Crosswalk for Louisiana Student Standards for Science and NGSS: Biology

This document provides guidance to assist teachers, schools, and systems with determining alignment to Louisiana Student Standards for Science for resources designed for the Next Generation Science Standards. This guidance document is considered a "living" document, as we believe that teachers and other educators will find ways to improve the document as they use it. Please send feedback to STEM@la.gov so that we may use your input when updating this guide.

Updated August 24, 2021

FROM MOLECULES TO ORGANISMS: STRUCTURES AND PROCESSES	**HS-LS1-1**
LSSS	**NGSS**
Construct an explanation based on evidence for 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	
Emphasis is on functions at the organism system level such as nutrient uptake, water delivery, or organism movement in response to neural stimuli. An example of an interacting system could be an artery depending on the proper function of elastic tissue and smooth muscle to regulate and deliver the proper amount of blood within the circulatory system.	NONE PROVIDED IN NGSS
Science and Engineering Practice:	Constructing explanations and designing solutions
Disciplinary Core Ideas:	Structure and function
Systems of specialized cells within organisms help them perform the essential functions of life. (HS.LS1A.a) All cells contain genetic information in the form of DNA molecules. Genes are regions in the DNA that contain the instructions that code for the formation of proteins which carry out the essential functions of life. (HS.LS1A.c)	Systems of specialized cells within organisms help them perform the essential functions of life. (HS.LS1A.a) All cells contain genetic information in the form of DNA molecules. Genes are regions in the DNA that contain the instructions that code for the formation of proteins, which carry out most of the work of cells.
Crosscutting Concepts:	Structure and function
Investigating or designing new systems or structures requires a detailed examination of the properties of different materials, the structures of different components, and connections of components to reveal its function and/ or solve a problem.	

Underlined sections denote* ***additional information or wording differences* *that appear in the Louisiana Student Standards for Science.*

FROM MOLECULES TO ORGANISMS: STRUCTURES AND PROCESSES	HS-LS1-2
LSSS	**NGSS**
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, or organism movement in response to neural stimuli. An example of an interacting system could be an artery depending on the proper function of elastic tissue and smooth muscle to regulate and deliver the proper amount of blood within the circulatory system.	
Science and Engineering Practice:	Developing and using models
Disciplinary Core Ideas:	Structure and function
Multicellular organisms have a hierarchical structural organization, in which any one system is made up of numerous parts and is itself a component of the next level. (HS.LS1A.b)	
Crosscutting Concepts:	Systems and system models
Models (e.g., physical, mathematical, computer models) can be used to simulate systems and interactions— including energy, matter, and information flows—within and between systems at different scales.	

FROM MOLECULES TO ORGANISMS: STRUCTURES AND PROCESSES	HS-LS1-3
LSSS	**NGSS**
Plan and conduct an investigation to provide evidence that feedback mechanisms maintain homeostasis <u>in living organisms.</u>	Plan and conduct an investigation to provide evidence that feedback mechanisms maintain homeostasis.
Clarification Statement	
Examples of investigations could include heart rate responses to exercise, stomatal responses to moisture and temperature, root development in response to water levels, <u>or cell response to hypertonic and hypotonic environments.</u>	Examples of investigations could include heart rate response to exercise, stomate response to moisture and temperature, and root development in response to water levels.
Science and Engineering Practice:	Planning and carrying out investigations
Disciplinary Core Ideas:	Structure and function
Feedback mechanisms maintain a living system's internal conditions within certain limits and mediate behaviors, allowing the organism to remain alive and functional even as external conditions change within some range. Feedback mechanisms can promote (through positive feedback) or inhibit (negative feedback) <u>activities within an organism to maintain homeostasis.</u> (HS.LS1A.d)	Feedback mechanisms maintain a living system's internal conditions within certain limits and mediate behaviors, allowing the organism to remain alive and functional even as external conditions change within some range. Feedback mechanisms can encourage (through positive feedback) or discourage (negative feedback) what is going on inside the living system.
Crosscutting Concepts:	Stability and change
Feedback (negative or positive) can stabilize or destabilize a system.	

