of photosynthesis, cellular respiration, decomposition, and combustion to explain the cycling of carbon in its various forms among the biosphere, atmosphere, hydrosphere, and geosphere. • Compare and contrast how nitrogen and phosphorus are cycled through the biosphere, atmosphere, hydrosphere, and geosphere with the carbon cycle
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Missouri Learning Standards

Priority Standard: Use a model to demonstrate how photosynthesis transforms light energy into stored chemical energy [Clarification Statement: Emphasis is on illustrating inputs and outputs of matter and the transfer and transformation of energy in photosynthesis by plants and other photosynthesizing organisms. Examples of models could include diagrams, chemical equations, and conceptual models.] (9-12.LS1.C.1).

Priority Standard: Use a model to demonstrate that cellular respiration is a chemical process whereby the bonds of molecules are broken and the bonds in new compounds are formed resulting in a net transfer of energy. [Clarification Statement: Emphasis is on the conceptual understanding of the inputs and outputs of the process of cellular respiration.] (9-12.LS1.C.2).

Priority Standard: Construct and revise an explanation based on evidence that the processes of photosynthesis, chemosynthesis, and aerobic and anaerobic respiration are responsible for the cycling of matter and flow of energy through ecosystems and that environmental conditions restrict which reactions can occur. [Clarification Statement: Examples of environmental conditions can include the availability of sunlight or oxygen.] (9-12.LS2.B.1).

Priority Standard: Use a model that illustrates the roles of photosynthesis, cellular respiration, decomposition, and combustion to explain the cycling of carbon in its various forms among the biosphere, atmosphere, hydrosphere, and geosphere. [Clarification Statement: The primary forms of carbon include carbon dioxide, hydrocarbons, waste, and biomass. Examples of models could include simulations and mathematical and conceptual models.] (9-12.LS2.B.3).

9th Grade Honors Biology

Unit 3: How Do Cells Store Life's Genetic Code and Replicate?

This unit examines the fundamental processes of genetic information storage and transmission in living organisms. Students will investigate DNA as the molecular basis of heredity, exploring how this molecule encodes the instructions for building and maintaining all living things. They will analyze the cell cycle and mitosis as mechanisms for growth, development, and repair in multicellular organisms, ensuring genetic continuity in somatic cells. By the end of this unit, students will understand the molecular basis of inheritance, the mechanisms of cellular reproduction, and how genetic information is maintained or diversified across generations.

Unit Essential Learning Targets	
<i>Enduring Understandings</i>	<i>Essential Questions</i>
- DNA is the molecule that stores genetic information - DNA uses semi-conservative replication - The cell cycle (interphase, mitosis, cytokinesis) produces two genetically identical somatic cells. - Sexual reproduction introduces genetic variation while asexual reproduction produces genetically identical offspring	- How is information for life coded? - How is genetic information stored and replicated? - How do cells maintain genetic continuity during growth and repair through the process of mitosis? - What are the advantages and disadvantages of sexual versus asexual reproduction?
<i>Students must know:</i>	<i>Students must be able to:</i>
- Terminology: DNA, RNA, gene, trait, sexual reproduction, base pair, asexual reproduction, mitosis, interphase (gap 1, synthesis, gap 2) prophase, metaphase, anaphase, telophase, cytokinesis, diploid, double helix, chromosome, chromatid, chromatin, somatic, semi-conservative replication, DNA helicase, polymerase, diploid, adenine, guanine, cytosine, thymine, centriole, spindle fibers, DNA ligase, okazaki fragments, antiparallel, and Chargaff's Rule - The stages of the cell cycle (interphase, mitosis, cytokinesis) - The stages of mitosis (prophase, metaphase, anaphase, telophase) and the structures involved - The process and purpose of mitosis - The differences between asexual and sexual reproduction - The structure of DNA (nucleotides, base pairing, double helix) and how the structure provides a mechanism for replication	- Construct a model of DNA. - Develop and use models of the phases of and structures involved in the cell cycle (interphase, mitosis, cytokinesis) - Explain the importance of cell division in the growth, repair and reproduction of organisms. - Compare and contrast sexual versus asexual reproduction, including the benefits and detriments of each. - Model the process of DNA replication differentiating between the leading and lagging strands of DNA

9th Grade Honors Biology

Unit 3: How Do Cells Store Life's Genetic Code and Replicate?

