Performance Expectation *and Louisiana Connectors*
K-PS2-1 Plan and conduct an investigation to compare the effects of different strengths or different directions of pushes and pulls on the motion of an object. ***LC-K-PS2-1a Identify the effect caused by different strengths or directions of pushes and pulls on the motion of an object.*** ***LC-K-PS2-1b Explain the effect of pushes and pulls on the motion of an object.*** ***LC-K-PS2-1c Identify the effect of different strengths and directions of pushes and pulls on the motion of an object.*** ***LC-K-PS2-1d Compare different strengths or different directions of pushes and pulls on an object.***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Planning and carrying out investigations: Planning and carrying out investigations to answer questions (science) or test solutions (engineering) to problems in K-2 builds on prior experiences and progresses to simple investigations, based on fair tests, which provide data to support explanations or design solutions. • With guidance, plan and conduct an investigation in collaboration with peers. ***With guidance, plan a simple investigation with peers.*** ***With guidance, conduct a simple investigation with peers.***	**FORCES AND MOTION** Pushes and pulls can have different strengths and directions. (LE.PS2A.a) ***An object can be pushed or pulled with different strengths.*** ***An object can be pushed or pulled from different directions.*** Pushing or pulling on an object can change the speed or direction of its motion and can start or stop it. (LE.PS2A.b) ***Pushing and pulling an object can change how it moves.*** ***Pushes and pulls can start or stop the motion of an object.*** ***Pushing or pulling on an object can change its position or motion.*** **TYPES OF INTERACTIONS** When objects touch or collide, they push on one another and can change motion. (LE.PS2B.a) ***A push or pull can be caused by objects touching or colliding.*** ***When objects touch or collide, the motion of the objects can change.*** **RELATIONSHIP BETWEEN ENERGY AND FORCES** A bigger push or pull makes things speed up or slow down more quickly. (LE.PS3C.a) ***A bigger push or pull can impact an object more than a smaller push or pull.***	**CAUSE AND EFFECT** Simple tests can be designed to gather evidence to support or refute student ideas about causes. ***Simple tests can be designed to gather evidence about cause and effect relationships.*** ***Evidence from simple tests can support ideas about causes.*** ***Evidence from simple tests can refute ideas about causes.***

Clarification Statement
Examples of pushes or pulls could include a string attached to an object being pulled, a person pushing an object, a person stopping a rolling ball, or two objects colliding and pushing on each other. Content includes contact forces with different relative strengths or different directions, but not both at the same time.

Performance Expectation *and Louisiana Connectors*
K-PS2-2 Analyze data to determine if a design solution works as intended to change the speed or direction of an object with a push or a pull. ***LC-K-PS2-2a Identify if something designed to push or pull an object makes it move the way it is intended.*** ***LC-K-PS2-2b Identify if something designed to change the speed of an object makes it move the way it is intended.*** ***LC-K-PS2-2c Identify if something designed to change the direction of an object makes it move the way it is intended.***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Analyzing and interpreting data: Analyzing data in K-2 builds on prior experiences and progresses to collecting, recording, and sharing observations. • Analyze data from tests of an object or tool to determine if it works as intended. ***Determine how well the design works as intended based on data.***	**FORCES AND MOTION** Pushes and pulls can have different strengths and directions. (LE.PS2A.a) ***An object can be pushed or pulled with different strengths.*** ***An object can be pushed or pulled from different directions.*** Pushing or pulling on an object can change the speed or direction of its motion and can start or stop it. (LE.PS2A.b) ***Pushing and pulling an object can change how it moves.*** ***Pushes and pulls can start or stop the motion of an object.*** ***Pushing or pulling on an object can change its position or motion.*** **ENGINEERING DESIGN** A situation that people want to change or create can be approached as a problem to be solved through engineering. Such problems may have many acceptable solutions. (LE.ETS1A.a) ***People can make plans to solve a problem.*** ***Tools or objects can be used to solve a simple problem.*** ***Engineers use technology to help people solve problems or develop solutions to problems.*** ***Engineers design devices or other items to help people solve problems.***	**CAUSE AND EFFECT** Simple tests can be designed to gather evidence to support or refute student ideas about causes. ***Simple tests can be designed to gather evidence about cause and effect relationships.*** ***Evidence from simple tests can support ideas about causes.*** ***Evidence from simple tests can refute ideas about causes.***

Clarification Statement
Examples of problems requiring a solution could include having a marble or other object move a certain distance, follow a particular path, or knock down other objects. Examples of solutions could include tools such as a ramp to increase the speed of the object, a structure that would cause an object such as a marble or ball to turn or using a rope or string to pull an object. Content does not include friction as a mechanism for change in speed.

Performance Expectation *and Louisiana Connectors*
K-PS3-1 Make observations to determine the effect of sunlight on Earth's surface. ***LC-K-PS3-1a Identify examples of sunlight heating different surfaces on Earth.***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Planning and carrying out investigations: Planning and carrying out investigations to answer questions or test solutions to problems in K-2 builds on prior experiences and progresses to simple investigations, based on fair tests, which provide data to support explanations or design solutions. • Make observations (firsthand or from media) and/or measurements of a proposed object or tool or solution to determine if it solves a problem or meets a goal. ***Make observations of proposed tools or objects to decide if they solve a problem.*** ***Take measurements of proposed tools or objects to decide if they solve a problem.*** ***Make observations of a proposed solution to decide if it solves a problem.*** ***Take measurements of a proposed solution to decide if it solves a problem.***	**CONSERVATION OF ENERGY AND ENERGY TRANSFER** Sunlight warms Earth's surface. (LE.PS3B.a) ***Sunlight feels warm.*** ***Sunlight warms the surface of the Earth.*** ***When sunlight hits an object, the light energy can become heat energy.***	**CAUSE AND EFFECT** Events have causes that generate observable patterns. ***One event can cause another event to occur. Sometimes this produces a pattern of events.***

Clarification Statement
Sunlight heats Earth’s natural surfaces including sand, soil, rocks, or water and the unnatural surfaces including man-made objects like plastics, asphalt, or concrete. Examples of observations could be relative changes in temperature of surfaces exposed to sunlight.

Performance Expectation *and Louisiana Connectors*
K-PS3-2 Use tools and materials to design and build a structure that will reduce the warming effect of sunlight on an area. ***LC-K-PS3-2a Identify a design structure (e.g., umbrella, canopy, tent) that will reduce the warming caused by the sun.*** ***LC-K-PS3-2b Identify tools and materials that can be used to build a structure that will reduce the warming effect of sunlight on an area.***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Constructing explanations and designing solutions: Constructing explanations (science) and designing solutions (engineering) in K-2 builds on prior experiences and progresses to the use of evidence and ideas in constructing evidence-based accounts of natural phenomena and designing solutions. • Use tools and/or materials to design and/or build a device that solves a specific problem or a solution to a specific problem. ***Tools and materials can be used to design a device that solves a specific problem.*** ***Tools and materials can be used to design a device that can be a solution to a specific problem.*** ***Tools and materials can be used to build a device that solves a specific problem.*** ***Tools and materials can be used to build a device that can be a solution to a specific problem.***	**CONSERVATION OF ENERGY AND ENERGY TRANSFER** Sunlight warms Earth's surface. (LE.PS3B.a) ***Sunlight feels warm.*** ***Sunlight warms the surface of the Earth.*** ***When sunlight hits an object, the light energy can become heat energy.***	**CAUSE AND EFFECT** Simple tests can be designed to gather evidence to support or refute student ideas about causes. ***Simple tests can be designed to gather evidence about cause and effect relationships.*** ***Evidence from simple tests can support ideas about causes.*** ***Evidence from simple tests can refute ideas about causes.***

Clarification Statement
Examples of structures could include umbrellas, canopies, or tents that minimize the warming effect of the sun.

Performance Expectation *and Louisiana Connectors*
K-LS1-1 Use observations to describe patterns of what plants and animals (including humans) need to survive. ***LC-K-LS1-1a Identify that animals need water and food to live and grow.*** ***LC-K-LS1-1b Identify that plants need water and light to live and grow.*** ***LC-K-LS1-1c Identify patterns of what living things need to survive.***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Analyzing and interpreting data: Analyzing data in K-2 builds on prior experiences and progresses to collecting, recording, and sharing observations. • Use observations to describe patterns and/or relationships in the natural and designed world(s) in order to answer scientific questions and solve problems. ***Observations can be used to describe patterns.*** ***Observations can be used to describe relationships.*** ***Observations can be used to answer scientific questions.*** ***Observations can be used to solve problems.***	**ORGANIZATION FOR MATTER AND ENERGY FLOW IN ORGANISMS** All animals need food in order to live and grow. Animals obtain their food from plants or from other animals. Plants need water and light to live and grow. (LE.LS1C.a) ***Plants and animals are living things.*** ***All living things need water, air, and sunlight to survive.*** ***Animals need food to live and grow.*** ***Animals eat plants or other animals for food.*** ***Sunlight and water are essential for plant survival.***	**PATTERNS** Patterns in the natural and human-designed world can be observed, used to describe phenomena, and used as evidence. ***Patterns in the world (natural and human-designed) can be observed.*** ***Patterns in the world (natural and human-designed) can be used to describe phenomena.*** ***Patterns in the world (natural and human-designed) can be used as evidence.***

Clarification Statement
Examples of patterns could include that plants make their own food while animals do not, the different kinds of food needed by different types of animals, the requirement of plants to have light, or that all living things need water.

Performance Expectation *and Louisiana Connectors*
K-ESS2-1 Use and share observations of local weather conditions to describe patterns over time. ***LC-K-ESS2-1a Identify patterns in weather conditions using observations of local weather.***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Analyzing and interpreting data: Analyzing data in K-2 builds on prior experiences and progresses to collecting, recording, and sharing observations. • Use observations to describe patterns and/or relationships in the natural and designed world(s) in order to answer scientific questions and solve problems. ***Observations can be used to describe patterns.*** ***Observations can be used to describe relationships.*** ***Observations can be used to answer scientific questions.*** ***Observations can be used to solve problems.***	**WEATHER AND CLIMATE** Weather is the combination of sunlight, wind, snow or rain, and temperature in a particular region at a particular time. People measure these conditions to describe and record the weather and to notice patterns over time. (LE.ESS2D.a) ***Weather can be observed and described (e.g., sunny, cloudy, rainy, warm, or cold).*** ***Weather is a combination of sunlight, wind, snow, or rain, and temperature.*** ***Snow is frozen ice crystals that fall from clouds when the temperature is below freezing.*** ***Rain is water that falls from the clouds when the temperature is above freezing.*** ***Hail and sleet are also forms of frozen precipitation.*** ***Weather can be observed, measured, and described through the use of simple tools such as a thermometer, rain gauge, and wind vane.*** ***By making observations about what the weather is like, patterns in local weather can be observed.*** ***Looking at the records of weather over time can help us find patterns.*** ***Weather doesn't always follow a pattern.***	**PATTERNS** Patterns in the natural and human-designed world can be observed, used to describe phenomena, and used as evidence. ***Patterns in the world (natural and human-designed) can be observed.*** ***Patterns in the world (natural and human-designed) can be used to describe phenomena.*** ***Patterns in the world (natural and human-designed) can be used as evidence.***

Clarification Statement
Examples of qualitative observations could include descriptions of the weather (such as sunny, cloudy, rainy, or warm); examples of quantitative observations could include numbers of sunny, windy, or rainy days in a month. Examples of patterns could include that it is cooler in the morning than in the afternoon or the number of sunny days versus cloudy days in different months.

Performance Expectation *and Louisiana Connectors*
K-ESS2-2 Construct an argument supported by evidence for how plants and animals (including humans) can change the environment to meet their needs. ***LC-K-ESS2-2a Identify examples of how animals change their environments to meet their needs.*** ***LC-K-ESS2-2b Identify examples of how plants change their environments to meet their needs.*** ***LC-K-ESS2-2c Identify ways that humans can affect the environment in which they live.***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Engaging in argument from evidence: Engaging in argument from evidence in K-2 builds on prior experiences and progresses to comparing ideas and representations about the natural and designed world(s). • Construct an argument with evidence to support a claim. ***A claim must be supported with evidence.*** ***Observational data may be used to support claims.*** ***Numerical data may be used to support claims.***	**BIOGEOLOGY** Plants and animals can change their environment. (LE.ESS2E.a) ***An interconnectedness exists among the living and nonliving parts of an environment. This interconnectedness can be observed by the changes made by plants and animals in their environment.*** ***Living things can change the places they live to meet their needs.*** **HUMAN IMPACTS ON EARTH SYSTEMS** Things that people do to live comfortably can affect the world around them; but they can make choices that reduce their impacts on the land, water, air, and other living things. (LE.ESS3C.a) ***People like to live comfortably.*** ***People can impact the environments that plants and animals live in.*** ***People can do things that reduce their impacts on the environments that plants and animals live in.***	**SYSTEMS AND SYSTEM MODELS** Systems in the natural and designed world have parts that work together. ***Systems and system models have many parts.*** ***Systems and system models can be used to understand the relationship between parts that work together.***

Clarification Statement
Examples of plants and animals changing their environment could include a squirrel digging in the ground to hide its food, tree roots breaking concrete, or a dandelion spreading seeds to generate more dandelions.

Performance Expectation *and Louisiana Connectors*
K-ESS3-1 Use a model to represent the relationship between the needs of different plants or animals (including humans) and the places they live. ***LC-K-ESS3-1a Given a model (e.g., representation, diagram, drawing), describe the relationship between the needs of different animals and the places they live (e.g., deer eat buds and leaves and live in forests).***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Developing and using models: Modeling in K-2 builds on prior experiences and progresses to include using and developing models (e.g., diagram, drawing, physical replica, diorama, dramatization, or storyboard) that represent concrete events or design solutions. • Develop and/or use a model to represent amounts, relationships, relative scales (bigger, smaller), and/or patterns in the natural and designed world(s). ***Models can be used to show relationships in the world (natural and human-designed).*** ***Models can be used to show different amounts or scales (bigger, smaller) in the world (natural and human- designed).*** ***Models can be used to show patterns in the world (natural and human-designed).***	**NATURAL RESOURCES** Living things need water, air, and resources from the land, and they live in places that have the things they need. Humans use natural resources for everything they do. (LE.ESS3A.a) ***All living things need water, air, sunlight, and resources from the land to survive.*** ***Living things live where they have access to the things they need.*** ***Humans need resources from the land.***	**SYSTEMS AND SYSTEM MODELS** Systems in the natural and designed world have parts that work together. ***Systems and system models have many parts.*** ***Systems and system models can be used to understand the relationship between parts that work together.***

Clarification Statement
Examples of relationships could include that deer eat buds and leaves and therefore usually live in forested areas; grasses need sunlight so they often grow in meadows. Plants, animals, and their surroundings make up a system.

Performance Expectation *and Louisiana Connectors*
K-ESS3-2 Ask questions to obtain information about the purpose of weather forecasting to prepare for and respond to severe weather. ***LC-K-ESS3-2a Identify how weather forecasting can help people avoid the most serious impacts of severe weather events.***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Asking questions and defining problems: Asking questions (science) and defining problems (engineering) in K-2 builds on prior experiences and progresses to simple descriptive questions that can be tested. • Ask questions based on observations to find more information about the natural and/or designed world(s). ***Making observations of the world (natural and human-designed) leads to asking questions about why patterns exist.***	**NATURAL HAZARDS** Some kinds of severe weather are more likely than others in a given region. Weather scientists forecast severe weather so that the communities can prepare for and respond to these events. (LE.ESS3B.a) ***Weather influences plants, animals, and human activity.*** ***Certain kinds of severe weather are more likely than others in some places.*** ***Severe weather includes hurricanes, tornados, and blizzards.*** ***Severe weather often has consequences for people.*** ***Heavy rains can also have consequences (flooding).*** ***Weather forecasting helps keep people safe.*** ***Predicting weather can help people better prepare.***	**CAUSE AND EFFECT** Events have causes that generate observable patterns. ***One event can cause another event to occur. Sometimes this produces a pattern of events.***

Clarification Statement
Emphasis is on local forms of severe weather and safety precautions associated with that severe weather.

Performance Expectation *and Louisiana Connectors*
K-ESS3-3 Communicate solutions that will reduce the impact of humans on the land, water, air, and/or other living things in the local environment. ***LC-K-ESS3-3a Identify different solutions that people can apply to the way they live to reduce the impact on the land, water, air, and other living things.***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Obtaining, evaluating, and communicating information: Obtaining, evaluating, and communicating information in K-2 builds on prior experiences and uses observations and texts to communicate new information. • Communicate information or design ideas and/or solutions with others in oral and/or written forms using models, drawings, writing, or numbers that provide detail about scientific ideas, practices, and/or design ideas. ***Share information with others in oral or written forms.*** ***Share information with others using models.*** ***Share information with others using numbers.*** ***Share information that provides details about scientific ideas or practices.*** ***Share information that provides details about design ideas.***	**HUMAN IMPACTS ON EARTH SYSTEMS** Things that people do to live comfortably can affect the world around them. But they can make choices that reduce their impacts on the land, water, air, and other living things. (LE.ESS3C.a) ***People like to live comfortably.*** ***People can impact the environments that plants and animals live in.*** ***People can do things that reduce their impacts on the environments that plants and animals live in.*** **DEVELOPING POSSIBLE SOLUTIONS** Designs can be conveyed through sketches, drawings, or physical models. These representations are useful in communicating ideas for a problem's solution(s) to other people. (LE.ETS1B.a) ***Design solutions can be shared with others as sketches or drawings.*** ***Design solutions can be shared with others as models.*** ***It is important to communicate information about solutions with others.***	**CAUSE AND EFFECT** Events have causes that generate observable patterns. ***One event can cause another event to occur. Sometimes this produces a pattern of events.***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Share design ideas with others in oral or written forms. ***Share design ideas with others using models.*** ***Share design ideas with others using numbers.*** ***Share design ideas that provide details about scientific ideas or practices.*** ***Share solutions with others in oral or written forms.*** ***Share solutions with others using models.*** ***Share solutions with others using numbers.*** ***Share solutions that provide details about scientific ideas or practices.*** ***Share solutions that provide details about design ideas.***		

Clarification Statement
Examples of human impact on the land could include cutting trees to produce paper and using resources to produce bottles. Examples of solutions could include reusing paper and recycling cans and bottles.

Performance Expectation *and Louisiana Connectors*
1-PS4-1 Plan and conduct investigations to provide evidence that vibrating materials can make sound and that sound can make materials vibrate. ***LC-1-PS4-1a Through collaborative investigations, recognize that sounds can cause materials to vibrate.*** ***LC-1-PS4-1b Through collaborative investigations, recognize that vibrating materials can make sound.*** ***LC-1-PS4-1c Use evidence to describe that vibrating materials can make sound.*** ***LC-1-PS4-1d Use evidence to describe that sound can make matter vibrate.***

Science and Engineering Practice	**Disciplinary Core Idea**	**Crosscutting Concept**
Planning and carrying out investigations: Planning and carrying out investigations to answer questions (science) or test solutions (engineering) to problems in K-2 builds on prior experiences and progresses to simple investigations, based on fair tests, which provide data to support explanations or design solutions. • Plan and conduct investigations collaboratively to produce data to serve as the basis for evidence to answer a question. ***Plan investigations collaboratively to produce data to answer a question.*** ***Conduct investigations collaboratively to produce data to answer a question.***	**WAVE PROPERTIES** Sound can make matter vibrate, and vibrating matter can make sound. (LE.PS4A.a) ***Sound can make materials vibrate.*** ***When materials vibrate, they can make a sound.***	**CAUSE AND EFFECT** Simple tests can be designed to gather evidence to support or refute student ideas about causes. ***Simple tests can be designed to gather evidence about cause and effect relationships.*** ***Evidence from simple tests can support ideas about causes.*** ***Evidence from simple tests can refute ideas about causes.***

Clarification Statement
Examples of vibrating materials that make sound could include tuning forks or plucking a stretched string. Examples of how sound can make matter vibrate could include holding a piece of paper near a speaker making sound or holding an object near a vibrating tuning fork.

Performance Expectation *and Louisiana Connectors*
1-PS4-2 Make observations to construct an evidence-based account that objects can be seen only when illuminated. ***LC-1-PS4-2a Through observations, recognize that objects can be seen only when illuminated by an external light source or when they give off their own light.***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Constructing explanations and designing solutions: Constructing explanations (science) and designing solutions (engineering) in K-2 builds on prior experiences and progresses to the use of evidence and ideas in constructing evidence-based accounts of natural phenomena and designing solutions. • Make observations (firsthand or from media) to construct an evidence-based account for natural phenomena. ***Making observations can be used to gather information.*** ***Make observations to describe natural phenomena.*** ***Observational evidence can be used to describe natural phenomena.*** ***Observational evidence can be used to explain natural phenomena.***	**ELECTROMAGNETIC RADIATION** Objects can be seen if light is available to illuminate them or if they give off their own light. Some objects give off their own light. (LE.PS4B.a) ***Darkness is the partial or total absence of light.*** ***Light is necessary for objects to be seen.*** ***Objects cannot be seen if there is no light to illuminate them.*** ***Objects can be seen if they give off their own light.*** ***Things that give off light are known as light sources including: stars, flashlights, street lamps, house lamps, and the sun.***	**CAUSE AND EFFECT** Events have causes that generate observable patterns. ***One event can cause another event to occur. Sometimes this produces a pattern of events.***

Clarification Statement
Examples of observations could include those made in a completely dark room, a pinhole box, or a video of a cave explorer with a flashlight. Illumination could be from an external light source or by an object giving off its own light. This can be explored with light tables, 3-way mirrors, overhead projectors, or flashlights.

Performance Expectation *and Louisiana Connectors*
1-PS4-3 Plan and conduct an investigation to determine the effect of placing objects made with different materials in the path of a beam of light. ***LC-1-PS4-3a Through collaborative investigations, recognize that some materials allow light to pass through them.*** ***LC-1-PS4-3b Through collaborative investigations, recognize that some materials allow only some light to pass through them.*** ***LC-1-PS4-3c Through collaborative investigations, recognize that some materials block all the light.***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Planning and carrying out investigations: Planning and carrying out investigations to answer questions or test solutions to problems in K-2 builds on prior experiences and progresses to simple investigations, based on fair tests, which provide data to support explanations or design solutions. • Plan and conduct an investigation collaboratively to produce data to serve as the basis for evidence to answer a question. ***Plan investigations collaboratively to produce data to answer a question.*** ***Conduct investigations collaboratively to produce data to answer a question.***	**ELECTROMAGNETIC RADIATION** Some materials allow light to pass through them, others allow only some light through and others block all the light and create a dark shadow on any surface beyond them, where the light cannot reach. Mirrors can be used to redirect a light beam. (The idea that light travels from place to place is developed through experiences with light sources, mirrors, and shadows, but no attempt is made to discuss the speed of light.) (LE.PS4B.b) ***The material that an object is made of impacts if light can or cannot pass through it.*** ***Some materials allow light to pass through them.*** ***A material that allows all light through (e.g., clear plastic, clear glass) results in the background lighting up.*** ***Some materials allow only some light to pass through them.*** ***A material that allows only some light through (e.g., wax paper, clouded plastic) results in the background lighting up, but not as bright as when the material allows all light in.*** ***Some materials block all the light.*** ***A material that blocks all of the light (e.g., cardboard, wood) will create a shadow.*** ***Different materials respond to light in different ways.*** ***Mirrors can be used to redirect light.*** ***A material that changes the direction of the light (e.g., mirror, aluminum foil) will light up the surrounding space in a different direction.***	**CAUSE AND EFFECT** Simple tests can be designed to gather evidence to support or refute student ideas about causes. ***Simple tests can be designed to gather evidence about cause and effect relationships.*** ***Evidence from simple tests can support ideas about causes.*** ***Evidence from simple tests can refute ideas about causes.***

Clarification Statement
Examples of materials could include those that are transparent (such as clear plastic), translucent (such as wax paper), opaque (such as cardboard), or reflective (such as a mirror).

Performance Expectation *and Louisiana Connectors*
1-PS4-4 Use tools and materials to design and build a device that uses light or sound to solve the problem of communicating over a distance. ***LC-1-PS4-4a When using tools and materials to design and build a device, identify features of devices that people use to send and receive information over long distances.***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Constructing explanations and designing solutions: Constructing explanations (science) and designing solutions (engineering) in K-2 builds on prior experiences and progresses to the use of evidence and ideas in constructing evidence-based accounts of natural phenomena and designing solutions. • Use tools and/or materials to design and/or build a device that solves a specific problem or a solution to a specific problem. ***Tools and materials can be used to design a device that solves a specific problem.*** ***Tools and materials can be used to design a device that can be a solution to a specific problem.*** ***Tools and materials can be used to build a device that solves a specific problem.*** ***Tools and materials can be used to***	**INFORMATION TECHNOLOGIES AND INSTRUMENTATION** People also use a variety of devices to communicate (send and receive information) over long distances. (LE.PS4C.a) ***Communication occurs when people share information with one another through the use of words, sounds, or signals.*** ***Light and sound can be used to communicate over long distances.*** ***A device can use light or sound to send or receive information over a given distance (e.g., cell phones, lighthouses).*** ***People use devices like telephones to communicate (send and receive information) over a distance.*** **DEVELOPING POSSIBLE SOLUTIONS** A situation that people want to change or create can be approached as a problem to be solved through engineering. (LE.ETS1A.a) ***People can make plans to solve a problem.*** ***Tools or objects can be used to solve a simple problem.*** ***Engineers use technology to help people solve problems or develop solutions to problems.*** ***Engineers design devices or other items to help people solve problems.***	**SYSTEMS AND SYSTEM MODELS** Systems in the natural and designed world have parts that work together. ***Systems and system models have many parts.*** ***Systems and system models can be used to understand the relationship between parts that work together.***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
build a device that can be a solution to a specific problem.		

Clarification Statement
Examples of devices could include a light source to send signals, paper cup and string "telephones," or a pattern of drumbeats.

Performance Expectation *and Louisiana Connectors*
1-LS1-1 Use tools and materials to design a solution to a human problem by mimicking how plants and/or animals use their external parts to help them survive, grow, and meet their needs. ***LC-1-LS1-1a Identify how animals use their external parts to help them survive, grow, and meet their needs.*** ***LC-1-LS1-1b Identify how plants use their external parts to help them survive, grow, and meet their needs.*** ***LC-1-LS1-1c Identify a design solution to a human problem which is similar to how a plant or animal uses its external parts to help it survive, grow, and meet its needs.***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Constructing explanations and designing solutions: Constructing explanations (science) and designing solutions (engineering) in K-2 builds on prior experiences and progresses to the use of evidence and ideas in constructing evidence-based accounts of natural phenomena and designing solutions. • Use tools and/or materials to design and/or build a device that solves a specific problem or a solution to a specific problem. ***Tools and materials can be used to design a device that solves a specific problem.*** ***Tools and materials can be used to design a device that can be a solution to a specific problem.*** ***Tools and materials can be used to build a device that solves a specific problem.*** ***Tools and materials can be used to***	**STRUCTURE AND FUNCTION** All organisms have external parts. Different animals use their body parts in different ways to see, hear, grasp objects, protect themselves, move from place to place, and seek, find, and take in food, water, and air. Plants also have different parts (roots, stems, leaves, flowers, fruits) that help them survive and grow. (LE.LS1A.a) ***Plants and animals are similar to and different from each other in observable structures and behavior.*** ***Plants and animals have external parts that help them survive.*** ***Animals use their body parts in different ways (see, hear, grasp objects, protection, movement, and seek, find, and take in food, water, and air).*** ***Plants have different parts (roots, stems, leaves, flowers, fruits) that help them survive and grow.*** **INFORMATION PROCESSING** Animals have body parts that capture and convey different kinds of information needed for growth and survival. Animals respond to these inputs with behaviors that help them survive. Plants also respond to some external inputs. (LE.LS1D.a) ***Plants and animals take in information so they can respond to situations.*** ***Animals use external structures to capture and convey different kinds of information they need.*** ***Animals respond to the information they receive from one another or the environment.*** ***Different external structures help protect plants and animals and help them respond to***	**STRUCTURE AND FUNCTION** The shape and stability of structures of natural and designed objects are related to their function(s). ***The shape of structures in the world (natural and human-designed) are related to their function(s).*** ***The stability of structures in the world (natural and human-designed) are related to their function(s).*** ***Shape and stability are related for a variety of structures.***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
build a device that can be a solution to a specific problem.	***things around them.*** **DEVELOPING POSSIBLE SOLUTIONS** Designs can be conveyed through sketches, drawings, or physical models. These representations are useful in communicating ideas for solutions to a problem. (LE.ETS1B.a) ***Design solutions can be shared with others as sketches or drawings.*** ***Design solutions can be shared with others as models.*** ***It is important to communicate information about solutions with others.*** **OPTIMIZING THE DESIGN SOLUTION** Because there is always more than one possible solution to a problem, it is useful to compare and test designs. (LE.ETS1C.a) ***There is often more than one way to solve a problem.*** ***It is useful to compare and test designs.***	

Clarification Statement
Examples of human problems that can be solved by mimicking plant or animal solutions could include designing clothing or equipment to protect bicyclists by mimicking turtle shells, acorn shells or animal scales; stabilizing structures by mimicking animal tails or roots on plants; keeping out intruders by mimicking thorns on branches or animal quills; and detecting intruders by mimicking eyes or ears.

Performance Expectation *and Louisiana Connectors*
1-LS1-2 Read grade-appropriate texts and use media to determine patterns in behavior of parents and offspring that help offspring survive. ***LC-1-LS1-2a Use texts or media to identify behaviors of offspring that help them survive.*** ***LC-1-LS1-2b Use texts or media to identify behaviors between parents and offspring that help the offspring survive.*** ***LC-1-LS1-2c Use texts or media to identify patterns in behavior between parents and offspring that help the offspring survive.***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Obtaining, evaluating, and communicating information: Obtaining, evaluating, and communicating information in K-2 builds on prior experiences and uses observations and texts to communicate new information. • Read grade-appropriate texts and/or use media to obtain scientific and/or technical information to determine patterns in and/or evidence about the natural and designed world(s). ***Gather evidence from grade-appropriate texts to determine patterns in the world (natural and human-designed).*** ***Gather evidence from grade-appropriate texts to determine evidence about the world (natural and human-designed).*** ***Gather evidence from media to determine patterns in the world (natural and human-designed).***	**GROWTH AND DEVELOPMENT OF ORGANISMS** Adult plants and animals can have offspring. In many kinds of animals, parents and the offspring themselves engage in behaviors that help the offspring to survive. (LE.LS1B.a) ***Plants and animals have offspring.*** ***Animals often help their offspring to survive.*** ***Parents and their offspring exhibit certain behaviors to ensure that the offspring survive.***	**PATTERNS** Patterns in the natural and human-designed world can be observed, used to describe phenomena, and used as evidence. ***Patterns in the world (natural and human-designed) can be observed.*** ***Patterns in the world (natural and human-designed) can be used to describe phenomena.*** ***Patterns in the world (natural and human-designed) can be used as evidence.***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Gather evidence from media to determine evidence about the world (natural and human-designed).		

Clarification Statement
Examples of patterns of behaviors could include the signals that offspring make (such as crying, cheeping, and other vocalizations) and the responses of the parents (such as feeding, comforting, and protecting the offspring).

Performance Expectation *and Louisiana Connectors*
1-LS3-1 Make observations to construct an evidence-based account that young plants and animals are similar, but not exactly like, their parents. ***LC-1-LS3-1a Make observations to identify a similarity or a difference in an external feature (e.g., shape of ears) between young animals and their parents.*** ***LC-1-LS3-1b Make observations to identify a similarity or a difference in an external feature (e.g., shape of leaves) between young plants and their parents.***

Science and Engineering Practice	**Disciplinary Core Idea**	**Crosscutting Concept**
Constructing explanations and designing solutions: Constructing explanations (science) and designing solutions (engineering) in K-2 builds on prior experiences and progresses to the use of evidence and ideas in constructing evidence-based accounts of natural phenomena and designing solutions. • Make observations to construct an evidence-based account for natural phenomena. ***Making observations can be used to gather information.*** ***Make observations to describe natural phenomena.*** ***Observational evidence can be used to describe natural phenomena.*** ***Observational evidence can be used to explain natural phenomena.***	**INHERITANCE OF TRAITS** Young animals are very much, but not exactly like, their parents. Plants also are very much, but not exactly like, their parents. (LE.LS3A.a) ***The offspring of some plants and animals resemble the parents.*** ***Young animals are like their parents, but not exactly the same.*** ***Young plants are like their parents, but not exactly the same.*** ***The offspring of some plants and animals do not resemble the parents.*** ***Similarities between parents and their offspring become more apparent as their life cycle continues.*** **VARIATION OF TRAITS** Individuals of the same kind of plant or animal are recognizable as similar but can also vary in many ways. (LE.LS3B.a) ***Animals of the same kind can have similar characteristics.*** ***Animals of the same kind can have major differences from each other.*** ***Plants of the same kind can have similar characteristics.*** ***Plants of the same kind can have major differences from each other.***	**PATTERNS** Patterns in the natural and human-designed world can be observed, used to describe phenomena, and used as evidence. ***Patterns in the world (natural and human-designed) can be observed.*** ***Patterns in the world (natural and human-designed) can be used to describe phenomena.*** ***Patterns in the world (natural and human-designed) can be used as evidence.***

Clarification Statement
Examples of observations could include: leaves from the same kind of plant are similar in shape but can differ in size, or a particular breed of dog looks like its parents but is not exactly the same. Examples of patterns could include features that plants or animals share.

Performance Expectation *and Louisiana Connectors*
1-ESS1-1 Use observations of the sun, moon, and stars to describe patterns that can be predicted. ***LC-1-ESS1-1a Use observations to describe patterns of movement of the sun, moon, and stars as seen from Earth.*** ***LC-1-ESS1-1b Use observations of patterns of movement to predict appearances of the sun or moon.***

Science and Engineering Practice	**Disciplinary Core Idea**	**Crosscutting Concept**
Analyzing and interpreting data: Analyzing and interpreting data in K-2 builds on prior experiences and progresses to collecting, recording, and sharing observations. • Use observations to describe patterns in the natural world in order to answer scientific questions. ***Use observations to determine patterns in the world.*** ***Use observations to answer scientific questions.***	**THE UNIVERSE AND ITS STARS** Patterns of the motion of the sun, moon, and stars in the sky can be observed, described, and predicted. (LE.ESS1A.a) ***Some objects are visible in the sky during the day (i.e., sun, moon, stars).*** ***Some objects are visible in the sky at night (i.e., sun, moon, stars).*** ***The sun and moon appear to move slowly across the sky.*** ***People can observe patterns of where the sun, moon, and stars are in the sky.*** ***Patterns in the motion of the sun, moon, and stars in the sky can be observed (i.e., the sun and moon can be seen at different positions during the day and night).*** ***Patterns in the motion of the sun, moon, and stars in the sky can be predicted.***	**PATTERNS** Patterns in the natural and human-designed world can be observed, used to describe phenomena, and used as evidence. ***Patterns in the world (natural and human-designed) can be observed.*** ***Patterns in the world (natural and human-designed) can be used to describe phenomena.*** ***Patterns in the world (natural and human-designed) can be used as evidence.***

Clarification Statement
Examples of patterns could include that the sun and moon appear to rise in one part of the sky, move across the sky, and set; and stars other than our sun are visible at night but not during the day.

Performance Expectation *and Louisiana Connectors*
1-ESS1-2 Make observations at different times of year to relate the amount of daylight to the time of year. ***LC-1-ESS1-2a Use observations to make relative comparisons between the amount of daylight in the winter to the amount of daylight in the spring or fall.***

Science and Engineering Practice	**Disciplinary Core Idea**	**Crosscutting Concept**
Planning and carrying out investigations: Planning and carrying out investigations to answer questions or test solutions to problems in K-2 build on prior experiences and progresses to simple investigations, based on fair tests, which provide data to support explanations or design solutions. • Make observations to collect data that can be used to make comparisons. ***Make observations to collect data.*** ***Use data to make comparisons.***	**EARTH AND THE SOLAR SYSTEM** Seasonal patterns of sunrise and sunset can be observed, described, and predicted. (LE.ESS1B.a) ***Seasonal changes of sunrise and sunset can be observed.*** ***Seasonal changes can be described by observing patterns in the sunrise and sunset.*** ***Seasonal changes can be predicted by observing patterns in the sunrise and sunset.***	**PATTERNS** Patterns in the natural and human-designed world can be observed, used to describe phenomena, and used as evidence. ***Patterns in the world (natural and human-designed) can be observed.*** ***Patterns in the world (natural and human-designed) can be used to describe phenomena.*** ***Patterns in the world (natural and human-designed) can be used as evidence.***

Clarification Statement
Emphasis is on relative comparisons of the amount of daylight in the winter to the amount in the spring, fall, or summer.

Performance Expectation *and Louisiana Connectors*
2-PS1-1 Plan and conduct an investigation to describe and classify different kinds of materials by their observable properties. ***LC-2-PS1-1a Use data to describe different kinds of materials by their observable properties (e.g., color, texture).*** ***LC-2-PS1-1b Use data to classify different kinds of materials by their observable properties (e.g., color, texture).***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Planning and carrying out investigations: Planning and carrying out investigations to answer questions (science) or test solutions (engineering) to problems in K-2 builds on prior experiences and progresses to simple investigations, based on fair tests, which provide data to support explanations or design solutions. • Plan and conduct investigations collaboratively to produce data to serve as the basis for evidence to answer a question. ***Plan investigations collaboratively to produce data to answer a question.*** ***Conduct investigations collaboratively to produce data to answer a question.***	**STRUCTURE AND PROPERTIES OF MATTER** Different kinds of matter exist and many of them can be either solid or liquid, depending on temperature. Matter can be described and classified by its observable properties. (LE.PS1A.c) ***Different kinds of matter exists.*** ***Matter is all around us and can be found as a solid or a liquid, depending on its temperature.*** ***Matter can be described by its observable properties.*** ***Matter can be classified by its observable properties.*** ***Materials can be described and classified according to the following physical properties: size, shape, mass, texture, color, and material composition.***	**PATTERNS** Patterns in the natural and human-designed world can be observed, used to describe phenomena, and used as evidence. ***Patterns in the world (natural and human-designed) can be observed.*** ***Patterns in the world (natural and human-designed) can be used to describe phenomena.*** ***Patterns in the world (natural and human-designed) can be used as evidence.***

Clarification Statement
Observations could include color, texture, hardness, or flexibility. Patterns could include the similar properties that different materials share.

Performance Expectation *and Louisiana Connectors*
2-PS1-2 Analyze data obtained from testing different materials to determine which materials have the properties that are best suited for an intended purpose. ***LC-2-PS1-2a Match a property of a material (e.g., hard, flexible, absorbent) to a potential purpose (e.g., hardness of a wooden shelf results in it being better suited for supporting materials than a soft sponge).***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Planning and carrying out investigations: Planning and carrying out investigations to answer questions (science) or test solutions (engineering) to problems in K-2 builds on prior experiences and progresses to simple investigations, based on fair tests, which provide data to support explanations or design solutions. • Plan and conduct investigations collaboratively to produce data to serve as the basis for evidence to answer a question. ***Plan investigations collaboratively to produce data to answer a question.*** ***Conduct investigations collaboratively to produce data to answer a question.***	**STRUCTURE AND PROPERTIES OF MATTER** Different properties are suited to different purposes. (LE.PS1A.a) ***Materials can have different properties (e.g., flexibility, hardness, texture).*** ***Properties of materials can be used to determine how a material could be used.*** ***The properties of materials influence their use.*** ***Some materials are more suitable for making a particular product or device.***	**CAUSE AND EFFECT** Simple tests can be designed to gather evidence to support or refute student ideas about causes. ***Simple tests can be designed to gather evidence about cause and effect relationships.*** ***Evidence from simple tests can support ideas about causes.*** ***Evidence from simple tests can refute ideas about causes.***

Clarification Statement
Examples of properties could include strength, flexibility, hardness, texture, or absorbency.

Performance Expectation *and Louisiana Connectors*
2-PS1-3 Make observations to construct an evidence-based account of how an object made of a small set of pieces can be disassembled and made into a new object. ***LC-2-PS1-3a Identify how a variety of objects can be built up from a small set of pieces.***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Constructing explanations and designing solutions: Constructing explanations (science) and designing solutions (engineering) in K-2 builds on prior experiences and progresses to the use of evidence and ideas in constructing evidence-based accounts of natural phenomena and designing solutions. • Make observations (firsthand or from media) to construct an evidence-based account for natural phenomena. ***Making observations can be used to gather information.*** ***Make observations to describe natural phenomena.*** ***Observational evidence can be used to describe natural phenomena.*** ***Observational evidence can be used to explain natural phenomena.***	**STRUCTURE AND PROPERTIES OF MATTER** Different properties are suited to different purposes. (LE.PS1A.a) ***Materials can have different properties (e.g., flexibility, hardness, texture).*** ***Properties of materials can be used to determine how a material could be used.*** ***The properties of materials influence their use.*** ***Some materials are more suitable for making a particular product or device.*** A great variety of objects can be built up from a small set of pieces. (LE.PS1A.b) ***Sometimes materials are used to make parts that can be put together to create a variety of objects.***	**ENERGY AND MATTER** Objects may break into smaller pieces, be put together into larger pieces, or change shapes. ***Objects can be broken down into smaller pieces.*** ***Objects can be built from a smaller set of pieces.*** ***Objects can be put together to form new shapes.***

Clarification Statement
Examples of pieces could include blocks, building bricks, or other assorted small objects. Provide students with the same number of objects to create a different object.

Performance Expectation ***and Louisiana Connectors***
2-PS1-4 Construct an argument with evidence that some changes caused by heating or cooling can be reversed and some cannot. ***LC-2-PS1-4a Identify examples of heating substances which cause changes that are sometimes reversible and sometimes not.*** ***LC-2-PS1-4b Identify examples of cooling substances which cause changes that are sometimes reversible and sometimes not.***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Engaging in argument from evidence: Engaging in argument from evidence in K-2 builds on prior experiences and progresses to comparing ideas and representations about the natural and designed world(s). • Construct an argument with evidence to support a claim. ***Construct an argument using a claim and support with evidence.*** ***Observational data may be used to support claims.*** ***Numerical data may be used to support claims.***	**CHEMICAL REACTIONS** Heating or cooling a substance may cause changes that can be observed. Sometimes these changes are reversible, and sometimes they are not. (LE.PS1B.a) ***Heating a substance may cause observable changes.*** ***Cooling a substance may cause observable changes.*** ***Sometimes changes to a substance from solid to liquid or liquid to solid can be reversed by heating or cooling.*** ***Sometimes changes to a substance from solid to liquid or liquid to solid cannot be reversed by heating or cooling.***	**CAUSE AND EFFECT** Events have causes that generate observable patterns. ***One event can cause another event to occur. Sometimes this produces a pattern of events.***

Clarification Statement
Demonstrations of reversible changes could include materials such as water, butter or crayons at different temperatures. Demonstrations of irreversible changes could include cooking an egg, freezing a plant leaf, or heating paper.

Performance Expectation *and Louisiana Connectors*
2-LS2-1 Plan and conduct an investigation to determine if plants need sunlight and water to grow. ***LC-2-LS2-1a Use data to describe that plants need water and light to grow.***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Planning and carrying out investigations: Planning and carrying out investigations to answer questions (science) or test solutions (engineering) to problems in K-2 builds on prior experiences and progresses to simple investigations, based on fair tests, which provide data to support explanations or design solutions. • Plan and conduct investigations collaboratively to produce data to serve as the basis for evidence to answer a question. ***Plan investigations collaboratively to produce data to answer a question.*** ***Conduct investigations collaboratively to produce data to answer a question.***	**INTERDEPENDENT RELATIONSHIPS IN ECOSYSTEMS** Plants depend on water and light to grow. (LE.LS2A.a) ***Plants are living things that need sunlight and water to grow.***	**CAUSE AND EFFECT** Events have causes that generate observable patterns. ***One event can cause another event to occur. Sometimes this produces a pattern of events.***

Clarification Statement
Emphasis is on testing one variable at a time during investigations.

Performance Expectation *and Louisiana Connectors*
2-LS2-2 Develop a simple model that mimics the function of an animal in dispersing seeds or pollinating plants. ***LC-2-LS2-2a Identify that plants need animals to move their seeds around.*** ***LC-2-LS2-2b Identify a simple model that mimics the function of an animal in dispersing seeds or pollinating plants.***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Developing and using models: Modeling in K-2 builds on prior experiences and progresses to include using and developing models (e.g., diagram, drawing, physical replica, diorama, dramatization, storyboard) that represent concrete events or design solutions. • Develop a simple model based on evidence to represent a proposed object or tool. ***Develop a model to represent a proposed object.*** ***Develop a model to represent a proposed tool.***	**INTERDEPENDENT RELATIONSHIPS IN ECOSYSTEMS** Plants may depend on animals for pollination or to move their seeds around. (LE.LS2A.b) ***Plants depend on insects and animals to help with pollination in order for more plants to grow.*** ***Plants depend on insects and animals to help with seed dispersal in order for more plants to grow.***	**STRUCTURE AND FUNCTION** The shape and stability of structures of natural and designed objects are related to their function(s). ***The shape of structures in the world (natural and human-designed) are related to their function(s).*** ***The stability of structures in the world (natural and human-designed) are related to their function(s).*** ***Shape and stability are related for a variety of structures.***

Clarification Statement
Students could use the model to describe: (1) How the structure of the model gives rise to its function; and (2) Structure-function relationships in the natural world that allow some animals to disperse seeds or pollinate plants.

Performance Expectation *and Louisiana Connectors*
2-LS4-1 Make observations of plants and animals to compare the diversity of life in different habitats. ***LC-2-LS4-1a Make observations to explain that different kinds of living things live in different habitats on land and in water.***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Planning and carrying out investigations: Planning and carrying out investigations to answer questions (science) or test solutions (engineering) to problems in K-2 builds on prior experiences and progresses to simple investigations, based on fair tests, which provide data to support explanations or design solutions. • Make observations and/or measurements to collect data that can be used to make comparisons. ***Make observations to collect data.*** ***Use data to make comparisons.***	**BIODIVERSITY AND HUMANS** There are many kinds of living things in any area, and they exist in different places on land, in water, and in air. (LE.LS4D.a) ***Around the world, plants and animals live in a variety of places on land, in water, and in air.*** ***There are several different land habitats (e.g., garden, forest, and dessert) and water habitats (e.g., swamp, pond, lake, and stream).*** ***Different types of plants are found in different habitats.*** ***Different animals live in different habitats.***	**PATTERNS** Patterns in the natural and human-designed world can be observed, used to describe phenomena, and used as evidence. ***Patterns in the world (natural and human-designed) can be observed.*** ***Patterns in the world (natural and human-designed) can be used to describe phenomena.*** ***Patterns in the world (natural and human-designed) can be used as evidence.***

Clarification Statement
Emphasis is on the diversity of living things in each of a variety of different habitats. Students could explore different habitats in the community (e.g., school, aquariums, and neighborhoods).

Performance Expectation *and Louisiana Connectors*
2-LS4-1 Make observations of plants and animals to compare the diversity of life in different habitats. ***LC-2-LS4-1a Make observations to explain that different kinds of living things live in different habitats on land and in water.***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Planning and carrying out investigations: Planning and carrying out investigations to answer questions (science) or test solutions (engineering) to problems in K-2 builds on prior experiences and progresses to simple investigations, based on fair tests, which provide data to support explanations or design solutions. • Make observations and/or measurements to collect data that can be used to make comparisons. ***Make observations to collect data.*** ***Use data to make comparisons.***	**BIODIVERSITY AND HUMANS** There are many kinds of living things in any area, and they exist in different places on land, in water, and in air. (LE.LS4D.a) ***Around the world, plants and animals live in a variety of places on land, in water, and in air.*** ***There are several different land habitats (e.g., garden, forest, and dessert) and water habitats (e.g., swamp, pond, lake, and stream).*** ***Different types of plants are found in different habitats.*** ***Different animals live in different habitats.***	**PATTERNS** Patterns in the natural and human-designed world can be observed, used to describe phenomena, and used as evidence. ***Patterns in the world (natural and human-designed) can be observed.*** ***Patterns in the world (natural and human-designed) can be used to describe phenomena.*** ***Patterns in the world (natural and human-designed) can be used as evidence.***

Clarification Statement
Emphasis is on the diversity of living things in each of a variety of different habitats. Students could explore different habitats in the community (e.g., school, aquariums, and neighborhoods).

Performance Expectation *and Louisiana Connectors*
2-ESS1-1 Use information from several sources to provide evidence that Earth events can occur quickly or slowly. ***LC-2-ESS1-1a Use evidence to understand that some Earth events happen quickly and can be observed (e.g., flood, volcano eruption, earthquake, or erosion of soil).*** ***LC-2-ESS1-1b Use evidence to understand that some Earth events happen slowly (e.g., erosion or weathering of rocks).***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Obtaining, evaluating, and communicating information: Obtaining, evaluating, and communicating information in K-2 builds on prior experiences and uses observations and texts to communicate new information. • Obtain information using various texts, text features (e.g., headings, tables of contents, glossaries, electronic menus, icons), and other media that will be useful in answering a scientific question and/or supporting a scientific claim. ***Read various texts to answer scientific questions.*** ***Read various texts to support a scientific claim.*** ***Use various forms of media to answer scientific questions.*** ***Use various forms of media to support a scientific claim.***	**THE HISTORY OF PLANET EARTH** Some events happen very quickly; others occur very slowly, over a time period much longer than one can observe. (LE.ESS1C.a) ***Changes happen to the Earth every day.*** ***Change can occur slowly or quickly.*** ***Earth is always changing.*** ***We can observe changes in the Earth every day.*** ***Some events are slow moving and evolve over time.*** ***Weathering of rocks and erosion are some events that occur very slowly.*** ***Flooding, severe storms, volcanic eruptions, earthquakes, landslides and erosion of soil can occur quickly.*** **DEFINING AND DELIMITING ENGINEERING PROBLEMS** Asking questions, making observations, and gathering information are helpful in thinking about problems. (ETS.LE.1A.b) ***Ask questions and gather information to define problems.*** ***Make observations to define problems.*** ***Before engineers develop a solution to a problem, they ask questions to understand the problems that people face.*** ***Questions allow scientists to define the problems that require solutions.*** ***Scientists must determine the problems in order to gather information and design solutions.*** ***The process of gathering information through the senses is called observation.***	**STABILITY AND CHANGE** Things may change slowly or rapidly. ***In the world, things may change slowly.*** ***In the world, things may change rapidly.***

Clarification Statement
Examples of events and timescales could include volcanic explosions and earthquakes, which happen quickly, and erosion of rocks, which occurs slowly.

Performance Expectation *and Louisiana Connectors*
2-ESS2-1 Compare multiple solutions designed to slow or prevent wind or water from changing the shape of the land. ***LC-2-ESS2-1a Identify a solution (e.g., using shrubs, grass, or trees) to slow or prevent wind from changing the shape of the land.*** ***LC-2-ESS2-2b Identify a solution (e.g., using shrubs, grass, or trees) to slow or prevent water from changing the shape of the land.***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Constructing explanations and designing solutions: Constructing explanations (science) and designing solutions (engineering) in K-2 builds on prior experiences and progresses to the use of evidence and ideas in constructing evidence-based accounts of natural phenomena and designing solutions. • Generate and/or compare multiple solutions to a problem. ***Generate solutions to a problem.*** ***Compare solutions to a problem.***	**EARTH MATERIALS AND SYSTEMS** Wind and water can change the shape of the land. (LE.ESS2A.a) ***Wind can cause changes in the land.*** ***Water can cause changes in the shape of the land.*** ***Wind can cause changes in the shape of land by blowing or moving away soil or sand.*** ***Water can cause changes in the shape of land by blowing or moving away soil or sand.*** **OPTIMIZING THE DESIGN SOLUTION** Because there is always more than one possible solution to a problem, it is useful to compare and test designs. (LE.ETS1C.a) ***Design solutions can be shared with others as sketches or drawings.*** ***Design solutions can be shared with others as models.*** ***It is important to communicate information about solutions with others.*** ***Testing and comparing designs can provide solutions to a problem.***	**STABILITY AND CHANGE** Things may change slowly or rapidly. ***In the world, things may change slowly.*** ***In the world, things may change rapidly.***

Clarification Statement
Examples of solutions could include different designs of dikes and windbreaks to hold back wind and water, and different designs for using shrubs, grass, and trees to hold back the land.

Performance Expectation *and Louisiana Connectors*
2-ESS2-2 Develop a model to represent the shapes and kinds of land and bodies of water in an area. *LC-2-ESS2-2a Use a model to Identify land features and bodies of water (e.g., hill, lake) in an area using a model.*

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Developing and using models: Modeling in K-2 builds on prior experiences and progresses to include using and developing models (i.e., diagram, drawing, physical replica, diorama, dramatization, storyboard) that represent concrete events or design solutions. • Develop and/or use a model to represent amounts, relationships, relative scales (bigger, smaller), and/or patterns in the natural and designed world(s). ***Develop models that can be used to show relationships in the world (natural and human-designed).*** ***Develop models that can be used to show different amounts or scales (bigger, smaller) in the world (natural and human-designed).*** ***Develop models that can be used to show patterns in the world (natural and human-designed).***	**PLATE TECTONICS AND LARGE-SCALE SYSTEM INTERACTIONS** Maps show where things are located. One can map the shapes and kinds of land and water in any area. (LE.ESS2B.a) ***Maps give us information about the land around us.*** ***Maps can show where to find different types of landforms.*** ***Maps can show where to find bodies of water.*** ***Maps can show us the shapes of landforms and bodies of water on Earth.*** ***Maps give us different kinds of information depending upon the type of map we are using.*** **DEVELOPING POSSIBLE SOLUTIONS** Designs can be conveyed through sketches, drawings, or physical models. These representations are useful in communicating ideas for solutions to a problem. (ETS.LE.1B.a) ***A model expresses ideas and concepts which can be used to interpret observations and experiments.*** ***Design solutions can be shared with others as sketches or drawings.*** ***Design solutions can be shared with others as models.*** ***It is important to communicate information about solutions with others.***	**PATTERNS** Patterns in the natural and human-designed world can be observed, used to describe phenomena, and used as evidence. ***Patterns in the world (natural and human-designed) can be observed.*** ***Patterns in the world (natural and human-designed) can be used to describe phenomena.*** ***Patterns in the world (natural and human-designed) can be used as evidence.***

Clarification Statement
Models do not have to be to scale.

Performance Expectation *and Louisiana Connectors*
2-ESS2-3 Obtain and communicate information to identify where water is found on Earth and that it can be solid or liquid. ***LC-2-ESS2-3a Use information to identify that water is found in many types of places.*** ***LC-2-ESS2-3b Use information to identify that that water exists as solid ice and in liquid form.***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Obtaining, evaluating, and communicating information: Obtaining, evaluating, and communicating information in K-2 builds on prior experiences and uses observations and texts to communicate new information. • Obtain information using various texts, text features (e.g., headings, tables of contents, glossaries, electronic menus, icons), and other media that will be useful in answering a scientific question and/or supporting a scientific claim. ***Read various texts to answer scientific questions.*** ***Read various texts to support a scientific claim.*** ***Use various forms of media to answer scientific questions.*** ***Use various forms of media to support a scientific claim.***	**THE ROLES OF WATER IN EARTH'S SURFACE PROCESSES** Water is found in the ocean, rivers, lakes, and ponds. Water exists as solid ice and in liquid form. (LE.ESS2C.a) ***On Earth, water is found in oceans, rivers, lakes, and ponds.*** ***This water can be solid or liquid in form.***	**PATTERNS** Patterns in the natural and human-designed world can be observed, used to describe phenomena, and used as evidence. ***Patterns in the world (natural and human-designed) can be observed.*** ***Patterns in the world (natural and human-designed) can be used to describe phenomena.*** ***Patterns in the world (natural and human-designed) can be used as evidence.***

Clarification Statement
Students use reliable sources to identify the patterns of where water is found and its natural form (solid or liquid). Examples of how water can be found on Earth as water or ice could include a frozen pond, a liquid pond, a frozen lake, or a liquid lake.

Performance Expectation *and Louisiana Connectors*
3-PS2-1 Plan and conduct an investigation to provide evidence of the effects of balanced and unbalanced forces on the motion of an object. ***LC-3-PS2-1a Identify ways to change the motion of an object (e.g., number, size, or direction of forces).*** ***LC-3-PS2-1b Describe how objects in contact exert forces on each other.***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Planning and carrying out investigations: Planning and carrying out investigations to answer questions (science) or test solutions (engineering) to problems in 3-5 builds on K-2 experiences and progresses to include investigations that control variables and provide evidence to support explanations or design solutions. • Plan and conduct an investigation collaboratively to produce data to serve as the basis for evidence, using fair tests in which variables are controlled and the number of trials considered. ***Plan investigations collaboratively to produce data to serve as the basis for evidence.*** ***Conduct investigations collaboratively to produce data to serve as the basis for evidence.*** ***Plan investigations collaboratively using fair tests in which variables are controlled and the number of trials considered.***	**FORCES AND MOTION** Each force acts on one particular object and has both strength and a direction. An object at rest typically has multiple forces acting on it but they add to give zero net force on the object. (UE.PS2A.a) ***A force is a push or pull.*** ***A force can cause an object to start moving, stop moving, or change the object's direction.*** ***All forces have strength and direction.*** ***Forces typically occur in pairs and can be either balanced or unbalanced.*** ***When balanced forces act on an object it will remain at rest, but if unbalanced forces act on the object it will begin to move.*** ***If an object is not moving, the total of the forces acting on it have a sum of zero.*** Forces that do not sum to zero can cause changes in the object's speed or direction of motion. (Qualitative and conceptual, but not quantitative addition of forces are used at this level.) (UE.PS2A.b) ***The motion of an object depends on the effects of multiple forces.*** ***If an object is moving, the total of the forces acting on it do not have a sum of zero.*** ***When unbalanced forces are applied to an object, they can cause the object to increase in speed or change in direction.*** **TYPES OF INTERACTIONS** Objects in contact exert forces on each other. (UE.PS2B.a) ***Whenever there is an interaction between two objects, there is a force upon each of the objects.***	**CAUSE AND EFFECT** Cause and effect relationships are routinely identified, tested, and used to explain change. ***Cause and effect relationships may be identified.*** ***Cause and effect relationships may be tested.*** ***Cause and effect relationships may be used to explain change.***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Conduct investigations collaboratively using fair tests in which variables are controlled and the number of trials considered.	***When two objects are no longer in contact with one another, the two objects no longer experience the force.***	

Clarification Statement
Examples could include an unbalanced force on one side of an object that can make it start moving, or balanced forces pushing on an object from opposite sides will not produce any motion at all. Investigations include one variable at a time: number, size, or direction of forces.

Performance Expectation *and Louisiana Connectors*
3-PS2-2 Make observations and/or measurements of an object's motion to provide evidence that a pattern can be used to predict future motion. ***LC-3-PS2-2a Describe the patterns of an object's motion in various situations (e.g., a pendulum swinging, a ball moving on a curved track, a magnet repelling another magnet).*** ***LC-3-PS2-2b Predict future motion of an object given its pattern of motion.***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Planning and carrying out investigations: Planning and carrying out investigations to answer questions (science) or test solutions (engineering) to problems in 3-5 builds on K-2 experiences and progresses to include investigations that control variables and provide evidence to support explanations or design solutions. • Make observations and/or measurements to produce data to serve as the basis for evidence for an explanation of a phenomenon or test a design solution. ***Make observations to collect data.*** ***Make measurements to collect data.*** ***Use data to as evidence for an explanation of a phenomenon.***	**FORCES AND MOTION** The patterns of an object's motion in various situations can be observed and measured; when that past motion exhibits a regular pattern, future motion can be predicted from it. (Technical terms, such as magnitude, velocity, momentum, and vector quantity, are not introduced at this level, but the concept that some quantities need both size and direction to be described is developed.) (UE.PS2A.c) ***Some objects move in a pattern (e.g., a pendulum swinging, a ball moving on a curved track, a magnet repelling another magnet).*** ***The patterns changing an object's motion can be observed and measured.*** ***The motion of an object can typically be observed and measured.*** ***Regular patterns changing an object's motion can be used to predict future motion.***	**PATTERNS** Patterns of change can be used to make predictions. ***A regular pattern of events can be used to predict a future event.***

Clarification Statement
Examples of motion with a predictable pattern could include a child swinging in a swing, a ball rolling back and forth in a bowl, or two children on a see-saw.

Performance Expectation *and Louisiana Connectors*
3-PS2-3 Ask questions to determine cause and effect relationships of electric or magnetic interactions between two objects not in contact with each other. ***LC-3-PS2-3a Ask questions to identify cause and effect relationships of magnetic interactions between two objects not in contact with each other (e.g., how the orientation of magnets affects the direction of the magnetic force).*** ***LC-3-PS2-3b Ask questions to identify cause and effect relationships of electric interactions (e.g., the force on hair from an electrically charged balloon) between two objects not in contact with each other (e.g., how the distance between objects affects the strength of the force).***

Science and Engineering Practice	**Disciplinary Core Idea**	**Crosscutting Concept**
Asking questions and defining problems: Asking questions (science) and defining problems (engineering) in 3-5 builds on K-2 experiences and progresses to specifying qualitative relationships. • Ask questions that can be investigated and predict reasonable outcomes based on patterns such as cause and effect relationships. ***Scientific questions arise in a variety of ways.*** ***Ask scientific questions to which the answers can be supported through investigation.*** ***Questions can be about the prediction of outcomes based on cause and effect relationships.***	**TYPES OF INTERACTIONS** Electric and magnetic forces between a pair of objects do not require that the objects be in contact. The sizes of the forces in each situation depend on the properties of the objects and their distances apart and, for forces between two magnets, on their orientation relative to each other. (UE.PS2B.b) ***There are some forces (e.g., electric and magnetic) that can change the motion of an object without having contact with that object.*** ***Magnets attract or repel other magnets and objects.*** ***Magnets can move objects without touching them.*** ***The size of the force depends on the properties of the objects.*** ***The size of the force also depends on the distance between the objects.*** ***The forces between two magnets depends on their orientation relative to each other.***	**CAUSE AND EFFECT** Cause and effect relationships are routinely identified, tested, and used to explain change. ***Cause and effect relationships may be identified.*** ***Cause and effect relationships may be tested.*** ***Cause and effect relationships may be used to explain change.***

Clarification Statement
Examples of an electric force could include the force on hair from an electrically charged balloon or the electrical forces between a charged rod and pieces of paper; examples of a magnetic force could include the force between two permanent magnets, the force between an electromagnet and steel paper clips, or

Clarification Statement
the force exerted by one magnet versus the force exerted by two magnets. Examples of cause and effect relationships could include how the distance between objects affects the strength of the force or how the orientation of magnets affects the direction of the magnetic force. Examples could include forces produced by objects that can be manipulated by students, or electrical interactions could include static electricity.

Performance Expectation *and Louisiana Connectors*
3-PS2-4 Define a simple design problem that can be solved by applying scientific ideas about magnets. ***LC-3-PS2-4a Identify and describe the scientific ideas necessary for solving a given problem about magnets (e.g., size of the force depends on the properties of objects, distance between the objects, and orientation of magnetic objects relative to one another).***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Asking questions and defining problems: Asking questions (science) and defining problems (engineering) in 3-5 builds on K-2 experiences and progresses to specifying qualitative relationships. • Define a simple design problem that can be solved through the development of an object, tool, process, or system and includes several criteria for success and constraints on materials, time, or cost. ***A simple design problem can be solved with the development of a new or improved object, tool, or process.*** ***Develop an object which solves a problem using a simple design.*** ***Develop a tool which solves a problem using a simple design.*** ***Develop a process which solves a problem using a simple design.*** ***Develop a system which solves a problem using a simple design.*** ***Consider criteria for success of a***	**TYPES OF INTERACTIONS** Electric and magnetic forces between a pair of objects do not require that the objects be in contact. The sizes of the forces in each situation depend on the properties of the objects and their distances apart and, for forces between two magnets, their orientation relative to each other. (UE.PS2B.b) ***There are some forces (e.g., electric and magnetic) that can change the motion of an object without having contact with that object.*** ***Magnets attract or repel other magnets and objects.*** ***Magnets can move objects without touching them.*** ***The size of the force depends on the properties of the objects.*** ***The size of the force also depends on the distance between the objects.*** ***The forces between two magnets depends on their orientation relative to each other.*** **DEFINING AND DELIMITING ENGINEERING PROBLEMS** Possible solutions to a problem are limited by available materials and resources (constraints). The success of a designed solution is determined by considering the desired features of a solution (criteria). Different proposals for solutions can be compared on the basis of how well each one meets the specified criteria for success or how well each takes the constraints into account. (UE.ETS1A.a) ***Possible limits to a design can be in terms of materials, time, or cost.*** ***The criteria for success of a design must be determined.*** ***Solutions can be compared on how well they each solve the problem.*** ***Solutions can be compared on how well they each take the constraints into account.***	**PATTERNS** Patterns can be used as evidence to support an explanation. ***Patterns can be used as evidence.*** ***Patterns can be used to support an explanation.***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
design. ***Consider limits to a design in terms of materials, time, or cost.***		

Clarification Statement
Examples of problems could include constructing a latch to keep a door shut or creating a device to keep two moving objects from touching each other.

Performance Expectation *and Louisiana Connectors*
3-LS1-1 Develop models to describe that organisms have unique and diverse life cycles but all have in common birth, growth, reproduction, and death. ***LC-3-LS1-1a Identify that organisms have unique and diverse life cycles.*** ***LC-3-LS1-1b Identify a common pattern between models of different life cycles.***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Developing and using models: Modeling in 3-5 builds on K-2 experiences and progresses to building and revising simple models and using models to represent events and design solutions. • Develop and/or use models to describe and/or predict phenomena. ***Use models to describe phenomena.*** ***Use models to predict phenomena.***	**GROWTH AND DEVELOPMENT OF ORGANISMS** Reproduction is essential to the continued existence of every kind of organism. Plants and animals have unique and diverse life cycles. (UE.LS1B.a) ***Organisms must reproduce in order for their population to survive.*** ***Organisms (both plants and animals) have different life cycles.*** ***All plants and animals go through a life cycle of birth, growth, development, reproduction, and death.*** ***Patterns in life cycles are describable and differ from organism to organism.***	**PATTERNS** Patterns of change can be used to make predictions. ***A regular pattern of events can be used to predict a future event.***

Clarification Statement
Changes that organisms go through during their lives form a pattern. For plant life cycles there is an emphasis on flowering plants.

Performance Expectation *and Louisiana Connectors*
3-LS2-1 Construct and support an argument that some animals form groups that help members survive. ***LC-3-LS2-1a Describe that animals within a group help the group obtain food for survival, defend themselves, and survive changes in their ecosystem.***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Engaging in argument from evidence: Engaging in argument from evidence in 3-5 builds on K-2 experiences and progresses to critiquing the scientific explanations or solutions proposed by peers by citing relevant evidence about the natural and designed world(s). • Construct and/or support an argument with evidence, data, and/or a model. ***Use evidence to construct an argument.*** ***Use evidence to support an argument.*** ***Use data to construct an argument.*** ***Use data to support an argument.*** ***Use a model to construct an argument.*** ***Use a model to support an argument.***	**SOCIAL INTERACTIONS AND GROUP BEHAVIOR** Being part of a group helps animals obtain food, defend themselves, and cope with changes. Groups may serve different functions and vary dramatically in size. (UE.LS2D.a) ***Being part of a group helps some animals obtain food.*** ***Being part of a group helps some animals defend themselves.*** ***Being part of a group helps some animals cope with changes in the environment.*** ***The structure of groups of animals may serve many purposes.*** ***Groups of animals vary in size.***	**SYSTEMS AND SYSTEM MODELS** A system is a group of related parts that make up a whole and can carry out functions its individual parts cannot. ***A system is a group of related parts.*** ***A system works as a whole unit.*** ***A system is able to perform functions that its individual part cannot.***

Clarification Statement
Arguments could include examples of group behavior such as division of labor in a bee colony, flocks of birds staying together to confuse or intimidate predators, or wolves hunting in packs to more efficiently catch and kill prey.

Performance Expectation *and Louisiana Connectors*
3-LS3-1 Analyze and interpret data to provide evidence that plants and animals have traits inherited from their parents and that variation of these traits exists in a group of similar organisms. ***LC-3-LS3-1a Identify similarities in the traits of a parent and the traits of an offspring.*** ***LC-3-LS3-1b Identify that characteristics of organisms are inherited from their parents.*** ***LC-3-LS3-1c Identify variations in similar traits in a group of similar organisms.***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Analyzing and interpreting data: Analyzing data in 3-5 builds on K-2 experiences and progresses to introducing quantitative approaches to collecting data and conducting multiple trials of qualitative observations. When possible and feasible, digital tools should be used. • Analyze and interpret data to make sense of phenomena, using logical reasoning, mathematics, and/or computation. ***Use logical reasoning to interpret data to make sense of phenomena.*** ***Use mathematics to interpret data to make sense of phenomena.*** ***Use computation to interpret data to make sense of phenomena.*** ***Analyze data to make sense of phenomena.***	**INHERITANCE OF TRAITS** Many characteristics of organisms are inherited from their parents. (UE.LS3A.a) ***Organisms inherit characteristics from parents.*** ***Organisms reproduce, develop, have predictable life cycles, and pass on many characteristics to their offspring.*** **VARIATION OF TRAITS** Different organisms vary in how they look and function because they have different inherited information. (UE.LS3B.a) ***Characteristics can vary within groups of similar organisms.*** ***Characteristics can vary within groups of similar organisms because of differences in what they inherited from their parents.*** ***Organisms with two parents inherit characteristics of both parents.***	**PATTERNS** Similarities and differences in patterns can be used to sort, classify, communicate and analyze simple rates of change for natural phenomena and designed products. ***Similarities and differences in patterns can be used to sort simple rates of change (natural phenomena and designed products).*** ***Similarities and differences in patterns can be used to classify simple rates of change (natural phenomena and designed products).*** ***Similarities and differences in patterns***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
		can be used to analyze simple rates of change (natural phenomena and designed products).

Clarification Statement
Emphasis is on organisms other than humans and does not include genetic mechanisms of inheritance and prediction of traits. Data can include drawings, photographs, measurements, or written observations. Patterns are the similarities and differences in traits shared between offspring and their parents, or among siblings.

Performance Expectation *and Louisiana Connectors*
3-LS3-2 Use evidence to support the explanation that traits can be influenced by the environment. ***LC-3-LS3-1a Identify examples of inherited traits that vary between organisms of the same type.*** ***LC-3-LS3-1b Identify a cause and effect relationship between an environmental factor and its effect on a given variation in a trait (e.g., not enough water produces plants that have fewer flowers than plants that had more water available).***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Constructing explanations and designing solutions: Constructing explanations (science) and designing solutions (engineering) in 3-5 builds on K-2 experiences and progresses to the use of evidence in constructing explanations that specify variables that describe and predict phenomena and in designing multiple solutions to design problems. • Use evidence (e.g., measurements, observations, patterns) to construct or support an explanation or design a solution to a problem. ***Support an explanation using evidence (e.g., measurements, observations, patterns).*** ***Construct an explanation using evidence (e.g., measurements, observations, patterns).***	**INHERITANCE OF TRAITS** Other characteristics result from individuals' interactions with the environment, which can range from diet to learning. Many characteristics involve both inheritance and environment. (UE.LS3A.b) ***Some traits in organisms that vary are influenced by the environment.*** ***Some traits in organisms that vary are influenced by the inheritance of traits.*** ***Many characteristics involve both inheritance and environment.*** **VARIATION OF TRAITS** The environment also affects the traits that an organism expresses. (UE.LS3B.b) ***The organism's environment can influence some traits.*** ***External environmental factors can modify an individual's specific development, appearance, behavior, and likelihood of producing offspring.***	**CAUSE AND EFFECT** Cause and effect relationships are routinely identified, tested, and used to explain change. ***Cause and effect relationships may be identified.*** ***Cause and effect relationships may be tested.*** ***Cause and effect relationships may be used to explain change.***

Clarification Statement
Examples of the environment affecting a trait could include normally tall plants grown with insufficient water are stunted or an animal that is given too much food and little exercise may become overweight.