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<table>
<tr><th>FROM MOLECULES TO ORGANISMS: STRUCTURES AND PROCESSES</th><th>HS-LS1-4</th></tr>
<tr><th>LSSS</th><th>NGSS</th></tr>
<tr><td>Use a model to illustrate the role of the <u>cell cycle</u> and differentiation in producing and maintaining complex organisms.</td><td>Use a model to illustrate the role of cellular division (mitosis) and differentiation in producing and maintaining complex organisms.</td></tr>
<tr><th colspan="2">Clarification Statement</th></tr>
<tr><td>Examples of investigations could include heart rate responses to exercise, stomatal responses to moisture and temperature, root development in response to water levels, <u>or cell response to hypertonic and hypotonic environments.</u></td><td>Examples of investigations could include heart rate response to exercise, stomate response to moisture and temperature, and root development in response to water levels.</td></tr>
<tr><th>Science and Engineering Practice:</th><td>Developing and using models</td></tr>
<tr><th>Disciplinary Core Ideas:</th><td>Growth and development of organisms</td></tr>
<tr><td>In multicellular organisms <u>the cell cycle is necessary for growth, maintenance and repair of multicellular organisms. Disruptions in the cell cycles of mitosis and meiosis can lead to disease such as cancer.</u> (HS.LS1B.a)</td><td>In multicellular organisms individual cells grow and then divide via a process called mitosis, thereby allowing the organism to grow.</td></tr>
<tr><td colspan="2">The organism begins as a single cell (fertilized egg) that divides successively to produce many cells, with each parent cell passing identical genetic material (two variants of each chromosome pair) to both daughter cells. (HS.LS1B.b)</td></tr>
<tr><td>Cellular division and differentiation <u>(stem cell)</u> produce and maintain a complex organism, composed of systems of tissues and organs that work together to meet the needs of the whole organism. (HS.LS1B.c)</td><td>Cellular division and differentiation produce and maintain a complex organism, composed of systems of tissues and organs that work together to meet the needs of the whole organism.</td></tr>
<tr><th>Crosscutting Concepts:</th><td>Systems and system models</td></tr>
<tr><td colspan="2">Models (e.g., physical, mathematical, computer models) can be used to simulate systems and interactions— including energy, matter, and information flows—within and between systems at different scales.</td></tr>
</table>

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FROM MOLECULES TO ORGANISMS: STRUCTURES AND PROCESSES	HS-LS1-5
LSSS	**NGSS**
Use a model to illustrate how photosynthesis transforms light energy into stored chemical energy.	
Clarification Statement	
Emphasis is on illustrating inputs and outputs of matter, the transfer and transformation of energy in photosynthesis by plants, and other photosynthesizing organisms. Examples of models could include diagrams, chemical equations, conceptual models, <u>and/ or laboratory investigations.</u>	Emphasis is on illustrating inputs and outputs of matter, the transfer and transformation of energy in photosynthesis by plants, and other photosynthesizing organisms. Examples of models could include diagrams, chemical equations, conceptual models.
Science and Engineering Practice:	Developing and using models
Disciplinary Core Ideas:	Organization for matter and energy flow in organisms
The process of photosynthesis converts light energy to stored chemical energy by converting carbon dioxide plus water into sugars plus released oxygen. (HS.LS1C.a)	
Crosscutting Concepts:	Energy and matter
Changes of energy and matter in a system can be described in terms of energy and matter flows into, out of, and within that system.	

<table>
<tr><th colspan="2">FROM MOLECULES TO ORGANISMS: STRUCTURES AND PROCESSES — HS-LS1-6</th></tr>
<tr><th>LSSS</th><th>NGSS</th></tr>
<tr><td colspan="2">Construct and revise an explanation based on evidence for how carbon, hydrogen, and oxygen from sugar molecules may combine with other elements to form amino acids and/ or other large carbon-based molecules.</td></tr>
<tr><th colspan="2">Clarification Statement</th></tr>
<tr><td>Emphasis is on <u>students constructing explanations for how sugar molecules are formed through photosynthesis and the components of the reaction (i.e. carbon, hydrogen, oxygen). This hydrocarbon backbone is used to make amino acids and other carbon-based molecules that can be assembled (anabolism) into larger molecules (such as proteins or DNA). Examples of models could include diagrams, chemical equations, or conceptual models.</u></td><td>Emphasis is on using evidence from models and simulations to support explanations.</td></tr>
<tr><td colspan="2">Science and Engineering Practice: Constructing explanations and designing solutions</td></tr>
<tr><td colspan="2">Disciplinary Core Ideas: Organization for matter and energy flow in organisms</td></tr>
<tr><td><u>The process of photosynthesis converts light energy to stored chemical energy by converting carbon dioxide plus water into sugars plus released oxygen.</u> (HS.LS1C.a)
The sugar molecules thus formed contain carbon, hydrogen, and oxygen: their hydrocarbon backbones are used to make amino acids and other carbon-based molecules that can be assembled into larger molecules (such as proteins or DNA) used, for example, to form new cells. (HS.LS1C.b)</td><td>As matter and energy flow through different organizational levels of living systems, chemical elements are recombined in different ways to form different products.
The sugar molecules thus formed contain carbon, hydrogen, and oxygen: their hydrocarbon backbones are used to make amino acids and other carbon-based molecules that can be assembled into larger molecules (such as proteins or DNA), used for example to form new cells.</td></tr>
<tr><td colspan="2">Crosscutting Concepts: Energy and matter</td></tr>
<tr><td colspan="2">Changes of energy and matter in a system can be described in terms of energy and matter flows into, out of, and within that system.</td></tr>
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FROM MOLECULES TO ORGANISMS: STRUCTURES AND PROCESSES	HS-LS1-7
LSSS	**NGSS**
Use a model to illustrate that cellular respiration is a chemical process whereby the bonds of food molecules and oxygen 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 processes of aerobic and anaerobic cellular respiration. Examples of models could include diagrams, chemical equations, conceptual models and/ or laboratory investigations.	Emphasis is on the conceptual understanding of the inputs and outputs of the process of cellular respiration.
Science and Engineering Practice:	Developing and using models
Disciplinary Core Ideas:	Organization for matter and energy flow in organisms
As matter and energy flow through different organizational levels of living systems, chemical elements are recombined in different ways to form different products. (HS.LS1C.c) As a result of these chemical reactions, energy is transferred from one system of interacting molecules to another. Cellular respiration is a chemical process in which the bonds of food molecules and oxygen molecules are broken and new compounds are formed that can transport energy to muscles. Cellular respiration also releases the energy needed to maintain body temperature despite ongoing energy transfer to the surrounding environment. (HS.LS1C.d)	
Crosscutting Concepts:	Energy and matter
Energy cannot be created or destroyed—it only moves between one place and another place, between objects and/ or fields, or between systems.	