Missouri Learning Standards

Priority Standard: Compare and contrast asexual and sexual reproduction with regard to genetic information and variation in offspring (9-12.LS3.B.1).

Priority Standard: Develop and use models to communicate the role of mitosis, cellular division, and differentiation in producing and maintaining complex organisms[Clarification Statement: Major events of the cell cycle include cell growth, DNA replication, preparation for division, separation of chromosomes, and separation of cell contents.]. (9-12.LS1.B.1).

Priority Standard: Construct a model of how the structure of DNA determines the structure of proteins which carry out the essential functions of life through systems of specialized cells. [Clarification Statement: Genes are the regions in DNA that code for proteins. Basic transcription and translation explain the roles of DNA and RNA in coding the instructions for making polypeptides.] (9-12.LS1.A.1)

9th Grade Honors Biology

Unit 4: How is life genetic's code expressed?

This unit explores the fundamental relationship between DNA structure and protein synthesis in living organisms. Students will trace the flow of genetic information from DNA to RNA to proteins to traits. They will examine how the nucleotide sequence in DNA determines amino acid sequences in proteins, which in turn dictate protein structure and function. Through modeling and analysis, students will discover the processes of transcription and translation, understanding how the genetic code is interpreted to build the proteins that carry out essential life processes. They will analyze how structural changes to genes (mutations) affect protein structure and function, potentially resulting in harmful, beneficial, or neutral effects on organisms. By the end of this unit, students will understand how differences in DNA direct the synthesis of various proteins that perform the essential functions of life.

Unit Essential Learning Targets	
<i>Enduring Understandings</i>	<i>Essential Questions</i>
- DNA contains the instructions for building proteins, which carry out essential life functions and are expressed as an organism's traits - The genetic code in DNA is transcribed to RNA and then translated into polypeptides - Mutations in DNA can alter protein structure and function, affecting an organism's traits in a harmful, beneficial, or neutral way - Environmental factors can influence mutations	- How is DNA read, and transcribed? - How is RNA translated and expressed? - How does DNA structure affect protein structure and function? - How do mutations in DNA structure affect the structure and function of organisms?
<i>Students must know:</i>	<i>Students must be able to:</i>
- Terminology: mRNA, tRNA, transcription, translation, codon, anticodon, mutations (insertion, deletion, substitution, frameshift, silent), RNA polymerase, uracil - The structure of RNA - The process of transcription (DNA → RNA) - The process of translation (RNA → protein) - The sequence of amino acids determines the protein made - The structure of a ribosome including small and large subunit and mRNA bonding sites	- Differentiate between RNA and DNA - Model how DNA is transcribed into mRNA and is translated into a unique protein - Model the synthesis of a polypeptide from a given strand of DNA or RNA using a CODON Chart or wheel. - Recognize that traits are the expression of proteins. - Classify the various types of mutations and predict their effects as harmful, neutral, or beneficial. - Demonstrate that environmental factors can cause mutations in genes

9th Grade Honors Biology

Unit 4: How is life genetic's code expressed?

- Explain the role of the ribosomal subunits in the translation process

Missouri Learning Standards

Priority Standard: Construct a model of how the structure of DNA determines the structure of proteins which carry out the essential functions of life through systems of specialized cells.

[Clarification Statement: Genes are the regions in DNA that code for proteins. Basic transcription and translation explain the roles of DNA and RNA in coding the instructions for making polypeptides.] (9-12.LS1.A.1)

Priority Standard: Develop and use a model to describe why structural changes to genes (mutations) located on chromosomes may affect proteins and may result in harmful, beneficial, or neutral effects to the structure and function of the organism (9-12.LS3.B.2).

Priority Standard: Make and defend a claim that inheritable genetic variations may result from: (1) new genetic combinations through meiosis, (2) mutations occurring during replication, and/or (3) mutations caused by environmental factors [Clarification Statement: Emphasis is on using data to support arguments for the way variation occurs.] (9-12.LS3.B.3).