Performance Expectation *and Louisiana Connectors*
3-LS4-1 Analyze and interpret data from fossils to provide evidence of the organisms and the environments in which they lived long ago. ***LC-3-LS4-1a Identify that fossils represent plants and animals that lived long ago.*** ***LC-3-LS4-1b Identify that fossils provide evidence about the environments in which organisms lived long ago (e.g., fossilized seashells indicate shelled organisms that lived in aquatic environments).***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Analyzing and interpreting data: Analyzing data in 3-5 builds on K-2 experiences and progresses to introducing quantitative approaches to collecting data and conducting multiple trials of qualitative observations. When possible and feasible, digital tools should be used. • Analyze and interpret data to make sense of phenomena, using logical reasoning, mathematics, and/or computation. ***Use logical reasoning to interpret data to make sense of phenomena.*** ***Use mathematics to interpret data to make sense of phenomena.*** ***Use computation to interpret data to make sense of phenomena.*** ***Analyze data to make sense of phenomena.***	**EVIDENCE OF COMMON ANCESTRY AND DIVERSITY** Some kinds of plants and animals that once lived on Earth are no longer found anywhere. (UE.LS4A.a) ***Some plants and animals that once lived on Earth are no longer alive.*** ***Most of the species that have lived on Earth no longer exist.*** Fossils provide evidence about the types of organisms that lived long ago and also about the nature of their environment. (UE.LS4A.b) ***Fossils provide us with evidence of organisms that lived long ago.*** ***Fossils provide us with evidence about the environment from the past in which living organisms once lived.***	**SCALE, PROPORTION, AND QUANTITY** Natural objects and/or observable phenomena exist from the very small to the immensely large or from very short to very long time periods. ***Natural processes vary in size (very small to the immensely large).*** ***Natural processes vary in time span (very short to very long).*** ***Observable phenomena vary in size (very small to the immensely large).*** ***Observable phenomena vary in time span (very short to very long).***

Clarification Statement
Examples of data could include type, size, and distributions of fossil organisms. Examples of fossils and environments could include major fossil types such as marine fossils found on dry land, tropical plant fossils found in arctic areas, or fossils of extinct organisms and relative ages.

Performance Expectation *and Louisiana Connectors*
3-LS4-2 Use evidence to construct an explanation for how the variations in characteristics among individuals of the same species may provide advantages in surviving, finding mates, and reproducing. ***LC-3-LS4-2a Identify features and characteristics that enable an organism to survive in a particular environment.*** ***LC-3-LS4-2b Identify features and characteristics that increase an organism's chances of finding mates.*** ***LC-3-LS4-2c Identify features and characteristics that increase an organism's chances of reproducing.***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Constructing explanations and designing solutions: Constructing explanations (science) and designing solutions (engineering) in 3-5 builds on K-2 experiences and progresses to the use of evidence in constructing explanations that specify variables that describe and predict phenomena and in designing multiple solutions to design problems. • Use evidence (e.g., measurements, observations, patterns) to construct or support an explanation or design a solution to a problem. ***Support an explanation using evidence (e.g., measurements, observations, patterns).*** ***Construct an explanation using evidence (e.g., measurements, observations, patterns).***	**NATURAL SELECTION** Sometimes the differences in characteristics between individuals of the same species provide advantages in surviving, finding mates, and reproducing. (UE.LS4B.a) ***Different plants and animals of the same species have some different characteristics.*** ***Some organisms have characteristics that make them better able to survive than other organisms of the same species.*** ***Some organisms have characteristics that make them better able to find mates than other organisms of the same species.*** ***Some organisms have characteristics that make them better able to reproduce than other organisms of the same species.*** ***Characteristics that make it easier for some organisms to survive, find mates, and reproduce give those organisms an advantage over other organisms of the same species that don't have those characteristics.***	**CAUSE AND EFFECT** Cause and effect relationships are routinely identified, tested, and used to explain change. ***Cause and effect relationships may be identified.*** ***Cause and effect relationships may be tested.*** ***Cause and effect relationships may be used to explain change.***

Clarification Statement
Examples of cause and effect relationships could be plants that have larger thorns than other plants may be less likely to be eaten or animals that have better camouflage coloration than other animals may be more likely to survive and therefore more likely to leave offspring.

Performance Expectation *and Louisiana Connectors*
3-LS4-3 Construct and support an argument with evidence that in a particular habitat some organisms can survive well, some survive less well, and some cannot survive at all. ***LC-3-LS4-3a Identify changes in a habitat that would cause some organisms to move to new locations.*** ***LC-3-LS4-3b Identify changes in a habitat that would cause some organisms to die.***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Engaging in argument from evidence: Engaging in argument from evidence in 3-5 builds on K-2 experiences and progresses to critiquing the scientific explanations or solutions proposed by peers by citing relevant evidence about the natural and designed world(s). • Construct and/or support an argument with evidence, data, and/or a model. ***Use evidence to construct an argument.*** ***Use evidence to support an argument.*** ***Use data to construct an argument.*** ***Use data to support an argument.*** ***Use a model to construct an argument.*** ***Use a model to support an argument.***	**ADAPTATION** For any particular environment, some kinds of organisms survive well, some survive less well, and some cannot survive at all. (UE.LS4C.a) ***Organisms of the same type can vary in appearance.*** ***Habitats can cause some organisms to survive well, less well, or not at all.*** ***There can be a cause and effect relationship between characteristics of some kinds of organisms (e.g., a specific variation in a characteristic) and its ability to survive and reproduce.*** ***These variations may provide an advantage in reproduction and survival.***	**CAUSE AND EFFECT** Cause and effect relationships are routinely identified, tested, and used to explain change. ***Cause and effect relationships may be identified.*** ***Cause and effect relationships may be tested.*** ***Cause and effect relationships may be used to explain change.***

Clarification Statement
Examples of evidence could include needs and characteristics of the organisms and habitats involved. The organisms and their habitats make up a system in which the parts depend on each other.

Performance Expectation *and Louisiana Connectors*
3-LS4-4 Make a claim about the merit of a solution to a problem caused when the environment changes and the types of plants and animals that live there may change. ***LC-3-LS4-4a Identify evidence that supports a claim that changes in habitats affect the organisms living there.*** ***LC-3-LS4-4b Identify a solution to a problem that is caused when the environment changes.***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Engaging in argument from evidence: Engaging in argument from evidence in 3-5 builds on K-2 experiences and progresses to critiquing the scientific explanations or solutions proposed by peers by citing relevant evidence about the natural and designed world(s). • Make a claim about the merit of a solution to a problem by citing relevant evidence about how it meets the criteria and constraints of a problem. ***Cite evidence to support a claim about the solution to a problem.*** ***Cite evidence to support a claim about how the solution to a problem meets the criteria.*** ***Cite evidence to support a claim about how the solution to a problem meets the constraints of problem the situation.***	**ECOSYSTEM DYNAMICS, FUNCTIONING, AND RESILIENCE** When the environment changes in ways that affect a place's physical characteristics, temperature, or availability of resources, some organisms survive and reproduce, others move to new locations, yet others move into the transformed environment, and some die. (UE.LS2C.a) ***Changes in one part of an Earth system affect other parts of the system.*** ***An environment's physical characteristics can change.*** ***An environment's temperature may change.*** ***Availability of natural resources can change over time in an environment.*** ***When an environment changes, some organisms survive and reproduce.*** ***When an environment changes, some organisms move to new locations.*** ***When an environment changes, some organisms move into the changed environment.*** ***When an environment changes, some organisms die.*** **BIODIVERSITY AND HUMANS** Populations live in a variety of habitats, and change in those habitats affects the organisms living there. (UE.LS4D.a) ***Populations of organisms live in many different habitats.*** ***Changes to an environment have an impact on the living organisms in the habitat.*** ***Organisms change over time.*** **DEVELOPING POSSIBLE SOLUTIONS**	**SYSTEMS AND SYSTEM MODELS** A system can be described in terms of its components and their interactions. ***A system can be described in terms of its parts.*** ***A system can be described in terms of how its parts interact.***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
	At whatever stage, communicating with peers about proposed solutions is an important part of the design process, and shared ideas can lead to improved designs. (ETS.UE.1B.b) ***Share ideas about how to solve problems with peers.*** ***Sharing ideas with peers can improve solution designs.***	

Clarification Statement
Examples of environmental change(s) could include changes in land characteristics, water distribution, temperature, food, and other biological communities. Louisiana specific examples could include impacts related to levees, dams, crop rotations, irrigation systems, hunting limits, diversion canals, or sea level rise.

Performance Expectation *and Louisiana Connectors*
3-ESS2-1 Represent data in tables and graphical displays to describe typical weather conditions expected during a particular season. ***LC-3-ESS2-1a Use data to describe observed weather conditions (e.g., temperature, precipitation, wind direction) during a season.*** ***LC-3-ESS2-1b Use data to predict weather conditions (e.g., temperature, precipitation, wind direction) during a season.***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Analyzing and interpreting data: Analyzing data in 3-5 builds on K-2 experiences and progresses to introducing quantitative approaches to collecting data and conducting multiple trials of qualitative observations. When possible and feasible, digital tools should be used. • Represent data in tables and/or various graphical displays (bar graphs, pictographs and/or pie charts) to reveal patterns that indicate relationships. ***Use data tables to describe patterns that show relationships.*** ***Use graphical displays (bar graphs, pictographs and/or pie charts) to describe patterns that show relationships.***	**WEATHER AND CLIMATE** Scientists record patterns of the weather across different times and areas so that they can make predictions about what kind of weather might happen next. (UE.ESS2D.a) ***Scientists can use data tables to show how the weather changes over time.*** ***Looking at the records of weather over time can help us identify weather patterns.*** ***There are seasonal patterns that help people predict future weather.*** ***Weather scientists, called meteorologists, use weather patterns to predict typical weather conditions during a particular season in different areas.***	**PATTERNS** Patterns of change can be used to make predictions. ***A regular pattern of events can be used to predict a future event.***

Clarification Statement
Examples of data could include average temperature, precipitation, and wind direction. Examples of data representations could include pictographs and bar graphs.

Performance Expectation ***and Louisiana Connectors***
3-ESS2-2 Obtain and combine information to describe climates in different regions around the world. ***LC-3-ESS2-2a Identify and describe climates in different regions of the world (e.g., equatorial, polar).***

Science and Engineering Practice	**Disciplinary Core Idea**	**Crosscutting Concept**
Obtaining, evaluating, and communicating information: Obtaining, evaluating, and communicating information in 3-5 builds on K-2 experiences and progresses to evaluating the merit and accuracy of ideas and methods. • Obtain and combine information from books and/ or other reliable media to explain phenomena or solutions to a design problem. ***Combine information from various books to explain phenomena.*** ***Combine information from various books to support a solution to a problem.*** ***Combine information from various forms of media to explain phenomena*** ***Combine information from various forms of media to support a solution to a problem.***	**WEATHER AND CLIMATE** Climate describes a range of an area's typical weather conditions and the extent to which those conditions vary over years. (UE.ESS2D.b) ***Patterns of weather can be attributed to the climates in different regions.*** ***Climate describes how weather conditions in a region varies over time.*** ***Patterns in climate can be used to predict typical weather conditions.***	**PATTERNS** Patterns of change can be used to make predictions. ***A regular pattern of events can be used to predict a future event.***

Clarification Statement
Information could include rainfall and temperature data.

Performance Expectation *and Louisiana Connectors*
3-ESS3-1 Make a claim about the merit of a design solution that reduces the impact of a weather-related hazard. ***LC-3-ESS3-1a Identify the positive impact of a solution humans can take to reduce the impact of weather-related hazards (e.g., barriers to prevent flooding).***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Engaging in argument from evidence: Engaging in argument from evidence in 3-5 builds on K-2 experiences and progresses to critiquing the scientific explanations or solutions proposed by peers by citing relevant evidence about the natural and designed world(s). • Make a claim about the merit of a solution to a problem by citing relevant evidence about how it meets the criteria and constraints of the problem. ***Cite evidence to support a claim about the solution to a problem.*** ***Cite evidence to support a claim about how the solution to a problem meets the criteria.*** ***Cite evidence to support a claim about how the solution to a problem meets the constraints of the situation.***	**NATURAL HAZARDS** A variety of natural hazards result from natural processes. Humans cannot eliminate natural hazards but can take steps to reduce their impacts. (UE.ESS3B.a) ***Natural hazards are the result of natural processes.*** ***Earth's processes can affect human life.*** ***Humans can take steps to reduce the impacts that natural hazards have on humans.*** ***Among other things, structures can be built outside of the natural floodplains; structures can be built to prevent areas from flooding (levees, barrier islands); and forecasting can prevent loss of life.*** **DEVELOPING POSSIBLE SOLUTIONS** Research on a problem should be carried out before beginning to design a solution. Testing a solution involves investigating how well it performs under a range of likely conditions. (ETS.UE.1B.a) ***Researching a problem allow scientists to define the problems that require solutions.*** ***Researching a possible solution to a problem will help show how well it is likely to meet the identified criteria for a successful solution.*** ***Testing a possible solution to a problem will help show how well it is likely to meet the identified criteria for a successful solution under different conditions.*** ***Engineers test their solutions under many conditions to determine the strengths and weaknesses of the solution.***	**CAUSE AND EFFECT** Cause and effect relationships are routinely identified, tested, and used to explain change. ***Cause and effect relationships may be identified.*** ***Cause and effect relationships may be tested.*** ***Cause and effect relationships may be used to explain change.***

Clarification Statement
Examples could include an unbalanced force on one side of an object that can make it start moving, or balanced forces pushing on an object from opposite sides will not produce any motion at all. Investigations include one variable at a time: number, size, or direction of forces.

Performance Expectation *and Louisiana Connectors*
4-PS3-1 Use evidence to construct an explanation relating the speed of an object to the energy of that object. ***LC-4-PS3-1a Identify that moving objects contain energy.*** ***LC-4-PS3-1b Demonstrate that objects moving faster possess more energy than objects moving slower.***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Constructing explanations and designing solutions: Constructing explanations (science) and designing solutions (engineering) in 3-5 builds on K-2 experiences and progresses to the use of evidence in constructing explanations that specify variables that describe and predict phenomena and in designing multiple solutions to design problems. • Use evidence (e.g., measurements, observations, patterns) to construct or support an explanation or design a solution to a problem. ***Support an explanation using evidence (e.g., measurements, observations, patterns).*** ***Construct an explanation using evidence (e.g., measurements, observations, patterns).***	**DEFINITIONS OF ENERGY** The faster a given object is moving, the more energy it possesses. (UE.PS3A.a) ***The speed of an object is related to the energy it possesses.*** ***The energy of a moving object depends on its speed.*** ***Objects moving faster possess more energy than objects moving slower.***	**ENERGY AND MATTER** Energy can be transferred in various ways and between objects. ***Energy can be transferred in a system.*** ***Energy can be transferred between objects.***

Clarification Statement
Relating the speed of an object to the energy of the object does not require calculation of the object's speed.

Performance Expectation *and Louisiana Connectors*
4-PS3-2 Make observations to provide evidence that energy can be transferred from place to place by sound, light, heat, and electric currents. ***LC-4-PS3-2a Identify examples of how energy can be moved from place to place (i.e., through sound or light traveling; by electrical currents; heat passing from one object to another).***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Planning and carrying out investigations: Planning and carrying out investigations to answer questions (science) or test solutions (engineering) to problems in 3-5 builds on K-2 experiences and progresses to include investigations that control variables and provide evidence to support explanations or design solutions. • Make observations and/or measurements to produce data to serve as the basis for evidence for an explanation of a phenomenon or test a design solution. ***Make observations to collect data.*** ***Make measurements to collect data.*** ***Use data as evidence for an explanation of a phenomenon.***	**DEFINITIONS OF ENERGY** Energy can be moved from place to place by moving objects or through sound, light, or electric currents. (UE.PS3A.b) ***Energy can be transferred by moving objects.*** ***Energy can be transferred through sound.*** ***Energy can be transferred through light.*** ***Energy can be transferred through electric currents.*** **CONSERVATION OF ENERGY AND ENERGY TRANSFER** Energy is present whenever there are moving objects, sound, light, or heat. When objects collide, energy can be transferred from one object to another, thereby changing their motion. In such collisions, some energy is typically also transferred to the surrounding air; as a result, the air gets heated and sound is produced. (UE.PS3B.a) ***Energy can be observed in a variety of situations (e.g., moving objects, sound, light, or heat).*** ***Pushing and pulling forces can be used to transfer energy from one object to another.*** ***Energy is transferred when objects collide.*** ***In a collision, some energy is also transferred to the surrounding air. As a result, sound is produced.*** ***An object's motion may change after a collision (i.e., increase or decrease speed, stop, or move an object farther than when the same object is moving more slowly),*** ***An object moving faster will have more energy due to motion; therefore, it will have a larger impact on another object. This impact results in an energy transfer.*** Light also transfers energy from place to place. (UE.PS3B.b)	**ENERGY AND MATTER** Energy can be transferred in various ways and between objects. ***Energy can be transferred in a system.*** ***Energy can be transferred between objects.***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
	Light is a form of energy. ***Light can transfer energy.*** ***When light is absorbed by a material, most of its energy is changed (transformed) into heat energy.*** Energy can also be transferred from place to place by electric currents, which can then be used locally to produce motion, sound, heat, or light. The currents may have been produced to begin with by transforming the energy of motion into electrical energy. (UE.PS3B.c) ***Electric currents can transfer energy.*** ***Electric currents can transform energy into motion, sound, heat, or light.*** ***Transforming motion into electrical energy produces electric currents.*** ***Electrical systems can be designed to perform a variety of tasks.***	

Clarification Statement
When energy is transferred it may change forms such as when light from the sun warms a window pane.

Performance Expectation *and Louisiana Connectors*
4-PS3-3 Ask questions and predict outcomes about the changes in energy that occur when objects collide. ***LC-4-PS3-3a Identify the change in energy or the change in objects' motions when objects collide (e.g., speeds as objects interact, direction).***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Asking questions and defining problems: Asking questions (science) and defining problems (engineering) in 3-5 builds on K-2 experiences and progresses to specifying qualitative relationships. • Ask questions that can be investigated and predict reasonable outcomes based on patterns such as cause and effect relationships. ***Scientific questions arise in a variety of ways.*** ***Ask scientific questions to which the answers can be supported through investigation.*** ***Questions can be about the prediction of outcomes based on cause and effect relationships.***	**DEFINITIONS OF ENERGY** Energy can be moved from place to place by moving objects or through sound, light, or electric currents. (UE.PS3A.b) ***Energy can be transferred by moving objects.*** ***Energy can be transferred through sound.*** ***Energy can be transferred through light.*** ***Energy can be transferred through electric currents.*** **CONSERVATION OF ENERGY AND ENERGY TRANSFER** Energy is present whenever there are moving objects, sound, light, or heat. When objects collide, energy can be transferred from one object to another, thereby changing their motion. In such collisions, some energy is typically also transferred to the surrounding air; as a result, the air gets heated and sound is produced. (UE.PS3B.a) ***Energy can be observed in a variety of situations (e.g., moving objects, sound, light, or heat).*** ***Pushing and pulling forces can be used to transfer energy from one object to another.*** ***Energy is transferred when objects collide.*** ***In a collision, some energy is also transferred to the surrounding air. As a result, sound is produced.*** ***An object's motion may change after a collision (i.e., increase or decrease speed, stop, or move an object farther than when the same object is moving more slowly).*** ***An object moving faster will have more energy due to motion; therefore, it will have a larger impact on another object. This impact results in an energy transfer.*** **RELATIONSHIP BETWEEN ENERGY AND FORCES**	**ENERGY AND MATTER** Energy can be transferred in various ways and between objects. ***Energy can be transferred in a system.*** ***Energy can be transferred between objects.***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
	When objects collide, the contact forces transfer energy so as to change the objects' motions. (UE.PS3C.a) ***When two objects collide they exert forces on each other.*** ***Objects with greater energy transfer some of the energy to the object with lesser energy within the system.*** ***The motion of an object is dependent on the amount of force applied to it.***	

Clarification Statement
Emphasis is on the change in the energy due to the change in speed, not on the forces, as objects interact. Quantitative measurements of energy are not included.

Performance Expectation *and Louisiana Connectors*
4-PS3-4 Apply scientific ideas to design, test, and refine a device that converts energy from one form to another. ***LC-4-PS3-4a Relate an example that demonstrates that energy can be converted from one form to another form (e.g., electric circuits that convert electrical energy into light, motion, sound or heat).***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Constructing explanations and designing solutions: Constructing explanations (science) and designing solutions (engineering) in 3-5 builds on K-2 experiences and progresses to the use of evidence in constructing explanations that specify variables that describe and predict phenomena and in designing multiple solutions to design problems. • Apply scientific ideas to solve design problems. ***Solve design problems by applying scientific knowledge.***	**CONSERVATION OF ENERGY AND ENERGY TRANSFER** Energy can also be transferred from place to place by electric currents, which can then be used locally to produce motion, sound, heat, or light. The currents may have been produced to begin with by transforming the energy of motion into electrical energy. (UE.PS3B.c) ***Electric currents can transfer energy.*** ***Electric currents can transform energy into motion, sound, heat, or light.*** ***Transforming motion into electrical energy produces electric currents.*** ***Electrical systems can be designed to perform a variety of tasks.*** **ENERGY IN CHEMICAL PROCESSES AND EVERYDAY LIFE** The expression “produce energy” typically refers to the conversion of stored energy into a desired form for practical use. (UE.PS3D.a) ***Energy can be produced (i.e., converted) to many forms.*** ***Energy cannot be created or destroyed.*** ***Energy can only be transferred or converted from one form to another.*** **OPTIMIZING THE DESIGN SOLUTION** Different solutions need to be tested in order to determine which of them best solves the problem, given the criteria and the constraints. (UE.ETS1C.a) ***Carry out tests in which variables are controlled and failure points are considered to determine which solution best solves the problem.*** ***Different solutions must be tested for defects.*** ***Evaluate the design solution according to how well it met the criteria and constraints.***	**ENERGY AND MATTER** Energy can be transferred in various ways and between objects. ***Energy can be transferred in a system.*** ***Energy can be transferred between objects.***

Clarification Statement
Examples of devices could include electric circuits that convert electrical energy into motion energy of a vehicle, light, or sound and a passive solar heater that converts light into heat. Example of constraints could include the materials, cost, or time to design the device.

Performance Expectation *and Louisiana Connectors*
4-PS4-1 Develop a model of waves to describe patterns in terms of amplitude and wavelength and to show that waves can cause objects to move. ***LC-4-PS4-1a Describe the properties of waves using a model (e.g., drawings, diagrams) to show amplitude (height) and wavelength.*** ***LC-4-PS4-1b Identify relationships involving wave amplitude, wavelength, and the motion of an object (e.g., when the amplitude increases, the object moves more).*** ***LC-4-PS4-1c Identify amplitude as a measure of energy in a wave.*** ***LC-4-PS4-1d Identify wavelength as the distance between a point on one wave and the identical point on the next wave.***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Developing and using models: Modeling in 3-5 builds on K-2 experiences and progresses to building and revising simple models and using models to represent events and design solutions. • Develop a model using an analogy, example, or abstract representation to describe a scientific principle or design solution. ***An analogy can be the basis of a model.*** ***A model is supported by examples.*** ***Models may use abstract representations.*** ***Models can be used to describe a scientific principle.*** ***Models can be used to describe a design solution.***	**WAVE PROPERTIES** Waves, which are regular patterns of motion, can be made in water by disturbing the surface. When waves move across the surface of deep water, the water goes up and down in place; it does not move in the direction of the wave except when the water meets the beach. (UE.PS4A.a) ***Waves are regular patterns of motion.*** ***A wave can travel in water.*** ***A wave traveling in water causes the water to move up and down in place.*** ***Water does not move in the direction of the wave.*** ***A wave becomes steep as it moves into shallow water near the shore and moves the water on to the beach.*** ***When waves meet the beach, they act differently by moving towards the shore.*** Waves of the same type can differ in amplitude (height of the wave) and wavelength (spacing between wave peaks). (UE.PS4A.b) ***Wave patterns can be observed by wave amplitude and wavelength.*** ***Waves vary in amplitude (height) and wavelength.***	**PATTERNS** Similarities and differences in patterns can be used to sort, classify, communicate and analyze simple rates of change for natural phenomena and designed products. ***Similarities and differences in patterns can be used to sort simple rates of change (natural phenomena and designed products).*** ***Similarities and differences in patterns can be used to classify simple rates of change (natural phenomena and designed products).*** ***Similarities and differences in patterns***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
		can be used to analyze simple rates of change (natural phenomena and designed products).

Clarification Statement
Examples of models could include diagrams, analogies, or physical models using wire to illustrate wavelength and amplitude of waves. Examples of wave patterns could include the vibrating patterns associated with sound or the vibrating patterns of seismic waves produced by earthquakes. Does not include interference effects, electromagnetic waves, non-periodic waves, or quantitative models of amplitude and wavelength.

Performance Expectation *and Louisiana Connectors*
4-PS4-2 Develop a model to describe that light reflecting from objects and entering the eye allows objects to be seen. ***LC-4-PS4-2a Arrange a model to show that light can be seen when light reflected from its surface enters the eye.***

Science and Engineering Practice	**Disciplinary Core Idea**	**Crosscutting Concept**
Developing and using models: Modeling in 3-5 builds on K-2 experiences and progresses to building and revising simple models and using models to represent events and design solutions. • Develop and/or use models to describe and/or predict phenomena. ***Models can be used to describe phenomena.*** ***Models can be used to predict phenomena.***	**ELECTROMAGNETIC RADIATION** An object can be seen when light reflected from its surface enters the eyes. (UE.PS4B.a) ***Objects in the dark cannot be seen.*** ***Objects can be seen when they are illuminated.*** ***Sight occurs when light reflects from objects and enters the eye.*** ***Objects cannot be seen if there is no light to illuminate them, but the same object in the same space can be seen if a light source is introduced.***	**CAUSE AND EFFECT** Cause and effect relationships are routinely identified, tested, and used to explain change. ***Cause and effect relationships may be identified.*** ***Cause and effect relationships may be tested.*** ***Cause and effect relationships may be used to explain change.***

Clarification Statement
Develop a model to make sense of a phenomenon involving the relationship between light reflection and visibility of objects. In the model, identify the relevant components including light and its source, objects, the path that light follows, and the eye.

Performance Expectation *and Louisiana Connectors*
4-LS1-1 Construct an argument that plants and animals have internal and external structures that function to support survival, growth, behavior, and reproduction. ***LC-4-LS1-1a Identify external macroscopic structures (e.g., bird beaks, eyes, feathers, roots, needles on a pine tree) that support growth, survival, behavior, and reproduction of organisms.*** ***LC-4-LS1-1b Identify internal structures (e.g., heart, muscles, bones) that support growth, survival, behavior, and reproduction of organisms.***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Engaging in argument from evidence: Engaging in argument from evidence in 3-5 builds on K-2 experiences and progresses to critiquing the scientific explanations or solutions proposed by peers by citing relevant evidence about the natural and designed world(s). • Construct and/or support an argument with evidence, data, and/or a model. ***Use evidence to construct an argument.*** ***Use evidence to support an argument.*** ***Use data to construct an argument.*** ***Use data to support an argument.*** ***Use a model to construct an argument.*** ***Use a model to support an argument.***	**STRUCTURE AND FUNCTION** Plants and animals have both internal and external structures that serve various functions in growth, survival, behavior, and reproduction. (UE.LS1A.a) ***Plants have structures like thorns, stems, and roots that support survival, growth, behavior, and reproduction.*** ***Animals have structures like hearts, stomachs, and lungs that support survival, growth, behavior, and reproduction.***	**SYSTEMS AND SYSTEM MODELS** A system can be described in terms of its components and their interactions. ***A system can be described in terms of its parts.*** ***A system can be described in terms of how its parts interact.***

Clarification Statement
Examples of structures could include thorns, stems, roots, colored petals, heart, stomach, lung, brain, shells, fur, or skin.

Performance Expectation ***and Louisiana Connectors***
4-LS1-2 Construct an explanation to describe how animals receive different types of information through their senses, process the information in their brains, and respond to the information in different ways. ***LC-4-LS1-2a Identify that sense receptors provide different kinds of information, which is processed by the brain.*** ***LC-4-LS1-2b Identify how animals use their sense receptors to respond to different types of information (e.g., sound, light, odor, temperature) in their surroundings with behaviors that help them survive.*** ***LC-4-LS1-2c Identify how animals use their memories to help them survive.***

Science and Engineering Practice	**Disciplinary Core Idea**	**Crosscutting Concept**
Constructing explanations and designing solutions: Constructing explanations (science) and designing solutions (engineering) in 3-5 builds on K-2 experiences and progresses to the use of evidence in constructing explanations that specify variables that describe and predict phenomena and in designing multiple solutions to design problems. • Construct an explanation of observed relationships (e.g., the distribution of plants in the back yard). ***An explanation relates how a variable(s) relate to another variable or a set of variables.*** ***An explanation can be based on an observed relationship.***	**STRUCTURE AND FUNCTION** Different sense receptors are specialized for particular kinds of information, which then may be processed by the animal's brain. Animals are able to use their perceptions and memories to guide their actions. (UE.LS1D.a) ***Senses help humans and other organisms detect internal and external cues.*** ***Animals have structures that aid them with receiving and processing information through their senses.*** ***Animals use their senses to respond to information they receive.*** ***The brain receives signals from parts of the body via the senses.*** ***In response, the brain sends signals to parts of the body to influence reactions.*** ***Animals also use memory to inform their actions.***	**CAUSE AND EFFECT** Events that occur together with regularity might or might not be a cause and effect relationship. ***Some events that occur together have a cause and effect relationship.*** ***Some events that occur together do not have a cause and effect relationship.***

Clarification Statement
Emphasis is on systems of information transfer. Responses could include animals running from predators, animals returning to breeding grounds, animals scavenging for food, or humans responding to stimuli.

Performance Expectation *and Louisiana Connectors*
4-ESS1-1 Identify evidence from patterns in rock formations and fossils in rock layers to support an explanation for changes in landforms over time. ***LC-4-ESS1-1a Identify rock formations that show how the Earth's surface has changed over time (e.g., change following earthquakes).*** ***LC-4-ESS1-1b Identify older fossils as being found in deeper, older rock layers.***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Constructing explanations and designing solutions: Constructing explanations (science) and designing solutions (engineering) in 3-5 builds on K-2 experiences and progresses to the use of evidence in constructing explanations that specify variables that describe and predict phenomena and in designing multiple solutions to design problems. • Identify the evidence that supports particular points in an explanation. ***Support an explanation with evidence.*** ***Specific points can be part of an explanation.*** ***Support each particular point with evidence.***	**THE HISTORY OF PLANET EARTH** Local, regional, and global patterns of rock formations reveal changes over time due to Earth's forces such as earthquakes and volcanoes. The presence and location of certain fossil types indicate the order in which rock layers were formed. (UE.ESS1C.a) ***As rocks and land formations change (e.g., Earth forces such as earthquakes and volcanoes), scientists are able to study the rock formations.*** ***The study of rock formations help explain how the landscape has changed over time.*** ***Rock formations can be examined to identify patterns in rock layers and fossils found in those rock layers.*** ***Patterns of rock formation can show the order in which rock layers were formed.*** ***Fossils in rock layers are evidence that Earth's surfaces have changed over time.***	**PATTERNS** Patterns can be used as evidence to support an explanation. ***Patterns can be used as evidence.*** ***Patterns can be used to support an explanation.***

Clarification Statement
Examples of evidence from patterns could include rock layers with marine shell fossils above rock layers with plant fossils and no shells, indicating a change from land to water over time, and a canyon with different rock layers in the walls and a river in the bottom, indicating that over time a river cut through the rock. Does not include specific knowledge of the mechanism of rock formation or memorization of specific rock formation and layers.

Performance Expectation *and Louisiana Connectors*
4-ESS2-1 Plan and conduct investigations on the effects of water, ice, wind, and vegetation on the relative rate of weathering and erosion. ***LC-4-ESS2-1a Use data to compare differences in the shape of the land due to the effects of weathering or erosion.*** ***LC-4-ESS2-1b Identify how living things affect the shape of the land.***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Planning and carrying out investigations: Planning and carrying out investigations to answer questions (science) or test solutions (engineering) to problems in 3-5 builds on K-2 experiences and progresses to include investigations that control variables and provide evidence to support explanations or design solutions. • Plan and conduct an investigation collaboratively to produce data to serve as the basis for evidence, using fair tests in which variables are controlled and the number of trials considered. ***Plan investigations collaboratively to produce data to serve as the basis for evidence.*** ***Conduct investigations collaboratively to produce data to serve as the basis for evidence.*** ***Plan investigations collaboratively using fair tests in which variables are controlled and the number of***	**EARTH MATERIALS AND SYSTEMS** Rainfall helps to shape the land and affects the types of living things found in a region. Water, ice, wind, living organisms, and gravity break rocks, soils, and sediments into smaller particles and move them around. (UE.ESS2A.a) ***Rainfall shapes the land.*** ***Rainfall affects living things.*** ***Water, ice, wind, and vegetation can break down rocks into smaller pieces.*** ***Water, ice, wind, and vegetation can break down soils and sediments into smaller pieces.*** ***Erosion is the movement of rocks, soil, and sediment from one place to another.*** ***Water, ice, wind, and vegetation can affect weathering and erosion by moving particles from one place to another.*** ***Ice erosion occurs when a large chunk of ice, usually a glacier, is moved (often due to gravity) and wears away the rocks or soil.*** ***Wind, or the movement of air, also causes erosion.*** ***Water or rainfall can chemically weather rocks.*** **BIOGEOLOGY** Living things affect the physical characteristics of their environment. (UE.ESS2E.a) ***Living organisms affect landforms.*** ***Living things impact the movement of rocks, soil, and sediments in different ways.*** ***Plants affect the environment in many ways; they die and decay and become part of the soil, some have roots that can stabilize or destabilize the soil.***	**CAUSE AND EFFECT** Cause and effect relationships are routinely identified, tested, and used to explain change. ***Cause and effect relationships may be identified.*** ***Cause and effect relationships may be tested.*** ***Cause and effect relationships may be used to explain change.***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
trials considered. ***Conduct investigations collaboratively using fair tests in which variables are controlled and the number of trials considered.***	***Animals affect the environment in many ways: some eat plants, they disturb rocks, soil, and sediment, some build dams or nests, others burrow into the ground.***	

Clarification Statement
Examples of variables to test could include angle of slope in the downhill movement of water, amount of vegetation, speed of wind, relative rate of deposition, cycles of freezing and thawing of water, cycles of heating and cooling, and volume of water flow.

Performance Expectation *and Louisiana Connectors*
4-ESS2-2 Analyze and interpret data from maps to describe patterns of Earth's features. ***LC-4-ESS2-2a Use maps to locate different land and water features of Earth.*** ***LC-4-ESS2-2b Use maps to determine that earthquakes and volcanoes often occur along the boundaries between continents.***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Analyzing and interpreting data: Analyzing data in 3-5 builds on K-2 experiences and progresses to introducing quantitative approaches to collecting data and conducting multiple trials of qualitative observations. When possible and feasible, digital tools should be used. • Analyze and interpret data to make sense of phenomena using logical reasoning. ***Use data to make sense of phenomena.*** ***Use logical reasoning to make sense of phenomena.*** ***Analyze data to make sense of phenomena.***	**PLATE TECTONICS AND LARGE-SCALE SYSTEM INTERACTIONS** The locations of mountain ranges, deep ocean trenches, ocean floor structures, earthquakes, and volcanoes occur in patterns. Most earthquakes and volcanoes occur in bands that are often along the boundaries between continents and oceans. Major mountain chains form inside continents or near their edges. Maps can help locate the different land and water features of Earth. (UE.ESS2B.a) ***The locations of mountain ranges, deep ocean trenches, earthquakes, and volcanoes occur in patterns.*** ***Most earthquakes and volcanoes are located on the boundaries of continents.*** ***Mountains form inside continents or on their boundaries.*** ***Maps can be used to track and illustrate changes of land and water features over time.*** ***Maps can be used to determine where earthquakes, volcanoes, mountain chains, and other land and water features occur on Earth.***	**PATTERNS** Patterns can be used as evidence to support an explanation. ***A scientific explanation is supported by evidence.*** ***Patterns can be used as evidence.***

Clarification Statement
Maps can include topographic maps of Earth's land and ocean floor, as well as maps of the locations of mountains, continental boundaries, volcanoes, and earthquakes.

Performance Expectation ***and Louisiana Connectors***
4-ESS2-3 Ask questions that can be investigated and predict reasonable outcomes about how living things affect the physical characteristics of their environment. ***LC-4-ESS2-3a Identify how plants affect the environment (e.g., some have roots that can stabilize or destabilize the soil).*** ***LC-4-ESS2-3b Identify how animals affect the environment (e.g., they disturb rocks, soil, and sediment; some build dams or nests).***

Science and Engineering Practice	**Disciplinary Core Idea**	**Crosscutting Concept**
Asking questions and defining problems: Asking questions (science) and defining problems (engineering) in 3-5 builds on K-2 experiences and progresses to specifying qualitative relationships. • Ask questions that can be investigated and predict reasonable outcomes based on patterns such as cause and effect relationships. ***Scientific questions arise in a variety of ways.*** ***Ask scientific questions to which the answers can be supported through investigation.*** ***Questions can be about the prediction of outcomes based on cause and effect relationships.***	**BIOGEOLOGY** Living things affect the physical characteristics of their environment. (UE.ESS2E.a) ***Living organisms affect landforms.*** ***Living things impact the movement of rocks, soil, and sediments in different ways.*** ***Plants affect the environment in many ways; they die and decay and become part of the soil, some have roots that can stabilize or destabilize the soil.*** ***Animals affect the environment in many ways: some eat plants, they disturb rocks, soil, and sediment, some build dams or nests, others burrow into the ground.***	**CAUSE AND EFFECT** Cause and effect relationships are routinely identified, tested, and used to explain change. ***Cause and effect relationships may be identified.*** ***Cause and effect relationships may be tested.*** ***Cause and effect relationships may be used to explain change.***

Clarification Statement
Investigations include making observations in various habitats in real life or virtual circumstances. Living things could include animals such as beavers, crawfish, armadillos, nutria, gophers, and plants such as kudzu, water hyacinth, and Chinese tallow.

Performance Expectation *and Louisiana Connectors*
4-ESS3-1 Obtain and combine information to describe that energy and fuels are derived from renewable and non-renewable resources and how their uses affect the environment. ***LC-4-ESS3-1a Identify the origins of the natural sources humans use for energy and fuel.*** ***LC-4-ESS3-1b Identify environmental effects associated with the use of a given energy resource.***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Obtaining, evaluating, and communicating information: Obtaining, evaluating, and communicating information in 3-5 builds on K-2 experiences and progresses to evaluating the merit and accuracy of ideas and methods. • Obtain and combine information from books and/or other reliable media to explain phenomena or solutions to a design problem. ***Obtain and combine information from various books to explain phenomena.*** ***Obtain and combine information from various books to support a solution to a problem.*** ***Obtain and combine information from various forms of media to explain phenomena.*** ***Obtain and combine information from various forms of media to support a solution to a problem.***	**NATURAL RESOURCES** Energy and fuels (fossil fuels, wind energy, solar energy, hydroelectric energy) that humans use are derived from natural sources, and their use affects the environment in multiple ways. Some resources are renewable over time, and others are not. (UE.ESS3A.a) ***Natural resources are materials found in nature that have not been made by people or animals.*** ***All of the energy and fuels that humans use come from natural resources.*** ***The use of natural resources by humans affects the environment.*** ***Humans can alter the living and non-living factors within an ecosystem, creating changes to the overall system.*** ***Different technologies are used to access resources to meet human wants and needs.*** ***Methods used to access resources for human wants and needs affect the environment.*** ***Some of these resources are renewable and can be used over or can be replaced.*** ***Some resources are non-renewable and are limited and cannot be replaced or reused.***	**CAUSE AND EFFECT** Cause and effect relationships are routinely identified, tested, and used to explain change. ***Cause and effect relationships may be identified.*** ***Cause and effect relationships may be tested.*** ***Cause and effect relationships may be used to explain change.***

Clarification Statement
Examples of renewable energy resources could include wind energy, hydroelectric energy, and solar energy; nonrenewable energy resources are fossil fuels. Examples of environmental effects could include loss of habitat due to dams, loss of habitat due to surface mining, and air pollution from burning fossil fuels.

Performance Expectation *and Louisiana Connectors*
4-ESS3-2 Generate and compare multiple solutions to reduce the impacts of natural Earth processes on humans. ***LC-4-ESS3-2a Describe solutions to reduce the impact of a natural Earth process (e.g., earthquake, flood, volcanic activity) on humans.***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Constructing explanations and designing solutions: Constructing explanations (science) and designing solutions (engineering) in 3-5 builds on K-2 experiences and progresses to the use of evidence in constructing explanations that specify variables that describe and predict phenomena and in designing multiple solutions to design problems. • Generate and compare multiple solutions to a problem based on how well they meet the criteria and constraints of the design solution. ***A design solution must include specifying constraints and criteria for desired qualities of the solution.*** ***Multiple solutions to a problem may be developed.*** ***Solutions can be compared.*** ***Comparisons should be based on how well each solution meets the constraints and criteria of the design.*** ***Design solutions can be revised and***	**NATURAL HAZARDS** A variety of natural hazards result from natural processes. Humans cannot eliminate natural hazards but can take steps to reduce their impacts. (UE.ESS3B.a) ***Natural hazards are the result of natural processes.*** ***Earth's processes can affect human life.*** ***Humans can take steps to reduce the impacts that natural hazards have on humans.*** ***Among other things, structures can be built outside of the natural floodplains; structures can be built to prevent areas from flooding (levees, barrier islands); and forecasting can prevent loss of life.*** **DEVELOPING POSSIBLE SOLUTIONS TO ENGINEERING PROBLEMS** Testing a solution involves investigating how well it performs under a range of likely conditions. (UE.ETS1B.d) ***Part of the engineering process is testing a solution.*** ***Testing a possible solution to a problem will help show how well it is likely to meet the identified criteria for a successful solution under different conditions.*** ***Engineers test their solutions under many conditions to determine the strengths and weaknesses of the solution.***	**CAUSE AND EFFECT** Cause and effect relationships are routinely identified, tested, and used to explain change. ***Cause and effect relationships may be identified.*** ***Cause and effect relationships may be tested.*** ***Cause and effect relationships may be used to explain change.***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
improved as part of the design process.		

Clarification Statement
Examples of solutions could include designing flood, wind, or earthquake resistant structures and models to prevent soil erosion.

Performance Expectation *and Louisiana Connectors*
5-PS1-1 Develop a model to describe that matter is made of particles too small to be seen. ***LC-5-PS1-1a Identify in a model (e.g., picture, diagram) which shows that all matter can be broken down into smaller and smaller pieces until they are too small to be seen by human eyes.***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Developing and using models: Modeling in 3-5 builds on K-2 experiences and progresses to building and revising simple models and using models to represent events and design solutions. • Develop and/or use models to describe and/or predict phenomena. ***Models can be used to describe phenomena.*** ***Models can be used to predict phenomena.***	**STRUCTURE AND PROPERTIES OF MATTER** Matter of any type can be subdivided into particles that are too small to see, but even then the matter still exists and can be detected by other means. A model showing that gases are made from matter particles that are too small to see and are moving freely around in space can explain many observations, including boiling water, the inflation and shape of a balloon, and the effects of air on larger particles or objects. (UE.PS1A.a) ***Matter is anything that occupies space and has mass.*** ***Everything around us (matter) is made up of particles that are too small to be seen.*** ***Models may be used to gain an understanding of these tiny particles.*** ***Matter that cannot be seen can be detected in other ways.*** ***Gas (air) has mass and takes up space.*** ***Gas (air) particles, which are too small to be seen, can affect larger particles and objects.*** ***Gas particles, which freely move around in space, until they hit a material that keeps them from moving further, thus trapping the gas (e.g., air inflating a basketball, an expanding balloon).***	**SCALE, PROPORTION, AND QUANTITY** Natural objects and/or observable phenomena exist from the very small to the immensely large or from very short to very long time periods. ***Natural processes vary in size (very small to the immensely large).*** ***Natural processes vary in time span (very short to very long).*** ***Observable phenomena vary in size (very small to the immensely large).*** ***Observable phenomena vary in time span (very short to very long).***

Clarification Statement
Examples of evidence could include adding air to expand a basketball, compressing air in a syringe, dissolving sugar in water, or evaporating salt water. Does not include atomic scale mechanism of evaporation and condensation or defining the unseen particles.

Performance Expectation *and Louisiana Connectors*
5-PS1-2 Measure and graph quantities to provide evidence that regardless of the type of change that occurs when heating, cooling, or mixing substances, the total amount of matter is conserved. ***LC-5-PS1-2a Identify using measurements that the total weight of matter is conserved when it changes form.*** ***LC-5-PS1-2b Identify using measurements that the total weight of matter is conserved before and after they are heated, cooled, or mixed.***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Using mathematics and computational thinking: Mathematical and computational thinking in 3-5 builds on K-2 experiences and progresses to extending quantitative measurements to a variety of physical properties and using computation and mathematics to analyze data and compare alternative design solutions. • Describe, measure, estimate, and/or graph quantities (e.g., area, volume, time) to address scientific and engineering questions and problems. ***Mathematics can be used to represent physical variables and their relationships.*** ***Tools can be used for observing, describing, measuring, recording, and graphing data.*** ***Descriptions can be used to address problems (scientific and***	**STRUCTURE AND PROPERTIES OF MATTER** The amount of mass in matter is conserved when it changes form, even in transitions in which it seems to vanish. (UE.PS1A.b) ***Matter can change in different ways.*** ***Regardless of the type of change, none of the particles are lost, and the total mass of the system is the same.*** ***The mass of substances are the same before and after they change form (e.g., heating, cooling, or mixing).*** **CHEMICAL REACTIONS** When two or more different substances are mixed, a new substance with different properties may be formed. (UE.PS1B.a) ***When substances are mixed, the change can result in a new substance.*** ***Substances change during a chemical reaction.*** ***A new substance may have different properties than the individual substances from which it was made.*** No matter what reaction or change in properties occurs, the total mass of the substances does not change. (UE.PS1B.b) ***In a closed system, the total mass will not change.*** ***During a physical or chemical change, the total mass of the substances do not change.*** ***After a change, the total mass of the new substance(s) will be the same as the total mass of***	**ENERGY AND MATTER** Matter flows and cycles can be tracked in terms of mass of the substances before and after a process occurs. The total mass of the substances does not change. This is what is meant by conservation of matter. Matter is transported into, out of, and within systems. ***Matter flows and cycles (e.g., water going back and forth between Earth's atmosphere and its surface).*** ***Matter can change, but, the total mass of the substances is the same.*** ***Matter is conserved.*** ***Matter can be***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
engineering). ***Measurements can be used to address problems (scientific and engineering).*** ***Estimates can be used to address problems (scientific and engineering).*** ***Graphing quantities (e.g., area, volume, time) can be used to address problems (scientific and engineering).***	***the beginning substances.*** ***The total mass of matter is conserved after heating, cooling or mixing substances.***	***transported into, out of, and within systems.***

Clarification Statement
Examples of chemical changes includes reactions that produce new substances with new properties. Examples of physical changes could include phase changes, dissolving, or mixing.

Performance Expectation *and Louisiana Connectors*
5-PS1-3 Make observations and measurements to identify materials based on their properties. ***LC-5-PS1-3a Identify that materials can be classified based on a variety of observable physical properties (e.g., shape, texture, buoyancy, color, magnetism, solubility).*** ***LC-5-PS1-3b Classify materials (e.g., shape, texture, buoyancy, color, magnetism, solubility) by measurable physical properties.***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Planning and carrying out Investigations: Planning and carrying out investigations to answer questions (science) or test solutions (engineering) to problems in 3-5 builds on K-2 experiences and progresses to include investigations that control variables and provide evidence to support explanations or design solutions. • Make observations and/or measurements to produce data to serve as the basis for evidence for an explanation of a phenomenon or test a design solution. ***Make observations to collect data.*** ***Make measurements to collect data.*** ***Use data to as evidence for an explanation of a phenomenon.***	**STRUCTURE AND PROPERTIES OF MATTER** Measurements of a variety of properties can be used to identify materials. (UE.PS1A.c) ***Everything around us has unique properties that can be used to identify them, such as what color they are, how hard they are, if they reflect light, whether they conduct electricity or heat, whether they are magnetic, and whether they dissolve in water.*** ***Properties can be used to identify materials.*** ***Properties can be measured.*** ***Materials can be identified based on their observable and measurable properties.*** ***Properties of materials may include color, hardness, reflectivity, electrical conductivity, thermal conductivity, response to magnetic forces, and solubility.*** ***Tools such as graduated cylinders, balances, rulers, magnifiers, simple circuits, and magnets are used to study the physical properties.***	**SCALE, PROPORTION, AND QUANTITY** Standard units are used to measure and describe physical quantities such as mass, time, temperature, and volume. ***Physical quantities (mass, time, temperature, and volume) can be measured.*** ***Physical quantities are measured using standard units.*** ***Measurements of physical properties can be used to describe physical quantities.***

Clarification Statement
Examples of materials to be identified could include baking soda and other powders, metals, minerals, or liquids. Examples of properties could include color, hardness, reflectivity, electrical conductivity, thermal conductivity, response to magnetic forces, or solubility; density is not intended to be used as an identifiable property. No attempt is made to define the unseen particles or explain the atomic-scale mechanism of evaporation and condensation.

Performance Expectation *and Louisiana Connectors*
5-PS1-4 Conduct an investigation to determine whether the mixing of two or more substances results in new substances. ***LC-5-PS1-4a Identify that when two or more different substances are mixed, a new substance with different properties may be formed.*** ***LC-5-PS1-4b Identify the changes that occur when two or more substances are mixed using evidence provided from data.***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Planning and carrying out Investigations: Planning and carrying out investigations to answer questions or test solutions to problems in 3-5 builds on K-2 experiences and progresses to include investigations that control variables and provide evidence to support explanations or design solutions. • Plan and conduct an investigation collaboratively to produce data to serve as the basis for evidence, using fair tests in which variables are controlled and the number of trials considered. ***Plan investigations collaboratively to produce data to serve as the basis for evidence.*** ***Conduct investigations collaboratively to produce data to serve as the basis for evidence.*** ***Plan investigations collaboratively using fair tests in which variables are controlled and the number of trials considered.***	**CHEMICAL REACTIONS** When two or more different substances are mixed, a new substance with different properties may be formed. (UE.PS1B.a) ***When substances are mixed, a change can occur which results in a new substance.*** ***Substances change during a chemical reaction.*** ***A new substance may have different properties than the individual substances from which it was made.***	**CAUSE AND EFFECT** Cause and effect relationships are routinely identified, tested, and used to explain change. ***Cause and effect relationships may be identified.*** ***Cause and effect relationships may be tested.*** ***Cause and effect relationships may be used to explain change.***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Conduct investigations collaboratively using fair tests in which variables are controlled and the number of trials considered.		

Clarification Statement
Examples of interactions forming new substances can include mixing baking soda and vinegar. Examples of interactions not forming new substances can include mixing baking soda and water.

Performance Expectation *and Louisiana Connectors*
5-PS2-1 Support an argument that the gravitational force exerted by the Earth is directed down. ***LC-5-PS2-1a Identify that the gravitational force exerted by Earth on objects is directed down.***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Engaging in argument from evidence: Engaging in argument from evidence in 3-5 builds on K-2 experiences and progresses to critiquing the scientific explanations or solutions proposed by peers by citing relevant evidence about the natural and designed world(s) • Construct and/or support an argument with evidence, data, and/or a model ***Use evidence to construct an argument.*** ***Use evidence to support an argument.*** ***Use data to construct an argument.*** ***Use data to support an argument.*** ***Use a model to construct an argument.*** ***Use a model to support an argument.***	**TYPES OF INTERACTIONS** The gravitational force of Earth acting on an object near Earth's surface pulls that object toward the planet's center. (UE.PS2B.c) ***Gravity is what makes things fall to Earth's center.*** ***Gravity is an invisible force.*** ***Some forces (e.g., gravity) can make things move without touching them.*** ***Gravity is what makes things fall.*** ***The gravitational pull of Earth always pulls down to the center of the planet.***	**CAUSE AND EFFECT** Cause and effect relationships are routinely identified, tested, and used to explain change. ***Cause and effect relationships may be identified.*** ***Cause and effect relationships may be tested.*** ***Cause and effect relationships may be used to explain change.***

Clarification Statement
"Down" is a local description of the direction that points toward the center of the spherical Earth. Earth's mass causes objects to have a force on them that points toward the center of the Earth, "down". Support for arguments can be drawn from diagrams, evidence, and data that are provided. This does not include mathematical representation of gravitational force.

Performance Expectation *and Louisiana Connectors*
5-PS3-1 Use models to describe that energy in animals' food (used for body repair, growth, motion, and to maintain body warmth) was once energy from the sun. ***LC-5-PS3-1a Identify that the energy in animals' food was once energy from the sun.***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Developing and using models: Modeling in 3-5 builds on K-2 experiences and progresses to building and revising simple models and using models to represent events and design solutions. • Develop and/or use models to describe and/or predict phenomena. ***Models can be used to describe phenomena.*** ***Models can be used to predict phenomena.***	**ENERGY IN CHEMICAL PROCESSES AND EVERYDAY LIFE** The energy released from food was once energy from the sun that was captured by plants in the chemical process that forms plant matter (from air and water). (UE.PS3D.b) ***All of the energy (i.e., food) that sustains ecosystems comes from the sun.*** ***Energy from the sun is taken in by plants along with air and water and changed into food for the plant.*** ***Plants need the sun's energy to grow and survive.*** ***Animals need food to provide materials and energy for life which they derive directly or indirectly from plants.*** **ORGANIZATION FOR MATTER AND ENERGY FLOW IN ORGANISMS** Food provides animals with the materials they need for body repair and growth and energy they need to maintain body warmth and for motion. (UE.LS1C.a) ***All organisms require energy.*** ***Animals depend on food for the materials they need to repair injuries.*** ***Animals depend on food the energy they need to maintain body temperature.*** ***Animals depend on food for the materials they need to grow and move.***	**ENERGY AND MATTER** Energy can be transferred in various ways and between objects. ***Energy can be transferred.*** ***Energy can be transferred between objects.***

Clarification Statement
Examples of models could include diagrams or flowcharts.

Performance Expectation *and Louisiana Connectors*
5-LS1-1 Ask questions about how air and water affect the growth of plants. ***LC-5-LS1-1a Identify that plants acquire material for growth chiefly from air and water, not from soil.***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Asking questions and defining problems: Asking questions (science) and defining problems (engineering) in 3-5 builds on K-2 experiences and progresses to specifying qualitative relationships. • Ask questions that can be investigated and predict reasonable outcomes based on patterns such as cause and effect relationships. ***Scientific questions arise in a variety of ways.*** ***Ask scientific questions to which the answers can be supported through investigation.*** ***Questions can be about the prediction of outcomes based on cause and effect relationships.***	**ORGANIZATION FOR MATTER AND ENERGY FLOW IN ORGANISMS** Plants acquire their material for growth chiefly from air and water. (UE.LS1C.b) ***A plant receives the material it needs for growth from air and water.*** ***Plants need the sun's energy to grow and survive.***	**ENERGY AND MATTER** Matter is transported into, out of, and within systems. ***Matter is anything that has mass and takes up space.*** ***A system is an organized group of components that interact.*** ***There are different types of systems.*** ***Matter can be transported into, out of, and within systems.***

Clarification Statement
Emphasis is on the idea that plant matter comes mostly from air and water, not from the soil. The chemical processes of photosynthesis and cellular respiration are not addressed at this grade level.

Performance Expectation *and Louisiana Connectors*
5-LS2-1 Develop a model to describe the movement of matter among plants, animals, decomposers, and the environment. ***LC-5-LS2-1a Identify a model that shows the movement of matter (e.g., plant growth, eating, composting) through living things.***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Developing and using models: Modeling in 3-5 builds on K-2 experiences and progresses to building and revising simple models and using models to represent events and design solutions. • Develop and/or use models to describe and/or predict phenomena. ***Models can be used to describe phenomena.*** ***Models can be used to predict phenomena.***	**INTERDEPENDENT RELATIONSHIPS IN ECOSYSTEMS** The food of almost any kind of animal can be traced back to plants. Organisms are related in food webs in which some animals eat plants for food and other animals eat the animals that eat plants. (UE.LS2A.a) ***Plants are the base of most ecosystems.*** ***Some animals eat only plants for food.*** ***Some animals eat other animals for food.*** ***Some animals eat both plants and animals for food.*** Some organisms, such as fungi and bacteria, break down dead organisms and therefore operate as "decomposers." Decomposition eventually restores (recycles) some materials back to the soil. (UE.LS2A.b) ***Decomposers break down dead plants and animals.*** ***Decomposers recycle nutrients and material back into the soil to be used by plants again.*** Organisms can survive only in environments in which their particular needs are met. A healthy ecosystem is one in which multiple species of different types are each able to meet their needs in a relatively stable web of life. (UE.LS2A.c) ***Organisms live in ecosystems that meet their needs.*** ***In a healthy ecosystem, organisms are connected to the other components and rely on the other components to survive.*** Newly introduced species can damage the balance of an ecosystem. (UE.LS2A.d) ***Some changes to an ecosystem (i.e., introduction of a new species) can upset the balance of***	**SYSTEMS AND SYSTEM MODELS** A system can be described in terms of its components and their interactions. ***A system can be described in terms of its parts.*** ***A system can be described in terms of how its parts interact.***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
	an ecosystem. **CYCLES OF MATTER AND ENERGY TRANSFER IN ECOSYSTEMS** Matter cycles between the air and soil and among plants, animals, decomposers, and microbes as these organisms live and die. Organisms obtain gases, and water, from the environment, and release waste matter (gas, liquid, or solid) back into the environment. (UE.LS2B.a) ***Food and other materials are broken down and cycled between the air, plants, animals, and the soil.*** ***Living organisms depend on air and water from the environment.*** ***Living organisms release waste matter back to the environment.***	

Clarification Statement
Emphasis is on the idea that matter that is not food (air, water, decomposed materials in soil) is changed by plants into matter that is food. Examples of systems could include organisms, ecosystems of the Earth not including molecular explanations.

Performance Expectation ***and Louisiana Connectors***
5-ESS1-1 Support an argument that differences in the apparent brightness of the sun compared to other stars is due to their relative distances from the Earth. ***LC-5-ESS1-1a Identify that the sun appears larger and brighter than other stars because the sun is much closer to Earth than other stars.***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Engaging in argument from evidence: Engaging in argument from evidence in 3-5 builds on K-2 experiences and progresses to critiquing the scientific explanations or solutions proposed by peers by citing relevant evidence about the natural and designed world(s). • Construct and/or support an argument with evidence, data, and/or a model. ***Use evidence to construct an argument.*** ***Use evidence to support an argument.*** ***Use data to construct an argument.*** ***Use data to support an argument.*** ***Use a model to construct an argument.*** ***Use a model to support an argument.***	**THE UNIVERSE AND ITS STARS** The sun is a star that appears larger and brighter than other stars because it is closer. Stars range greatly in their distance from Earth. (UE.ESS1A.a) ***The sun is a star.*** ***The sun is the brightest object in Earth's sky.*** ***Other stars are much farther from Earth.*** ***Other stars appear dimmer and smaller than the sun because they are very far away from Earth.***	**SCALE, PROPORTION, AND QUANTITY** Natural objects and/or observable phenomena exist from the very small to the immensely large or from very short to very long time periods. ***Natural processes vary in size (very small to the immensely large).*** ***Natural processes vary in time span (very short to very long).*** ***Observable phenomena vary in size (very small to the immensely large).*** ***Observable phenomena vary in time span (very short to very long).***

Clarification Statement
Examples include the relative distances of the stars, but not the sizes. It does not include other factors that affect apparent brightness (such as stellar masses, age, stage).

Performance Expectation ***and Louisiana Connectors***
5-ESS1-2 Represent data in graphical displays to reveal patterns of daily changes in length and direction of shadows, day and night, and the seasonal appearance of some stars in the night sky. ***LC-5-ESS1-2a Describe similarities and differences in the timing of observable changes in shadows.*** ***LC-5-ESS1-2b Describe similarities and differences in the timing of observable changes in day and night.*** ***LC-5-ESS1-2c Describe similarities and differences in the timing of observable changes in the appearance of stars that are visible only in particular months.***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Analyzing and interpreting data: Analyzing data in 3-5 builds on K-2 experiences and progresses to introducing quantitative approaches to collecting data and conducting multiple trials of qualitative observations. When possible and feasible, digital tools should be used. • Represent data in tables and/or various graphical displays (bar graphs, pictographs and/or pie charts) to reveal patterns that indicate relationships. ***Use data tables to describe patterns that show relationships.*** ***Use graphical displays (bar graphs, pictographs and/or pie charts) to describe patterns that show relationships.***	**HISTORY OF PLANET EARTH** The orbits of Earth around the sun and of the moon around Earth, together with the rotation of Earth about an axis between its North and South poles, cause observable patterns. These include: day and night, daily changes in the length and direction of shadows, and different positions of the sun, moon, and stars at different times of the day, month, and year. (UE.ESS1B.a) ***Gravitational force from the sun keeps Earth in orbit around the sun, and the moon in orbit around Earth.*** ***Earth rotates about its axis between the North and South poles.*** ***As Earth revolves (moves around the sun) and rotates (spins on its axis), changes such as the movement of shadows can be observed.*** ***As Earth moves around the sun and rotates on its axis, changes such as patterns of night and day can be observed.*** ***As Earth revolves (moves around the sun) and rotates (spins on its axis), changes such as nightly, monthly, and seasonal movements of the moon can be observed.*** ***As Earth revolves (moves around the sun) and rotates (spins on its axis), changes such as nightly, monthly, and seasonal movements of the stars can be observed.*** ***Observable, predictable patterns of movement in the sun, Earth, moon system occur because of gravitational interaction and energy from the sun.***	**PATTERNS** Similarities and differences in patterns can be used to sort, classify, communicate and analyze simple rates of change for natural phenomena and designed products. ***Similarities and differences in patterns can be used to sort simple rates of change (natural phenomena and designed products).*** ***Similarities and differences in patterns can be used to classify simple rates of change (natural phenomena and designed products).*** ***Similarities and differences in patterns***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
		can be used to analyze simple rates of change (natural phenomena and designed products).

Clarification Statement
Patterns could include the position and motion of Earth with respect to the sun and selected stars that are visible only in particular months; not including the causes of the seasons.

Performance Expectation *and Louisiana Connectors*
5-ESS2-1 Develop a model using an example to describe ways the geosphere, biosphere, hydrosphere, and/or atmosphere interact. ***LC-5-ESS2-1a Describe that the Earth's major systems interact and affect Earth's surface materials and processes.***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Developing and using models: Modeling in 3-5 builds on K-2 experiences and progresses to building and revising simple models and using models to represent events and design solutions. • Develop and/or use models to describe and/or predict phenomena. ***Models can be used to describe phenomena.*** ***Models can be used to predict phenomena.***	**EARTH MATERIALS AND SYSTEMS** Earth's major systems are the geosphere (solid and molten rock, soil, and sediments), the hydrosphere (water and ice), the atmosphere (air), and the biosphere (living things, including humans). These systems interact in multiple ways to affect Earth's surface materials and processes. The ocean supports a variety of ecosystems and organisms, shapes landforms, and influences climate. Winds and clouds in the atmosphere interact with the landforms to determine patterns of weather. (UE.ESS2A.b) ***Earth is a dynamic system resulting from interactions among the geosphere, hydrosphere, atmosphere and biosphere.*** ***All of Earth's features, everything on land (soil, sediments, rocks, and landforms), all the water, and all living things on Earth interact with each other.*** ***Earth's systems interact with each other.*** ***Earth's vast oceans support life and many ecosystems.*** ***Earth's vast oceans shape the land (e.g., coasts).*** ***Earth's vast oceans influence climate.*** ***Coastal locations are often cooler in the summer and warmer in the winter due to the slow temperature change of the ocean and winds that blow air onto land.*** ***Clouds are shaped by winds and are made of small water droplets or ice crystals.*** ***Earth's atmosphere is influenced by the surface features of the Earth creating weather.*** ***Interactions between landforms and the atmosphere create weather patterns.*** ***Weather changes daily and seasonally.*** ***While the weather can change in just a few hours, climate takes hundreds, thousands, even millions of years to change.***	**SYSTEMS AND SYSTEM MODELS** A system can be described in terms of its components and their interactions. ***A system can be described in terms of its parts.*** ***A system can be described in terms of how its parts interact.***

Clarification Statement
Examples could include the influence of the ocean on ecosystems, landform shape, and climate; the influence of the atmosphere on landforms and ecosystems through weather and climate; and the influence of mountain ranges on winds and clouds in the atmosphere. The geosphere, hydrosphere, atmosphere, and biosphere are each a system.

Performance Expectation *and Louisiana Connectors*
5-ESS2-2 Describe and graph the amounts and percentages of water and fresh water in various reservoirs to provide evidence about the distribution of water on Earth. ***LC-5-ESS2-2a Determine that the majority of water on Earth is found in the oceans as salt water and most of the Earth's fresh water is stored in glaciers.***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Using mathematics and computational thinking: Mathematical and computational thinking in 3-5 builds on K-2 experiences and progresses to extending quantitative measurements to a variety of physical properties and using computation and mathematics to analyze data and compare alternative design solutions. • Describe, measure, estimate, and/or graph quantities (e.g., area, volume, time) to address scientific and engineering questions and problems. ***Mathematics can be used to represent physical variables and their relationships.*** ***Tools can be used for observing, describing, measuring, recording, and graphing data.*** ***Descriptions can be used to address problems (scientific and engineering).*** ***Measurements can be used to***	**THE ROLES OF WATER IN EARTH'S SURFACE PROCESSES** Nearly all of Earth's available water is in the ocean. Most fresh water is in glaciers or underground; only a tiny fraction is in streams, lakes, wetlands, and the atmosphere. (UE.ESS2C.a) ***Most of Earth's water is found in oceans.*** ***A small amount of freshwater is accessible to humans.*** ***Most freshwater is found in glaciers or underground.*** ***Streams, wetlands, and lakes contain only a small part of Earth's freshwater.*** Liquid water can become the gas form of water (water vapor) and liquid water can become a solid as ice. (UE.ESS2C.b) ***Water may undergo physical changes such as freezing (solid), melting (liquid), or evaporating (water vapor).*** ***Water moves from one place on Earth to another in a continuous cycle through the processes of evaporation, condensation, and precipitation.***	**SCALE, PROPORTION, AND QUANTITY** Standard units are used to measure and describe physical quantities such as mass, time, temperature, and volume. ***Physical quantities (mass, time, temperature, and volume) can be measured.*** ***Physical quantities are measured using standard units.*** ***Measurements of physical properties can be used to describe physical quantities.***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
address problems (scientific and engineering). ***Estimates can be used to address problems (scientific and engineering).*** ***Graphing quantities (e.g., area, volume, time) can be used to address problems (scientific and engineering).***		

Clarification Statement
Examples include oceans, lakes, rivers, glaciers, ground water, and polar ice caps.

Performance Expectation *and Louisiana Connectors*
5-ESS3-1 Generate and compare multiple solutions about ways individual communities can use science to protect the Earth's resources and environment. ***LC-5-ESS3-1a Identify ways people can help protect the Earth's resources and environment.***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Constructing explanations and designing solutions: Constructing explanations (science) and designing solutions (engineering) in 3-5 builds on K-2 experiences and progresses to the use of evidence in constructing explanations that specify variables that describe and predict phenomena and in designing multiple solutions to design problems. • Generate and compare multiple solutions to a problem based on how well they meet the criteria and constraints of the design solution. ***A design solution must include specific constraints and criteria for desired qualities of the solution.*** ***Multiple solutions to a problem may be developed.*** ***Solutions can be compared.*** ***Comparisons should be based on how well each solution meets the constraints and criteria of the design.*** ***Design solutions can be revised and***	**HUMAN IMPACTS ON EARTH SYSTEMS** Human activities in agriculture, industry, and everyday life have had major effects on the land, vegetation, streams, ocean and the atmosphere. But individuals and communities are doing things to help protect Earth's resources and environments. (UE.ESS3C.a) ***People use a variety of plants and animals found throughout the world for food, clothing, and shelter.*** ***The flow of river water can be affected by human activities.*** ***Ground cover can be affected by human activities.*** ***Land can be affected by human activities.*** ***Humans use natural resources to meet their needs and wants.*** ***Some changes to ecosystems are due to humans using resources within the ecosystem.*** ***Humans have had major effects on the land, vegetation, streams, ocean and the atmosphere.*** ***Human activities may cause pollution of air, water, and soil.*** ***There are many ways for people to conserve natural resources and energy by recycling, reducing and reusing.*** ***There are many ways for people to conserve natural resources.*** **DEVELOPING POSSIBLE SOLUTIONS** Tests are often designed to identify failure points or difficulties, which suggest the elements of the design that need to be improved. (ETS.UE.1B.c) ***Tests can be carried out to identify failure points or difficulties.*** ***After testing, defects are identified.*** ***Using information from testing, improvements to a solution to best solve a problem can be determined.***	**SYSTEMS AND SYSTEM MODELS** A system can be described in terms of its components and their interactions. ***A system can be described in terms of its parts.*** ***A system can be described in terms of how its parts interact.***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
improved as part of the design process.		

Clarification Statement
Examples of solutions can include cleanup of oil spills, protecting against coastal erosion, or prevention of polluted runoff into waterways.

Performance Expectation ***and Louisiana Connectors***
6-MS-PS1-1 Develop models to describe the atomic composition of simple molecules and extended structures. **LC-6-MS-PS1-1a Identify a model that shows an atom's nucleus is made of protons and neutrons, and is surrounded by electrons.** **LC-6-MS-PS1-1b Identify a model that shows individual atoms of the same or different types that repeat to form compounds (e.g., sodium chloride).**

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Developing and using models: Modeling in 6-8 builds on K-5 and progresses to developing, using and revising models to describe, test, and predict more abstract phenomena and design systems. • Develop and/or use a model to predict and/or describe phenomena. **Models can be used to describe phenomena.** **Models can be used to predict phenomena.**	**STRUCTURE AND PROPERTIES OF MATTER** Substances are made from different types of atoms, which combine with one another in various ways. Atoms form molecules that range in size from two to thousands of atoms. (MS.PS1.A.a) **All matter is composed of tiny particles called atoms.** **Atoms are the basic unit of a chemical element.** **Substances are made from different types of atoms.** **Atoms form molecules ranging from small to very complex structures.** **A molecule is a group of atoms that are joined together and act as a single unit.** **Molecules can contain as many as a billion atoms or as few as two.** **The arrangement, motion, and interaction of these particles determine the three states of matter (solid, liquid, and gas).** Solids may be formed from molecules, or they may be extended structures with repeating subunits (e.g., crystals). (MS.PS1A.e) **Solids have a definite volume and a definite shape.** **Solids may be formed from molecules.** **Solids can be extended structures with repeating subunits.** **Repeating subunits can create crystal structures.** **Salt, sugar, sand, and snow are examples of crystalline solids.**	**SCALE, PROPORTION, AND QUANTITY** Time, space, and energy phenomena can be observed at various scales using models to study systems that are too large or too small. **Phenomena can be observed at different scales (micro and macro) in a system.** **Phenomena can be studied using models.** **Models can be used to explain time, space, and energy phenomena.**

Clarification Statement
Emphasis is on developing models of molecules that vary in complexity. Examples of simple molecules could include carbon dioxide and water. Examples of extended structures could include sodium chloride or diamonds. Examples of molecular-level models could include drawings, 3-D models, or computer representations showing different molecules with different types of atoms.