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FROM MOLECULES TO ORGANISMS: STRUCTURES AND PROCESSES	HS-LS1-8
***Standard HS-PS1-8 appears in the Louisiana Student Standards for Science (LSSS) ONLY**	
Obtain, evaluate, and communicate information about (1) viral and bacterial reproduction and adaptation, (2) the body's primary defenses against infection, and (3) how these features impact the design of effective treatment.	
Clarification Statement	
Emphasis is on the speed of reproduction which produces many generations in a short time, allowing for rapid adaptation, the role of antibodies in the body's immune response to infection and how vaccination protects an individual from infectious disease.	
Science and Engineering Practice:	Obtaining, evaluating, and communicating information
Disciplinary Core Ideas:	Public health
Viruses are obligate intracellular parasites that replicate using a cell's protein expression mechanisms. (HS.LS1E.a) Vaccines provide immunity to infections by exposing the immune system to antigens before infection which decreases the immune system's response time. Some vaccines may require more than one dose. (HS.LS1E.b) Antibiotics are effective treatments against most bacterial infections. Some bacteria may develop resistance to these treatments. (HS.LS1E.c) Microorganisms can cause diseases and can provide beneficial services. Microorganisms live in a variety of environments as both parasites and free-living organisms. (HS.LS1E.d) Microorganisms can reproduce quickly. (HS.LS1E.e)	
Crosscutting Concepts:	Scale, proportion, and quantity
The significance of a phenomenon is dependent on the scale, proportion, and quantity at which it occurs.	

ECOSYSTEMS: INTERACTIONS, ENERGY AND DYNAMICS	HS-LS2-1
LSSS	**NGSS**
Use mathematical and/ or computational representations to support explanations of factors that affect carrying capacity, biodiversity and populations of ecosystems at different scales.	Use mathematical and/or computational representations to support explanations of factors that affect carrying capacity of ecosystems at different scales.
Clarification Statement	
Emphasis is on quantitative analysis and comparison of the relationships among interdependent factors including boundaries, resources, climate and competition. Examples of mathematical comparisons could include graphs, charts, histograms, or population changes gathered from simulations or historical data sets.	
Science and Engineering Practice:	Using mathematics and computational thinking
Disciplinary Core Ideas:	Interdependent relationships in ecosystems
Ecosystems have carrying capacities, which are limits to the numbers of organisms and populations they can support. These limits result from such factors as the availability of living and nonliving resources and from such challenges as predation, competition, and disease that affect biodiversity, including genetic diversity within a population and species diversity within an ecosystem. Organisms would have the capacity to produce populations of great size were it not for the fact that environments and resources are finite. This fundamental tension affects the abundance (number of individuals) of species in any given ecosystem. (HS.LS2A.a) Human activity directly and indirectly affect biodiversity and ecosystem health (e.g., habitat fragmentation, introduction of nonnative or invasive species, overharvesting, pollution and climate change). (HS.LS2A.b)	Ecosystems have carrying capacities, which are limits to the numbers of organisms and populations they can support. These limits result from such factors as the availability of living and nonliving resources and from such challenges as predation, competition, and disease. Organisms would have the capacity to produce populations of great size were it not for the fact that environments and resources are finite. This fundamental tension affects the abundance (number of individuals) of species in any given ecosystem.
Crosscutting Concepts:	Scale, proportion, and quantity
The significance of a phenomenon is dependent on the scale, proportion, and quantity at which it occurs.	

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ECOSYSTEMS: INTERACTIONS, ENERGY AND DYNAMICS	HS-LS2-2
LSSS	**NGSS**
HS-LS2-2 DOES NOT APPEAR IN LOUISIANA STANDARDS	Use mathematical representations to support and revise explanations based on evidence about factors affecting biodiversity and populations in ecosystems of different scales.
Clarification Statement	
HS-LS2-2 DOES NOT APPEAR IN LOUISIANA STANDARDS	Examples of mathematical representations include finding the average, determining trends, and using graphical comparisons of multiple sets of data.
Science and Engineering Practice:	Using mathematics and computational thinking
Disciplinary Core Ideas:	Interdependent relationships in ecosystems
HS-LS2-2 DOES NOT APPEAR IN LOUISIANA STANDARDS	Ecosystems have carrying capacities, which are limits to the numbers of organisms and populations they can support. These limits result from such factors as the availability of living and nonliving resources and from such challenges such as predation, competition, and disease. Organisms would have the capacity to produce populations of great size were it not for the fact that environments and resources are finite. This fundamental tension affects the abundance (number of individuals) of species in any given ecosystem.
	Ecosystem dynamics, functioning, and resilience
HS-LS2-2 DOES NOT APPEAR IN LOUISIANA STANDARDS	A complex set of interactions within an ecosystem can keep its numbers and types of organisms relatively constant over long periods of time under stable conditions. If a modest biological or physical disturbance to an ecosystem occurs, it may return to its more or less original status (i.e., the ecosystem is resilient), as opposed to becoming a very different ecosystem. Extreme fluctuations in conditions or the size of any population, however, can challenge the functioning of ecosystems in terms of resources and habitat availability.
Crosscutting Concepts:	Scale, proportion, and quantity
HS-LS2-2 DOES NOT APPEAR IN LOUISIANA STANDARDS	Using the concept of orders of magnitude allows one to understand how a model at one scale relates to a model at another scale.