9th Grade Honors Biology

Unit 5: How is information for life inherited and varied?

This unit investigates the mechanisms of inheritance and the sources of genetic variation in living organisms. Students will explore how genetic information is transmitted from parents to offspring through the processes of meiosis and fertilization in sexual reproduction. The unit emphasizes mathematical modeling through the application of Punnett squares and probability to predict inheritance patterns and explain the distribution of traits in populations. By the end of this unit, students will understand the mechanisms that generate genetic diversity and how traits are passed from one generation to the next.

Unit Essential Learning Targets	
<i>Enduring Understandings</i>	<i>Essential Questions</i>
- Meiosis and fertilization are the mechanisms by which genetic information is passed from parents to offspring in sexual reproduction - Genetic variation arises from processes during meiosis, mutations, and environmental factors - Patterns of inheritance follow predictable mathematical models	- How does meiosis produce gametes? - How does genetics influence the frequency of traits? - What processes create genetic variation in organisms? - How can we predict the inheritance patterns of traits in offspring?
<i>Students must know:</i>	<i>Students must be able to:</i>
- Terminology: meiosis, haploid, gamete, fertilization, sexual reproduction, nondisjunction, crossing over, karyotype, trisomy, monosomy, zygote, sperm, egg, homozygous, heterozygous, genotype, phenotype, dominant, recessive, probability, Punnett Square, frequency, homologous pairs, incomplete dominance, codominance, pedigree, reduction division, prophase I, metaphase I, anaphase I, telophase I, prophase II, metaphase II, anaphase II, telophase II, dihybrid crosses, multiple alleles, sex-linked traits - Mendelian inheritance patterns (dominant/recessive, incomplete dominance, codominance) - Inheritance patterns can be predicted through the use of Punnett Squares - The process of meiosis creates genetically different haploid gametes - Sexual reproduction is the fertilization of gametes - Crossing over, independent assortment and nondisjunction can result in genetic variation	- Make and defend a claim that inheritable genetic variations may result from new genetic combinations through meiosis, mutations occurring during replication, and/or mutations caused by environmental factors - Describe the process of nondisjunction and the effect it has on chromosome number in the gamete and the effect on the organism if fertilized - Interpret a karyotype - Interpret a pedigree - Complete and analyze the outcome of a monohybrid cross - Determine the probability of expressed traits using a monohybrid cross - Determine the probability of expressed traits using a dihybrid cross - Predict the pattern of inheritance of sex-linked traits using Punnett squares - Model how DNA is passed from parent to offspring through the process of meiosis - Compare and contrast mitosis and meiosis - Explain how crossing over, independent assortment, nondisjunction and sexual

9th Grade Honors Biology

Unit 5: How is information for life inherited and varied?

• How cellular differentiation leads to specialized cells in multicellular organisms • Patterns of inheritance (sex-linked, multiple alleles, dihybrid crosses) can be predicted from data using Punnett Squares	reproduction affect the variations in offspring • Contrast the uses of haploid and diploid cells in mitosis and meiosis • Model the phases of meiosis I and meiosis II • Describe similarities and differences between the phases and outcomes of meiosis I, meiosis II, and mitosis
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Missouri Learning Standards

Priority Standard: Develop and use models to clarify relationships about how DNA in the form of chromosomes is passed from parents to offspring through the processes of meiosis and fertilization in sexual reproduction (9-12.LS3.A.1).

Priority Standard: Make and defend a claim that inheritable genetic variations may result from: (1) new genetic combinations through meiosis, (2) mutations occurring during replication, and/or (3) mutations caused by environmental factors [Clarification Statement: Emphasis is on using data to support arguments for the way variation occurs.] (9-12.LS3.B.3).

Priority Standard: Apply concepts of statistics and probability to explain the variation and distribution of expressed traits in a population [Clarification Statement: Emphasis is on the use of mathematics (Punnett Squares) to describe the probability of traits as it relates to genetic and environmental factors in the expression of traits.] (9-12.LS3.B.4).

Priority Standard: Compare and contrast asexual and sexual reproduction with regard to genetic information and variation in offspring (9-12.LS3.B.1).