Performance Expectation *and Louisiana Connectors*
6-MS-PS2-1 Apply Newton's Third Law to design a solution to a problem involving the motion of two colliding objects. **LC-6-MS-PS2-1a Describe the motion of two colliding objects in terms of the strength of the force and the relationship of action and reaction forces given a model or scenario.** **LC-6-MS-PS2-1b Develop a solution to a problem involving the motion of two colliding objects.**

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Constructing explanations and designing solutions: Constructing explanations (science) and designing solutions (engineering) in 6-8 builds on K-5 experiences and progresses to include designing solutions supported by multiple sources of evidence consistent with scientific ideas, principles, and theories. • Apply scientific ideas or principles to design, construct, and/or test a design of an object, tool, process or system. **To design an object, tool, process or system, scientists and engineers use scientific ideas and principles.** **To construct an object, tool, process or system, scientists and engineers use scientific ideas and principles.** **In science and engineering, a design plan includes testing an object, tool, process, or system.**	**FORCES AND MOTION** For any pair of interacting objects, the force exerted by the first object on the second object is equal in strength to the force that the second object exerts on the first, but in the opposite direction (Newton's third law). (MS.PS2A.a) **Forces can be used to transfer energy from one object to another.** **Force is required in order to change the speed or direction of an object's motion.** **Whenever an object pushes or pulls another object, it gets pushed or pulled back in the opposite direction with an equal force.** **Forces are equal and opposite in magnitude or strength.** **DEVELOPING POSSIBLE SOLUTIONS** A solution needs to be tested, to prove the validity of the design and then modified on the basis of the test results in order to improve it. There are systematic processes for evaluating solutions with respect to how well they meet the criteria and constraints of a problem. Sometimes parts of different solutions can be combined to create a solution that is better than any of its predecessors. Models of all kinds are important for testing solutions. (MS.ETS1B.a) **Design solutions must be tested.** **Tests are often designed to identify failure points or difficulties.** **Testing a solution involves investigating how well it performs under a range of likely conditions.** **Solutions are modified on the basis of the test results.** **Different solutions can be combined to create a better solution.** **Designing solutions to problems is a systematic process.**	**SYSTEMS AND SYSTEM MODELS** Models can be used to represent systems and their interactions—such as inputs, processes and outputs—and energy, matter, and information flows within systems. **Models can represent systems and their interactions.** **In many systems there are cycles of various types of interactions.** **Energy flows within systems.** **Matter flows within systems.** **Information flows within systems.**

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
	There are many types of models. **Models can be used to investigate how a design might work.** **Models allow the designer to better understand the features of a design problem.**	

Clarification Statement
Examples of practical problems could include reducing the effects of impact of two objects such as two cars hitting each other, an object hitting a stationary object, or a meteor hitting a spacecraft.

Performance Expectation *and Louisiana Connectors*
6-MS-PS2-2 Plan an investigation to provide evidence that the change in an object's motion depends on the sum of the forces on the object and the mass of the object. **LC-6-MS-PS2-2a Identify using provided data that a change in an object's motion is due to the mass of an object and the forces acting on that object.**

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Planning and carrying out investigations: Planning and carrying out investigations to answer questions (science) or test solutions (engineering) to problems in 6-8 builds on K-5 experiences and progresses to include investigations that use multiple variables and provide evidence to support explanations or solutions. • Plan an investigation individually and collaboratively, and in the design: identify independent and dependent variables and controls, what tools are needed to do the gathering, how measurements will be recorded, and how many data are needed to support a claim. **Scientific investigations may be undertaken to support a claim.** **Scientific investigations should be planned.** **Scientific investigations can be developed with others.** **The design plan must include what tools are needed.**	**FORCES AND MOTION** The motion of an object is determined by the sum of the forces acting on it; if the total force on the object is not zero, its motion will change. The greater the mass of the object, the greater the force needed to achieve the same change in motion. For any given object, a larger force causes a larger change in motion (acceleration) (MS.PS2A.b) **Multiple forces can act on an object.** **The motion of an object depends on the sum of the forces acting on it.** **If an object is moving, the total of the forces acting on it does not have a sum of zero.** **If an object is not moving, the total sum of the forces action in it is equal to zero.** **An object subject to balanced forces does not change its motion. It will continue in a straight line at the same speed.** **An object subject to unbalanced forces changes its motion over time.** **Unbalanced forces cause an object to speed up, slow down, and/or change direction.** **The change in motion of an object is affected by the mass of the object and the size of the force applied.** **A larger force will cause a larger change in motion (acceleration) when compared to a smaller force.** All positions of objects and the directions of forces and motions must be described in an arbitrarily chosen reference frame and arbitrarily chosen units of size. In order to share information with other people, these choices must also be shared. (MS.PS2A.c) **Forces and motions can be described using units.** **To describe the direction of forces and motions, there needs to be a reference frame or 3-dimensional coordinate system associated with the measurement.** **To describe the position of objects, there needs to be a reference frame or 3-dimensional**	**STABILITY AND CHANGE** Explanations of stability and change in natural or designed systems can be constructed by examining the changes over time and forces at different scales, including atomic scales. **Stability is a condition in which some aspects of a system (natural or designed) are unchanging.** **Change can be observed at different scales (large and small/atomic) in a system.**

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
The design plan must include how measurements will be recorded. **The design plan must include what kind of data must be gathered.** **The design plan must include experimental variables including independent, dependent, and controls.**	**coordinate system associated with the measurement.** **The units of measurement and reference frame must be defined.** **To share information about forces and motions with others, the units and reference frame must be shared as well.** The motion of an object is dependent upon the reference frame of the observer. The reference frame must be shared when discussing the motion of an object. (MS.PS2A.d) **The motion of an object depends on the reference frame or 3-dimensional coordinate system defined by the observer.** **To share information about the motion of an object with others, the reference frame must be shared as well.**	

Clarification Statement
Emphasis is on balanced (Newton's First Law) and unbalanced forces in a system, qualitative comparisons of forces, mass and changes in motion (Newton's Second Law) in one dimension to a given frame of reference, or specification of units.

Performance Expectation *and Louisiana Connectors*
6-MS-PS2-3 Ask questions about data to determine the factors that affect the strength of electric and magnetic forces. **LC-6-MS-PS2-3a Identify that electricity can be used to produce magnetism, or magnetism can be used to make electricity.** **LC-6-MS-PS2-3b Examine data of objects (e.g., a model that demonstrates that a piece of metal, when magnetized by electricity, can pick up many times its own weight) to identify cause and effect relationships that affect electromagnetic forces.**

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Asking questions and defining problems: Asking questions (science) and defining problems (engineering) in grades 6-8 builds from grades K-5 experiences and progresses to specifying relationships between variables, and clarifying arguments and making models. • Ask questions that can be investigated within the scope of the classroom, outdoor environment, and museums and other public facilities with available resources and, when appropriate, frame a hypothesis based on observations and scientific principles. **Scientific questions can be investigated in a variety of ways.** **The answers to scientific questions can be supported with available resources.** **Questions can be framed by a hypothesis based on observations.** **Questions can be framed by a**	**TYPES OF INTERACTIONS** Electric and magnetic (electromagnetic) forces can be attractive (opposite charges) or repulsive (like charges), have polar charges (north and south poles) and their sizes depend on the magnitudes of the charges, currents, or magnetic strengths involved and on the distances between the interacting objects. (MS.PS2B.a) **Electrical energy is a form of energy that can be transferred.** **Some materials are magnetic and can be pushed or pulled by other magnets.** **Electric forces can be attractive or repulsive.** **Magnetic forces can be attractive or repulsive.** **Electric forces have polar charges.** **Magnetic forces have polar charges.** **The size of electric forces depends on the magnitudes of the charges, currents, or magnetic strengths between the interacting objects.** **The size of magnetic forces depends on the magnitudes of the charges, currents, or magnetic strengths between the interacting objects.** **The size of electric forces depends on the distances between the interacting objects.** **The size of magnetic forces depends on the distances between the interacting objects.**	**CAUSE AND EFFECT** Cause and effect relationships may be used to predict phenomena in natural or designed systems. **Cause and effect relationships may be used to predict phenomena.**

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
hypothesis based on scientific principles.		

Clarification Statement
Questions about data might require quantitative answers related to proportional reasoning and algebraic thinking. Examples of devices that use electric and magnetic forces could include electromagnets. Examples of data could include the effect of the number of turns of wire on the strength of an electromagnet, or the effect of increasing the number or strength of magnets on the speed of an electric motor.

Performance Expectation *and Louisiana Connectors*
6-MS-PS2-4 Construct and present arguments using evidence to support the claim that gravitational interactions are attractive and depend on the masses of interacting objects. **LC-6-MS-PS2-4a Using a chart displaying the mass of those objects and the strength of interaction, compare the magnitude of gravitational force on interacting objects of different mass (e.g., the Earth and the sun)**

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Engaging in argument from evidence: Engaging in argument from evidence in 6-8 builds from K-5 experiences and progresses to constructing a convincing argument that supports or refutes claims for either explanations or solutions about the natural and designed world(s). • Construct, use, and/or present an oral and written argument supported by empirical evidence and scientific reasoning to support or refute an explanation or a model for a phenomenon or a solution to a problem. **Use empirical evidence to construct an argument.** **Use empirical evidence to support an argument.** **Use scientific reasoning to construct an argument.** **Use scientific reasoning to support an argument.** **Use an argument to support a**	**TYPES OF INTERACTIONS** Gravitational forces are always attractive. There is a gravitational force between any two masses, but it is very small except when one or both of the objects have large mass (e.g., Earth and the sun). (MS.PS2B.b) **Objects with mass are sources of gravitational fields and are affected by the gravitational fields of all other objects with mass.** **Gravity is a force that acts between masses over very large distances.** **The force of gravity is always attractive.** **The force of gravity is always present.** **The strength of the force of gravity between objects depends on the objects' masses.** **An object with a large mass (e.g., Earth) will cause a larger force of gravity between objects when compared to an object with a small mass.**	**SYSTEMS AND SYSTEM MODELS** Models can be used to represent systems and their interactions—such as inputs, processes and outputs—and energy, matter, and information flows within systems. **Models can represent systems and their interactions.** **In many systems there are cycles of various types of interactions.** **Energy flows within systems.** **Matter flows within systems.** **Information flows within systems.**

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
model for a phenomena. **Use an argument to refute a model for a phenomena.** **Use an argument to support a solution to a problem.** **Use an argument to refute a solution to a problem.**		

Clarification Statement
Examples of evidence for arguments could include data generated from simulations or digital tools and charts displaying mass, strength of interaction, distance from the sun, or orbital periods of objects within the solar system, not necessarily including Newton's Law of Gravitation or Kepler's Laws.

Performance Expectation ***and Louisiana Connectors***
6-MS-PS2-5 Conduct an investigation and evaluate the experimental design to provide evidence that fields exist between objects exerting forces on each other even though the objects are not in contact. **LC-6-MS-PS2-5a Evaluate a change in the strength of a force (i.e., electric and magnetic) using data.** **LC-6-MS-PS2-5b Identify evidence that fields exist between objects exerting forces on each other even though the objects are not in contact.**

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Planning and carrying out investigations: Planning and carrying out investigations to answer questions (science) or test solutions (engineering) to problems in 6-8 builds on K-5 experiences and progresses to include investigations that use multiple variables and provide evidence to support explanations or solutions. • Collect data to produce data to serve as the basis for evidence to answer scientific questions or test design solutions under a range of conditions. **Use data as evidence to answer scientific questions.** **Use data as evidence to test design solutions.** **Collect evidence under a range of conditions.**	**TYPES OF INTERACTIONS** Forces that act at a distance (electric, magnetic, and gravitational) can be explained by fields that extend through space and can be mapped by their effect on a test object (a charged object, or a ball, respectively). (MS.PS2B.c) **Forces can be used to transfer energy from one object to another.** **Gravitational, electric, and magnetic forces between a pair of objects do not require that they be in contact.** **Gravitational, electric, and magnetic forces are explained by force fields that contain energy and can transfer energy through space.** **Electric forces have fields that extend through space.** **Magnetic forces have fields that extend through space.** **Gravitational forces have fields that extend through space.** **Electric forces have fields that can be mapped by their effect on a test object.** **Magnetic forces have fields that can be mapped by their effect on a test object.** **Gravitational forces have fields that can be mapped by their effect on a test object.**	**CAUSE AND EFFECT** Cause and effect relationships may be used to predict phenomena in natural or designed systems. **Cause and effect relationships may be used to predict phenomena.**

Clarification Statement
Examples of this phenomenon could include the interactions of magnets, electrically-charged strips of tape, or electrically-charged pith balls. Examples of investigations could include first-hand experiences or simulations designed to provide qualitative evidence for the existence of fields.

Performance Expectation *and Louisiana Connectors*
6-MS-PS3-1 Construct and interpret graphical displays of data to describe the relationships of kinetic energy to the mass of an object and to the speed of an object. **LC-6-MS-PS3-1a Use graphical displays of data to describe the relationship of kinetic energy to the mass of an object and to the speed of an object.**

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Analyzing and interpreting data: Analyzing data in 6-8 builds on K-5 experiences and progresses to extending quantitative analysis to investigations, distinguishing between correlation and causation, and basic statistical techniques of data and error analysis. • Construct, analyze, and/or interpret graphical displays of data and/or large data sets to identify linear and nonlinear relationships. **Use graphical displays of data to identify linear relationships.** **Use graphical displays of data to identify nonlinear relationships.** **Use large data sets to identify linear relationships.** **Use large data sets to identify nonlinear relationships.**	**DEFINITIONS OF ENERGY** Motion energy is properly called kinetic energy; it is proportional to the mass of the moving object and grows with the square of its speed. (MS.PS3A.a) **When an object is in motion, the energy it contains is called kinetic energy.** **The kinetic energy of an object is the energy that it possesses due to its motion.** **The kinetic energy of an object is proportional to its mass.** **Kinetic energy doubles as the mass of an object doubles.** **The kinetic energy of an object grows with the square of its speed. If velocity is doubled, kinetic energy is quadrupled.**	**SCALE, PROPORTION, AND QUANTITY** Proportional relationships (e.g., speed as the ratio of distance traveled to time taken) among different types of quantities provide information about the magnitude of properties and processes. **Ratio and proportionality are used in science.** **Ratio and proportionality provide information about the magnitude of properties.** **Ratio and proportionality provide information about the magnitude of processes.**

Clarification Statement
Emphasis is on descriptive relationships between kinetic energy and mass as well as kinetic energy and speed. Examples could include riding a bicycle at different speeds, rolling different masses of rocks downhill, or the impact of a wiffle ball versus a tennis ball.

Performance Expectation *and Louisiana Connectors*
6-MS-PS3-2 Develop a model to describe that when the arrangement of objects interacting at a distance changes, different amounts of potential energy are stored in the system. **LC-6-MS-PS3-2a Describe, using models, how changing distance changes the amount of potential energy stored in the system (e.g., carts at varying positions on a hill).**

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Developing and using models: Modeling in 6-8 builds on K-5 experiences and progresses to developing, using and revising models to describe, test, and predict more abstract phenomena and design systems. • Develop a model to describe unobservable mechanisms. **A model can be used to describe a mechanism which cannot be seen.**	**DEFINITIONS OF ENERGY** An object or system of objects may also contain stored (potential) energy, depending on their relative positions. (MS.PS3A.b) **When an object is at rest, the energy it contains is called potential energy.** **An object may contain stored (potential) energy depending on its relative position.** **A system of objects may contain stored (potential) energy depending on their relative positions.** **As the relative position of two objects changes, the potential energy of the system changes.** **RELATIONSHIP BETWEEN ENERGY AND FORCES** When two objects interact, each one exerts a force on the other that can cause energy to be transferred to or from the object. (MS.PS3C.a) **Whenever an object pushes or pulls another object, it gets pushed or pulled back by that object.** **Energy can be transferred to or from one object to another when they interact.** **The transfer of energy can happen when two objects interact.**	**SYSTEMS AND SYSTEM MODELS** Models can be used to represent systems and their interactions—such as inputs, processes and outputs—and energy, matter, and information flows within systems. **Models can represent systems.** **In many systems there are cycles of various types.** **Energy flows within systems.** **Matter flows within systems.** **Information flows within systems.**

Clarification Statement
Emphasis is on relative amounts of potential energy, not on calculations of potential energy. Examples of objects within systems interacting at varying distances could include: the Earth and either a roller coaster cart at varying positions on a hill or objects at varying heights on shelves, changing the direction/orientation

Clarification Statement
of a magnet, or a balloon with static electrical charge being brought closer to a classmate’s hair. Examples of models could include representations, diagrams, pictures, or written descriptions of systems.

Performance Expectation *and Louisiana Connectors*
6-MS-PS4-1 Use mathematical representations to describe a simple model for waves that includes how the amplitude of a wave is related to the energy in a wave and how the frequency and wavelength change the expression of the wave. **LC-6-MS-PS4-1a Identify how the amplitude of a wave is related to the energy in a wave using a mathematical or graphical representation.**

Science and Engineering Practice	**Disciplinary Core Idea**	**Crosscutting Concept**
Using mathematics and computational thinking: Mathematical and computational thinking in 6-8 builds on K-5 experiences and progresses to identifying patterns in large data sets and using mathematical concepts to support explanations and arguments. • Use mathematical representations to describe and/or support scientific conclusions and design solutions. **Use mathematical representations to describe scientific conclusions.** **Use mathematical representations to support scientific conclusions.** **Use mathematical representations to describe design solutions.** **Use mathematical representations to support design solutions.**	**WAVE PROPERTIES** A simple wave has a repeating pattern with a specific wavelength, frequency, and amplitude. (MS.PS4A.a) **A simple wave has a repeating pattern.** **A simple wave has a specific wavelength.** **A simple wave has a specific frequency.** **A simple wave has a specific amplitude.** **The wavelength and frequency of a wave are related to one another by the speed of travel of the wave.** **The higher the frequency of the wave the shorter the wavelength.** **The lower the frequency of the wave the longer the wavelength.** **The higher the frequency of the wave the higher the amplitude.** **The lower the frequency of the wave the lower the amplitude.**	**PATTERNS** Graphs, charts, and images can be used to identify patterns in data. **Graphs can be used to identify patterns.** **Charts can be used to identify patterns.** **Images can be used to identify patterns.**

Clarification Statement
Emphasis is on describing mechanical waves with both qualitative and quantitative thinking.

Performance Expectation *and Louisiana Connectors*
6-MS-PS4-2 Develop and use a model to describe that waves are refracted, reflected, absorbed, transmitted, or scattered through various materials. **LC-6-MS-PS4-2a Describe, using a model, how sound waves are reflected, absorbed, or transmitted through various materials (e.g., water, air, glass).** **LC-6-MS-PS4-2b Describe, using a model, how light waves are reflected, absorbed, or transmitted through various materials (e.g., water, air, glass).**

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Developing and using models: Modeling in 6-8 builds on K-5 experiences and progresses to developing, using, and revising models to describe, test, and predict more abstract phenomena and design systems. • Develop and/or use a model to predict and/or describe phenomena. **Use a model to predict phenomena.** **Use a model to describe phenomena.** **Develop a model to predict phenomena.** **Develop a model to describe phenomena.**	**WAVE PROPERTIES** A sound wave needs a medium through which it is transmitted. (MS.PS4A.b) **Sound waves need a medium (air, water, or solid material) to travel through.** **ELECTROMAGNETIC RADIATION** When light shines on an object, it is reflected, absorbed, transmitted, or scattered through the object, depending on the object's material and the frequency (color) of the light. (MS.PS4B.a) **When light shines on an object, it can be reflected by the object.** **When light shines on an object, it can be absorbed by the object.** **When light shines on an object, it can be transmitted by the object.** **When light shines on an object, it can be scattered through the object.** **What happens to light when it shines on an object depends on the object's material.** **What happens to light when it shines on an object depends on the frequency (color) of the light.** **The selective absorption of different wavelengths of white light determines the color of most objects.** The path that light travels can be traced as straight lines, except at surfaces between different transparent materials (e.g., air and water, air, and glass) where the light path bends (Refraction). (MS.PS4B.b) **The path of light travels in a straight line.** **The path of light bends at surfaces between different transparent materials (e.g., air and**	**STRUCTURE AND FUNCTION** Structures can be designed to serve particular functions by taking into account properties of different materials, and how materials can be shaped and used. **Structures can be designed to serve different functions.** **The design of a structure must be based on the properties of its materials.** **The design of a structure must be based on its shape.** **The design of a structure must be based on how it is being used.** **Structure does not**

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
	water, air, and glass). **Light usually refracts when passing from one material into another.** A wave model of light is useful for explaining brightness, color, and the frequency-dependent bending of light at a surface between media. However, because light can travel through a vacuum, it cannot be a mechanical wave, like sound or water waves. (MS.PS4B.c) **Light can be described using a wave model.** **A wave model of light can be used to explain its brightness.** **A wave model of light can be used to explain its color.** **A wave model of light can be used to explain the bending of light at a surface between media.** **Light can travel through a vacuum.** **Light cannot be described as a mechanical wave.** **At the surface between two media, like any wave, light can be reflected, refracted (its path bent), or absorbed.**	**always determine function.** **Differentiating structures can have the same function.**

Clarification Statement
Emphasis is on both light and mechanical waves interacting with various objects such as light striking a mirror and a water wave striking a jetty. Examples of models could include drawings, simulations, or written descriptions.

Performance Expectation *and Louisiana Connectors*
6-MS-ESS1-1 Develop and use a model of the Earth-sun-moon system to describe the reoccurring patterns of lunar phases, eclipses of the sun and moon, and seasons. **LC-6-MS-ESS1-1a Use an Earth-sun-moon model to show that the Earth-moon system orbits the sun once an Earth year and the orbit of the moon around Earth corresponds to a month.** **LC-6-MS-ESS1-1b Use an Earth-sun-moon model to explain eclipses of the sun and the moon.** **LC-6-MS-ESS1-1c Use an Earth-sun-moon model to explain how variations in the amount of the sun's energy hitting Earth's surface results in seasons.**

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Developing and using models: Modeling in 6-8 builds on K-5 experiences and progresses to developing, using, and revising models to describe, test, and predict more abstract phenomena and design systems. • Develop and use a model to describe phenomena. **Use a model to describe phenomena.** **Develop a model to describe phenomena.**	**THE UNIVERSE AND ITS STARS** Patterns of the apparent motion of the sun, the moon, and stars in the sky can be observed, described, predicted, and explained with models. (MS.ESS1A.a) **Earth rotates on its tilted axis once an Earth day.** **The moon orbits Earth approximately once a month.** **Earth-moon system orbits the sun once an Earth year.** **The Earth's rotation axis is tilted with respect to its orbital plane around the sun. Earth maintains the same relative orientation in space, with its North Pole pointed toward the North Star throughout its orbit.** **Models can be used to explain the relationship and motion of the sun, the moon, and the stars.** **Patterns of the apparent motion of the sun, the moon, and stars in the sky can be observed.** **Patterns of the apparent motion of the sun, the moon, and stars in the sky can be described.** **Patterns of the apparent motion of the sun, the moon, and stars in the sky can be predicted.** **Patterns of the apparent motion of the sun, the moon, and stars in the sky can be explained with models.** **EARTH AND THE SOLAR SYSTEM** This model of the solar system can explain eclipses of the sun and the moon. Earth's spin axis is fixed in direction over the short term but tilted relative to its orbit around the sun. The	**PATTERNS** Patterns can be used to identify cause and effect relationships. **Scientists use patterns to identify cause and effect relationships.**

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
	seasons are a result of that tilt and are caused by the differential intensity of sunlight on different areas of Earth across the year. (MS.ESS1B.b) **Models of the solar system can be used to explain eclipses of the sun and the moon.** **In the shadow of the moon that falls on Earth during a total solar eclipse, sunlight is prevented from reaching that part of Earth because the moon is located between the sun and Earth.** **Earth's axis is tilted relative to its orbit around the sun.** **As the Earth orbits around the sun, the angle at which the sun's rays strike Earth's surface changes due to the position of Earth's tilted axis relative to the sun.** **Different seasons are caused by the intensity of sunlight on the Earth at different times of the year.** **Summer occurs in the Northern Hemisphere at times in the Earth's orbit when the northern axis of Earth is tilted toward the sun.** **Winter occurs in the Northern Hemisphere at times in the Earth's orbit when the northern axis of Earth is tilted away from the sun.**	

Clarification Statement
Earth's rotation relative to the positions of the moon and sun describes the occurrence of tides; the revolution of Earth around the sun explains the annual cycle of the apparent movement of the constellations in the night sky; the moon's revolution around Earth explains the cycle of spring/neap tides and the occurrence of eclipses; the moon's elliptical orbit mostly explains the occurrence of total and annular eclipses. Examples of models can be physical, graphical, or conceptual.

Performance Expectation ***and Louisiana Connectors***
6-MS-ESS1-2 Use a model to describe the role of gravity in the motions within galaxies and the solar system. **LC-6-MS-ESS1-2a Use a model to identify the solar system as one of many systems orbiting the center of the larger system of the Milky Way galaxy, which is one of many galaxy systems in the universe.** **LC-6-MS-ESS1-2b Use a model to describe the relationships and interactions between components of the solar system as a collection of many varied objects held together by gravity.**

Science and Engineering Practice	**Disciplinary Core Idea**	**Crosscutting Concept**
Developing and using models: Modeling in 6-8 builds on K-5 experiences and progresses to developing, using, and revising models to describe, test, and predict more abstract phenomena and design systems. • Develop and/or use a model to predict and/or describe phenomena. **Use a model to predict phenomena.** **Use a model to describe phenomena.** **Develop a model to predict phenomena.** **Develop a model to describe phenomena.**	**THE UNIVERSE AND ITS STARS** Earth and its solar system are part of the Milky Way galaxy, which is one of many galaxies in the universe. (MS.ESS1A.b) **Earth is a part of the solar system.** **The solar system is part of the Milky Way galaxy.** **The Milky Way galaxy is one of many galaxies in the universe.** **There are many other galaxies in the universe, each containing many other stars.** **EARTH AND THE SOLAR SYSTEM** The solar system consists of the sun and a collection of objects, including planets, their natural satellite(s) (moons), and asteroids that are held in orbit around the sun by its gravitational pull on them. (MS.ESS1B.a) **The solar system contains the sun, planets, moons, and asteroids.** **The solar system is held together by the sun's gravitational force.** **The sun's gravity keeps all planets in a predictable orbit around it.** **The gravitational forces from the center of the Milky Way cause stars and stellar systems to orbit around the center of the galaxy.** The solar system appears to have formed from a disk of dust and gas, drawn together by gravity. (MS.ESS1B.c) **The solar system formed from dust and gas.**	**SYSTEMS AND MODELS** Models (e.g., physical, mathematical, computer models) can be used to represent systems and their interactions—such as inputs, processes and outputs—and energy, matter, and information flows within systems. **Models can represent systems.** **In many systems there are cycles of various types.** **Energy flows within systems.** **Matter flows within systems.** **Information flows within systems.**

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
	The components of the solar system are drawn together by gravity. **The result was the formation of moon-planet and planet-sun orbiting systems.**	

Clarification Statement
Emphasis for the model is on gravity as the force that holds together the solar system and Milky Way galaxy and controls orbital motions within them. Examples of models can be physical (such as the analogy of distance along a football field or computer visualizations of elliptical orbits) or conceptual (such as mathematical proportions relative to the size of familiar objects such as their school or state).

Performance Expectation *and Louisiana Connectors*
6- MS-ESS1-3 Analyze and interpret data to determine scale properties of objects in the solar system. **LC-6-MS-ESS1-3a Use data (e.g., statistical information, drawings and photographs, and models) to determine similarities and differences among solar system objects.**

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Analyzing and interpreting data: Analyzing data in 6-8 builds on K-5 experiences and progresses to extending quantitative analysis to investigations, distinguishing between correlation and causation, and basic statistical techniques of data and error analysis. • Analyze and interpret data to determine similarities and differences in findings. **Use data to determine similarities in findings.** **Use data to determine differences in findings.**	**EARTH AND THE SOLAR SYSTEM** The solar system consists of the sun and a collection of objects, including planets, their natural satellite(s) (moons), comets, and asteroids that are held in orbit around the sun by its gravitational pull on them. (MS.ESS1B.a) **The solar system contains the sun, planets, moons, and asteroids.** **The solar system is held together by the sun's gravitational force.** **The sun's gravity keeps all planets in a predictable orbit around it.** **The gravitational forces from the center of the Milky Way cause stars and stellar systems to orbit around the center of the galaxy.**	**SCALE, PROPORTION, AND QUANTITY** Time, space, and energy phenomena can be observed at various scales using models to study systems that are too large or too small. **Phenomena can be observed at different scales (micro and macro) in a system.** **Phenomena can be studied using models.** **Models can be used to explain time, space, and energy phenomena.**

Clarification Statement
Emphasis is on the analysis of data from Earth-based instruments, space-based telescopes, and spacecraft to determine similarities and differences among solar system objects. Examples of scale properties include the sizes of an object's layers (such as crust and atmosphere), atmospheric composition, surface features (such as volcanoes), and orbital radius. Examples of data include statistical information, drawings and photographs, and models.

Performance Expectation ***and Louisiana Connectors***
6-MS-ESS3-4 Construct an argument supported by evidence for how increases in human population and per-capita consumption of natural resources impact Earth's systems. **LC-6-MS-ESS3-4 Identify changes that human populations have made to Earth's natural systems using a variety of resources.**

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Engaging in argument from evidence: Engaging in argument from evidence in 6-8 builds on K-5 experiences and progresses to constructing a convincing argument that supports or refutes claims for either explanations or solutions about the natural and designed world(s). • Construct, use, and/or present an oral and written argument supported by empirical evidence and scientific reasoning to support or refute an explanation or a model for a phenomenon or a solution to a problem. **Use empirical evidence to construct an argument.** **Use empirical evidence to support an argument.** **Use scientific reasoning to construct an argument.** **Use scientific reasoning to support an argument.** **Use an argument to support a**	**HUMAN IMPACTS ON EARTH SYSTEMS** Typically as human populations and per-capita consumption of natural resources increase, so do the negative impacts on Earth unless the activities and technologies involved are engineered otherwise. (MS.ESS3C.b) **As the human population grows, so does the consumption of natural resources.** **As the human population grows, so do the human impacts on the planet.** **People impact the environment by:** **• poor agricultural practices (e.g., wasteful water),** **• polluting the air, water, and ground,** **• tourism and recreational development (e.g., ski resorts, golf courses), and** **• clearing forests and grasslands for cities.** **People can minimize the impact on the environment by:** **• practicing proper agriculture (e.g., rotating crops),** **• reusing, reducing, and recycling materials,** **• natural resource management,** **• conserving water and electricity, and** **• maintaining some forest and grassland areas.** **Some negative effects of human activities are reversible using technology.** **The sustainability of human societies and of the biodiversity that supports them requires responsible management of natural resources.** **BIOGEOLOGY** Living organisms interact with Earth materials resulting in changes of the Earth. (MS.ESS2E.a) **Living things have changed the makeup of Earth's geosphere, hydrosphere, and atmosphere**	**CAUSE AND EFFECT** Cause and effect relationships may be used to predict phenomena in natural or designed systems. **Cause and effect relationships may be used to predict phenomena.**

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
model for a phenomena. **Use an argument to refute a model for a phenomena.** **Use an argument to support a solution to a problem.** **Use an argument to refute a solution to a problem.**	**over geological time.** **The flow of water can be affected by living organisms.** **Ground cover can be affected by living organisms.** **The slope of the land can be affected by living organisms.** **RESOURCE MANAGEMENT FOR LOUISIANA** Responsible management of Louisiana's natural resources promotes economic growth, a healthy environment, and vibrant productive ecosystems. (MS.EVS1B.a) **Responsible management of Louisiana's natural resources helps create economic growth.** **Responsible management of Louisiana's natural resources helps create a healthy environment.** **Responsible management of Louisiana's natural resources helps sustain vibrant productive ecosystems.**	

Clarification Statement
Examples of evidence include grade-appropriate databases on human populations and the rates of consumption of food and natural resources (such as freshwater, mineral, and energy). Examples of impacts can include changes to the appearance, composition, and structure of Earth's systems as well as the rates at which they change. The consequences of increases in human populations and consumption of natural resources are described by science, but science does not make the decisions.

Performance Expectation *and Louisiana Connectors*
6-MS-LS1-1 Conduct an investigation to provide evidence that living things are made of cells, either one or many different numbers and types. **LC-6-MS-LS1-1a Identify that living things may be made of one cell or many different numbers and types of cells.**

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Planning and carrying out investigations: Planning and carrying out investigations to answer questions (science) or test solutions (engineering) to problems in 6-8 builds on K-5 experiences and progresses to include investigations that use multiple variables and provide evidence to support explanations or solutions. • Conduct an investigation and/or evaluate and/or revise the experimental design to produce data to serve as the basis for evidence that meet the goals of the investigation. **Conduct an investigation to produce data to meet its goals.** **Evaluate the experimental design to ensure it meets its goals.** **Revise the experimental design to ensure it meets it goals.** **Data may serve as evidence that an investigation has met its goals.**	**STRUCTURE AND FUNCTION** All living things are made up of cells, which are the smallest living unit. An organism may consist of one single cell (unicellular) or many different numbers and types of cells (multicellular). (MS.LS1A.a) **All living things are made up of cells.** **The cell is the smallest living unit.** **The cell is the fundamental unit of life.** **An organism can consist of a single cell.** **An organism can consist of many cells.** **An organism can consist of many different types of cells.** **Single-celled organisms are composed of one cell that can survive independently.** **Multi-cellular organisms consist of individual cells that cannot survive independently.**	**SCALE, PROPORTION, AND QUANTITY** Phenomena that can be observed at one scale may not be observable at another scale. **Different phenomena correspond to different scales.** **Some phenomena are observable at some scales.** **Some phenomena cannot be observed at certain scales.**

Clarification Statement
Emphasis is on developing evidence that living things are made of cells, distinguishing between living and nonliving things, and understanding that living things may be made of one or many cells, including specialized cells. Examples could include animal cells (blood, muscle, skin, nerve, bone, or reproductive) or plant cells (root, leaf, or reproductive).

Performance Expectation *and Louisiana Connectors*
6-MS-LS1-2 Develop and use a model to describe the function of a cell as a whole and ways parts of cells contribute to the function. **LC-6-MS-LS1-2a Using a model(s), identify the function of a cell as a whole.** **LC-6-MS-LS1-2b Using a model(s), identify special structures within cells are responsible for particular functions.** **LC-6-MS-LS1-2c Using a model(s), identify the components of a cell.** **LC-6-MS-LS1-2d Using a model(s), identify the functions of components of a cell.**

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Developing and using models: Modeling in 6-8 builds on K-5 experiences and progresses to developing, using, and revising models to describe, test, and predict more abstract phenomena and design systems. • Develop and/or use a model to predict and/or describe phenomena. **Models can be used to describe phenomena.** **Models can be used to predict phenomena.**	**STRUCTURE AND FUNCTION** Within cells, special structures (organelles) are responsible for particular functions. The cell membrane forms the boundary that controls the material(s) that enter and leave the cells in order to maintain homeostasis. (MS.LS1A.b) **Organelles are structures within cells.** **Most cells contain a set of observable structures called organelles which allow them to carry out life processes.** **Organelles perform specific functions.** **A living cell depends on its organelles to function properly.** **Major organelles include vacuoles, cell membrane, nucleus, and mitochondria.** **Plant cells are structurally and functionally different from animal cells.** **Plants contain organelles such as cell wall and chloroplasts that are not found in animal cells.** **A cell membrane surrounds every cell.** **The cell membrane controls what goes in and out of a cell.** **Plant cells have a cell wall in addition to a cell membrane, whereas animal cells have only a cell membrane. Plants use cell walls to provide structure to the plant.** **A living cell maintains stable internal conditions (homeostasis) despite changes in its surroundings.** **The functions of the organelles contribute to the cell's overall function as a whole (e.g., maintain the cells internal processes, the structure of the cell, what enters and leaves the cell, and overall cellular function).**	**STRUCTURE AND FUNCTION** Complex and microscopic structures and systems can be visualized, modeled, and used to describe how their function depends on the shapes, composition, and relationships among its parts; therefore, complex natural and designed structures/systems can be analyzed to determine how they function. **Complex structures can be visualized.** **Microscopic structures can be visualized.** **Complex structures can be modeled.**

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
		Microscopic structures can be modeled. The function of a structure depends on its shape. The function of a structure depends on its composition. The function of a structure depends on relationships among its parts. Designed structures/systems can be analyzed to determine how they function.

Clarification Statement
Emphasis is on the cell functioning as a whole system and the primary role of identified parts of the cell, such as the nucleus, chloroplasts, mitochondria, cell membrane, or cell wall.

Performance Expectation ***and Louisiana Connectors***
6-MS-LS2-1 Analyze and interpret data to provide evidence for the effects of resource availability on organisms and populations of organisms in an ecosystem. **LC-6-MS-LS2-1a Recognize data that shows growth of organisms and population increases are limited by access to resources.** **LC-6-MS-LS2-1b Identify factors (e.g., resources, climate or competition) in an ecosystem that influence growth in populations of organisms.**

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Analyzing and interpreting data: Analyzing data in 6-8 builds on K-5 experiences and progresses extending quantitative analysis to investigations, distinguishing between correlation and causation, and basic statistical techniques of data and error analysis. • Analyze and interpret data to provide evidence for phenomena. **Interpret data to provide evidence for phenomena.** **Analyze data to provide evidence for phenomena.**	**INTERDEPENDENT RELATIONSHIPS IN ECOSYSTEMS** Organisms, and populations of organisms, are dependent on their environmental interactions both with other living things and with nonliving factors. (MS.LS2A.a) **In any ecosystem, there are physical and biological factors.** **All living organisms interact with the living and nonliving parts of their surroundings to meet their needs for survival.** **Organisms are dependent on other living things.** **Organisms are dependent on nonliving factors.** **Populations are dependent on other living things.** **Populations are dependent on nonliving factors.** **The size of populations may change as a result of the interrelationships among organisms.** In any ecosystem, organisms and populations with similar requirements for food, water, oxygen, or other resources may compete with each other for limited resources, access to which consequently constrains their growth and reproduction. (MS.LS2A.b) **A population consists of all individuals of a species that occur together at a given place and time.** **All populations living together (biotic factors) and the physical factors with which they interact (abiotic factors) compose an ecosystem.** **Organisms and populations cope with the physical conditions of their immediate surroundings.** **Organisms may compete with other organisms for resources (e.g., food, water, oxygen, shelter).** **Availability of resources (e.g., food, water, oxygen, shelter) can lead to changes in**	**CAUSE AND EFFECT** Cause and effect relationships may be used to predict phenomena in natural or designed systems. **Cause and effect relationships may be used to predict phenomena.**

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
	populations. **Access to resources is needed for organisms to grow and reproduce.** Growth of organisms and population increases are limited by access to resources. (MS.LS2A.c) **Growth of organisms are limited by access to resources.** **Population increases are limited by access to resources.** **In order to survive, populations within an ecosystem require a balance of resources.**	

Clarification Statement
Emphasis is on cause and effect relationships between resources and growth of individual organisms and the numbers of organisms in ecosystems during periods of abundant or scarce resources.

Performance Expectation ***and Louisiana Connectors***
6-MS-LS2-2 Construct an explanation that predicts patterns of interactions among organisms across multiple ecosystems. **LC-6-MS-LS2-2a Use an explanation of interactions between organisms in an ecosystem to identify examples of competitive, predatory, or symbiotic relationships.**

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Constructing explanations and designing solutions: Constructing explanations (science) and designing solutions (engineering) in 6-8 builds on K- 5 experiences and progresses to include constructing explanations and designing solutions supported by multiple sources of evidence consistent with scientific ideas, principles, and theories. • Construct an explanation that includes qualitative or quantitative relationships between variables that predict(s) and/or describe(s) phenomena. **Construct an explanation that includes qualitative relationships to predict a phenomena.** **Construct an explanation that includes qualitative relationships to describe a phenomena.** **Construct an explanation that includes quantitative relationships to predict a phenomena.** **Construct an explanation that**	**INTERDEPENDENT RELATIONSHIPS IN ECOSYSTEMS** Predatory interactions may reduce the number of organisms or eliminate whole populations of organisms. Mutually beneficial interactions, in contrast, may become so interdependent that each organism requires the other for survival. Although the species involved in these competitive, predatory, and mutually beneficial interactions vary across ecosystems, the patterns of interactions of organisms with their environments, both living and nonliving, are shared. (MS.LS2A.d) **A predatory species can reduce the number of organisms in a population.** **A predatory species can eliminate whole populations.** **Predator/Prey relationships can have a negative correlation.** **Different organisms may be interdependent on each other for survival.** **When organisms depend on each other, it is called a mutually beneficial interaction.** **The species in these cause and effect relationships (competitive, predatory, and mutually beneficial) vary across ecosystems.** **Patterns can be observed in these cause and effect relationships (competitive, predatory, and mutually beneficial) across ecosystems.** **Organisms within an ecosystem may interact symbiotically through mutualism, parasitism, and commensalism.**	**PATTERNS** Patterns can be used to identify cause and effect relationships. **Scientists use patterns to identify cause and effect relationships.**

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
includes quantitative relationships to describe a phenomena.		

Clarification Statement
Emphasis is on (1) predicting consistent patterns of interactions in different ecosystems and (2) relationships among and between biotic and abiotic components of ecosystems. Examples of types of interactions could include competitive, predatory, mutually beneficial, or other symbiotic relationships.

Performance Expectation ***and Louisiana Connectors***
6-MS-LS2-3 Develop a model to describe the cycling of matter and flow of energy among living and nonliving parts of an ecosystem. **LC-6-MS-LS2-3a Using a model(s), describe energy transfer between producers and consumers in an ecosystem using a model (e.g., producers provide energy for consumers).** **LC-6-MS-LS2-3b Using a model(s), describe the cycling of matter among living and nonliving parts of a defined system (e.g., the atoms that make up the organisms in an ecosystem are cycled repeatedly between the living and nonliving parts of the ecosystem).**

Science and Engineering Practice	**Disciplinary Core Idea**	**Crosscutting Concept**
Developing and using models: Modeling in 6-8 builds on K-5 experiences and progresses to developing, using, and revising models to describe, test, and predict more abstract phenomena and design systems. • Develop and/or use a model to predict and/or describe phenomena. **Models can be used to describe phenomena.** **Models can be used to predict phenomena.**	**CYCLE OF MATTER AND ENERGY TRANSFER IN ECOSYSTEMS** Food webs are models that demonstrate how matter and energy is transferred between producers, consumers, and decomposers as the three groups interact within an ecosystem. (MS.LS2B.a) **Matter and energy cycle through both living and non-living parts of ecosystems.** **Matter and energy are transferred between producers, consumers, and decomposers within an ecosystem.** **In most ecosystems, energy enters as sunlight and is transformed by producers into a biologically usable form of matter through photosynthesis.** **Food webs are models that show how matter and energy is transferred within and across groups of organisms in an ecosystem.** **Some animals are herbivores, eat plants and algae.** **Some animals are omnivores, eat plants and/or animals.** **Some animals are carnivores, which eat animals that have eaten photosynthetic organisms.** Transfers of matter into and out of the physical environment occur at every level. (MS.LS2B.b) **Matter cycles through living systems and between living systems and the physical environment.** **Over time, matter is transferred repeatedly from one organism to another and between organisms and their physical environment.** **When a consumer eats a producer, matter is transferred.** **When a producer or consumer decomposes, matter is transferred.** **When a consumer eats a consumer, matter is transferred.**	**ENERGY** The transfer of energy can be tracked as energy flows through a designed or natural system. **Energy cannot be created or destroyed.** **Energy can be transferred.** **Energy flows through systems (natural and designed).**

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
	Decomposers recycle nutrients from dead plant or animal matter back to the soil in terrestrial environments or to the water in aquatic environments. (MS.LS2B.c) **Dead plants and animals are broken down by decomposers.** **Decomposers recycle nutrients and material back into the soil in terrestrial environments.** **Decomposers recycle nutrients and material back into the water in aquatic environments.** **Food webs recycle matter continuously as organisms are decomposed after death to return food materials to the environment where it re-enters a food web.** The atoms that make up the organisms in an ecosystem are cycled repeatedly between the living and nonliving parts of the ecosystem. Geochemical cycles include carbon, nitrogen, and the water cycle. (MS.LS2B.d) **Living things are composed of atoms.** **All the atoms that make up organisms are repeatedly cycled between living and nonliving parts of the ecosystem.** **The total amount of matter remains constant, even though its form and location change.** **Matter and energy continually cycle through Earth's geochemical cycles (carbon, nitrogen, and the water cycle).**	

Clarification Statement
Emphasis is on describing the conservation of matter and flow of energy into and out of various ecosystems, and on defining the boundaries of the system.

Performance Expectation ***and Louisiana Connectors***
7-MS-PS1-2 Analyze and interpret data on the properties of substances before and after the substances interact to determine if a chemical reaction has occurred. ***LC-7-MS-PS2-1a Using data, identify changes that occur after a chemical reaction has taken place (e.g., change in color occurs, gas is created, heat or light is given off or taken in).***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Analyzing and interpreting data: Analyzing data in 6-8 builds on K-5 experiences and progresses to extending quantitative analysis to investigations, distinguishing between correlation and causation, and basic statistical techniques of data and error analysis. • Analyze and interpret data to determine similarities and differences in findings. ***Use data to determine similarities in findings.*** ***Use data to determine differences in findings.***	**STRUCTURE AND PROPERTIES OF MATTER** Each pure substance has characteristic physical and chemical properties (for any bulk quantity under given conditions) under normal conditions that can be used to identify it. (MS.PS1A.b) ***Pure substances are made from a single type of atom or molecule.*** ***Elements and compounds are pure substances.*** ***Pure substances have characteristics (physical and chemical properties) that are used to identify them.*** **CHEMICAL REACTIONS** Substances react chemically in characteristic ways. In a chemical process, the atoms that make up the original substances are regrouped into different molecules, and these new substances have different properties from those of the reactants. (MS.PS1B.a) ***Substances react in characteristic ways.*** ***When a chemical reaction occurs, the parts that make up the original substance are regrouped in a new way that makes a new substance with new properties.*** ***If atoms are rearranged, the ending result is a different substance.*** ***Many substances react chemically with other substances to form new substances with different properties.***	**PATTERNS** Macroscopic patterns are related to the nature of microscopic and atomic-level structure. ***Patterns can be related to microscopic and atomic-level structures. For example, chemical molecules contain particular ratios of different atoms. Macroscopic patterns are determined by microscopic and atomic level structures.***

Clarification Statement
Examples of reactions could include burning sugar or steel wool, fat reacting with sodium hydroxide, or mixing zinc with hydrogen chloride. Examples of chemical and physical properties to analyze include density, melting point, boiling point, solubility, flammability, or odor.

Clarification Statement
Performance Expectation *and Louisiana Connectors*
7-MS-PS1-4 Develop a model that predicts and describes changes in particle motion, temperature, and the state of a pure substance when thermal energy is added or removed. ***LC-7-MS-PS1-4a Use drawings and diagrams to Identify that adding or removing thermal energy increases or decreases particle motion until a change of state occurs.***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Developing and using models: Modeling in 6-8 builds on K-5 experiences and progresses to developing, using and revising models to describe, test, and predict more abstract phenomena and design systems. • Develop and/or use a model to predict and/or describe phenomena. ***Models, such as drawings and diagrams, can be used to describe phenomena.*** ***Models can be used to predict phenomena.***	**STRUCTURE AND PROPERTIES OF MATTER** Gases and liquids are made of molecules or inert atoms (the noble gases) that are moving about relative to each other. (MS.PS1A.c) ***Gases and liquids are made of molecules, which are always moving.*** ***In the liquid state, particles are loosely packed and move past each other.*** ***In a gaseous state, particles freely move past one another.*** ***As the temperature in a system increases, solid, liquid, and gas molecules increase in speed.*** ***As the temperature in a system decreases, solid, liquid, and gas molecules decrease in speed.*** In a liquid, the molecules are constantly in motion and in contact with others; in a gas, they are widely spaced except when they happen to collide. In a solid, atoms are closely spaced and may vibrate in position but do not change relative locations. (MS.PS1A.d) ***The molecules in a liquid are always in motion and in contact with other molecules.*** ***The molecules in a gas are widely spaced.*** ***The molecules in a solid are closely spaced. A solid's molecules may vibrate, but they do not change position.*** ***Particles in all three states are in constant motion.*** The changes of state that occur with variations in temperature or pressure can be described and predicted using temperature and pressure models of matter. (MS.PS1A.f) ***Heating and cooling of materials may produce changes in the state of solids, liquids, and***	**CAUSE AND EFFECT** Cause and effect relationships may be used to predict phenomena in natural or designed systems. ***Cause and effect relationships may be used to predict phenomena.***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
	gases. ***The state of matter is determined by the temperature and pressure of a substance.*** ***The state of matter can be predicted using temperature and pressure models.*** ***A phase change may occur when a material absorbs or releases heat energy.*** ***Changes in phase do not change the particles but do change how they are arranged.*** The temperature of a system is proportional to the average internal kinetic energy and potential energy per atom or molecule (whichever is the appropriate building block for the system's material). The details of that relationship depend on the type of atom or molecule and the interactions among the atoms in the material. Temperature is not a direct measure of a system's total thermal energy. The total thermal energy (sometimes called the total internal energy) of a system depends jointly on the temperature, the total number of atoms in the system, and the state of the material. (MS.PS.3A.c) ***Temperature is a measure of how fast particles are moving inside of a substance (i.e., the energy a substance contains).*** ***Matter at any temperature above absolute zero contains thermal energy. Thermal energy is the random motion of particles.*** ***The amount of matter in a system will affect the amount of energy needed to change the temperature of the matter.*** The term "heat" as used in everyday language refers both to thermal energy (the motion of atoms or molecules within a substance) and the transfer of that thermal energy from one object to another. In science, heat is used only for this second meaning; it refers to the energy transferred due to the temperature difference between two objects. (MS.PS3A.e) ***The term heat, in science, refers to the transfer of thermal energy.***	

Clarification Statement
Emphasis is on qualitative molecular-level models of solids, liquids, and gases to show that adding or removing thermal energy increases or decreases kinetic energy of the particles until a change of state occurs. Examples of models could include drawings or diagrams. Examples of particles could include molecules or inert atoms such as the noble gases. Examples of pure substances could include water, carbon dioxide, or helium.

Performance Expectation *and Louisiana Connectors*
7-MS-PS1-5 Develop and use a model to describe how the total number of atoms does not change in a chemical reaction and thus mass is conserved. ***LC-7-MS-PS1-5a Use a model to identify a chemical reaction in which the mass of the reactants is shown to be equal to the mass of the products.*** ***LC-7-MS-PS1-5b Use a model to show how the total number of atoms does not change in a chemical reaction and thus mass is conserved.***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Developing and using models: Modeling in 6-8 builds on K-5 experiences and progresses to developing, using and revising models to describe, test, and predict more abstract phenomena and design systems. • Develop a model to describe unobservable mechanisms. ***A model, such as a drawing or illustration, can be used to describe a mechanism which cannot be seen.***	**CHEMICAL REACTIONS** Substances react chemically in characteristic ways. In a chemical process, the atoms that make up the original substances are regrouped into different molecules, and these new substances have different properties from those of the reactants. (MS.PS1B.a) ***Substances react in characteristic ways.*** ***Chemical reactions result in new substances with properties that are different from those of the component parts.*** ***When a chemical reaction occurs, the parts that make up the original substance are regrouped in a new way that makes a new substance with new properties.*** ***If atoms are rearranged, the ending result is a different substance.*** ***Many substances react chemically with other substances to form new substances with different properties.*** The total number of each type of atom is conserved, and thus the mass does not change. (MS.PS1B.b) ***Matter cannot be created or destroyed.*** ***During a chemical reaction and rearrangement, all the atoms are accounted for and none are lost.*** ***The atoms are just in a new configuration and the total number of atoms present before the reaction is equal to the number of atoms after the reaction.*** ***The total mass of the mixture is equal to the sum of the masses of the components.*** ***Total mass is conserved when different substances are mixed.***	**ENERGY AND MATTER** Matter is conserved because atoms are conserved in physical and chemical processes. ***Matter is conserved because the original number of atoms before a reaction occurs (product) is the same as the number of atoms after the reaction occurs (reactant).***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
	When materials interact within a closed system, the total mass of the system remains the same.	

Clarification Statement
Emphasis is on the law of conservation of matter and on physical models or drawings, including digital forms that represent atoms. The use of atomic masses, balancing symbolic equations, or intermolecular forces is not the focus of this performance expectation.

Performance Expectation ***and Louisiana Connectors***
7-MS-PS3-4 Plan an investigation to determine the relationships among the energy transferred, the type of matter, the mass, and the change in the average kinetic energy of the particles as measured by the temperature of the sample. ***LC-7-MS-PS3-4a Using examples and data measurements, describe the relationship between different masses of the same substance and the change in average kinetic energy when thermal energy is added to or removed from the system.***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Planning and carrying out investigations: Planning and carrying out investigations to answer questions or test solutions to problems in 6-8 builds on K-5 experiences and progresses to include investigations that use multiple variables and provide evidence to support explanations or solutions. • Plan an investigation individually and collaboratively, and in the design: identify independent and dependent variables and controls, what tools are needed to do the gathering, how measurements will be recorded, and how many data are needed to support a claim. ***Scientific investigations may be undertaken to support a claim.*** ***Scientific investigations should be planned.*** ***Scientific investigations can be developed with others.*** ***The design plan must include what***	**DEFINITIONS OF ENERGY** Temperature is a measure of the average kinetic energy; the relationship between the temperature and the total energy of the system depends on the types, states, and amounts of matter present. (MS.PS3A.d) ***Temperature is a measurement used to determine how fast the particles are moving inside of a substance or how much energy the substance contains.*** ***The temperature of matter is a measurement of the matter's average kinetic energy.*** ***The state, amount of substance, and the type of substance will all affect the total amount of energy it has.*** **CONSERVATION OF ENERGY AND ENERGY TRANSFER** The amount of energy transfer needed to change the temperature of a matter sample by a given amount depends on the nature of the matter, the mass of the sample, and the environment. (MS.PS3B.b) ***The amount of matter in a system will affect the amount of energy needed to change the temperature of the matter.*** ***The type of matter in a system will affect the amount of energy needed to change the temperature of the matter.*** ***The environment of a system will affect the amount of energy needed to change the temperature of the matter.*** Energy is spontaneously transferred out of hotter regions or objects and into colder ones. (MS.PS3B.c)	**SCALE, PROPORTION, AND QUANTITY** Proportional relationships (e.g., speed as the ratio of distance traveled to time taken) among different types of quantities provide information about the magnitude of properties and processes. ***Ratio and proportionality are used in science.*** ***Ratio and proportionality provide information about the magnitude of properties.*** ***Ratio and proportionality provide information about the***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
tools are needed. ***The design plan must include how measurements will be recorded.*** ***The design plan must include what kind of data must be gathered.*** ***The design plan must include experimental variables including independent, dependent, and controls.***	***Energy is transferred out of hotter regions into colder ones.*** ***Energy is transferred out of hotter objects into colder ones.*** ***Heat energy transfers from warmer substances to cooler substances until they reach the same temperature.***	***magnitude of processes.***

Clarification Statement
Emphasis is on observing change in temperature as opposed to calculating total thermal energy transferred. Examples of experiments could include comparing final water temperatures after different masses of ice melted in the same volume of water with the same initial temperature, the temperature change of samples of different materials with the same mass as they cool or heat in the environment, or the same material with different masses when a specific amount of energy is added.

Performance Expectation *and Louisiana Connectors*
7-MS-ESS2-4 Develop a model to describe the cycling of water through Earth's systems driven by energy from the sun and the force of gravity. ***LC-7-MS-ESS2-4a Using a model(s), identify components in a model of water cycling among land, ocean, and atmosphere, and recognize how it is propelled by sunlight and gravity.***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Developing and using models: Modeling in 6-8 builds on K-5 experiences and progresses to developing, using, and revising models to describe, test, and predict more abstract phenomena and design systems. • Develop a model to describe unobservable mechanisms. ***A model can be used to describe a mechanism which cannot be seen.***	**THE ROLES OF WATER IN EARTH'S SURFACE PROCESSES** Water continually cycles among land, ocean, and atmosphere via transpiration, evaporation, condensation and crystallization, and precipitation, as well as downhill flows on land. (MS.ESS2C.a) ***Through the water cycle, water is cycled and recycled through both the living and non-living components of Earth's ecosystems.*** ***Water cycles through transpiration, evaporation, condensation, crystallization, and precipitation, as well as downhill flows on land through run-off and groundwater.*** ***Water within a watershed travels over and through the land at various speeds based on the rate of change in elevation and the permeability and porosity of the soil.*** Global movements of water and its changes in form are propelled by sunlight and gravity. (MS.ESS2C.c) ***Energy from the sun and the force of gravity drive the continual cycling of water.*** ***Sunlight causes evaporation and propels oceanic and atmospheric circulation.*** ***Gravity causes precipitation to fall from clouds and water to flow downward on the land.*** **LOUISIANA'S NATURAL RESOURCES** Replenishable resources such as groundwater and oxygen are purified by the movement through Earth's cycles. (MS.EVS1A.c) ***As water moves Earth's cycles, it is purified (e.g., groundwater).*** ***As oxygen moves through Earth's cycles, it is purified.***	**ENERGY AND MATTER** Within a natural or designed system, the transfer of energy drives the motion and/or cycling of matter. ***Energy can be transferred.*** ***Energy transfer drives the motion of matter through systems (natural and designed).*** ***Energy transfer drives the cycling of matter through systems (natural and designed).***

Clarification Statement
Emphasis is on the ways water changes its state and location as it moves through the multiple pathways of the hydrologic cycle. Examples of models can be conceptual or physical.

Performance Expectation *and Louisiana Connectors*
7-MS-ESS2-5 Collect data to provide evidence for how the motions and complex interactions of air masses results in changes in weather conditions. ***LC-7-MS-ESS2-5a Using data, identify how water influences weather and weather patterns through atmospheric, land, and oceanic circulation.*** ***LC-7-MS-ESS2-5b Using data, identify examples of how the sun drives all weather patterns on Earth (e.g., flow of energy that moves through Earth's land, air, and water).***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Planning and carrying out investigations: Planning and carrying out investigations to answer questions (science) or test solutions (engineering) to problems in 6-8 builds on K-5 experiences and progresses to include investigations that use multiple variables and provide evidence to support explanations or solutions. • Collect data to produce data to serve as the basis for evidence to answer scientific questions or test design solutions under a range of conditions. ***Use data to answer scientific questions.*** ***Use data to test design solutions.*** ***Collect data across a range of conditions.***	**THE ROLES OF WATER IN EARTH'S SURFACE PROCESSES** The complex patterns of the changes and the movement of water in the atmosphere, determined by winds, landforms, and ocean temperatures and currents, are major determinants of local weather patterns. (MS.ESS2C.b) ***Local weather at any point in time varies at different locations around the world.*** ***Weather can change in a short amount of time.*** ***Factors such as air pressure, temperature, humidity, precipitation, and wind can cause weather changes and weather patterns.*** ***Some weather events, such as snowstorms, hurricanes, thunderstorms or tornadoes are more likely to occur at different times of the year.*** **WEATHER AND CLIMATE** Weather and climate are influenced by interactions involving sunlight, the ocean, the atmosphere, ice, landforms, and living things. These interactions vary with latitude, altitude, and local and regional geography, all of which can affect oceanic and atmospheric flow patterns. Because these patterns are so complex, weather can only be predicted probabilistically. (MS.ESS2D.a) ***The sun drives all weather patterns on Earth.*** ***Sunlight heats Earth's surface, which in turn heats the atmosphere.*** ***The sun's energy heats Earth's surface, and the surface heats the air above it.*** ***The sun's energy heats Earth's surface unevenly.*** ***The ocean exerts a major influence on weather and climate.*** ***The ocean moderates and stabilizes global climates.***	**CAUSE AND EFFECT** Cause and effect relationships may be used to predict phenomena in natural or designed systems. ***Cause and effect relationships may be used to predict phenomena.***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
	Differences in latitude, altitude, and local and regional geography can cause different types of weather. ***The climate at a location on Earth is the result of several interacting variables such as latitude, altitude, regional geography, and/or proximity to water.*** ***Weather can be predicted, but weather forecasting has not been perfected.*** ***Weather and climate are influenced by interactions involving sunlight, the ocean, the atmosp here, ice, landforms, and living things.***	

Clarification Statement
Emphasis is on how air masses flow from regions of high pressure to low pressure, causing weather (defined by temperature, pressure, humidity, precipitation, and wind) at a fixed location to change over time, and how sudden changes in weather can result when different air masses collide. Emphasis is on how weather can be predicted within probabilistic ranges. Examples of data can be provided to students (such as weather maps, diagrams, and visualizations) or obtained through laboratory experiments (such as condensation).

Performance Expectation *and Louisiana Connectors*
7-MS-ESS2-6 Develop and use a model to describe how unequal heating and rotation of the Earth causes patterns of atmospheric and oceanic circulation that determine regional climates. ***7-MS-ESS2-6a Using a model(s), identify that as the sun's energy warms the air over the land (expands and rises), the air over the ocean (cooler air) rushes in to take its place and is called wind (sea breeze).*** ***7-MS-ESS2-6b Using a model(s), identify that weather and climate vary with latitude, altitude, and regional geography.***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Developing and using models: Modeling in 6-8 builds on K-5 experiences and progresses to developing, using, and revising models to describe, test, and predict more abstract phenomena and design systems. • Develop and use a model to describe phenomena. ***Use a model to describe phenomena.*** ***Develop a model to describe phenomena.***	**THE ROLES OF WATER IN EARTH'S SURFACE PROCESSES** Variations in density due to variations in temperature and salinity drive a global pattern of interconnected ocean currents. (MS.ESS2C.d) ***The movement of water among the geosphere, hydrosphere, and atmosphere affects such things as weather systems, ocean currents, and global climate.*** ***Ocean currents and sea surface temperature are directly related to global climate patterns.*** ***Ocean currents are the result of variations in the ocean's density.*** ***The density of different regions of the ocean is due to temperature and salinity variations.*** **WEATHER AND CLIMATE** Weather and climate are influenced by interactions involving sunlight, the ocean, the atmosphere, ice, landforms, and living things. These interactions vary with latitude, altitude, and local and regional geography, all of which can affect oceanic and atmospheric flow patterns. Because these patterns are so complex, weather can only be predicted probabilistically. (MS.ESS2D.a) ***The sun drives all weather patterns on Earth.*** ***Sunlight heats Earth's surface, which in turn heats the atmosphere.*** ***The ocean exerts a major influence on weather and climate.*** ***The ocean moderates and stabilizes global climates.*** ***Differences in latitude, altitude, and local and regional geography can cause different types of weather.*** ***The climate at a location on Earth is the result of several interacting variables such as latitude, altitude, regional geography, and/or proximity to water.***	**SYSTEMS AND SYSTEM MODELS** Models can be used to represent systems and their interactions—such as inputs, processes and outputs—and energy, matter, and information flows within systems. ***Models can represent systems.*** ***In many systems there are cycles of various types.*** ***Energy flows within systems.*** ***Matter flows within systems.*** ***Information flows within systems.***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
	Weather can be predicted, but weather forecasting has not been perfected. The ocean exerts a major influence on weather and climate by absorbing energy from the sun, releasing it over time, and globally redistributing it through ocean currents. (MS.ESS2D.b) ***The ocean absorbs and stores large amounts of energy from the sun and releases it very slowly.*** ***The ocean's thermal capacity contributes to moderating temperature variations around the globe.*** ***Energy is redistributed globally through ocean currents.*** ***Ocean currents can redistribute energy from the sun, which can affect regional climates.***	

Clarification Statement
Emphasis is on how patterns vary by latitude, altitude, and geographic land distribution. Emphasis of atmospheric circulation is on the sunlight-driven latitudinal banding, the Coriolis effect, and resulting prevailing winds; emphasis of ocean circulation (e.g. el Niño/la Niña) is on the transfer of heat by the global ocean convection cycle, which is constrained by the Coriolis effect and the outlines of continents. Examples of models can be diagrams, maps and globes, or digital representations.

Performance Expectation *and Louisiana Connectors*
7-MS-ESS3-5 Ask questions to clarify evidence of the factors that have caused the rise in global temperatures over the past century. ***LC-7-MS-ESS3-5a Identify evidence of the effects of human activities on changes in global temperatures over the past century using a variety of resources (e.g., tables, graphs, and maps of global and regional temperatures; atmospheric levels of gases, such as carbon dioxide and methane; and rates of human activities).*** ***LC-7-MS-ESS3-5b Using a variety of resources, ask questions or make observations about how the effects of human activities have changed global temperatures.***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Asking questions and defining problems: Asking questions (science) and defining problems (engineering) in 6-8 builds on K-5 experiences and progresses to specifying relationships between variables, clarifying arguments and making models. • Ask questions to identify and/or clarify evidence and/ or the premise(s) of an argument. ***Ask questions to identify the premise of an argument.*** ***Ask questions to clarify the premise of an argument.*** ***Ask questions to identify evidence.*** ***Ask questions to clarify evidence.***	**GLOBAL CLIMATE CHANGE** Human activities, such as the release of greenhouse gases from burning fossil fuels, are major factors in the current rise in Earth's mean surface temperature. Addressing climate change and reducing human vulnerability to whatever climate changes do occur depend on the understanding of climate science, engineering capabilities, and other kinds of knowledge, such as understanding of human behavior and on applying that knowledge wisely in decisions and activities. (MS.ESS3D.a) ***Heat energy stored in the oceans and transferred by currents influence climate.*** ***A disruption of the circulation and temperature of the world's oceans would foster climate change and have environmental and economic consequences.*** ***Global climate change is driven by both natural phenomena and by human activities.*** ***Global climate change could have large consequences for all of Earth's surface systems.*** ***With further scientific research, people can learn more about climate changes and help guide more effective responses.*** ***Using science-based predictive models, humans can anticipate long-term change more effectively and plan accordingly.***	**STABILITY AND CHANGE** Stability might be disturbed either by sudden events or gradual changes that accumulate over time. ***Stability can be disturbed by sudden events.*** ***Stability can be disturbed by an accumulation of gradual changes.***

Clarification Statement
Examples of factors include human activities (such as fossil fuel combustion, cement production, and agricultural activity) and natural processes (such as changes in incoming solar radiation or volcanic activity). Examples of evidence can include tables, graphs, and maps of global and regional temperatures,

Clarification Statement
atmospheric levels of gases such as carbon dioxide and methane, and the rates of human activities. Emphasis is on the major role that human activities play in causing the rise in global temperatures.)

Performance Expectation *and Louisiana Connectors*
7-MS-LS1-3 Use an argument supported by evidence for how the body is a system of interacting subsystems composed of groups of cells. ***LC-7-MS-LS1-3a Identify that the body is a system of multiple interacting subsystems.*** ***LC-7-MS-LS1-3b Identify evidence which supports a claim about how the body is composed of various levels of organization for structure and function which includes cells, tissues, organs, organ systems, and organisms using models or diagrams.***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Engaging in argument from evidence: Engaging in argument from evidence in 6-8 builds on K-5 experiences and progresses to constructing a convincing argument that supports or refutes claims for either explanations or solutions about the natural and designed world(s). • Construct, use, and/or present an oral and written argument supported by empirical evidence and scientific reasoning to support or refute an explanation or a model for a phenomenon or a solution to a problem. ***Construct an argument to support or refute an explanation, model, or solution to a problem.*** ***Use an argument to support or refute an explanation, model, or solution to a problem.*** ***Present an argument to support or refute an explanation, model, or solution to a problem.***	**STRUCTURE AND FUNCTION** In multicellular organisms, the body is a system of multiple interacting subsystems. These subsystems are groups of cells that work together to form tissues and organs that are specialized for particular body functions in order to maintain homeostasis. (MS.LS1A.c) ***In multicellular organisms, groups of cells work together to perform tasks and are called tissues.*** ***Groups of tissues may work together to form organs.*** ***Organs work together as systems to perform particular functions in the body.*** ***The body systems work together to maintain stable conditions (homeostasis) in the body.*** ***The human body has systems that perform functions necessary for life.*** ***Major systems of the human body include the digestive, respiratory, reproductive, and circulatory systems, etc.*** **INFORMATION PROCESSING** Each sense receptor responds to different inputs (electromagnetic, mechanical, chemical), transmitting them as signals that travel along nerve cells to the brain. The signals are then processed in the brain, resulting in immediate behaviors or memories. (MS.LS1D.a) ***An organism's ability to sense and respond to its environment enhances its chance of surviving and reproducing.*** ***Animals have external and internal sensory receptors that detect different kinds of information.*** ***An animal's sense receptors transfer information to the brain as signals.*** ***The brain processes the signals into usable information.*** ***The brain can guide a response behavior and store memories.***	**SYSTEMS AND SYSTEM MODELS** Systems may interact with other systems; they may have subsystems and be a part of larger complex systems. ***Systems may work with other systems.*** ***Systems can be made of smaller subsystems.*** ***A system can be a part of a larger system.***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
	Nerve cells communicate with each other to transmit information from the internal and external environment often resulting in physiological or behavioral responses.	

Clarification Statement
Emphasis is on the conceptual understanding that cells form tissues and tissues form organs specialized for particular body functions. Examples could include the interaction of subsystems within a system and the normal functioning of those systems. Systems could include circulatory, excretory, digestive, respiratory, muscular, endocrine, or nervous systems.