ECOSYSTEMS: INTERACTIONS, ENERGY AND DYNAMICS	HS-LS2-3
LSSS	**NGSS**
HS-LS2-3 DOES NOT APPEAR IN LOUISIANA STANDARDS	Construct and revise an explanation based on evidence for the cycling of matter and flow of energy in aerobic and anaerobic conditions.
Clarification Statement	
HS-LS2-3 DOES NOT APPEAR IN LOUISIANA STANDARDS	Emphasis is on conceptual understanding of the role of aerobic and anaerobic respiration in different environments.
Science and Engineering Practice:	Constructing explanations and designing solutions
Disciplinary Core Ideas:	Cycles of matter and energy transfer in ecosystems
HS-LS2-3 DOES NOT APPEAR IN LOUISIANA STANDARDS	Photosynthesis and cellular respiration (including anaerobic processes) provide most of the energy for life processes.
Crosscutting Concepts:	Energy and matter
HS-LS2-3 DOES NOT APPEAR IN LOUISIANA STANDARDS	Energy drives the cycling of matter within and between systems.

ECOSYSTEMS: INTERACTIONS, ENERGY AND DYNAMICS	HS-LS2-4
LSSS	**NGSS**
Use mathematical representations to support claims for the cycling of matter and flow of energy among organisms in an ecosystem.	
Clarification Statement	
Emphasis is on using a mathematical model of stored energy in biomass to describe the transfer of energy from one trophic level to another and that matter and energy are conserved as matter cycles and energy flows through ecosystems. Emphasis is on atoms and molecules such as carbon, oxygen, hydrogen and nitrogen being conserved as they move through an ecosystem.	
Science and Engineering Practice:	Using mathematical and computational thinking
Disciplinary Core Ideas:	Cycles of matter and energy transfer in ecosystems
Energy is inefficiently transferred from one trophic level to another that affect the relative number of organisms that can be supported at each trophic level and necessitates a constant input of energy from sunlight or inorganic compounds from the environment. (HS.LS2B.b) Photosynthesis, cellular respiration, decomposition and combustion are important components of the carbon cycle, in which carbon is exchanged among the biosphere, atmosphere, hydrosphere, and geosphere through chemical, physical, geological, and biological processes. (HS.LS2B.c) Photosynthesis, chemosynthesis, aerobic and anaerobic respiration and cellular respiration (including anaerobic processes) provide most of the energy for life processes. Environmental conditions restrict which and when reactions can occur. (HS.LS2B.a) (suggested extension)	Plants or algae from the lowest level of the food web. At each link upward in a food web, only a small fraction of the matter is consumed at the lower level is transferred upward, to produce growth and release energy in cellular respiration at the higher level. Given this inefficiency, there are generally fewer organisms at higher levels of a food web. Some matter reacts to release energy for life functions, some matter is stored in newly made structures, and much is discarded. The chemical elements that make up the molecules of organisms pass through food webs and into and out of the atmosphere and soil, and they are combined and recombined in different ways. At each link in an ecosystem, matter and energy are conserved.
Crosscutting Concepts:	Energy and matter
Energy cannot be created or destroyed—it only moves between one place and another place, between objects and/ or fields, or between systems.	

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ECOSYSTEMS: INTERACTIONS, ENERGY AND DYNAMICS	HS-LS2-5
LSSS	**NGSS**
HS-LS2-5 DOES NOT APPEAR IN LOUISIANA STANDARDS	Develop a model to illustrate the role of photosynthesis and cellular respiration in the cycling of carbon among the biosphere, atmosphere, hydrosphere, and geosphere.
Clarification Statement	
HS-LS2-5 DOES NOT APPEAR IN LOUISIANA STANDARDS	Examples of models could include simulations and mathematical models.
Science and Engineering Practice:	Developing and using models
Disciplinary Core Ideas:	Cycles of matter and energy transfer in ecosystems
HS-LS2-5 DOES NOT APPEAR IN LOUISIANA STANDARDS	Photosynthesis and cellular respiration are important components of the carbon cycle, in which carbon is exchanged among the biosphere, atmosphere, oceans, and geosphere through chemical, physical, geological, and biological processes.
	Energy in chemical processes
HS-LS2-5 DOES NOT APPEAR IN LOUISIANA STANDARDS	The main way that solar energy is captured and stored on Earth is through the complex chemical process known as photosynthesis.
Crosscutting Concepts:	Systems and system models
HS-LS2-5 DOES NOT APPEAR IN LOUISIANA STANDARDS	Models (e.g., physical, mathematical, computer models) can be used to simulate systems and interactions—including energy, matter, and information flows—within and between systems at different scales.