9th Grade Honors Biology

Unit 6: How is the information for life changed over time?

This unit examines the evidence for evolution and the processes that drive biological diversity on Earth. Students will analyze multiple lines of empirical evidence supporting common ancestry and biological evolution, including DNA sequences, anatomical structures, embryological development, fossils and biogeography. They will investigate how natural selection acts on genetic variation within populations, leading to adaptation and evolutionary change over time. Through data analysis and modeling, students will explore how environmental changes drive adaptation, emergence of new species, and extinction, shaping biodiversity throughout Earth's history.

Unit Essential Learning Targets	
<i>Enduring Understandings</i>	<i>Essential Questions</i>
- Multiple lines of evidence support the process of evolution and common ancestry - Evolution, through natural selection, can lead to adaptation within a population. - Environmental conditions drive adaptation, new species, and extinction - Organisms and Earth's systems have co-evolved throughout history - Human activities impact biodiversity and evolutionary processes	- What evidence supports the process of evolution and common ancestry? - How does natural selection lead to adaptation and evolution? - How do environmental conditions affect the frequency of traits which leads to the survival and evolution of a species? - How have Earth's systems and life co-evolved throughout Earth's history? - How do human activities impact biodiversity and evolutionary processes?
<i>Students must know:</i>	<i>Students must be able to:</i>
- Terminology: evolution, natural selection, adaptation, fitness, frequency of traits (directional, stabilizing, disruptive), homologous structures, analogous structures, geographic distribution, biogeography, embryology, species, population, artificial selection, divergent evolution, convergent evolution, - Multiple lines of evidence for evolution (DNA, anatomical structures, embryology, fossils and biogeography) - Factors that drive evolution by natural selection include, the potential for a species to increase in number, the heritable genetic variation of individuals in a species due to mutation and sexual reproduction, competition for limited resources, and proliferation of those organisms that are better able to survive and reproduce in the environment. - Environmental changes lead to adaptation, new species, and extinction	- Analyze and evaluate the role of evidence relating to common ancestry and biological evolution - Explain how adaptations affect the fitness of an organism - Analyze the conditions needed for evolution by natural selection - Evaluate the evolutionary fitness of an organism given environmental conditions and how it influences the frequency of traits in a population - Describe factors which influence the emergence of new species over time and the extinction of other species. - Predict the type of selection based on analyzing shifts in numerical distribution - Analyze a graph to describe the frequency of traits as directional, stabilizing, or disruptive - Describe the difference between natural and artificial selection

9th Grade Honors Biology

Unit 6: How is the information for life changed over time?

- Differentiate between divergent and convergent evolution

Missouri Learning Standards

Priority Standard: Communicate scientific information that common ancestry and biological evolution are supported by multiple lines of empirical evidence **[Clarification statement: Emphasis is on a conceptual understanding of the role each line of evidence has relating to common ancestry and biological evolution. Examples of evidence could include similarities in DNA sequences, anatomical structures, and order of appearance of structures in embryological development. Communicate could mean written report, oral discussion, etc.]** (9-12.LS4.A.1).

Priority Standard: Analyze displays of pictorial data to compare patterns of similarities in the embryological development across multiple species to identify relationships not evident in the fully formed anatomy **[Clarification Statement: Emphasis is on inferring general patterns of relatedness among embryos of different organisms by comparing the macroscopic appearance of diagrams or pictures.]** (9-12.LS4.A.2).

Priority Standard: Construct an explanation based on evidence that the process of evolution primarily results from four factors: (1) the potential for a species to increase in number, (2) the heritable genetic variation of individuals in a species due to mutation and sexual reproduction, (3) competition for limited resources, and (4) the proliferation of those organisms that are better able to survive and reproduce in the environment **[Clarification Statement: Emphasis is on using evidence to explain the influence each of the four factors has on the number of organisms, behaviors, morphology, or physiology in terms of ability to compete for limited resources and subsequent survival of individuals and adaptation of species. Examples of evidence could include mathematical models such as simple distribution graphs and proportional reasoning.]** (9-12.LS4.B.1).