Performance Expectation *and Louisiana Connectors*
7-MS-LS1-6 Construct a scientific explanation based on evidence for the role of photosynthesis and cellular respiration in the cycling of matter and flow of energy into and out of organisms. ***LC-MS-LS1-6 Use a scientific explanation about photosynthesis to identify the movement of matter and flow of energy as plants use the energy from light to make sugars.***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Constructing explanations and designing solutions: Constructing explanations (science) and designing solutions (engineering) in 6-8 builds on K-5 experiences and progresses to include constructing explanations and designing solutions supported by multiple sources of evidence consistent with scientific ideas, principles, and theories. • Construct a scientific explanation based on valid and reliable evidence obtained from sources (including the students' own experiments) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future. ***Obtain evidence from valid and reliable sources.*** ***Construct a scientific explanation based on evidence.*** ***Construct a scientific explanation***	**ORGANIZATION FOR MATTER AND ENERGY FLOW IN ORGANISMS** Plants, plant-like protists (including algae and phytoplankton), and other microorganisms use the energy from light, to make sugars (food) from carbon dioxide from the atmosphere and water from the environment through the process of photosynthesis, which also releases oxygen. These sugars can be used immediately or stored for growth or later use. (MS.LS1C.a) ***Almost all energy that drives the cycling of matter comes from the sun.*** ***Plants, algae, and photosynthetic microorganisms require energy (in the form of sunlight), carbon dioxide, and water to survive.*** ***Plants and other organisms use the sun's energy to make sugars (food).*** ***Plant cells contain organelles called chloroplasts, while animal cells do not.*** ***Chloroplasts allow plants to make the food they need to live through photosynthesis.*** ***During photosynthesis, food is made from carbon dioxide and water, and oxygen is released.*** ***The organism can use the food created immediately or store it for later use.*** The chemical reaction by which plants produce complex food molecules (sugars) requires an energy input (i.e., from sunlight) to occur. In this reaction, carbon dioxide and water combine to form carbon-based organic molecules and release oxygen. Cellular respiration in plants and animals involve chemical reactions with oxygen that release stored energy. In these processes, complex molecules containing carbon react with oxygen to produce carbon dioxide and other materials. (MS.PS3D.a) ***The sun provides the energy required for photosynthesis.*** ***Photosynthesis is a chemical reaction.***	**ENERGY AND MATTER** Within a natural or designed system, the transfer of energy drives the motion and/or cycling of matter. ***Energy can be transferred.*** ***Energy transfer drives the motion of matter through systems (natural and designed).*** ***Energy transfer drives the cycling of matter through systems (natural and designed).***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
based on the assumption that theories and laws that describe the natural world operate today as they did in the past.	***A chemical reaction is a process by which different reactants are converted to a new substance.*** ***During photosynthesis, food molecules are made from carbon dioxide and water.*** ***During photosynthesis, plants release oxygen into the environment.*** ***Plants and animals can take the energy stored in food through a process called cellular respiration.*** ***A chemical reaction also occurs in animals during cellular respiration.*** ***In cellular respiration, the food molecules react with oxygen to release energy and produce carbon dioxide and water.*** **LOUISIANA'S NATURAL RESOURCES** Renewable resources have the ability to self-maintain due to the processes of photosynthesis. (MS.EVS1A.a) ***Matter and energy cycle through both living and non-living parts of ecosystems.*** ***Plants are renewable resources because they reproduce.*** ***Renewable resources can maintain themselves by photosynthesis.***	

Clarification Statement
Emphasis is on tracing movement of matter and flow of energy.

Performance Expectation *and Louisiana Connectors*
7-MS-LS1-7 Develop a model to describe how food is rearranged through chemical reactions forming new molecules that support growth and/or release energy as this matter moves through an organism. ***LC-7-MS-LS1-7a Use a model to identify the outcome of the process of breaking down food molecules (e.g., sugar) as the release of energy, which can be used to support other processes within the organism.***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Developing and using models: Modeling in 6-8 builds on K-5 experiences and progresses to developing, using, and revising models to describe, test, and predict more abstract phenomena and design systems. • Develop and/or use a model to predict and/or describe phenomena. ***Models can be used to describe phenomena.*** ***Models can be used to predict phenomena.***	**ORGANIZATION FOR MATTER AND ENERGY FLOW IN ORGANISMS** Within individual organisms, food (energy) moves through a series of chemical reactions in which it is broken down and rearranged to form new molecules, to support growth, or to release energy through aerobic and anaerobic respiration. (MS.LS1C.b) ***Organisms need food to provide materials and energy for life.*** ***Organisms breakdown food molecules for energy.*** ***Organisms need energy to form new molecules and to grow.*** ***Energy can be released through aerobic and anaerobic respiration.*** Cellular respiration in plants and animals involves chemical reactions with oxygen that release stored energy. In these processes, complex molecules containing carbon react with oxygen to produce carbon dioxide and other materials. (MS.LS1C.c) ***Plants and animals can get the energy stored in food through a process called cellular respiration.*** ***A chemical reaction also occurs in animals during cellular respiration.*** ***In cellular respiration, the food molecules react with oxygen to release energy and produce carbon dioxide and water.*** ***Other materials from food are used for building and repairing cell parts.***	**ENERGY AND MATTER** Matter is conserved because atoms are conserved in physical and chemical processes. ***Matter cannot be created or destroyed. Matter is conserved because the original number of atoms before a reaction occurs (reactant) is the same as the number of atoms after the reaction occurs (product).***

Clarification Statement
Emphasis is on describing that molecules are broken apart and put back together and that in this process, energy is released.

Performance Expectation ***and Louisiana Connectors***
7-MS-LS2-5 Undertake a design project that assists in maintaining diversity and ecosystem services. ***LC-7-MS-LS2-5a Identify a design project that shows the stability of an ecosystem's biodiversity is the foundation of a healthy, functioning ecosystem.***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Constructing explanations and designing solutions: Constructing explanations (science) and designing solutions (engineering) in 6-8 builds on K-5 experiences and progresses to include constructing explanations and designing solutions supported by multiple sources of evidence consistent with scientific ideas, principles, and theories. • Undertake a design project, engaging in the design cycle, to construct and/or implement a solution that meets specific design criteria and constraints. ***Design solutions must meet certain criteria and constraints.*** ***In the design cycle, solutions are modified on the basis of specific design criteria and constraints.*** ***A solution must meet specific design criteria and constraints before it can be implemented.***	**ECOSYSTEM DYNAMICS, FUNCTIONING, AND RESILIENCE** Biodiversity describes the variety of species found in Earth's terrestrial and aquatic ecosystems. The completeness or integrity of an ecosystem's biodiversity is often used as a measure of its health. (MS.LS2C.b) ***Biodiversity refers to the variety of life an ecosystem contains (i.e., numbers of different species).*** ***An ecosystem's health is measured by its biodiversity or the variety of life it contains.*** **BIODIVERSITY AND HUMANS** Changes in biodiversity can influence humans' resources, such as food, energy, and medicines, as well as ecosystem services on which humans rely. (MS.LS4D.a) ***A change in an ecosystem's biodiversity can impact humans.*** ***Humans rely on ecosystems for resources (e.g., food, energy, medicine).*** ***Humans and other organisms impact biodiversity.*** **ENGINEERING DESIGN: DEVELOPING POSSIBLE SOLUTIONS** A solution needs to be tested to prove the validity of the design and then modified on the basis of the test results in order to improve it. There are systematic processes for evaluating solutions with respect to how well they meet the criteria and constraints of a problem. Sometimes parts of different solutions can be combined to create a solution that is better than any of its predecessors. Models of all kinds are important for testing solutions (MS.ETS1B.a) ***Design solutions must be tested.*** ***Tests are often designed to identify failure points or difficulties.***	**STABILITY AND CHANGE** **S**mall changes in one part of a system might cause large changes in another part. ***A small change in one part of a system may have a big effect elsewhere in the system.***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
	Testing a solution involves investigating how well it performs under a range of likely conditions. ***Solutions are modified on the basis of the test results.*** ***Different solutions can be combined to create a better solution.*** ***Designing solutions to problems is a systematic process.*** ***There are many types of models.*** ***Models can be used to investigate how a design might work.*** ***Models allow the designer to better understand the features of a design problem.*** ***Engineering design is tested and altered due to criteria and constraints.***	

Clarification Statement
Examples of ecosystem services could include water purification, nutrient recycling, habitat conservation or soil erosion mitigation. Examples of design solution constraints could include scientific, economic, or social considerations.

Performance Expectation *and Louisiana Connectors*
7- MS-LS2-4 Construct an argument supported by empirical evidence that changes to physical or biological components of an ecosystem affect populations. ***LC-7-MS-LS2-4a Using evidence, identify the outcome of changes in physical or biological components of an ecosystem to populations of organisms in that ecosystem.***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Engaging in argument from evidence: Engaging in argument from evidence in 6-8 builds on K-5 experiences and progresses to constructing a convincing argument that supports or refutes claims for either explanations or solutions about the natural and designed world(s). • Construct, use, and/or present an oral and written argument supported by empirical evidence and scientific reasoning to support or refute an explanation or a model for a phenomenon or a solution to a problem. ***Construct an argument to support or refute an explanation, model, or solution to a problem.*** ***Use an argument to support or refute an explanation, model, or solution to a problem.*** ***Present an argument to support or refute an explanation, model, or solution to a problem.***	**ECOSYSTEM DYNAMICS, FUNCTIONING, AND RESILIENCE** Ecosystems are dynamic in nature; their characteristics can vary over time. Disruptions to any physical or biological component of an ecosystem can lead to shifts in all its populations. (MS.LS2C.a) ***Ecosystems naturally change over time.*** ***Disruptions to an ecosystem can affect all its populations.*** ***Organisms and their environments are interconnected. Changes in one part of the system will affect other parts of the system.*** ***Changes in an organism's environment may cause a shift in populations.***	**STABILITY AND CHANGE** Small changes in one part of a system might cause large changes in another part. ***A small change in one part of a system may have a big effect elsewhere in the system.***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Clarification Statement		
Emphasis is on recognizing patterns in data, making inferences about changes in populations, and on evaluating empirical evidence supporting arguments about changes to ecosystems.		

Performance Expectation *and Louisiana Connectors*
7-MS-LS3-2 Develop and use a model to describe why asexual reproduction results in offspring with identical genetic information and sexual reproduction results in offspring with genetic variation. ***LC-7-MS-LS3-2a Using a model(s), identify that in asexual reproduction identical inherited traits are passed from parents to offspring.*** ***LC-7-MS-LS3-2b Using a model(s), identify that in sexual reproduction a variety of inherited traits are passed from parents to offspring and lead to differences in offspring (e.g., eye color).***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Developing and using models: Modeling in 6-8 builds on K-5 experiences and progresses to developing, using, and revising models to describe, test, and predict more abstract phenomena and design systems. • Develop and/or use a model to predict and/or describe phenomena. ***Models can be used to describe phenomena.*** ***Models can be used to predict phenomena.***	**GROWTH AND DEVELOPMENT OF ORGANISMS** Organisms reproduce, either sexually or asexually, and transfer their genetic information to their offspring. (MS.LS1B.a) ***Organisms can reproduce and transfer their genetic information to their offspring.*** ***Sexual reproduction is the production of new living organisms by combining genetic information from two individuals of different types (sexes).*** ***In asexual reproduction, the offspring results in identical genetic information.*** ***Sexual reproduction results in offspring that have greater genetic diversity than those resulting from asexual reproduction.*** Cells divide through the processes of mitosis and meiosis. (LS.MS.1B.b) ***Cells undergo a regular sequence of growth and division.*** ***There are two processes of cell division, mitosis and meiosis.*** ***Cell division occurs via a process called mitosis, when a cell divides in two.*** ***Mitosis produces two cells with identical genetic material.*** ***In sexual reproduction, a specialized type of cell division called meiosis occurs.*** ***Meiosis results in the production of sex cells, which contain only half the chromosomes from the parent cell.*** ***When the sex cells combine, one-half of the offspring's genetic information comes from the "male" parent and one-half comes from the "female" parent.*** **INHERITANCE OF TRAITS**	**CAUSE AND EFFECT** Cause and effect relationships may be used to predict phenomena in natural or designed systems. ***Cause and effect relationships may be used to predict phenomena.***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
	Variations of inherited traits between parent and offspring arise from genetic differences that result from the subset of chromosomes (and therefore genes) inherited. (MS.LS3A.d) ***In all organisms, the genetic instructions for forming species' characteristics are carried in the chromosomes.*** ***Variations of inherited traits between the parent and offspring arise from random genetic differences.*** ***Through inheritance, traits are passed from one generation to the next.*** ***Genetic differences help to ensure the survival of offspring in varied environments.*** In sexually reproducing organisms, each parent contributes to the genes acquired (at random) by the offspring. Individuals have two of each chromosome and hence two alleles of each gene, one acquired from each parent. These versions may be identical or may differ from each other. (MS.LS3B.a) ***Genetic information is transferred to the offspring through egg and sperm cells.*** ***The offspring have a combination of genetic information from each parent.*** ***In species that reproduce sexually, each cell contains two variants of each chromosome, one inherited from each parent.*** ***These variants are called alleles. An allele is defined as one of a pair of genes that appear at a particular location on a particular chromosome and control the same characteristic.*** ***Each parent contributes half of the gene, or one allele, acquired at random by the offspring.*** ***Individuals have two of each chromosome and hence two alleles of each gene, one acquired from each parent. These alleles may be identical or may differ from each other.***	

Clarification Statement
Emphasis is on using models such as Punnett squares, diagrams, and simulations to describe the cause and effect relationship of gene transmission from parent(s) to offspring and resulting genetic variation.

Performance Expectation ***and Louisiana Connectors***
7-MS-LS4-4 Construct an explanation based on evidence that describes how genetic variations of traits in a population increase some individuals' probability of surviving and reproducing in a specific environment. ***LC-7-MS-LS4-4a Identify a similarity or difference in an external feature (e.g., shape of ears on animals or shape of leaves on plants) between young plants and animals and their parents.*** ***LC-7-MS-LS4-4b Describe the relationship between genetic variation and the success of organisms in a specific environment (e.g., individual organisms that have genetic variations and traits that are disadvantageous in a particular environment will be less likely to survive, and those traits will decrease from generation to generation due to natural selection).***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Constructing explanations and designing solutions: Constructing explanations (science) and designing solutions (engineering) in 6-8 builds on K-5 experiences and progresses to include constructing explanations and designing solutions supported by multiple sources of evidence consistent with scientific ideas, principles, and theories. • Construct an explanation that includes qualitative or quantitative relationships between variables that predict(s) and/or describe(s) phenomena. ***Construct an explanation that includes qualitative relationships to predict and describe a phenomena.*** ***Construct an explanation that includes quantitative relationships***	**NATURAL SELECTION** Natural selection leads to the predominance of certain traits in a population and the suppression of others. (MS.LS4B.a) ***The diversity and changing of life forms over many generations is the result of natural selection.*** ***Within every population, there are variations of organisms.*** ***Some of these variations exhibit traits that favor the chance to survive and reproduce, while others will decrease the likelihood to survive and reproduce.*** ***Natural selection leads to more organisms in a population with traits that favor the chance to survive and reproduce.*** ***Therefore, organisms with advantageous traits survive, reproduce, and pass those traits to offspring.***	**CAUSE AND EFFECT** Phenomena may have more than one cause, and some cause and effect relationships in systems can only be described using probability. ***Phenomena may have more than one cause.*** ***Some cause and effect relationships in systems can only be described using probability.*** ***Some cause and effect relationships are complex and can only be predicted using probabilities.***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
to predict and describe a phenomena.		

Clarification Statement
Emphasis is on using simple probability statements and proportional reasoning to construct explanations about why some traits are suppressed and other traits become more prevalent for those individuals better at finding food, shelter, or avoiding predators.

Performance Expectation *and Louisiana Connectors*
7-MS-LS4-5 Gather, read, and synthesize information about technologies that have changed the way humans influence the inheritance of desired traits in organisms. ***LC-7-MS-LS4-5a Identify ways in which technologies (e.g., artificial selection for breeding of certain plants and animals) have changed the way humans influence the inheritance of desired traits in plants and animals.***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Obtaining, evaluating, and communicating information: Obtaining, evaluating, and communicating information in 6-8 builds on K-5 experiences and progresses to evaluating the merit and validity of ideas and methods. • Gather, read, and synthesize information from multiple appropriate sources and assess the credibility, accuracy, and possible bias of each publication and methods used, and describe how they are supported or not supported by evidence. ***Gather information from multiple appropriate sources.*** ***Read information from multiple appropriate sources.*** ***Synthesize information from multiple appropriate sources.*** ***Assess the credibility of each publication.*** ***Assess the accuracy of each publication.***	**NATURAL SELECTION** Genetic engineering techniques can manipulate the DNA within various organisms. Technology has changed the way humans influence the inheritance of desired traits in organisms (e.g., selective breeding, gene modification, gene therapy, or other methods). (MS.LS4B.b) ***Through the use of biotechnology, scientists engineer plants and manipulate growing conditions to meet human needs and wants.*** ***Genetic engineering manipulates the DNA within organisms.*** ***Through technology, humans have found ways to enhance the rate at which some beneficial traits in some organisms occur.*** ***These technologies may include concepts such as genetic modification, animal husbandry, and gene therapy.*** ***Selective breeding is used to cultivate plants and domesticated animals with desirable traits.*** ***In artificial selection, humans can choose desired parental traits determined by genes, which are then passed on to offspring.***	**CAUSE AND EFFECT** Phenomena may have more than one cause, and some cause and effect relationships in systems can only be described using probability. ***Phenomena may have more than one cause.*** ***Some cause and effect relationships in systems can only be described using probability.*** ***Some cause and effect relationships are complex and can only be predicted using probabilities.***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Assess the possible bias of each publication. ***Assess the methods used by each publication.*** ***Use evidence to describe how the methods used are supported or not supported.***		

Clarification Statement
Emphasis is on synthesizing information from reliable sources about the influence of humans on genetic outcomes in artificial selection (such as genetic modification, animal husbandry, gene therapy) and on the impacts these technologies have on society as well as the technologies leading to these scientific discoveries.

Performance Expectation *and Louisiana Connectors*
8-MS-PS1-1 Develop models to describe the atomic composition of simple molecules and extended structures. ***LC-8-MS-PS1-1a Using a model(s), identify that an atom's nucleus as made of protons and neutrons and is surrounded by electrons.*** ***LC-8-MS-PS1-1b Using a model(s), identify that individual atoms of the same or different types that repeat to form extended structures (e.g., sodium chloride).***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Developing and using models: Modeling in 6-8 builds on K-5 experiences and progresses to developing, using and revising models to describe, test, and predict more abstract phenomena and design systems. • Develop and/or use a model to predict and/or describe phenomena. ***Models can be used to describe phenomena.*** ***Models can be used to predict phenomena.***	**STRUCTURE AND PROPERTIES OF MATTER** Substances are made from different types of atoms, which combine with one another in various ways. Atoms form molecules that range in size from two to thousands of atoms. (MS.PS1A.a) ***All matter is composed of tiny particles called atoms.*** ***Atoms are the basic unit of a chemical element.*** ***Substances are made from different type of atoms.*** ***Atoms form molecules ranging from small to very complex structures.*** ***A molecule is a group of atoms that are joined together and act as a single unit.*** ***Molecules can contain as many as a billion atoms or a few as two.*** ***The arrangement, motion, and interaction of these particles determine the three states of matter (solid, liquid, and gas).*** Solids may be formed from molecules, or they may be extended structures with repeating subunits (e.g., crystals). (MS.PS1A.e) ***Solids have a definite volume and a definite shape.*** ***Solids may be formed from molecules.*** ***Solids can be extended structures with repeating subunits.*** ***Repeating subunits can create crystal structures.*** ***Salt, sugar, sand, and snow are examples of crystalline solids.***	**SCALE, PROPORTION, AND QUANTITY** Time, space, and energy phenomena can be observed at various scales using models to study systems that are too large or too small. ***Phenomena can be observed at different scales (micro and macro) in a system.*** ***Phenomena can be studied using models.*** ***Models can be used to explain time, space, and energy phenomena.***

Clarification Statement
Emphasis is on developing models of molecules that vary in complexity. Examples of extended structures could include minerals such as but not limited to halite, agate, calcite, or sapphire. Examples of molecular-level models could include drawings, 3-D models, or computer representations showing different molecules with different types of atoms.

Performance Expectation *and Louisiana Connectors*
8-MS-PS1-3 Gather and make sense of information to describe that synthetic materials come from natural resources and impact society. ***LC-8-MS-PS1-3a Compare and contrast characteristics of natural and synthetic materials (e.g., fibers) from provided information (e.g., text, media, visual displays, and data).*** ***LC-8-MS-PS1-3b Identify ways in which natural resources undergo a chemical process to form synthetic materials (e.g., medicine, textiles, clothing) which impact society.***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Obtaining, evaluating, and communicating information: Obtaining, evaluating, and communicating information in 6-8 builds on K-5 experiences and progresses to evaluating the merit and validity of ideas and methods. • Gather, read, and synthesize information from multiple appropriate sources and assess the credibility, accuracy, and possible bias of each publication and methods used, and describe how they are supported or not supported by evidence. ***Gather information from multiple appropriate sources.*** ***Identify and locate information from multiple appropriate sources.*** ***Assess the credibility of each publication.*** ***Assess the accuracy of each publication.*** ***Assess the possible bias of each***	**STRUCTURE AND PROPERTIES OF MATTER** Each pure substance has characteristic physical and chemical properties (for any bulk quantity under given conditions) under normal conditions that can be used to identify it. (MS.PS1A.b) ***Pure substances are made from a single type of atom or molecule.*** ***Elements and compounds are pure substances (e.g., carbon, oxygen, water, sodium chloride, methane).*** ***Pure substances have characteristics (physical and chemical properties) that are used to identify them.*** **CHEMICAL REACTIONS** Substances react chemically in characteristic ways. In a chemical process, the atoms that make up the original substances are regrouped into different molecules, and these new substances have different properties from those of the reactants. (MS.PS1B.a) ***A natural substance is made up of multiple elements found in nature.*** ***A synthetic substance is made up of multiple substances in a lab by scientists (e.g., pesticides, medicines).*** ***Substances react in characteristic ways (e.g., form gas, form precipitates, change color).*** ***When a chemical reaction occurs, the parts that make up the original substance are regrouped in a new way that makes a new substance with new properties.*** ***If atoms are rearranged, the ending result is a different substance.*** ***Many substances react chemically with other substances to form new substances with different properties.***	**STRUCTURE AND FUNCTION** Structures can be designed to serve particular functions by taking into account properties of different materials, and how materials can be shaped and used. ***Structures can be designed to serve different functions.*** ***The design of a structure must be based on the properties of its materials.*** ***The design of a structure must be based on its shape.*** ***The design of a structure must be based on how it is being used.***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
publication. ***Assess the methods used by each publication.*** ***Describe how the methods used are supported or not supported.***		

Clarification Statement
Emphasis is on natural resources that undergo a chemical process to form synthetic materials. These natural resources may or may not be pure substances. Examples of new materials could include new medicine, foods, or alternative fuels, and focus is on qualitative as opposed to quantitative information.

Performance Expectation *and Louisiana Connectors*
8-MS-PS1-6 Undertake a design project to construct, test, and modify a device that either releases or absorbs thermal energy by chemical processes. ***LC-8-MS-PS1-6a Identify a chemical process that releases or absorbs thermal energy (e.g., dissolving ammonium chloride or calcium chloride) which, given the features of a problem, may provide a solution.*** ***LC-8-MS-PS1-6b Identify a way to test or modify a device that either releases or absorbs thermal energy by chemical processes.***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Constructing explanations and designing solutions: Constructing explanations and designing solutions in 6-8 builds on K-5 experiences and progresses to include designing solutions supported by multiple sources of evidence consistent with scientific ideas, principles, and theories. • Undertake a design project, engaging in the design cycle, to construct and/or implement a solution that meets specific design criteria and constraints. ***Design solutions must meet certain criteria and constraints.*** ***In the design cycle, solutions are modified on the basis of specific design criteria and constraints.*** ***A solution must meet specific design criteria and constraints before it can be implemented.***	**CHEMICAL REACTIONS** Some chemical reactions release energy (exothermic reactions), others store energy (endothermic reactions). (MS.PS1B.c) ***When a substance interacts with other substances, called chemical reactions, it sometimes releases energy and sometimes stores energy.*** ***Some reactions release energy (e.g., burning fuel in the presence of oxygen), and others require energy input (e.g., synthesis of sugars from carbon dioxide and water).*** ***Exothermic reactions release energy.*** ***Endothermic reactions absorb energy.*** **OPTIMIZING THE DESIGN SOLUTION** Although one design may not perform the best across all tests, identifying the characteristics of the design that performs best in each test can provide useful information for the redesign process-that is, some of those characteristics may be incorporated into the new design. (MS.ETS1.C.a) ***One design may not perform the best across all tests.*** ***Identify and explain why one model is better than another.*** ***Analyze data from tests to identify how aspects of different design solutions can be modified to create a new design and a better solution.*** ***Analyze data from tests to identify how aspects of different design solutions can be combined to create a new design and a better solution.*** ***Optimization often requires making trade-offs among competing criteria.***	**ENERGY AND MATTER: FLOWS, CYCLES, AND CONSERVATION** The transfer of energy can be tracked as energy flows through a designed or natural system. ***Energy cannot be created or destroyed.*** ***Energy can be transferred.*** ***Energy flows through systems (natural and designed).***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
	Thus, one criterion is traded off for another that is deemed more important. Sometimes, different designs, each of them optimized for different conditions, are needed.	

Clarification Statement
Emphasis is on the design, controlling the transfer of energy to the environment, and modification of a device using factors such as type and concentration of a substance. Examples of designs could involve chemical reactions such as dissolving ammonium chloride, calcium chloride or a citric acid and baking soda (sodium bicarbonate) reaction in order to warm or cool an object.

Performance Expectation *and Louisiana Connectors*
8-MS-PS3-3 Apply scientific principles to design, construct, and test a device that either minimizes or maximizes thermal energy transfer. ***LC-8-MS-PS3-3a Use information (e.g., graph, model) to identify a device (e.g., foam cup, insulated box) that either minimizes or maximizes thermal energy transfer (e.g., keeping liquids hot or cold).***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Constructing explanations and designing solutions: Constructing explanations and designing solutions in 6-8 builds on K-5 experiences and progresses to include constructing explanations and designing solutions supported by multiple sources of evidence consistent with scientific ideas, principles, and theories. • Apply scientific ideas, principles, and/or evidence to construct, revise and/or use an explanation for real-world phenomena, examples, or events. ***Apply scientific ideas, principles, and evidence to construct an explanation of phenomena or events.*** ***Apply scientific ideas, principles, and evidence to revise an explanation of phenomena or events.*** ***Apply scientific ideas, principles, and evidence to use an explanation of phenomena or events.***	**DEFINITIONS OF ENERGY** Temperature is a measure of the average kinetic energy; the relationship between the temperature and the total energy of the system depends on the types, states, and amounts of matter present. (MS.PS3A.d) ***Temperature is a measurement used to determine how fast particles are moving inside of a substance or how much energy the substance contains.*** ***The temperature of matter is a measurement of the matter's average kinetic energy.*** ***The state, amount of substance, and the type of substance will all affect the total amount of energy it has.*** **CONSERVATION OF ENERGY AND ENERGY TRANSFER** Energy is spontaneously transferred out of hotter regions or objects and into colder ones. (MS.PS3B.c) ***Energy is transferred out of hotter regions into colder ones.*** ***Energy is transferred out of hotter objects into colder ones.*** ***Heat energy transfers from warmer substances to cooler substances until they reach the same temperature.*** **DEFINING AND DELIMITING AN ENGINEERING PROBLEM** The more precisely a design task's criteria and constraints can be defined, the more likely it is that the designed solution will be successful. Specification of constraints includes consideration of scientific principles and other relevant knowledge that is likely to limit possible solutions.(MS.ETS1A.a) ***The engineering design process begins with the identification of a problem to solve and the***	**ENERGY AND MATTER: FLOWS, CYCLES, AND CONSERVATION** The transfer of energy can be tracked as energy flows through a designed or natural system. ***Energy can be transferred.*** ***Energy flows through systems (natural and designed).***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
	specification of criteria, that the final product or system must meet. ***Define a design problem that can be solved through consideration of potential impacts on people and the environment, and scientific or other issues that are relevant to the problem.*** ***Engineering design is guided by criteria and constraints.*** A solution needs to be tested, to prove the validity of the design and then modified on the basis of the test results in order to improve it. There are systematic processes for evaluating solutions with respect to how well they meet the criteria and constraints of a problem. Sometimes parts of different solutions can be combined to create a solution that is better than any of its predecessors. Models of all kinds are important for testing solutions.(MS.ETS1B.a) ***Design solutions must be tested.*** ***Tests are often designed to identify failure points or difficulties.*** ***Testing a solution involves investigating how well it performs under a range of likely conditions.*** ***Solutions are modified on the basis of the test results.*** ***Different solutions can be combined to create a better solution.*** ***Designing solutions to problems is a systematic process.*** ***There are many types of models.*** ***Models can be used to investigate how a design might work.*** ***Models allow the designer to better understand the features of a design problem.***	

Clarification Statement
Emphasis is on the ability to maximize or minimize thermal energy transfer as it relates to devices used when an area loses electricity after a natural disaster. Examples of devices could include an insulated box or a solar cooker. Testing of the device relies on performance and not direct calculation of the total amount of thermal energy transferred.

Performance Expectation *and Louisiana Connectors*
8-MS-PS3-5 Construct, use, and present arguments to support the claim that when the kinetic energy of an object changes, energy is transferred to or from the object. ***LC-8-MS-PS3-5a Using information from graphical displays of data and models, describe the change in the kinetic energy of an object as energy transferred to or from an object.***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Engaging in argument from evidence: Engaging in argument from evidence in 6-8 builds on K-5 experiences and progresses to constructing a convincing argument that supports or refutes claims for either explanations or solutions about the natural and designed world(s). • Construct, use, and/or present an oral and written argument supported by empirical evidence and scientific reasoning to support or refute an explanation or a model for a phenomenon or a solution to a problem. ***Construct an argument to support or refute an explanation, model, or solution to a problem.*** ***Use an argument to support or refute an explanation, model, or solution to a problem.*** ***Present an argument to support or refute an explanation, model, or solution to a problem.***	**CONSERVATION OF ENERGY AND ENERGY TRANSFER** When the kinetic energy of an object changes, there is inevitably some other change in energy at the same time. (MS.PS3B.a) ***Mechanical energy comes from the motion (kinetic energy) and position (potential energy) of objects.*** ***Potential energy transforms into kinetic energy (e.g., a book sitting on a counter is at rest, it has potential energy. If a person knocks the book off of the counter, the book has kinetic energy as it falls, because it is in motion and the potential energy has transformed into kinetic energy).*** ***A decrease of one form of energy is accompanied by an increase in one or more other forms of energy and vice versa.*** ***Energy may transfer into or out of a system and it may change forms, but the total energy cannot change.*** ***Within a system, the change in stored energy is always balanced by a change in total kinetic energy.***	**ENERGY AND MATTER** Energy may take different forms (e.g., energy in fields, thermal energy, energy of motion). ***Different forms of energy (e.g., energy in fields, thermal energy, energy of motion) exist.*** ***Energy is transformed from one form of energy to another.***

Clarification Statement
Examples of empirical evidence used in arguments could include an inventory or other representation of the energy (i.e., mechanical, thermal, or other forms of energy) before and after the transfer in the form of temperature changes or motion of object. This does not include the quantification of the energy transferred in the system.

Performance Expectation *and Louisiana Connectors*
8-MS-ESS1-4 Construct a scientific explanation based on evidence from rock strata for how the geologic time scale is used to organize Earth's geologic history. ***LC-8-MS-ESS1-4a Sequence the relative order of events from Earth's history shown by rock strata and patterns of layering (organize was more complex as a task/term than sequence).***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Constructing explanations and designing solutions: Constructing explanations and designing solutions in 6-8 builds on K-5 experiences and progresses to include constructing explanations and designing solutions supported by multiple sources of evidence consistent with scientific ideas, principles, and theories. • Construct a scientific explanation based on valid and reliable evidence obtained from sources (including the students' own experiments) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future. ***Obtain evidence from valid and reliable sources.*** ***Construct a scientific explanation based on evidence.*** ***Construct a scientific explanation based on the assumption that theories and laws that describe the***	**THE HISTORY OF PLANET EARTH** The geologic time scale interpreted from rock strata provides a way to organize Earth's history. Analyses of rock strata and the fossil record provide only relative dates, not an absolute scale. (MS.ESS1C.a) ***Past geological events and environments can be reconstructed by interpreting rock strata.*** ***Earth's history is documented in the chronological order of its layers of rock. However, this ordering is not able to provide absolute dates.*** ***Absolute dating is a method of estimating the age of a rock sample in years via radiometric techniques.*** ***Scientists use relative dating and fossil evidence to correlate sedimentary rock sequences.*** ***Relative dating is a scientific process of evaluation used to determine the relative order of past events, but does not determine the absolute age of an object.*** Scientists use data from radioactive dating techniques to estimate the age of Earth's materials. (MS.ESS1C.b) ***Most elements are stable.*** ***Some elements exist in forms that are unstable.*** ***Over time these elements breakdown or decay by releasing particles and energy.*** ***This process is called radioactive decay.*** ***Scientists use the rate at which these elements decay to calculate a rock's age.*** ***Scientists use radioactive elements as natural clocks for determining ages of certain types of rocks.***	**SCALE, PROPORTION, AND QUANTITY** Time, space, and energy phenomena can be observed at various scales using models to study systems that are too large or too small. ***Phenomena can be observed at different scales (micro and macro) in a system.*** ***Phenomena can be studied using models.*** ***Models can be used to explain time, space, and energy phenomena.***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
natural world operate today as they did in the past.		

Clarification Statement
Emphasis is on analyses of rock formations and fossils they contain to establish relative ages of major events in Earth's history. Major events could include the formation of mountain chains and ocean basins, adaptation and extinction of particular living organisms, volcanic eruptions, periods of massive glaciation, and the development of watersheds and rivers through glaciation and water erosion. The events in Earth's history happened in the past continue today. Scientific explanations can include models.

Performance Expectation *and Louisiana Connectors*
8-MS-ESS2-1 Develop a model to describe the cycling of Earth's materials and the flow of energy that drives this process. ***LC-8-MS-ESS2-1a Identify relationships between components in a model showing the cycling of energy flows and matter within and among Earth's systems, including the sun and Earth's interior as primary energy sources.***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Developing and using models: Modeling in 6-8 builds on K-5 experiences and progresses to developing, using, and revising models to describe, test, and predict more abstract phenomena and design systems. • Develop and/or use a model to predict and/or describe phenomena. ***Models can be used to describe phenomena.*** ***Models can be used to predict phenomena.***	**EARTH'S MATERIALS AND SYSTEMS** All Earth processes are the result of energy flowing and matter cycling within and among the planet's systems. This energy is derived from the sun and Earth's hot interior. The energy that flows and matter that cycles produce chemical and physical changes in Earth's materials and living organisms. (MS.ESS2A.a) ***Energy and matter cycle throughout our planet.*** ***The energy which drives these processes is derived from the sun and Earth's hot interior.*** ***Transfers of energy and movements of matter cause physical and chemical changes to occur in Earth's materials and organisms.*** ***The four spheres of the Earth are the atmosphere, the biosphere, the hydrosphere and the lithosphere.*** ***Earth's four spheres interact as part of a dynamic system in which changes over time are the result of external and internal energy sources.***	**STABILITY AND CHANGE** Explanations of stability and change in natural or designed systems can be constructed by examining the changes over time and forces at different scales, including the atomic scale. ***Stability is a condition in which some aspects of a system (natural or designed) are unchanging.*** ***Change can be observed at different scales (large and small/atomic) in a system.***

Clarification Statement
Emphasis is on the processes of melting, crystallization, weathering, deformation, and sedimentation, which act together to form minerals and rocks through the cycling of Earth's materials.

Performance Expectation ***and Louisiana Connectors***
8-MS-ESS2-2 Construct an explanation based on evidence for how geoscience processes have changed Earth's surface at varying time and spatial scales. ***LC-8-MS-ESS2-2a Identify examples of processes to explain that change Earth's surface at varying time and spatial scales that can be large (e.g., plate motions) or small (e.g., landslides).***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Constructing explanations and designing solutions: Constructing explanations and designing solutions in 6-8 builds on K-5 experiences and progresses to include constructing explanations and designing solutions supported by multiple sources of evidence consistent with scientific ideas, principles, and theories. • Construct a scientific explanation based on valid and reliable evidence obtained from sources (including the students' own experiments) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future. ***Obtain evidence from valid and reliable sources.*** ***Construct a scientific explanation based on evidence from readings, diagrams, charts, and/or tables.*** ***Construct a scientific explanation based on the assumption that the***	**EARTH'S MATERIALS AND SYSTEMS** The planet's systems interact over scales that range from microscopic to global in size, and they operate over fractions of a second to billions of years. These interactions have shaped Earth's history and will determine its future. (MS.ESS2A.b) ***Earth's systems are dynamic.*** ***Earth's systems interact over a wide range of temporal (fractions of a second to billions of years) and spatial (microscopic to global) scales.*** ***Earth's systems, microscopic to global in size, have cycles that interact with each other.*** ***Most changes occur gradually, but larger and rapid catastrophic events (e.g., volcanic eruptions, earthquakes, hurricanes) also account for changes to Earth's surface.*** ***These processes and their interactions have shaped and will continue to shape the Earth.*** ***Some satellites allow scientists to observe, over time, large-scale changes in the geosphere.*** **THE ROLE OF WATER IN EARTH'S SURFACE PROCESSES** Water's movements—both on the land and underground—cause weathering and erosion, which change the land's surface features and create underground formations. (MS.ESS2C.e) ***Sedimentary rocks are formed through the processes of weathering, erosion, and deposition.*** ***Erosion shapes rock particles.*** ***Erosion shapes and reshapes the land surface (e.g., coastal erosions land loss).*** ***Over time, microscopic particle movement that takes place during weathering and erosion by the water cycle's continuous movement change the land's surface features (e.g., deposition by the movement of water, ice and wind).***	**SCALE, PROPORTION, AND QUANTITY** Time, space, and energy phenomena can be observed at various scales using models to study systems that are too large or too small. ***Phenomena can be observed at different scales (micro and macro) in a system.*** ***Phenomena can be studied using models.*** ***Models can be used to explain time, space, and energy phenomena.***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
natural world operates today as they did in the past.	***Over time, the water cycle's continuous movement create underground formations (e.g., aquifers).***	

Clarification Statement
Emphasis is on how processes change Earth's surface at time and spatial scales that can be large (such as slow plate motions or the uplift of a large mountain ranges) or small (such as rapid landslides on microscopic geochemical reactions), and how many geosciences processes usually behave gradually but are punctuated by catastrophic events (such as earthquakes, volcanoes, and meteor impacts). Examples of geoscience processes include surface weathering and deposition by the movements of water, ice, and wind. Emphasis is on geoscience processes that shape local geographic features, where appropriate.

Performance Expectation ***and Louisiana Connectors***
8-MS-ESS2-3 Analyze and interpret data on the distribution of fossils and rocks, continental shapes, and sea floor structures to provide evidence of the past plate motions. ***LC-8-MS-ESS2-3a Using graphical displays of data, identify how the shapes of the continents (e.g., fit like a jigsaw puzzle) and fossil comparisons (e.g., fit together) along the edges of continents to demonstrate lithospheric plate movement.***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Analyzing and interpreting data: Analyzing data in 6-8 builds on K-5 experiences and progresses to extending quantitative analysis to investigations, distinguishing between correlation and causation, and basic statistical techniques of data and error analysis. • Analyze and interpret data to provide evidence for phenomena. ***Interpret data to provide evidence for phenomena.*** ***Analyze data to provide evidence for phenomena.***	**THE HISTORY OF PLANET EARTH** Tectonic processes continually generate new ocean sea floor at ridges and destroy old sea floor at trenches. (MS.ESS1C.c) ***Tectonic processes cause the movement of Earth's plates and sea floor spreading.*** ***Large plates of Earth's surface have moved and continue to move due to natural forces in the Earth's interior.*** ***These movements generate new ocean sea floor at mid-ocean ridges.*** ***These movements destroy old ocean floor at trenches (e.g., subduction zones) as plates overlap or pull away from each other.*** ***In sea floor spreading, molten material forms new rock along the mid-ocean ridge.*** ***All subducted plates are oceanic, which keeps the ocean floor in a constant stat e of change; whereas, the continents change much more slowly in geologic tim e.*** **PLATE TECTONICS AND LARGE-SCALE SYSTEM INTERACTIONS** Maps of ancient land and water patterns, based on investigations of rocks and fossils, make clear how Earth's plates have moved great distances, collided, and spread apart. (MS.ESS2B.a) ***The theory of plate tectonics explains plate movements and how they cause continental drift.*** ***Scientist believe that at one time the continents were connected and then grad***	**PATTERNS** Patterns in rates of change and other numerical relationships can provide information about natural and human designed systems. ***Patterns in rates of change can provide information about systems (natural and designed).*** ***Patterns in numerical relationships can provide information about systems (natural and designed).***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
	ually separated by lithospheric plate movement. ***The shapes of the continents (fit like a jigsaw puzzle) demonstrate lithospheric plate movement.*** ***Evidence of the continents being connected include the shapes of the continent s, and fossil and rock similarities from continents no longer connected.*** ***Fossil comparisons along the edges of continents demonstrate lithospheric plate movement.*** ***Data analysis, including maps, the distribution of fossils and rocks, continental shapes, and sea floor spreading provide evidence of past plate motion.***	

Clarification Statement
Examples of data include similarities of rock and fossil types on different continents, the shapes of the continents (including continental shelves), and the locations of ocean structures (such as ridges, fracture zones, and trenches).

Performance Expectation *and Louisiana Connectors*
8-MS-ESS3-1 Construct a scientific explanation based on evidence for how the uneven distributions of Earth's mineral, energy, and groundwater resources are the result of past and current geoscience processes. ***LC-8-MS-ESS3-1a Identify explanations of the uneven distributions of Earth's minerals, energy, and groundwater resources due to past and current geoscience processes or by removal of resources.***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Constructing explanations and designing solutions: Constructing explanations and designing solutions in 6-8 builds on K-5 experiences and progresses to include constructing explanations and designing solutions supported by multiple sources of evidence consistent with scientific ideas, principles, and theories. • Construct a scientific explanation based on valid and reliable evidence obtained from sources (including the students' own experiments) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future. ***Obtain evidence from valid and reliable sources.*** ***Construct a scientific explanation based on evidence.*** ***Construct a scientific explanation based on the assumption that theories and laws that describe the***	**NATURAL RESOURCES** Humans depend on Earth's land, ocean, atmosphere, and biosphere for many different resources. Minerals, fresh water, and biosphere resources are limited, and many are not renewable or replaceable over human lifetimes. These resources are distributed unevenly around the planet as a result of past geologic processes. (MS.ESS3A.a) ***Humans rely on natural resources from the Earth to meet their ever changing needs.*** ***Many of these resources are not renewable or replaceable over a human lifetime.*** ***Some natural resources, called renewable resources, are naturally replaced in a relatively short time.*** ***Natural resources that are not replaced as they are used are called non-renewable resources.*** ***Natural resources occur all around the world, but are not distributed evenly.*** ***In some locations on Earth, where geological processes have concentrated resources, they may be readily available.*** **LOUISIANA'S NATURAL RESOURCES** Non-renewable resources such as our state's fossil fuels are vast but limited. (MS.EVS1A.b) ***Louisiana has a variety of natural resources that are important for human life.*** ***Non-renewable resources, like the state's fossil fuels we burn for energy, are not replaceable over human lifetimes.***	**CAUSE AND EFFECT** Cause and effect relationships may be used to predict phenomena in natural or designed systems. ***Cause and effect relationships may be used to predict phenomena.***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
natural world operate today as they did in the past.		

Clarification Statement
Emphasis is on how these resources are limited and typically non-renewable, and how their distributions are significantly changing as a result of removal by humans. Examples of uneven distributions of resources as a result of past processes include but are not limited to petroleum (locations of the burial of organic marine sediments and subsequent geologic traps), metal ores (locations of past volcanic and hydrothermal activity associated with subduction zones), and soil (locations of active weathering and/or deposition of rock).

Performance Expectation ***and Louisiana Connectors***
8-MS-ESS3-2 Analyze and interpret data on natural hazards to forecast future catastrophic events and inform the development of technologies to mitigate their effects. ***LC-8-MS-ESS3-2a Use maps, charts, and images of natural hazards to look for patterns in past occurrences of catastrophic events in each of two regions to predict which location may receive a future similar catastrophic event.*** ***LC-8-MS-ESS3-2b Identify technologies that mitigate the effects of natural hazards (e.g., the design of buildings and bridges to resist earthquakes, storm shelters for tornados, levees along rivers to prevent flooding).***

Science and Engineering Practice	**Disciplinary Core Idea**	**Crosscutting Concept**
Analyzing and interpreting data: Analyzing data in 6-8 builds on K-5 experiences and progresses to extending quantitative analysis to investigations, distinguishing between correlation and causation, and basic statistical techniques of data and error analysis. • Analyze and interpret data to provide evidence for phenomena. ***Interpret data to provide evidence for phenomena.*** ***Analyze data to provide evidence for phenomena.***	**NATURAL HAZARDS** Mapping the history of natural hazards in a region, combined with an understanding of related geologic forces can help forecast the locations and likelihoods of future events. (MS.ESS3B.a) ***Natural processes can cause sudden or gradual changes to Earth's systems.*** ***Natural hazards such as earthquakes, tsunamis, volcanic eruptions, severe weather, floods, and coastal erosion, adversely affect humans.*** ***Studying patterns of natural hazards allow scientists to assess potential risks so preparations can be made to minimize the hazards.*** ***By mapping the natural events in an area and understanding the geological forces involved, future events can be predicted.*** ***While humans cannot eliminate natural hazards, they can take steps to reduce their impacts.***	**PATTERNS** Graphs, charts, and images can be used to identify patterns in data. ***Graphs can be used to identify patterns.*** ***Charts can be used to identify patterns.*** ***Images can be used to identify patterns.***

Clarification Statement
Emphasis is on how some natural hazards, such as volcanic eruptions and severe weather, are preceded by phenomena that allow for reliable predictions, but others, such as earthquakes, occur suddenly and with no notice, and thus are not yet predictable. Examples of natural hazards can be taken from interior processes (such as earthquakes and volcanic eruptions), surface processes (such as mass wasting and tsunamis), or severe weather events (such as hurricanes, tornadoes, and floods). Examples of data can include the locations, magnitudes, and frequencies of the natural hazards. Examples of technologies can be global (such as satellite systems to monitor hurricanes or forest fires) or local (such as building basements in tornado-prone regions or reservoirs to mitigate droughts).

Performance Expectation *and Louisiana Connectors*
8-MS-ESS3-3 Apply scientific principles to design a method for monitoring and minimizing human impact on the environment. *LC-8-MS-ESS3-3 Using data from a design solution for minimizing a human impact on the environment, identify limitations of the solution.*

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Constructing explanations and designing solutions: Constructing explanations and designing solutions in 6-8 builds on K-5 experiences and progresses to include constructing explanations and designing solutions supported by multiple sources of evidence consistent with scientific ideas, principles, and theories. • Apply scientific ideas or principles to design, construct, and/or test a design of an object, tool, process or system. ***To design an object, tool, process or system, scientists and engineers use scientific ideas and principles.*** ***To construct an object, tool, process or system, scientists and engineers use scientific ideas and principles.*** ***In science and engineering, a design plan includes testing an object, tool, process or system.***	**HUMAN IMPACTS ON EARTH'S SYSTEMS** Human activities, globally and locally, have significantly altered the biosphere, sometimes damaging or destroying natural habitats and causing the extinction of other species. But changes to Earth's environments can have different impacts (negative and positive) for different living things. (MS.ESS3C.a) ***People can harm Earth's resources in a variety of ways (e.g., polluting, deforestation, overhunting, wasting water, and electricity, etc.).*** ***The growth in human activities is stretching natural resources to their limit.*** ***This may have a negative impact on Earth unless actions are taken to mitigate this impact.*** ***Some changes to Earth's environment can have a positive impact for living things.*** Typically as human populations and per-capita consumption of natural resources increase, so do the negative impacts on Earth unless the activities and technologies involved are engineered otherwise. (MS.ESS3C.b) ***As the human population grows, so does the consumption of natural resources.*** ***As the human population grows, so do the human impacts on the planet.*** ***Some negative effects of human activities are reversible using technology.*** **DEVELOPING POSSIBLE SOLUTIONS** A solution needs to be tested to prove the validity of the design and then modified on the basis of the test results in order to improve it. There are systematic processes for evaluating solutions with respect to how well they meet the criteria and constraints of a problem. Sometimes parts of different solutions can be combined to create a solution that is better than any of its predecessors. Models of all kinds are important for testing solutions. (ETS.MS.1B.a)	**CAUSE AND EFFECT** Relationships can be classified as causal or correlational, and correlation does not necessarily imply causation. When describing relationships in science, sometimes one event or effect is the direct result of another event or effect; this is a causal relationship. ***When describing relationships in science, sometimes two events or effects can be described by the strength (e.g., strong or weak) of their relationship; this is a correlational relationship.*** ***When there is a correlation between events or effects, it does***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
	Design solutions must be tested. *Tests are often designed to identify failure points or difficulties.* *Testing a solution involves investigating how well it performs under a range of likely conditions.* *Solutions are modified on the basis of the test results.* *Different solutions can be combined to create a better solution.* *Designing solutions to problems is a systematic process.* *There are many types of models.* *Models can be used to investigate how a design might work.* *Models allow the designer to better understand the features of a design problem.*	*not automatically mean that one event or effect is the direct result of another event or effect.*

Clarification Statement
Examples of the design process may include examining human environmental impacts, assessing the kinds of solutions that are feasible, and designing and evaluating solutions that could reduce that impact. Examples of human impacts may include water usage (such as the withdrawal of water from streams and aquifers or the construction of dams and levees), land usage (such as urban development, agriculture, or the removal of wetlands), and pollution (such as of the air, water, or land).

Performance Expectation *and Louisiana Connectors*
8-MS-LS1-4 Construct and use argument(s) based on empirical evidence and scientific reasoning to support an explanation for how characteristic animal behaviors and specialized plant structures affect the probability of survival and successful reproduction of animals and plants respectively. ***LC-8-MS-LS1-4a Identify behaviors animals engage in (e.g., vocalization) that increase the likelihood of reproduction.*** ***LC-8-MS-LS1-4b Identify specialized plant structures (e.g., bright flower parts) that increase the likelihood of reproduction.***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Engaging in argument from evidence: Engaging in argument from evidence in 6-8 builds on K-5 experiences and progresses to constructing a convincing argument that supports or refutes claims for either explanations or solutions about the natural and designed world(s). • Construct, use, and/or present an oral and written argument supported by empirical evidence and scientific reasoning to support or refute an explanation or a model for a phenomenon or a solution to a problem. ***Use empirical evidence to construct an argument.*** ***Use empirical evidence to support an argument.*** ***Use scientific reasoning to construct an argument.*** ***Use scientific reasoning to support an argument.*** ***Use an argument to support a***	**GROWTH AND DEVELOPMENT OF ORGANISMS** Animals engage in characteristic behaviors that increase the odds of reproduction. (MS.LS1B.c) ***Animals typically have behaviors that increase their likelihood to survive and reproduce.*** ***A stimulus is a signal that causes an organism to react in some way.*** ***A response is an organism's reaction to the stimulus.*** ***An animals response may include external actions, internal changes (e.g., increased heartrate), or both.*** ***There are similarities and differences in how organisms respond to stimuli.*** Plants (flowering and non-flowering) reproduce in a variety of ways, sometimes depending on animal behavior and specialized features for reproduction. (MS.LS1B.d) ***Plants reproduce in a variety of ways.*** ***Some plants rely on animals to survive and reproduce, such as brightly colored flowers to attract pollinators.*** Group behavior has evolved because membership can increase the chances of survival for individuals and their genetic relatives. (MS.LS2D.a) ***There is usually some advantage to living in a group.*** ***Animals form groups which increase their likelihood to survive and reproduce.*** ***In herds, some may watch for danger while others feed.*** ***Animals in groups communicate information (e.g., food sources, danger, defending themselves) to each other.***	**CAUSE AND EFFECT** Phenomena may have more than one cause, and some cause and effect relationships in systems can only be described using probability. ***Phenomena may have more than one cause.*** ***Some cause and effect relationships in systems can only be described using probability.*** ***Some cause and effect relationships are complex and can only be predicted using probabilities.***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
model for a phenomena. ***Use an argument to refute a model for a phenomena.*** ***Use an argument to support a solution to a problem.*** ***Use an argument to refute a solution to a problem.***	***Some animal groups migrate to an area that provides abundant food, or a favorable place for reproduction, or both.***	

Clarification Statement
Examples of behaviors that affect the probability of animal reproduction could include nest building to protect young from cold, herding of animals to protect young from predators, or vocalization of animals and colorful plumage to attract mates for breeding. Examples of animal behaviors that affect the probability of plant reproduction could include transferring pollen or seeds or creating conditions for seed germination and growth. Examples of plant structures could include bright flowers attracting butterflies that transfer pollen, flower nectar and odors that attract insects that transfer pollen, or hard shells on nuts that squirrels bury.

Performance Expectation *and Louisiana Connectors*
8-MS-LS1-5 Construct a scientific explanation based on evidence for how environmental and genetic factors influence the growth of organisms. ***LC-8-MS-LS1-5a Identify a scientific explanation for how environmental factors (e.g., availability of light, space, water, size of habitat) affect the growth of animals and plants.*** ***LC-8-MS-LS1-5b Identify a scientific explanation for how genetic factors (e.g., specific breeds of plants and animals and their typical sizes) affect the growth of animals and plants.***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Constructing explanations and designing solutions: Constructing explanations (science) and designing solutions (engineering) in 6-8 builds on K-5 experiences and progresses to include constructing explanations and designing solutions supported by multiple sources of evidence consistent with scientific ideas, principles, and theories. • Construct a scientific explanation based on valid and reliable evidence obtained from sources (including the students' own experiments) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future. ***Construct a scientific explanation based on evidence.*** ***Construct a scientific explanation based on the assumption that theories and laws that describe the***	**GROWTH AND DEVELOPMENT OF ORGANISMS** Genetic factors as well as local conditions affect the growth of the adult plant. (MS.LS1B.e) ***Environmental factors (e.g., availability of light, space, water, size of habitat) affect the growth of plants.*** ***Genetic factors (e.g., specific breeds of plants) affect the growth of plants.*** ***Genetic factors as well as local conditions affect the size of the adult plant.***	**CAUSE AND EFFECT** Phenomena may have more than one cause, and some cause and effect relationships in systems can only be described using probability. ***Phenomena may have more than one cause.*** ***Some cause and effect relationships in systems can only be described using probability.*** ***Some cause and effect relationships are complex and can only be predicted using probabilities.***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
natural world operate today as they did in the past.		

Clarification Statement
Examples of local environmental conditions could include availability of food, light, space, and water. Examples of genetic factors could include large breed cattle and species of grass affecting growth of organisms. Examples of evidence could include drought decreasing plant growth, fertilizer increasing plant growth, different varieties of plant seeds growing at different rates in different conditions, or fish growing larger in large ponds than they do in small ponds.

Performance Expectation *and Louisiana Connectors*
8-MS-LS3-1 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. ***LC-8-MS-LS3-1a Use a model to explain how genetic variations in specific traits may occur as organisms pass on their genetic material from one generation to the next, along with small changes.***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Developing and using models: Modeling in 6-8 builds on K-5 experiences and progresses to developing, using, and revising models to describe, test, and predict more abstract phenomena and design systems. • Develop and/or use a model to predict and/or describe phenomena. ***Models can be used to describe phenomena.*** ***Models can be used to predict phenomena.***	**INHERITANCE OF TRAITS** Genes are located in the chromosomes of cells, with each chromosome pair containing two variants (alleles) of each of many distinct genes. Each distinct gene chiefly controls the production of specific proteins, which in turn affects the traits of the individual. (MS.LS3A.a) ***In sexual reproduction after the egg is fertilized, each of the new cells in the developing organism receives an exact copy of the genetic information contained in the nucleus of a fertilized egg.*** ***Chromosomes are found in the nucleus of the cell and contain genes that are made of DNA.*** ***Inherited traits of individuals are controlled by genes.*** ***Each cell contains two variants of each chromosome, one inherited from each parent.*** ***An allele is defined as one of a pair of genes that appear at a particular location on a particular chromosome.*** ***Each gene affects the traits of the individual.*** Changes (mutations) to genes can result in changes to proteins, which can affect the structures and functions of the organism and thereby change traits. (MS.LS3A.b) ***Mutations occur randomly.*** ***Mutations can introduce variations in traits.*** ***Mutations can affect structures and resulting functions of the organism's trait characteristics.*** **VARIATION OF TRAITS** In addition to variations that arise from sexual reproduction, genetic information can be	**STRUCTURE AND FUNCTION** Complex and microscopic structures and systems can be visualized, modeled, and used to describe how their function depends on the shapes, composition, and relationships among its parts; therefore, complex natural and designed structures/systems can be analyzed to determine how they function. ***Complex structures can be visualized.*** ***Microscopic structures can be visualized.*** ***Complex structures can be modeled.*** ***Microscopic structures***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
	altered because of mutations. Though rare, mutations may result in changes to the structure and function of proteins. Some changes are beneficial, others harmful, and some neutral to the organism. (MS.LS3B.b) ***Alternative versions of genes (different alleles) account for variations in inherited characteristics.*** ***Traits that have changed can be passed from parent to offspring.*** ***Mutations can be inherited.*** ***Mutations can be harmful, neutral, or an advantage for an organism.***	***can be modeled.*** ***The function of a structure depends on its shape.*** ***The function of a structure depends on its composition.*** ***The function of a structure depends on relationships among its parts.*** ***Designed structures/systems can be analyzed to determine how they function.***

Clarification Statement
Emphasis is on conceptual understanding that changes in genetic material may result in making different proteins. Examples include radiation treated plants, genetically modified organisms (e.g., roundup resistant crops, bioluminescence), or mutations both harmful and beneficial.

Performance Expectation *and Louisiana Connectors*
8-MS-LS4-1 Analyze and interpret data for patterns in the fossil record that document the existence, diversity, extinction, and change of life forms throughout the history of life on Earth under the assumption that natural laws operate today as in the past. ***LC-8-MS-LS4-1a Use data to identify that fossils of different animals that lived at different times are placed in chronological order (i.e., fossil record) and located in different sedimentary layers.***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Analyzing and interpreting data: Analyzing data in 6-8 builds on K-5 experiences and progresses to extending quantitative analysis to investigations, distinguishing between correlation and causation, and basic statistical techniques of data and error analysis. • Analyze and interpret data to determine similarities and differences in findings. ***Use data to determine similarities in findings.*** ***Use data to determine differences in findings.***	**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) ***All living organisms on earth show tremendous differences of form and function.*** ***Scientists can compare DNA sequences to determine how species are related.*** ***Scientists can compare protein (i.e., amino acid) sequences to determine how species are related.*** ***Genetic information varies among species, but there are many overlaps.*** ***Similarities in DNA sequences, anatomical structure, and embryonic development can serve as evidence of evolution.*** ***Genetic information, similar structures, embryological development, and fossil evidence support hypotheses of common ancestry.***	**PATTERNS** Graphs, charts, and images can be used to identify patterns in data. ***Graphs can be used to identify patterns.*** ***Charts can be used to identify patterns.*** ***Images can be used to identify patterns.***

Clarification Statement
Emphasis is on finding patterns of changes in the level of complexity of anatomical structures in organisms and the chronological order of fossil appearance in the rock layers.

Performance Expectation *and Louisiana Connectors*
8-MS-LS4-2 Apply scientific ideas to construct an explanation for the anatomical similarities and differences among modern organisms and between modern and fossil organisms to infer evolutionary relationships. ***LC-8-MS-LS4-2a Recognize that similarities and differences in external structures can be used to infer evolutionary relationships between living and fossil organisms.*** ***LC-8-MS-LS4-2b Identify an explanation of the evolutionary relationships between modern and fossil organisms.***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Constructing explanations and designing solutions: Constructing explanations (science) and designing solutions (engineering) in 6-8 builds on K-5 experiences and progresses to include constructing explanations and designing solutions supported by multiple sources of evidence consistent with scientific ideas, principles, and theories. • Apply scientific ideas, principles, and/or evidence to construct, revise and/or use an explanation for real-world phenomena, examples, or events. ***Apply scientific ideas to construct an explanation of phenomena or events.*** ***Apply scientific principles to construct an explanation of phenomena or events.*** ***Apply scientific evidence to construct an explanation of phenomena or events.***	**EVIDENCE OF COMMON ANCESTRY AND DIVERSITY** Anatomical similarities and differences between various organisms living today and between them and organisms in the fossil record, enable the reconstruction of evolutionary history and the inference of lines of evolutionary descent. (MS.LS4A.b) ***By comparing modern-day organisms to organisms of the past, scientist can infer how closely related they are in an evolutionary sense (e.g., comparing pictures of an ape, caveman, and human).*** ***The Earth's present day species evolved from earlier, distinctly different species.*** ***Similarities and differences in anatomical structures between living organisms and extinct organisms can serve as evidence of evolution.*** ***Similarities and differences in anatomical structures between living organisms (e.g., skulls of modern crocodiles, skeletons of birds, features of modern whales and elephants) and extinct organisms (e.g., skulls of fossilized crocodiles and fossilized dinosaurs) can show lines of evolutionary descent.*** ***More recently deposited rock layers are more likely to contain fossils resembling existing species.*** Comparison of the embryological development of different species also reveals similarities that show relationships not evident in the fully-formed anatomy. (MS.LS4A.c) ***Similarities in embryonic development can serve as evidence of the relatedness of different species.*** ***Similarities in early development stages are evidence that species are related and shared a common ancestor.***	**PATTERNS** Patterns can be used to identify cause and effect relationships. ***Scientists use patterns to identify cause and effect relationships.*** ***Identify causes and effects of different phenomena.***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Apply scientific ideas to revise an explanation of phenomena or events. *Apply scientific principles to revise an explanation of phenomena or events.* *Apply scientific evidence to revise an explanation of phenomena or events.* *Apply scientific ideas to use an explanation of phenomena or events.* *Apply scientific principles to use an explanation of phenomena or events.* *Apply scientific evidence to use an explanation of phenomena or events.*		

Clarification Statement
Emphasis is on explanations of the evolutionary relationships among organisms in terms of similarity or differences of the gross appearance of anatomical structures.

Performance Expectation *and Louisiana Connectors*
8-MS-LS4-3 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. ***LC-8-MS-LS4-3a Identify patterns (i.e., pictorial displays, representations, data) in the embryological development as evidence of relationships among species.***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Analyzing and interpreting data: Analyzing data in 6-8 builds on K-5 experiences and progresses to extending quantitative analysis to investigations, distinguishing between correlation and causation, and basic statistical techniques of data and error analysis. • Construct, analyze, and/or interpret graphical displays of data and/or large data sets to identify linear and nonlinear relationships. ***Use graphical display of data to define the meaning of linear relationships.*** ***Use graphical display of data to define the meaning of nonlinear relationships.*** ***Use graphical displays of data to identify linear relationships.*** ***Use graphical displays of data to identify nonlinear relationships.*** ***Use large data sets to identify***	**EVIDENCE OF COMMON ANCESTRY AND DIVERSITY** Anatomical similarities and differences between various organisms living today and between them and organisms in the fossil record, enable the reconstruction of evolutionary history and the inference of lines of evolutionary descent. (MS.LS4A.b) ***By comparing modern-day organisms, scientists can infer how closely related they are in an evolutionary sense.*** ***The Earth's present day species evolved from earlier, distinctly different species.*** ***Similarities and differences in anatomical structures between living organisms and extinct organisms can serve as evidence of evolution.*** ***Similarities and differences in anatomical structures between living organisms and extinct organisms can show lines of evolutionary descent.*** ***More recently deposited rock layers are more likely to contain fossils resembling existing species.*** Comparison of the embryological development of different species also reveals similarities that show relationships not evident in the fully-formed anatomy. (MS.LS4A.c) ***Similarities in embryonic development can serve as evidence of the relatedness of different species.*** ***Similarities in early development stages are evidence that species are related and shared a common ancestor.***	**PATTERNS** Graphs, charts, and images can be used to identify patterns in data. ***Graphs can be used to identify patterns.*** ***Charts can be used to identify patterns.*** ***Images can be used to identify patterns.***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
linear relationships. ***Use large data sets to identify nonlinear relationships.***		

Clarification Statement
Emphasis is on inferring general patterns of relatedness among embryos of different organisms by comparing the macroscopic appearance of diagrams or pictures.

Performance Expectation *and Louisiana Connectors*
8-MS-LS4-6 Use mathematical representations to support explanations of how natural selection may lead to increases and decreases of specific traits in populations of species over time. ***LC-8-MS-LS4-6a Analyze numerical data sets that represent a proportional relationship between some change in the environment and corresponding changes in genetic variation (i.e., traits) over time.***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Using mathematics and computational thinking: Mathematical and computational thinking in 6-8 builds on K-5 experiences and progresses to identifying patterns in large data sets and using mathematical concepts to support explanations and arguments. • Use mathematical representations to describe and/or support scientific conclusions and design solutions. ***Use mathematical representations to describe scientific conclusions.*** ***Use mathematical representations to support scientific conclusions.*** ***Use mathematical representations to describe design solutions.*** ***Use mathematical representations to support design solutions.***	**ADAPTATION** Adaptation by natural selection acting over generations is one important process by which populations change over time in response to changes in environmental conditions. Traits that support successful survival and reproduction in the new environment tend to become more common; those that do not become less common. Thus, the distribution of traits in a population changes. (MS.LS4C.a) ***Some organisms in a population exhibit traits and behaviors that will favor their chance to survive and reproduce.*** ***Adaptations are the favorable traits and behaviors, which allow an organism to survive in its environment.*** ***Adaptation by natural selection leads to more organisms in a population with traits that favor the chance to survive and reproduce.*** ***Inherited traits that aid survival and reproduction are much more likely to become common in a population, than traits that don't aid survival.*** ***Species acquire many of their unique characteristics through biological adaptations, which involve the selection of naturally occurring variations in populations.*** ***These organisms reproduce, develop, have predictable life cycles, and pass on heritable traits to their offspring.***	**CAUSE AND EFFECT** Phenomena may have more than one cause, and some cause and effect relationships in systems can only be described using probability. ***Phenomena may have more than one cause.*** ***Some cause and effect relationships in systems can only be described using probability.*** ***Some cause and effect relationships are complex and can only be predicted using probabilities.***

Clarification Statement
Emphasis is on using mathematical models, probability statements, and proportional reasoning to support explanations of trends in changes to populations over time. Students should be able to explain trends in data for the number of individuals with specific traits changing over time.

Clarification Statement
Performance Expectation *and Louisiana Connectors*
HS-PS1-1 Use the periodic table as a model to predict the relative properties of elements based on the patterns of electrons in the outermost energy level and the composition of the nucleus of atoms. ***LC-HS-PS1-1a Identify the periodic table as a model to use to predict the properties of elements.*** ***LC-HS-PS1-1b Identify that the periodic table was created based on the patterns of electrons in the outermost energy level of atoms.*** ***LC-HS-PS1-1c Identify that the number of electrons in the outermost energy level of atoms impacts the behavior of the element.*** ***LC-HS-PS1-1d Identify the periodic table as a model that predicts the number of electrons and other subatomic particles.***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Developing and using models: Modeling in 9-12 builds on K-8 experiences and progresses to using, synthesizing, and developing models to predict and show relationships among variables between systems and their components in the natural and designed worlds. • Develop, revise, and/or use a model based on evidence to illustrate and/or predict the relationships between systems or between components of a system. ***Use a model based on evidence to identify and describe the components of a system.*** ***Use a model based on evidence to identify and describe the relationships between the components of a system.*** ***Use a model based on evidence to predict relationships between***	**STRUCTURE AND PROPERTIES OF MATTER** Each atom has a charged substructure consisting of a nucleus, which is made of protons and neutrons, surrounded by electrons. (HS.PS1A.a) ***Atoms are the basic unit of a chemical element.*** ***Atoms are made of subatomic particles: protons, neutrons, and electrons.*** ***Atoms have a nucleus.*** ***The nucleus of an atom is made of positively charged protons and neutrons, which have no net charge.*** ***A positively charged nucleus is surrounded by smaller negatively charged electrons.*** The periodic table orders elements horizontally by the number of protons in the atom's nucleus and places those with similar chemical properties in columns. The repeating patterns of this table reflect patterns of outer electron states. (HS.PS1A.b) ***Electrons in the outermost energy level are called valence electrons.*** ***The periodic table of elements is an arrangement of the chemical elements ordered by atomic number or the number of protons in atoms.*** ***The periodic table is used to predict the patterns of behavior of elements.*** ***The arrangement of the groups of the periodic table reflects the patterns of electrons in the outermost energy level of atoms, and therefore, the chemical properties of the elements in each group.*** ***The atomic mass listed for each element on the periodic table corresponds to the relative***	**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. ***Patterns can be used to explain phenomena.*** ***Different patterns can be observed at different scales (micro and macro) in a system.*** ***Classifications used at one scale may fail or need revision when information from smaller or larger scales is introduced.***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
systems or within a system. ***Identify that models can help illustrate relationships between systems or within a system.***	***abundance of that element's different isotopes.*** **TYPES OF INTERACTIONS** Attraction and repulsion between electric charges at the atomic scale explain the structure, properties, and transformations of matter, as well as the contact forces between material objects. (HS.PS2B.c) ***The patterns and behaviors of elements are based on the attraction and repulsion between electrically charged particles and the patterns of the outermost electrons.*** ***The reactivity and electronegativity of atoms can be determined by an element's location on the periodic table and its valence electrons attraction to the nucleus.*** ***The number and types of bonds formed by an element and between elements, the number and charges of stable ions, and the relative sizes of atoms can be determined by an element's location on the periodic table.***	

Clarification Statement	
Physical Science	Examples of properties that could be predicted from patterns could include metals, nonmetals, metalloids, number of valence electrons, types of bonds formed, or atomic mass. Emphasis is on main group elements.
Chemistry	Examples of properties that could be predicted from patterns could include reactivity of metals, types of bonds formed, numbers of bonds formed, atomic radius, atomic mass, or reactions with oxygen. Emphasis is on main group elements and qualitative understanding of the relative trends of ionization energy and electronegativity.

Performance Expectation *and Louisiana Connectors*
HS-PS1-2 Construct and revise an explanation for the outcome of a simple chemical reaction based on the outermost electron states of atoms, trends in the periodic table, and knowledge of the patterns of chemical properties. ***LC-HS-PS1-2a Identify an explanation for the outcome of a simple chemical reaction based on the outermost electron states of atoms.*** ***LC-HS-PS1-2b Identify an explanation for the outcome of a simple chemical reaction based on trends in the periodic table.*** ***LC-HS-PS1-2c Construct an explanation for the outcome of a simple chemical reaction based on the chemical properties of the elements involved.***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Constructing explanations and designing solutions: Constructing explanations (science) and designing solutions (engineering) in 9-12 builds on K-8 experiences and progresses to explanations and designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific ideas, principles, and theories. • Construct and revise an explanation based on valid and reliable evidence obtained from a variety of sources (including students' own investigations, models, theories, simulations, peer review) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future. ***Construct an explanation based on valid and reliable evidence from a***	**STRUCTURE AND PROPERTIES OF MATTER** The periodic table orders elements horizontally by the number of protons in the atom's nucleus and places those with similar chemical properties in columns. The repeating patterns of this table reflect patterns of outer electron states. (HS.PS1A.b) ***Electrons in the outermost energy level are called valence electrons.*** ***The periodic table of elements is an arrangement of the chemical elements ordered by atomic number as determined by an atoms number of protons.*** ***The periodic table is used to predict the patterns of behavior of elements.*** ***The arrangement of the groups of the periodic table reflects the patterns of electrons in the outermost energy level of atoms, and therefore, the chemical properties of the elements in each group.*** ***The atomic mass listed for each element on the periodic table corresponds to the relative abundance of that element's different isotopes.*** **CHEMICAL REACTIONS** The fact that atoms are conserved, together with knowledge of the chemical properties of the elements involved, can be used to describe and predict chemical reactions. (HS.PS1B.c) ***A chemical reaction is the process in which substances undergo chemical changes that results in the formation of new substances.*** ***Atoms are conserved in chemical reactions.*** ***Predicting involves making an inference about a future event based on evidence.***	**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. ***Patterns can be used to explain phenomena.*** ***Different patterns can be observed at different scales (micro and macro) in a system.*** ***Classifications used at one scale may fail or need revision when information from smaller or larger scales is introduced.***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
variety of sources. *Construct an explanation based on valid and reliable evidence from the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future.* *Revise an explanation based on valid and reliable evidence from a variety of sources.* *Revise an explanation based on valid and reliable evidence from the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future.*	*An element's chemical and physical properties can be predicted knowing only its position on the periodic table.*	

Clarification Statement	
Physical Science	Examples of chemical reactions could include the reaction of sodium and chlorine, carbon and oxygen, or hydrogen and oxygen. Reaction classification includes synthesis, decomposition, single displacement, double displacement, and acid-base.
Chemistry	Examples of chemical reactions could include the reaction of sodium and chlorine, carbon and oxygen, or carbon and hydrogen. Reaction classification aids in the prediction of products (e.g., synthesis, decomposition, single displacement, double displacement, and acid-base).

Performance Expectation *and Louisiana Connectors*
HS-PS1-3 Plan and conduct an investigation to gather evidence to compare the structure of substances at the macroscale to infer the strength of electrical forces between particles. ***LC-HS-PS1-3a Identify bulk properties of substances (i.e., melting point, boiling point, and surface tension).*** ***LC-HS-PS1-3b Identify that electrical forces within and between atoms can keep particles close together.*** ***LC-HS-PS1-3c Conduct an experiment to gather evidence of the strength of electrical forces between particles.***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Planning and carrying out investigations: Planning and carrying out investigations to answer questions (science) or test solutions (engineering) to problems in 9-12 builds on K-8 experiences and progresses to include investigations that provide evidence for and test conceptual, mathematical, physical, and empirical models. • Plan and conduct an investigation individually and/or collaboratively to produce data to serve as the basis for evidence, and in the design: decide on types, how much, and accuracy of data needed to produce reliable measurements and consider limitations on the precision of the data (e.g., number of trials, cost, risk, time), and refine the design accordingly. ***Plan an investigation individually***	**STRUCTURE AND PROPERTIES OF MATTER** The structure and interactions of matter at the macro scale are determined by electrical forces within and between atoms. (HS.PS1A.c) ***Electrical attractions and repulsions between charged particles (i.e., atomic nuclei and electrons) in matter explain the structure of atoms and the forces between atoms that cause them to form compounds.*** ***The varied properties (e.g., hardness, conductivity) of the materials can be understood in terms of the atomic and molecular constituents and the forces within and between them.*** **TYPES OF INTERACTIONS** Attraction and repulsion between electric charges at the atomic scale explain the structure, properties, and transformations of matter, as well as the contact forces between material objects. (secondary) (HS.PS2B.c) ***An atom's electron structure determines its physical and chemical properties.*** ***The arrangement and motion of atoms vary in characteristic ways, depending on the substance and its current state (e.g., solid, liquid).*** ***The charged substructure of an atom connects to the concepts of attraction and repulsion between electric charges at the atomic scale.*** ***The interactions of the electric charges at the atomic scale explain the structure, properties, and transformations of matter.***	**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. ***Patterns can be used to explain phenomena.*** ***Different patterns can be observed at different scales (micro and macro) in a system.*** ***Classifications used at one scale may fail or need revision when information from smaller or larger scales is introduced.***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
and collaboratively to produce data to serve as the basis for evidence, and in the design: decide on types, how much, and accuracy of data needed to produce reliable measurements. ***Revise an investigation individually and collaboratively to produce data to serve as the basis for evidence.*** ***Conduct an investigation individually and collaboratively to produce data to serve as the basis for evidence.***		

Clarification Statement	
Physical Science	Examples of evaluation and refinement could include determining the success of a device at protecting an object from damage such as, but not limited to, impact resistant packaging and modifying the design to improve it. Emphasis is on qualitative evaluations.
Chemistry	Examples of evaluation and refinement could include determining the success of the device at protecting an object from damage and modifying the design to improve it by applying the impulse-momentum theorem. Examples of a device could include a football helmet or an airbag. Emphasis is on qualitative evaluations and/or algebraic manipulations.

Performance Expectation *and Louisiana Connectors*
HS-PS1-4 Develop a model to illustrate that the release or absorption of energy from a chemical reaction system depends upon the changes in total bond energy. ***LC-HS-PS1-4a Determine whether energy is released or absorbed in a chemical reaction system using various types of models (e.g., drawings, graphs, etc.).***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Developing and using models: Modeling in 9-12 builds on K-8 experiences and progresses to using, synthesizing, and developing models to predict and show relationships among variables between systems and their components in the natural and designed worlds. • Develop, revise, and/or use a model based on evidence to illustrate and/or predict the relationships between systems or between components of a system. ***Develop or use a model to identify and describe the components of a system.*** ***Develop or use a model to identify and describe the relationships between the components of a system.*** ***Develop or use a model to predict relationships between systems or within a system.*** ***Identify that models can help***	**STRUCTURE AND PROPERTIES OF MATTER** A stable molecule has less energy than the same set of atoms separated; one must provide at least this energy in order to take the molecule apart. (HS.PS1A.d) ***Matter can be broken apart and rearranged to form new compounds/substances.*** ***Forces between atoms that cause them to form molecules (via chemical bonds), which range in size from two to thousands of atoms.*** ***The energy required to break apart compound is equal or greater to the energy of its formation.*** **CHEMICAL REACTIONS** Chemical processes, their rates, and whether or not energy is stored or released can be understood in terms of the collisions of molecules and the rearrangements of atoms into new molecules, with consequent changes in the sum of all bond energies in the set of molecules that are matched by changes in kinetic energy. (HS.PS1B.a) ***The total energy change of the chemical reaction system is matched by an equal but opposite change of energy in the surroundings.*** ***The properties of the macromolecules depend on the properties of the molecules used in their formation.*** ***Any chemical process involves a change in chemical bonds and the related bond energies and thus in the total chemical binding energy.*** ***This change is matched by a difference between the total kinetic energy of the set of reactant molecules before the collision and that of the set of product molecules after the collision (conservation of energy).***	**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. ***The processes of energy transformation and energy transfer can be used to understand the changes that take place in physical systems.***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
illustrate relationships between systems or within a system.		

Clarification Statement
Emphasis is on the idea that a chemical reaction is a system that affects the energy change. Examples of models could include molecular-level drawings and diagrams of reactions, graphs showing the relative energies of reactants and products, and representations showing energy is conserved.

Performance Expectation *and Louisiana Connectors*
HS-PS1-5 Apply scientific principles and evidence to provide an explanation about the effects of changing the temperature or concentration of the reacting particles on the rate at which a reaction occurs. ***LC-HS-PS1-5a Identify the effects of changing the temperature of the reacting particles at the rate at which a simple reaction (i.e., two reactants) occurs using a model (e.g., a table of data) of the number and energy of collisions between particles.*** ***LC-HS-PS1-5b Identify the effects of changing the concentration of the reacting particles at the rate at which a simple reaction (i.e., two reactants) occurs using a model (e.g., a table of data) of the number and energy of collisions between particles.***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Constructing explanations and designing solutions: Constructing explanations (science) and designing solutions (engineering) in 9-12 builds on K-8 experiences and progresses to explanations and designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific ideas, principles, and theories. • Apply scientific ideas, principles, and/or evidence to provide an explanation of phenomena and solve design problems, taking into account possible unanticipated effects. ***Apply scientific ideas to provide an explanation of phenomena taking into account possible unanticipated effects.*** ***Apply scientific ideas to solve design problems, taking into***	**CHEMICAL REACTIONS** Chemical processes, their rates, and whether or not energy is stored or released can be understood in terms of the collisions of molecules and the rearrangements of atoms into new molecules, with consequent changes in the sum of all bond energies in the set of molecules that are matched by changes in kinetic energy. (HS.PS1B.a) ***The total energy change of the chemical reaction system is matched by an equal but opposite change of energy in the surroundings.*** ***The properties of the macromolecules depend on the properties of the molecules used in their formation.*** ***Any chemical process involves a change in chemical bonds and the related bond energies and thus in the total chemical binding energy.*** ***This change is matched by a difference between the total kinetic energy of the set of reactant molecules before the collision and that of the set of product molecules after the collision (conservation of energy).***	**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. ***Patterns can be used to explain phenomena.*** ***Different patterns can be observed at different scales (micro and macro) in a system.*** ***Classifications used at one scale may fail or need revision when information from smaller or larger scales is introduced.***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
account possible unanticipated effects. *Apply scientific principles to provide an explanation of phenomena taking into account possible unanticipated effects.* *Apply scientific principles to solve design problems, taking into account possible unanticipated effects.* *Apply scientific evidence to provide an explanation of phenomena taking into account possible unanticipated effects.* *Apply scientific evidence to solve design problems, taking into account possible unanticipated effects.*		

Clarification Statement
Student reasoning should focus on the number and energy of collisions between molecules. Emphasis is on simple reactions in which there are only two reactants; evidence from temperature, concentration, and rate data; and qualitative relationships between rate and temperature.

Performance Expectation ***and Louisiana Connectors***
HS-PS1-6 Refine the design of a chemical system by specifying a change in conditions that would produce increased amounts of products at equilibrium. ***LC-HS-PS1-6a Identify a change in one variable (i.e., temperature, concentration, pressure) of a chemical equation that would produce increased amounts of products at equilibrium.***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Constructing explanations and designing solutions: Constructing explanations (science) and designing solutions (engineering) in 9-12 builds on K-8 experiences and progresses to explanations and designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific ideas, principles, and theories. • Design, evaluate, and/or refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations. ***Design a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations.*** ***Evaluate a solution to a complex real-world problem, based on scientific knowledge, student-***	**CHEMICAL REACTIONS** In many situations, a dynamic and condition-dependent balance between a reaction and the reverse reaction determines the numbers of all types of molecules present. (HS.PS1B.b) ***A system at equilibrium appears stable at the macroscopic level.*** ***The speeds at which a reaction and its reverse reaction occur determines the numbers of all types of reactants and products present in a system. (Sometimes they are not balanced.)*** ***Reversible reactions will reach an equilibrium point where the concentrations of the reactants and products will no longer change.*** ***The balance between a reaction and the reverse reaction determines the numbers of all types of molecules present.*** **OPTIMIZING THE DESIGN SOLUTION** Criteria may need to be broken down into simpler ones that can be approached systematically, and decisions about the priority of certain criteria over others (tradeoffs) may be needed (secondary). (HS.ETS1C.a) ***It is important to prioritize the benefits and costs of the design of a solution to a problem.*** ***The decision as to which criteria are critical and which ones can be traded off is a judgment based on the situation and the needs of the system.***	**STABILITY AND CHANGE** Much of science deals with constructing explanations of how things change and how they remain stable. ***Science deals with constructing explanations of how things change.*** ***Science deals with constructing explanations of how things remain stable.***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
generated sources of evidence, prioritized criteria, and tradeoff considerations. ***Refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations.***		

Clarification Statement
Emphasis is on the application of Le Chatelier's Principle and on refining designs of chemical reaction systems, including descriptions of the connection between changes made at the macroscopic level and what happens at the molecular level. Examples of designs could include different ways to increase product formation including adding reactants or removing products.

Performance Expectation *and Louisiana Connectors*
HS-PS1-7 Use mathematical representations to support the claim that atoms, and therefore mass, are conserved during a chemical reaction. ***LC-HS-PS1-7a Identify a chemical equation, and identify the reactants and products which support the claim that matter (i.e., atoms) is neither created or destroyed in a chemical reaction.*** ***LC-HS-PS1-7b Identify a mathematical representation (e.g., table, graph) or pictorial depictions that illustrates the claim that mass is conserved during a chemical reaction.***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Using mathematical and computational thinking: Mathematical and computational thinking in 9-12 builds on K-8 experiences and progresses to using algebraic thinking and analysis, a range of linear and nonlinear functions, including computational tools for statistical analysis to analyze, represent, and model data. Simple computational simulations are created and used based on mathematical models of basic assumptions. • Use mathematical, computational, and/or algorithmic representations of phenomena or design solutions to describe and/or support claims and/or explanations. ***Use mathematical or algorithmic forms for scientific modeling of phenomena to describe claims.*** ***Use mathematical or algorithmic forms for scientific modeling of***	**CHEMICAL REACTIONS** The fact that atoms are conserved, together with knowledge of the chemical properties of the elements involved, can be used to describe and predict chemical reactions. (HS.PS1B.c) ***A chemical reaction is the process in which substances undergo chemical changes that results in the formation of new substances.*** ***Atoms are conserved in chemical reactions.*** ***Predicting involves making an inference about a future event based on evidence.*** ***An element's chemical and physical properties can be predicted knowing only its position on the periodic table.*** ***The periodic table can be used to predict the outcome of chemical reactions.***	**ENERGY AND MATTER** The total amount of energy and matter in closed systems is conserved. ***When materials interact within a closed system, the total mass of the system remains the same.*** ***When materials interact within a closed system, energy may change forms, but the total amount of energy within the system remains the same.***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
design solutions to describe claims. ***Use mathematical or algorithmic forms for scientific modeling of phenomena to support claims.*** ***Use mathematical or algorithmic forms for scientific modeling of design solutions to support claims.*** ***Use mathematical or algorithmic forms for scientific modeling of phenomena to describe explanations.*** ***Use mathematical or algorithmic forms for scientific modeling of design solutions to describe explanations.*** ***Use mathematical or algorithmic forms for scientific modeling of phenomena to support explanations.*** ***Use mathematical or algorithmic forms for scientific modeling of design solutions to support explanations.***		

Clarification Statement	
Physical Science	Emphasis is on using mathematical ideas to communicate the relationship between masses of reactants and products as well as balancing chemical equations.
Chemistry	Emphasis is on using mathematical ideas as they relate to stoichiometry to communicate the proportional relationships between masses of atoms in the reactants and the products, and the translation of these relationships to the macroscopic scale using the mole as the conversion from the atomic to the

Clarification Statement	
	macroscopic scale. Emphasis is on assessing students' use of mathematical thinking and not on memorization and rote application of problem-solving techniques.

Performance Expectation *and Louisiana Connectors*
HS-PS1-8 Develop models to illustrate the changes in the composition of the nucleus of the atom and the energy released during the processes of fission, fusion, and radioactive decay. ***LC-HS-PS1-8a Identify models that illustrate nuclear processes (i.e., fusion, fission, and radioactive decays), involve the release or absorption of energy.*** ***LC-HS-PS1-8b Contrast changes during the processes of alpha, beta, or gamma radioactive decay using graphs or pictorial depictions of the composition of the nucleus of the atom and the energy released.***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Developing and using models: Modeling in 9-12 builds on K-8 experiences and progresses to using, synthesizing, and developing models to predict and show relationships among variables between systems and their components in the natural and designed world(s). • Develop, revise, and/or use a model based on evidence to illustrate and/or predict the relationships between systems or between components of a system. ***Develop or use a model to identify and describe the components of a system.*** ***Develop or use a model to identify and describe the relationships between the components of a system.*** ***Develop or use a model to predict relationships between systems or within a system.*** ***Identify that models can help***	**NUCLEAR PROCESSES** Nuclear processes, including fusion, fission, and radioactive decays of unstable nuclei, involve release or absorption of energy. The total number of neutrons plus protons does not change in any nuclear process. (HS.PS1C.a) ***Fission, fusion, and radioactive decay (alpha, beta, and gamma) are nuclear processes.*** ***Nuclear fission and fusion reactions release energy.*** ***In fission reactions, an atom is split into two or more smaller atoms.*** ***In fusion reactions, two smaller atoms fuse together to create a heavier atom.*** ***When a nuclear process takes place, radioactive particles and/or rays may be produced.*** ***Radioactive decay is the breakdown of an atomic nucleus resulting in the release of energy and matter from the nucleus.*** ***The total number of neutrons plus protons is the same both before and after the nuclear process of radioactive decay.*** ***Typically nuclear processes release much more energy per atom involved than do chemical processes.*** ***The energy that is released or absorbed during nuclear processes are harmful to human tissues.***	**ENERGY AND MATTER** In nuclear processes, atoms are not conserved, but the total number of protons plus neutrons is conserved. ***The total number of protons plus neutrons is the same before and after nuclear processes occur.***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
illustrate relationships between systems or within a system.		

Clarification Statement	
Physical Science	Emphasis is only on simple qualitative models, such as pictures or diagrams, and on the scale of energy released in nuclear processes relative to other kinds of transformations. Radioactive decay focus is on its relationship to half-life.
Chemistry	Emphasis is on simple qualitative models, such as pictures or diagrams, and on the scale of energy released in nuclear processes relative to other kinds of transformations. Emphasis is on alpha, beta, and gamma radioactive decays.

Performance Expectation ***and Louisiana Connectors***
HS-PS2-6 Communicate scientific and technical information about why the atomic-level, subatomic-level, and/or molecular level structure is important in the functioning of designed materials. ***LC-HS-PS2-6a Communicate that different materials have different molecular structures and properties which determine different functioning of the material (e.g., flexible, but durable).***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Obtaining, evaluating, and communicating information: Obtaining, evaluating, and communicating information in 9-12 builds on K-8 experiences and progresses to evaluating the validity and reliability of the claims, methods, and designs. • Communicate scientific and/or technical information or ideas (e.g., about phenomena and/or the process of development and the design and performance of a proposed process or system) in multiple formats (i.e., orally, graphically, textually, mathematically). ***Communicate scientific information in multiple formats (i.e., orally, graphically, textually, mathematically).*** ***Communicate technical information in multiple formats (i.e., orally, graphically, textually, mathematically).***	**STRUCTURE AND PROPERTIES OF MATTER** The structure and interactions of matter at the macro scale are determined by electrical forces within and between atoms. (HS.PS1A.c) ***Electrical attractions and repulsions between charged particles (i.e., atomic nuclei and electrons) in matter explain the structure of atoms and the forces between atoms that cause them to form compounds.*** ***The varied properties (e.g., hardness, conductivity) of the materials can be understood in terms of the atomic and molecular constituents and the forces within and between them.*** **TYPES OF INTERACTIONS** Attraction and repulsion between electric charges at the atomic scale explain the structure, properties, and transformations of matter, as well as the contact forces between material objects. (HS.PS2B.c) ***An atom's electron structure determines its physical and chemical properties.*** ***The arrangement and motion of atoms vary in characteristic ways, depending on the substance and its current state (e.g., solid, liquid).*** ***The charged substructure of an atom connects to the concepts of attraction and repulsion between electric charges at the atomic scale.*** ***The interactions of the electric charges at the atomic scale explain the structure, properties, and transformations of matter.*** **ELECTROMAGNETIC RADIATION** Photoelectric materials emit electrons when they absorb light of a high-enough frequency. (HS.PS4B.c)	**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. ***Designing new structures/systems requires knowledge of the properties (e.g., rigidity and hardness) of the materials needed for specific parts of the structure.*** ***Designing new structures/systems requires knowledge of***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Communicate scientific ideas in multiple formats (i.e., orally, graphically, textually, mathematically).	***The photoelectric effect is the movement of electrons in a substance when light is shined on it. This movement causes an electric current to flow.*** ***Some materials (e.g., solar panels) absorb photons of light and release electrons that can be transformed into an electric current.*** Atoms of each element emit and absorb characteristic frequencies of light. These characteristics allow identification of the presence of an element, even in microscopic quantities. (HS.PS4B.d) ***When the atoms of an element absorb energy, the electrons make transitions from lower energy levels to higher energy levels.*** ***When electrons subsequently return from higher energy levels to lower energy levels, energy is released predominantly in the form of electromagnetic radiation.*** ***If emitted photons are in the visible region of the spectrum, they may be perceived different colors.*** ***The result is called a line emission spectrum and can serve as a 'fingerprint' of the element to which the atoms belong.***	***the structures of different components.*** ***Designing a new structure requires a detailed examination of the connections of components to reveal its function.*** ***Designing a new structure requires a detailed examination of the connections of components to reveal any problems.***

Clarification Statement
Emphasis is on the attractive and repulsive forces that determine the functioning of the material. Examples could include why electrically conductive materials are often made of metal, fireworks and neon signs are made of certain elements, flexible but durable materials are made up of long chained molecules, and pharmaceuticals are designed to interact with specific receptors.

Performance Expectation ***and Louisiana Connectors***
HS-PS3-1 Create a computational model to calculate the change in the energy of one component in a system when the change in energy of the other component(s) and energy flows in and out of the system are known. ***LC-HS-PS3-1a Identify a model showing the change in the energy of one component in a system compared to the change in energy of another component in the system.*** ***LC-HS-PS3-1b Identify a model showing the change in energy of one component in a system when the change in energy of the other component(s) and energy flows in and out of the system are known.***

Science and Engineering Practice	**Disciplinary Core Idea**	**Crosscutting Concept**
Using mathematics and computational thinking: Mathematical and computational thinking in 9-12 builds on K-8 experiences and progresses to using algebraic thinking and analysis, a range of linear and nonlinear functions including computational tools for statistical analysis to analyze, represent, and model data. Simple computational simulations are created and used based on mathematical models of basic assumptions. • Create and/or revise a computational model or simulation of a phenomenon, designed device, process, or system. ***Create a computational model of a phenomenon.*** ***Revise a computational model of a phenomenon.*** ***Create a simulation of a***	**DEFINITIONS OF ENERGY** Energy is a quantitative property of a system that depends on the motion and interactions of matter and radiation within that system. That there is a single quantity called energy is due to the fact that a system's total energy is conserved, even as, within the system, energy is continually transferred from one object to another and between its various possible forms. (HS.PS3A.a) ***Energy is the ability to do work or cause change.*** ***Energy transforms from one form to another, but these transformations are not always reversible.*** ***A system's total energy is conserved regardless of the transfers within the system.*** ***The total energy of a system changes only by the amount of energy transferred into and out of the system.*** **CONSERVATION OF ENERGY AND ENERGY TRANSFER** Conservation of energy means that the total change of energy in any system is always equal to the total energy transferred into or out of the system. (HS.PS3B.a) ***The law of conservation of energy states that when one form of energy is converted to another, no energy is destroyed in the process.*** ***According to the law of conservation of energy, energy cannot be created or destroyed.*** ***The total change of energy in any system is always equal to the total energy transferred into or out of the system.***	**SYSTEMS AND SYSTEM MODELS** Models can be used to predict the behavior of a system, but these predictions have limited precision and reliability due to the assumptions and approximations inherent in models. ***Models can be valuable in predicting a system's behaviors.*** ***Any model of a system incorporates assumptions and approximations.*** ***As a result, model-based predictions have limited precision and reliability.***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
phenomenon. ***Revise a simulation of a phenomenon.*** ***Create a computational model of a designed device.*** ***Revise a computational model of a designed device.*** ***Create a simulation of a designed device.*** ***Revise a simulation of a designed device.*** ***Create a computational model of a process.*** ***Revise a computational model of a process.*** ***Create a simulation of a process.*** ***Revise a simulation of a process.*** ***Create a computational model of a system.*** ***Revise a computational model of a system.*** ***Create a simulation of a system.*** ***Revise a simulation of a system.***	Energy cannot be created or destroyed, but it can be transported from one place to another and transferred between systems. (HS.PS3B.b) ***Energy cannot be created or destroyed.*** ***Energy can be transferred from one object to another and can be transformed from one form to another.*** ***The processes of energy transformation and energy transfer can be used to understand the changes that take place in physical systems.*** Mathematical expressions allow the concept of conservation of energy to be used to predict and describe system behavior. These expressions quantify how the stored energy in a system depends on its configuration (e.g., relative positions of charged particles, compression of a spring) and how kinetic energy depends on mass and velocity. (HS.PS3B.c) ***The amount of energy available in a system is mathematically calculable.*** ***Mathematical expressions quantify forms of energy in a system.*** ***These forms can be grouped into types of energy that are associated with the motion of mass (kinetic energy), and types of energy associated with the position of mass and energy fields (potential energy).*** The availability of energy limits what can occur in any system. (HS.PC3B.d) ***The amount of energy available in a system determines what the system is capable of doing.***	

Clarification Statement	
Physical Science	Emphasis is on explaining the meaning of mathematical expressions used in the model. Focus is on basic algebraic expression or computations, systems of two or three components, and thermal energy.
Chemistry	Emphasis is on explaining the meaning of mathematical expressions used in the model. Focus is on basic algebraic expression or computations; systems of

Clarification Statement	
	two or three components; and thermal energy, kinetic energy, and/or the energies in gravitational, magnetic, or electric fields.

Performance Expectation *and Louisiana Connectors*
HS-PS3-3 Design, build, and refine a device that works within given constraints to convert one form of energy into another form of energy. ***LC-HS-PS3-3a Identify the forms of energy that will be converted by a device that converts one form of energy into another form of energy.*** ***LC-HS-PS3-3b Identify steps in a model of a device showing the transformations of energy that occur (e.g., solar cells, solar ovens, generators, turbines).*** ***LC-HS-PS3-3c Describe constraints to the design of the device which converts one form of energy into another form of energy (e.g., cost or efficiency of energy conversion).***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Constructing explanations and designing solutions: Constructing explanations (science) and designing solutions (engineering) in 9-12 builds on K-8 experiences and progresses to explanations and designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific ideas, principles, and theories. • Design, evaluate, and/or refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and trade-off considerations. ***Design a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and trade-off***	**DEFINITIONS OF ENERGY** At the macroscopic scale, energy manifests itself in multiple ways, such as in motion, sound, light, and thermal energy. (HS.PS3A.b) ***Energy takes many forms; forms may include motion, sound, light, and thermal energy.*** **ENERGY IN CHEMICAL PROCESSES** Although energy cannot be destroyed, it can be converted to other forms—for example, to thermal energy in the surrounding environment. (HS.PS3D.a) ***A system does not destroy energy when carrying out any process.*** ***When carrying out a process, most often some or all of the energy has been transferred to heat the surrounding environment.*** ***Energy can be transformed into other energy forms.*** ***To produce energy typically means to convert some stored energy into a desired form.*** **DEFINING AND DELIMITING ENGINEERING PROBLEMS** Criteria and constraints also include satisfying any requirements set by society, such as taking issues of risk mitigation into account, and they should be quantified to the extent possible and stated in such a way that one can tell if a given design meets them. (HS.ETS1A.a) ***A first step in designing a device to solve a problem is prioritizing criteria and constraints for the design of the device.***	**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. ***The processes of energy transformation and energy transfer can be used to understand the changes that take place in physical systems.***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
considerations. ***Evaluate a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and trade-off considerations.*** ***Refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and trade-off considerations.***	***The social, economic, and political forces of a society have a significant influence on what science and technology solutions are implemented.***	

Clarification Statement	
Physical Science	Examples of phenomena at the macroscopic scale could include the conversion of potential energy to kinetic and thermal energy. Examples of models could include diagrams, drawings, descriptions, and computer simulations.
Chemistry	Examples of phenomena at the macroscopic scale could include the conversion of potential energy to kinetic and thermal energy, and the energy stored between two electrically-charged plates. Examples of models could include diagrams, drawings, descriptions, and computer simulations.

Performance Expectation *and Louisiana Connectors*
HS-PS3-4 Plan and conduct an investigation to provide evidence that the transfer of thermal energy when two components of different temperature are combined within a closed system results in a more uniform energy distribution among the components in the system (second law of thermodynamics). ***LC-HS-PS3-4a Identify the temperatures of two liquids of different temperature before mixing and after combining to show uniform energy distribution.*** ***LC-HS-PS3-4b Investigate the transfer of thermal energy when two substances are combined within a closed system.***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Planning and carrying out investigations: Planning and carrying out investigations to answer questions (science) or test solutions to problems (engineering) in 9-12 builds on K-8 experiences and progresses to include investigations that provide evidence for and test conceptual, mathematical, physical, and empirical models. • Plan and conduct an investigation individually and collaboratively to produce data to serve as the basis for evidence, and in the design: decide on types, how much, and accuracy of data needed to produce reliable measurements and consider limitations on the precision of the data (e.g., number of trials, cost, risk, time), and refine the design accordingly. ***Plan an investigation individually and collaboratively to produce data***	**CONSERVATION OF ENERGY AND ENERGY TRANSFER** Energy cannot be created or destroyed, but it can be transported from one place to another, transformed into other forms, and transferred between systems. (HS.PS3B.b) ***Energy cannot be created or destroyed.*** ***Energy can be transferred from one object to another and can be transformed from one form to another.*** ***The processes of energy transformation and energy transfer can be used to understand the changes that take place in physical systems.*** Uncontrolled systems always evolve toward more stable states—that is, toward more uniform energy distribution (e.g., water flows downhill, objects hotter than their surrounding environment cool down). (HS.PS3B.e) ***Energy can change from one kind to another.*** ***When two substances (e.g., water or air) of different temperatures are combined (within a closed system), the result will be a more uniform temperature (energy) distribution in the system.*** **ENERGY IN CHEMICAL PROCESSES AND EVERYDAY LIFE** Although energy cannot be destroyed, it can be converted to less useful other forms—for example, to thermal energy in the surrounding environment. (HS.PS3D.a) ***Energy can be transformed into other energy forms.***	**SYSTEMS AND SYSTEM MODELS** When investigating or describing a system, the boundaries and initial conditions of the system need to be defined and their inputs and outputs analyzed and described using models. ***Making models help people understand things they cannot observe directly.*** ***Scientists use models to represent things that are either very large or very small.*** ***Any model of a system incorporates assumptions and approximations (e.g., the boundaries and initial conditions of the***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
to serve as the basis for evidence, and in the design: decide on types, how much, and accuracy of data needed to produce reliable measurements. *Revise an investigation individually and collaboratively to produce data to serve as the basis for evidence.* *Conduct an investigation individually and collaboratively to produce data to serve as the basis for evidence.*	*When "producing" or "using" energy, most often some or all of the energy has been transferred to heat the surrounding environment.*	*system, inputs and outputs).* *It is critical to be aware of a system's physical, chemical, biological, and social interactions and how they affect the model's reliability and precision.*

Clarification Statement	
Physical Science, Chemistry, and Physics	Emphasis is on analyzing data from student investigations and using mathematical thinking appropriate to the subject to describe the energy changes quantitatively and conceptually. Examples of investigations could include mixing liquids at different initial temperatures or adding objects at different temperatures to water.

Performance Expectation *and Louisiana Connectors*
HS-PS3-6 Evaluate the validity and reliability of claims in published materials about the viability of nuclear power as a source of alternative energy relative to other forms of energy (e.g., fossil fuels, wind, solar, geothermal). ***LC-HS-PS3-6a Identify the relationship between increasing energy demand and the technologies developed to meet these needs.*** ***LC-HS-PS3-6b Identify an alternative energy system with minimal social and environmental consequences.*** ***LC-HS-PS3-6c Evaluate a claim about nuclear energy as an alternative source of energy as opposed to other forms of energy.***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Obtaining, evaluating, and communicating information: Obtaining, evaluating, and communicating information in 9-12 builds on K-8 experiences and progresses to evaluating the validity and reliability of the claims, methods, and designs. • Evaluate the validity and reliability of and/or synthesize multiple claims, methods, and/or designs that appear in scientific and technical texts or media reports, verifying the data when possible. ***Evaluate the validity and reliability of claims that appear in scientific and technical texts, verifying the data when possible.*** ***Evaluate the validity and reliability of claims that appear in media reports, verifying the data when possible.*** ***Evaluate the validity and reliability***	**NUCLEAR PROCESSES** Nuclear processes, including fusion, fission, and radioactive decays of unstable nuclei, involve release or absorption of energy. The total number of neutrons plus protons does not change in any nuclear process. (HS.PS1C.a) ***Fission, fusion, and radioactive decay (alpha, beta, and gamma) are nuclear processes.*** ***Nuclear fission and fusion reactions release energy.*** ***In fission reactions, an atom is split into two or more smaller atoms.*** ***In fusion reactions, two smaller atoms fuse together to create a heavier atom.*** ***When a nuclear process takes place, radioactive particles and/or gamma radiation may be produced.*** ***Radioactive particles or decay occur when an unstable atomic nucleus loses energy by emitting radiation.*** ***The total number of neutrons plus protons is the same both before and after the nuclear process of radioactive decay.*** ***Typically nuclear processes release much more energy per atom involved than do chemical processes.*** ***The energy that is released or absorbed during nuclear processes are harmful to human tissues.*** **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)	**ENERGY AND MATTER** In nuclear processes, atoms are not conserved, but the total number of protons plus neutrons is conserved. ***The total number of nuclear particles are the same both before and after the nuclear process, although the total number of protons and the total number of neutrons may be different before and after.***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
of methods that appear in scientific and technical texts, verifying the data when possible. ***Evaluate the validity and reliability of methods that appear in media reports, verifying the data when possible.*** ***Evaluate the validity and reliability of designs that appear in scientific and technical texts, verifying the data when possible.*** ***Evaluate the validity and reliability of designs that appear in media reports, verifying the data when possible.***	***It is important to determine the full impact of the advantages and disadvantages when evaluating a solution.*** ***The development of solutions is driven by the following factors: economical, political, cultural, social, safety, and environmental.*** **NATURAL RESOURCES** All forms of energy production and other resource extraction have associated economic, social, environmental, and geopolitical costs and risks as well as benefits. New technologies and social regulations can change the balance of these factors. (HS.ESS3A.b) ***Energy production has associated economic, social, environmental, and geopolitical costs and risks.*** ***Energy production also has associated economic, social, environmental, and geopolitical benefits.*** ***Advances in technology can and advancement in science influence and drive each other forward to help balance these factors.***	

Clarification Statement
Emphasis is on the tradeoffs existing between the amount of energy produced, the types and amounts of pollution produced, safety, and cost. Examples of published materials could include trade books, magazines, web resources, videos, and other passages that may reflect bias.

Performance Expectation *and Louisiana Connectors*
HS-EVS1-1 Analyze and interpret data to identify the factors that affect sustainable development and natural resource management in Louisiana. **LC-HS-EVS1-1a Identify factors (e.g., human activity, population size, types of crops grown) that affect sustainable development in Louisiana.** **LC-HS-EVS1-1b Identify factors (e.g., human activity, population size, types of crops grown) that affect natural resource management in Louisiana.**

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Analyzing and interpreting data: Analyzing data in 9-12 builds on K-8 experiences and progresses to introducing more detailed statistical analysis, the comparison of data sets for consistency, and the use of models to generate and analyze data. • Analyze data using tools, technologies, and/or models (e.g., computational, mathematical) in order to make valid and reliable scientific claims or determine an optimal design solution. **Analyze data using tools in order to make valid and reliable scientific claims.** **Analyze data using tools in order to determine an optimal design solution.** **Analyze data using technology in order to make valid and reliable scientific claims.** **Analyze data using technology in order to determine an optimal design solution.**	**LOUISIANA'S NATURAL RESOURCES** Ecosystem capital can be characterized as goods (removable products) and services such as the functions and values of wetlands. (HS.EVS1A.a) **Ecosystem attributes or services are important to value.** **Ecosystem capital are the resources or benefits provided by ecosystems that are needed for economic development.** **Ecosystems provide different goods or removable products such as timber, food, medicines, and fuel.** **Ecosystems serve important functions for human and wildlife (e.g., natural water filtration, control of floods by absorbing extra runoff from heavy rains, providing animal habitats).** **Ecosystems provide social and cultural services such as recreation.** **Changes to ecosystems (e.g., wetlands, forests) for commercial development, tourism, or agriculture to produce ecosystem capital can threaten and degrade those ecosystems.**	**STABILITY AND CHANGE** Change and rates of change can be quantified and modeled over very short or very long periods of time. Some system changes are irreversible. **Change and rates of change can be quantified over very short or very long periods of time.** **Change and rates of change can be modeled over very short or very long periods of time.** **Some system changes are irreversible.**

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Analyze data using models in order to make valid and reliable scientific claims. **Analyze data using models in order to determine an optimal design solution.**		

Clarification Statement
Evidence of Louisiana’s natural resource wealth is found in understanding functions and values of varied ecosystems and environments, supply of non-renewable mining products and profitable agricultural commodities. Examples of key natural resources include state waterways (such as rivers, lakes, and bayous) and the aquatic life found in them, regions of agriculture (pine forests, sugar cane, and rice fields) and high concentrations of minerals and fossil fuels on and off shore. Factors to consider in reviewing the management of natural resources include a review of historical practices, costs of resource extraction and waste management, consumption of natural resources, ongoing research and the advancements in technology.

Performance Expectation *and Louisiana Connectors*
HS-EVS1-2 Obtain, evaluate and communicate information on the effectiveness of management or conservation practices for one of Louisiana's natural resources with respect to common considerations such as social, economic, technological, and influencing political factors over the past 50 years. ***LC-HS-EVS1-2a Identify the effectiveness of management practices for one of Louisiana's natural resources related to social factors over the past 50 years.*** ***LC-HS-EVS1-2b Identify the effectiveness of management practices for one of Louisiana's natural resources related to economic factors over the past 50 years.*** ***LC-HS-EVS1-2c Identify the effectiveness of management practices for one of Louisiana's natural resources related to technological factors over the past 50 years.*** ***LC-HS-EVS1-2d Identify the effectiveness of management practices for one of Louisiana's natural resources related to political factors over the past 50 years.***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Analyzing and interpreting data: Analyzing data in 9-12 builds on K-8 experiences and progresses to introducing more detailed statistical analysis, the comparison of data sets for consistency, and the use of models to generate and analyze data. • Analyze data to identify design features or characteristics of the components of a proposed process or system to optimize it relative to criteria for success. ***Analyze data using tools in order to make valid and reliable scientific claims.*** ***Analyze data using tools in order to determine an optimal design solution.*** ***Analyze data using technology in order to make valid and reliable scientific claims.***	**RESOURCE MANAGEMENT FOR LOUISIANA** Some changes to our natural environment such as the building of levees and hydrological modification have provided for economic and social development but have resulted in unintended negative impacts. (HS.EVS1.B.b) ***The natural environment can be changed by human activity.*** ***Human activity can have both positive and negative effects on the natural environment.*** ***The economic and social development benefits from building levees and hydrological modification include supplying sources of power (i.e., clean, inexpensive, and renewable energy), water for irrigation and drinking, and reduction of flooding downstream.*** ***Negative impacts of hydrological modification (e.g., building dams and levees) can include altering the temperature and speed of water, reduction in organisms and in-stream vegetation, movement of fish populations, increased flooding downstream, and preventing seasonal overbank flooding that can provide needed nutrients to soils.*** ***Humans can take steps to restore some damaged ecosystems (e.g., fish ladders, consideration of environmental impacts of new or renewed licenses for hydroelectric dams).***	**CAUSE AND EFFECT** Cause and effect relationships can be suggested and predicted for complex natural and human-designed systems by examining what is known about smaller scale mechanisms within the system. ***Cause and effect relationships can be suggested for complex systems (natural and human-designed) by examining what is known about smaller scale mechanisms within the system.*** ***Cause and effect relationships can be***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Analyze data using technology in order to determine an optimal design solution. ***Analyze data using models in order to make valid and reliable scientific claims.*** ***Analyze data using models in order to determine an optimal design solution.***		***predicted for complex systems (natural and human-designed) by examining what is known about smaller scale mechanisms within the system.***

Clarification Statement
The rate of land loss and habitat conversion from a variety of forces results in stresses and constraints that influence decisions and carry consequences that affect quality of life and have a bearing on sustainability. Increases in commercial and recreational uses may result in the need for environmental policies and call for changes in long established practices. Community efforts to address changes to secure growth while preserving the resources depend on education and collaboration between groups. Examples may include ground water conservation, erosion/flood control, forestry stewardship, game and wildlife, commercial fishing, oil and gas industry, dredging, or regulatory factors.

Performance Expectation *and Louisiana Connectors*
HS-EVS1-3 Analyze and interpret data about the consequences of environmental decisions to determine the risk-benefit values of actions and practices implemented for selected issues. ***LC-HS-EVS1-3a Identify the risk-benefit values of implemented actions using data for selected environmental issues.*** ***LC-HS-ESV1-3b Identify the risk-benefit values of implemented practices using data for selected environmental issues.***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Analyzing and interpreting data: Analyzing data in 9-12 builds on K-8 experiences and progresses to introducing more detailed statistical analysis, the comparison of data sets for consistency, and the use of models to generate and analyze data. • Analyze data to identify design features or characteristics of the components of a proposed process or system to optimize it relative to criteria for success. ***Analyze data using tools in order to make valid and reliable scientific claims.*** ***Analyze data using tools in order to determine an optimal design solution.*** ***Analyze data using technology in order to make valid and reliable scientific claims.*** ***Analyze data using technology in***	**RESOURCE MANAGEMENT FOR LOUISIANA** Some changes to our natural environment such as the building of levees and hydrological modification have provided for economic and social development but have resulted in unintended negative impacts. (HS.EVS1B.b) ***The natural environment can be changed by human activity.*** ***Human activity can have both positive and negative effects on the natural environment.*** ***The economic and social development benefits from building levees and hydrological modification include supplying sources of power (i.e., clean, inexpensive, and renewable energy), water for irrigation and drinking, and reduction of flooding downstream.*** ***Negative impacts of hydrological modification (e.g., building dams and levees) can include altering the temperature and speed of water, reduction in organisms and in-stream vegetation, movement of fish populations, increased flooding downstream, and preventing seasonal overbank flooding that can provide needed nutrients to soils.*** ***Humans can take steps to restore some damaged ecosystems (e.g., fish ladders, consideration of environmental impacts of new or renewed licenses for hydroelectric dams).***	**CAUSE AND EFFECT** Cause and effect relationships can be suggested and predicted for complex natural and human-designed systems by examining what is known about smaller scale mechanisms within the system. ***Cause and effect relationships can be suggested for complex systems (natural and human-designed) by examining what is known about smaller scale mechanisms within the system.*** ***Cause and effect relationships can be predicted for complex***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
order to determine an optimal design solution. ***Analyze data using models in order to make valid and reliable scientific claims.*** ***Analyze data using models in order to determine an optimal design solution.***		***systems (natural and human-designed) by examining what is known about smaller scale mechanisms within the system.***

Clarification Statement
Examples could be taken from system interactions: (1) loss of ground vegetation causing an increase in water runoff and soil erosion; (2) dammed rivers increasing ground-water recharge, decreasing sediment transport, and increasing coastal erosion; (3) loss of wetlands reducing storm protection buffer zones allowing further wetland reduction; and (4) hydrological modification such as levees providing protection to infrastructure at a cost to ecosystems.

Performance Expectation *and Louisiana Connectors*
HS-EVS2-1 Design and evaluate a solution to limit the introduction of non-point source pollution into state waterways. ***LC-HS-EVS2-1a Use data or qualitative scientific and technical information to evaluate a solution to limit a non-point source pollution (e.g., land or urban runoff, abandoned mines) into state waterways.***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Constructing explanations and designing solutions: Constructing explanations (science) and designing solutions (engineering) in 9-12 builds on K-8 experiences and progresses to explanations and designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific ideas, principles, and theories. • Design, evaluate and/or refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria and trade-off considerations. ***Design a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and trade-off considerations.*** ***Evaluate a solution to a complex real-world problem, based on scientific knowledge, student-***	**POLLUTION AND THE ENVIRONMENT** Pollution includes both natural and man-made substances which occur at rates and levels which incur harm (i.e., combustion of fossil fuels, agricultural waste, and industrial byproducts). Pollution can be categorized as point-source pollution and non-point source pollution. (HS.EVS2A.a) ***Pollution is any change to the environment that has a negative effect on living things. Natural pollution includes events that pollute the air including forest fires, volcanic eruptions, dust storms, and wind erosion.*** ***Pollution (e.g., air pollution) is often the result of an activity that benefits humans (e.g., generating electricity by burning coal, building and maintaining factories, burning fossil fuels, carbon dioxide from vehicles, and other fine particles suspended in the air).*** ***Some data suggest that the levels of pollution are increasing rapidly (i.e., increase in greenhouse gases).*** ***Pollution can be categorized as point-source pollution which are identifiable sources of pollution from which pollutants are discharged such as a pipe, ditch, ship, refineries, automobile manufacturers, factories or sewage treatment plants.*** ***Pollution can also be categorized as non-point source pollution which results from runoff or rain or melted snow as it moves over the ground (e.g., following a heavy rain, water flows across the surface of a road and picks up oil and gas left by car or chemicals used in agriculture or lawn care flow into storm drains and then into nearby by bodies of water).*** **ENVIRONMENTAL CHOICES** Different approaches can be used to manage impacts to our environment. Generally speaking, we can change human activities to limit negative impacts. Alternately, we can use technologies that reduce impact or we can perform restoration work to recover natural functions and values. (HS.EVS2C.a)	**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. ***Designing and/or investigating new structures/systems requires knowledge of the properties (e.g., rigidity and hardness) of the materials needed for specific parts of the structure.*** ***Designing and/or investigating new structures/systems***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
generated sources of evidence, prioritized criteria, and trade-off considerations. *Refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and trade-off considerations.*	*Exponential growth of the global human population and the resulting increase in consumption places severe stress on finite resources.* *Advances in technology can help mitigate human impact on the environment.* *Changes in human behaviors and activities (e.g., reduce the use of coal and other fossil fuels) and laws that control air and water quality and promote development of new technology can limit negative impacts on the environment.* *Technological solutions (e.g., wet scrubber; baghouse, solar panels, emission controls) can result in lower levels of pollution (e.g., cleaner air) and reduce the environmental impact.* *Technological solutions (e.g., desalination of water to provide clean drinking water, vehicle fuel efficiency) can also restore or recover natural functions and values in the environment.* Trade-offs occur when we make environmental choices. (HS.EVS2C.b) *Environmental choices often requires making trade-offs among competing criteria (cost, reliability, and aesthetic, social, cultural, and political impacts).* *Many factors, including environmental or health impacts, change over time and vary from place to place.* **DEFINING AND DELIMITING ENGINEERING PROBLEMS** Humanity faces major global challenges today, such as the need for supplies of clean water and food or for energy sources that minimize pollution, which can be addressed through engineering. These global challenges also may have manifestations in local communities. (HS.ETS1A.b) *There are common challenges faced by humans living across the world.* *Human survival depends on developing practices that will achieve sustainable systems.* *Common problems include the need for clean water and air, food (decreased crop yield), and sources of energy that minimize pollution (e.g., solar energy).* *These common problems faced by humans living across the world may also create issues in local communities including illness (asthma), lack of clean drinking water, reduction in ecosystems and plants and animals.*	*requires knowledge of the structures of different components.* *Designing and/or investigating a new structure requires a detailed examination of the connections of components to reveal its function.* *Designing and/or investigating a new structure requires a detailed examination of the connections of components to reveal any problems.*

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept

Clarification Statement
Examples of non-point source water pollution could include nitrogen and phosphorus compounds from agricultural activities and sediments from poor land-use practices. Nitrogen and phosphorus contribute to eutrophication and are anthropogenic drivers of the Gulf of Mexico hypoxic area known as the dead zone.

Performance Expectation *and Louisiana Connectors*
HS-EVS2-2 Use a model to predict the effects that pollution as a limiting factor has on an organism's population density. ***LC-HS-EVS2-2a Recognize the relationship between pollution and its effect on an organism's population size.*** ***LC-HS-EVS2-2b Predict the effects that pollution as a limiting factor has on an organism's population density using a model (e.g., mathematical, diagrams, simulations).***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Developing and using models: Modeling in 9-12 builds on K-8 experiences and progresses to using, synthesizing, and developing models to predict and show relationships among variables between systems and their components in the natural and designed world(s). • Develop and/or use a model (including mathematical and computational) to generate data to support explanations, predict phenomena, analyze systems and/or solve problems. ***Develop or use a model to identify and describe the components of a system.*** ***Develop or use a model to identify and describe the relationships between the components of a system.*** ***Develop or use a model to predict relationships between systems or within a system.*** ***Identify that models can help***	**POLLUTION AND THE ENVIRONMENT** Different organisms have unique tolerances to pollution hazards. Many of the organisms most tolerant of pollution are the least desirable to humans (e.g., for food, for recreation, for ecosystem services). (HS.EVS2A.b) ***Different organisms (plants and animals) have different abilities to respond to pollution hazards (e.g., some organisms can survive in poor water quality with lower oxygen levels).*** ***In nature, populations of organisms rarely grow uncontrolled.*** ***Each ecosystem has a carrying capacity or number of organisms it can sustain.*** ***Carrying capacities in ecosystems are impacted by pollution and can limit the numbers of organisms or populations they can support.*** ***Tolerance levels refer to the amount of pollution organisms can handle before dying or moving to another habitat.*** ***A system with proportionally dense populations of tolerant organisms indicates poor environmental quality.*** ***Many organisms that are most tolerant of pollution are not desired by humans for food (e.g., aquatic worms) and recreation or are not economically viable.***	**CAUSE AND EFFECT** Cause and effect relationships can be suggested and predicted for complex natural and human-designed systems by examining what is known about smaller scale mechanisms within the system. ***Cause and effect relationships can be suggested for complex systems (natural and human-designed) by examining what is known about smaller scale mechanisms within the system.*** ***Cause and effect relationships can be predicted for complex systems (natural and human-designed) by***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
illustrate relationships between systems or within a system.		***examining what is known about smaller scale mechanisms within the system.***

Clarification Statement
The law of limiting factors is often illustrated as a graphic tolerance curve and can be used to infer the range of tolerance a species has for specific pollution hazards. When combined with real-world data such as field measurements of abiotic factors, these models can be used to help predict the suitability of an ecosystem for a particular species.

Performance Expectation *and Louisiana Connectors*
HS-EVS2-3 Use multiple lines of evidence to construct an argument addressing the negative impacts that introduced organisms have on Louisiana's native species. ***LC-HS-EVS2-3a Evaluate evidence supporting an argument regarding negative impacts of introduced organisms (e.g., zebra mussel, fire ant, nutria) have on Louisiana's native species.***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Engaging in argument from evidence: Engaging in argument from evidence in 9-12 builds on K-8 experiences and progresses to using appropriate and sufficient evidence and scientific reasoning to defend and critique claims and explanations about natural and designed world(s). Arguments may also come from current scientific or historical episodes in science. • Construct, use, and/or present an oral and written argument or counterarguments based on data and evidence. ***Construct an oral argument based on data and evidence.*** ***Construct a written argument based on data and evidence.*** ***Construct an oral counterargument based on data and evidence.*** ***Construct a written counterargument based on data and evidence.***	**ECOSYSTEM CHANGE** The introduction of exotic/invasive species causes a disruption in natural ecosystems and can lead to the loss of native species (i.e., threatened/endangered). (HS.EVS2B.a) ***Invasive species are plants, animals, or other organisms that are introduced to a given area outside their original range and cause harm in their new home.*** ***Invasive species can be any kind of a living organism including plant, fungus, or an animal species that is not native to an ecosystem.*** ***Because there are no natural "enemies," invasive species can spread aggressively and can become difficult to control as the factors that influence their survival (e.g., diseases and other organisms) are not present.*** ***Some invasive species (e.g., ornamental plants, kudzu) are intentionally or accidentally released and can cause damage to the ecosystem.*** ***Invasive species impose great costs to agriculture, forestry, fisheries, and other human enterprises, as well as to human health.*** Changes in ecosystems impact the availability of natural resources (e.g. sediment starvation, climate change). (HS.EVS2B.b) ***People compete with each other and other living things for Earth's limited resources.*** ***Changes in human populations have affected the biodiversity of local organisms and availability of natural resources in given ecosystems (e.g., habitat loss, water quality).*** ***The availability of natural resources is impacted by the changes in ecosystems.*** ***Extracting natural resources can affect ecosystems and the organisms within.*** ***Sediment starvation is a lack of sediment transport and is often caused by man-made structures such as dams.***	**CAUSE AND EFFECT** Cause and effect relationships can be suggested and predicted for complex natural and human-designed systems by examining what is known about smaller scale mechanisms within the system. ***Cause and effect relationships can be suggested for complex systems (natural and human-designed) by examining what is known about smaller scale mechanisms within the system.*** ***Cause and effect relationships can be predicted for complex systems (natural and human-designed) by***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
	Movement of sediment is important in providing habitats for fish and other organisms in rivers. ***Ecosystems undergo major changes as a result of such factors as climate change, introduction of new species, and habitat destruction.***	***examining what is known about smaller scale mechanisms within the system.***

Clarification Statement
The exotic organisms introduced in Louisiana include plants such as Chinese tallow, kudzu, and water hyacinth, and animals including nutria, Asian tiger mosquitoes, and zebra mussels. These organisms can have impacts on scales ranging from the level of the individual (e.g., competition) to that of the landscape (e.g., the destruction of coastal marshes by nutria).

Performance Expectation ***and Louisiana Connectors***
HS-EVS3-1 Construct and evaluate arguments about the positive and negative consequences of using disposable resources versus reusable resources. ***LC-HS-EVS3-1 Evaluate evidence supporting the positive consequences of using disposable resources versus reusable resources.*** ***LC-HS-EVS3-2 Evaluate evidence supporting the negative consequences of using disposable resources versus reusable resources.***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Engaging in argument from evidence: Engaging in argument from evidence in 9-12 builds on K-8 experiences and progresses to using appropriate and sufficient evidence and scientific reasoning to defend and critique claims and explanations about natural and designed world(s). Arguments may also come from current scientific or historical episodes in science. • Evaluate the claims, evidence, and/or reasoning behind currently accepted explanations or solutions to determine the merits of arguments. ***Evaluate the claims behind currently accepted explanations to determine the merits of arguments.*** ***Evaluate the claims behind currently accepted solutions to determine the merits of arguments.*** ***Evaluate the evidence behind currently accepted explanations to determine the merits of arguments.*** ***Evaluate the evidence behind***	**STEWARDSHIP** Ecosystem sustainability can be used as a model for a sustainable society (e.g., recycling, energy efficiency, diversity). (HS.EVS3A.a) ***A sustainable society is one that can continue indefinitely where the level of consumption reflects environmental and resource balance (e.g., not depleting resources).*** ***A healthy ecosystem is one in which plant and animal populations interact in balance with each other and abiotic factors (e.g., rocks, soil, and water).*** ***Complex systems are systems composed of many different components.*** ***A sustainable human society relies upon natural resources (such as energy, fauna, wood, or water), socioeconomic resources (such as labor or capital), and cultural resources (arts, beliefs, institutions).*** ***As in any ecosystem, a sustainable human society is based on preservation, protection, or restoration of the natural environment as well as the human ecosystem.*** Louisiana citizens are responsible for conserving our state's natural resources. Personal actions can have a positive or negative impact. (HS.EVS3A.b) ***Resources are features of environments that are important and of value to humans in some form.*** ***Protecting the environment and biodiversity helps sustain human life.*** ***Each citizen of Louisiana is responsible for conserving the state's natural resources to ensure that all citizens can have a healthy standard of living (e.g., clean air and water) and the state's ecosystems are sustained.*** ***Reducing, reusing, and recycling materials help to conserve natural resources.*** ***The quality of the lives of future generations may depend on people's use of natural resources today.***	**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. ***The processes of energy transformation and energy transfer can be used to understand the changes that take place in physical systems.***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
currently accepted solutions to determine the merits of arguments. ***Evaluate the reasoning behind currently accepted explanations to determine the merits of arguments.*** ***Evaluate the reasoning behind currently accepted solutions to determine the merits of arguments.*** • Construct, use, and/or present an oral and written argument or counterarguments based on data and evidence. ***Construct an oral argument based on data and evidence.*** ***Construct a written argument based on data and evidence.*** ***Construct an oral counterargument based on data and evidence.*** ***Construct a written counterargument based on data and evidence.***	***Each citizen can make lifestyle choices that reduce the use of the Earth's natural resources.*** ***Each citizen can reduce his or her demand on natural resources by recycling (replace and reuse products).*** ***Personal actions can have a positive impact on the state's natural resources (e.g., using public transportation and reducing demand for oil).*** ***Personal actions can have a negative impact on the state's natural resources (e.g., not recycling paper products or cans).***	

Clarification Statement
Resources can be both natural and man-made and may include renewable and non-renewable energy sources, soil, ecosystems, forestry, fisheries, plastic, paper, or aluminum products. Energy used to create and dispose of products may also be considered.

Performance Expectation *and Louisiana Connectors*
HS-ESS2-2 Analyze geoscience data to make the claim that one change to Earth's surface can create feedbacks that cause changes to other Earth's systems. ***LC-HS-ESS2-2a Identify relationships, using a model, of how the Earth's surface is a complex and dynamic set of interconnected systems (i.e., geosphere, hydrosphere, atmosphere, and biosphere).***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Analyzing and interpreting data: Analyzing data in 9-12 builds on K-8 experiences and progresses to introducing more detailed statistical analysis, the comparison of data sets for consistency, and the use of models to generate and analyze data. • Analyze data using tools, technologies, and/or models (e.g., computational, mathematical) in order to make valid and reliable scientific claims or determine an optimal design solution. ***Analyze data using tools in order to make valid and reliable scientific claims.*** ***Analyze data using tools in order to determine an optimal design solution.*** ***Analyze data using technology in order to make valid and reliable scientific claims.*** ***Analyze data using technology in order to determine an optimal***	**EARTH MATERIALS AND SYSTEMS** Earth's systems, being dynamic and interacting, include feedback effects that can increase or decrease the original changes. (HS.ESS2A.a) ***Earth's systems are dynamic and interacting.*** ***Earth has interconnected spheres: lithosphere or geosphere, hydrosphere, biosphere, atmosphere and cryosphere.*** ***Changes in one system can cause changes to other systems.*** ***Rates of change of Earth's internal and surface processes occur over very short and very long periods of time.*** ***Many complex linkages and feedbacks among erosional and climatic processes in addition to tectonic ones change Earth's systems.*** ***Such complexities include feedback, stabilizing or destabilizing links between component processes.*** ***A change in one sphere can cause changes to other spheres, resulting in positive or negative feedback loops.*** **WEATHER AND CLIMATE** The foundation for Earth's global climate systems is the electromagnetic radiation from the sun, as well as its reflection, absorption, storage, and redistribution among the atmosphere, hydrosphere, and land systems, and this energy's re-radiation into space. (HS.ESS2D.a) ***Sunlight is a portion of the electromagnetic radiation given off by the sun.*** ***Energy from the sun travels to Earth and heats Earth's surface.*** ***Some of this energy is radiated back into Earth's atmosphere.*** ***The sun's energy drives Earth's climate systems.***	**STABILITY AND CHANGE** Feedback (negative or positive) can stabilize or destabilize a system. ***Stability denotes a condition in which a system is in balance.*** ***A feedback loop is any mechanism in which a condition triggers some action that causes a change in that same condition.*** ***The mechanisms of external controls and internal feedback loops are important elements for a stable system.*** ***A change in one part of a system can cause changes to other parts of the system, resulting in positive or negative feedback loops.*** ***The changes (negative***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
design solution. ***Analyze data using models in order to make valid and reliable scientific claims.*** ***Analyze data using models in order to determine an optimal design solution.***	***Uneven heating of Earth's components (i.e., water, land, and air) produces local and global atmospheric and oceanic movement.*** ***Heat energy stored in the oceans and transferred by currents influence climate.***	***or positive) can stabilize or destabilize a system.***

Clarification Statement
Examples could include climate feedbacks such as how an increase in greenhouse gases causes a rise in global temperatures that melts glacial ice which reduces the amount of sunlight reflected from Earth's surface increasing surface temperatures and further reducing the amount of ice. Examples could also be taken from other system interactions such as how the loss of ground vegetation causes an increase in water runoff and soil erosion; how damned rivers increase ground water recharge, decrease sediment transport, and increase coastal erosion; or how the loss of wetlands causes a decrease in local humidity that further reduces the wetland extent.

Performance Expectation *and Louisiana Connectors*
HS-ESS2-4 Analyze and interpret data to explore how variations in the flow of energy into and out of Earth's systems result in changes in atmosphere and climate. ***LC-HS-ESS2-4a Identify different causes of climate change and results of those changes with respect to the Earth's surface temperatures, precipitation patterns or sea levels over a wide range of temporal and spatial scales using a model.***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Analyzing and interpreting data: Analyzing data in 9-12 builds on K-8 experiences and progresses to introducing more detailed statistical analysis, the comparison of data sets for consistency, and the use of models to generate and analyze data. • Analyze data using tools, technologies, and/or models (e.g., computational, mathematical) in order to make valid and reliable scientific claims or determine an optimal design solution. ***Analyze data using tools in order to make valid and reliable scientific claims.*** ***Analyze data using tools in order to determine an optimal design solution.*** ***Analyze data using technology in order to make valid and reliable scientific claims.*** ***Analyze data using technology in***	**EARTH AND THE SOLAR SYSTEM** Cyclical changes in the shape of Earth's orbit around the sun, together with changes in the tilt of the planet's axis of rotation, both occurring over hundreds of thousands of years, have altered the intensity and distribution of sunlight falling on Earth. These phenomena cause a cycle of ice ages and other gradual climate changes. (HS.ESS1B.b) ***Gradual changes in the shape of Earth's orbit around the sun contributes to phenomena causing ice ages and other gradual climate changes.*** ***Earth's global temperatures can warm up or cool down if the amount of sunlight that enters the atmosphere is significantly altered.*** ***Cyclic variations of Earth's orbit around the sun impact the amount of sunlight that reaches Earth's surface.*** ***Gradual changes to the tilt of Earth's axis relative to its orbit around the sun have produced different weather patterns.*** **EARTH MATERIALS AND SYSTEMS** The geological record shows that changes to global and regional climate can be caused by interactions among changes in the sun's energy output or Earth's orbit, tectonic events, hydrosphere circulation, volcanic activity, glaciers, vegetation, and human activities. These changes can occur on a variety of time scales from sudden (e.g., volcanic ash clouds) to intermediate (ice ages) to very long-term tectonic cycles. (HS.ESS2A.d) ***All Earth processes are the result of energy flowing and matter cycling within and among Earth's systems.*** ***Changes to climate occur over a wide range of temporal and spatial scales.***	**CAUSE AND EFFECT** Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. ***Evidence is required when attributing an observed phenomenon to a specific cause.*** ***Evidence is required to explain the causal mechanisms in a system under study.*** ***Evidence is required to support a claim about the causal mechanisms in a system under study.***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
order to determine an optimal design solution. ***Analyze data using models in order to make valid and reliable scientific claims.*** ***Analyze data using models in order to determine an optimal design solution.***	***The geological record (ice cores, sediment deposits, fossil evidence, and paleo vegetation restorations) shows that changes to global and regional climate can be caused by several factors (Earth's orbit, tectonic events, volcanic glaciers, vegetation, etc.).*** ***Changes to the input, output, storages or redistribution of energy on Earth can occur over a short or extended time frame and can cause extreme weather conditions.*** **WEATHER AND CLIMATE** The foundation for Earth's global climate systems is the electromagnetic radiation from the sun, as well as its reflection, absorption, storage, and redistribution among the atmosphere, hydrosphere and land systems, and this energy's re-radiation into space. (HS.ESS2D.a) ***Sunlight is a portion of the electromagnetic radiation given off by the sun.*** ***Energy from the sun travels to Earth and heats Earth's surface.*** ***Some of this energy is radiated back into Earth's atmosphere.*** ***The sun's energy drives Earth's climate systems.*** ***Uneven heating of Earth's components (i.e., water, land, air) produce local and global atmospheric and oceanic movement.*** ***Heat energy stored in the oceans and transferred by currents influence climate.*** Gradual atmospheric changes were due to plants and other organisms that captured carbon dioxide and released oxygen. (HS.ESS2D.b) ***Plants contribute to the make-up of Earth's atmosphere by absorbing carbon dioxide and releasing oxygen.*** ***Carbon continuously cycles from one sphere to another.*** ***In the past, the relative amount of carbon that cycled through the hydrosphere, atmosphere, lithosphere or geosphere, and biosphere was partially due to the activity of plants and other organisms.*** Changes in the atmosphere due to human activity have increased carbon dioxide concentrations and thus affect climate. (HS.ESS2D.c)	

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
	Human activities that add carbon dioxide to the atmosphere may be warming Earth's atmosphere. ***A large amount of carbon dioxide has been released into Earth's atmosphere by human-related fossil fuel combustion.*** ***An increase in atmospheric carbon can increase the amount of heat energy stored in the system.***	

Clarification Statement
Changes differ by timescale, from sudden (large volcanic eruption, hydrosphere circulation) to intermediate (hydrosphere circulation, solar output, human activity) and long-term (Earth's orbit and the orientation of its axis and changes in atmospheric composition). Examples of human activities could include fossil fuel combustion, cement production, or agricultural activity and natural processes such as changes in incoming solar radiation or volcanic activity. Examples of data can include tables, graphs, maps of global and regional temperatures, and atmospheric levels of gases.

Performance Expectation *and Louisiana Connectors*
HS-ESS2-5 Plan and conduct an investigation on the properties of water and its effects on Earth materials and surface processes. ***LC-HS-ESS2-5a Identify a connection between the properties of water and its effects on Earth materials.*** ***LC-HS-ESS2-5b Investigate the effects of water on Earth materials and/or surface processes.***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Planning and carrying out investigations: Planning and carrying out investigations to answer questions (science) or test solutions (engineering) to problems in 9-12 builds on K-8 experiences and progresses to include investigations that provide evidence for and test conceptual, mathematical, physical, and empirical models. • Plan an investigation (science) or test a design (engineering) individually and collaboratively to produce data to serve as the basis for evidence as part of building and revising models, supporting explanations for phenomena, or testing solutions to problems. Consider possible confounding variables or effects and evaluate the investigation's design to ensure variables are controlled. ***Plan an investigation (science) individually and collaboratively to produce data to serve as the basis***	**THE ROLE OF WATER IN EARTH'S SURFACE PROCESSES** The abundance of liquid water on Earth's surface and its unique combination of physical and chemical properties are central to the planet's dynamics. These properties include water's exceptional capacity to absorb, store, and release large amounts of energy, transmit sunlight, expand upon freezing, dissolve and transport materials, and lower the viscosities and melting points of rocks. (HS.ESS2C.a) ***Water has many unique properties (e.g., capacity to absorb, store, and release large amounts of energy; to expand upon freezing; to dissolve and transport many materials) that play a role in how it affects Earth systems (e.g., ocean thermal capacity contributes to moderating temperature variations, ice expansion contributes to rock erosion).*** ***Water exhibits a polar nature due to its molecular structure.*** ***Patterns of temperature, the movement of air, and the movement and availability of water at Earth's surface can be related to the effect of the properties of water on energy transfer.*** ***Mechanical effects of water (e.g., stream transportation and deposition, erosion using variations in soil moisture content, and expansion of water as it freezes) on Earth's materials can be used to infer the effect of water on Earth's surface properties.*** ***Chemical effects of water (e.g., properties of solubility, the reaction of water on iron) on Earth materials can be used to infer the effect of water on Earth's surface processes.***	**STRUCTURE AND FUNCTION** The functions and properties of natural and designed objects and systems can be inferred from their overall structure, the way their components are shaped and used, and the molecular substructures of its various materials. ***There are relationships between structure and function of natural and designed objects.*** ***There are relationships between structure and function of systems.*** ***Relationships between structure and function can be inferred from their overall structure.*** ***Relationships between structure and function***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
for evidence as part of building and revising models. Consider possible confounding variables or effects and evaluate the investigation's design to ensure variables are controlled. *Test a design (engineering) individually and collaboratively to produce data to serve as the basis for evidence as part of building and revising models. Consider possible confounding variables or effects and evaluate the investigation's design to ensure variables are controlled.* *Plan an investigation (science) individually and collaboratively to produce data to serve as the basis for evidence for supporting explanations for phenomena. Consider possible confounding variables or effects and evaluate the investigation's design to ensure variables are controlled.* *Test a design (engineering) individually and collaboratively to produce data to serve as the basis for evidence for supporting explanations for phenomena. Consider possible confounding variables or effects and evaluate the investigation's design to ensure*		*can be inferred from the way their components are shaped.* *Relationships between structure and function can be inferred from the molecular substructures of its various materials.*

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
variables are controlled. ***Plan an investigation (science individually and collaboratively to produce data to serve as the basis for evidence for testing solutions to problems. Consider possible confounding variables or effects and evaluate the investigation's design to ensure variables are controlled.*** ***Test a design (engineering) individually and collaboratively to produce data to serve as the basis for evidence for testing solutions to problems. Consider possible confounding variables or effects and evaluate the investigation's design to ensure variables are controlled.)***		

Clarification Statement
Emphasis is on mechanical and chemical investigations with water and a variety of solid materials to provide the evidence for connections between the hydrologic cycle and system interactions commonly known as the rock cycle. Examples of mechanical investigations include stream transportation and deposition using a stream table, erosion using variations in soil moisture content, or frost wedging by the expansion of water as it freezes. Examples of chemical investigations include chemical weathering and recrystallization (by testing the solubility of different materials) or melt generation (by examining how water lowers the melting temperature of most solids).

Performance Expectation *and Louisiana Connectors*
HS-ESS2-6 Develop a quantitative model to describe the cycling of carbon among the hydrosphere, atmosphere, geosphere, and biosphere. ***LC-HS-ESS2-6a Use a model of photosynthesis to identify that carbon is exchanged between living and nonliving systems.*** ***LC-HS-ESS2-6b Use a model of cellular respiration to identify that carbon is exchanged between living and nonliving systems.*** ***LC-HS-ESS2-6c Develop and/or use a quantitative model to identify relative amount of and/or the rate at which carbon is transferred among hydrosphere, atmosphere, geosphere, and biosphere.***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Developing and using models: Modeling in 9-12 builds on K-8 experiences and progresses to using, synthesizing, and developing models to predict and show relationships among variables between systems and their components in the natural and designed worlds. • Develop a model based on evidence to illustrate the relationships between systems or between components of a system. ***Develop a model based on evidence to illustrate the relationships between systems.*** ***Develop a model based on evidence to illustrate the components of a system.***	**WEATHER AND CLIMATE** Gradual atmospheric changes were due to plants and other organisms that captured carbon dioxide and released oxygen. (HS.ESS2D.b) ***Plants contribute to the make-up of Earth's atmosphere by absorbing carbon dioxide and releasing oxygen.*** ***Carbon continuously cycles from one sphere to another.*** ***In the past, the relative amount of carbon that cycled through the hydrosphere, atmosphere, lithosphere or geosphere, and biosphere was partially due to the activity of plants and other organisms.*** Changes in the atmosphere due to human activity have increased carbon dioxide concentrations and thus affect climate. (HS.ESS2D.c) ***Human activities that add carbon dioxide to the atmosphere may be warming Earth's atmosphere.*** ***A large amount of carbon dioxide has been released into Earth's atmosphere by human-related fossil fuel combustion.*** ***An increase in atmospheric carbon can increase the amount of heat energy stored in the system.***	**ENERGY AND MATTER** The total amount of energy and matter in closed systems is conserved. ***When materials interact within a closed system, the total mass of the system remains the same. Energy may change forms, but the total amount of energy cannot change in physical systems.***

Clarification Statement
Emphasis is on modeling biogeochemical cycles that include the cycling of carbon through the ocean, atmosphere, soil, and biosphere (including humans), providing the foundation for living organisms.
Performance Expectation *and Louisiana Connectors*
HS-ESS3-1 Construct an explanation based on evidence for how the availability of natural resources, occurrence of natural hazards, and changes in climate have influenced human activity. ***LC-HS-ESS3-1a Explain the relationship between human activity (e.g., population size, where humans live, types of crops grown) and changes in the amounts of natural resources using evidence.*** ***LC-HS-ESS3-1b Explain the relationship between human activity (e.g., population size, where humans live, types of crops grown) and changes in the occurrence of natural hazards using evidence.***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Constructing explanations and designing solutions: Constructing explanations (science) and designing solutions (engineering) in 9-12 builds on K-8 experiences and progresses to explanations and designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific ideas, principles, and theories. • Construct an explanation based on valid and reliable evidence obtained from a variety of sources (including students' own investigations, models, theories, simulations, peer review) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to	**NATURAL RESOURCES** Resource availability has guided the development of human society. (HS.ESS3A.a) ***The availability of natural resources has influenced where humans have populated regions of Earth.*** ***Environmental factors have affected human populations over the course of history.*** ***Resource availability has driven global development of societies, sizes of human populations, and human migrations.*** ***Evidence (e.g., from text or other investigations) show correlations between human population distribution and regional availability of resources such as fresh water, fertile soils, and fossils fuels.*** **NATURAL HAZARDS** Natural hazards and other geologic events have shaped the course of human history; [they] have significantly altered the sizes of human populations and have driven human migrations. (HS.ESS3B.a) ***Natural hazards such as earthquakes, tsunamis, volcanic eruptions, severe weather, floods, and coastal erosion, have historically affected the sizes and distributions of human populations.***	**CAUSE AND EFFECT** Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. ***Evidence is required when attributing an observed phenomenon to a specific cause.*** ***Evidence is required to explain the causal mechanisms in a system under study.*** ***Evidence is required to support a claim about the causal mechanisms***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
do so in the future. ***Construct an explanation based on valid and reliable evidence from a variety of sources.*** ***Construct an explanation based on valid and reliable evidence from the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future.*** ***Revise an explanation based on valid and reliable evidence from a variety of sources.*** ***Revise an explanation based on valid and reliable evidence from the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future.***	***Environmental factors have affected human populations over the course of history.*** ***Natural disasters and other geologic events have driven global development of societies, sizes of human populations, and human migrations.*** ***Historical accounts of natural disasters (e.g., Krakatoa eruption, American Dust Bowl, Super storm Sandy, and Hurricane Katrina), resulting human suffering and loss of life could provide empirical evidence of past impacts on human population size and distribution.***	***in a system under study.***

Clarification Statement
Examples of key natural resources include access to fresh water (such as rivers, lakes, and groundwater), regions of fertile soils such as river deltas, and high concentrations of minerals and fossil fuels. Examples of natural hazards can be from interior processes (such as volcanic eruptions and earthquakes), surface processes (such as tsunamis, mass wasting and soil erosion), and severe weather (such as hurricanes, floods, and droughts). Natural hazards and other geologic events exhibit some non-random patterns of occurrence. Examples of the results of changes in climate that can affect populations or drive mass migrations include changes to sea level, regional patterns of temperature and precipitation, and the types of crops and livestock that can be raised.

Performance Expectation *and Louisiana Connectors*
HS-ESS3-2 Evaluate competing design solutions for developing, managing, and utilizing energy and mineral resources based on cost-benefit ratios. ***LC-HS-ESS3-2a Identify a solution that demonstrates the most preferred cost-benefit ratios for developing, managing, and utilizing energy and mineral resources (i.e., conservation, recycling, and reuse of resources).*** ***LC-HS-ESS3-2b Compare design solutions for developing, managing, and/or utilizing energy or mineral resources.***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Constructing explanations and designing solutions: Constructing explanations (science) and designing solutions (engineering) in 9-12 builds on K-8 experiences and progresses to explanations and designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific ideas, principles, and theories. • Design, evaluate, and/or refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations. ***Design a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized***	**NATURAL RESOURCES** All forms of energy production and other resource extraction have associated economic, social, environmental, and geopolitical costs and risks as well as benefits. New technologies and social regulations can change the balance of these factors. (HS.ESS3A.b) ***Anything in the environment that is naturally occurring and used by people is a natural resource.*** ***Demand for energy by society leads to continuous exploration in order to expand supplies of fossil fuels.*** ***The increase in energy demand and the new technologies being developed to meet these needs and improve the efficiencies of energy systems have social and environmental consequences.*** ***New technologies of energy production are being developed. For example, the technique of using hydraulic fracturing to extract natural gas from shale deposits versus other traditional means of acquiring energy from natural resources.*** ***New technologies could have deep impacts on society and the environment, including some that were not anticipated.*** ***New technologies are being developed to increase the use of alternate energy sources.*** **DESIGNING SOLUTIONS TO ENGINEERING PROBLEMS** 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	**SYSTEMS AND SYSTEM MODELS** Systems can be designed to do specific tasks. ***Systems can be designed to explain phenomena (scientific).*** ***Systems can be designed to refine solutions (engineering).*** ***Systems can be designed for understanding and testing ideas that are applicable throughout science and engineering.***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
criteria, and trade-off considerations. ***Evaluate a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and trade-off considerations.*** ***Refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and trade-off considerations.***	environmental impacts. (HS.ETS1B.a) ***It is important to determine the full impact of the advantages and disadvantages when evaluating a solution.*** ***New technologies offer solutions based on cost-benefit ratios, scientific ideas and principles, empirical evidence, and logical arguments regarding relevant factors (e.g., economic, societal, environmental, and ethical considerations).***	

Clarification Statement
Emphasis is on the conservation, recycling, and reuse of resources (such as minerals and metals) where possible, and on minimizing impacts where it is not. Examples include developing best practices for agricultural, soil use, forestry, and mining (coal, tar sands, and oil shales), and pumping (ground water, petroleum and natural gas). Science knowledge indicates what can happen in natural systems—not what should happen.

Performance Expectation *and Louisiana Connectors*
HS-ESS3-3 Create a computational simulation to illustrate the relationships among management of natural resources, the sustainability of human populations, and biodiversity. ***LC-HS-ESS3-3 Use numerical data to determine the effects of a conservation strategy to manage natural resources and to sustain human society and plant and animal life.***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Using mathematics and computational thinking: Mathematical and computational thinking in 9-12 builds on K-8 experiences and progresses to using algebraic thinking and analysis, a range of linear and nonlinear functions (e.g., trigonometric, exponential and logarithmic) and computational tools for statistical analysis to analyze, represent, and model data. Simple computational simulations are created and used based on mathematical models of basic assumptions. • Create a computational model or simulation of a phenomenon, designed device, process, or system. ***Create/use a computational model of a phenomenon.***	**HUMAN IMPACTS ON EARTH SYSTEMS** The sustainability of human societies and the biodiversity that supports them requires responsible management of natural resources. (HS.ESS3C.a) ***Responsible use of energy requires consideration of energy availability, efficiency of its use, the environmental impact, and possible alternate sources.*** ***Poor management of natural resources can have negative impacts on human populations.***	**STABILITY AND CHANGE** Change and rates of change can be quantified and modeled over very short or very long periods of time. Some system changes are irreversible. ***Change and rates of change can be quantified over very short or very long periods of time.*** ***Change and rates of change can be modeled over very short or very long periods of time.*** ***Some system changes are irreversible.***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Revise a computational model of a phenomenon. *Create/use a simulation of a phenomenon.* *Revise a simulation of a phenomenon.* *Create/use a computational model of a process.* *Revise a computational model of a process.* *Create/use a simulation of a process.* *Revise a simulation of a process.* *Create/use a computational model of a system.* *Revise a computational model of a system.* *Create/use a simulation of a system.* *Revise a simulation of a system.*		

Clarification Statement
Examples of data on the impacts of human activities could include the quantities and types of pollutants released, changes to biomass and species diversity, or areal changes in land surface use (such as for urban development, agriculture and livestock, or surface mining). Examples for limiting future impacts could range from local efforts (such as reducing, reusing, and recycling resources) to large-scale geoengineering design solutions (such as altering global temperatures by making large changes to the atmosphere or ocean).

Performance Expectation *and Louisiana Connectors*
HS-ESS3-4 Evaluate or refine a technological solution that reduces impacts of human activities on natural systems. **LC-HS-ESS3-4a Connect a technological solution (e.g., wet scrubber; baghouse) to its outcome (e.g., clean air) and its outcome to the human activity impact that it is reducing (e.g., air pollution).**

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Constructing explanations and designing solutions: Constructing explanations (science) and designing solutions (engineering) in 9-12 builds on K-8 experiences and progresses to explanations and designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific ideas, principles, and theories. • Design or refine a solution to a complex real-world problem, based on scientific knowledge, student generated sources of evidence, prioritized criteria, and tradeoff considerations. **Design a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff**	**HUMAN IMPACTS ON EARTH SYSTEMS** Scientists and engineers can make major contributions by developing technologies that produce less pollution and waste and that preclude ecosystem degradation. (HS.ESS3C.b) **Scientists and engineers can develop technological solutions to reduce human impacts on natural systems.** **Societal expectations for a sustainable environment will require new, cleaner technologies for the production and use of energy.** **DESIGNING SOLUTIONS TO ENGINEERING PROBLEMS** 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) **It is important to determine the full impact of the advantages and disadvantages when evaluating a solution.** **New technologies offer solutions based on cost benefit ratios, scientific ideas and principles, empirical evidence, and logical arguments regarding relevant factors (e.g., economic, societal, environmental, and ethical considerations).** **When scientists and engineers create solutions to problems, they use specific criteria to guide the development of their solutions.**	**STABILITY AND CHANGE** Feedback (negative or positive) can stabilize or destabilize a system. **Stability denotes a condition in which a system is in balance.** **A feedback loop is any mechanism in which a condition triggers some action that causes a change in that same condition.** **The mechanisms of external controls and internal feedback loops are important elements for a stable system.** **A change in one part of a system can cause changes to other parts of the system, resulting**

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
considerations. Evaluate a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations. Refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations.	When scientists and engineers create solutions to problems, they consider the constraints of their design solutions including cost, safety, aesthetics, and reliability.	in positive or negative feedback loops. The changes (negative or positive) can stabilize or destabilize a system.

Clarification Statement
Examples of data on the impacts of human activities could include the quantities and types of pollutants released, changes to biomass and species diversity, or areal changes in land surface use (such as for urban development, agriculture and livestock, or surface mining). Examples for limiting future impacts could range from local efforts (such as reducing, reusing, and recycling resources) to large-scale geoengineering design solutions (such as altering global temperatures by making large changes to the atmosphere or ocean).

Performance Expectation *and Louisiana Connectors*
HS-ESS3-5 Analyze geoscience data and the results from global climate models to make an evidence-based forecast of the current rate of global or regional climate change and associated future impacts to Earth systems. **LC-ESS3-5a Use geoscience data to determine the relationship between a change in climate (e.g., precipitation, temperature) and its impact in a region.**

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Analyzing and interpreting data: Analyzing data in 9-12 builds on K-8 experiences and progresses to introducing more detailed statistical analysis, the comparison of data sets for consistency, and the use of models to generate and analyze data. • Analyze data using tools, technologies, and/or models (e.g., computational, mathematical) in order to make valid and reliable scientific claims or determine an optimal design solution. **Analyze data using tools in order to make valid and reliable scientific claims.** **Analyze data using tools in order to determine an optimal design solution.**	**GLOBAL CLIMATE CHANGE** **Though the magnitudes of human impacts are greater than they have ever been, so too are human abilities to model, predict, and manage current and future impacts. (HS.ESS3D.a)** **Technological advances throughout history have led to the discovery and use of different forms of energy and to more efficient use of all forms of energy.** **The increase in energy demand and the new technologies being developed to meet these needs and improve the efficiencies of energy systems have social and environmental consequences.** **Changes in weather technology have occurred in the areas of gathering weather data and using computers to make forecasts.** **This has allowed scientists to model, predict, and manage current and future impacts using global climate models.** **Geoscience data is used to explain climate change over a wide-range of timescales including:** **• one to ten years: large volcanic eruptions, ocean circulation;** **• ten to hundreds of years: changes in human activity, ocean circulation, solar output;** **• tens of thousands to hundreds of thousands of years: changes to Earth's orbit and the orientation of its axis; and** **• tens of millions to hundreds of millions of years: long-term changes in atmospheric composition.**	**STABILITY AND CHANGE** Change and rates of change can be quantified and modeled over very short or long periods of time. Some system changes are irreversible. **Change and rates of change can be quantified over very short or very long periods of time.** **Change and rates of change can be modeled over very short or very long periods of time.** **Some system changes are irreversible.**

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Analyze data using technology in order to make valid and reliable scientific claims. **Analyze data using technology in order to determine an optimal design solution.** **Analyze data using models in order to make valid and reliable scientific claims.** **Analyze data using models in order to determine an optimal design solution.**		

Clarification Statement
Examples of evidence, for both data and climate model outputs, are for climate changes (such as precipitation and temperature) and their associated impacts (such as on sea level, glacial ice volumes, or atmosphere and ocean composition).

Performance Expectation *and Louisiana Connectors*
HS-ESS3-6 Use a computational representation to illustrate the relationships among Earth systems and how those relationships are being modified due to human activity. ***LC-HS-ESS3-6a Use representations to describe the relationships among Earth systems and how those relationships are being modified due to human activity (e.g., increase in atmospheric carbon dioxide, increase in ocean acidification, effects on organisms in the ocean (coral reef), carbon cycle of the ocean, possible effects on marine populations).***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Using mathematics and computational thinking: Mathematical and computational thinking in 9-12 builds on K-8 experiences and progresses to using algebraic thinking and analysis, a range of linear and nonlinear functions (e.g., trigonometric, exponential and logarithmic) and computational tools for statistical analysis to analyze, represent, and model data. Simple computational simulations are created and used based on mathematical models of basic assumptions. • Use a computational representation of phenomena or design solutions to describe and/or support claims and/or explanations. ***Use a computational representation of phenomena to describe claims.***	**WEATHER AND CLIMATE** Current models predict that, although future regional climate changes will be complex and varied, average global temperatures will continue to rise. The outcomes predicted by global climate models strongly depend on the amounts of human-generated greenhouse gases added to the atmosphere each year and by the ways in which these gases are absorbed by the ocean and biosphere. (HS.ESS2D.d) ***Current models of Earth's natural systems include system boundaries, initial conditions, inputs and outputs, and relationships that determine the interaction (e.g., the relationship between atmospheric carbon dioxide and production of photosynthetic biomass and ocean acidification).*** ***The increased carbon dioxide level in the atmosphere traps more heat. This will lead to a gradual increase in the temperature of Earth's atmosphere.*** ***Human activities, such as the release of greenhouse gases from burning fossil fuels, are major factors in the current rise in Earth's mean surface temperature.*** ***Based on current models, Earth's average global temperatures will continue to rise due to an increase in human-generated greenhouse gases (e.g., carbon dioxide and methane) in Earth's atmosphere and associated feedbacks.*** ***Human impact on climate change must be addressed.*** ***Reducing the level of climate change and reducing human vulnerability to whatever climate changes do occur depend on the understanding of climate science and engineering capabilities.***	**SYSTEMS AND SYSTEM MODELS** When investigating or describing a system, the boundaries and initial conditions of the system need to be defined and their inputs and outputs analyzed and described using models. ***When investigating a system, the boundaries and initial conditions of the system need to be defined.*** ***When describing a system, the boundaries and initial conditions of the system need to be defined.*** ***When investigating a system, the inputs and***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Use a computational representation of phenomena to describe explanations. *Use a computational representation of phenomena to support claims.* *Use a computational representation of phenomena to support explanations.* *Use a computational representation of a design solution to describe claims.* *Use a computational representation of a design solution to describe explanations.* *Use a computational representation of a design solution to support claims.* *Use a computational representation of a design solution to support explanations.*	**GLOBAL CLIMATE CHANGE** Important discoveries are still being made about how the ocean, the atmosphere, and the biosphere interact and are modified in response to human activities (e.g., through computer simulations and other discoveries satellite imagery). (HS.ESS3D.b) *Scientists continually learn more about how Earth's systems interact and are changed by human activities.* *Modern civilization depends on major technological systems.* *Through computer simulations and other studies, important discoveries are still being made about how the ocean, atmosphere, and biosphere interact and are modified in response to human activities.* *Scientists and engineers use human-generated models including computer simulations, to predict how the amount of greenhouse gases in Earth's atmosphere impacts the biological and physical processes on Earth (e.g., oceanic acidification, coral bleaching, ocean circulation, etc.).*	*outputs need to be analyzed and described using models.* *When describing a system, the inputs and outputs need to be analyzed and described using models.*

Clarification Statement
Examples of Earth systems to be considered are the hydrosphere, atmosphere, cryosphere, geosphere, and/or biosphere. An example of the far-reaching impacts from a human activity is how an increase in atmospheric carbon dioxide results in an increase in photosynthetic biomass on land and an increase in ocean acidification, with resulting impacts on sea organism health and marine populations.

Performance Expectation *and Louisiana Connectors*
HS-LS2-1 Use mathematical and/or computational representations to support explanations of factors that affect carrying capacity, biodiversity and populations of ecosystems at different scales. ***LC-HS-LS2-1a Recognize that the carrying capacities of ecosystems are related to the availability of living and nonliving resources and challenges (e.g., predation, competition, disease).*** ***LC-HS-LS2-1b Use a graphical representation to identify carrying capacities in ecosystems as limits to the numbers of organisms or populations they can support.***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Using mathematics and computational thinking: Mathematical and computational thinking in 9-12 builds on K-8 experiences and progresses to using algebraic thinking and analysis, a range of linear and nonlinear functions (e.g., trigonometric, exponential and logarithmic) and computational tools for statistical analysis to analyze, represent, and model data. Simple computational simulations are created and used based on mathematical models of basic assumptions. • Use mathematical, computational, and/or algorithmic representations of phenomena or design solutions to describe and/or support claims	**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) ***Carrying capacities are limits to the numbers of organisms and populations an ecosystem can support.*** ***The carrying capacity for a specific population in an ecosystem depends on the resources available.*** ***These limits can be a result of shifting living (predators, competition, and available food) and non-living (shelter, water, and climate) factors within a specific environment.*** ***Given adequate biotic and abiotic resources and no disease or predators, populations increase at rapid rates.*** ***Resources, (limiting factors), predation and climate, limit the growth of populations in specific niches in an ecosystem.***	**SCALE, PROPORTION, AND QUANTITY** The significance of a phenomenon is dependent on the scale, proportion, and quantity at which it occurs. ***The size and time scales relevant to various objects, systems, and processes determine the significance of a phenomena. Specific phenomena correspond to a specific scale (e.g., the size of the nucleus of an atom to the size***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
and/or explanations. ***Use mathematical or algorithmic forms for scientific modeling of phenomena to describe claims.*** ***Use mathematical or algorithmic forms for scientific modeling of design solutions to describe claims.*** ***Use mathematical or algorithmic forms for scientific modeling of phenomena to support claims.*** ***Use mathematical or algorithmic forms for scientific modeling of design solutions to support claims.*** ***Use mathematical or algorithmic forms for scientific modeling of phenomena to describe explanations.*** ***Use mathematical or algorithmic forms for scientific modeling of design solutions to describe explanations.*** ***Use mathematical or algorithmic forms for scientific modeling of phenomena to support explanations*** ***Use mathematical or algorithmic forms for scientific modeling of design solutions to support explanations.***	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) ***Humans are an integral part of the natural system, and human activities can alter the stability of ecosystems.*** ***Human-related changes to one or more of these factors can result in an ecosystem breaking down or the creation of an entirely new ecosystem.*** ***Human activities have a major effect on other species. For example, increased land use reduces habitat available to other species, pollution changes the chemical composition of air, soil, and water, and introduction of non-native species disrupts the ecological balance.***	***of the galaxy and beyond).***

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.

Performance Expectation *and Louisiana Connectors*
HS-LS2-4 Use mathematical representations to support claims for the cycling of matter and flow of energy among organisms in an ecosystem. ***LC-HS-LS2-4a Use a graphical or mathematical representation to identify the changes in the amount of matter as it travels through a food web.*** ***LC-HS-LS2-4b Use a graphical or mathematical representation to identify the changes in the amount of energy as it travels through a food web.***

Science and Engineering Practice	**Disciplinary Core Idea**	**Crosscutting Concept**
Using mathematics and computational thinking: Mathematical and computational thinking in 9-12 builds on K-8 experiences and progresses to using algebraic thinking and analysis, a range of linear and nonlinear functions (e.g., trigonometric, exponential and logarithmic) and computational tools for statistical analysis to analyze, represent, and model data. Simple computational simulations are created and used based on mathematical models of basic assumptions. • Use mathematical, computational, and/or algorithmic representations of phenomena or design solutions to	**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) ***Only a fraction of the energy available at the lower level of a food web is transferred up, resulting in fewer organisms at higher levels.*** ***The inefficiency of energy transfer determines the number of trophic levels and affects the relative number of organisms at each trophic level in an ecosystem.*** ***All energy is conserved as it passes from the sun through an ecosystem.*** ***During energy transformations, some energy is converted to unusable heat.*** ***A continual input of energy from the sun keeps the process going.*** ***On average, regardless of scale, 10% of energy is transferred up from one trophic level to another.*** 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)	**ENERGY AND MATTER: FLOWS, CYCLES, AND CONSERVATION** Energy cannot be created or destroyed—it only moves between one place and another place, between objects and/or fields, or between systems. ***Energy cannot be created or destroyed. Energy can be transferred from one object to another and can be transformed from one form to another, but the total***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
describe and/or support claims and/or explanations. ***Use mathematical or algorithmic forms for scientific modeling of phenomena to describe claims.*** ***Use mathematical or algorithmic forms for scientific modeling of design solutions to describe claims.*** ***Use mathematical or algorithmic forms for scientific modeling of phenomena to support claims.*** ***Use mathematical or algorithmic forms for scientific modeling of design solutions to support claims.*** ***Use mathematical or algorithmic forms for scientific modeling of phenomena to describe explanations.*** ***Use mathematical or algorithmic forms for scientific modeling of design solutions to describe explanations.*** ***Use mathematical or algorithmic forms for scientific modeling of phenomena to support explanations.*** ***Use mathematical or algorithmic forms for scientific modeling of design solutions to support explanations.***	***Carbon is an essential element cycled through all levels of life from cellular to ecosystems, and is required for survival of all living organisms.*** ***Photosynthesis (the main way that solar energy is captured and stored on Earth) and cellular respiration are important components of the carbon cycle, in which carbon is exchanged between living and nonliving systems.*** ***Matter needed to sustain life in ecosystems is continually recycled (e.g., carbon cycle, water cycle, nitrogen cycle, mineral cycles) among organisms and between organisms and the environment.*** 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) ***The processes of photosynthesis (making oxygen and sugars) and cellular respiration (making energy from sugar, done in plants and animals) provide most of the energy for life on earth.*** ***The reactants and products of photosynthesis and cellular respiration (aerobic and anaerobic) can be used to relate the Law of Conservation of Matter and the Law of Conservation of Energy to ecosystems, using the carbon cycle can as a reference.***	***amount of energy never changes.***

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.

Performance Expectation *and Louisiana Connectors*
HS-LS2-6 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. ***HS-LS2-6a Use evidence to identify how modest biological or physical changes versus extreme changes affect stability and change (e.g., number and types of organisms) in ecosystems.*** ***HS-LS2-6b Evaluate explanations of how living things in an ecosystem are affected by changes in the environment (e.g., changes to the food supply, climate change, or the introduction of predators).*** ***HS-LS2-6c Evaluate explanations of how interactions in ecosystems maintain relatively stable conditions, but changing conditions may result in a new ecosystem.***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Engaging in argument from evidence: Engaging in argument from evidence in 9-12 builds on K-8 experiences and progresses to using appropriate and sufficient evidence and scientific reasoning to defend and critique claims and explanations about the natural and designed world(s). Arguments may also come from current scientific or historical episodes in science. • Evaluate the claims, evidence, and/or reasoning behind currently accepted explanations or solutions to determine the merits of arguments.	**ECOSYSTEM DYNAMICS, FUNCTIONING, AND RESILIENCE** The dynamic 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 and may result in new ecosystems. (HS.LS2C.a) ***Under most circumstances a natural balance is maintained within an ecosystem.*** ***Organisms both cooperate and compete in ecosystems.*** ***The interrelationships and interdependencies of these organisms may generate complex ecosystems that are stable over long periods of time and tend to have cyclic fluctuations around an equilibrium (i.e., the ecosystem is resilient).*** ***Extreme fluctuations, such as from natural disasters, can challenge the functioning of ecosystems in terms of resources and habitat availability.***	**STABILITY AND CHANGE** Much of science deals with constructing explanations of how things change and how they remain stable. ***Science deals with constructing explanations of how things change. Science deals with constructing explanations of how things remain stable.***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Evaluate the claims behind currently accepted explanations to determine the merits of arguments. Evaluate the claims behind currently accepted solutions to determine the merits of arguments. Evaluate the evidence behind currently accepted explanations to determine the merits of arguments. Evaluate the evidence behind currently accepted solutions to determine the merits of arguments. Evaluate the reasoning behind currently accepted explanations to determine the merits of arguments. Evaluate the reasoning behind currently accepted solutions to determine the merits of arguments.	*These changes can result in an ecosystem breaking down or the creation of an entirely 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. Emphasis should be on describing drivers of ecosystem stability and change, not on the organismal mechanisms of responses and interactions.

Performance Expectation *and Louisiana Connectors*
HS-LS2-7 Design, evaluate, and refine a solution for reducing the impacts of human activities on the environment and biodiversity. ***LC-HS-LS2-7a Describe how people can help protect the Earth's environment and biodiversity (e.g., preserving ecosystems) and how a human activity would threaten Earth's environment and biodiversity (e.g., pollution, damaging habitats, over hunting).*** ***LC-HS-LS2-7b Evaluate or refine a solution to changes in an ecosystem (biodiversity) resulting from a human activity.***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Constructing explanations and designing solutions: Constructing explanations (science) and designing solutions (engineering) in 9-12 builds on K-8 experiences and progresses to explanations and designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific ideas, principles, and theories. • Design, evaluate, and/or refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and trade-off considerations. ***Design a solution to a complex real-***	**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) ***Biodiversity helps maintain stability in ecosystems. However, factors caused by humans (e.g., habitat destruction, pollution, introduction of invasive species) have negative effects on the environment and biodiversity. Some system changes are irreversible.*** **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	**STABILITY AND CHANGE** Much of science deals with constructing explanations of how things change and how they remain stable. ***Science deals with constructing explanations of how things change. Science deals with constructing explanations of how things remain stable.***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and trade-off considerations. ***Evaluate a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and trade-off considerations.*** ***Refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and trade-off considerations.***	enhancing life on Earth. Sustaining biodiversity also aids humanity by preserving landscapes of recreational or inspirational value. (HS.LS4D.a) ***Humans depend on the living world for resources.*** ***Thus, protecting the environment and biodiversity helps sustain human life.*** ***Ecosystems undergo major changes as a result of such human-related factors as overpopulation, overexploitation, habitat destruction, pollution, introduction of invasive species, and climate change.*** ***Sustainability of human societies and the biodiversity that supports them require responsible management of natural resources.*** ***Changes in the physical, chemical, or biological conditions of an ecosystem can alter the diversity of species in the system.*** ***Over time, ecosystems change and populations of organisms adapt, move, or become extinct.*** **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) ***It is important to determine the full impact of the advantages and disadvantages when evaluating a solution.*** ***The development of solutions is driven by the following factors: economical, political, cultural, social, safety, and environmental.***	

Clarification Statement
Examples of human activities can include urbanization, building dams, or dissemination of invasive species.

Performance Expectation ***and Louisiana Connectors***
HS-ESS1-1 Develop a model based on evidence to illustrate the life span of the sun and the role of nuclear fusion in the sun's core to release energy that eventually reaches Earth in the form of radiation. **LC-HS-ESS1-1a Describe components of a model illustrating that the sun shines because of nuclear fusion reactions which release light and heat energy which make life on Earth possible.**

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Developing and using models: Modeling in 9-12 builds on K-8 experiences and progresses to using, synthesizing, and developing models to predict and show relationships among variables between systems and their components in the natural and designed worlds. • Develop and/or use multiple types of models to provide mechanistic accounts and/or predict phenomena, and move flexibly between model types based on merits and limitations. **Develop multiple types of models to provide mechanistic accounts and move flexibly between model types based on merits and limitations.** **Use multiple types of models to provide mechanistic accounts and move flexibly between model types based on merits and limitations.** **Develop multiple types of models to predict phenomena and move flexibly between model types based on merits and limitations.** **Use multiple types of models to predict phenomena and move**	**THE UNIVERSE AND ITS STARS** All stars, such as our sun, are evolving. The star called Sol, our sun, will burn out over a lifespan of approximately 10 billion years. (HS.ESS1A.a) **The sun is but one of a vast number of stars in the Milky Way galaxy.** **Stars go through a sequence of developmental stages—they are formed; evolve in size, mass, and brightness; and eventually burn out.** **The sun is a medium-sized star.** **The sun's lifespan is about 10 billion years.** **The sun is about halfway through its predicted life span.** The Big Bang theory is supported by observations of distant galaxies receding from our own, of the measured composition of stars and non-stellar gases, and of the maps of spectra of the primordial radiation (cosmic microwave background) that still fills the universe. (HS.ESS1A.c) **The Big Bang theory is a core scientific theory that is supported by a large body of evidence.** **According to this theory, the universe began with a period of extreme and rapid expansion known as the Big Bang, which occurred about 13.7 billion years ago.** **It states that the universe began in a hot dense state of energy and matter, and the universe has been expanding ever since.** **Spectroscopes are used to analyze starlight to reveal information about the composition and evolution of stars.** **The sun and our Solar System are part of the Milky Way galaxy consisting of billions of other stars that appear to be made of the same elements found on Earth.** **Stars' radiation of visible light and other forms of energy can be measured and studied to develop explanations about the formation, age, and composition of the universe.** **ENERGY IN CHEMICAL PROCESSES AND EVERYDAY LIFE** Nuclear fusion processes in the center of the sun release the energy that ultimately reaches Earth as radiation. (HS.PS3D.c) **The sun is a star that gives off radiant energy that drives Earth systems.** **The source of the sun's energy is the fusion of hydrogen atoms into helium.** **The sun's energy reaches Earth as solar radiation.**	**SCALE, PROPORTION, AND QUANTITY** The significance of a phenomenon is dependent on the scale, proportion, and quantity at which it occurs. **The size and time scales relevant to various objects, systems, and processes determine the significance of a phenomena.** **Specific phenomena correspond to a specific scale (e.g., the size of the nucleus of an atom to the size of the galaxy and beyond).**

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
flexibly between model types based on merits and limitations.		

Clarification Statement
Emphasis is on the energy transfer mechanisms that allow energy from nuclear fusion in the sun's core to reach Earth. Examples of evidence for the model include observations of the masses and lifetimes of other stars, as well as the ways that the sun's radiation varies due to sudden solar flares ("space weather"), the 11-year sunspot cycle, and non-cyclic variations over centuries.

Performance Expectation *and Louisiana Connectors*
HS-ESS1-1 Develop a model based on evidence to illustrate the life span of the sun and the role of nuclear fusion in the sun's core to release energy that eventually reaches Earth in the form of radiation. **LC-HS-ESS1-1a Describe components of a model illustrating that the sun shines because of nuclear fusion reactions which release light and heat energy which make life on Earth possible.**

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Developing and using models: Modeling in 9-12 builds on K-8 experiences and progresses to using, synthesizing, and developing models to predict and show relationships among variables between systems and their components in the natural and designed worlds. • Develop and/or use multiple types of models to provide mechanistic accounts and/or predict phenomena, and move flexibly between model types based on merits and limitations. **Develop multiple types of models to provide mechanistic accounts and move flexibly between model types based on merits and limitations.** **Use multiple types of models to provide mechanistic accounts and move flexibly between model types based on merits and limitations.** **Develop multiple types of models to predict phenomena and move flexibly between model types based on merits and limitations.** **Use multiple types of models to predict phenomena and move flexibly between model types based on merits and limitations.**	**THE UNIVERSE AND ITS STARS** All stars, such as our sun, are evolving. The star called Sol, our sun, will burn out over a lifespan of approximately 10 billion years. (HS.ESS1A.a) **The sun is but one of a vast number of stars in the Milky Way galaxy.** **Stars go through a sequence of developmental stages—they are formed; evolve in size, mass, and brightness; and eventually burn out.** **The sun is a medium-sized star.** **The sun's lifespan is about 10 billion years.** **The sun is about halfway through its predicted life span.** The Big Bang theory is supported by observations of distant galaxies receding from our own, of the measured composition of stars and non-stellar gases, and of the maps of spectra of the primordial radiation (cosmic microwave background) that still fills the universe. (HS.ESS1A.c) **The Big Bang theory is a core scientific theory that is supported by a large body of evidence.** **According to this theory, the universe began with a period of extreme and rapid expansion known as the Big Bang, which occurred about 13.7 billion years ago.** **It states that the universe began in a hot dense state of energy and matter, and the universe has been expanding ever since.** **Spectroscopes are used to analyze starlight to reveal information about the composition and evolution of stars.** **The sun and our Solar System are part of the Milky Way galaxy consisting of billions of other stars that appear to be made of the same elements found on Earth.** **Stars' radiation of visible light and other forms of energy can be measured and studied to develop explanations about the formation, age, and composition of the universe.** **ENERGY IN CHEMICAL PROCESSES AND EVERYDAY LIFE** Nuclear fusion processes in the center of the sun release the energy that ultimately reaches Earth as radiation. (HS.PS3D.c) **The sun is a star that gives off radiant energy that drives Earth systems.** **The source of the sun's energy is the fusion of hydrogen atoms into helium.** **The sun's energy reaches Earth as solar radiation.**	**SCALE, PROPORTION, AND QUANTITY** The significance of a phenomenon is dependent on the scale, proportion, and quantity at which it occurs. **The size and time scales relevant to various objects, systems, and processes determine the significance of a phenomena.** **Specific phenomena correspond to a specific scale (e.g., the size of the nucleus of an atom to the size of the galaxy and beyond).**

Clarification Statement
Emphasis is on the energy transfer mechanisms that allow energy from nuclear fusion in the sun's core to reach Earth. Examples of evidence for the model include observations of the masses and lifetimes of other stars, as well as the ways that the sun's radiation varies due to sudden solar flares ("space weather"), the 11-year sunspot cycle, and non-cyclic variations over centuries.

Performance Expectation *and Louisiana Connectors*
HS-ESS1-3 Communicate scientific ideas about the way stars, over their life cycle, produce elements. **LC-HS-ESS1-3a Communicate by using models that solar activity creates elements through nuclear fusion.**

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Obtaining, evaluating, and communicating information: Obtaining, evaluating, and communicating information in 9-12 builds on K-8 and progresses to	**THE UNIVERSE AND ITS STARS** The study of stars' light spectra and brightness is used to identify compositional elements of stars, their movements, and their distances from Earth. (HS.ESS1A.b) **The composition of stars can be determined by analysis of their spectra.**	**ENERGY AND MATTER** In nuclear processes, atoms are not conserved, but the total number of protons plus

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
evaluating the validity and reliability of the claims, methods, and designs. • Communicate scientific and/or technical information or ideas (e.g., about phenomena and/or the process of development and the design and performance of a proposed process or system) in multiple formats (i.e., orally, graphically, textually, mathematically). **Communicate scientific information in multiple formats (i.e., orally, graphically, textually, mathematically).** **Communicate technical information in multiple formats (i.e., orally, graphically, textually, mathematically).** **Communicate scientific ideas in multiple formats (i.e., orally, graphically, textually, mathematically).**	**Stars range greatly in their size and distance from Earth.** **Stars' light spectra and brightness are used to identify their distances from Earth.** **Our knowledge of the history of the Universe is based on electromagnetic energy that has traveled vast distances and takes a long period of time to reach us.** Other than the hydrogen and helium formed at the time of the Big Bang, nuclear fusion within stars produces all atomic nuclei lighter than and including iron, and the process releases electromagnetic energy. Heavier elements are produced when certain massive stars achieve a supernova stage and explode. (HS.ESS1A.d) **Most elements are formed as a result of natural astronomical processes, either in the Big Bang itself or in the natural evolution of stars.** **Nuclear fusion within stars produces all atomic nuclei lighter than and including iron.** **A supernova is the explosion of a dying giant or supergiant star.** **After a supernova, some of the material (e.g., heavier elements) from the star expands into space.** **ENERGY IN CHEMICAL PROCESSES AND EVERYDAY LIFE** Nuclear fusion processes in the center of the sun release the energy that ultimately reaches Earth as radiation. (HS.PS3D.c) **The sun is a star that gives off radiant energy that drives Earth systems.** **The source of the sun's energy is the fusion of hydrogen atoms into helium.** **The sun's energy reaches Earth as solar radiation.**	neutrons is conserved. **The total number of nuclear particles are the same both before and after the nuclear process, although the total number of protons and the total number of neutrons may be different before and after.**

Clarification Statement
Emphasis is on the way nucleosynthesis, and therefore the different elements created, depends on the mass of a star and the stage of its lifetime.

Performance Expectation *and Louisiana Connectors*
HS-ESS1-4 Use mathematical or computational representations to predict the motion of orbiting objects in the solar system. **LC-HS-ESS1-4a Recognize that objects in the solar system orbit the sun and have an orderly motion (e.g., elliptical paths around the sun).** **LC-HS-ESS1-4b Relate Earth's orbital characteristics to other bodies in the solar system.** **LC-HS-ESS1-4c Use a mathematical or computational representation to predict the motion of orbiting objects in the solar system.**

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Using mathematics and computational thinking: Mathematical and computational thinking in 9-12 builds on K-8 experiences and progresses to using algebraic thinking and analysis, a range of linear and nonlinear functions (e.g., trigonometric,	**EARTH AND THE SOLAR SYSTEM** Kepler's laws describe common features of the motions of orbiting objects, including their elliptical paths around the sun. Orbits may change due to the gravitational effects from, or collisions with, other objects in the solar system. (HS.ESS1B.a) **Kepler discovered that the orbit of each planet is an ellipse.** **Kepler's laws describe the elliptical paths around the sun in which objects in the solar system move.**	**SCALE, PROPORTIONS, AND QUANTITY** Algebraic thinking is used to examine scientific data and predict the effect of a change in one variable on another (e.g., linear

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
exponential, and logarithmic) and computational tools for statistical analysis to analyze, represent, and model data. Simple computational simulations are created and used based on mathematical models of basic assumptions. • Use mathematical, computational, and/or algorithmic representations of phenomena or design solutions to describe and/or support claims and/or explanations. **Use mathematical or algorithmic forms for scientific modeling of phenomena and/or design solutions to describe claims.** **Use mathematical or algorithmic forms for scientific modeling of phenomena and/or design solutions to support claims.** **Use mathematical or algorithmic forms for scientific modeling of phenomena and/or design solutions to describe explanations.** **Use mathematical or algorithmic forms for scientific modeling of phenomena and/or design solutions to support explanations.**	**Objects' orbits may change due to the gravitational interactions of other objects in the solar system.** **Objects' orbits may change due to collisions with other objects in the solar system.**	growth vs. exponential growth). **Examine scientific data to predict the effect of a change in one variable on another.** **Algebraic thinking can be used to explore complex mathematical relationships in science (e.g., the difference between linear growth and exponential growth).**

Clarification Statement
Emphasis is on Newtonian gravitational laws governing orbital motions, which apply to human-made satellites as well as other celestial bodies (e.g., graphical representations of orbits).

Performance Expectation *and Louisiana Connectors*
HS-ESS1-5 Evaluate evidence of the past and current movements of continental and oceanic crust and the theory of plate tectonics to explain the ages of crustal rocks. **LC-HS-ESS1-5a Explain the relationship between the motion of continental plates and how materials of different ages are arranged on Earth's surface.** **LC-HS-ESS1-5b Relate/evaluate evidence of past and/or current movements in Earth's crust (plate tectonics) with the ages of crustal rocks.**

Science and Engineering Practice	**Disciplinary Core Idea**	**Crosscutting Concept**
Engaging in argument from evidence: Engaging in argument from evidence in 9-12 builds on K-8 experiences and progresses to using appropriate and sufficient evidence and scientific reasoning to defend and critique claims and explanations	**THE HISTORY OF PLANET EARTH** Continental rocks, which can be older than 4 billion years, are generally much older than the rocks of the ocean floor, which are less than 200 million years old. (HS.ESS1C.b) **According to theory of plate tectonics, evidence of the past and current movements of continental and oceanic crust can be used to explain the ages of crustal rocks.** **Sea floor spreading adds new crust to the ocean floor.** **Earth's internal and surface processes operate at different spatial and temporal scales to**	**PATTERNS** Empirical evidence is needed to identify patterns. **Evidence is required when identifying a**

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
about the natural and designed world(s). Arguments may also come from current scientific or historical episodes in science. • Evaluate the claims, evidence, and/or reasoning behind currently accepted explanations or solutions to determine the merits of arguments. **Evaluate the claims behind currently accepted explanations to determine the merits of arguments.** **Evaluate the claims behind currently accepted solutions to determine the merits of arguments.** **Evaluate the evidence behind currently accepted explanations to determine the merits of arguments.** **Evaluate the evidence behind currently accepted solutions to determine the merits of arguments.** **Evaluate the reasoning behind currently accepted explanations to determine the merits of arguments.** **Evaluate the reasoning behind currently accepted solutions to determine the merits of arguments.**	**form continental and ocean-floor features.** **Continental rocks can be older than 4 billion years.** **Rocks of the ocean floor are less than 200 million years old.** Although active geologic processes, such as plate tectonics and erosion, have destroyed or altered most of the very early rock record on Earth, other objects in the solar system, such as lunar rocks, asteroids, and meteorites, have changed little over billions of years. Studying these objects can provide information about Earth's formation and early history. (HS.ESS1C.c) **Active geologic processes have destroyed or altered most of the very early rock record on Earth.** **Some objects in the solar system have changed little over billions of years.** **Scientists study objects in the solar system (i.e., lunar rocks, asteroids, meteorites) to search for clues about Earth's history.** **Studying these objects can help scientists deduce the solar system's age and history, including the formation of planet Earth.** **PLATE TECTONICS AND LARGE-SCALE SYSTEM INTERACTIONS** Plate tectonics is the unifying theory that explains the past and current movements of the rocks at Earth's surface and provides a framework for understanding its geologic history. (HS.ESS2B.a) **Plate tectonics is the theory that explains the past and current movement of Earth's plates.** **Plate tectonics also provides a framework for understanding Earth's geologic history.** **NUCLEAR PROCESSES** Spontaneous radioactive decays follow a characteristic exponential decay law. Nuclear lifetimes allow radiometric dating to be used to determine the ages of rocks and other materials. (HS.PS1C.b) **Radioactive elements found in rocks decay at a constant rate.** **The half-life of a radioactive element is the time it takes for half of the radioactive atoms to decay.** **Scientists compare the amount of a radioactive element in a rock with the amount of stable element into which the radioactive element decays.**	**pattern in an observed phenomenon.** **Evidence is required to explain the pattern in a system under study.** **Evidence is required to support a claim about the pattern in a system under study.**

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
	Thus, scientists use radioactive dating to determine the absolute ages of rocks and other materials.	

Clarification Statement
Emphasis is on the ability of plate tectonics to explain the ages of crustal rocks. Examples include evidence of the ages of oceanic crust increasing with distance from mid-ocean ridges (a result of plate spreading) and the ages of North American continental crust decreasing with distance away from a central ancient continental center (a result of past plate interactions).

Performance Expectation *and Louisiana Connectors*
HS-ESS1-6 Apply scientific reasoning and evidence from ancient Earth materials, meteorites, and other planetary surfaces to construct an account of Earth's formation and early history. **LC-HS-ESS1-6a Identify ancient Earth materials, lunar rocks, asteroids, and meteorites as sources of evidence scientists use to understand Earth's early history.**

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Constructing explanations and designing solutions: Constructing explanations (science) and designing solutions (engineering) in 9-12	**THE HISTORY OF PLANET EARTH** Although active geologic processes, such as plate tectonics and erosion, have destroyed or altered most of the very early rock record on Earth, other objects in the solar system, such as lunar rocks, asteroids, and meteorites, have changed little over billions of years. Studying	**STABILITY AND CHANGE** Much of science deals with constructing explanations of how

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
builds on K-8 experiences and progresses to explanations and designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific ideas, principles, and theories. • Apply scientific reasoning, theory, and/or models to link evidence to the claims to assess the extent to which the reasoning and data support the explanation or conclusion. **Apply scientific reasoning to link evidence to the claims to assess the extent to which the reasoning and data support the explanation.** **Apply scientific theory to link evidence to the claims to assess the extent to which the reasoning and data support the explanation.** **Apply scientific modeling to link evidence to the claims to assess the extent to which the reasoning and data support the explanation.** **Apply scientific reasoning to link evidence to the claims to assess the extent to which the reasoning and data support the conclusion.** **Apply scientific theory to link evidence to the claims to assess the**	these objects can provide information about Earth's formation and early history. (HS.ESS1C.c) **Active geologic processes have destroyed or altered most of the very early rock record on Earth.** **Some objects in the solar system have changed little over billions of years.** **Scientists study objects in the solar system (i.e., lunar rocks, asteroids, meteorites) to search for clues about Earth's history.** **Studying these objects can help scientists deduce the solar system's age and history, including the formation of planet Earth.** **NUCLEAR PROCESSES** Spontaneous radioactive decays follow a characteristic exponential decay law. Nuclear lifetimes allow radiometric dating to be used to determine the ages of rocks and other materials. (HS.PS1C.b) **Radioactive elements found in rocks decay at a constant rate.** **The half-life of a radioactive element is the time it takes for half of the radioactive atoms to decay.** **Scientists compare the amount of a radioactive element in a rock with the amount of stable element into which the radioactive element decays.** **Thus, scientists use radioactive dating to determine the absolute ages of rocks and other materials.**	things change and how they remain stable. **Science deals with constructing explanations of how things change.** **Science deals with constructing explanations of how things remain stable.**

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
extent to which the reasoning and data support the conclusion. **Apply scientific modeling to link evidence to the claims to assess the extent to which the reasoning and data support the conclusion.**		

Clarification Statement
Emphasis is on using available evidence within the solar system to reconstruct the early history of Earth, which formed along with the rest of the solar system 4.6 billion years ago. Examples include the absolute age of ancient materials (obtained by radiometric dating of meteorites, moon rocks, and Earth's oldest materials), the sizes and compositions of solar system objects, and the impact cratering record of planetary surfaces.

Performance Expectation *and Louisiana Connectors*
HS-ESS2-1 Develop a model to illustrate how Earth's internal and surface processes operate at different spatial and temporal scales to form continental and ocean-floor features. **LC-HS-ESS2-1a Use a model of Earth to identify that the motion of the mantle and its plates occurs primarily through thermal convection, which is primarily driven by radioactive decay within Earth's interior.**

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Developing and using models: Modeling in 9-12 builds on K-8 experiences and progresses to using,	**EARTH MATERIALS AND SYSTEMS** Earth's systems, being dynamic and interacting, cause feedback effects that can increase or decrease the original changes. (HS.ESS2A.a)	**STABILITY AND CHANGE** Change and rates of change can be

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
synthesizing, and developing models to predict and show relationships among variables between systems and their components in the natural and designed worlds. • Develop, revise, and/or use a model based on evidence to illustrate and/or predict the relationships between systems or between components of a system. **Develop or use a model to identify and describe the components of a system.** **Develop or use a model to identify and describe the relationships between the components of a system.** **Develop or use a model to predict relationships between systems or within a system.** **Identify that models can help illustrate relationships between systems or within a system.**	**Earth's systems are dynamic and interacting.** **Earth has interconnected spheres: lithosphere or geosphere, hydrosphere, biosphere, atmosphere, and cryosphere.** **Changes in one system can cause changes to other systems.** **Rates of change of Earth's internal and surface processes occur over very short and very long periods of time.** **Many complex linkages and feedbacks among erosional and climatic processes in addition to tectonic ones change Earth's systems.** **Such complexities include feedback and stabilizing or destabilizing links between component processes.** **A change in one sphere can cause changes to other spheres, resulting in positive or negative feedback loops.** **PLATE TECTONICS AND LARGE-SCALE SYSTEM INTERACTIONS** Plate tectonics is the unifying theory that explains the past and current movements of rocks at Earth's surface and provides a framework for understanding its geologic history. (HS.ESS2B.a) **Plate tectonics is the theory that explains the past and current movement of Earth's plates.** **Plate tectonics also provides a framework for understanding Earth's geologic history.** Plate movements are responsible for most continental and ocean-floor features and for the distribution of most rocks and minerals within Earth's crust. (HS.ESS2B.b) **Plate movements are responsible for both continental and ocean-floor features.** **Plate movements are responsible to the distribution of most rocks and minerals on Earth.** **Maps showing the distribution of minerals can be used to draw inferences regarding how plates have moved over time.**	quantified and modeled over very short or very long periods of time. Some system changes are irreversible. **Change and rates of change can be quantified over very short or very long periods of time.** **Change and rates of change can be modeled over very short or very long periods of time.** **Some system changes are irreversible.**

Clarification Statement
Emphasis is on using available evidence within the solar system to reconstruct the early history of Earth, which formed along with the rest of the solar system 4.6 billion years ago. Examples include the absolute age of ancient materials (obtained by radiometric dating of meteorites, moon rocks, and Earth's oldest materials), the sizes and compositions of solar system objects, and the impact cratering record of planetary surfaces.

Performance Expectation *and Louisiana Connectors*
HS-ESS2-2 Analyze geoscience data to make the claim that one change to Earth's surface can create feedbacks that cause changes to other Earth's systems. **LC-HS-ESS2-2a Identify relationships, using a model, of how the Earth's surface is a complex and dynamic set of interconnected systems (i.e., geosphere, hydrosphere, atmosphere, and biosphere).**

Science and Engineering Practice	**Disciplinary Core Idea**	**Crosscutting Concept**
Analyzing and interpreting data: Analyzing data in 9-12 builds on K-8 experiences and progresses to introducing more detailed statistical analysis, the comparison of data	**EARTH MATERIALS AND SYSTEMS** Earth's systems, being dynamic and interacting, include feedback effects that can increase or decrease the original changes. (HS.ESS2A.a) **Earth's systems are dynamic and interacting.**	**STABILITY AND CHANGE** Feedback (negative or positive) can stabilize or destabilize a system.

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
sets for consistency, and the use of models to generate and analyze data • Analyze data using tools, technologies, and/or models (e.g., computational, mathematical) in order to make valid and reliable scientific claims or determine an optimal design solution. **Analyze data using tools in order to make valid and reliable scientific claims.** **Analyze data using tools in order to determine an optimal design solution.** **Analyze data using technology in order to make valid and reliable scientific claims.** **Analyze data using technology in order to determine an optimal design solution.** **Analyze data using models in order to make valid and reliable scientific claims.** **Analyze data using models in order to determine an optimal design solution.**	**Earth has interconnected spheres: lithosphere or geosphere, hydrosphere, biosphere, atmosphere, and cryosphere.** **Changes in one system can cause changes to other systems.** **Rates of change of Earth's internal and surface processes occur over very short and very long periods of time.** **Many complex linkages and feedbacks among erosional and climatic processes in addition to tectonic ones change Earth's systems.** **Such complexities include feedback, stabilizing or destabilizing links between component processes.** **A change in one sphere can cause changes to other spheres, resulting in positive or negative feedback loops.** **WEATHER AND CLIMATE** The foundation for Earth's global climate systems is the electromagnetic radiation from the sun, as well as its reflection, absorption, storage, and redistribution among the atmosphere, hydrosphere, and land systems, and this energy's re-radiation into space. (HS.ESS2D.a) **Sunlight is a portion of the electromagnetic radiation given off by the sun.** **Energy from the sun travels to Earth and heats Earth's surface.** **Some of this energy is radiated back into Earth's atmosphere.** **The sun's energy drives Earth's climate systems.** **Uneven heating of Earth's components (i.e., water, land, air) produce local and global atmospheric and oceanic movement.** **Heat energy stored in the oceans and transferred by currents influences climate.**	**Stability denotes a condition in which a system is in balance.** **A feedback loop is any mechanism in which a condition triggers some action that causes a change in that same condition.** **The mechanisms of external controls and internal feedback loops are important elements for a stable system.** **A change in one part of a system can cause changes to other parts of the system, resulting in positive or negative feedback loops.** **The changes (negative or positive) can stabilize or destabilize a system.**

Clarification Statement
Examples could include climate feedbacks such as how an increase in greenhouse gases causes a rise in global temperatures that melts glacial ice which reduces the amount of sunlight reflected from Earth's surface increasing surface temperatures and further reducing the amount of ice. Examples could also be taken from other system interactions such as how the loss of ground vegetation causes an increase in water runoff and soil erosion; how damned rivers increase ground water recharge, decrease sediment transport, and increase coastal erosion; or how the loss of wetlands causes a decrease in local humidity that further reduces the wetland extent.

Performance Expectation ***and Louisiana Connectors***
HS-ESS2-3 Develop a model based on evidence of Earth's interior to describe the cycling of matter by thermal convection. **LC-HS-ESS2-3a Use a model of Earth to identify that the motion of the mantle and its plates occurs primarily through thermal convection, which is primarily driven by radioactive decay within Earth's interior.**

Science and Engineering Practice	**Disciplinary Core Idea**	**Crosscutting Concept**
Developing and using models: Modeling in 9-12 builds on K-8 experiences and progresses to using,	**EARTH MATERIALS AND SYSTEMS** Evidence from deep probes and seismic waves, reconstructions of historical changes in Earth's surface and its magnetic field, and an understanding of physical and chemical processes lead	**ENERGY AND MATTER** Energy drives the cycling of matter within and

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
synthesizing, and developing models to predict and show relationships among variables between systems and their components in the natural and designed worlds. • Develop a model based on evidence to illustrate the relationships between systems or components of a system. **Develop a model based on evidence to illustrate the relationships between systems.** **Develop a model based on evidence to illustrate the components of a system.**	to a model of Earth with a hot but solid inner core, a liquid outer core, a viscous mantle and solid crust. (HS.ESS2A.b) **Seismic waves are vibrations that travel through Earth carrying the energy released during an earthquake.** **A seismograph records the ground movements caused by seismic waves as they move through the Earth.** **Scientists monitor seismic activity to better understand Earth's interior and to determine earthquake risk.** **Earth's interior is a hot, but solid, inner core and a liquid outer core surrounded by a solid mantle and crust.** **Earth's geosphere is composed of layers of rocks which have separated due to density and temperature differences and classified chemically into a crust (which includes continental and oceanic rock), a hot, convecting mantle, and a dense metallic core.** Motions of the mantle and its plates occur primarily through thermal convection, which involves the cycling of matter due to the outward flow of energy from Earth's interior and gravitational movement of denser materials toward the interior. (HS.ESS2A.c) **Convection is the transfer of heat by movements of a heated fluid.** **The flow of heat and matter from Earth's core and the mantle causes crustal plates to move.** **Heat from Earth's mantle and core causes convection currents to form in the athenosphere.** **Hot, therefore less dense, columns of mantle material rise through the athenosphere.** **At the top of the athenosphere, the hot material spreads out, and the cooler, therefore more dense, material sinks back into the athenosphere.** **PLATE TECTONICS AND LARGE-SCALE SYSTEM INTERACTIONS** The radioactive decay of unstable isotopes continually generates new energy within Earth's crust and mantle, providing the primary source of the heat that drives mantle convection. Plate tectonics can be viewed as the surface expression of mantle convection. (HS.ESS2B.c) **The transfer of energy through empty space is called radiation.**	between systems. **In many systems there also are cycles of various types. The most readily observable cycling may be of matter. Any such cycle of matter also involves associated energy transfers at each stage. To fully understand the cycling of matter, how matter moves between each part of the system, one must recognize the energy transfer mechanisms that are critical for that motion.**

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
	Energy released by radioactive decay in the Earth's crust provides energy that drives the flow of matter in the mantle. **The convection currents in the athenosphere cause the movement of Earth's plates.** **Earth has radial layers determined by density, together with the cycling of matter by thermal convection, results in plate tectonics.** **WAVE PROPERTIES** Geologists use seismic waves and their reflections at interfaces between layers to probe structures deep in the planet. (HS.PS4A.c) **Scientists study how seismic waves travel through Earth to understand how the planet is put together (i.e., Earth is made up of several layers).** **Seismic data is used to determine the age of Earth's crust.** **The interpretation of seismic data is used to model the interior of the Earth.**	

Clarification Statement
Emphasis is on both a one-dimensional model of Earth, with radial layers determined by density, and a three-dimensional model, which is controlled by mantle convection and the resulting plate tectonics. Examples of evidence include maps of the Earth's three-dimensional structure obtained from seismic wave data, records of the rate of change of Earth's magnetic field (as constraints on convection in the outer core), and identification of the composition of Earth's layers from high pressure laboratory experiments.

Performance Expectation *and Louisiana Connectors*
HS-ESS2-4 Analyze and interpret data to explore how variations in the flow of energy into and out of Earth's systems result in changes in atmosphere and climate. **LC-HS-ESS2-4a Identify different causes of climate change and results of those changes with respect to the Earth's surface temperatures, precipitation patterns or sea levels over a wide range of temporal and spatial scales using a model.**

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Analyzing and interpreting data: Analyzing data in 9-12 builds on K-8 experiences and progresses to introducing more detailed statistical analysis, the comparison of data sets for consistency, and the use of models to generate and analyze data. • Analyze data using tools, technologies, and/or models (e.g., computational, mathematical) in order to make valid and reliable scientific claims or determine an optimal design solution. **Analyze data using tools in order to make valid and reliable scientific claims.** **Analyze data using tools in order to determine an optimal design solution.** **Analyze data using technology in order to make valid and reliable scientific claims.** **Analyze data using technology in order to determine an optimal design solution.** **Analyze data using models in order to make valid and reliable scientific claims.** **Analyze data using models in order**	**EARTH AND THE SOLAR SYSTEM** Cyclical changes in the shape of Earth's orbit around the sun, together with changes in the tilt of the planet's axis of rotation, both occurring over hundreds of thousands of years, have altered the intensity and distribution of sunlight falling on Earth. These phenomena cause a cycle of ice ages and other gradual climate changes. (HS.ESS1B.b) **Gradual changes in the shape of Earth's orbit around the sun contributes to phenomena causing ice ages and other gradual climate changes.** **Earth's global temperatures can warm up or cool down if the amount of sunlight that enters the atmosphere is significantly altered.** **Cyclic variations of Earth's orbit around the sun impact the amount of sunlight that reaches Earth's surface.** **Gradual changes to the tilt of Earth's axis relative to its orbit around the sun have produced different weather patterns.** **EARTH MATERIALS AND SYSTEMS** The geological record shows that changes to global and regional climate can be caused by interactions among changes in the sun's energy output or Earth's orbit, tectonic events, hydrosphere circulation, volcanic activity, glaciers, vegetation, and human activities. These changes can occur on a variety of time scales from sudden (e.g., volcanic ash clouds) to intermediate (ice ages) to very long-term tectonic cycles. (HS.ESS2A.d) **All Earth processes are the result of energy flowing and matter cycling within and among Earth's systems.** **Changes to climate occur over a wide range of temporal and spatial scales.** **The geological record (ice cores, sediment deposits, fossil evidence, and paleovegetation restorations) shows that changes to global and regional climate can be caused by several factors (Earth's orbit, tectonic events, volcanic glaciers, vegetation, etc.).** **Changes to the input, output, storages, or redistribution of energy on Earth can occur over a short or extended time frame and can cause extreme weather conditions.** **WEATHER AND CLIMATE**	**CAUSE AND EFFECT** Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. **Evidence is required when attributing an observed phenomenon to a specific cause.** **Evidence is required to explain the causal mechanisms in a system under study.** **Evidence is required to support a claim about the causal mechanisms in a system under study.**

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
to determine an optimal design solution.	The foundation for Earth's global climate systems is the electromagnetic radiation from the sun, as well as its reflection, absorption, storage, and redistribution among the atmosphere, hydrosphere and land systems, and this energy's re-radiation into space. (HS.ESS2D.a) **Sunlight is a portion of the electromagnetic radiation given off by the sun.** **Energy from the sun travels to Earth and heats Earth's surface.** **Some of this energy is radiated back into Earth's atmosphere.** **The sun's energy drives Earth's climate systems.** **Uneven heating of Earth's components (i.e., water, land, air) produce local and global atmospheric and oceanic movement.** **Heat energy stored in the oceans and transferred by currents influence climate.** Gradual atmospheric changes were due to plants and other organisms that captured carbon dioxide and released oxygen. (HS.ESS2D.b) **Plants contribute to the make-up of Earth's atmosphere by absorbing carbon dioxide and releasing oxygen.** **Carbon continuously cycles from one sphere to another.** **In the past, the relative amount of carbon that cycled through the hydrosphere, atmosphere, lithosphere or geosphere, and biosphere was partially due to the activity of plants and other organisms.** Changes in the atmosphere due to human activity have increased carbon dioxide concentrations and thus affect climate. (HS.ESS2D.c) **Human activities that add carbon dioxide to the atmosphere may be warming Earth's atmosphere.** **A large amount of carbon dioxide has been released into Earth's atmosphere by human-related fossil fuel combustion.** **An increase in atmospheric carbon can increase the amount of heat energy stored in the system.**	

Clarification Statement
Changes differ by timescale, from sudden (large volcanic eruption, hydrosphere circulation) to intermediate (hydrosphere circulation, solar output, human activity) and long-term (Earth's orbit and the orientation of its axis and changes in atmospheric composition). Examples of human activities could include fossil fuel combustion, cement production, or agricultural activity and natural processes such as changes in incoming solar radiation or volcanic activity. Examples of data can include tables, graphs, maps of global and regional temperatures, and atmospheric levels of gases.

Performance Expectation *and Louisiana Connectors*
HS-ESS2-5 Plan and conduct an investigation on the properties of water and its effects on Earth materials and surface processes. **LC-HS-ESS2-5a Identify a connection between the properties of water and its effects on Earth materials.** **LC-HS-ESS2-5b Investigate the effects of water on Earth materials and/or surface processes.**

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Planning and carrying out investigations: Planning and carrying out investigations to answer questions (science) or test	**THE ROLE OF WATER IN EARTH'S SURFACE PROCESSES** The abundance of liquid water on Earth's surface and its unique combination of physical and chemical properties are central to the planet's dynamics. These properties include water's exceptional capacity to absorb, store, and release large amounts of energy, transmit sunlight,	**STRUCTURE AND FUNCTION** The functions and properties of natural

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
solutions (engineering) to problems in 9-12 builds on K-8 experiences and progresses to include investigations that provide evidence for and test conceptual, mathematical, physical, and empirical models. • Plan an investigation (science) or test a design (engineering) individually and collaboratively to produce data to serve as the basis for evidence as part of building and revising models, supporting explanations for phenomena, or testing solutions to problems. Consider possible confounding variables or effects and evaluate the investigation's design to ensure variables are controlled. **Plan an investigation (science) individually and collaboratively to produce data to serve as the basis for evidence as part of building and revising models. Consider possible confounding variables or effects and evaluate the investigation's design to ensure variables are controlled.** **Test a design (engineering) individually and collaboratively to produce data to serve as the basis**	expand upon freezing, dissolve and transport materials, and lower the viscosities and melting points of rocks. (HS.ESS2C.a) **Water has many unique properties (e.g., capacity to absorb, store, and release large amounts of energy; to expand upon freezing; to dissolve and transport many materials) that play a role in how it affects Earth systems (e.g., ocean thermal capacity contributes to moderating temperature variations, ice expansion contributes to rock erosion).** **Water exhibits a polar nature due to its molecular structure.** **Patterns of temperature, the movement of air, the movement and availability of water at Earth's surface can be related to the effect of the properties of water on energy transfer.** **Mechanical effects of water (e.g., stream transportation and deposition, erosion using variations in soil moisture content, and expansion of water as it freezes) on Earth's materials can be used to infer the effect of water on Earth's surface properties.** **Chemical effects of water (e.g., properties of solubility, the reaction of water on iron) on Earth materials can be used to infer the effect of water on Earth's surface processes.**	and designed objects and systems can be inferred from their overall structure, the way their components are shaped and used, and the molecular substructures of its various materials. **There are relationships between structure and function of natural and designed objects.** **There are relationships between structure and function of systems.** **Relationships between structure and function can be inferred from their overall structure.** **Relationships between structure and function can be inferred from the way their components are shaped.** **Relationships between structure and function can be inferred from the molecular**

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
for evidence as part of building and revising models. Consider possible confounding variables or effects and evaluate the investigation's design to ensure variables are controlled. Plan an investigation (science) individually and collaboratively to produce data to serve as the basis for evidence for supporting explanations for phenomena. Consider possible confounding variables or effects and evaluate the investigation's design to ensure variables are controlled. Test a design (engineering) individually and collaboratively to produce data to serve as the basis for evidence for supporting explanations for phenomena. Consider possible confounding variables or effects and evaluate the investigation's design to ensure variables are controlled. Plan an investigation (science) individually and collaboratively to produce data to serve as the basis for evidence for testing solutions to problems. Consider possible confounding variables or effects and evaluate the investigation's design to ensure variables are		substructures of its various materials.

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
controlled. Test a design (engineering) individually and collaboratively to produce data to serve as the basis for evidence for testing solutions to problems. Consider possible confounding variables or effects and evaluate the investigation's design to ensure variables are controlled.		

Clarification Statement
Emphasis is on mechanical and chemical investigations with water and a variety of solid materials to provide the evidence for connections between the hydrologic cycle and system interactions commonly known as the rock cycle. Examples of mechanical investigations include stream transportation and deposition using a stream table, erosion using variations in soil moisture content, or frost wedging by the expansion of water as it freezes. Examples of chemical investigations include chemical weathering and recrystallization (by testing the solubility of different materials) or melt generation (by examining how water lowers the melting temperature of most solids).

Performance Expectation *and Louisiana Connectors*
HS-ESS2-6 Develop a quantitative model to describe the cycling of carbon among the hydrosphere, atmosphere, geosphere, and biosphere. **LC-HS-ESS2-6a Use a model of photosynthesis to identify that carbon is exchanged between living and nonliving systems.** **LC-HS-ESS2-6b Use a model of cellular respiration to identify that carbon is exchanged between living and nonliving systems.** **LC-HS-ESS2-6c Develop and/or use a quantitative model to identify relative amount of and/or the rate at which carbon is transferred among hydrosphere, atmosphere, geosphere, and biosphere.**

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Developing and using models: Modeling in 9-12 builds on K-8 experiences and progresses to using, synthesizing, and developing models to predict and show relationships among variables between systems and their components in the natural and designed worlds. • Develop a model based on evidence to illustrate the relationships between systems or between components of a system. **Develop a model based on evidence to illustrate the relationships between systems.** **Develop a model based on evidence to illustrate the components of a system.**	**WEATHER AND CLIMATE** Gradual atmospheric changes were due to plants and other organisms that captured carbon dioxide and released oxygen. (HS.ESS2D.b) **Plants contribute to the make-up of Earth's atmosphere by absorbing carbon dioxide and releasing oxygen.** **Carbon continuously cycles from one sphere to another.** **In the past, the relative amount of carbon that cycled through the hydrosphere, atmosphere, lithosphere or geosphere, and biosphere was partially due to the activity of plants and other organisms.** Changes in the atmosphere due to human activity have increased carbon dioxide concentrations and thus affect climate. (HS.ESS2D.c) **Human activities that add carbon dioxide to the atmosphere may be warming Earth's atmosphere.** **A large amount of carbon dioxide has been released into Earth’s atmosphere by human-related fossil fuel combustion.** **An increase in atmospheric carbon can increase the amount of heat energy stored in the system.**	**ENERGY AND MATTER** The total amount of energy and matter in closed systems is conserved. **When materials interact within a closed system, the total mass of the system remains the same.** **Energy may change forms, but the total amount of energy cannot change in physical systems.**

Clarification Statement
Emphasis is on modeling biogeochemical cycles that include the cycling of carbon through the ocean, atmosphere, soil, and biosphere (including humans), providing the foundation for living organisms.

Performance Expectation *and Louisiana Connectors*
HS-ESS2-7 Construct an argument based on evidence about the simultaneous coevolution of Earth systems and life on Earth. **LC-HS-ESS2-7a Identify examples of coevolution of Earth's systems and the evolution of life on Earth.** **LC-HS-ESS2-7b Identify evidence (e.g., causal links and/or feedback mechanisms between changes in the biosphere and changes in Earth’s other systems) in an argument that there is simultaneous coevolution of Earth's systems and life on Earth.**

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Engaging in argument from evidence: Engaging in argument from evidence in 9-12 builds on K-8 experiences and progresses to using appropriate and sufficient evidence and scientific reasoning to defend and critique claims and explanations about the natural and designed world(s). Arguments may also come from current scientific or historical episodes in science. • Construct an oral and written argument or counterarguments based on data and evidence. **Construct an oral argument based on data and evidence.** **Construct a written argument based on data and evidence.** **Construct an oral counterargument based on data and evidence.** **Construct a written counterargument based on data and evidence.**	**WEATHER AND CLIMATE** Gradual atmospheric changes were due to plants and other organisms that captured carbon dioxide and released oxygen. (HS.ESS2D.b) **Plants contribute to the make-up of Earth's atmosphere by absorbing carbon dioxide and releasing oxygen.** **Carbon continuously cycles from one sphere to another.** **In the past, the relative amount of carbon that cycled through the hydrosphere, atmosphere, lithosphere or geosphere, and biosphere was partially due to the activity of plants and other organisms.** **BIOGEOLOGY** The many dynamic and delicate feedbacks between the biosphere and other Earth systems cause a continual co-evolution of Earth's surface and the life that exists on it. (HS.ESS2E.a) **Feedback (negative or positive) can stabilize or destabilize a system.** **The feedbacks between life on Earth and the Earth's systems cause life on Earth to evolve and the surface of the Earth to undergo changes at the same time.** **Examples of feedback include how an increase in greenhouse gases causes a rise in global temperatures that melts glacial ice, thus reducing the amount of sunlight reflected from Earth's surface, which in turn increases surface temperatures and further reduces the amount of ice.**	**STABILITY AND CHANGE** Much of science deals with constructing explanations of how things change and how they remain stable. **Science deals with constructing explanations of how things change.** **Science deals with constructing explanations of how things remain stable.**

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 Earth's surface. Examples 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 the evolution of new life forms.

Performance Expectation *and Louisiana Connectors*
HS-ESS3-1 Construct an explanation based on evidence for how the availability of natural resources, occurrence of natural hazards, and changes in climate have influenced human activity. **LC-HS-ESS3-1a Explain the relationship between human activity (e.g., population size, where humans live, types of crops grown) and changes in the amounts of natural resources using evidence.** **LC-HS-ESS3-1b Explain the relationship between human activity (e.g., population size, where humans live, types of crops grown) and changes in the occurrence of natural hazards using evidence.**

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Constructing explanations and designing solutions: Constructing explanations (science) and designing solutions (engineering) in 9-12 builds on K-8 experiences and progresses to explanations and designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific ideas, principles, and theories. • Construct an explanation based on valid and reliable evidence obtained from a variety of sources (including students' own investigations, models, theories, simulations, peer review) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future. **Construct an explanation based on valid and reliable evidence from a variety of sources.** **Construct an explanation based on valid and reliable evidence from the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future.**	**NATURAL RESOURCES** Resource availability has guided the development of human society. (HS.ESS3A.a) **The availability of natural resources has influenced where humans have populated regions of Earth.** **Environmental factors have affected human populations over the course of history.** **Resource availability has driven global development of societies, sizes of human populations, and human migrations.** **Evidence (e.g., from text or other investigations) show correlations between human population distribution and regional availability of resources such as fresh water, fertile soils, and fossils fuels.** **NATURAL HAZARDS** Natural hazards and other geologic events have shaped the course of human history; they have significantly altered the sizes of human populations and have driven human migrations. (HS.ESS3B.a) **Natural hazards, such as earthquakes, tsunamis, volcanic eruptions, severe weather, floods, and coastal erosion, have historically affected the sizes and distributions of human populations.** **Environmental factors have affected human populations over the course of history.** **Natural disasters and other geologic events have driven global development of societies, sizes of human populations, and human migrations.** **Historical accounts of natural disasters (e.g., Krakatoa eruption, American Dust Bowl, Superstorm Sandy, and Hurricane Katrina) resulting human suffering and loss of life could provide empirical evidence of past impacts on human population size and distribution.**	**CAUSE AND EFFECT** Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. **Evidence is required when attributing an observed phenomenon to a specific cause.** **Evidence is required to explain the causal mechanisms in a system under study.** **Evidence is required to support a claim about the causal mechanisms in a system under study.**

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Revise an explanation based on valid and reliable evidence from a variety of sources. **Revise an explanation based on valid and reliable evidence from the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future.**		

Clarification Statement
Examples of key natural resources include access to fresh water (such as rivers, lakes, and groundwater), regions of fertile soils such as river deltas, and high concentrations of minerals and fossil fuels. Examples of natural hazards can be from interior processes (such as volcanic eruptions and earthquakes), surface processes (such as tsunamis, mass wasting and soil erosion), and severe weather (such as hurricanes, floods, and droughts). Natural hazards and other geologic events exhibit some non-random patterns of occurrence. Examples of the results of changes in climate that can affect populations or drive mass migrations include changes to sea level, regional patterns of temperature and precipitation, and the types of crops and livestock that can be raised.

Performance Expectation *and Louisiana Connectors*
HS-ESS3-2 Evaluate competing design solutions for developing, managing, and utilizing energy and mineral resources based on cost-benefit ratios. **LC-HS-ESS3-2a Identify a solution that demonstrates the most preferred cost-benefit ratios for developing, managing, and utilizing energy and mineral resources (i.e., conservation, recycling, and reuse of resources).** **LC-HS-ESS3-2b Compare design solutions for developing, managing, and/or utilizing energy or mineral resources.**

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Constructing explanations and designing solutions: Constructing explanations (science) and designing solutions (engineering) in 9-12 builds on K-8 experiences and progresses to explanations and designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific ideas, principles, and theories. • Design, evaluate, and/or refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations. **Design a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations.** **Evaluate a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations.** **Refine a solution to a complex real-world problem, based on scientific**	**NATURAL RESOURCES** All forms of energy production and other resource extraction have associated economic, social, environmental, and geopolitical costs and risks as well as benefits. New technologies and social regulations can change the balance of these factors. (HS.ESS3A.b) **Anything in the environment that is naturally occurring and used by people is a natural resource.** **Demand for energy by society leads to continuous exploration in order to expand supplies of fossil fuels.** **The increase in energy demand and the new technologies being developed to meet these needs and improve the efficiencies of energy systems have social and environmental consequences.** **New technologies of energy production are being developed. For example, the technique of using hydraulic fracturing to extract natural gas from shale deposits is used to acquire energy from natural resources versus other traditional means.** **New technologies could have deep impacts on society and the environment, including some that were not anticipated.** **New technologies are being developed to increase the use of alternate energy sources.** **DESIGNING SOLUTIONS TO ENGINEERING PROBLEMS** 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) **It is important to determine the full impact of the advantages and disadvantages when evaluating a solution.** **New technologies offer solutions based on cost benefit ratios, scientific ideas and principles, empirical evidence, and logical arguments regarding relevant factors (e.g., economic, societal, environmental, and ethical considerations).**	**SYSTEMS AND SYSTEM MODELS** Systems can be designed to do specific tasks. **Systems can be designed to explain phenomena (scientific).** **Systems can be designed to refine solutions (engineering).** **Systems can be designed for understanding and testing ideas that are applicable throughout science and engineering.**

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations.		

Clarification Statement
Emphasis is on the conservation, recycling, and reuse of resources (such as minerals and metals) where possible, and on minimizing impacts where it is not. Examples include developing best practices for agricultural, soil use, forestry, and mining (coal, tar sands, and oil shales), and pumping (ground water, petroleum, and natural gas). Science knowledge indicates what can happen in natural systems—not what should happen.

Performance Expectation ***and Louisiana Connectors***
HS-ESS3-3 Create a computational simulation to illustrate the relationships among management of natural resources, the sustainability of human populations, and biodiversity. **LC-HS-ESS3-3a Use numerical data to determine the effects of a conservation strategy to manage natural resources and to sustain human society and plant and animal life.**

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Using mathematics and computational thinking: Mathematical and computational thinking in 9-12 builds on K-8 experiences and progresses to using algebraic thinking and analysis, a range of linear and nonlinear functions (e.g., trigonometric, exponential and logarithmic) and computational tools for statistical analysis to analyze, represent, and model data. Simple computational simulations are created and used based on mathematical models of basic assumptions. • Create a computational model or simulation of a phenomenon, designed device, process, or system. **Create/use a computational model of a phenomenon.** **Revise a computational model of a phenomenon.** **Create/use a simulation of a phenomenon.** **Revise a simulation of a phenomenon.** **Create/use a computational model of a process.** **Revise a computational model of a process.** **Create/use a simulation of a**	**HUMAN IMPACTS ON EARTH SYSTEMS** The sustainability of human societies and the biodiversity that supports them requires responsible management of natural resources. (HS.ESS3C.a) **Responsible use of energy requires consideration of energy availability, efficiency of its use, the environmental impact, and possible alternate sources.** **Poor management of natural resources can have negative impacts on human populations.**	**STABILITY AND CHANGE** Change and rates of change can be quantified and modeled over very short or very long periods of time. Some system changes are irreversible. **Change and rates of change can be quantified over very short or very long periods of time.** **Change and rates of change can be modeled over very short or very long periods of time.** **Some system changes are irreversible.**

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
process. **Revise a simulation of a process.** **Create/use a computational model of a system.** **Revise a computational model of a system.** **Create/use a simulation of a system.** **Revise a simulation of a system.**		

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.

Performance Expectation *and Louisiana Connectors*
HS-ESS3-4 Evaluate or refine a technological solution that reduces impacts of human activities on natural systems. **LC-HS-ESS3-4a Connect a technological solution (e.g., wet scrubber; baghouse) to its outcome (e.g., clean air) and its outcome to the human activity impact that it is reducing (e.g., air pollution).**

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Constructing explanations and designing solutions: Constructing explanations (science) and designing solutions (engineering) in 9-12 builds on K-8 experiences and progresses to explanations and designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific ideas, principles, and theories. • Design or refine a solution to a complex real-world problem, based on scientific knowledge, student generated sources of evidence, prioritized criteria, and tradeoff considerations. **Design a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations.** **Evaluate a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations.** **Refine a solution to a complex real-world problem, based on scientific**	**HUMAN IMPACTS ON EARTH SYSTEMS** Scientists and engineers can make major contributions by developing technologies that produce less pollution and waste and that preclude ecosystem degradation. (HS.ESS3C.b) **Scientists and engineers can develop technological solutions to reduce human impacts on natural systems.** **Societal expectations for a sustainable environment will require new, cleaner technologies for the production and use of energy.** **DESIGNING SOLUTIONS TO ENGINEERING PROBLEMS** 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) **It is important to determine the full impact of the advantages and disadvantages when evaluating a solution.** **New technologies offer solutions based on cost benefit ratios, scientific ideas and principles, empirical evidence, and logical arguments regarding relevant factors (e.g., economic, societal, environmental, and ethical considerations).** **When scientists and engineers create solutions to problems, they use specific criteria to guide the development of their solutions.** **When scientists and engineers create solutions to problems, they consider the constraints of their design solutions including cost, safety, aesthetics, and reliability.**	**STABILITY AND CHANGE** Feedback (negative or positive) can stabilize or destabilize a system. **Stability denotes a condition in which a system is in balance.** **A feedback loop is any mechanism in which a condition triggers some action that causes a change in that same condition.** **The mechanisms of external controls and internal feedback loops are important elements for a stable system.** **A change in one part of a system can cause changes to other parts of the system, resulting in positive or negative feedback loops.** **The changes (negative or positive) can stabilize or destabilize a system.**

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations.		

Clarification Statement
Examples of data on the impacts of human activities could include the quantities and types of pollutants released, changes to biomass and species diversity, or areal changes in land surface use (such as for urban development, agriculture and livestock, or surface mining). Examples for limiting future impacts could range from local efforts (such as reducing, reusing, and recycling resources) to large-scale geoengineering design solutions (such as altering global temperatures by making large changes to the atmosphere or ocean).

Performance Expectation *and Louisiana Connectors*
HS-ESS3-5 Analyze geoscience data and the results from global climate models to make an evidence-based forecast of the current rate of global or regional climate change and associated future impacts to Earth systems. **LC-ESS3-5a Use geoscience data to determine the relationship between a change in climate (e.g., precipitation, temperature) and its impact in a region.**

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Analyzing and interpreting data: Analyzing data in 9-12 builds on K-8 experiences and progresses to introducing more detailed statistical analysis, the comparison of data sets for consistency, and the use of models to generate and analyze data. • Analyze data using tools, technologies, and/or models (e.g., computational, mathematical) in order to make valid and reliable scientific claims or determine an optimal design solution. **Analyze data using tools in order to make valid and reliable scientific claims.** **Analyze data using tools in order to determine an optimal design solution.** **Analyze data using technology in order to make valid and reliable scientific claims.** **Analyze data using technology in order to determine an optimal design solution.** **Analyze data using models in order to make valid and reliable scientific claims.** **Analyze data using models in order**	**GLOBAL CLIMATE CHANGE** **Though the magnitudes of human impacts are greater than they have ever been, so too are human abilities to model, predict, and manage current and future impacts. (HS.ESS3D.a)** **Technological advances throughout history have led to the discovery and use of different forms of energy and to more efficient use of all forms of energy.** **The increase in energy demand and the new technologies being developed to meet these needs and improve the efficiencies of energy systems have social and environmental consequences.** **Changes in weather technology have occurred in the areas of gathering weather data and using computers to make forecasts.** **This has allowed scientists to model, predict, and manage current and future impacts using global climate models.** **Geoscience data is used to explain climate change over a wide-range of timescales including:** **• one to ten years: large volcanic eruptions, ocean circulation;** **• ten to hundreds of years: changes in human activity, ocean circulation, solar output;** **• tens of thousands to hundreds of thousands of years: changes to Earth's orbit and the orientation of its axis; and** **• tens of millions to hundreds of millions of years: long-term changes in atmospheric composition.**	**STABILITY AND CHANGE** Change and rates of change can be quantified and modeled over very short or long periods of time. Some system changes are irreversible. **Change and rates of change can be quantified over very short or very long periods of time.** **Change and rates of change can be modeled over very short or very long periods of time.** **Some system changes are irreversible.**

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
to determine an optimal design solution.		

Clarification Statement
Examples of evidence, for both data and climate model outputs, are for climate changes (such as precipitation and temperature) and their associated impacts (such as on sea level, glacial ice volumes, or atmosphere and ocean composition).

Performance Expectation ***and Louisiana Connectors***
HS-ESS3-6 Use a computational representation to illustrate the relationships among Earth systems and how those relationships are being modified due to human activity. **LC-HS-ESS3-6a Use representations to describe the relationships among Earth systems and how those relationships are being modified due to human activity (e.g., increase in atmospheric carbon dioxide, increase in ocean acidification, effects on organisms in the ocean (coral reef), carbon cycle of the ocean, possible effects on marine populations).**

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Using mathematics and computational thinking: Mathematical and computational thinking in 9-12 builds on K-8 experiences and progresses to using algebraic thinking and analysis, a range of linear and nonlinear functions (e.g., trigonometric, exponential and logarithmic) and computational tools for statistical analysis to analyze, represent, and model data. Simple computational simulations are created and used based on mathematical models of basic assumptions. • Use a computational representation of phenomena or design solutions to describe and/or support claims and/or explanations. **Use a computational representation of phenomena to describe claims.** **Use a computational representation of phenomena to describe explanations.** **Use a computational representation of phenomena to support claims.** **Use a computational representation of phenomena to support explanations.**	**WEATHER AND CLIMATE** Current models predict that, although future regional climate changes will be complex and varied, average global temperatures will continue to rise. The outcomes predicted by global climate models strongly depend on the amounts of human-generated greenhouse gases added to the atmosphere each year and by the ways in which these gases are absorbed by the ocean and biosphere. (HS.ESS2D.d) **Current models of Earth's natural systems include system boundaries, initial conditions, inputs and outputs, and relationships that determine the interaction (e.g., the relationship between atmospheric carbon dioxide and production of photosynthetic biomass and ocean acidification).** **Increased carbon dioxide level in the atmosphere traps more heat. This will lead to a gradual increase in the temperature of Earth's atmosphere.** **Human activities, such as the release of greenhouse gases from burning fossil fuels, are major factors in the current rise in Earth's mean surface temperature.** **Based on current models, Earth's average global temperatures will continue to rise due to an increase in human-generated greenhouse gases (e.g., carbon dioxide and methane) in Earth's atmosphere and associated feedbacks.** **Human impact on climate change must be addressed.** **Reducing the level of climate change and reducing human vulnerability to whatever climate changes do occur depend on the understanding of climate science and engineering capabilities.** **GLOBAL CLIMATE CHANGE** Important discoveries are still being made about how the ocean, the atmosphere, and the biosphere interact and are modified in response to human activities (e.g., through computer simulations and other discoveries satellite imagery). (HS.ESS3D.b) **Scientists continually learn more about how Earth's systems interact and are changed by human activities.** **Modern civilization depends on major technological systems.** **Through computer simulations and other studies, important discoveries are still being made**	**SYSTEMS AND SYSTEM MODELS** When investigating or describing a system, the boundaries and initial conditions of the system need to be defined and their inputs and outputs analyzed and described using models. **When investigating a system, the boundaries and initial conditions of the system need to be defined.** **When describing a system, the boundaries and initial conditions of the system need to be defined.** **When investigating a system, the inputs and outputs need to be analyzed and described using models.** **When describing a system, the inputs and outputs need to be analyzed and described using models.**

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Use a computational representation of a design solution to describe claims. **Use a computational representation of a design solution to describe explanations.** **Use a computational representation of a design solution to support claims.** **Use a computational representation of a design solution to support explanations.**	**about how the ocean, atmosphere, and biosphere interact and are modified in response to human activities.** **Scientists and engineers use human-generated models including computer simulations, to predict how the amount of greenhouse gases in Earth's atmosphere impacts the biological and physical processes on Earth (e.g., oceanic acidification, coral bleaching, ocean circulation, etc.).**	

Clarification Statement
Examples of Earth systems to be considered are the hydrosphere, atmosphere, cryosphere, geosphere, and/or biosphere. An example of the far-reaching impacts from a human activity is how an increase in atmospheric carbon dioxide results in an increase in photosynthetic biomass on land and an increase in ocean acidification, with resulting impacts on sea organism health and marine populations.

Performance Expectation *and Louisiana Connectors*
HS-LS1-1 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. ***LC-HS-LS1-1a Relate DNA molecules to the way cells store and use information to guide their functions.*** ***LC-HS-LS1-1b Relate groups of specialized cells (e.g., heart cells, nerve cells, muscle cells, epithelial cells, fat cells, blood cells) within organisms to the performance of essential functions of life.***

Performance Expectation *and Louisiana Connectors*
LC-HS-LS1-1c Identify evidence supporting an explanation of how a substance called DNA carries genetic information in all organisms which codes for the proteins that are essential to an organism.

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Constructing explanations and designing solutions: Constructing explanations (science) and designing solutions (engineering) in 9-12 builds on K-8 experiences and progresses to explanations and designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific ideas, principles, and theories. • Construct and revise an explanation based on valid and reliable evidence obtained from a variety of sources (including students' own investigations, models, theories, simulations, peer review) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future. ***Construct an explanation based on valid and reliable evidence from a***	**STRUCTURE AND FUNCTION** Systems of specialized cells within organisms help them perform the essential functions of life. (HS.LS1A.a) ***All living things are made of cells.*** ***In multicellular organisms, the cells are often quite different from each other in size and structure.*** ***The structure of each kind of cell is suited to the unique function it carries out.*** ***Systems of cells, tissues, and organs work together to meet the needs of the whole organism.*** 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 DNA.*** ***DNA contains regions that are called genes.*** ***The sequence of genes contains instructions that code for proteins.*** ***Groups of specialized cells (tissues) use proteins to carry out functions that are essential to the organism.***	**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. ***Designing and/or investigating new structures/systems requires knowledge of the properties (e.g., rigidity and hardness) of the materials needed for specific parts of the structure.*** ***Designing and/or***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
variety of sources. *Construct an explanation based on valid and reliable evidence from the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future.* *Revise an explanation based on valid and reliable evidence from a variety of sources.* *Revise an explanation based on valid and reliable evidence from the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future.*		*investigating new structures/systems requires knowledge of the structures of different components.* *Designing and/or investigating a new structure requires a detailed examination of the connections of components to reveal its function.* *Designing and/or investigating a new structure requires a detailed examination of the connections of components to reveal any problems.*

Clarification Statement
Emphasis is on the conceptual understanding that DNA sequences determine the amino acid sequence and thus protein structure. Students can produce scientific writing, or presentations, and/or physical models that communicate constructed explanations.

Performance Expectation *and Louisiana Connectors*
HS-LS1-2 Develop and use a model to illustrate the hierarchical organization of interacting systems that provide specific functions within multicellular organisms. *LC-HS-LS1-2a Using model(s), identify that different systems of the body carry out essential functions (e.g., digestive system, respiratory system, circulatory system, nervous system).* *LC-HS-LS1-2b Using model(s), identify the hierarchical organization of systems that perform specific functions within multicellular organisms.*

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Developing and using models: Modeling in 9-12 builds on K-8 experiences and progresses to using synthesizing and developing models to predict and show relationships among variables between systems and their components in the natural and designed world(s). • Develop, revise, and/or use a model based on evidence to illustrate and/or predict the relationships between systems or between components of a system. ***Develop or use a model to identify and describe the components of a system.*** ***Develop or use a model to identify and describe the relationships between the components of a system.*** ***Develop or use a model to predict relationships between systems or within a system.*** ***Identify that models can help illustrate relationships between systems or within a system.***	**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) ***Cells may be organized into larger structures beginning with tissues and increasing in size and complexity to maintain organs, organ-systems, and eventually an organism.*** ***Multicellular organisms have a hierarchical structural organization in which one system is made of numerous parts.*** ***The hierarchical organization of interacting systems provide specific functions within multicellular organisms.*** ***Models can be used to illustrate how the parts (e.g., organ system, organs, and their component tissues) and processes (e.g., transport of fluids, motion) of body systems in multicellular organisms function.***	**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. ***Models can be used to simulate systems.*** ***Models can be used to simulate interactions.*** ***Models can be used simulate interactions within systems at different scales.*** ***Models can be used simulate interactions between systems at different scales.***

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.

Performance Expectation ***and Louisiana Connectors***
HS-LS1-3 Plan and conduct an investigation to provide evidence that feedback mechanisms maintain homeostasis in living organisms. ***LC-HS-LS1-3a Identify how different organisms react (e.g., heart rate, body temperature) to changes in their external environment.*** ***LC-HS-LS1-3b Identify examples of how organisms use feedback mechanisms to maintain dynamic homeostasis.***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Planning and carrying out investigations: Planning and carrying out investigations to answer questions or test solutions to problems in 9-12 builds on K-8 experiences and progresses to	**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 (through negative feedback) activities within an organism to maintain homeostasis. (HS.LS1A.d)	**STABILITY AND CHANGE** Feedback (negative or positive) can stabilize or destabilize a system. ***Stability denotes a***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
include investigations that provide evidence for and test conceptual, mathematical, physical, and empirical models. • Plan and conduct an investigation individually and collaboratively to produce data to serve as the basis for evidence, and in the design: decide on types, how much, and accuracy of data needed to produce reliable measurements and consider limitations on the precision of the data (e.g., number of trials, cost, risk, time), and refine the design accordingly. ***Plan an investigation individually and collaboratively to produce data to serve as the basis for evidence, and in the design: decide on types, how much, and accuracy of data needed to produce reliable measurements.*** ***Revise an investigation individually and collaboratively to produce data to serve as the basis for evidence.*** ***Conduct an investigation individually and collaboratively to produce data to serve as the basis for evidence.***	***Organisms' systems can maintain balance (homeostasis) within an organism to ensure its survival.*** ***Positive and negative feedback mechanisms regulate organisms' systems in order to help an organism maintain homeostasis.*** ***These feedback mechanisms can encourage or discourage physiological responses in living systems.***	***condition in which a system is in balance.*** ***A feedback loop is any mechanism in which a condition triggers some action that causes a change in that same condition.*** ***The mechanisms of external controls and internal feedback loops are important elements for a stable system.*** ***A change in one part of a system can cause changes to other parts of the system, resulting in positive or negative feedback loops.*** ***The changes (negative or positive) can stabilize or destabilize a system.***

Clarification Statement
Examples of investigations could include heart rate responses to exercise, stomate responses to moisture and temperature, root development in response to water levels, or cell response to hypertonic and hypotonic environments.

Performance Expectation *and Louisiana Connectors*
HS-LS1-4 Use a model to illustrate the role of the cell cycle and differentiation in producing and maintaining complex organisms. ***LC-HS-LS1-4a Identify how growth and/or maintenance (repair/replacement) occurs when cells multiply (i.e., mitosis) using a model.***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Developing and using models: Modeling in 9-12 builds on K-8 experiences and progresses to using, synthesizing, and developing models	**GROWTH AND DEVELOPMENT OF ORGANISMS** In multicellular organisms 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 diseases such as cancer. (HS.LS1B.a)	**SYSTEMS AND SYSTEM MODELS** Models (e.g., physical, mathematical,

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
to predict and show relationships among variables between systems and their components in the natural and designed world(s). • Develop, revise, and/or use a model based on evidence to illustrate and/or predict the relationships between systems or between components of a system. ***Develop a model based on evidence to illustrate the relationships between systems.*** ***Develop a model based on evidence to predict the relationships between systems.*** ***Develop a model based on evidence to illustrate the relationships between components of a system.*** ***Develop a model based on evidence to predict the relationships between components of a system.*** ***Revise a model based on evidence to illustrate the relationships between systems.*** ***Revise a model based on evidence to predict the relationships between systems.*** ***Revise a model based on evidence to illustrate the relationships between components of a system.*** ***Revise a model based on evidence***	 ***Cells undergo a regular sequence of growth and division called the cell cycle.*** ***The amount of time it takes to complete the cell cycle varies in different cells.*** ***Complex multicellular organisms maintain themselves by growing and developing through cellular divisions (mitosis) and differentiation of cells.*** ***There are times when cell cycles are disrupted.*** ***Cancer is a disease that can occur when control of the cell cycle is lost.*** ***Cancer is caused by uncontrolled cell division.*** 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) ***During cell division, the organism's genetic material is copied into each new cell.*** ***Daughter cells receive identical genetic information from a parent cell or a fertilized egg.*** ***Mitotic cell division produces two genetically identical daughter cells from one parent cell.*** ***Differences between different cell types within a multicellular organism are due to differentiated gene expression.*** Cellular division and differentiation (stem cell) 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) ***Cellular division and differentiation are required to meet the needs of living organisms.*** ***Mitotic cell division results in more cells that: 1) allow growth of the organism; 2) can differentiate to create different cell types; and 3) can replace dead or damaged cells to maintain a complex organism.*** ***In multicellular organisms, the body is a system of multiple interacting subsystems.*** ***These subsystems are groups of cells that work together to form tissues and organs that are specialized for particular body functions.***	computer models) can be used to simulate systems and interactions—including energy, matter, and information flows—within and between systems at different scales. ***Models can be used to simulate systems.*** ***Models can be used to simulate interactions.*** ***Models can be used simulate interactions within systems at different scales.*** ***Models can be used simulate interactions between systems at different scales.***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
to predict the relationships between components of a system. *Use a model based on evidence to illustrate the relationships between systems.* *Use a model based on evidence to predict the relationships between systems.* *Use a model based on evidence to illustrate the relationships between components of a system.* *Use a model based on evidence to predict the relationships between components of a system.*		

Clarification Statement
Emphasis is on conceptual understanding that mitosis passes on genetically identical materials via replication, not on the details of each phase in mitosis.

Performance Expectation *and Louisiana Connectors*
HS-LS1-5 Use a model to illustrate how photosynthesis transforms light energy into stored chemical energy. *LC-HS-LS1-5a Identify model of photosynthesis, which shows the conversion of light energy to stored chemical energy.*

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Developing and using models: Modeling in 9-12 builds on K-8 experiences and progresses to using	**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)	**ENERGY AND MATTER** Changes of energy and matter in a system can

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
synthesizing and developing models to predict and show relationships among variables between systems and their components in the natural and designed world. • Develop, revise, and/or use a model based on evidence to illustrate and/or predict the relationships between systems or between components of a system. ***Develop or use a model to identify and describe the components of a system.*** ***Develop or use a model to identify and describe the relationships between the components of a system.*** ***Develop or use a model to predict relationships between systems or within a system.*** ***Identify that models can help illustrate relationships between systems or within a system.***	***The processes of photosynthesis (making oxygen and sugar) are done in plants, photosynthetic bacteria and protists.*** ***Photosynthesis transforms light energy into stored chemical energy by converting carbon dioxide plus water into sugars plus released oxygen.*** ***The energy needed for most life is ultimately derived from the sun through photosynthesis.*** ***Plants, algae (including phytoplankton), and other energy fixing microorganisms use sunlight, water, and carbon dioxide to facilitate photosynthesis, which stores energy, forms plant matter, releases oxygen, and maintains plants' activities.***	be described in terms of energy and matter flows into, out of, and within that system. ***The processes of energy transformation and energy transfer can be used to understand the changes that take place in physical systems.***

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, and/or laboratory investigations.

Performance Expectation *and Louisiana Connectors*
HS-LS1-6 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. ***LC-HS-LS1-6a Using a model(s), identify how organisms take in matter and rearrange the atoms in chemical reactions to form different products allowing for growth and maintenance.***

Science and Engineering Practice	**Disciplinary Core Idea**	**Crosscutting Concept**
Constructing explanations and designing solutions: Constructing explanations (science) and designing solutions (engineering) in 9-12	**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)	**ENERGY AND MATTER** Changes of energy and matter in a system can be described in terms of

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
builds on K-8 experiences and progresses to explanations and designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific ideas, principles, and theories. • Construct and revise an explanation based on valid and reliable evidence obtained from a variety of sources (including students' own investigations, models, theories, simulations, peer review) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future, and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future. ***Construct an explanation based on valid and reliable evidence from a variety of sources.*** ***Construct an explanation based on valid and reliable evidence from the assumption that theories and laws that describe the natural world operate today as they did in the***	***The processes of photosynthesis (making oxygen and sugar) are done in plants, photosynthetic bacteria and protists.*** ***Photosynthesis transforms light energy into stored chemical energy by converting carbon dioxide plus water into sugars plus released oxygen.*** ***The energy needed for most life is ultimately derived from the sun through photosynthesis.*** ***Plants, algae (including phytoplankton), and other energy fixing microorganisms use sunlight, water, and carbon dioxide to facilitate photosynthesis, which stores energy, forms plant matter, releases oxygen, and maintains plants' activities.*** 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) ***Molecules combine, break apart, and recombine to form necessary compounds for life.*** ***The carbon, hydrogen, and oxygen atoms from sugar molecules formed in or ingested by an organism are those same atoms found in its amino acids and other large carbon-based molecules.*** ***Sugar molecules are composed of carbon, oxygen, and hydrogen.*** ***Amino acids and other carbon-based molecules are composed of carbon, oxygen, and hydrogen.***	energy and matter flows into, out of, and within that system. ***The processes of energy transformation and energy transfer can be used to understand the changes that take place in physical systems.***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
past and will continue to do so in the future. ***Revise an explanation based on valid and reliable evidence from a variety of sources.*** ***Revise an explanation based on valid and reliable evidence from the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future.***		

Clarification Statement
Emphasis is on 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.

Performance Expectation ***and Louisiana Connectors***
HS-LS1-7 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. ***LC-HS-LS1-7a Using a model(s), identify respiration as the transfer of stored energy to the cell to sustain life's processes (i.e., energy to muscles or energy for maintaining body temperature).***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Developing and using models: Modeling in 9-12 builds on K-8	**ORGANIZATION FOR MATTER AND ENERGY FLOW IN ORGANISMS** As matter and energy flow through different organizational levels of living systems, chemical	**ENERGY AND MATTER** Energy cannot be

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
experiences and progresses to using synthesizing and developing models to predict and show relationships among variables between systems and their components in the natural and designed world(s). • Develop, revise, and/or use a model based on evidence to illustrate and/or predict the relationships between systems or between components of a system. ***Develop a model based on evidence to illustrate the relationships between systems.*** ***Develop a model based on evidence to predict the relationships between systems.*** ***Develop a model based on evidence to illustrate the relationships between components of a system.*** ***Develop a model based on evidence to predict the relationships between components of a system.*** ***Revise a model based on evidence to illustrate the relationships between systems.*** ***Revise a model based on evidence to predict the relationships between systems.*** ***Revise a model based on evidence to illustrate the relationships***	elements are recombined in different ways to form different products. (HS.LS1C.c) ***Energy drives the cycling of matter within and between systems.*** ***All organisms take in matter and rearrange the atoms in chemical reactions.*** ***The process of creating the compounds needed for life is done by organisms at a cellular level.*** ***Chemical reactions can create products that are more complex than the reactants.*** ***Chemical reactions involve changes in the energies of the molecules involved in the reaction.*** 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) ***The process of cellular respiration (making energy from sugar) is done in plants and animals.*** ***Cellular respiration in plants and animals involves chemical reactions with oxygen that release stored energy.*** ***In cellular respiration, complex molecules containing carbon react with oxygen to produce carbon dioxide and other materials.*** ***Cellular respiration also releases the energy needed to maintain body temperature.***	created or destroyed—it only moves between one place and another place, between objects and/or fields, or between systems. ***Energy cannot be created or destroyed.*** ***Energy can be transferred from one object to another and can be transformed from one form to another, but the total amount of energy never changes.***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
between components of a system. *Revise a model based on evidence to predict the relationships between components of a system.* *Use a model based on evidence to illustrate the relationships between systems.* *Use a model based on evidence to predict the relationships between systems.* *Use a model based on evidence to illustrate the relationships between components of a system.* *Use a model based on evidence to predict the relationships between components of a system.*		

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.

Performance Expectation *and Louisiana Connectors*
HS-LS1-8 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. *LC-LS1-8a Identify the process by which a virus uses a host cell's functions to make new viruses.* *LC-LS1-8b Recognize that most bacteria reproduce asexually resulting in two cells exactly like the parent cell.* *LC-LS1-8c Identify ways to protect against infectious diseases to maintain a body's health (e.g., eat nutritious food, washing hands, rest, exercise, etc.).* *LC-LS1-8d Identify treatments and/or prevention of viral and/or bacterial infections (e.g., antibiotics and vaccines).*

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Obtaining, evaluating, and communicating information: Obtaining, evaluating, and communicating information in 9-12 builds on K-8 experiences and progresses to evaluating the validity and reliability of the claims, methods, and designs. • Critically read scientific literature adapted for classroom use to determine the central ideas or conclusions and/or to obtain scientific and/or technical information to summarize complex evidence, concepts, processes, or information by presenting them in simpler but still accurate terms. ***Engage in a critical reading of primary scientific literature (adapted for classroom use) to determine the central ideas to summarize complex evidence, concepts, processes, or information by presenting them in simpler but still accurate terms.*** ***Engage in a critical reading of primary scientific literature (adapted for classroom use) to determine the conclusions to summarize complex evidence, concepts, processes, or information***	**PUBLIC HEALTH** Viruses are obligate intracellular parasites that replicate using a cell's protein expression mechanisms. (HS.LS1E.a) ***Viruses are considered nonliving because they are not composed of cells.*** ***Viruses do not use energy to grow or respond to their surroundings.*** ***Obligate intracellular parasites cannot reproduce outside their host cell.*** ***An obligate intracellular parasite is entirely reliant on intracellular resources.*** ***Obligate intracellular parasites of humans include viruses.*** 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) ***A vaccine is a substance that stimulates the body to produce chemicals that destroy viruses, bacteria, or other disease-causing organisms.*** ***Vaccines can prevent some viral and bacterial diseases.*** ***Vaccines are important tools to prevent the spread of infectious diseases.*** Antibiotics are effective treatments against most bacterial infections. Some bacteria may develop resistance to these treatments. (HS.LS1E.c) ***An antibiotic is a chemical that can kill bacteria without harming a person's cells.*** ***Bacterial diseases can be treated with antibiotics.*** ***Resistant bacteria are able to survive in the presence of an antibiotic.*** ***Those bacteria survive and reproduce.*** ***Today, many resistant bacteria exist.*** 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) ***Parasites are organisms that live on or in a host and causes harm to the host.***	**SCALE, PROPORTION, AND QUANTITY** The significance of a phenomenon is dependent on the scale, proportion, and quantity at which it occurs. ***The size and time scales relevant to various objects, systems, and processes determine the significance of a phenomena.*** ***Specific phenomena correspond to a specific scale (e.g., the size of the nucleus of an atom to the size of the galaxy and beyond).***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
by presenting them in simpler but still accurate terms. *Engage in a critical reading of primary scientific literature (adapted for classroom use) to obtain scientific information to summarize complex evidence, concepts, processes, or information by presenting them in simpler but still accurate terms.* *Engage in a critical reading of primary scientific literature (adapted for classroom use) to obtain technical information to summarize complex evidence, concepts, processes, or information by presenting them in simpler but still accurate terms.*	*Parasites and other microorganisms can cause disease.* *Microorganisms can provide beneficial services.* *Bacteria are involved in fuel and food production, environmental recycling and cleanup, and the production of medicines.* *Microorganisms live in a variety of environments.* *Microorganisms can be both parasites and free-living organisms.* Microorganisms can reproduce quickly. (HS.LS1E.e) *Microorganisms can reproduce quickly. Some bacteria can reproduce as often as once every 20 minutes.*	

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.

Performance Expectation *and Louisiana Connectors*
HS-LS2-1 Use mathematical and/or computational representations to support explanations of factors that affect carrying capacity, biodiversity and populations of ecosystems at different scales. *LC-HS-LS2-1a Recognize that the carrying capacities of ecosystems are related to the availability of living and nonliving resources and challenges (e.g., predation, competition, disease).* *LC-HS-LS2-1b Use a graphical representation to identify carrying capacities in ecosystems as limits to the numbers of organisms or populations they can support.*

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Using mathematics and computational thinking: Mathematical and computational thinking in 9-12 builds on K-8 experiences and progresses to using algebraic thinking and analysis, a range of linear and nonlinear functions (e.g., trigonometric, exponential and logarithmic) and computational tools for statistical analysis to analyze, represent, and model data. Simple computational simulations are created and used based on mathematical models of basic assumptions. • Use mathematical, computational, and/or algorithmic representations of phenomena or design solutions to describe and/or support claims and/or explanations. ***Use mathematical or algorithmic forms for scientific modeling of phenomena and/or design solutions to describe claims.*** ***Use mathematical or algorithmic forms for scientific modeling of phenomena and/or design solutions to support claims.*** ***Use mathematical or algorithmic forms for scientific modeling of phenomena and/or design***	**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) ***Carrying capacities are limits to the numbers of organisms and populations an ecosystem can support.*** ***The carrying capacity for a specific population in an ecosystem depends on the resources available.*** ***These limits can be a result of shifting living (predators, competition, and available food) and non-living (shelter, water, and climate) factors within a specific environment.*** ***Given adequate biotic and abiotic resources and no disease or predators, populations increase at rapid rates.*** ***Resources, (limiting factors), predation and climate, limit the growth of populations in specific niches in an ecosystem.*** 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) ***Humans are an integral part of the natural system, and human activities can alter the stability of ecosystems.*** ***Human-related changes to one or more of these factors can result in an ecosystem breaking down or the creation of an entirely new ecosystem.*** ***Human activities have a major effect on other species. For example, increased land use reduces habitat available to other species, pollution changes the chemical composition of air, soil, and water, and introduction of non-native species disrupts the ecological balance.***	**SCALE, PROPORTION, AND QUANTITY** The significance of a phenomenon is dependent on the scale, proportion, and quantity at which it occurs. ***The size and time scales relevant to various objects, systems, and processes determine the significance of a phenomena.*** ***Specific phenomena correspond to a specific scale (e.g., the size of the nucleus of an atom to the size of the galaxy and beyond).***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
solutions to describe explanations. Use mathematical or algorithmic forms for scientific modeling of phenomena and/or design solutions to support explanations.		

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.

Performance Expectation *and Louisiana Connectors*
HS-LS2-4 Use mathematical representations to support claims for the cycling of matter and flow of energy among organisms in an ecosystem. ***LC-HS-LS2-4a Use a graphical or mathematical representation to identify the changes in the amount of matter as it travels through a food web.*** ***LC-HS-LS2-4b Use a graphical or mathematical representation to identify the changes in the amount of energy as it travels through a food web.***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Using mathematics and computational thinking: Mathematical and computational thinking in 9-12 builds on K-8 experiences and progresses to using algebraic thinking and analysis, a range of linear and nonlinear functions (e.g., trigonometric, exponential and logarithmic) and computational tools for statistical analysis to analyze, represent, and model data. Simple computational simulations are created and used based on mathematical models of basic assumptions. • Use mathematical, computational, and/or algorithmic representations of phenomena or design solutions to describe and/or support claims and/or explanations. ***Use mathematical or algorithmic forms for scientific modeling of phenomena and/or design solutions to describe claims.*** ***Use mathematical or algorithmic forms for scientific modeling of phenomena and/or design solutions to support claims.*** ***Use mathematical or algorithmic forms for scientific modeling of phenomena and/or design***	**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) ***Only a fraction of the energy available at the lower level of a food web is transferred up, resulting in fewer organisms at higher levels.*** ***The inefficiency of energy transfer determines the number of trophic levels and affects the relative number of organisms at each trophic level in an ecosystem.*** ***All energy is conserved as it passes from the sun through an ecosystem.*** ***During energy transformations, some energy is converted to unusable heat.*** ***A continual input of energy from the sun keeps the process going.*** ***On average, regardless of scale, 10% of energy is transferred up from one trophic level to another.*** 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) ***Carbon is an essential element cycled through all levels of life from cellular to ecosystems and is required for survival of all living organisms.*** ***Photosynthesis (the main way that solar energy is captured and stored on Earth) and cellular respiration are important components of the carbon cycle, in which carbon is exchanged between living and nonliving systems.*** ***Matter needed to sustain life in ecosystems is continually recycled (e.g., carbon cycle, water cycle, nitrogen cycle, mineral cycles) among organisms and between organisms and the environment.*** 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) ***The processes of photosynthesis (making oxygen and sugar) and cellular respiration (making energy from sugar done in plants and animals) provide most of the energy for life***	**ENERGY AND MATTER: FLOWS, CYCLES, AND CONSERVATION** Energy cannot be created or destroyed—it only moves between one place and another place, between objects and/or fields, or between systems. ***Energy cannot be created or destroyed. Energy can be transferred from one object to another and can be transformed from one form to another, but the total amount of energy never changes.***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
solutions to describe explanations. Use mathematical or algorithmic forms for scientific modeling of phenomena and/or design solutions to support explanations.	***on earth.*** ***The reactants and products of photosynthesis and cellular respiration (aerobic and anaerobic) can be used to relate the Law of Conservation of Matter and the Law of Conservation of Energy to ecosystems, using the carbon cycle can as a reference.***	

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.

Performance Expectation *and Louisiana Connectors*
HS-LS2-6 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. ***LC-HS-LS2-6a Use evidence to identify how modest biological or physical changes versus extreme changes affect stability and change (e.g., number and types of organisms) in ecosystems.*** ***LC-HS-LS2-6b Evaluate explanations of how living things in an ecosystem are affected by changes in the environment (e.g., changes to the food supply, climate change, or the introduction of predators).*** ***LC-HS-LS2-6c Evaluate explanations of how interactions in ecosystems maintain relatively stable conditions, but changing conditions may result in a new ecosystem.***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Engaging in argument from evidence: Engaging in argument from evidence in 9-12 builds on K-8 experiences and progresses to using appropriate and sufficient evidence and scientific reasoning to defend and critique claims and explanations about the natural and designed world(s). Arguments may also come from current scientific or historical episodes in science. • Evaluate the claims, evidence, and/or reasoning behind currently accepted explanations or solutions to determine the merits of arguments. ***Evaluate the claims behind currently accepted explanations to determine the merits of arguments.*** ***Evaluate the claims behind***	**ECOSYSTEM DYNAMICS, FUNCTIONING, AND RESILIENCE** The dynamic 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 and may result in new ecosystems. (HS.LS2C.a) ***Under most circumstances, a natural balance is maintained within an ecosystem.*** ***Organisms both cooperate and compete in ecosystems.*** ***The interrelationships and interdependencies of these organisms may generate complex ecosystems that are stable over long periods of time and tend to have cyclic fluctuations around an equilibrium (i.e., the ecosystem is resilient).*** ***Extreme fluctuations, such as from natural disasters, can challenge the functioning of ecosystems in terms of resources and habitat availability.*** ***These changes can result in an ecosystem breaking down or the creation of an entirely new ecosystem.***	**STABILITY AND CHANGE** Much of science deals with constructing explanations of how things change and how they remain stable. ***Science deals with constructing explanations of how things change.*** ***Science deals with constructing explanations of how things remain stable.***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
currently accepted solutions to determine the merits of arguments. Evaluate the evidence behind currently accepted explanations to determine the merits of arguments. Evaluate the evidence behind currently accepted solutions to determine the merits of arguments. Evaluate the reasoning behind currently accepted explanations to determine the merits of arguments. Evaluate the reasoning behind currently accepted solutions to determine the merits of arguments.		

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. Emphasis should be on describing drivers of ecosystem stability and change, not on the organismal mechanisms of responses and interactions.

Performance Expectation *and Louisiana Connectors*
HS-LS2-7 Design, evaluate, and refine a solution for reducing the impacts of human activities on the environment and biodiversity. ***LC-HS-LS2-7a Describe how people can help protect the Earth's environment and biodiversity (e.g., preserving ecosystems) and how a human activity would threaten Earth's environment and biodiversity (e.g., pollution, damaging habitats, over hunting).*** ***LC-HS-LS2-7b Evaluate or refine a solution to changes in an ecosystem (biodiversity) resulting from a human activity.***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Constructing explanations and designing solutions: Constructing explanations (science) and designing solutions (engineering) in 9-12 builds on K-8 experiences and progresses to explanations and designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific ideas, principles, and theories. • Design, evaluate, and/or refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and trade-off considerations. ***Design a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and trade-off considerations.***	**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) ***Biodiversity helps maintain stability in ecosystems.*** ***However, factors caused by humans (e.g., habitat destruction, pollution, introduction of invasive species) have negative effects on the environment and biodiversity.*** ***Some system changes are irreversible.*** **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) ***Humans depend on the living world for resources.*** ***Thus, protecting the environment and biodiversity helps sustain human life.*** ***Ecosystems undergo major changes as a result of such human-related factors as***	**STABILITY AND CHANGE** Much of science deals with constructing explanations of how things change and how they remain stable. ***Science deals with constructing explanations of how things change.*** ***Science deals with constructing explanations of how things remain stable.***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Evaluate a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and trade-off considerations. ***Refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and trade-off considerations.***	***overpopulation, overexploitation, habitat destruction, pollution, introduction of invasive species, and climate change.*** ***Sustainability of human societies and the biodiversity that supports them require responsible management of natural resources.*** ***Changes in the physical, chemical, or biological conditions of an ecosystem can alter the diversity of species in the system.*** ***Over time, ecosystems change and populations of organisms adapt, move, or become extinct.*** **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) ***It is important to determine the full impact of the advantages and disadvantages when evaluating a solution.*** ***The development of solutions is driven by the following factors: economical, political, cultural, social, safety, and environmental.***	

Clarification Statement
Examples of human activities can include urbanization, building dams, or dissemination of invasive species.

Performance Expectation *and Louisiana Connectors*
HS-LS3-1 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. ***LC-HS-LS3-1a Identify that DNA molecules in all cells contain the instructions for traits passed from parents to offspring.*** ***LC-HS-LS3-1b Identify appropriate questions about the relationships between DNA and chromosomes and how traits are passed from parents to offspring.***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Asking questions and defining problems: Asking questions (science) and defining problems (engineering) in 9-12 builds on K-8 experiences and progresses to formulating, refining, and evaluating empirically testable questions and design problems using models and simulations. • Ask questions that arise from examining models or a theory, to clarify and/or seek additional information and relationships. ***Ask questions that arise from examining models to clarify relationships.*** ***Ask questions that arise from examining models to seek additional information.*** ***Ask questions that arise from examining a theory to clarify relationships.*** ***Ask questions that arise from***	**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 DNA.*** ***DNA contains regions that are called genes.*** ***The sequence of genes contains instructions that code for proteins.*** ***Groups of specialized cells (tissues) use proteins to carry out functions that are essential to the organism.*** **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) ***All cells contain genetic information in the form of DNA molecules.*** ***DNA molecules contain the instructions for forming species' characteristics.*** ***All cells in an organism have the same genetic content.*** ***There are several types of DNA, including DNA that codes for proteins, DNA that is involved in regulatory or structural functions (cell membrane proteins, cyclins), and DNA that has no known function (introns).***	**CAUSE AND EFFECT** Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. ***Evidence is required when attributing an observed phenomenon to a specific cause.*** ***Evidence is required to explain the causal mechanisms in a system under study.*** ***Evidence is required to support a claim about the causal mechanisms in a system under study.***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
examining a theory to seek additional information.	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) ***One allele is provided by each parent of an offspring. In complete dominance, a recessive trait can be carried by an organism. Following this mode of inheritance, a recessive trait will be masked (or will not be apparent) if the dominant allele is present.***	

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.

Performance Expectation ***and Louisiana Connectors***
HS-LS3-2 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. ***LC-HS-LS3-2a Identify a model showing evidence that parents and offspring may have different traits.*** ***LC-HS-LS3-2b Identify that meiosis is a process which distributes genetic material among the new cells (i.e., gametes) produced, which results in genetic variation.*** ***LC-HS-LS3-2c Identify that when DNA makes a copy of itself, sometimes errors occur that may lead to genetic variations.*** ***LC-HS-LS3-2d Identify examples of mutations in DNA caused by environmental factors.*** ***LC-HS-LS3-2e Use evidence to support a claim about a source of inheritable genetic variations.***

Science and Engineering Practice	**Disciplinary Core Idea**	**Crosscutting Concept**
Engaging in argument from evidence: Engaging in argument from evidence in 9-12 builds on K-8 experiences and progresses to using appropriate and sufficient evidence and scientific reasoning to defend and critique claims and explanations about the natural and designed world(s). Arguments may also come from current scientific or historical episodes in science. • Make and defend a claim based on evidence about the natural world or the effectiveness of a design solution that reflects scientific knowledge and student-generated evidence. ***Make and defend a claim based on evidence about the natural world that reflects scientific knowledge and student-generated evidence.***	**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) ***New genetic combinations lead to increased genetic variation.*** ***New genetic combinations are the result of:*** ***• sexual reproduction,*** ***• crossing over and random assortment during meiosis,*** ***• mutations due to errors in DNA replication, or*** ***• environmental influences.*** 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) ***Genes play an important role in shaping how organisms look and act (specific traits of an individual).***	**CAUSE AND EFFECT** Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. ***Evidence is required when attributing an observed phenomenon to a specific cause.*** ***Evidence is required to explain the causal mechanisms in a system under study.*** ***Evidence is required to support a claim about the causal mechanisms in a system under study.***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Make and defend a claim based on evidence about the effectiveness of a design solution that reflects scientific knowledge and student-generated evidence.	***Mutations can be passed to offspring from parents (i.e., mutations that occur in gametes).*** ***Common changes in genes are responsible for many of the normal variations between people such as eye color, hair color, and blood type.*** ***Many common mutations have no negative effects on a person's health.*** 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) ***Environmental factors (climate, diet, pollution, lifestyle) have influence on gene expression.*** ***Mutations can also occur when cells are aging or have been exposed to certain chemicals or radiation.*** ***Inheritable genetic variations may result from new genetic combinations through meiosis, viable errors occurring during replication, and/or 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.

Performance Expectation *and Louisiana Connectors*
HS-LS3-3 Apply concepts of statistics and probability to explain the variation and distribution of expressed traits in a population. ***LC-HS-LS3-3a Calculate the probability (e.g., two out of four) of a particular trait in an offspring based on a completed Punnett square.*** ***LC-HS-LS3-3b Identify examples, using data, of environmental factors which affect the expression of traits, and so then affect the probability of occurrences of traits in a population.***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Analyzing and interpreting data: Analyzing data in 9-12 builds on K-8 experiences and progresses to introducing more detailed statistical analysis, the comparison of data sets for consistency, and the use of models to generate and analyze data. • Apply concepts of statistics and probability (e.g., determining function fits to data and correlation coefficient for linear or nonlinear fits) to scientific and engineering questions and problems, using digital tools when feasible. ***Apply concepts of statistics and probability (e.g., determining function fits to data and correlation coefficient for linear or nonlinear fits) to scientific questions and problems, using digital tools when feasible.*** ***Apply concepts of statistics and probability (e.g., determining***	**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) ***New genetic combinations lead to increased genetic variation.*** ***New genetic combinations are the result of:*** ***• sexual reproduction,*** ***• crossing over and random assortment during meiosis,*** ***• mutations due to errors in DNA replication, or*** ***• environmental influences.*** 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) ***Genes play an important role in shaping how organisms look and act (specific traits of an individual).*** ***Mutations can be passed to offspring from parents (i.e., mutations that occur in gametes).*** ***Common changes in genes are responsible for many of the normal variations between***	**SCALE, PROPORTION, AND QUANTITY** 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). ***Examine scientific data to predict the effect of a change in one variable on another.*** ***Algebraic thinking can be used to explore complex mathematical relationships in science (e.g., the difference between linear growth and exponential growth).***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
function fits to data and correlation coefficient for linear or nonlinear fits) to engineering questions and problems, using digital tools when feasible.	*people such as eye color, hair color, and blood type.* *Many common mutations have no negative effects on a person's health.*	

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.

Performance Expectation *and Louisiana Connectors*
HS-LS4-1 Analyze and interpret scientific information that common ancestry and biological evolution are supported by multiple lines of empirical evidence. ***LC-HS-LS4-1a Identify patterns (e.g., DNA sequences, fossil records) as evidence to a claim of common ancestry.***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Analyzing and interpreting data: Analyzing data in 9-12 builds on K-8 experiences and progresses to introducing more detailed statistical analysis, the comparison of data sets for consistency, and the use of models to generate and analyze data. • Compare and contrast various types of data sets (e.g., self-generated, archival) to examine consistency of measurements and observations. ***Compare and contrast various types of data sets (e.g., self-generated, archival) to examine consistency of measurements.*** ***Compare and contrast various types of data sets (e.g., self-generated, archival) to examine consistency of observations.***	**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) ***Evolution is a change in allelic frequencies of a population over time.*** ***Highly similar DNA sequences among species leads to anatomical similarities and provides evidence of evolution.*** ***Organisms are classified into a hierarchy of groups and subgroups based on similarities in structure, comparisons in DNA and protein and evolutionary relationships.*** ***Differences in DNA sequences among species contributes to the diversity of living things.*** ***The theory of evolution is supported by extensive biochemical, structural, embryological, and fossil evidence.***	**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. ***Patterns can be used to explain phenomena.*** ***Different patterns can be observed at different scales (micro and macro) in a system.*** ***Classifications used at one scale may fail or need revision when information from smaller or larger scales is introduced.***

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.

Performance Expectation *and Louisiana Connectors*
HS-LS4-2 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. ***LC-HS-LS4-2a Recognize that as a species grows in number, competition for limited resources also increases.*** ***LC-HS-LS4-2b Recognize that different individuals have specific traits that give advantages (e.g., survive and reproduce at higher rates) over other individuals in the species.*** ***LC-HS-LS4-2c Identify how evolution may be a result of genetic variation through mutations and sexual reproduction in a species that is passed on to their offspring.***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Constructing explanations and designing solutions: Constructing explanations (science) and designing solutions (engineering) in 9-12 builds on K-8 experiences and progresses to explanations and designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific ideas, principles, and theories. • Construct and revise an explanation based on valid and reliable evidence obtained from a variety of sources (including students' own investigations, models, theories, simulations, peer review) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do in the future.	**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) ***Biological traits become either more or less common in a population through the process of natural selection.*** ***Different factors (including mutations and sexual reproduction) contribute to variation in a population and that natural selection can influence frequencies of heritable traits by providing survival advantages to some individuals.*** ***Four factors primarily influence evolution: (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.*** The traits that positively affect survival are more likely to be reproduced, and thus are more common in the population. (HS.LS4B.c) ***Offspring with advantageous adaptations are more likely to survive and reproduce, thus***	**CAUSE AND EFFECT** Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. ***Evidence is required when attributing an observed phenomenon to a specific cause.*** ***Evidence is required to explain the causal mechanisms in a system under study.*** ***Evidence is required to support a claim about the causal mechanisms in a system under study.***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Construct an explanation based on valid and reliable evidence from a variety of sources. *Construct an explanation based on valid and reliable evidence from the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future.* *Revise an explanation based on valid and reliable evidence from a variety of sources.* *Revise an explanation based on valid and reliable evidence from the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future.*	*increasing the proportion of individuals within a population with advantageous characteristics.*	

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.

Performance Expectation *and Louisiana Connectors*
HS-LS4-3 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. ***LC-HS-LS4-3a Use patterns in data to identify how heritable variations in a trait may lead to an increasing proportion of individuals within a population with that trait (i.e., an advantageous characteristic).***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Analyzing and interpreting data: Analyzing data in 9-12 builds on K-8 experiences and progresses to introducing more detailed statistical analysis, the comparison of data sets for consistency, and the use of models to generate and analyze data. • Apply concepts of statistics and probability (e.g., determining function fits to data and correlation coefficient for linear or nonlinear fits) to scientific and engineering questions and problems, using digital tools when feasible. ***Apply concepts of statistics and probability (e.g., determining function fits to data and correlation coefficient for linear or nonlinear fits) to scientific questions and problems, using digital tools when feasible.*** ***Apply concepts of statistics and probability (e.g., determining function fits to data and correlation***	**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) ***Biological traits become either more or less common in a population through the process of natural selection.*** ***Different factors (including mutations and sexual reproduction) contribute to variation in a population and that natural selection can influence frequencies of heritable traits by providing survival advantages to some individuals.*** ***Four factors primarily influence evolution: (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.*** The traits that positively affect survival are more likely to be reproduced, and thus are more common in the population. (HS.LS4B.c) ***Offspring with advantageous adaptations are more likely to survive and reproduce, thus increasing the proportion of individuals within a population with advantageous characteristics.*** **ADAPTATION** Natural selection leads to adaptation that is, to a population dominated by organisms that are	**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. ***Patterns can be used to explain phenomena.*** ***Different patterns can be observed at different scales (micro and macro) in a system.*** ***Classifications used at one scale may fail or need revision when information from smaller or larger scales is introduced.***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
coefficient for linear or nonlinear fits) to engineering questions and problems, using digital tools when feasible.	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) ***The inheritance of certain traits can lead to a competitive advantage for certain organisms in a population.*** ***Advantages lead to increased survival and/or reproductive rates within the population.*** ***Natural selection leads to adaptation in a population dominated by organisms that are anatomically, behaviorally, and physiologically well suited to survive and reproduce in a specific environment.*** Adaptation also means that the distribution of traits in a population can change when conditions change. (HS.LS4C.b) ***Natural selection causes shifts in the frequency of traits within a population over time.*** ***Relationships between biotic and abiotic differences in ecosystems and their contributions to a change in gene frequency over time, leads to adaptation of populations, and thus, proportional increases in organisms with advantageous heritable traits.***	

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.

Performance Expectation *and Louisiana Connectors*
HS-LS4-4 Construct an explanation based on evidence for how natural selection and other mechanisms lead to genetic changes in populations. ***LC-HS-LS4-4a Use data to provide evidence for how specific biotic or abiotic differences in ecosystems (e.g., ranges of seasonal temperature, acidity, light, geographic barriers) support the claim that organisms with an advantageous heritable trait are better able to survive over time.***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Constructing explanations and designing solutions: Constructing explanations (science) and designing solutions (engineering) in 9-12 builds on K-8 experiences and progresses to explanations and designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific ideas, principles, and theories. • Construct and revise an explanation based on valid and reliable evidence obtained from a variety of sources (including students' own investigations, models, theories, simulations, peer review) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future. ***Construct an explanation based on valid and reliable evidence from a variety of sources.***	**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) ***Biological traits become either more or less common in a population through the process of natural selection.*** ***Different factors (including mutations and sexual reproduction) contribute to variation in a population and that natural selection can influence frequencies of heritable traits by providing survival advantages to some individuals.*** ***Four factors primarily influence evolution: (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.*** Genetic drift and gene flow can lead to genetic changes in populations, not adaptations. (HS.LS4B.b) ***Other factors that influence evolution include: sexual selection, mutation, genetic drift, and genetic modification.*** ***Genetic drift is a mechanism of evolution that affects the genetic makeup of the population through a random process. It does not produce adaptations.*** ***Gene flow moves alleles between populations. Migration is a common way gene flow***	**CAUSE AND EFFECT** Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. ***Evidence is required when attributing an observed phenomenon to a specific cause.*** ***Evidence is required to explain the causal mechanisms in a system under study.*** ***Evidence is required to support a claim about the causal mechanisms in a system under study.***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Construct an explanation based on valid and reliable evidence from the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future. ***Revise an explanation based on valid and reliable evidence from a variety of sources.*** ***Revise an explanation based on valid and reliable evidence from the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future.***	***occurs.*** **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) ***The inheritance of certain traits can lead to a competitive advantage for certain organisms in a population.*** ***Advantages lead to increased survival and/or reproductive rates within the population.*** ***Natural selection leads to adaptation in a population dominated by organisms that are anatomically, behaviorally, and physiologically well suited to survive and reproduce in a specific environment.*** 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) ***Environmental changes have a strong influence on the evolutionary process.*** ***Changes in the physical environment, naturally occurring or human induced, contribute to changes in biodiversity. Changes may include species expansion, invasive species, and extinction.*** ***Possible outcomes of human interactions include changes in the number of individuals of some species, emergence of new species over time, and the extinction of other species.***	

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.

Performance Expectation *and Louisiana Connectors*
HS-LS4-5 Evaluate evidence supporting claims that changes in environmental conditions can affect the distribution of traits in a population causing: (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. ***LC-HS-LS4-5a Identify the relationship between naturally occurring or human-induced changes in the environment (e.g., drought, flood, deforestation, fishing, application of fertilizers) and the expression of traits in a species (e.g., peppered moth studies).*** ***LC-HS-LS4-5b Identify the relationship between naturally occurring or human-induced changes in the environment (e.g., drought, flood, deforestation, fishing, application of fertilizers) and the emergence of new species over time.*** ***LC-HS-LS4-5c Identify that species become extinct because they can no longer survive and reproduce given changes in the environment.***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Engaging in argument from evidence: Engaging in argument from evidence in 9-12 builds on K-8 experiences and progresses to using appropriate and sufficient evidence and scientific reasoning to defend and critique claims and explanations about the natural and designed world(s). Arguments may also come from current scientific or historical episodes in science. • Evaluate the claims, evidence, and/or reasoning behind currently accepted explanations or solutions to determine the merits of arguments. ***Evaluate the claims behind currently accepted explanations to determine the merits of arguments.*** ***Evaluate the claims behind currently accepted solutions to***	**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) ***Environmental changes have a strong influence on the evolutionary process.*** ***Changes in the physical environment, naturally occurring or human-induced, contribute to changes in biodiversity. Changes may include species expansion, invasive species, and extinction.*** ***Possible outcomes of human interactions include changes in the number of individuals of some species, emergence of new species over time, and the extinction of other species.*** 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) ***When a physical change to an organism's environment is sudden and/or extreme, a species becomes extinct when they are no longer able to survive and reproduce.*** ***Thus, drastic changes to an environment limits the possibilities of species' evolution.***	**CAUSE AND EFFECT** Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. ***Evidence is required when attributing an observed phenomenon to a specific cause.*** ***Evidence is required to explain the causal mechanisms in a system under study.*** ***Evidence is required to support a claim about the causal mechanisms in a system under study.***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
determine the merits of arguments. Evaluate the evidence behind currently accepted explanations to determine the merits of arguments. Evaluate the evidence behind currently accepted solutions to determine the merits of arguments. Evaluate the reasoning behind currently accepted explanations to determine the merits of arguments. Evaluate the reasoning behind currently accepted solutions to determine the merits of arguments.		

Clarification Statement
Emphasis is on determining cause and effect relationships for how changes to the environment such as deforestation, overfishing, application of fertilizers, drought, flood, and the rate of change of the environment affect distribution or disappearance of traits in species.

Performance Expectation ***and Louisiana Connectors***
HS-PS1-1 Use the periodic table as a model to predict the relative properties of elements based on the patterns of electrons in the outermost energy level and the composition of the nucleus of atoms. **LC-HS-PS1-1a Identify the periodic table as a model to use to predict the properties of elements.** **LC-HS-PS1-1b Identify that the periodic table was created based on the patterns of electrons in the outermost energy level of atoms.** **LC-HS-PS1-1c Identify that the number of electrons in the outermost energy level of atoms impacts the behavior of the element.** **LC-HS-PS1-1d Identify the periodic table as a model that predicts the number of electrons and other subatomic particles.**

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Developing and using models: Modeling in 9-12 builds on K-8 experiences and progresses to using, synthesizing, and developing models to predict and show relationships among variables between systems and their components in the natural and designed worlds. • Develop, revise, and/or use a model based on evidence to illustrate and/or predict the relationships between systems or between components of a system. **Use a model based on evidence to identify and describe the components of a system.** **Use a model based on evidence to identify and describe the relationships between the components of a system.** **Use a model based on evidence to predict relationships between systems or within a system.**	**STRUCTURE AND PROPERTIES OF MATTER** Each atom has a charged substructure consisting of a nucleus, which is made of protons and neutrons, surrounded by electrons. (HS.PS1A.a) **Atoms are the basic unit of a chemical element.** **Atoms are made of subatomic particles: protons, neutrons, and electrons.** **Atoms have a nucleus.** **The nucleus of an atom is made of positively charged protons and neutrons, which have no net charge.** **A positively charged nucleus is surrounded by smaller negatively charged electrons.** The periodic table orders elements horizontally by the number of protons in the atom's nucleus and places those with similar chemical properties in columns. The repeating patterns of this table reflect patterns of outer electron states. (HS.PS1A.b) **Electrons in the outermost energy level are called valence electrons.** **The periodic table of elements is an arrangement of the chemical elements ordered by atomic number or the number of protons in atoms.** **The periodic table is used to predict the patterns of behavior of elements.** **The arrangement of the groups of the periodic table reflects the patterns of electrons in the outermost energy level of atoms, and therefore, the chemical properties of the elements in each group.** **The atomic mass listed for each element on the periodic table corresponds to the relative abundance of that element's different isotopes.**	**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. **Patterns can be used to explain phenomena.** **Different patterns can be observed at different scales (micro and macro) in a system.** **Classifications used at one scale may fail or need revision when information from smaller or larger scales is introduced.**

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Identify that models can help illustrate relationships between systems or within a system.	**TYPES OF INTERACTIONS** Attraction and repulsion between electric charges at the atomic scale explain the structure, properties, and transformations of matter, as well as the contact forces between material objects. (HS.PS2B.c) **The patterns and behaviors of elements are based on the attraction and repulsion between electrically charged particles and the patterns of the outermost electrons.** **The reactivity and electronegativity of atoms can be determined by an element's location on the periodic table and its valence electrons attraction to the nucleus.** **The number and types of bonds formed by an element and between elements, the number and charges of stable ions, and the relative sizes of atoms can be determined by an element's location on the periodic table.**	

Clarification Statement	
Physical Science	Examples of properties that could be predicted from patterns could include metals, nonmetals, metalloids, number of valence electrons, types of bonds formed, or atomic mass. Emphasis is on main group elements.
Chemistry	Examples of properties that could be predicted from patterns could include reactivity of metals, types of bonds formed, numbers of bonds formed, atomic radius, atomic mass, or reactions with oxygen. Emphasis is on main group elements and qualitative understanding of the relative trends of ionization energy and electronegativity.

Performance Expectation ***and Louisiana Connectors***
HS-PS1-2 Construct and revise an explanation for the outcome of a simple chemical reaction based on the outermost electron states of atoms, trends in the periodic table, and knowledge of the patterns of chemical properties. **LC-HS-PS1-2a Identify an explanation for the outcome of a simple chemical reaction based on the outermost electron states of atoms.** **LC-HS-PS1-2b Identify an explanation for the outcome of a simple chemical reaction based on trends in the periodic table.** **LC-HS-PS1-2c Construct an explanation for the outcome of a simple chemical reaction based on the chemical properties of the elements involved.**

Science and Engineering Practice	**Disciplinary Core Idea**	**Crosscutting Concept**
Constructing explanations and designing solutions: Constructing explanations (science) and designing solutions (engineering) in 9-12 builds on K-8 experiences and progresses to explanations and designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific ideas, principles, and theories. • Construct and revise an explanation based on valid and reliable evidence obtained from a variety of sources (including students' own investigations, models, theories, simulations, peer review) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future. **Construct an explanation based on valid and reliable evidence from a**	**STRUCTURE AND PROPERTIES OF MATTER** The periodic table orders elements horizontally by the number of protons in the atom's nucleus and places those with similar chemical properties in columns. The repeating patterns of this table reflect patterns of outer electron states. (HS.PS1A.b) **Electrons in the outermost energy level are called valence electrons.** **The periodic table of elements is an arrangement of the chemical elements ordered by atomic number as determined by an atoms number of protons.** **The periodic table is used to predict the patterns of behavior of elements.** **The arrangement of the groups of the periodic table reflects the patterns of electrons in the outermost energy level of atoms, and therefore, the chemical properties of the elements in each group.** **The atomic mass listed for each element on the periodic table corresponds to the relative abundance of that element's different isotopes.** **CHEMICAL REACTIONS** The fact that atoms are conserved, together with knowledge of the chemical properties of the elements involved, can be used to describe and predict chemical reactions. (HS.PS1B.c) **A chemical reaction is the process in which substances undergo chemical changes that results in the formation of new substances.** **Atoms are conserved in chemical reactions.** **Predicting involves making an inference about a future event based on evidence.**	**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. **Patterns can be used to explain phenomena.** **Different patterns can be observed at different scales (micro and macro) in a system.** **Classifications used at one scale may fail or need revision when information from smaller or larger scales is introduced.**

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
variety of sources. Construct an explanation based on valid and reliable evidence from the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future. Revise an explanation based on valid and reliable evidence from a variety of sources. Revise an explanation based on valid and reliable evidence from the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future.	An element's chemical and physical properties can be predicted knowing only its position on the periodic table.	

Clarification Statement	
Physical Science	Examples of chemical reactions could include the reaction of sodium and chlorine, carbon and oxygen, or hydrogen and oxygen. Reaction classification includes synthesis, decomposition, single displacement, double displacement, and acid-base.
Chemistry	Examples of chemical reactions could include the reaction of sodium and chlorine, carbon and oxygen, or carbon and hydrogen. Reaction classification aids in the prediction of products (e.g., synthesis, decomposition, single displacement, double displacement, and acid-base).

Performance Expectation ***and Louisiana Connectors***
HS-PS1-7 Use mathematical representations to support the claim that atoms, and therefore mass, are conserved during a chemical reaction. **LC-HS-PS1-7a Identify a chemical equation, and identify the reactants and products which support the claim that matter (i.e., atoms) is neither created or destroyed in a chemical reaction.** **LC-HS-PS1-7b Identify a mathematical representation (e.g., table, graph) or pictorial depictions that illustrates the claim that mass is conserved during a chemical reaction.**

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Using mathematics and computational thinking: Mathematical and computational thinking in 9-12 builds on K-8 experiences and progresses to using algebraic thinking and analysis, a range of linear and nonlinear functions, including computational tools for statistical analysis to analyze, represent, and model data. Simple computational simulations are created and used based on mathematical models of basic assumptions. • Use mathematical, computational, and/or algorithmic representations of phenomena or design solutions to describe and/or support claims and/or explanations. **Use mathematical or algorithmic forms for scientific modeling of phenomena to describe claims.** **Use mathematical or algorithmic forms for scientific modeling of**	**CHEMICAL REACTIONS** The fact that atoms are conserved, together with knowledge of the chemical properties of the elements involved, can be used to describe and predict chemical reactions. (HS.PS1B.c) **A chemical reaction is the process in which substances undergo chemical changes that results in the formation of new substances.** **Atoms are conserved in chemical reactions.** **Predicting involves making an inference about a future event based on evidence.** **An element's chemical and physical properties can be predicted knowing only its position on the periodic table.** **The periodic table can be used to predict the outcome of chemical reactions.**	**ENERGY AND MATTER** The total amount of energy and matter in closed systems is conserved. **When materials interact within a closed system, the total mass of the system remains the same.** **When materials interact within a closed system, energy may change forms, but the total amount of energy within the system remains the same.**

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
design solutions to describe claims. Use mathematical or algorithmic forms for scientific modeling of phenomena to support claims. Use mathematical or algorithmic forms for scientific modeling of design solutions to support claims. Use mathematical or algorithmic forms for scientific modeling of phenomena to describe explanations. Use mathematical or algorithmic forms for scientific modeling of design solutions to describe explanations. Use mathematical or algorithmic forms for scientific modeling of phenomena to support explanations. Use mathematical or algorithmic forms for scientific modeling of design solutions to support explanations.		

Clarification Statement	
Physical Science	Emphasis is on using mathematical ideas to communicate the relationship between masses of reactants and products as well as balancing chemical equations.
Chemistry	Emphasis is on using mathematical ideas as they relate to stoichiometry to communicate the proportional relationships between masses of atoms in the reactants and the products, and the translation of these relationships to the macroscopic scale using the mole as the conversion from the atomic to the

Clarification Statement	
	macroscopic scale. Emphasis is on assessing students' use of mathematical thinking and not on memorization and rote application of problem-solving techniques.

Performance Expectation ***and Louisiana Connectors***
HS-PS1-8 Develop models to illustrate the changes in the composition of the nucleus of the atom and the energy released during the processes of fission, fusion, and radioactive decay. **LC-HS-PS1-8a Identify models that illustrate nuclear processes (i.e., fusion, fission, and radioactive decays), involve the release or absorption of energy.** **LC-HS-PS1-8b Contrast changes during the processes of alpha, beta, or gamma radioactive decay using graphs or pictorial depictions of the composition of the nucleus of the atom and the energy released.**

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Developing and using models: Modeling in 9-12 builds on K-8 experiences and progresses to using, synthesizing, and developing models to predict and show relationships among variables between systems and their components in the natural and designed world(s). • Develop, revise, and/or use a model based on evidence to illustrate and/or predict the relationships between systems or between components of a system. **Develop or use a model to identify and describe the components of a system.** **Develop or use a model to identify and describe the relationships between the components of a system.** **Develop or use a model to predict relationships between systems or within a system.** **Identify that models can help**	**NUCLEAR PROCESSES** Nuclear processes, including fusion, fission, and radioactive decays of unstable nuclei, involve release or absorption of energy. The total number of neutrons plus protons does not change in any nuclear process. (HS.PS1C.a) **Fission, fusion, and radioactive decay (alpha, beta, and gamma) are nuclear processes.** **Nuclear fission and fusion reactions release energy.** **In fission reactions, an atom is split into two or more smaller atoms.** **In fusion reactions, two smaller atoms fuse together to create a heavier atom.** **When a nuclear process takes place, radioactive particles and/or gamma radiation may be produced.** **Radioactive decay is the breakdown of an atomic nucleus resulting in the release of energy and matter from the nucleus.** **The total number of neutrons plus protons is the same both before and after the nuclear process of radioactive decay.** **Typically nuclear processes release much more energy per atom involved than do chemical processes.** **The energy that is released or absorbed during nuclear processes are harmful to human tissues.**	**ENERGY AND MATTER** In nuclear processes, atoms are not conserved, but the total number of protons plus neutrons is conserved. **The total number of protons plus neutrons is the same before and after nuclear processes occur.**

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
illustrate relationships between systems or within a system.		

Clarification Statement	
Physical Science	Emphasis is only on simple qualitative models, such as pictures or diagrams, and on the scale of energy released in nuclear processes relative to other kinds of transformations. Radioactive decay focus is on its relationship to half-life.
Chemistry	Emphasis is on simple qualitative models, such as pictures or diagrams, and on the scale of energy released in nuclear processes relative to other kinds of transformations. Emphasis is on alpha, beta, and gamma radioactive decays.

Performance Expectation *and Louisiana Connectors*
HS-PS2-1 Analyze data to support the claim that Newton's second law of motion describes the mathematical relationship among the net force on a macroscopic object, its mass, and its acceleration. **LC-HS-PS2-1a Predict changes in the motion of a macroscopic object, such as a falling object, an object rolling down a ramp, or a moving object being pulled by a constant force using data (e.g., tables or graphs of position or velocity as a function of time for an object subject to a net unbalanced force).**

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Analyzing and interpreting data: Analyzing data in 9-12 builds on K-8 experiences and progresses to introducing more detailed statistical analysis, the comparison of data sets for consistency, and the use of models to generate and analyze data. • Analyze data using tools, technologies, and/or models (e.g., computational, mathematical) in order to make valid and reliable scientific claims or determine an optimal design solution. **Analyze data using tools in order to make valid and reliable scientific claims.** **Analyze data using tools in order to determine an optimal design solution.** **Analyze data using technology in order to make valid and reliable scientific claims.** **Analyze data using technology in order to determine an optimal**	**FORCES AND MOTION** Newton's second law accurately predicts changes in the motion of macroscopic objects. (HS.PS2.A.a) **Unbalanced forces applied to an object will cause acceleration.** **The size of this acceleration is determined by the mass of the object and the size of force applied.** **Forces might change the motion of objects (e.g., During tug-of-war, if forces on opposite teams are equal, the rope will not move.).** **Forces change the motion of objects. Newton's Laws can be used to predict these changes.** **Newton's second law describes the effects of the size of the total force and the object's mass on its resulting acceleration.** **The reason why objects may react differently to equal sized forces is explained by Newton's second law.**	**CAUSE AND EFFECT** Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. **Evidence is required when attributing an observed phenomenon to a specific cause.** **Evidence is required to explain the causal mechanisms in a system under study.** **Evidence is required to support a claim about the causal mechanisms in a system under study.**

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
design solution. **Analyze data using models in order to make valid and reliable scientific claims.** **Analyze data using models in order to determine an optimal design solution.**		

Clarification Statement	
Physical Science	Examples of data could include tables or graphs of position or velocity as a function of time for objects subject to a net unbalanced force, such as a falling object, an object rolling down a ramp, or a moving object being pulled by a constant force. Emphasis is on one-dimensional motion and macroscopic objects moving at nonrelativistic speeds.
Chemistry	Examples of data could include tables or graphs of position or velocity as a function of time for objects subject to a net unbalanced force, such as a falling object, an object rolling down a ramp, or a moving object being pulled by a constant force. Emphasis is on kinematics, one-dimensional motion, two-dimensional motion, and macroscopic objects moving at non-relativistic speeds.

Performance Expectation ***and Louisiana Connectors***
HS-PS2-2 Use mathematical representations to support the claim that the total momentum of a system of objects is conserved when there is no net force on the system. **LC-HS-PS2-2a Identify an example of the law of conservation of momentum (e.g., in a collision, the momentum change of an object is equal to and opposite of the momentum change of the other object) represented using graphical or visual displays (e.g., pictures, pictographs, drawings, written observations, tables, charts).**

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Using mathematics and computational thinking: Mathematical and computational thinking in 9-12 builds on K-8 experiences and progresses to using algebraic thinking and analysis, a range of linear and nonlinear functions, including computational tools for statistical analysis to analyze, represent, and model data. Simple computational simulations are created and used based on mathematical models of basic assumptions. • Use mathematical, computational, and/or algorithmic representations of phenomena or design solutions to describe and/or support claims and/or explanations. **Use mathematical or algorithmic forms for scientific modeling of phenomena to describe claims.** **Use mathematical or algorithmic**	**FORCES AND MOTION** Momentum is defined for a particular frame of reference; it is the mass times the velocity of the object. In any system, total momentum is always conserved. (HS.PS2A.b) **Momentum is the product of an object's mass and its velocity.** **Momentum is determined by the speed of an object and the direction it is traveling (velocity) of an object and the object's mass.** **The momentum of an object is in the same direction as its velocity.** **The more momentum an object has, the harder it is to stop.** **The Law of Conservation of Momentum can be used to predict the outcomes of collisions between objects and can aid in understanding the energy transfers and energy transformations in these collisions.** If a system interacts with objects outside itself, the total momentum of the system can change; however, any such change is balanced by changes in the momentum of objects outside the system. (HS.PS2A.c) **Momentum is conserved as long as there are no new objects added to the system.** **The total momentum of any group of objects remains the same unless outside forces act on the object.** **Only unbalanced forces can change the momentum of an object.** **An impulse represents how much the momentum of an object changes when a force acts on it over a period of time.**	**SYSTEMS AND SYSTEM MODELS** When investigating or describing a system, the boundaries and initial conditions of the system need to be defined and their inputs and outputs analyzed and described using models. **Making models helps people understand things they cannot observe directly.** **Scientists use models to represent things that are either very large or very small.** **Any model of a system incorporates assumptions and approximations (e.g., the boundaries and initial conditions of the**

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
forms for scientific modeling of design solutions to describe claims. Use mathematical or algorithmic forms for scientific modeling of phenomena to support claims. Use mathematical or algorithmic forms for scientific modeling of design solutions to support claims. Use mathematical or algorithmic forms for scientific modeling of phenomena to describe explanations. Use mathematical or algorithmic forms for scientific modeling of design solutions to describe explanations. Use mathematical or algorithmic forms for scientific modeling of phenomena to support explanations. Use mathematical or algorithmic forms for scientific modeling of design solutions to support explanations.	The impulse describes the relationship between the force acting on an object and the change it produces in the object's momentum.	system, inputs and outputs). It is critical to be aware of a system's physical, chemical, biological, and social interactions and how they affect the model's reliability and precision.

Clarification Statement	
Physical Science	Emphasis is on calculating momentum and the qualitative meaning of conservation of momentum.
Chemistry	Emphasis is on the quantitative conservation of momentum in interactions and the qualitative meaning of this principle as well as systems of two macroscopic bodies moving in one dimension.

Performance Expectation ***and Louisiana Connectors***
HS-PS2-3 Apply scientific and engineering ideas to design, evaluate, and refine a device that minimizes the force on a macroscopic object during a collision. **LC-HS-PS2-3a Evaluate a device (e.g., football helmet or a parachute) designed to minimize force by comparing data (i.e., momentum, mass, velocity, force, or time).**

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Constructing explanations and designing solution: Constructing explanations (science) and designing solutions (engineering) in 9-12 builds on K-8 experiences and progresses to explanations and designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific ideas, principles, and theories. • Design, evaluate, and/or refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations. **Design a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations.** **Evaluate a solution to a complex real-world problem, based on**	**FORCES AND MOTION** If a system interacts with objects outside itself, the total momentum of the system can change; however, any such change is balanced by changes in the momentum of objects outside the system. (HS.PS2A.c) **Momentum is conserved as long as there are no new objects added to the system.** **The total momentum of any group of objects remains the same unless outside forces act on the object.** **Only unbalanced forces can change the momentum of an object.** **An impulse represents how much the momentum of an object changes when a force acts on it over a periods of time.** **The impulse describes the relationship between the force acting on an object and the change it produces in the object's momentum.** **DEFINING AND DELIMITING ENGINEERING PROBLEMS** Criteria and constraints also include satisfying any requirements set by society, such as taking issues of risk mitigation into account, and they should be quantified to the extent possible and stated in such a way that one can tell if a given design meets them. (HS.ETS1A.a) **A first step in designing a device to solve a problem is prioritizing criteria and constraints for the design of the device.** **The social, economic, and political forces of a society have a significant influence on what science and technology solutions are implemented.** **OPTIMIZING THE DESIGN SOLUTION** Criteria may need to be broken down into simpler ones that can be approached	

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations. **Refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations.**	systematically, and decisions about the priority of certain criteria over others (tradeoffs) may be needed. (HS.ETS1C.a) **It is important to prioritize the benefits and costs of the design of a solution to a problem. The decision as to which criteria are critical and which ones can be traded off is a judgment based on the situation and the needs of the system.**	

Clarification Statement	
Physical Science	Examples of evaluation and refinement could include determining the success of a device at protecting an object from damage such as, but not limited to, impact resistant packaging and modifying the design to improve it. Emphasis is on qualitative evaluations.
Chemistry	Examples of evaluation and refinement could include determining the success of the device at protecting an object from damage and modifying the design to improve it by applying the impulse-momentum theorem. Examples of a device could include a football helmet or an airbag. Emphasis is on qualitative evaluations and/or algebraic manipulations.

Performance Expectation *and Louisiana Connectors*
HS-PS2-5 Plan and conduct an investigation to provide evidence that an electric current can produce a magnetic field and that a changing magnetic field can produce an electric current. **LC-HS-PS2-5a Identify situations and provide evidence where an electric current is producing a magnetic field.** **LC-HS-PS2-5b Identify situations and provide evidence where a magnetic field is producing an electric current.**

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Planning and carrying out Investigations: Planning and carrying out investigations to answer questions or test solutions to problems in 9-12 builds on K-8 experiences and progresses to include investigations that provide evidence for and test conceptual, mathematical, physical, and empirical models. • Plan and conduct an investigation individually and collaboratively to produce data to serve as the basis for evidence, and in the design: decide on types, how much, and accuracy of data needed to produce reliable measurements and consider limitations on the precision of the data (e.g., number of trials, cost, risk, time), and refine the design accordingly. **Plan an investigation individually and collaboratively to produce data to serve as the basis for evidence, and in the design: decide on types,**	**TYPES OF INTERACTIONS** Forces that act over a distance are explained by fields (gravitational, electric, and magnetic) permeating space that can transfer energy through space. Magnets or electric currents cause magnetic fields; electric charges or changing magnetic fields cause electric fields. (HS.PS2B.b) **Moving electric charges produce magnetic fields; changing magnetic fields induce electric currents.** **An electric field is the field around a charged particle that exerts a force on other charged particles.** **A magnetic field is a region around a magnet in which a magnetic force acts. (It is not always an attraction, sometimes it is a repulsion.)** **Moving electric charges produce magnetic fields.** **Electrical energy carried by currents in wires can be used to create magnetic fields.** **Magnets and rotating coils can be used to create electric currents.** **DEFINITIONS OF ENERGY** "Electrical energy" may mean energy stored in a battery or energy transmitted by electric currents. (HS.PS3A.d) **Electrical energy is a form of energy that can be transferred by moving charges through a complete circuit.** **A battery is a combination of two or more electrochemical cells in a series.** **Batteries are portable sources of electrical energy.**	**CAUSE AND EFFECT** Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. **Evidence is required when attributing an observed phenomenon to a specific cause.** **Evidence is required to explain the causal mechanisms in a system under study.** **Evidence is required to support a claim about the causal mechanisms in a system under study.**

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
how much, and accuracy of data needed to produce reliable measurements. Revise an investigation individually and collaboratively to produce data to serve as the basis for evidence. Conduct an investigation individually and collaboratively to produce data to serve as the basis for evidence.		

Clarification Statement	
Physical Science	Emphasis is on designing and conducting investigations including evaluating simple series and parallel circuits. Qualitative evidence is used to explain the relationship between a current-carrying wire and a magnetic compass.
Chemistry	Evidence of changes within a circuit can be represented numerically, graphically, or algebraically using Ohm's law. Emphasis is on designing and conducting investigations using qualitative evidence to determine the relationship between electric current and magnetic fields. Examples of evidence can include movement of a magnetic compass needle when placed in the vicinity of a current-carrying wire, and a magnet passing through a coil that turns on the light of a Faraday flashlight.

Performance Expectation ***and Louisiana Connectors***
HS-PS3-2 Develop and use models to illustrate that energy at the macroscopic scale can be accounted for as a combination of energy associated with the motions of particles/objects and energy associated with the relative positions of particles/objects. **LC-HS-PS3-2a Identify that two factors, an object's mass and height above the ground, affect gravitational potential energy (i.e., energy stored due to position of an object above Earth) at the macroscopic level.** **LC-HS-PS3-2b Identify that the mass of an object and its speed determine the amount of kinetic energy the object possesses.**

Science and Engineering Practice	**Disciplinary Core Idea**	**Crosscutting Concept**
Developing and using models: **Developing and using models:** Modeling in 9-12 builds on K-8 experiences and progresses to using, synthesizing, and developing models to predict and show relationships among variables between systems and their components in the natural and designed world(s). • Develop, revise, and/or use a model based on evidence to illustrate and/or predict the relationships between systems or between components of a system. **Develop or use a model to identify and describe the components of a system.** **Develop or use a model to identify and describe the relationships between the components of a system.** **Develop or use a model to predict relationships between systems or within a system.**	**DEFINITIONS OF ENERGY** Energy is a quantitative property of a system that depends on the motion and interactions of matter and radiation within that system. There is a single quantity called energy. A system's total energy is conserved, even as, within the system, energy is continually transferred from one object to another and between its various possible forms. (HS.PS3A.a) **Energy is the ability to do work or cause change.** **Energy transforms from one form to another, but these transformations are not always reversible.** **A system's total energy is conserved regardless of the transfers within the system.** **The total energy of a system changes only by the amount of energy transferred into and out of the system.** At the macroscopic scale, energy manifests itself in multiple ways, such as in motion, sound, light, and thermal energy. (HS.PS3A.b) **Energy takes many forms; forms may include motion, sound, light, and thermal energy.** These relationships are better understood at the microscopic scale, at which all of the different manifestations of energy can be modeled as a combination of energy associated with the motion of particles and energy associated with the configuration (relative position of the particles). In some cases the relative position energy can be thought of as stored in fields (which mediate interactions between particles). This last concept includes radiation, a phenomenon in which energy stored in fields moves across space. (HS.PS3A.c)	**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. **Energy cannot be created or destroyed. Energy can be transferred from one object to another and can be transformed from one form to another, but the total amount of energy never changes.**

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Identify that models can help illustrate relationships between systems or within a system.	**Energy can be modeled as either motions of particles or as stored in force fields (electric, magnetic, gravitational).** **At the microscopic scale, energy can be understood as a force that mediates interactions between particles.** **Electromagnetic radiation is a phenomenon in which energy stored in fields moves across space (light, radio waves) with no supporting matter medium.**	

Clarification Statement	
Physical Science	Emphasis is on designing and conducting investigations including evaluating simple series and parallel circuits. Qualitative evidence is used to explain the relationship between a current-carrying wire and a magnetic compass.
Chemistry	Evidence of changes within a circuit can be represented numerically, graphically, or algebraically using Ohm's law. Emphasis is on designing and conducting investigations using qualitative evidence to determine the relationship between electric current and magnetic fields. Examples of evidence can include movement of a magnetic compass needle when placed in the vicinity of a current-carrying wire, and a magnet passing through a coil that turns on the light of a Faraday flashlight.

Performance Expectation *and Louisiana Connectors*
HS-PS3-3 Design, build, and refine a device that works within given constraints to convert one form of energy into another form of energy. **LC-HS-PS3-3a Identify the forms of energy that will be converted by a device that converts one form of energy into another form of energy.** **LC-HS-PS3-3b Identify steps in a model of a device showing the transformations of energy that occur (e.g., solar cells, solar ovens, generators, turbines).** **LC-HS-PS3-3c Describe constraints to the design of the device which converts one form of energy into another form of energy (e.g., cost or efficiency of energy conversion).**

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Constructing explanations and designing solutions: Constructing explanations (science) and designing solutions (engineering) in 9-12 builds on K-8 experiences and progresses to explanations and designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific ideas, principles, and theories. • Design, evaluate, and/or refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations. **Design a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations.** **Evaluate a solution to a complex**	**DEFINITIONS OF ENERGY** At the macroscopic scale, energy manifests itself in multiple ways, such as in motion, sound, light, and thermal energy. (HS.PS3A.b) **Energy takes many forms; forms of energy are motion, sound, light, and thermal energy.** **ENERGY IN CHEMICAL PROCESSES** Although energy cannot be destroyed, it can be converted to other forms—for example, to thermal energy in the surrounding environment. (HS.PS3D.a) **A system does not destroy energy when carrying out any process.** **When carrying out a process, most often some or all of the energy has been transferred to heat the surrounding environment.** **Energy can be transformed into other energy forms.** **To produce energy typically means to convert some stored energy into a desired form.** **DEFINING AND DELIMITING ENGINEERING PROBLEMS** Criteria and constraints also include satisfying any requirements set by society, such as taking issues of risk mitigation into account, and they should be quantified to the extent possible and stated in such a way that one can tell if a given design meets them. (HS.ETS1A.a) **A first step in designing a device to solve a problem is prioritizing criteria and constraints for the design of the device.**	**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. **The processes of energy transformation and energy transfer can be used to understand the changes that take place in physical systems.**

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations. **Refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations.**	**The social, economic, and political forces of a society have a significant influence on what science and technology solutions are implemented.**	

Clarification Statement	
Physical Science	Emphasis is on qualitative evaluations of devices. Constraints could include use of renewable energy forms and efficiency. Emphasis is on devices constructed with teacher approved materials. Examples of devices can be drawn from chemistry or physics clarification statements below.
Chemistry	Emphasis is on both qualitative and quantitative evaluations of devices. Constraints could include use of renewable energy forms and efficiency. Focus of quantitative evaluations is limited to total output for a given input. Emphasis is on devices constructed with teacher approved materials. Examples of devices in chemistry could include hot/cold packs and batteries.
Physics	Emphasis is on both qualitative and quantitative evaluations of devices. Constraints could include use of renewable energy forms and efficiency. Focus of quantitative evaluations is limited to total output for a given input. Emphasis is on devices constructed with teacher approved materials. Examples of devices in physics could include Rube Goldberg devices, wind turbines, solar cells, solar ovens, and electric motors.

Performance Expectation ***and Louisiana Connectors***
HS-PS3-4 Plan and conduct an investigation to provide evidence that the transfer of thermal energy when two components of different temperature are combined within a closed system results in a more uniform energy distribution among the components in the system (second law of thermodynamics). **LC-HS-PS3-4a Identify the temperatures of two liquids of different temperature before mixing and after combining to show uniform energy distribution.** **LC-HS-PS3-4b Investigate the transfer of thermal energy when two substances are combined within a closed system.**

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Planning and carrying out investigations: Planning and carrying out investigations to answer questions (science) or test solutions to problems (engineering) in 9-12 builds on K-8 experiences and progresses to include investigations that provide evidence for and test conceptual, mathematical, physical, and empirical models. • Plan and conduct an investigation individually and collaboratively to produce data to serve as the basis for evidence, and in the design: decide on types, how much, and accuracy of data needed to produce reliable measurements and consider limitations on the precision of the data (e.g., number of trials, cost, risk, time), and refine the design accordingly. **Plan an investigation individually and collaboratively to produce data to serve as the basis for evidence,**	**CONSERVATION OF ENERGY AND ENERGY TRANSFER** Energy cannot be created or destroyed, but it can be transported from one place to another, transformed into other forms, and transferred between systems. (HS.PS3B.b) **Energy cannot be created or destroyed.** **Energy can be transferred from one object to another and can be transformed from one form to another.** **The processes of energy transformation and energy transfer can be used to understand the changes that take place in physical systems.** Uncontrolled systems always evolve toward more stable states—that is, toward more uniform energy distribution (e.g., water flows downhill, objects hotter than their surrounding environment cool down). (HS.PS3B.e) **Energy can change from one kind to another.** **When two substances (e.g., water or air) of different temperature are combined (within a closed system), the result will be a more uniform temperature (energy) distribution in the system.** **ENERGY IN CHEMICAL PROCESSES AND EVERYDAY LIFE** Although energy cannot be destroyed, it can be converted to less useful other forms—for example, to thermal energy in the surrounding environment. (HS.PS3D.a) **Energy can be transformed into other energy forms.**	**SYSTEMS AND SYSTEM MODELS** When investigating or describing a system, the boundaries and initial conditions of the system need to be defined and their inputs and outputs analyzed and described using models. **Making models helps people understand things they cannot observe directly.** **Scientists use models to represent things that are either very large or very small.** **Any model of a system incorporates assumptions and approximations (e.g., the boundaries and initial conditions of the system, inputs and**

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
and in the design: decide on types, how much, and accuracy of data needed to produce reliable measurements. Revise an investigation individually and collaboratively to produce data to serve as the basis for evidence. Conduct an investigation individually and collaboratively to produce data to serve as the basis for evidence.	When "producing" or "using" energy, most often some or all of the energy has been transferred to heat the surrounding environment.	outputs). It is critical to be aware of a system's physical, chemical, biological, and social interactions and how they affect the model's reliability and precision.

Clarification Statement	
Physical Science, Chemistry, and Physics	Emphasis is on analyzing data from student investigations and using mathematical thinking appropriate to the subject to describe the energy changes quantitatively and conceptually. Examples of investigations could include mixing liquids at different initial temperatures or adding objects at different temperatures to water.

Performance Expectation *and Louisiana Connectors*
HS-PS3-2 Develop and use models to illustrate that energy at the macroscopic scale can be accounted for as a combination of energy associated with the motions of particles/objects and energy associated with the relative positions of particles/objects. **LC-HS-PS3-2a Identify that two factors, an object's mass and height above the ground, affect gravitational potential energy (i.e., energy stored due to position of an object above Earth) at the macroscopic level.** **LC-HS-PS3-2b Identify that the mass of an object and its speed determine the amount of kinetic energy the object possesses.**

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Developing and using models: **Developing and using models:** Modeling in 9-12 builds on K-8 experiences and progresses to using, synthesizing, and developing models to predict and show relationships among variables between systems and their components in the natural and designed world(s). • Develop, revise, and/or use a model based on evidence to illustrate and/or predict the relationships between systems or between components of a system. **Develop or use a model to identify and describe the components of a system.** **Develop or use a model to identify and describe the relationships between the components of a system.** **Develop or use a model to predict relationships between systems or within a system.**	**DEFINITIONS OF ENERGY** Energy is a quantitative property of a system that depends on the motion and interactions of matter and radiation within that system. There is a single quantity called energy. A system's total energy is conserved, even as, within the system, energy is continually transferred from one object to another and between its various possible forms. (HS.PS3A.a) **Energy is the ability to do work or cause change.** **Energy transforms from one form to another, but these transformations are not always reversible.** **A system's total energy is conserved regardless of the transfers within the system.** **The total energy of a system changes only by the amount of energy transferred into and out of the system.** At the macroscopic scale, energy manifests itself in multiple ways, such as in motion, sound, light, and thermal energy. (HS.PS3A.b) **Energy takes many forms; forms may include motion, sound, light, and thermal energy.** These relationships are better understood at the microscopic scale, at which all of the different manifestations of energy can be modeled as a combination of energy associated with the motion of particles and energy associated with the configuration (relative position of the particles). In some cases the relative position energy can be thought of as stored in fields (which mediate interactions between particles). This last concept includes radiation, a phenomenon in which energy stored in fields moves across space. (HS.PS3A.c)	**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. **Energy cannot be created or destroyed. Energy can be transferred from one object to another and can be transformed from one form to another, but the total amount of energy never changes.**

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Identify that models can help illustrate relationships between systems or within a system.	Energy can be modeled as either motions of particles or as stored in force fields (electric, magnetic, gravitational). At the microscopic scale, energy can be understood as a force that mediates interactions between particles. Electromagnetic radiation is a phenomenon in which energy stored in fields moves across space (light, radio waves) with no supporting matter medium.	

Clarification Statement	
Physical Science	Emphasis is on designing and conducting investigations including evaluating simple series and parallel circuits. Qualitative evidence is used to explain the relationship between a current-carrying wire and a magnetic compass.
Chemistry	Evidence of changes within a circuit can be represented numerically, graphically, or algebraically using Ohm's law. Emphasis is on designing and conducting investigations using qualitative evidence to determine the relationship between electric current and magnetic fields. Examples of evidence can include movement of a magnetic compass needle when placed in the vicinity of a current-carrying wire, and a magnet passing through a coil that turns on the light of a Faraday flashlight.

Performance Expectation *and Louisiana Connectors*
HS-PS3-3 Design, build, and refine a device that works within given constraints to convert one form of energy into another form of energy. **LC-HS-PS3-3a Identify the forms of energy that will be converted by a device that converts one form of energy into another form of energy.** **LC-HS-PS3-3b Identify steps in a model of a device showing the transformations of energy that occur (e.g., solar cells, solar ovens, generators, turbines).** **LC-HS-PS3-3c Describe constraints to the design of the device which converts one form of energy into another form of energy (e.g., cost or efficiency of energy conversion).**

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Constructing explanations and designing solutions: Constructing explanations (science) and designing solutions (engineering) in 9-12 builds on K-8 experiences and progresses to explanations and designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific ideas, principles, and theories. • Design, evaluate, and/or refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations. **Design a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations.** **Evaluate a solution to a complex**	**DEFINITIONS OF ENERGY** At the macroscopic scale, energy manifests itself in multiple ways, such as in motion, sound, light, and thermal energy. (HS.PS3A.b) **Energy takes many forms; forms of energy are motion, sound, light, and thermal energy.** **ENERGY IN CHEMICAL PROCESSES** Although energy cannot be destroyed, it can be converted to other forms—for example, to thermal energy in the surrounding environment. (HS.PS3D.a) **A system does not destroy energy when carrying out any process.** **When carrying out a process, most often some or all of the energy has been transferred to heat the surrounding environment.** **Energy can be transformed into other energy forms.** **To produce energy typically means to convert some stored energy into a desired form.** **DEFINING AND DELIMITING ENGINEERING PROBLEMS** Criteria and constraints also include satisfying any requirements set by society, such as taking issues of risk mitigation into account, and they should be quantified to the extent possible and stated in such a way that one can tell if a given design meets them. (HS.ETS1A.a) **A first step in designing a device to solve a problem is prioritizing criteria and constraints for the design of the device.**	**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. **The processes of energy transformation and energy transfer can be used to understand the changes that take place in physical systems.**

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations. **Refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations.**	**The social, economic, and political forces of a society have a significant influence on what science and technology solutions are implemented.**	

Clarification Statement	
Physical Science	Emphasis is on qualitative evaluations of devices. Constraints could include use of renewable energy forms and efficiency. Emphasis is on devices constructed with teacher approved materials. Examples of devices can be drawn from chemistry or physics clarification statements below.
Chemistry	Emphasis is on both qualitative and quantitative evaluations of devices. Constraints could include use of renewable energy forms and efficiency. Focus of quantitative evaluations is limited to total output for a given input. Emphasis is on devices constructed with teacher approved materials. Examples of devices in chemistry could include hot/cold packs and batteries.
Physics	Emphasis is on both qualitative and quantitative evaluations of devices. Constraints could include use of renewable energy forms and efficiency. Focus of quantitative evaluations is limited to total output for a given input. Emphasis is on devices constructed with teacher approved materials. Examples of devices in physics could include Rube Goldberg devices, wind turbines, solar cells, solar ovens, and electric motors.

Performance Expectation *and Louisiana Connectors*
HS-PS3-5 Develop and use a model of two objects interacting through electric or magnetic fields to illustrate the forces between objects and the changes in energy of the objects due to the interaction. **LC-HS-PS3-5a Use a model to identify the cause and effect relationships between forces produced by electric or magnetic fields and the change of energy of the objects in the system.**

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Developing and using models: Modeling in 9-12 builds on K-8 experiences and progresses to using synthesizing and developing models to predict and show relationships among variables between systems and their components in the natural and designed world(s). • Develop, revise, and/or use a model based on evidence to illustrate and/or predict the relationships between systems or between components of a system. **Develop or use a model to identify and describe the components of a system.** **Develop or use a model to identify and describe the relationships between the components of a system.** **Develop or use a model to predict relationships between systems or within a system.** **Identify that models can help**	**RELATIONSHIP BETWEEN ENERGY AND FORCES** When two objects interacting through a field change relative position, the energy stored in the field is changed. (HS.PS3C.a) **When two objects interact, each one exerts a force on the other.** **These forces can transfer energy between the objects.** **Forces between two objects at a distance are explained by force fields (gravitational, electric, or magnetic) between them.** **The energy stored in the field is consistent with the change in energy of the objects.**	**CAUSE AND EFFECT** Cause and effect relationships can be suggested and predicted for complex natural and human-designed systems by examining what is known about smaller scale mechanisms within the system. **An understanding of small scale mechanisms within a system can uncover cause and effect relationships for complex systems (natural and human-designed).** **An understanding of small scale mechanisms within a system can be predictive of cause and effect relationships for**

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
illustrate relationships between systems or within a system.		**complex systems (natural and human-designed).**

Clarification Statement	
Physical Science	Examples of models could include drawings, diagrams, simulations and texts, such as what happens when two charged objects or two magnetic poles are near each other.
Physics	Examples of models could include drawings, diagrams, and texts, such as drawings of what happens when two charges of opposite polarity are near each other.

Performance Expectation ***and Louisiana Connectors***
HS-PS4-1 Use mathematical representations to support a claim regarding relationships among the frequency, wavelength, and speed of waves traveling in various media. **LC-HS-PS4-1a Qualitatively describe cause and effect relationships between changes in wave speed and type of media through which the wave travels using mathematical and graphical representations.** **LC-HS-PS4-1b Identify examples that illustrate the relationship between the frequency and wavelength of a wave.** **LC-HS-PS4-1c Identify evidence that the speed of a wave depends on the media through which it travels.**

Science and Engineering Practice	**Disciplinary Core Idea**	**Crosscutting Concept**
Using mathematics and computational thinking: Mathematical and computational thinking in 9-12 builds on K-8 experiences and progresses to using algebraic thinking and analysis, a range of linear and nonlinear functions (e.g., trigonometric, exponential and logarithmic) and computational tools for statistical analysis to analyze, represent, and model data. Simple computational simulations are created and used based on mathematical models of basic assumptions. • Use mathematical, computational, and/or algorithmic representations of phenomena or design solutions to describe and/or support claims and/or explanations. **Use mathematical or algorithmic forms for scientific modeling of phenomena to describe claims.**	**WAVE PROPERTIES** The wavelength and frequency of a wave are related to one another by the speed of travel of the wave, which depends on the type of wave and the medium through which it is passing. (HS.PS4A.a) **The speed of a wave in a particular medium is constant. For this wave, the frequency and the wavelength are related to one another.** **The speed of a wave can also be affected by the type of material through which it travels.**	**CAUSE AND EFFECT** Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. **Evidence is required when attributing an observed phenomenon to a specific cause.** **Evidence is required to explain the causal mechanisms in a system under study.** **Evidence is required to support a claim about the causal mechanisms in a system under study.**

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Use mathematical or algorithmic forms for scientific modeling of design solutions to describe claims. Use mathematical or algorithmic forms for scientific modeling of phenomena to support claims. Use mathematical or algorithmic forms for scientific modeling of design solutions to support claims. Use mathematical or algorithmic forms for scientific modeling of phenomena to describe explanations. Use mathematical or algorithmic forms for scientific modeling of design solutions to describe explanations. Use mathematical or algorithmic forms for scientific modeling of phenomena to support explanations. Use mathematical or algorithmic forms for scientific modeling of design solutions to support explanations.		

Clarification Statement	
Physical Science	Emphasis is on describing waves both qualitatively and quantitatively. Qualitative focus includes standard repeating waves and transmission/absorption of electromagnetic waves/radiation.

Clarification Statement	
Physics	Examples of data could include electromagnetic radiation traveling through a vacuum and glass, sound waves traveling through air and water, and seismic waves traveling through the Earth. Emphasis is on algebraic relationships and describing those relationships qualitatively.

Performance Expectation *and Louisiana Connectors*
PS4-4 Evaluate the validity and reliability of claims in published materials regarding the effects that different frequencies of electromagnetic radiation have when absorbed by matter. **LC-PS4-4a Recognize the relationship between the damage to living tissue from electromagnetic radiation and the energy of the radiation.**

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Obtaining, evaluating, and communicating information: Obtaining, evaluating, and communicating information in 9-12 builds on K-8 experiences and progresses to evaluating the validity and reliability of the claims, methods, and designs. • Evaluate the validity and reliability of and/or synthesize multiple claims, methods, and/or designs that appear in scientific and technical texts or media reports, verifying the data when possible. **Evaluate the validity and reliability of claims that appear in scientific and technical texts, verifying the data when possible.** **Evaluate the validity and reliability of claims that appear in media reports, verifying the data when possible.** **Evaluate the validity and reliability of methods that appear in scientific and technical texts, verifying the**	**ELECTROMAGNETIC RADIATION** When light or longer wavelength electromagnetic radiation is absorbed in matter, it is generally converted into thermal energy (heat). Shorter wavelength electromagnetic radiation (ultraviolet, X-rays, gamma rays) can ionize atoms and cause damage to living cells. (HS.PS4B.b) **Energy from the sun takes the form of electromagnetic waves such as infrared, visible, and ultraviolet electromagnetic waves.** **Electromagnetic waves carry a single form of energy called electromagnetic (radiant) energy.** **The radiation from the sun consists of a range of energies in the electromagnetic spectrum.** **Electromagnetic radiation when absorbed can be converted to thermal energy.** **Electromagnetic waves carry energy that can have important consequences when transferred to objects or substances.** **Some electromagnetic radiation can cause damage to living cells.**	**CAUSE AND EFFECT** Cause and effect relationships can be suggested and predicted for complex natural and human-designed systems by examining what is known about smaller scale mechanisms within the system. **An understanding of small scale mechanisms within a system can uncover cause and effect relationships for complex systems (natural and human-designed).** **An understanding of small scale mechanisms within a system can be predictive of cause and effect relationships for complex systems**

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
data when possible. **Evaluate the validity and reliability of methods that appear in media reports, verifying the data when possible.** **Evaluate the validity and reliability of designs that appear in scientific and technical texts, verifying the data when possible.** **Evaluate the validity and reliability of designs that appear in media reports, verifying the data when possible.**		**(natural and human-designed).**

Clarification Statement
Emphasis is on the idea that photons associated with different frequencies of light have different energies, and the damage to living tissue from electromagnetic radiation depends on the energy of the radiation. Examples of published materials could include trade books, magazines, web resources, videos, and other passages that may reflect bias. Emphasis is on qualitative descriptions.

Performance Expectation *and Louisiana Connectors*
HS-PS2-2 Use mathematical representations to support the claim that the total momentum of a system of objects is conserved when there is no net force on the system. ***LC-HS-PS2-2a Identify an example of the law of conservation of momentum (e.g., in a collision, the momentum change of an object is equal to and opposite of the momentum change of the other object) represented using graphical or visual displays (e.g., pictures, pictographs, drawings, written observations, tables, charts).***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Analyzing and interpreting data: Analyzing data in 9-12 builds on K-8 experiences and progresses to introducing more detailed statistical analysis, the comparison of data sets for consistency, and the use of models to generate and analyze data. • Analyze data using tools, technologies, and/or models (e.g., computational, mathematical) in order to make valid and reliable scientific claims or determine an optimal design solution. ***Analyze data using tools in order to make valid and reliable scientific claims.*** ***Analyze data using tools in order to determine an optimal design solution.*** ***Analyze data using technology in order to make valid and reliable scientific claims.***	**FORCES AND MOTION** Newton's second law accurately predicts changes in the motion of macroscopic objects. (HS.PS2.A.a) ***Unbalanced forces applied to an object will cause acceleration.*** ***The size of this acceleration is determined by the mass of the object and the size of force applied.*** ***Forces might change the motion of objects (e.g., During tug-of-war, if forces on opposite teams are equal, the rope will not move.).*** ***Forces change the motion of objects. Newton's Laws can be used to predict these changes.*** ***Newton's second law describes the effects of the size of the total force and the object's mass on its resulting acceleration.*** ***The reason why objects may react differently to equal sized forces is explained by Newton's second law.***	**CAUSE AND EFFECT** Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. ***Evidence is required when attributing an observed phenomenon to a specific cause.*** ***Evidence is required to explain the causal mechanisms in a system under study.*** ***Evidence is required to support a claim about the causal mechanisms in a system under study.***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Analyze data using technology in order to determine an optimal design solution. ***Analyze data using models in order to make valid and reliable scientific claims.*** ***Analyze data using models in order to determine an optimal design solution.***		

Clarification Statement	
Physical Science	Examples of data could include tables or graphs of position or velocity as a function of time for objects subject to a net unbalanced force, such as a falling object, an object rolling down a ramp, or a moving object being pulled by a constant force. Emphasis is on one-dimensional motion and macroscopic objects moving at nonrelativistic speeds.
Chemistry	Examples of data could include tables or graphs of position or velocity as a function of time for objects subject to a net unbalanced force, such as a falling object, an object rolling down a ramp, or a moving object being pulled by a constant force. Emphasis is on kinematics, one-dimensional motion, two-dimensional motion, and macroscopic objects moving at non-relativistic speeds.

Performance Expectation *and Louisiana Connectors*
HS-PS2-2 Use mathematical representations to support the claim that the total momentum of a system of objects is conserved when there is no net force on the system. ***LC-HS-PS2-2a Identify an example of the law of conservation of momentum (e.g., in a collision, the momentum change of an object is equal to and opposite of the momentum change of the other object) represented using graphical or visual displays (e.g., pictures, pictographs, drawings, written observations, tables, charts).***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Using mathematics and computational thinking: Mathematical and computational thinking in 9-12 builds on K-8 experiences and progresses to using algebraic thinking and analysis, a range of linear and nonlinear functions, including, computational tools for statistical analysis to analyze, represent, and model data. Simple computational simulations are created and used based on mathematical models of basic assumptions. • Use mathematical, computational, and/or algorithmic representations of phenomena or design solutions to describe and/or support claims and/or explanations. ***Use mathematical or algorithmic forms for scientific modeling of phenomena to describe claims.*** ***Use mathematical or algorithmic***	**FORCES AND MOTION** Momentum is defined for a particular frame of reference; it is the mass times the velocity of the object. In any system, total momentum is always conserved. (HS.PS2A.b) ***Momentum is the product of an object's mass and its velocity.*** ***Momentum is determined by the speed of an object and the direction it is traveling (velocity) of an object and the object's mass.*** ***The momentum of an object is in the same direction as its velocity.*** ***The more momentum an object has, the harder it is to stop.*** ***The Law of Conservation of Momentum can be used to predict the outcomes of collisions between objects and can aid in understanding the energy transfers and energy transformations in these collisions.*** If a system interacts with objects outside itself, the total momentum of the system can change; however, any such change is balanced by changes in the momentum of objects outside the system. (HS.PS2A.c) ***Momentum is conserved as long as there are no new objects added to the system.*** ***The total momentum of any group of objects remains the same unless outside forces act on the object.*** ***Only unbalanced forces can change the momentum of an object.*** ***An impulse represents how much the momentum of an object changes when a force acts on it over a period of time.***	**SYSTEMS AND SYSTEM MODELS** When investigating or describing a system, the boundaries and initial conditions of the system need to be defined and their inputs and outputs analyzed and described using models. ***Making models helps people understand things they cannot observe directly.*** ***Scientists use models to represent things that are either very large or very small.*** ***Any model of a system incorporates assumptions and approximations (e.g., the boundaries and initial conditions of the***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
forms for scientific modeling of design solutions to describe claims. *Use mathematical or algorithmic forms for scientific modeling of phenomena to support claims.* *Use mathematical or algorithmic forms for scientific modeling of design solutions to support claims.* *Use mathematical or algorithmic forms for scientific modeling of phenomena to describe explanations.* *Use mathematical or algorithmic forms for scientific modeling of design solutions to describe explanations.* *Use mathematical or algorithmic forms for scientific modeling of phenomena to support explanations.* *Use mathematical or algorithmic forms for scientific modeling of design solutions to support explanations.*	*The impulse describes the relationship between the force acting on an object and the change it produces in the object's momentum.*	*system, inputs and outputs).* *It is critical to be aware of a system's physical, chemical, biological, and social interactions and how they affect the model's reliability and precision.*

Clarification Statement	
Physical Science	Emphasis is on calculating momentum and the qualitative meaning of conservation of momentum.
Chemistry	Emphasis is on the quantitative conservation of momentum in interactions and the qualitative meaning of this principle as well as systems of two macroscopic bodies moving in one dimension.

Performance Expectation ***and Louisiana Connectors***
HS-PS2-3 Apply scientific and engineering ideas to design, evaluate, and refine a device that minimizes the force on a macroscopic object during a collision. ***LC-HS-PS2-3a Evaluate a device (e.g., football helmet or a parachute) designed to minimize force by comparing data (i.e., momentum, mass, velocity, force, or time).***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Constructing explanations and designing solution: Constructing explanations (science) and designing solutions (engineering) in 9-12 builds on K-8 experiences and progresses to explanations and designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific ideas, principles, and theories. • Design, evaluate, and/or refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations. ***Design a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations.*** ***Evaluate a solution to a complex real-world problem, based on***	**FORCES AND MOTION** If a system interacts with objects outside itself, the total momentum of the system can change; however, any such change is balanced by changes in the momentum of objects outside the system. (HS.PS2A.c) ***Momentum is conserved as long as there are no new objects added to the system.*** ***The total momentum of any group of objects remains the same unless outside forces act on the object.*** ***Only unbalanced forces can change the momentum of an object.*** ***An impulse represents how much the momentum of an object changes when a force acts on it over a periods of time.*** ***The impulse describes the relationship between the force acting on an object and the change it produces in the object's momentum.*** **DEFINING AND DELIMITING ENGINEERING PROBLEMS** Criteria and constraints also include satisfying any requirements set by society, such as taking issues of risk mitigation into account, and they should be quantified to the extent possible and stated in such a way that one can tell if a given design meets them. (HS.ETS1A.a) ***A first step in designing a device to solve a problem is prioritizing criteria and constraints for the design of the device.*** ***The social, economic, and political forces of a society have a significant influence on what science and technology solutions are implemented.*** **OPTIMIZING THE DESIGN SOLUTION** Criteria may need to be broken down into simpler ones that can be approached systematically, and decisions about the priority of certain criteria over others (tradeoffs) may be needed. (HS.ETS1C.a)	**CAUSE AND EFFECT** Systems can be designed to cause a desired effect. ***It is important to describe the design of a solution and the features that make it successful.*** ***An intentional change to a system can cause a desired effect.***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations. *Refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations.*	*It is important to prioritize the benefits and costs of the design of a solution to a problem. The decision as to which criteria are critical and which ones can be traded off is a judgment based on the situation and the needs of the system.*	

Clarification Statement	
Physical Science	Examples of evaluation and refinement could include determining the success of a device at protecting an object from damage such as, but not limited to, impact resistant packaging and modifying the design to improve it. Emphasis is on qualitative evaluations.
Chemistry	Examples of evaluation and refinement could include determining the success of the device at protecting an object from damage and modifying the design to improve it by applying the impulse-momentum theorem. Examples of a device could include a football helmet or an airbag. Emphasis is on qualitative evaluations and/or algebraic manipulations.

Performance Expectation ***and Louisiana Connectors***
HS-PS2-4 Use mathematical representations of Newton's Law of Gravitation and Coulomb's Law to describe and predict the gravitational and electrostatic forces between objects. ***LC-HS-PS2-4a Use Newton's law of universal gravitation as a mathematical model to qualitatively describe or predict the effects of gravitational forces in systems with two objects.*** ***LC-HS-PS2-4b Use Coulomb's law to qualitatively describe or predict the electrostatic forces in systems with two objects.***

Science and Engineering Practice	**Disciplinary Core Idea**	**Crosscutting Concept**
Using mathematics and computational thinking: Mathematical and computational thinking in 9-12 builds on K-8 experiences and progresses to using algebraic thinking and analysis, a range of linear and nonlinear functions (e.g., trigonometric, exponential and logarithmic) and computational tools for statistical analysis to analyze, represent, and model data. Simple computational simulations are created and used based on mathematical models of basic assumptions. • Use mathematical, computational, and/or algorithmic representations of phenomena or design solutions to describe and/or support claims and/or explanations. ***Use mathematical or algorithmic forms for scientific modeling of phenomena to describe claims.*** ***Use mathematical or algorithmic***	**TYPES OF INTERACTIONS** Newton's Law of Universal Gravitation and Coulomb's Law provide the mathematical models to describe and predict the effects of gravitational and electrostatic forces between objects not in physical contact. (HS.PS2B.a) ***Gravitational, electric, and magnetic forces between a pair of objects do not require that they be in contact.*** ***These forces are explained by force fields that contain energy and can transfer energy through space.*** ***Gravitational force is a universal force of attraction that acts between masses, but this force is only significant when one (or both) of the objects is massive (for example, a star, planet or moon).*** ***Newton's Law of Universal Gravitation provides the mathematical model to describe and predict the effects of gravitational forces between distant objects.*** ***Electric forces and magnetic forces are different aspects of a single electromagnetic interaction.*** ***Coulomb's law provides the mathematical model to describe and predict the effects of electrostatic forces (relating to stationary electric charges or fields) between distant objects*** ***Attractive or repulsive forces between objects are relative to their charges and the distance between them (Coulombs Law).*** Forces at a distance are explained by fields (gravitational, electric, and magnetic) permeating space that can transfer energy through space. Magnets or electric currents cause magnetic fields; electric charges or changing magnetic fields cause electric fields. (HS.PS2B.b) ***Moving electric charges produce magnetic fields; changing magnetic fields induce electric currents.***	**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. ***Patterns can be used to explain phenomena.*** ***Different patterns can be observed at different scales (micro and macro) in a system.*** ***Classifications used at one scale may fail or need revision when information from smaller or larger scales is introduced.***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
forms for scientific modeling of design solutions to describe claims. *Use mathematical or algorithmic forms for scientific modeling of phenomena to support claims.* *Use mathematical or algorithmic forms for scientific modeling of design solutions to support claims.* *Use mathematical or algorithmic forms for scientific modeling of phenomena to describe explanations.* *Use mathematical or algorithmic forms for scientific modeling of design solutions to describe explanations.* *Use mathematical or algorithmic forms for scientific modeling of phenomena to support explanations.* *Use mathematical or algorithmic forms for scientific modeling of design solutions to support explanations.*	*An electric field is the field around a charged particle that exerts a force on other charged particles.* *A magnetic field is a region around a magnet in which a magnetic force acts. (It is not always an attraction, sometimes it is a repulsion.)* *Moving electric charges produce magnetic fields.* *Electrical energy carried by currents in wires can be used to create magnetic fields.* *Magnets and rotating coils can be used to create electric currents.*	

Clarification Statement
Emphasis is on both quantitative and conceptual descriptions of gravitational and electric fields.

Performance Expectation *and Louisiana Connectors*
HS-PS2-5 Plan and conduct an investigation to provide evidence that an electric current can produce a magnetic field and that a changing magnetic field can produce an electric current. ***LC-HS-PS2-5a Identify situations and provide evidence where an electric current is producing a magnetic field.*** ***LC-HS-PS2-5b Identify situations and provide evidence where a magnetic field is producing an electric current.***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Planning and carrying out Investigations: Planning and carrying out investigations to answer questions or test solutions to problems in 9-12 builds on K-8 experiences and progresses to include investigations that provide evidence for and test conceptual, mathematical, physical, and empirical models. • Plan and conduct an investigation individually and collaboratively to produce data to serve as the basis for evidence, and in the design: decide on types, how much, and accuracy of data needed to produce reliable measurements and consider limitations on the precision of the data (e.g., number of trials, cost, risk, time), and refine the design accordingly. ***Plan an investigation individually and collaboratively to produce data to serve as the basis for evidence,***	**TYPES OF INTERACTIONS** Forces that act over a distance are explained by fields (gravitational, electric, and magnetic) permeating space that can transfer energy through space. Magnets or electric currents cause magnetic fields; electric charges or changing magnetic fields cause electric fields. (HS.PS2B.b) ***Moving electric charges produce magnetic fields; changing magnetic fields induce electric currents.*** ***An electric field is the field around a charged particle that exerts a force on other charged particles.*** ***A magnetic field is a region around a magnet in which magnetic attraction acts.*** ***Gravity is the force which pulls objects together.*** ***Moving electric charges produce magnetic fields.*** ***Electrical energy carried by currents in wires can be used to create magnetic fields.*** ***Magnets and rotating coils can be used to create electric currents.*** **DEFINITIONS OF ENERGY** "Electrical energy" may mean energy stored in a battery or energy transmitted by electric currents. (HS.PS3A.d) ***Electrical energy is a form of energy that can be transferred by moving charges through a complete circuit.*** ***A battery is a combination of two or more electrochemical cells in a series.*** ***Batteries are portable sources of electrical energy.***	**CAUSE AND EFFECT** Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. ***Evidence is required when attributing an observed phenomenon to a specific cause.*** ***Evidence is required to explain the causal mechanisms in a system under study.*** ***Evidence is required to support a claim about the causal mechanisms in a system under study.***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
and in the design: decide on types, how much, and accuracy of data needed to produce reliable measurements. ***Revise an investigation individually and collaboratively to produce data to serve as the basis for evidence.*** ***Conduct an investigation individually and collaboratively to produce data to serve as the basis for evidence.***		

Clarification Statement	
Physical Science	Emphasis is on designing and conducting investigations including evaluating simple series and parallel circuits. Qualitative evidence is used to explain the relationship between a current-carrying wire and a magnetic compass.
Chemistry	Evidence of changes within a circuit can be represented numerically, graphically, or algebraically using Ohm's law. Emphasis is on designing and conducting investigations using qualitative evidence to determine the relationship between electric current and magnetic fields. Examples of evidence can include movement of a magnetic compass needle when placed in the vicinity of a current-carrying wire, and a magnet passing through a coil that turns on the light of a Faraday flashlight.

Performance Expectation *and Louisiana Connectors*
HS-PS3-1 Create a computational model to calculate the change in the energy of one component in a system when the change in energy of the other component(s) and energy flows in and out of the system are known. ***LC-HS-PS3-1a Identify a model showing the change in the energy of one component in a system compared to the change in energy of another component in the system.*** ***LC-HS-PS3-1b Identify a model showing the change in energy of one component in a system when the change in energy of the other component(s) and energy flows in and out of the system are known.***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Using mathematics and computational thinking: Mathematical and computational thinking in 9-12 builds on K-8 experiences and progresses to using algebraic thinking and analysis, a range of linear and nonlinear functions including, computational tools for statistical analysis to analyze, represent, and model data. Simple computational simulations are created and used based on mathematical models of basic assumptions. • Create and/or revise a computational model or simulation of a phenomenon, designed device, process, or system. ***Create a computational model of a phenomenon.*** ***Revise a computational model of a phenomenon.*** ***Create a simulation of a***	**DEFINITIONS OF ENERGY** Energy is a quantitative property of a system that depends on the motion and interactions of matter and radiation within that system. That there is a single quantity called energy is due to the fact that a system's total energy is conserved, even as, within the system, energy is continually transferred from one object to another and between its various possible forms. (HS.PS3A.a) ***Energy is the ability to do work or cause change.*** ***Energy transforms from one form to another, but these transformations are not always reversible.*** ***A system's total energy is conserved regardless of the transfers within the system.*** ***The total energy of a system changes only by the amount of energy transferred into and out of the system.*** **CONSERVATION OF ENERGY AND ENERGY TRANSFER** Conservation of energy means that the total change of energy in any system is always equal to the total energy transferred into or out of the system. (HS.PS3B.a) ***The law of conservation of energy states that when one form of energy is converted to another, no energy is destroyed in the process.*** ***According to the law of conservation of energy, energy cannot be created or destroyed.*** ***The total change of energy in any system is always equal to the total energy transferred into or out of the system.***	**SYSTEMS AND SYSTEM MODELS** Models can be used to predict the behavior of a system, but these predictions have limited precision and reliability due to the assumptions and approximations inherent in models. ***Models can be valuable in predicting a system's behaviors.*** ***Any model of a system incorporates assumptions and approximations.*** ***As a result, model-based predictions have limited precision and reliability.***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
phenomenon. ***Revise a simulation of a phenomenon.*** ***Create a computational model of a designed device.*** ***Revise a computational model of a designed device.*** ***Create a simulation of a designed device.*** ***Revise a simulation of a designed device.*** ***Create a computational model of a process.*** ***Revise a computational model of a process.*** ***Create a simulation of a process.*** ***Revise a simulation of a process.*** ***Create a computational model of a system.*** ***Revise a computational model of a system.*** ***Create a simulation of a system.*** ***Revise a simulation of a system.***	Energy cannot be created or destroyed, but it can be transported from one place to another and transferred between systems. (HS.PS3B.b) ***Energy cannot be created or destroyed.*** ***Energy can be transferred from one object to another and can be transformed from one form to another.*** ***The processes of energy transformation and energy transfer can be used to understand the changes that take place in physical systems.*** Mathematical expressions allow the concept of conservation of energy to be used to predict and describe system behavior. These expressions quantify how the stored energy in a system depends on its configuration (e.g., relative positions of charged particles, compression of a spring) and how kinetic energy depends on mass and velocity. (HS.PS3B.c) ***The amount of energy available in a system is mathematically calculable.*** ***Mathematical expressions quantify forms of energy in a system.*** ***These forms can be grouped into types of energy that are associated with the motion of mass (kinetic energy), and types of energy associated with the position of mass and energy fields (potential energy).*** The availability of energy limits what can occur in any system. (HS.PC3B.d) ***The amount of energy available in a system determines what the system is capable of doing.***	

Clarification Statement	
Physical Science	Emphasis is on explaining the meaning of mathematical expressions used in the model. Focus is on basic algebraic expression or computations, systems of two or three components, and thermal energy.
Chemistry	Emphasis is on explaining the meaning of mathematical expressions used in the model. Focus is on basic algebraic expression or computations; systems of

Clarification Statement	
	two or three components; and thermal energy, kinetic energy, and/or the energies in gravitational, magnetic, or electric fields.

Performance Expectation ***and Louisiana Connectors***
HS-PS3-2 Develop and use models to illustrate that energy at the macroscopic scale can be accounted for as a combination of energy associated with the motions of particles (objects) and energy associated with the relative positions of particles (objects). ***LC-HS-PS3-2a Identify that two factors, an object's mass and height above the ground, affect gravitational potential energy (i.e., energy stored due to position of an object above Earth) at the macroscopic level.*** ***LC-HS-PS3-2b Identify that the mass of an object and its speed determine the amount of kinetic energy the object possesses.***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Developing and using models: Modeling in 9-12 builds on K-8 experiences and progresses to using, synthesizing, and developing models to predict and show relationships among variables between systems and their components in the natural and designed world(s). • Develop, revise, and/or use a model based on evidence to illustrate and/or predict the relationships between systems or between components of a system. ***Develop or use a model to identify and describe the components of a system.*** ***Develop or use a model to identify and describe the relationships between the components of a system.*** ***Develop or use a model to predict relationships between systems or within a system.*** ***Identify that models can help***	**DEFINITIONS OF ENERGY** Energy is a quantitative property of a system that depends on the motion and interactions of matter and radiation within that system. There is a single quantity called energy. A system's total energy is conserved, even as, within the system, energy is continually transferred from one object to another and between its various possible forms. (HS.PS3A.a) ***Energy is the ability to do work or cause change.*** ***Energy transforms from one form to another, but these transformations are not always reversible.*** ***A system's total energy is conserved regardless of the transfers within the system.*** ***The total energy of a system changes only by the amount of energy transferred into and out of the system.*** At the macroscopic scale, energy manifests itself in multiple ways, such as in motion, sound, light, and thermal energy. (HS.PS3A.b) ***Energy takes many forms; forms may include motion, sound, light, and thermal energy.*** These relationships are better understood at the microscopic scale, at which all of the different manifestations of energy can be modeled as a combination of energy associated with the motion of particles and energy associated with the configuration (relative position of the particles). In some cases the relative position energy can be thought of as stored in fields (which mediate interactions between particles). This last concept includes radiation, a phenomenon in which energy stored in fields moves across space. (HS.PS3A.c)	**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. ***Energy cannot be created or destroyed.*** ***Energy can be transferred from one object to another and can be transformed from one form to another, but the total amount of energy never changes.***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
illustrate relationships between systems or within a system.	*Energy can be modeled as either motions of particles or as stored in force fields (electric, magnetic, gravitational).* *At the microscopic scale, energy can be understood as a force that mediates interactions between particles.* *Electromagnetic radiation is a phenomenon in which energy stored in fields moves across space (light, radio waves) with no supporting matter medium.*	

Clarification Statement	
Physical Science	Emphasis is on designing and conducting investigations including evaluating simple series and parallel circuits. Qualitative evidence is used to explain the relationship between a current-carrying wire and a magnetic compass.
Chemistry	Evidence of changes within a circuit can be represented numerically, graphically, or algebraically using Ohm's law. Emphasis is on designing and conducting investigations using qualitative evidence to determine the relationship between electric current and magnetic fields. Examples of evidence can include movement of a magnetic compass needle when placed in the vicinity of a current-carrying wire, and a magnet passing through a coil that turns on the light of a Faraday flashlight.

Performance Expectation ***and Louisiana Connectors***
HS-PS3-3 Design, build, and refine a device that works within given constraints to convert one form of energy into another form of energy. ***LC-HS-PS3-3a Identify the forms of energy that will be converted by a device that converts one form of energy into another form of energy.*** ***LC-HS-PS3-3b Identify steps in a model of a device showing the transformations of energy that occur (e.g., solar cells, solar ovens, generators, turbines).*** ***LC-HS-PS3-3c Describe constraints to the design of the device which converts one form of energy into another form of energy (e.g., cost or efficiency of energy conversion).***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Constructing explanations and designing solutions: Constructing explanations (science) and designing solutions (engineering) in 9-12 builds on K-8 experiences and progresses to explanations and designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific ideas, principles, and theories. • Design, evaluate, and/or refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations. ***Design a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations.*** ***Evaluate a solution to a complex***	**DEFINITIONS OF ENERGY** At the macroscopic scale, energy manifests itself in multiple ways, such as in motion, sound, light, and thermal energy. (HS.PS3A.b) ***Energy takes many forms; forms may include motion, sound, light, and thermal energy.*** **ENERGY IN CHEMICAL PROCESSES** Although energy cannot be destroyed, it can be converted to other forms—for example, to thermal energy in the surrounding environment. (HS.PS3D.a) ***A system does not destroy energy when carrying out any process.*** ***When carrying out a process, most often some or all of the energy has been transferred to heat the surrounding environment.*** ***Energy can be transformed into other energy forms.*** ***To produce energy typically means to convert some stored energy into a desired form.*** **DEFINING AND DELIMITING ENGINEERING PROBLEMS** Criteria and constraints also include satisfying any requirements set by society, such as taking issues of risk mitigation into account, and they should be quantified to the extent possible and stated in such a way that one can tell if a given design meets them. (HS.ETS1A.a) ***A first step in designing a device to solve a problem is prioritizing criteria and constraints for the design of the device.***	**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. ***The processes of energy transformation and energy transfer can be used to understand the changes that take place in physical systems.***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations. *Refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations.*	*The social, economic, and political forces of a society have a significant influence on what science and technology solutions are implemented.*	

Clarification Statement	
Physical Science	Emphasis is on qualitative evaluations of devices. Constraints could include use of renewable energy forms and efficiency. Emphasis is on devices constructed with teacher approved materials. Examples of devices can be drawn from chemistry or physics clarification statements below.
Chemistry	Emphasis is on both qualitative and quantitative evaluations of devices. Constraints could include use of renewable energy forms and efficiency. Focus of quantitative evaluations is limited to total output for a given input. Emphasis is on devices constructed with teacher approved materials. Examples of devices in chemistry could include hot/cold packs and batteries.
Physics	Emphasis is on both qualitative and quantitative evaluations of devices. Constraints could include use of renewable energy forms and efficiency. Focus of quantitative evaluations is limited to total output for a given input. Emphasis is on devices constructed with teacher approved materials. Examples of devices in physics could include Rube Goldberg devices, wind turbines, solar cells, solar ovens, and electric motors.

Performance Expectation ***and Louisiana Connectors***
HS-PS3-4 Plan and conduct an investigation to provide evidence that the transfer of thermal energy when two components of different temperature are combined within a closed system results in a more uniform energy distribution among the components in the system (second law of thermodynamics). ***LC-HS-PS3-4a Identify the temperatures of two liquids of different temperature before mixing and after combining to show uniform energy distribution.*** ***LC-HS-PS3-4b Investigate the transfer of thermal energy when two substances are combined within a closed system.***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Planning and carrying out investigations: Planning and carrying out investigations to answer questions (science) or test solutions to problems (engineering) in 9-12 builds on K-8 experiences and progresses to include investigations that provide evidence for and test conceptual, mathematical, physical, and empirical models. • Plan and conduct an investigation individually and collaboratively to produce data to serve as the basis for evidence, and in the design: decide on types, how much, and accuracy of data needed to produce reliable measurements and consider limitations on the precision of the data (e.g., number of trials, cost, risk, time), and refine the design accordingly. ***Plan an investigation individually and collaboratively to produce data to serve as the basis for evidence,***	**CONSERVATION OF ENERGY AND ENERGY TRANSFER** Energy cannot be created or destroyed, but it can be transported from one place to another, transformed into other forms, and transferred between systems. (HS.PS3B.b) ***Energy cannot be created or destroyed.*** ***Energy can be transferred from one object to another and can be transformed from one form to another.*** ***The processes of energy transformation and energy transfer can be used to understand the changes that take place in physical systems.*** Uncontrolled systems always evolve toward more stable states—that is, toward more uniform energy distribution (e.g., water flows downhill, objects hotter than their surrounding environment cool down). (HS.PS3B.e) ***Energy can change from one kind to another.*** ***When two substances (e.g., water or air) of different temperature are combined (within a closed system), the result will be a more uniform temperature (energy) distribution in the system.*** **ENERGY IN CHEMICAL PROCESSES AND EVERYDAY LIFE** Although energy cannot be destroyed, it can be converted to less useful other forms—for example, to thermal energy in the surrounding environment. (HS.PS3D.a) ***Energy can be transformed into other energy forms.***	**SYSTEMS AND SYSTEM MODELS** When investigating or describing a system, the boundaries and initial conditions of the system need to be defined and their inputs and outputs analyzed and described using models. ***Making models helps people understand things they cannot observe directly.*** ***Scientists use models to represent things that are either very large or very small.*** ***Any model of a system incorporates assumptions and approximations (e.g., the boundaries and initial conditions of the system, inputs and***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
and in the design: decide on types, how much, and accuracy of data needed to produce reliable measurements. ***Revise an investigation individually and collaboratively to produce data to serve as the basis for evidence.*** ***Conduct an investigation individually and collaboratively to produce data to serve as the basis for evidence.***	***When "producing" or "using" energy, most often some or all of the energy has been transferred to heat the surrounding environment.***	***outputs).*** ***It is critical to be aware of a system's physical, chemical, biological, and social interactions and how they affect the model's reliability and precision.***

Clarification Statement	
Physical Science, Chemistry, and Physics	Emphasis is on analyzing data from student investigations and using mathematical thinking appropriate to the subject to describe the energy changes quantitatively and conceptually. Examples of investigations could include mixing liquids at different initial temperatures or adding objects at different temperatures to water.

Performance Expectation *and Louisiana Connectors*
HS-PS3-5 Develop and use a model of two objects interacting through electric or magnetic fields to illustrate the forces between objects and the changes in energy of the objects due to the interaction. ***LC-HS-PS3-5a Use a model to identify the cause and effect relationships between forces produced by electric or magnetic fields and the change of energy of the objects in the system.***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Developing and using models: Modeling in 9-12 builds on K-8 experiences and progresses to using synthesizing and developing models to predict and show relationships among variables between systems and their components in the natural and designed world(s). • Develop, revise, and/or use a model based on evidence to illustrate and/or predict the relationships between systems or between components of a system. ***Develop or use a model to identify and describe the components of a system.*** ***Develop or use a model to identify and describe the relationships between the components of a system.*** ***Develop or use a model to predict relationships between systems or within a system.*** ***Identify that models can help***	**RELATIONSHIP BETWEEN ENERGY AND FORCES** When two objects interacting through a field change relative position, the energy stored in the field is changed. (HS.PS3C.a) ***When two objects interact, each one exerts a force on the other.*** ***These forces can transfer energy between the objects.*** ***Forces between two objects at a distance are explained by force fields (gravitational, electric, or magnetic) between them.*** ***The energy stored in the field is consistent with the change in energy of the objects.***	**CAUSE AND EFFECT** Cause and effect relationships can be suggested and predicted for complex natural and human-designed systems by examining what is known about smaller scale mechanisms within the system. ***An understanding of small scale mechanisms within a system can uncover cause and effect relationships for complex systems (natural and human-designed).*** ***An understanding of small scale mechanisms within a system can be predictive of cause and effect relationships for complex systems***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
illustrate relationships between systems or within a system.		***(natural and human-designed).***

Clarification Statement	
Physical Science	Examples of models could include drawings, diagrams, simulations and texts, such as what happens when two charged objects or two magnetic poles are near each other.
Physics	Examples of models could include drawings, diagrams, and texts, such as drawings of what happens when two charges of opposite polarity are near each other.

Performance Expectation *and Louisiana Connectors*
HS-PS4-1 Use mathematical representations to support a claim regarding relationships among the frequency, wavelength, and speed of waves traveling in various media. ***LC-HS-PS4-1a Qualitatively describe cause and effect relationships between changes in wave speed and type of media through which the wave travels using mathematical and graphical representations.*** ***LC-HS-PS4-1b Identify examples that illustrate the relationship between the frequency and wavelength of a wave.*** ***LC-HS-PS4-1c Identify evidence that the speed of a wave depends on the media through which it travels.***

Science and Engineering Practice	**Disciplinary Core Idea**	**Crosscutting Concept**
Using mathematics and computational thinking: Mathematical and computational thinking in 9-12 builds on K-8 experiences and progresses to using algebraic thinking and analysis, a range of linear and nonlinear functions (e.g., trigonometric, exponential and logarithmic) and computational tools for statistical analysis to analyze, represent, and model data. Simple computational simulations are created and used based on mathematical models of basic assumptions. • Use mathematical, computational, and/or algorithmic representations of phenomena or design solutions to describe and/or support claims and/or explanations. ***Use mathematical or algorithmic forms for scientific modeling of phenomena to describe claims.***	**WAVE PROPERTIES** The wavelength and frequency of a wave are related to one another by the speed of travel of the wave, which depends on the type of wave and the medium through which it is passing. (HS.PS4A.a) ***The speed of a wave in a particular medium is constant. For this wave, the frequency and the wavelength are related to one another.*** ***The speed of a wave can also be affected by the type of material through which it travels.***	**CAUSE AND EFFECT** Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. ***Evidence is required when attributing an observed phenomenon to a specific cause.*** ***Evidence is required to explain the causal mechanisms in a system under study.*** ***Evidence is required to support a claim about the causal mechanisms in a system under study.***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Use mathematical or algorithmic forms for scientific modeling of design solutions to describe claims. ***Use mathematical or algorithmic forms for scientific modeling of phenomena to support claims.*** ***Use mathematical or algorithmic forms for scientific modeling of design solutions to support claims.*** ***Use mathematical or algorithmic forms for scientific modeling of phenomena to describe explanations.*** ***Use mathematical or algorithmic forms for scientific modeling of design solutions to describe explanations.*** ***Use mathematical or algorithmic forms for scientific modeling of phenomena to support explanations.*** ***Use mathematical or algorithmic forms for scientific modeling of design solutions to support explanations.***		

Clarification Statement	
Physical Science	Emphasis is on describing waves both qualitatively and quantitatively. Qualitative focus includes standard repeating waves and transmission/absorption of electromagnetic waves/radiation.
Physics	Examples of data could include electromagnetic radiation traveling through a vacuum and glass, sound waves traveling through air and water, and seismic

Clarification Statement	
	waves traveling through the Earth. Emphasis is on algebraic relationships and describing those relationships qualitatively.

Performance Expectation *and Louisiana Connectors*
HS-PS4-3 Evaluate the claims, evidence, and reasoning behind the idea that electromagnetic radiation can be described either by a wave model or a particle model, and that for some situations one model is more useful than the other. ***LC-HS-PS4-3a Identify a model or description of electromagnetic radiation as a wave model.*** ***LC-HS-PS4-3b Identify a model or description of electromagnetic radiation as a particle model.***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Engaging in argument from evidence: Engaging in argument from evidence in 9-12 builds on K-8 experiences and progresses to using appropriate and sufficient evidence and scientific reasoning to defend and critique claims and explanations about the natural and designed world(s). Arguments may also come from current scientific or historical episodes in science. • Evaluate the claims, evidence, and reasoning behind currently accepted explanations or solutions to determine the merits of arguments. ***Evaluate the claims behind currently accepted explanations to determine the merits of arguments.*** ***Evaluate the claims behind currently accepted solutions to determine the merits of arguments.*** ***Evaluate the evidence behind currently accepted explanations to determine the merits of arguments.*** ***Evaluate the evidence behind***	**WAVE PROPERTIES** Waves can add or cancel one another as they cross, depending on their relative phase (i.e., relative position of peaks and troughs of the waves), but they emerge unaffected by each other. (HS.PS4A.b) ***Interference is when two waves interact.*** ***Standing waves are formed by the interference of two waves moving in the opposite direction through the same medium.*** ***Interfering waves emerge unaffected by each other.*** **ELECTROMAGNETIC RADIATION** Electromagnetic radiation (e.g., radio, microwaves, light) can be modeled as a wave of changing electric and magnetic fields or as particles called photons. The wave model is useful for explaining many features of electromagnetic radiation, and the particle model explains other features. (HS.PS4B.a) ***Energy from the sun takes the form of electromagnetic waves such as infrared, visible, and ultraviolet electromagnetic waves.*** ***Electromagnetic waves carry a single form of energy called electromagnetic (radiant) energy.*** ***The radiation from the sun consists of a range of energies in the electromagnetic spectrum.*** ***Electromagnetic radiation when absorbed can be converted to thermal energy.*** ***Electromagnetic waves carry energy that can have important consequences when transferred to objects or substances.*** ***Some electromagnetic radiation can cause damage to living cells.***	**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. ***Models can be used to simulate systems.*** ***Models can be used to simulate interactions.*** ***Models can be used simulate interactions within systems at different scales.*** ***Models can be used simulate interactions***

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
currently accepted solutions to determine the merits of arguments. Evaluate the reasoning behind currently accepted explanations to determine the merits of arguments. Evaluate the reasoning behind currently accepted solutions to determine the merits of arguments.		***between systems at different scales.***

Clarification Statement
Emphasis is on how the experimental evidence supports the claim and how a theory is generally modified in light of new evidence. Examples of a phenomenon could include resonance, interference, diffraction, and photoelectric effect. Quantum theory is not included.