ECOSYSTEMS: INTERACTIONS, ENERGY AND DYNAMICS	HS-LS2-6
LSSS	**NGSS**
Evaluate the claims, evidence and reasoning that the complex interactions in ecosystems maintain relatively consistent numbers and types of organisms in stable conditions, but changing conditions may result in a new ecosystem.	
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. <u>Emphasis should be on describing drivers of ecosystem stability and change, not on the organismal mechanisms of responses and interactions.</u>	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.
Science and Engineering Practice:	Engaging in argument from evidence
Disciplinary Core Ideas:	Ecosystem dynamics, functioning, and resilience
<u>The dynamic</u> interactions within an ecosystem can keep its numbers and types of organisms relatively constant over long periods of time under stable conditions. If a modest biological or physical disturbance to an ecosystem occurs, it may return to its more or less original status (i.e., the ecosystem is resilient), as opposed to becoming a very different ecosystem. Extreme fluctuations in conditions or the size of any population, however, can challenge the functioning of ecosystems in terms of resources and habitat availability <u>and may result in new ecosystems.</u> (HS.LS2C.a)	A complex set of interactions within an ecosystem can keep its numbers and types of organisms relatively constant over long periods of time under stable conditions. If a modest biological or physical disturbance to an ecosystem occurs, it may return to its more or less original status (i.e., the ecosystem is resilient), as opposed to becoming a very different ecosystem. Extreme fluctuations in conditions or the size of any population, however, can challenge the functioning of ecosystems in terms of resources and habitat availability.
Crosscutting Concepts:	Stability and change
Much of science deals with constructing explanations of how things change and how they remain stable.	

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ECOSYSTEMS: INTERACTIONS, ENERGY AND DYNAMICS	**HS-LS2-7**
LSSS	**NGSS**
Design, evaluate, and refine a solution for reducing the impacts of human activities on the environment and biodiversity.	
Clarification Statement	
Examples of human activities can include urbanization, building dams, or dissemination of invasive species.	
Science and Engineering Practice:	Constructing explanations and designing solutions
Disciplinary Core Ideas:	Ecosystem dynamics, functioning, and resilience
Ecosystems with a greater biodiversity tend to have a greater resistance and resilience to change. Moreover, anthropogenic changes (induced by human activity) in the environment—including habitat destruction, pollution, introduction of invasive species, overexploitation, and climate change—can disrupt an ecosystem and threaten the survival of some species. (HS.LS2C.b)	Moreover, anthropogenic changes (induced by human activity) in the environment—including habitat destruction, pollution, introduction of invasive species, overexploitation, and climate change—can disrupt an ecosystem and threaten the survival of some species.
	Biodiversity and humans
Biodiversity is increased by the formation of new species (speciation) and decreased by the loss of species (extinction). Humans depend on the living world for the resources and other benefits provided by biodiversity. Human activity is also having adverse impacts on biodiversity through overpopulation, overexploitation, habitat destruction, pollution, introduction of invasive species, and climate change. Thus, sustaining biodiversity so that ecosystem functioning and productivity are maintained is essential to supporting and enhancing life on Earth. Sustaining biodiversity also aids humanity by preserving landscapes of recreational or inspirational value. (HS.LS4D.a)	
	Developing possible solutions
When evaluating solutions it is important to take into account a range of constraints including cost, safety, reliability and aesthetics and to consider social, cultural and environmental impacts. (HS.ETS1B.a)	
Crosscutting Concepts:	Stability and change
Much of science deals with constructing explanations of how things change and how they remain stable.	

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ECOSYSTEMS: INTERACTIONS, ENERGY AND DYNAMICS	HS-LS2-8
LSSS	**NGSS**
HS-LS2-8 DOES NOT APPEAR IN LOUISIANA STANDARDS	Evaluate evidence for the role of group behavior on individual and species' chances to survive and reproduce.
Clarification Statement	
HS-LS2-8 DOES NOT APPEAR IN LOUISIANA STANDARDS	Emphasis is on: (1) distinguishing between group and individual behavior, (2) identifying evidence supporting the outcomes of group behavior, and (3) developing logical and reasonable arguments based on evidence. Examples of group behaviors could include flocking, schooling, herding, and cooperative behaviors such as hunting, migrating, and swarming.
Science and Engineering Practice:	Engaging in argument from evidence
Disciplinary Core Ideas:	Social interactions and group behavior
HS-LS2-8 DOES NOT APPEAR IN LOUISIANA STANDARDS	Group behavior has evolved because membership can increase the chances of survival for individuals and their genetic relatives.
Crosscutting Concepts:	Cause and effect
HS-LS2-8 DOES NOT APPEAR IN LOUISIANA STANDARDS	Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects.