Priority Standard: Apply concepts of statistics and probability to support explanations that organisms with an advantageous heritable trait tend to increase in proportion to organisms lacking this trait **[Clarification Statement: Emphasis is on analyzing shifts in numerical distribution of traits and using these shifts as evidence to support explanations.]** (9-12.LS4.B.2).

Priority Standard: Construct an explanation based on evidence for how natural selection leads to adaptation of populations **[Clarification Statement: Emphasis is on using data to provide evidence for how specific biotic and abiotic differences in ecosystems (such as ranges of seasonal temperature, long-term climate change, acidity, light, geographic barriers, or evolution of other organisms) contribute to a change in gene frequency over time, leading to adaptation of populations.]** (9-12.LS4.C.1).

Priority Standard: Evaluate the evidence supporting claims that changes in environmental conditions may result in: (1) increases in the number of individuals of some species, (2) the emergence of new species over time, and (3) the extinction of other species **[Clarification statement: Emphasis is on determining cause and effect relationships for how changes to the environment such as deforestation, fishing, and application of fertilizers, droughts, flood, and the rate of change of the environment affects distribution or disappearance of traits in species.]** (9-12.LS4.C.2).

9th Grade Honors Biology

Unit 7: How do organisms interact with each other and their environment?

This unit investigates the complex interactions within ecosystems and the impact of human activities on natural systems. Students will examine how biotic and abiotic factors affect carrying capacity and biodiversity, using representations to analyze ecosystem dynamics. They will trace the cycling of matter and flow of energy through trophic levels, understanding how these processes sustain life. Through data analysis, students will evaluate how ecosystems maintain relatively stable populations under consistent conditions but may experience new dynamics when conditions change. The unit emphasizes the relationship between human activities and Earth's systems. Students will recognize negative impacts that humans can have on ecosystems and then will be challenged to design, evaluate, and refine solutions that positively impact the environment and biodiversity. Students will illustrate the relationships among natural resource management, human sustainability, and biodiversity conservation. By the end of this unit, students will understand the delicate balance within ecosystems and our responsibility to develop sustainable practices.

Unit Essential Learning Targets	
<i>Enduring Understandings</i>	<i>Essential Questions</i>
- Ecosystems maintain balance and stability through complex interactions among biotic and abiotic factors - Energy flows through ecosystems while matter cycles within them - Carrying capacity and biodiversity are influenced by various environmental conditions - Ecosystems are dynamic and respond to changing conditions - Human activities impact Earth's systems and biodiversity in both positive and negative ways	- How do living organisms interact with each other and their environment? - How do biotic and abiotic factors affect ecosystem stability and biodiversity? - How does matter (biomass) and energy move through ecosystems? - What factors determine the carrying capacity of an ecosystem? - How do ecosystems respond to changing environmental conditions? - How do human activities impact Earth's systems and biodiversity? - What solutions can be developed to mitigate negative impacts on ecosystems? - How do living organisms thrive in diverse and dynamic ecosystems?
<i>Students must know:</i>	<i>Students must be able to:</i>
Terminology: community, ecosystem, biosphere, niche, food chain/food web, biomass, 10% rule, producer, primary consumer, secondary consumer, tertiary consumer, population distribution, density dependent factor, density independent factor, carrying capacity, decomposer, autotroph, heterotroph, herbivore, carnivore, detritivore, scavenger, trophic, exponential growth curve, logistic growth	- Describe an organism's niche within an ecosystem - Design and analyze a food chain and food web - Predict the relative abundance of species at each level in a trophic pyramid - Calculate the relative biomass at each level in a trophic pyramid

9th Grade Honors Biology

Unit 7: How do organisms interact with each other and their environment?