HEREDITY: INHERITANCE AND VARIATION OF TRAITS	HS-LS3-1
LSSS	**NGSS**
Formulate, refine, and evaluate questions to clarify relationships about the role of DNA and chromosomes in coding the instructions for characteristic traits passed from parents to offspring.	Ask questions to clarify relationships about the role of DNA and chromosomes in coding the instructions for characteristic traits passed from parents to offspring.
Clarification Statement	
Emphasis should be on traits including completely dominant, codominant, incompletely dominant, and sex-linked traits (e.g., pedigrees, karyotypes, genetic disorders, Punnett squares). Examples do not need to include dihybrid crosses.	NONE PROVIDED
Science and Engineering Practice:	Asking questions and defining problems
Disciplinary Core Ideas:	Structure and function
All cells contain genetic information in the form of DNA molecules. Genes are regions in the DNA that contain the instructions that code for the formation of proteins which carry out the essential functions of life. (HS.LS1A.c)	All cells contain genetic information in the form of DNA molecules. Genes are regions in the DNA that contain the instructions that code for the formation of proteins.
	Inheritance of traits
Each chromosome consists of a single very long DNA molecule, and each gene on the chromosome is a particular segment of that DNA. The instructions for forming species' characteristics are carried in DNA. All cells in an organism have the same genetic content, but the genes used (expressed) by the cell may be regulated in different ways. Not all DNA codes for a protein; some segments of DNA are involved in regulatory or structural functions, and some have no as-yet known function. (HS.LS3A.a) In Mendel's model of inheritance an organism's phenotype is determined by the combined expression of two inherited versions they have for each gene. However, most traits follow more complex patterns of inheritance such as traits that are codominant, incomplete dominant, and polygenic. (HS.LS3A.b)	Each chromosome consists of a single very long DNA molecule, and each gene on the chromosome is a particular segment of that DNA. The instructions for forming species' characteristics are carried in DNA. All cells in an organism have the same genetic content, but the genes used (expressed) by the cell may be regulated in different ways. Not all DNA codes for a protein; some segments of DNA are involved in regulatory or structural functions, and some have no as-yet known function.
Crosscutting Concepts:	Cause and effect
Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects.	

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HEREDITY: INHERITANCE AND VARIATION OF TRAITS	HS-LS3-2
LSSS	**NGSS**
Make and defend a claim based on evidence that inheritable genetic variations may result from: (1) new genetic combinations through meiosis, (2) viable errors 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. Claims should not include the phases of meiosis or the biochemical mechanisms of specific steps in the process.	
Science and Engineering Practice:	Engaging in argument from evidence
Disciplinary Core Ideas:	Variation of traits
In sexual reproduction, chromosomes can sometimes swap sections or cross over during the process of meiosis (cell division), thereby creating new genetic combinations and thus more genetic variation. Although DNA replication is tightly regulated and remarkably accurate, errors do occur and result in mutations, which are also a source of genetic variation. Environmental factors can also cause mutations in genes, and viable mutations are inherited. (HS.LS3B.a) Mutations may occur due to errors during DNA replication and/ or environmental factors. In general, only mutations that occur in gametes (sperm and egg) can be passed to offspring. Genes have variations (alleles) that code for specific variants of a protein (or RNA), and therefore specific traits of an individual. (HS.LS3B.b) Environmental factors also affect expression of traits, and hence affect the probability of occurrences of traits in a population. Thus the variation and distribution of traits observed depends on both genetic and environmental factors. (HS.LS3B.c)	In sexual reproduction, chromosomes can sometimes swap sections during the process of meiosis (cell division), thereby creating new genetic combinations and thus more genetic variation. Although DNA replication is tightly regulated and remarkably accurate, errors do occur and result in mutations, which are also a source of genetic variation. Environmental factors can also cause mutations in genes, and viable mutations are inherited. Environmental factors also affect expression of traits, and hence affect the probability of occurrences of traits in a population. Thus the variation and distribution of traits observed depends on both genetic and environmental factors.
Crosscutting Concepts:	Cause and effect
Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects.	

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HEREDITY: INHERITANCE AND VARIATION OF TRAITS	HS-LS3-3
LSSS	**NGSS**
Apply concepts of statistics and probability to explain the variation and distribution of expressed traits in a population.	
Clarification Statement	
Emphasis is on distribution and variation of traits in a population and the use of mathematics (e.g., calculations of frequencies in Punnett squares, graphical representations) to describe the distribution.	Emphasis is on the use of mathematics to describe the probability of traits as it relates to genetic and environmental factors in the expression of traits.
Science and Engineering Practice:	Engaging in argument from evidence
Disciplinary Core Ideas:	Variation of traits
In sexual reproduction, chromosomes can sometimes swap sections or cross over during the process of meiosis (cell division), thereby creating new genetic combinations and thus more genetic variation. Although DNA replication is tightly regulated and remarkably accurate, errors do occur and result in mutations, which are also a source of genetic variation. Environmental factors can also cause mutations in genes, and viable mutations are inherited. (HS.LS3B.a) Mutations may occur due to errors during DNA replication and/ or caused by environmental factors. In general, only mutations that occur in gametes (sperm and egg) can be passed to offspring. Genes have variations (alleles) that code for specific variants of a protein (or RNA), and therefore specific traits of an individual. (HS.LS3B.b)	Environmental factors also affect expression of traits, and hence affect the probability of occurrences of traits in a population. Thus the variation and distribution of traits observed depends on both genetic and environmental factors.
Crosscutting Concepts:	Cause and effect
Algebraic thinking is used to examine scientific data and predict the effect of a change in one variable on another (e.g., linear growth vs. exponential growth).	