curve, biodiversity, symbiosis, parasitism, commensalism, mutualism, predator-prey, invasive species, keystone species, primary succession, secondary succession, coevolution • The relationship between carrying capacity and biodiversity • Biotic and abiotic factors influence ecosystem dynamics • Energy flows through trophic levels • Ecosystems maintain homeostasis under stable conditions and respond to environmental changes • The positive and negative impact of human activities on biodiversity and Earth's systems • The importance of the relationship between conservation, resource management, human population, and biodiversity	• Communicate the cycle of matter and flow of energy through trophic levels in an ecosystem • Explain how the biodiversity and carrying capacity of populations are affected by biotic and abiotic factors using mathematical and computational representations (graphs, charts, histograms). • Evaluate, create a model, and design solutions for adverse human impacts on biotic and abiotic factors in an ecosystem. • Identify relationships between organisms (parasitism, commensalism, mutualism, competition, predator-prey) and their effects on the ecosystem. • Construct an argument on how species undergo coevolution in response to their interaction with each other and with Earth's systems. • Evaluate causes, predict effects, and design solutions to biodiversity threats
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9th Grade Honors Biology

Unit 7: How do organisms interact with each other and their environment?

Missouri Learning Standards

Priority Standard: Explain how various biotic and abiotic factors affect the carrying capacity and biodiversity of an ecosystem using mathematical and/or computational representations

[Clarification Statement: Examples of biotic factors could include relationships among individuals (e.g., feeding relationships, symbioses, competition) and disease. Examples of abiotic factors could include climate and weather conditions, natural disasters, and availability of resources. Genetic diversity includes within a population and species within an ecosystem. Examples of mathematical comparisons could include graphs, charts, histograms, and population changes gathered from simulations or historical data sets.] (9-12.LS2.A.1).

Priority Standard: Communicate the pattern of the cycling of matter and the flow of energy among trophic levels in an ecosystem **[Clarification Statement:** Emphasis is on using a model of stored energy in biomass to describe the transfer of energy from one trophic level to another. Emphasis is on atoms and molecules as they move through an ecosystem.] (9-12.LS2.B.2).

Priority Standard: Evaluate the claims, evidence, and reasoning that the interactions in ecosystems maintain relatively consistent populations of species while conditions remain stable, but changing conditions may result in new ecosystem dynamics **[Clarification Statement:** Examples of changes in ecosystem conditions could include modest biological or physical changes, such as moderate hunting or a seasonal flood; and extreme changes, such as volcanic eruption or sea level rise.] (9-12.LS2.C.1).

Priority Standard: Design, evaluate, and/or refine solutions that positively impact the environment and biodiversity **[Clarification Statement:** Examples of solutions may include captive breeding programs, habitat restoration, pollution mitigation, energy conservation, agriculture and mining programs, and ecotourism.] (9-12.LS2.C.2).

Priority Standard: Create or revise a model to test a solution to mitigate adverse impacts of human activity on biodiversity **[Clarification Statement:** Emphasis is on designing solutions for a proposed problem related to threatened or endangered species, or to genetic variation of organisms for multiple species.] (9-12.LS4.C.3).

Priority Standard: Predict how human activity affects the relationships between Earth systems in both positive and negative ways. **[Clarification Statement:** Examples of Earth systems to be considered are the hydrosphere, atmosphere, cryosphere, geosphere, and/or biosphere.] (9-12.ESS3.D.2)

Priority Standard: Create a computational simulation to illustrate the relationships among management of natural resources, the sustainability of human populations, and biodiversity. **[Clarification Statement:** Examples of factors that affect the management of natural resources include costs of resource extraction and waste management, per-capita consumption, and the development of new technologies. Examples of factors that affect human sustainability include agricultural efficiency, levels of conservation, and urban planning.] (9-12.ESS3.C.1)

Priority Standard: Construct an argument based on evidence about the simultaneous coevolution of Earth's systems and life on Earth. **[Clarification Statement:** Emphasis is on the dynamic causes, effects, and feedbacks between the biosphere and Earth's other systems, whereby geoscience factors control the evolution of life, which in turn continuously alters

9th Grade Honors Biology

Unit 7: How do organisms interact with each other and their environment?

Earth's surface. Examples of coevolution include how photosynthetic life altered the atmosphere through the production of oxygen, which in turn increased weathering rates and allowed for the evolution of animal life; how microbial life on land increased the formation of soil, which in turn allowed for the evolution of land plants; or how the evolution of corals created reefs that altered patterns of erosion and deposition along coastlines and provided habitats for new life.] (9-12.ESS2.E.1)