Underlined sections denote* ***wording differences* *in the Louisiana Student Standards for Science.*

BIOLOGICAL EVOLUTION: UNITY AND DIVERSITY	HS-LS4-1
LSSS	**NGSS**
Analyze and interpret scientific information that common ancestry and biological evolution are supported by multiple lines of empirical evidence.	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 (e.g., similarities in DNA sequences, order of appearance of structure during embryological development, cladograms, homologous and vestigial structures, fossil records) demonstrates as related to common ancestry and biological evolution.	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.
Science and Engineering Practice:	Analyzing and interpreting data
Disciplinary Core Ideas:	Evidence of common ancestry and diversity
Genetic information provides evidence of evolution. DNA sequences vary among species, but there are many overlaps; in fact, the ongoing branching that produces multiple lines of descent can be inferred by comparing the DNA sequences of different organisms. Such information is also derivable from the similarities and differences in amino acid sequences and from observable anatomical and embryological evidence. (HS.LS4A.a)	
Crosscutting Concepts:	Patterns
Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations of phenomena.	

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BIOLOGICAL EVOLUTION: UNITY AND DIVERSITY	**HS-LS4-2**
LSSS	**NGSS**
Construct an explanation based on evidence that biological diversity is influenced by (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 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 or proportional reasoning.	
Science and Engineering Practice:	Constructing explanations and designing solutions
Disciplinary Core Ideas:	Natural selection
Natural selection occurs only if there is both (1) variation in the genetic information between organisms in a population e.g. mutations and sexual reproduction and (2) variation in the expression of that genetic information—that is, trait variation—that leads to differences in performance among individuals. Natural selection leads to populations that have more individuals with behavioral, anatomical, and physiological adaptations. (HS.LS4B.a) The traits that positively affect survival are more likely to be reproduced, and thus are more common in the population. (HS.LS4B.c)	Natural selection occurs only if there is both (1) variation in the genetic information between organisms in a population and (2) variation in the expression of that genetic information—that is, trait variation—that leads to differences in performance among individuals.
	Adaptation
THIS DISCIPLINARY CORE IDEA DOES NOT APPEAR IN THE LOUISIANA STANDARD	Evolution is a consequence of the interaction of four factors: (1) the potential for a species to increase in number, (2) the genetic variation of individuals in a species due to mutation and sexual reproduction, (3) competition for an environment's limited supply of the resources that individuals need in order to survive and reproduce, and (4) the ensuing proliferation of those organisms that are better able to survive and reproduce in that environment.
Crosscutting Concepts:	Cause and effect
Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects.	

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BIOLOGICAL EVOLUTION: UNITY AND DIVERSITY	HS-LS4-3
LSSS	**NGSS**
Apply concepts of statistics and probability to support explanations that populations of organisms adapt when an advantageous heritable trait increases 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 for adaptations. Explanations could include basic statistical or graphical analysis.	Emphasis is on analyzing shifts in numerical distribution of traits and using these shifts as evidence to support explanations. Explanations limited to basic statistical and graphical analysis.
Science and Engineering Practice:	Analyzing and interpreting data
Disciplinary Core Ideas:	Natural selection
Natural selection occurs only if there is both (1) variation in the genetic information between organisms in a population e.g. mutations and sexual reproduction and (2) variation in the expression of that genetic information—that is, trait variation—that leads to differences in performance among individuals. Natural selection leads to populations that have more individuals with behavioral, anatomical, and physiological adaptations. (HS.LS4B.a) The traits that positively affect survival are more likely to be reproduced, and thus are more common in the population. (HS.LS4B.c)	Natural selection occurs only if there is both (1) variation in the genetic information between organisms in a population and (2) variation in the expression of that genetic information—that is, trait variation—that leads to differences in performance among individuals. The traits that positively affect survival are more likely to be reproduced, and thus are more common in the population.
	Adaptation
Natural selection leads to adaptation, that is, to a population dominated by organisms that are anatomically, behaviorally, and physiologically well suited to survive and reproduce in a specific environment. That is, the differential survival and reproduction of organisms in a population that have an advantageous heritable trait leads to an increase in the proportion of individuals in future generations that have the trait and to a decrease in the proportion of individuals that do not. (HS.LS4C.a) Adaptation also means that the distribution of traits in a population can change when conditions change. (HS.LS4C.b)	
Crosscutting Concepts:	Patterns
Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations of phenomena.	

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<table>
<tr><th colspan="2">BIOLOGICAL EVOLUTION: UNITY AND DIVERSITY — HS-LS4-4</th></tr>
<tr><th>LSSS</th><th>NGSS</th></tr>
<tr><td>Construct an explanation based on evidence for how natural selection and other mechanisms lead to genetic changes in populations.</td><td>Construct an explanation based on evidence for how natural selection leads to adaptation of populations.</td></tr>
<tr><th colspan="2">Clarification Statement</th></tr>
<tr><td colspan="2">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.</td></tr>
<tr><th colspan="2">Science and Engineering Practice: — Constructing explanations and designing solutions</th></tr>
<tr><th colspan="2">Disciplinary Core Ideas: — Natural selection</th></tr>
<tr><td>Natural selection occurs only if there is both (1) variation in the genetic information between organisms in a population e.g. mutations and sexual reproduction and (2) variation in the expression of that genetic information—that is, trait variation—that leads to differences in performance among individuals. Natural selection leads to populations that have more individuals with behavioral, anatomical, and physiological adaptations. (HS.LS4B.a)
Genetic drift and gene flow can lead to genetic changes in populations, not adaptations. (HS.LS4B.b)</td><td>NONE PROVIDED</td></tr>
<tr><th colspan="2">Adaptation</th></tr>
<tr><td colspan="2">Natural selection leads to adaptation, that is, to a population dominated by organisms that are anatomically, behaviorally, and physiologically well suited to survive and reproduce in a specific environment. That is, the differential survival and reproduction of organisms in a population that have an advantageous heritable trait leads to an increase in the proportion of individuals in future generations that have the trait and to a decrease in the proportion of individuals that do not. (HS.LS4C.a)
Changes in the physical environment, whether naturally occurring or human induced, have thus contributed to the expansion of some species, the emergence of new distinct species as populations diverge under different conditions, and the decline–and sometimes the extinction–of some species. (HS.LS4C.c)</td></tr>
<tr><th colspan="2">Crosscutting Concepts: — Cause and effect</th></tr>
<tr><td colspan="2">Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects.</td></tr>
</table>

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BIOLOGICAL EVOLUTION: UNITY AND DIVERSITY	HS-LS4-5
LSSS	**NGSS**
Evaluate evidence supporting claims that changes in environmental conditions <u>can affect the distribution of traits in a population causing:</u> (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.	Evaluate 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, <u>over</u>fishing, application of fertilizers, drought, flood, and the rate of change of the environment affect distribution or disappearance of traits in species	Emphasis is on determining cause and effect relationships for how changes to the environment such as deforestation, fishing, application of fertilizers, drought, flood, and the rate of change of the environment affect distribution or disappearance of traits in species.
Science and Engineering Practice:	Engaging in argument from evidence
Disciplinary Core Ideas:	Adaptation
Changes in the physical environment, whether naturally occurring or human induced, have thus contributed to the expansion of some species, the emergence of new distinct species as populations diverge under different conditions, and the decline–and sometimes the extinction–of some species. (HS.LS4C.c) Species become extinct because they can no longer survive and reproduce in their altered environment. If members cannot adjust to change that is too fast or drastic, the opportunity for the species' evolution is lost. (HS.LS4C.d)	
Crosscutting Concepts:	Cause and effect
Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects.	

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BIOLOGICAL EVOLUTION: UNITY AND DIVERSITY	HS-LS4-6
LSSS	**NGSS**
HS-LS4-6 DOES NOT APPEAR IN LOUISIANA STANDARDS	Create or revise a simulation to test a solution to mitigate adverse impacts of human activity on biodiversity.
Clarification Statement	
HS-LS4-6 DOES NOT APPEAR IN LOUISIANA STANDARDS	Emphasis is on testing solutions for a proposed problem related to threatened or endangered species, or to genetic variation of organisms for multiple species.
Science and Engineering Practice:	Using mathematics and computational thinking
Disciplinary Core Ideas:	Adaptation
HS-LS4-6 DOES NOT APPEAR IN LOUISIANA STANDARDS	Changes in the physical environment, whether naturally occurring or human induced, have thus contributed to the expansion of some species, the emergence of new distinct species as populations diverge under different conditions, and the decline–and sometimes the extinction–of some species.
	Biodiversity and humans
HS-LS4-6 DOES NOT APPEAR IN LOUISIANA STANDARDS	Humans depend on the living world for the resources and other benefits provided by biodiversity. But human activity is also having adverse impacts on biodiversity through overpopulation, overexploitation, habitat destruction, pollution, introduction of invasive species, and climate change. Thus sustaining biodiversity so that ecosystem functioning and productivity are maintained is essential to supporting and enhancing life on Earth. Sustaining biodiversity also aids humanity by preserving landscapes of recreational or inspirational value.

	Developing possible solutions
HS-LS4-6 DOES NOT APPEAR IN LOUISIANA STANDARDS	When evaluating solutions, it is important to take into account a range of constraints, including cost, safety, reliability, and aesthetics, and to consider social, cultural, and environmental impacts. (secondary) Both physical models and computers can be used in various ways to aid in the engineering design process. Computers are useful for a variety of purposes, such as running simulations to test different ways of solving a problem or to see which one is most efficient or economical; and in making a persuasive presentation to a client about how a given design will meet his or her needs. (secondary)
Crosscutting Concepts:	Cause and effect
HS-LS4-6 DOES NOT APPEAR IN LOUISIANA STANDARDS	Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects.