 

Craig City School District

K-12
Science Curriculum

MAY 2016

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ACKNOWLEDGEMENTS

CURRICULUM COMMITTEE

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WE WOULD ALSO LIKE TO RECOGNIZE

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INTRODUCTION

Science is a process of seeking to understand the natural world. This process includes skills in observing, questioning, problem solving, and logical reasoning through the collection, interpretation, and communication of data. Science by its nature is interdisciplinary, requiring the integration of mathematics, language, and interpersonal skills.

The Science curriculum document is designed to serve as a guide for teachers, administrators, parents, and community members as to the concepts and content that will be instructed at each grade level or course.

STANDARDS ALIGNMENT CODING

The Science curriculum has been aligned with the Alaska Content and Cultural Standards and the Next Generation Science Standards. The complete text of the standards may be found in the appendix. The following coding is used throughout this document to correlate the core objectives with the Alaska Content Standards.

ALASKA CONTENT AND CULTURAL STANDARDS

This example is History.

Content Standard ▷ **H.B.8a** ◁ Standard and Subdivision (if necessary)
△
Key Element of the Content Standard

E/LA	= English/Language Arts
M	= Mathematics
S	= Science
GY	= Geography
G/C	= Government and Citizenship
H	= History
HL	= Skills for a Healthy Life
A	= Arts
WL	= World Languages
T	= Technology
EM	= Employability
L/IL	= Library/Information Literacy
CS	= Cultural Standards

NEXT GENERATION SCIENCE STANDARDS

Examples:

Grade Level ▷ **K-PS2-1** ◁ Performance Expectation

PS2-A Disciplinary Core Idea

SCOPE AND SEQUENCE

Kindergarten	Kindergarten/First Grade Combination	First Grade
Life Science: • From Seed to Plant **Earth Science:** • Finding the Moon **Physical Science:** • Investigating Water	**Life Science:** • Classroom Plants **Earth Science:** • Sifting Through Science **Physical Science:** • Wood and Paper	**Life Science:** • Observing an Aquarium **Earth Science:** • Sunshine and Shadows **Physical Science:** • Properties
First Grade/Second Grade Combination	**Second Grade**	**Second Grade/Third Grade Combination**
Life Science: • Butterflies and Moths **Earth Science:** • Air and Weather **Physical Science:** • Secret Formulas	**Life Science:** • Using Your Senses **Earth Science:** • Pebbles, Sand, and Silt **Physical Science:** • Balance and Motion • Force and Motion	**Life Science:** • New Plants **Earth Science:** • Earth Materials **Physical Science:** • Solids and Liquids • Involving Dissolving
Third Grade	**Third Grade/Fourth Grade Combination**	**Fourth Grade**
Life Science: • Dinosaurs and Fossils **Earth Science:** • Solar System • Weather Instruments **Physical Science:** • Looking at Liquids • States of Matter	**Life Science:** • Food Chains and Webs • Plant and Animal Life **Earth Science:** • Earth Movements **Physical Science:** • Physics of Sound	**Life Science:** • Human Body **Earth Science:** • Water Cycle **Physical Science:** • Magnetism and Electricity • Ideas and Inventions
Fourth Grade/Fifth Grade Combination	**Fifth Grade**	
Life Science: • Pollution **Earth Science:** • Erosion • Oceans **Physical Science:** • Flight and Rocketry	**Life Science:** • You and Your Body • Fungi – Small Wonders **Earth Science:** • Rocks and Minerals **Physical Science:** • Simple Machines	

SCOPE AND SEQUENCE

Sixth Grade	Seventh Grade	Eighth Grade
Life Science: • Cells • Invertebrates • Vertebrates **Earth Science:** • Weathering and Erosion • Atmosphere • Oceans **Physical Science:** • Basic Science Skills • Introduction to Chemical and Physical Changes • Introduction to Atoms, Elements and the Periodic Table • Motion and Forces • Electricity and Magnetism	**Life Science:** • Macro-invertebrates and Water • Bacteria and Plants • Ecology **Earth Science:** • Water Quality • Rocks and Minerals • Plate Tectonics • Earthquakes and Volcanoes **Physical Science:** • Energy • Waves – Sound and Light	**Life Science:** • Cell Processes • Cell Reproduction • Heredity and Genetics • Human Body Systems **Earth Science:** • Solar System **Physical Science:** • Atoms, Elements, and Chemical Bonds

HIGH SCHOOL COURSE LIST
Earth Science (Grades 9-10) Physical Science (Grades 9-12) Biology (Grades10-12, Prerequisite: Earth Science or teacher recommendation) Chemistry (Grades 10-12, Prerequisite: Biology and Algebra I) Physics (Grades 10-12 Prerequisite: Algebra I) Marine Biology (Grades 10-12), Prerequisite: Biology) Alaska Natural Science (Grades 10-12, Prerequisite: Biology)

ELEMENTARY SCIENCE CURRICULUM
Grades K-5

SECTION CONTENTS

ONGOING LEARNER GOALS

Students will:

- utilize the scientific process skills: observing, classifying, measuring, interpreting data, inferring, communicating, controlling variables, developing models and theories, hypothesizing, predicting and experimenting (S.A.1)
- integrate reading, writing, technology and mathematics with science inquiry (S.E.1, LA, M)
- understand that science includes the process of asking and refining questions so they can be tested (S.G.2, S.A.2)
- understand that scientists use different kinds of investigations depending on the questions they are trying to answer (S.A.1, S.E.2)
- understand that an experiment must be repeated many times and yield consistent results before the results are accepted as valid (S.A.1)
- use appropriate tools and follow procedures safely
- communicate scientific procedures and explanations based on evidence (S.A.2, LA)
- develop critical thinking, decision making, and problem solving skills (S.A.1, S.A.2)
- develop an awareness that society, culture, history and environment contribute to the development of scientific knowledge (S.A.3, S.E.3)
- recognize scientific contributions from scientists representing a diversity of cultures, ethnicities and genders (S.G.1, S.F)
- understand that science is ongoing and subject to change as new evidence becomes available (S.G.3)
- recognize that advances in science depend on curiosity, creativity, imagination and a broad knowledge base (S.G.4)
- recognize that the processes of science require integrity, skepticism, openness and peer review (S.A.2)
- utilize and/or render statistics in order to make reasoned descriptions, judgments, inferences and opinions about data.

KINDERGARTEN

CORE CONCEPTS	PERFORMANCE OBJECTIVES
Life Science Concepts	**Students who demonstrate understanding will:**
• Students will distinguish between living and non-living things. • Students will understand that many different kinds of plants live in different environments on Earth. • Students will understand that many different kinds of animals live in different environments on Earth. • Students will learn about our five senses. • Students will learn that living things change as they grow. • Students will learn that exercise, eating healthy food and having good hygiene is important for all people. • Students will learn that children are very similar to their parents but not exactly like them. • Students will learn that many different kinds of plants and animals live in many different places. • Students will understand that people need to use resources carefully, so that they don't run out. • Students will explore ways that technology can help make people's lives better.	• explain the basic needs of all living things – food, water, air, and space to live in. • discuss that living things are alike in some ways and different in others. • identify similarities and differences in plants. • identify similarities and differences in animals and group animals according to features such as size, color, etc. • identify basic parts of the body and explain that the parts work together to help us live. • describe how people are alike in some ways and different in some ways. • describe the ways different plants and animals grow and will compare the sizes of various living things. • explain how people like doctors and nurses help us when we are sick. • explain that plants and animals depend on each other to survive. • locate some of Earth's habitats and the tell which plants and animals that live there. • explain that some animals are extinct and that some living things are in danger of becoming extinct and need to be protected. • identify tools that help us do work and explain why people cannot always make every tool they think of.

CORE CONCEPTS	PERFORMANCE OBJECTIVES
Physical Science Concepts	**Students who demonstrate understanding will:**
• Students will learn that objects can be described according to the materials they are made of and that many things are made of smaller parts. • Students will learn that people and nature can change some properties of matter by doing something to it e.g., cutting, heating, freezing, etc. • Students will explore how matter and energy interact. • Students will discuss how things move—in a straight line, back and forth, fast, slowly, etc. • Students will continue to explore the relationship of force and motion. • Students will learn that a model is like the real thing in some ways and different in others.	• explain that materials can exist in different states. • explain that different materials respond in different ways when people try to change them. • discuss that heat can be produced in different ways and that all living things need energy that comes from food. • demonstrate how pushing or pulling changes the way things are moving. • explain natural forces like gravity and magnets. • explain how models can help us learn. • describe things by telling how it is like something else.
Earth Science Concepts	**Students who demonstrate understanding will:**
• Students will learn that everyone can do science and that working with others can be helpful. • Students will learn about some common science tools. • Students will learn about the importance of safety in the science lab. • Students will identify rocks, soil and water as the basic materials that make up Earth. • Students will be introduced to Earth's waterways—oceans, rivers, lakes, ponds, etc. • Students will explore the types of weather that happen on Earth and talk about seasons. • Students will learn about day and night and the objects we can see in the sky at different times. • Students will learn that the sun provides light and heat for the Earth.	• explain that scientists can learn by observing and investigating. • describe things accurately as they talk to each other about their observations. • discuss some safety equipment and some basic rules for staying safe when doing investigations and making observations. • explain that rocks and other things on Earth come in many different sizes. • discuss the importance of water to all life on Earth. • demonstrate safety procedures to follow during severe weather conditions. • identify that there is a pattern to the way the moon looks. • explain why the sun can only be seen during the day and will discuss sunrise and sunset.

FIRST GRADE

CORE CONCEPTS	PERFORMANCE OBJECTIVES
Life Science Concepts	**Students who demonstrate understanding will:**
• Students will distinguish between living and non-living things. • Students will understand that many different kinds of plants live in different environments on Earth. • Students will learn about different systems that help animals get what they need to survive. • Students will understand that people have different systems that perform different functions—movement, digestion, respiration, etc. • Students will learn that exercise helps us stay healthy. • Students will learn that children are very similar to their parents but not exactly like them. • Students will learn about different habitats on Earth that plants and animals call home. • Students will understand that people need to use resources carefully, so that they don't run out. • Students will explore ways that technology can help make people's lives better.	• explain the basic needs of all living things – food, water, air, and space to live in. • discuss that living things are alike in some ways and different in others. • identify the parts of plants—roots, stem, leaves and flowers—and learn about the functions of each part. • describe how animals use plants and other animals for food. • identify similarities and differences in animals and their parents. • identify some of the parts of the body associated with each body system. • discuss that there are similarities and differences between children and their parents. • describe some ways that human and animal parents take care of their young. • identify foods that we should eat often and foods that we should eat only occasionally. • explain how doctors, nurses and medicines help us when we are sick. • explain that plants and animals depend on each other to survive. • locate some of Earth's habitats and the tell which plants and animals that live there. • explain that some kinds of plants and animals that once lived on Earth are no longer alive but are similar to some living things that are. • explain that some animals are extinct and that some living things are in danger of becoming extinct and need to be protected. • identify tools that help us do work and understand that people can work alone or in groups to find new ways to solve problems.

CORE CONCEPTS	PERFORMANCE OBJECTIVES
Physical Science Concepts	**Students who demonstrate understanding will:**
• Students will learn that objects can be described according to the materials they are made of and that many things are made of smaller parts. • Students will learn that people and nature can change some properties of matter by doing something to it e.g., cutting, heating, freezing, etc. • Students will explore how matter and energy interact. • Students will discuss how things move—in a straight line, back and forth, fast, slowly, etc. • Students will continue to explore the relationship of force and motion. • Students will learn that most things are made of parts that work together and that things may not work if parts are missing.	• explain that materials can exist in different states and the differences between solids and liquids. • explain that different materials respond in different ways when people try to change them. • describe changes in size, shape, color, etc. and note what properties stay the same. • demonstrate how pushing or pulling changes the way things are moving. • explain natural forces like gravity and magnets. • describe how, put together, parts can do things they couldn't do separately.
Earth Science Concepts	**Students who demonstrate understanding will:**
• Students will learn that everyone can do science and that working with others can be helpful. • Students will learn about some common science tools discuss scientific investigations. • Students will learn about the importance of safety in the science lab. • Students will identify rocks, soil and water as the basic materials that make up Earth. • Students will be introduced to Earth's waterways—oceans, rivers, lakes, ponds, etc. • Students will explore the types of weather that happen on Earth. • Students will learn about day and night and the objects we can see in the sky at different times. • Students will learn that the sun provides light and heat for the Earth.	• explain that scientists can learn by observing and investigating. • describe things accurately and to compare observations with others. • discuss some safety equipment and some basic rules for staying safe when doing investigations and making observations. • explain that rocks and other things on Earth come in many different sizes. • Explain how people and animals can change their environments. • describe some of the plants and animals that live in water habitats. • compare weather patterns from season to season and describe how seasons affect plants and animals. • demonstrate safety procedures to follow during severe weather conditions. • explain that we need a telescope to see some things in space. • describe the way the moon looks as it follows a pattern. • explain how the rotation of the Earth is responsible for sunrise and sunset. • explain how the sun causes shadows on the Earth.

SECOND GRADE

CORE CONCEPTS	PERFORMANCE OBJECTIVES
Life Science Concepts	**Students who demonstrate understanding will:**
• Students will expand their knowledge of the basic needs of all living things and how they meet those needs. • Students will understand that many different kinds of plants live in different environments on Earth. • Students will learn that many different kinds of animals live in different environments on Earth. • Students will understand that people have different systems that perform different functions— circulation, digestion, respiration, etc. • Students will learn that living things need energy to grow and that they change as they grow. • Students will learn that regular exercise helps us stay healthy. • Students will learn that children are very similar to their parents but not exactly like them. • Students will learn about different habitats on Earth that plants and animals call home. • Students will understand that people need to use resources carefully, so that they don't run out. • Students will explore ways that technology can help make people's lives better.	• explain that living things of all kinds have structures that serve various functions and that all living things are made of cells. • identify various plant structures and the functions they perform. • explain the life cycles of plants • describe how animals use plants for shelter • explain the life cycles of animals. • identify the parts of the body associated with each body system. • discuss the ways that living things get energy. • explain the life cycle of humans from infancy to adulthood. • identify foods that we should eat often and foods that we should eat only occasionally. • discuss ways to avoid getting sick and explain that doctors, nurses and medicine can help us get better. • discuss how people can influence the quality of life of those around them. • describe how we can associate living things with their environments by looking at their structures, e.g., fins and gills allow fish to swim and breathe underwater. • explain how people can conserve resources. • explain that living things are in danger of becoming extinct and need to be protected. • discuss important changes in technology in the past and present. • explain why it is important that when people want to build something new, they should try to figure out how it will affect other people.

CORE CONCEPTS	PERFORMANCE OBJECTIVES
Physical Science Concepts	**Students who demonstrate understanding will:**
• Students will learn that all objects are made of matter and that different materials are used to make different things. • Students will learn that people and nature can change some properties of matter by doing something to it e.g., cutting, heating, freezing, etc. • Students will explore how matter and energy interact. • Students will discuss how things move—in a straight line, back and forth, fast, slowly, etc. • Students will continue to explore the relationship of force and motion. • Students will learn that most things are made of parts that work together and that things may not work if parts are missing.	• explain that materials can exist in different states and the differences between solids, liquids, and gases. • explain that different materials respond in different ways when people try to change them. • describe how some materials can be mixed together and then separated again. • explain the different ways in which heat can be produced. • explain that all living things need energy that comes from food. • demonstrate how pushing or pulling changes the way things are moving. • discuss how vibrations cause sounds. • explain natural forces like gravity and magnets. • describe how, put together, parts can do things they couldn't do separately. • Describe a model energy system such as an aquarium.
Earth Science Concepts	**Students who demonstrate understanding will:**
• Students will learn that everyone can do science and that working with others can be helpful. • Students will learn about some common science tools discuss scientific investigations. • Students will learn about the importance of safety in the science lab. • Students will identify rocks, soil and water as the basic materials that make up Earth. • Students will expand their knowledge of Earth's waterways—oceans, rivers, lakes, ponds, etc. • Students will expand their knowledge of types of weather that happen on Earth. • Students will learn that many objects are in space. • Students will learn about day and night and the objects we can see in the sky at different times. • Students will learn that the sun provides light and heat for the Earth.	• explain that scientists can learn by observing and investigating. • describe things accurately and to compare observations with others. • explain why it is important to repeat investigations and to expect similar results. • discuss some safety equipment and some basic rules for staying safe when doing investigations and making observations. • describe the three layers of Earth—crust, mantle and core. • describe some ways the earth changes. • explain how clean water is important to all living things. • describe how water can exist as a liquid, a solid or a gas. • measure and record weather conditions and use appropriate weather terminology. • demonstrate safety procedures to follow during severe weather conditions. • investigate the phases of the moon and explain its different shapes • describe stars in terms of brightness, size and patterns. • explain how the rotation of the Earth is responsible for sunrise and sunset in a 24 hour period.. • explain how rainbows are formed.

THIRD GRADE

CORE CONCEPTS	PERFORMANCE OBJECTIVES
Life Science Concepts	**Students who demonstrate understanding will:**
• Students will study the diversity of life on Earth, scientific classification and how living things survive in a variety of environments. • Students will be introduced to the microscopic world. • Students will be introduced to the concept of similar cells developing into different systems. • Students will study features and diversity of the animal kingdom. • Students will study dinosaurs, early mammals and other creatures. • Students will be introduced to how life works in systems and how living things get energy. • Students will be introduced to the concepts of adaptation and competition. • Students will learn about the human organism. • Students will study important characteristics of invertebrate animals.	• explain how scientific classification of living things is used. • describe adaptability as it concerns living things in the environment. • describe the function and types of microscopic life. • explain how similar cells can develop into different systems.. • discuss features and diversity of organisms in diverse environments. • describe the features of dinosaurs, early mammals and other species. • explain the function of energy systems in living things. • define how organisms adapt to their environment and how competition in the environment between organisms is part of the ordering process. • identify and explain many of the systems and processes of the human organism. • identify and explain many of the systems and processes of the invertebrate animals.
Physical Science Concepts	**Students who demonstrate understanding will:**
• Students will get an overview of the branches of science and how science has changed our world. • Students will study the concepts of scientific inquiry, scientific method, measurement and scientific problem solving. • Students will be introduced to atoms, elements and molecules. • Students will study liquids, solids and gases. • Students will explore the properties of various types of matter. • Students will be given an overview of forms of energy. • Students will be introduced to principles of motion and force. • Students will consider how energy can be transferred and transformed.	• define the different branches of science and explain how science has changed the world. • demonstrate the use of the scientific method in solving science –based problems. • explain the properties of atoms, elements, and molecules. • explain the properties of solids, liquids, and gases. • define the properties of matter. • explain the forms of energy. • discuss the principles of motion and force. • Explain how energy can be transferred or transformed from one state to another

CORE CONCEPTS	PERFORMANCE OBJECTIVES
Earth Science Concepts	**Students who demonstrate understanding will:**
• Students will investigate the uses of simple machines and modern technologies. • Students will study rocks, minerals, soils and layers inside and outside the Earth. • Students will be introduced to volcanoes, tectonic plates and earthquakes. • Students will learn about weather, oceans and the water cycle. • Students will study constellations, the Earth's seasons/climates and the phases of the moon. • Students will study our solar system with previously presented concepts such as motion, energy and light. • Students will explore galaxies, stars and some new space discoveries.	• describe the application of simple machines in everyday settings. • explain the properties rocks, minerals, and soils. • diagram the layers of the Earth and define their properties. • explain the movement of tectonic plates and the effect of this activity on volcanoes and earthquakes. • diagram and identify the components of the water cycle. • identify major constellations and explain the relationship of the Earth’s seasons and climates with the moon’s phases. • explain how all the members of the solar system are affected by the motion of the others and the energy and light produced by the sun. • discuss current theories of the galaxy and the impact of new discoveries on scientific theory.

FOURTH GRADE

CORE CONCEPTS	PERFORMANCE OBJECTIVES
Life Science Concepts	**Students who demonstrate understanding will:**
• Students will study the structure and function of living things. • Students will discuss inherited traits in various living things and the importance of genetic diversity to the survival and well being of organisms. • Students will examine the ways living things interact with their environment and with each other. • Students will consider the importance of adaptation. • Students will study the process by which plants grow, thrive and reproduce. • Students will study the characteristics and behavior of various land animals. • Students will study various animals of extinct and endangered species. • Students will be introduced to the major organ systems of the human body and their functions. • Students will consider the importance of staying fit and healthy. • Students will study the science of medicine.	• explain the similarities and differences among various types of organisms. Define and explain the various parts that make up an organism, such as cells, tissues and organs. • discuss historical theories to concerning how heredity and diversity have evolved. • analyze how different environments sustain different organisms. • diagram components of food webs and their role in ecosystems. • explain how adaptation allows for competition and ultimately survival. • discuss the importance of plants to people and animals. • explain the various traits that allow animals to survive in a range of habitats. • identify characteristics of mammals, reptiles, birds and vertebrates. • distinguish among extinct, endangered, and threatened species. dicuss the impacts of activities such as poaching, over-fishing and deforestation that lead to unstable species. • diagram the organ systems of the body. • describe ways people can achieve and maintain good health. • discuss the components that go into creating a fit person, such as flexibility, muscle strength and body composition. • discuss advances in the medical field in the past, present and future. • explain the benefits of antibiotics, vaccines and surgery, among etc.

CORE CONCEPTS	PERFORMANCE OBJECTIVES
Physical Science Concepts	**Students who demonstrate understanding will:**
• Students will be introduced to the nature of science, the scientific process, and the habits required to solve problems. • Students will explore the concept that all matter has properties that can be seen and measured. • Students will discuss how matter can be changed from one state to another and how it can be combined physically or chemically. • Students will be introduced to the world of atoms, elements and particles. • Students will study the various forms of energy, the flow of energy in a system, and the ways energy can be changed from one form to another. • Students will define the difference between renewable and non-renewable forms of energy. • Students will examine the properties of light and sound. • Students will be introduced to the relationship of electric charges, magnetic forces and electric currents. • Students will learn how electrical power is created and used. • Students will learn about motion, speed and direction. • Students will also study the components of waves and how friction causes things to stop. • Students will study different types of forces and how they affect objects.	• identify specific tools that help scientists study different aspects of science. • discuss some of the specific properties of matter, such as physical and chemical properties. • explain how matter moves in solids, liquids and gases. • identify some of the tools used to measure and observe the features of matter. • define characteristics of different forms of energy. • define light's characteristics of speed, reflection and refraction. • define the components of sound such as vibration, pitch and volume. • analyze ways that motion can be predicted, measured and described. • explain ways that forces can be predicted, measured and described. • analyze the effect of force on different amounts of mass.

CORE CONCEPTS	PERFORMANCE OBJECTIVES
Earth Science Concepts	**Students who demonstrate understanding will:**
• Students will learn about the processes that shape the earth. • Students will also learn about the spheres that layer the Earth, such as the atmosphere, hydrosphere and biosphere. • Students will study the characteristics of various bodies of water. • Students will learn about the food chains and the fragility of these ecosystems. • Students will be introduced to the properties of different types of soil, the organisms that affect soil, and how the quality of soil affects growing plants. • Students will study the water cycle. • Students will also study weather patterns, seasons and meteorology. • Students will learn about various types of natural disasters and their effects on living things and their environments. • Students will also learn techniques used to keep people safe in a natural disaster. • Students will consider ways natural resources improve the quality of life and will discuss the importance of protecting and conserving natural resources. • Students will also learn about recyclable resources. • Students will study the characteristics of celestial bodies and the organization of stars, moons and planets in our solar system. • Students will explore the relationship of Earth to the sun, moon and other planets. • Students will also study various features of galaxies. • Students will consider the relationship of science and technology in modern society.	• analyze the Earth's constant change that is brought about by waves, weather and shifting landmasses. • discuss the various forms of life that exist in Earth's oceans, rivers and streams. • diagram the rock cycle and explain how rocks can be turned into soil. • define organic materials. • analyze ways weather is predicted, observed and recorded. • discuss the methods used to predict natural disasters. • compare and contrast renewable and non-renewable sources. • define the characteristics of the eight planets of our ecosystem. • analyze how features such as gravity and the Earth's tilt affect regions of the Earth. • discuss the affect of technology in agriculture, human disabilities and entertainment. • discuss responsibilities of scientists and researchers. • define aspects of the technology cycle.

FIFTH GRADE

CORE CONCEPTS	PERFORMANCE OBJECTIVES
Life Science Concepts	**Students who demonstrate understanding will:**
• Students will examine diversity of life and taxonomy. • Students will be introduced to the eight kingdoms of life. • Students will explore the world of microscopic organisms. • Students will compare the features of plant and animal cells. • Students will be introduced to inherited traits, environmental adaptation, and survival. • Students will consider the role of learning and environment in affecting traits as well. • Students will study plant diversity, photosynthesis, and pollination. • Students will study the photosynthesis cycle. • Students will be introduced to basic animal taxonomy, diversity, and endangered species. • Students will learn about some of the amazing capabilities of animals. • Students will be introduced to scientific time periods. • Students will explore ecosystems, food chains, and Earth's fragile environments. • Students will study the human organism. • Students will also learn about basic human anatomy. • Students will study the human brain, our senses and the way people learn.	. • define taxonomy and describe how it is used to group aspects of biology. • define cells and microbes. • define genetics and explain how it is used to study the transfer of traits. • explain the value of plants in supporting human life. • diagram plant systems and pollination. • analyze the characteristics of each animal group. • discuss the behaviors of a variety of animals. • analyze characteristics such as how animals raise young, find food, and avoid predators, etc. • discuss dinosaurs and early mammals. • explain the reasons dinosaurs may have gone extinct. • explain how animals thrive in certain environments while others do not. • analyze the interdependency of animals. • define body systems and their functions. • diagram the four parts of the cerebral cortex and will explain the functions of each. • compare the brains of various animals.

CORE CONCEPTS	PERFORMANCE OBJECTIVES
Physical Science Concepts	**Students who demonstrate understanding will:**
• Students will be introduced to the nature of science, its various fields, and methods of inquiring about the universe. • Students will examine structure, properties, and changes in matter. • Students will be introduced to liquids, solids and gases and will study the molecule structures of each. • Students will study the foundation for understanding heat transfer, temperature, expansion and contraction. • Students will explore the wonders of sound and light. • Students will be introduced to basic concepts of electricity and magnetism. • Students will study the principles of motion and force. • Students will compare the simple machines of the past with modern technology. • Students will also learn about the components of the internal-combustion engine. • Students will discuss major technologies in today's society as well as societies of the past.	• define the scientific method and explain how it is applied to scientific inquiries. • use images to identify the three main parts of an atom and to learn about chemical bonding. • define terms associated with matter, such as elements, molecules, mass, volume and density. • identify items that have all three types of matter as well as examples of each type. • identify the difference between heat and temperature. • explain the properties of radiation and convection. • explain the importance of the sun in sustaining Earth's existence. • define characteristics of light and sound, such as the electromagnetic spectrum, refraction and decibels. • discuss electricity's origin and electrical flow. • explain how electricity is manipulated through fuses, breakers, conductors and insulators. • explain how closely related electricity and magnetism are. • analyze Newton's Laws, the three statements that summarize motion energy. • define potential energy, motion and kinetic energy. • explain how information technology evolved into modern computers. • diagram advancements in communication, transportation and production. • explain how advancements in medicine have changed our lifestyles.

CORE CONCEPTS	PERFORMANCE OBJECTIVES
Earth Science Concepts	**Students who demonstrate understanding will:**
• Students will be introduced to the structure of the earth and plate tectonics. • Students will examine the rock cycle, volcanoes, earthquakes, and glaciers. • Students will study soil horizons, soil content, and erosion. They will learn about the effects of pollution on soil quality. • Students will also learn how humans have shaped landscapes to help preserve soil. • Students will consider how oceans provide air, food, water, and other resources for life on earth. • Students will explore protection and conservation of natural resources and will compare renewable and nonrenewable energy sources. • Students will study the water cycle and weather. • Students will look at the four seasons and the relationship between the sun, the moon and Earth. • Students will be given an overview of the solar system, including recent astronomical discoveries. • Students will explore galaxies, constellations, stars, nebulae, and black holes.	• They will identify features of each layer of the Earth. • They will consider how plate tectonics have shaped the continents into Earth as we know it today. • They will learn how igneous, sedimentary and metamorphic rocks are formed. • They will learn about the features and boundaries of the ocean. • They will learn about the continental shelf and the abyssal plains. • Students will consider ways in which scientists work together in conducting research and gathering data to ensure the protection of the environment. • Students will also consider Earth Day as a way to remember the value of protecting the Earth. • They will define processes such as evaporation, condensation and transpiration. • Students will consider how water molecules interact with air molecules to make wind. • They will learn how water is transported throughout Earth via features such as aquifers and artesian wells. • They will also study the phases on the moon. • Students will study the characteristics of various features of our solar system, such as comets, meteors, asteroids and orbits. • They will also define the features of each of the eight planets and the dwarf planet, Pluto. • They will learn that the temperature of stars affects their size, shape and color. • Students will also consider how various stars and galaxies look to us from Earth. • They will define magnitude in respect to stars. •

MIDDLE SCHOOL SCIENCE CURRICULUM
Grades 6-8

SECTION CONTENTS

MIDDLE SCHOOL SCIENCE CURRICULUM

INTRODUCTION

The Craig City School District's middle school science curriculum is designed to advance students understanding of the natural world. Such understanding requires knowing science concepts, laws and theories of the physical, life, and earth sciences, as well as ideas that are common across the natural sciences. For middle school-level students, the essence of learning science has shifted from rote memorization to an understanding of the basic themes and concepts of science. Students can begin to develop the skills of investigation and the understanding that scientific inquiry is guided by asking questions; making observations; and gathering, organizing and analyzing data as well as communicating results.

Technology will play a prominent role in learning science. The use of technology will not replace basic understanding and skills; rather it will be a tool to help develop a deeper understanding of science concepts. The use of technology will help promote and motivate students thinking and interest in science. With respect to ethical, social, and cultural issues, the middle school science curriculum will include the history, process, facts, concepts, principles, theories, and technological applications of science.

GRADE OVERVIEW

Integrated Science: 6th grade

Students in 6th grade science are expected to develop an understanding of key concepts in Life, Earth, and Physical Science that serve as the foundation for 7th and 8th grade science. The topics in Life Science include learning about invertebrates, vertebrates, and cell organelles. The topics in Earth Science include weathering and erosion, the atmosphere, and oceans. Physical Science topics will include describing the physical and chemical properties of matter, an introduction to atoms, elements, and the periodic table, and motion and forces.. Throughout the year, interwoven into the curriculum content, students will design and conduct scientific investigations to continue to develop awareness of different ways of thinking and the exploration of multiple paths involved in scientific inquiry.

Integrated Science: 7th grade

The 7th grade curriculum for Life Science emphasizes learning about Southeast Alaska's natural environment. Students will study water quality and macro-invertebrates in local environments. Students will also learn about plants and ecological factors affecting the area. Earth Science topics will include learning about rocks and minerals, plate tectonics, earthquakes, and volcanoes. The students will learn about energy, sound and light, and electricity and magnetism. Throughout the year, interwoven into the curriculum content, students will design and conduct scientific investigations to continue to develop awareness of different ways of thinking and the exploration of multiple paths involved in scientific inquiry.

Integrated Science: 8th grade

In 8th grade, students will gain a more in-depth understanding of general life, earth, and physical science topics. Life Science topics will include cellular processes, cellular reproduction, and the study of heredity and genetics. Students will also learn about the skeletal, muscular, and integumentary systems. In Earth Science, the focus will be solely on the solar system. Physical Science topics will help students develop an understanding of atoms, elements, and chemical bonds. Throughout the year, interwoven into the curriculum content, students will design and conduct scientific investigations to continue to develop awareness of different ways of thinking, and the exploration of multiple paths involved in scientific inquiry.

ONGOING LEARNER GOALS
6th-8th

Students will:

- Know the historical significance of major scientific discoveries, advances, and how they happened, as well as present-day endeavors that affect the future. (S.G)
- Use the processes of science (observing, classifying, measuring, interpreting data, inferring, communicating, controlling variables, developing models, hypothesizing, and predicting) with appropriate instruments. (S.A)
- Integrate reading, writing, and mathematics with science inquiry. (S.E.1, LA, M)
- Follow directions using appropriate safety procedures in the classroom laboratory and field to ensure a cooperative, safe work environment. (S.E, S.A) Follow lab and safety procedures when conducting scientific investigations.
- Use appropriate technology to investigate, analyze, evaluate, and propose solutions to science related issues. (S.E)
- Know that personal observations can be affected by bias, personal beliefs, and cultural beliefs. (S.F)
- Know that an experiment must be repeated many times and yield consistent results before the results are accepted as valid. (S.A)
- Understand that scientists use different kinds of investigations, depending on the questions they are trying to answer. (S.A)
- Design and conduct a scientific investigation/experiment (e.g., formulate hypotheses, design and carry out investigations, interpret data, synthesize evidence into explanations, propose alternative explanations for observations, critique explanations, and procedures). (S.A)
- Know ways in which science distinguishes itself from other ways of knowing and from other bodies of knowledge (e.g., use empirical standards, logical arguments, skepticism). (S.A)
- Use science knowledge to describe, understand, and make informed choices about local and current issues. (S.A, S.F)

Research and develop awareness of career possibilities in the field of science. (EM.B.2-4)

These strands are not to be taught in a sequential order but should be integrated throughout the year.

Sixth Grade

<table>
<tr><td>Length: Two Semesters</td><td colspan="2">Overview:
Students in 6th grade science are expected to develop an understanding of key concepts in Life, Earth, and Physical Science that serve as the foundation for 7th and 8th grade science. The topics in Life Science include learning about invertebrates, vertebrates, and cell organelles. The topics in Earth Science include weathering and erosion, the atmosphere, and oceans. Physical Science topics will include describing the physical and chemical properties of matter, an introduction to atoms, elements, and the periodic table, and motion and forces.. Throughout the year, interwoven into the curriculum content, students will design and conduct scientific investigations to continue to develop awareness of different ways of thinking and the exploration of multiple paths involved in scientific inquiry.</td></tr>
<tr><th>CORE IDEAS</th><th>PERFORMANCE EXPECTATIONS</th><th>SUGGESTED EXPLORATIONS</th></tr>
<tr><td>Scientific Process Skills</td><td colspan="2">Students who demonstrate understanding will:</td></tr>
<tr><td>Science process skills are best taught in context. Therefore, these performance expectations will be incorporated into each content area. Not all of these performance expectations will be incorporated into every activity, however, opportunities to learn these skills will be provided throughout the course.

AKSS: SA1.1, SA3.1

NGSS: MS-LS-1, MS-ESS2-5, MS-PS1-2, MS-PS2-2, MS-PS2-5</td><td>• Ask questions, predict, observe, describe, measure, classify, make generalizations, infer and communicate. [SA1.1]
• Plan and carry out scientific investigations of various types, such as systematic observations or experiments, identify variables, collect and organize data, interpret data in charts, tables, and graphics, analyze information, make predictions, and defend conclusions. [SA1.1, MS-LS-1, MS-ESS2-5, MS-PS1-2, MS-PS2-2, MS-PS2-5]
• Select appropriate tools for collecting qualitative and quantitative data and record measurements (volume, mass, and distance) in metric units. [SA1.1]
• Develop a model to describe phenomena. [SA1.1, MS-LS2-3]
• Conduct research to learn how the local environment is used by a variety of competing interests (e.g., competition for habitat/resources, tourism, oil and mining companies, hunting groups). [SA3.1]
• Use standard safety practices for all classroom laboratory and field investigations.</td><td></td></tr>
</table>

Life Science Concepts	**Students who demonstrate understanding will:**	
Cells: Patterns of cellular organization Understand the processes, structures and functions of living organisms that enable them to survive, reproduce and carry out the basic functions of life. **LS1.A: Structure and Function:** • All living things are made up of cells, which is the smallest unit that can be said to be alive. An organism may consist of one single cell (unicellular) or many different numbers and types of cells (multicellular). (MS-LS-1) **AKSS:** SA1.1, SA2.1, SC2.1, SC2.3 **NGSS**: MS-LS1-1-3	• Differentiate between unicellular organisms and multicellular organisms and name common examples of each. [SC2.1, MS-LS -1, MS-LS1-2] • Explain how specialized cells perform specialized functions in multicellular organisms. [SC2.1, SA1.1, SA2.1, MS-LS1 -3]	• Observation: Observe and identify single cell and multicellular microorganisms from local pond water by making wet mount slides and observing with microscopes. • Technology: use resources on the Internet to observe and describe electron micrograph of single cells and single celled organisms. Research Project: Research bacteria (single cell organisms) and produce brochure/poster or power point, showing relationships with disease in living organisms. • Microscope Lab: Compare animal (check cells to plants cells (onion) using microscope & complete drawings of each type of cell- label cell parts. • Inquiry Experiment: Develop a decomposition chamber to observe and collect data on microorganisms. • Lab Activity: Observe slides of different tissue types using microscope or computer and diagram structures for each type of tissue.
MS-LS2: Ecosystems: Interactions, Energy, and Dynamics A system of living and nonliving things operate to meet the needs of the organisms in an ecosystem. **AKSS**: SC1.2, SC2.1-2, SC3.1-2, SA3.1, SC3.1-2, SF1.1-3.1 **NGSS**: MS-LS2-1-5, MS-LS2-2	• Use a dichotomous key to classify animals and plants into groups based on external or internal features. [SC2.1] • Explain how organisms and populations of organisms are dependent on interactions with other living and nonliving factors. [SC1.2, SC2.2, MS-LS2-1, MS-LS2-2] • Identify sunlight as one of the major sources of energy for all ecosystems. [SC3.1] • Explain patterns of interactions between organisms in an ecosystem (competitive, predatory, and mutually beneficial, cause and effect relationships). [SC1.2, 6, SC2.2, MS-LS2-2]	• Dissect flowers and seeds to classify monocots and dicots. • Research a plant or animal from the local environment; examine its internal and external structure and relate it to similar species found in other areas. • Dichotomous Key activity • Create a terrestrial and aquatic biosphere using a 2 liter bottle. • Dissect owl pellets and relate findings to a food web. Use or create a dichotomous key to identify the bones. • Identify plants located around the school grounds.

	• Describe and construct a food web and food pyramid. [SC3.1, SC3.2, MS-LS2-3] • Classify and explain the roles of organisms within a food web as producers, consumers, or decomposers. [SC3.2, MS-LS2-3] • Ecosystems are dynamic in nature and disruptions to the physical or biological components can lead to shifts in all populations, which then influence humans' availability of resources such as food, energy, medicines, etc. [MS-LS2-5] • Examine how the local environment is used by a variety of competing interests including hunters, miners, tourists, animals, and plants. [SA3.1, SF1.1-3.1] •	• Determine which plants are native and which plants are invasive. • Create ecosystem poster labeling parts of ecosystems and relationship of living organisms (e.g., producers, consumers, and decomposers). • Diagram or construct a food web showing relationships of organisms (e.g., producers, consumers and decomposers). • Create a flow chart showing relationships of species, populations, community, and ecosystems in Alaska. • Dissection Lab: Dissect owl pellets, develop a skeleton of organisms found, graph results from class totals of all organisms found, predict and infer diet of owls. • Computer simulation: Students choose number of predator/prey and collect data on observations of survival and graph results. • Inquiry Activity: Students observe number of plants, animals (insects) within specific area, measure soil & air temperature and develop a story of related factors that may have influenced or changed the habitat and animals living in the environment. • Long Term Ecosystem Research site. • Interview Elders for a village perspective of climate change. • Fictitious mining unit on selecting a mine, effects on the land, and the local population (Lab Aids). • Bill Nye: Atmosphere video for climate change. • Interview villagers about changes observed connected to changing climate. • Use current events to track climate change in mining, tourism, pipeline, hunting, or the environment.
MS-LS1: From Molecules to Organisms: Structures and Processes Cells are the smallest unit of life that can function independently and perform all	• Explain that all living things are composed of cells that carry on functions that sustain life. [SC2.1, MS-LS1-1, MS-LS1 -2] • Recognize and explain how cells of all organisms undergo similar processes, including growth, obtaining energy, getting	• Develop a model of either a plant cell or animal cell. • Discuss historical significance of development of microscope. • Create a timeline of scientists and discoveries that show the

the necessary functions of life. **AKSS**: SA1.1; SC1.1, 3; SC2.1, SE3.1; SG.1.3 **NGSS**: MS-LS1-1-2, 6-7 **Suggested Pacing: 4-6 weeks**	rid of wastes and reproducing. [SC1.1, SC2.1, SG3.1, MS-LS1 -2] • Identify and label cell structure and organelles; cell membrane, cell wall, cytoplasm, nucleus, chloroplast and mitochondria. [SC2.1, MS-LS1-2] • Compare and contrast the structure and function of major organelles of plant and animal cells; (cell wall, cell membrane, nucleus, cytoplasm, chloroplasts, mitochondria, and vacuoles). [SC2.1, MS-LS1 -2] • Observe cells by using technology or constructing cell models. [SA1.1, SC2.1, SE3.1, MS-LS1 -2] • Investigate and explain the components of the scientific theory of cells. [SE3.1] • Explain how producers transfer the sun's energy into chemical energy through photosynthesis. [SC3.1, MS-LS1-6] Analyze the role of nutrients in providing energy to carry on life processes. [SA1.1, SC3.1, SD1.2, MS-LS1-7]	history of cells. • Observe by using microscopes or computers: plant and animal cells. • Create Keynote, flow chart or Mind Map of differences between sexual and asexual reproduction of cells. • Osmosis: Egg experiment: soak raw eggs in vinegar to remove shell, and then soak in various solutions (e.g., sugar, salt water). Weigh egg between solutions to observe/demonstrate the process of osmosis in cells. • Mitosis: Complete online Onion Root Tip Lab -Biology project - Cell Biology. • Demonstration Activity: Place leaves of plant in water to observe carbon dioxide bubbles rising to the surface. • Diagram a structure of a plant leaf labeling parts relating to photosynthesis. Create a diagram or model of the carbon cycle including the relationship of plants, living organisms, soil and air.
Physical Science Concepts	**Students who demonstrate understanding will:**	
MS-PS2: Motion and Stability: Forces and Interactions Gravity is the force that causes two particles to pull towards each other. **AKSS:** S.A.1-3, S.F.2, S.G.3-4, CS.B.2 **NGSS:**	• Recognize that objects exert gravitational force on other objects. • Investigate Newton's Third Law of Motion.	• Design, test, and revise bottle rockets. • Using components such as string, papers and balloons, design a rocket. • Design, test, and revise various styles of paper airplanes for specific purposes (e.g., distance, ability to fly in a straight line, gliding). • Observe a blanket toss to describe and explain balance of forces at each stage.
Earth and Space Concepts	**Students who demonstrate understanding will:**	
MS-ESS2: Earth's Systems **Weather/Climate**: Energy from the sun is transferred between systems and circulates through the ocean and atmosphere results in weather patterns. Unequal heating from	• Describe/illustrate continual water cycle propelled by sunlight and gravity including transpiration, evaporation, condensation and crystallization, precipitation, and downhill flows on land. [SD1.2, MS-ESS2-4] • Describe the effects of the ocean and the water cycle on the weather. [SD3.1, MS-ESS2-4] • Identify and analyze movement of air masses from regions of	• Examine weather maps, diagrams, and visualizations to collect data on motion and interactions of air masses. • Explore the air currents with student-created hot air balloons. • Observe convection currents with convection currents paper dots lab. • Record weather observations for a length of time using

the sun and the rotation of the Earth cause atmospheric and oceanic circulation that determines regional climates. **AKSS:** S.A.1-3, S.D.1, 3, S.E.1-3, S.F.1-3, CS.A.3 **NGSS:** MS-ESS2-4-6	high to low pressure (convection currents) and the effects on the weather. [SA1.2, MS-ESS2-5] • Describe how unequal heating and rotation of Earth determines regional climates. [MS-ESS2-6] • Identify that energy transfer is affected by surface conditions. [SD3.2] • Explain the interrelationship and effects of permafrost on the physical environment. [SA3.1, SE3.1] • Investigate how climate change impacts communities. [SE1.1] • Investigate and compare multiple explanations and theories related to climate change. [SA2.1, SE2.2] • Explain climate change and the effects on the physical environment. [SG3.1, SE3.1]	UAF's Arctic Climate Modeling Project lessons. • Compare and contrast weather in Alaska to that of Hawaii with UAF's Arctic Climate Modeling Project Lessons and extend lesson to hypothesize how our Alaska communities would be affected if the two different climates suddenly flipped. • Analyze the past 90 years' worth of monthly average temperatures in Fairbanks Alaska to show empirical evidence of climate change. • Compare and contrast current and past satellite images of various land forms. • Research steps that could be taken to reduce the causes of climate change as well as adaptations Alaskans can take to cope with climate changes. • Retell a traditional story that explains a natural event and relate it to a scientific explanation. • Predict the date of ice break-up on the river based on qualitative and quantitative observations of temperature, ice thickness, rate of run-off, and wind factors.

Seventh Grade

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The 7th grade curriculum for Life Science emphasizes learning about Southeast Alaska's natural environment. Students will study water quality and macro-invertebrates in local environments. Students will also learn about plants and ecological factors affecting the area. Earth Science topics will include learning about rocks and minerals, plate tectonics, earthquakes, and volcanoes. The students will learn about energy, sound and light, and electricity and magnetism. Throughout the year, interwoven into the curriculum content, students will design and conduct scientific investigations to continue to develop awareness of different ways of thinking and the exploration of multiple paths involved in scientific inquiry.</td></tr>
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AKSS: SA1.1, SA3.1

NGSS: MS-LS1-1-2, 7-8, MS-LS-4-3, MS-LS3-1-2, MS-ESS2-1</td><td>• Ask questions, predict, observe, describe, measure, classify, make generalizations, infer and communicate. [SA1.1]
• Plan and carry out scientific investigations of various types, such as systematic observations or experiments, identify variables, collect and organize data, interpret data in charts, tables, and graphics, analyze information, make predictions, and defend and communicate results. [SA1.1, MS-LS1-1, MS-LS-4-3, MS-ESS2-5]
• Select appropriate tools for collecting qualitative and quantitative data and record measurements (volume, mass, and distance) in metric units. [SA1.1]
• Develop and use a model to describe phenomena including models that describe unobservable mechanisms. [SA1.1, MS-LS1-2, MS-LS1-7, MS-LS3-1, MS-LS3-2, MS-ESS2-1]
• Read, identify and evaluate the sources used to support scientific statements. [SA2.1, MS-LS1-8, MS-LS4-5]
• Design and conduct a simple investigation about the local environment. [SA 3.1]
• Use standard safety practices</td><td></td></tr>
</table>

Asking Questions and Defining Problems: Asking questions and defining problems in grades 6–8 builds from grades K–5 experiences and progresses to specifying relationships between variables, and clarifying arguments and models. **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. **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 design solutions. **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. **Obtaining, Evaluating, and Communicating Information:** Obtaining, evaluating, and communicating information in 6–8 builds on K–5 and progresses to evaluating the merit and validity of ideas and methods.		

AKSS: **NGSS:** MS-LS1-1-2, 7-8, MS-LS2-3, MS-LS4-1, 3		
Engineering Concepts	**Students who demonstrate understanding will:**	
MS-ETS1: Engineering Design: Engineering and design skills are best taught in context. Therefore, these core objectives will be incorporated into each of the following content areas. Not all of these objectives will be incorporated into every activity, but opportunities to learn these skills will be provided throughout the course. **Defining the Problem:** At the middle school level, students are expected to define the problem with precision, thinking more deeply than elementary students about the problem and the goals of the design as well as the effects on the end user, broader society, and the environment. **Developing solutions:** In middle school, the focus is on using a systematic method, such as a trade-off matrix to determine which solutions are most promising, testing different solutions and then redesigning. **Improving Designs:** At the middle school level, students should be testing designs, analyzing results, modifying designs, and retesting. Students may go through this cycle multiple times to reach an optimal design. **AKSS:** **NGSS:**	• Define a design problem that can be solved through the development of an object, tool, process or system that included multiple criteria and constraints, including the scientific knowledge that my limit possible solutions. [MS-ETS1-1] • Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem. [MS-ETS1-2]	• Use the design process to build and test a capsule that safely lands an egg dropped from a designated height. Demonstrate your knowledge of factors that affect the speed of a falling object. Calculate speed and acceleration.

Life Science Concepts	Students who demonstrate understanding will:	

MS-LS4: Biological Evolution: Unity and Diversity
 	
LS4.A: Evidence of Common Ancestry and Diversity
• The collection of fossils and their placement in chronological order (e.g., through the location of the sedimentary layers in which they are found or through radioactive dating) is known as the fossil record. It documents the existence, diversity, extinction, and change of many life forms throughout the history of life on Earth. (MS-LS4-1)
• 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-LS4-2)
• Comparison of the embryological development of different species also reveals similarities that show relationships not evident in the fully-formed anatomy. (MS-LS4-3)
 	
LS4.B: Natural Selection
• Natural selection leads to the predominance of certain traits in a population, and the suppression of others. (MS-LS4-4)
• In *artificial* selection, humans have the capacity to influence certain characteristics of organisms by
	• Identify living things using similarities and differences based on the current taxonomic system of classification. [SA1.1, SC2.1, SC2.2, SE2.1]
	• Explain that differences and similarities in living things are based on structure and basic behaviors (e.g., migrations, communication, adaptation, hibernation) used by organisms to meet the requirements of life. [SC2.1, SC2.2, MS-LS1-4]
	• Explain how the theory of biological evolution accounts for the diversity of species through gradual changes over time. [SC1.2, SE3.1, MS-LS4-1, MS-LS4-2, MS-LS4-3, MS-LS4-6]
	• Describe natural selection and its relationship to the theory of evolution and genetic variability. [SC1.2, MS-LS4-4, MS-LS4-5]
		• Classification Lab: students observe preserved specimens (or use pictures of microorganisms, fungi, plants & animals) and decide how to group them based on similarities. Include discussion on local Alaskan animals: subsistence hunting, and impacts of permafrost environments on animals.
		• Classification Activities:
		  ○ Develop a taxonomic key for classifying organisms.
		  ○ Use taxonomic key to identify local trees by their leaves.
		  ○ Classification activity: students sort animal cards into vertebrates & invertebrates.
		• Technology: create PowerPoint research project on animals, and present to classmates.
		• Inquiry Experiment: Students set up their own bottle ecosystem using fish, water, aquatic plants and snails. Students keep observations for 3-6 weeks in their science notebook. Using data collected, describe what or why changes occurred in bottle ecosystem.
		
		• Inquiry for Natural Selection: Simulation of peppered moth survival: students color paper moths and hide from classmates. Survival rate is graphed and analyzed on reasons of survival rate of different colored moths.
		• Use differences in bird beaks as inquiry activity.

<table>
<tr><td>selective breeding. One can choose desired parental traits determined by genes, which are then passed on to offspring. (MS-LS4-5)

LS4.C: Adaptation
• Adaptation by natural selection acting over generations is one important process by which species change over time in response to changes in environmental conditions. Traits that support successful survival and reproduction in the new environment become more common; those that do not become less common. Thus, the distribution of traits in a population changes. (MS-LS4-6)

LS1.B: Growth and Development of Organisms
• Animals engage in characteristic behaviors that increase the odds of reproduction. (MS-LS1-4)
• Plants reproduce in a variety of ways, sometimes depending on animal behavior and specialized features for reproduction. (MS-LS1-4)

AKSS: SA1.1-2, SC1.1-3, SC2.1-2, SE2.1, 3

NGSS: MS-LS1-4, MS-LS4-1-6

Suggested Pacing: 6-9 weeks</td><td></td><td></td></tr>
<tr><th>Physical Science Concepts</th><th colspan="2">Students who demonstrate understanding will:</th></tr>
<tr><td>MS-PS2: Motion and Stability: Forces and Interactions</td><td>• Demonstrate the relationship between electricity and magnetism. [SB2.1, SB2.2, SB4.2]
• Ask questions about data to determine the factors that affect</td><td>• Design and conduct experiments with electromagnets, testing how the strength of the magnet varies with wire length, number of wraps, voltage source, size of core,</td></tr>
</table>

PS2.B: Types of Interactions • Electric and magnetic (electromagnetic) forces can be attractive or repulsive, and their sizes depend on the magnitudes of the charges, currents, or magnetic strengths involved and on the distances between the interacting objects. (MS-PS2-3) • 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-PS2-5)	the strength of electric and magnetic forces. [MS-PS2-3] • Conduct an investigation to provide evidence that fields exit between objects exerting forces on each other even though the objects are not in contact. [MS-PS2-5] • 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. [MS-PS 4-1] • Investigate the ways that light and sound interact with matter, expanding on wavelength, color, refraction, and reflection (grades 7-9). [SB4.3, MS-PS 4-2]	current, composition of core, neatness of wraps, etc. • Design and conduct experiments related to the speed of an electric motor (varying voltage, current, number of magnets, etc.). • Use a compass to detect an electric field around an electrical current. Compare the potential energy of a magnet held at different positions within a magnetic field or the potential energy of a statically charged balloon at different distances from a classmate's hair.
MS-PS3: Energy **PS3.B: 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 size of the sample, and the environment. (MS-PS3-4) **PS3.C: Relationship Between Energy and Forces** • When two objects interact, each on exerts a force on the other that can cause energy to be transferred to or from the object. (MS-PS3-2)	• Identify various sources and forms of energy and classify them as potential or kinetic. [SE1.1, PS 3.A] • Apply scientific principles to design, construct, and test a device that either minimized or maximized thermal energy transfer. [MS-PS 3.3] • Investigate relationships among the amount of energy transferred, the type of matter, the mass and the change in temperature of a sample (the average kinetic energy of the particles in the sample). [MS-PS3-4] • Examine energy transfers, conservation of energy, and identify energy that is useful vs. energy that is unavailable (grades 7-8). [SB2.1, SD3.2, MS-PS3.B] • Differentiate between renewable and non-renewable energy resources. [SB2.1] • Explain how changes in the arrangement of objects interacting at a distance changes the amounts of potential energy stored in the system. [MS-PS3-2] • Investigate how energy is produced and used including alternative energy sources in Alaska. Evaluate the impact of	• Marble raceway. • Labs with diffraction gratings, mirrors, and spinners. • Build mini-homes with the same heat source (e.g., light bulb). • Design, build, test, and redesign a solar cooker, insulated box, house design that would be less likely to melt permafrost, etc. • Compare the temperature change of different materials as they cool or heat the environment. Apply this to practical applications (heat reservoirs in building, etc.). • Research project in the library and on computers.

MS-PS4: Waves and Their Applications in Technologies for Information Transfer **PS4.A: Wave Properties** • A simple wave has a repeating pattern with a specific wavelength, frequency, and amplitude. (MS-PS4-1) • A sound wave needs a medium through which it is transmitted. (MS-PS4-2) **PS4.B: Electromagnetic Radiation** • When light shines on an object, it is reflected, absorbed, or transmitted through the object, depending on the object's material and the frequency (color) of the light. (MS-PS4-2) • 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. (MS-PS4-2) • However, because light can travel through space, it cannot be a matter of wave, like sound or water waves. (MS-PS4-2)	energy production methods on the environment. [SB2.1, SE 3.1, MS-ESS3-3] • Investigate through experimentation and "real-life" examples, the relationship among (1) force, mass, acceleration, and gravity, (2) speed, distance, time and acceleration, (3) force and friction. [SB4.2, SF1.1-3] • Plan an investigation to provide evidence that the change in an object's motion depends on the sum of the forces on the object (balanced and unbalanced forces) and the mass of the object. [SB4.2, MS-PS2-2] • Demonstrate that an object's motion can be described and represented graphically according to its position, direction of motion, and speed [SB4.1, MS-PS2-2] • 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. [MS-PS3-1] • Support the claim that when the kinetic energy of an object changes, the energy is transferred to or from that object. [MS-PS3-5]	• Inquiry Labs: ○ Block cars, weights and elapse times. (Use variables: (a) add sandpaper to the track; (b) graphite on wheels. Graph the block car lab runs and compare.) ○ Catapults and marshmallows. ○ Balloon races. ○ Scooter races. Skateboards and raw eggs. ○ Rockets (model, Alka-Seltzer rockets). ○ Build a rollercoaster for a marble.

Suggested Pacing: 9 weeks **MS-PS2: Motion and Stability: Forces and Interactions** **PS2.A: 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-PS2-1) • 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. (MS-PS2-2) • 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-PS2-2) **PS2.B: Types of Interactions** • Gravitational forces are always	• Explain "real-life" examples of linear and rotational motion using Newton's Laws of Motion. [SB4.1, MS-PS2.A] • Describe gravity as an attractive force between two objects that depends on the mass of the interacting objects. Explain how the orbital motion of planets provides evidence for this force. [SB4.2, MS-PS2-4] Explain how changes in the arrangement of objects interacting at a distance changes the amounts of potential energy stored in the system. [MS-PS3-2]	• Discuss riding in a car or flying in a Super Cub; include using a GPS and topographic maps for planning a hunting/fishing trip. • Project explaining the physics of a favorite sport or activity including forces, speed, acceleration, laws of motion and the ways that energy is converted between potential and kinetic energy. Compare the potential energy of a rollercoaster care at different points on a rollercoaster, or the energy of a sled at different positions on a hill.

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-PS2-4) • 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-PS2-5)		
Earth Science Concepts	**Students who demonstrate understanding will:**	
MS-ESS1: Earth's Place in the Universe Alaska Geology **ESS1.C: 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-ESS1-4)	• Explain the interrelationship among the rock (7th grade), water (6th), and cycles. [SD1.1, SD1.2] • Know that sedimentary, igneous, and metamorphic rocks contain evidence of the minerals, temperatures, and the forces that created them. [SD2.2, MS-ESS1-4] • Identify the basic rocks of Alaska and tell their classification. [SA1.1, SD1.1] • Analyze how landforms are created through constructive and destructive forces caused by movement of the tectonic plates. [SD2.2, MS-ESS2-3, ESS1-4]	• Use baking chips as rocks and have students demonstrate the rock cycle using the chips through different pathways. • Use the Alaska rock kits for identification & classification. • Create puzzles of the plates and label volcanoes, earthquakes, and the kind of plate movement. • Use a tub with ice, hot water, & Styrofoam for convection currents & plate movement.
MS-ESS2: Earth's Systems **ESS2.B: 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-ESS2-3)	• Develop a model to describe the cycling of Earth's materials and the flow of energy that drives this process; to include melting, crystallization, weathering, deformation, and sedimentation that act together to form minerals and rocks. [SD1.1, SD2.1, NGSS MS-ESS2-1] • Make connections between components of locally observable geologic environment and the rock cycle. [SD1.1] • Explain how geoscience processes have changed Earth's surface at varying time and spatial scales (i.e., earthquakes, tsunamis, volcanoes, floods, landslides, avalanches). [SD2.3,	• Use a tub with ice, hot water, & Styrofoam for convection currents & plate movement. • Play game on orienteering called *Orient.* Lab: create an Ice Lens.

AKSS: S.A.1-3, S.D.1-4, S.E.1-4, S.F.1-3, S.G.1-4, CS.E.2 **NGSS**: MS-ESS1-4, MS-ESS2-3 **MS-ESS2: Earth's Systems** **ESS2.A: Earth's Materials and Systems** All Earth processes are the result of energy from the Sun and Earth's hot interior flowing and matter cycling within and among the Earth's systems. Earth's systems interact on a microscopic to global level in size, and operate in a fraction of a second to billions of years. **AKSS**: S.A.1-3, S.D.1, S.D.2, S.F.1-3, S.G.1-4, C.S.E.2 **NGSS**: MS-ESS2-1-3	SA1.1, NGSS MS-ESS2-2] • Apply knowledge of water cycle to explain changes in Earth's surface. [SD1.2] Analyze and interpret data on distribution of fossils and rocks, continental shapes, and seafloor structures to provide evidence of past plate motions. [NGSS MS-ESS2-3]	

Eighth Grade

Length: Two Semesters	**Overview:** In 8th grade, students will gain a more in-depth understanding of general life, earth, and physical science topics. Life Science topics will include cellular processes, cellular reproduction, and the study of heredity and genetics. Students will also learn about the skeletal, muscular, and integumentary systems. In Earth Science, the focus will be solely on the solar system. Physical Science topics will help students develop an understanding of atoms, elements, and chemical bonds. Throughout the year, interwoven into the curriculum content, students will design and conduct scientific investigations to continue to develop awareness of different ways of thinking, and the exploration of multiple paths involved in scientific inquiry.	
CORE IDEAS	**PERFORMANCE EXPECTATIONS**	**SUGGESTED EXPLORATIONS**
Scientific Process Skills	**Students who demonstrate understanding will:**	
Science process & engineering design skills are best taught in context. Therefore, these core performance expectations will be incorporated into. Not all performance expectations will be incorporated into every activity however, opportunities to learn these skills will be provided throughout the course. **AKSS**: SA1.1, SA2.2, SA3.1, SG1.1 **NGSS**: MS-PS1-1-2, MS-PS1-4, MS-PS2-2-3, MS-PS3-4, MS-PS4-2, MS-ESS1-1, MS-ETS-1-1-3 (PS1=Matter) (PS2=Motion & Force) (PS3=Energy) (PS4=Waves) (ETS1=Engineering) **Asking Questions and Defining Problems** Asking questions and defining problems in grades 6–8 builds from grades K–5 experiences and progresses to specifying relationships between variables, and clarifying arguments and models. **NGSS**: MS-PS2-3, MS-ETS-1	• Ask questions, predict, observe, describe, measure, classify, make generalizations, infer communicate, and when appropriate, frame a hypothesis based on observations and scientific principles. [SA1.1, MS-PS2-3] • Plan and carry out scientific investigations of various types, such as systematic observations or experiments, identify variables, collect and organize data, interpret data in charts, tables, and graphics, analyze information, make predictions, and defend and communicate results. [SA1.1, MS-PS1-2, MS-PS2-2, MS-PS3-4] • Recognize and analyze differing scientific explanations and develop a model to predict and/or describe phenomena including models that describe unobservable mechanisms. [SA1.2, SA2.2, MS-ESS1-1, MS-PS1-1, MS-PS1-4, MS-PS3-2, MS-PS4-2] • Select appropriate tools for collecting qualitative and quantitative data and record measurements (volume, mass, and distance) in metric units. [SA1.1] • Read, identify and evaluate the sources used to support scientific statements. [SA2.1, SG1.1 MS-PS1-3] • Conduct research to learn how the local environment is used by a variety of competing interests (e.g., competition for habitat/resources, tourism, oil and mining companies, hunting groups). [SA3.1] • Use standard safety practices for all classroom laboratory and	• Design and conduct an experiment to test how an object's mass and/or speed affect its momentum. • Research and compare different models of atoms (Thomson, Rutherford, Bohr, Quantum Cloud models). • Design and conduct experiments on factors affecting the strength of electromagnets.

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 an design systems. **NGSS**: MS-PS1-1, 4-5, MS-PS4-2 **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 design solutions. **NGSS**: MS-PS2-2, **Analyzing and Interpreting Data** Analyzing data in 6–8 builds on K–5 and progresses to extending quantitative analysis to investigations, distinguishing between correlation and causation, and basic statistical techniques of data and error analysis. **NGSS**: MS-PS1-2 **Obtaining, evaluating, and communicating information** Obtaining, evaluating, and communicating information in 6–8 builds on K–5 and progresses to evaluating the merit and validity of ideas and methods **NGSS**: MS-PS1-3 **Engaging in Argument from Evidence**	field investigations.	

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. **NGSS**: MS-ETS1-2		
Engineering Design Concepts	**Students who demonstrate understanding will:**	
Developing solutions In middle school the focus is on using a systematic method, such as a tradeoff matrix to determine which solutions are most promising, testing different solutions and then redesigning. **Improving designs** At the middle school level students should be testing designs, analyzing results, modifying designs, and retesting. Students may go through this cycle multiple times to reach an optimal design.	• Define a design problem that can be solved through the development of an object, tool, process or system that included multiple criteria and constraints, including the scientific knowledge that my limit possible solutions. [SA1.1 MS-ETS1-1] • Evaluate competing design solution based on jointly developed and agreed-upon design criteria. [SA1.1, SA1.2, MS-ETS1-2] • Students will investigate and explain that all matter is made up atoms and understand that substances have physical properties that are unique to each substance.	• Use the design process to build and test a capsule that safely lands an egg dropped from a designated height. • Demonstrate your knowledge of factors that affect the speed of a falling object. • Calculate speed and acceleration.
Life Science Concepts	**Students who demonstrate understanding will:**	
Cells: Patterns of cellular organization Understand the processes, structures and functions of living organisms that enable them to survive, reproduce and carry out the basic functions of life. **LS1.A: 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	• Differentiate among cells, tissues, organs, organ systems and whole organism. [SC2.3, MS-LS1 -3] • Identify and investigate the general functions of the major systems of the human body (digestive, respiratory, circulatory, skeletal, muscular, excretory, nervous, integument and immune) and describe the ways these systems interact with each other. [SC2.1, SC2.3, MS-LS1 -3] • Explain how disease can be a breakdown in structures or functions of an organism, or the result of damage by infection from other organisms or environmental factors. [SC2.1, SC2.3]	• Experiment: growing bread mold. • Technology Computer Simulation: Observe the reproduction rate of bacteria and compare to reproduction of multicellular organisms. (http://www.cellsalive.com) • Levels of organization: students arrange pictures of different levels from smallest to largest. • Develop a concept map showing relationships of cells, tissues, organs, organ systems, organisms and the environment. • Lab Activity: students check their heart rate before, during

specialized for particular body functions. (MS-LS1-3) **AKSS:** SA1.1, SA2.1, SC2.1, SC2.3 NGSS**: MS-LS1-1-3**		and after exercise and create a graph using data from lab activity to show relationship between heart rate and exercise. Include discussion on high altitude activities. • Dissection lab: Dissect frogs to identify/observe musculoskeletal system of frog and compare with humans. • Lab Activity: students predict and test lung capacity and compare to classmates.
MS-LS3: Heredity: Inheritance and Variation of Traits This standard is students are introduced to genetics with general overview of nature of DNA, genes, chromosomes and the important role they play in the transmission of traits from one generation to the next. **LS3.A: Inheritance of Traits:** • Genes are located in the chromosome cells, with each chromosome pair containing two variants 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. 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-LS3-1) • Variations of inherited traits between parent and offspring arise from genetic differences that result from the subset of chromosomes (and therefore genes) inherited. (MS-LS3-2)	• Explain how every organism has a set of instructions which pass characteristics from one generation to another by genes through reproduction. [SC1.1, SA1.1, SA2.1, SG1.1, SG3.1, SC1.1] • Explain that an inherited trait can be determined by one or many genes, and a single gene can influence more than one trait. [C1.2, SC1.1, SC2.2, MS-LS3-2] • Explain the differences between sexual and asexual reproduction. [SA1.1 SC.1.1, MS-LS3-2] Describe possible outcomes of mutations (e.g., no effect, damage, benefit). [SC1.2, MS-LS3-1]	• Class Activity: diagram a model or flow chart showing the steps of meiosis. • Use Punnet square to predict the results of simple genetic traits. • Class Activity: class survey to determine visible genotypes of classmates. • Computer Simulation: observe genetic simulation and determine how gender is produced in humans. Model: use marbles to predict and collect data on results of genetic crosses. Design a species with 3-5 inherited traits & create chart showing Dominant/recessive traits. Genetic Monsters

<table>
<tr><td>LS3.B: Variation of Traits:
• In sexually reproducing organisms, each parent contributions half of the gene acquired (at random) by 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-LS3-2)
• In addition to variations that arise from sexual reproduction, genetic information can be altered because of mutation. Though rare, mutations may result in changes to the structure and function of proteins. Some changes to the structure and function of proteins. Some changes are beneficial, others are harmful, and some are neutral to the organism. (MS-LS3-1)

AKSS: SA1.1-2, SA2.1, SC1.1-2, SC2.2, SG1.1, 3

NGSS: MS-LS3-1-2

Suggested Pacing: 3-4 weeks</td><td></td><td></td></tr>
<tr><th>Physical Science Concepts</th><th colspan="2">Students who demonstrate understanding will:</th></tr>
<tr><td>MS-PS1: Matter and Its Interactions

PS1.A: 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-PS1-1)
• Each pure substance has</td><td>• Develop and use models to demonstrate how atoms and elements form molecules and compounds. [NGSS MS-PS1-1, SA2.1, SB1.1, SB3.2]
• Measure and use physical properties such as to compare and separate substances. [SB1.1 NGSS PS1-2]
• Classify everyday materials as elements, compounds, or mixtures. [SA1.1, SB1.1]
• Use a model that predicts and describes changes in particle motion, temperature and state of a pure substance when</td><td>• Research and utilize a variety of models of atoms & molecules online.
• Examples of molecular level models could include drawings, 3-D ball and stick structures, or computer representations showing different molecules with different types of atoms. (At this level, students are not expected to explain valence electrons or bonding energy.)
• Examples of reactions could include burning sugar or steel wool, fat reacting with sodium hydroxide and mixing zinc</td></tr>
</table>

characteristic physical and chemical properties (for any bulk quantity under given conditions) that can be used to identify it. (MS-PS1-2, MS-PS1-3) • Gases and liquids are made of molecules or inert atoms that are moving about relative to each other. (MS-PS1-4) • The changes of state that occur with variations in temperature or pressure can be described and predicted using these models of matter. (MS-PS1-4) **PS1.B: 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-PS1-2, MS-PS1-3, MS-PS1-5) • Some chemical reactions release energy, others store energy. (MS-PS1-6) **PS3.A: Definitions of Energy** • 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	thermal energy is added or removed. [SB3.1, SB 2.1, NGSS MS-PS1-4] • Analyze and interpret data on the properties of substances before and after the substances interact to determine if a chemical reaction has occurred. [NGSS MS-PS1-2, AK SB 1.1] • 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 (grades 7-8). [SB1.1, MS-PS1.5] • Recognize the role chemistry has in our everyday lives, including the production of synthetic materials from natural resources (e.g., soil and water testing, extraction of minerals, consumer science). [SA1.2, SE2.1, SE2.2, SG2.1, SG3.1 NGSS MS-PS1-3]	with hydrogen chloride. • Lab Activity: Test for differences in salinity using water softening salts and determine its affect on groundwater. • Show elements, create/show compounds, make mixtures (lemonade, fizzy lemonade made with baking soda). • Create ice cream; measure temperature changes and graph. Discuss Native ways of making ice cream. • Make a periodic table using shoes, coffee cups, and ordinary objects, or a class periodic table where students each have a family, creating one wall-sized chart. • Lab: Experiment with rusting. • Lab: Soil and water chemistry. • Inquiry Lab: develop an experiment with any consumer product based on the Scientific Method. • Collect current events from newspapers with elements in the news from Alaskan areas (e.g., Mining, water quality).

system depends jointly on the temperature, the total number of atoms in the system, and the state of the material. (Secondary to MS-PS1-4) **AKSS**: S.A.1-3, S.B.1-3, S.E 1-3, S.F.1, S.G.2-4, CS.E.2 **Suggested Pacing**: 9 weeks		
MS-ESS3: Earth and Human Activity **ESS3.C: 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-ESS3-3, MS-ESS3-4) **MS-ETS1: Engineering Design** **ETS1.B: Developing Possible Solutions** • A solution needs to be tested, and then modified on the basis of the test results, in order to improve it. (MS-ETS1-4) • There are systematic processes for evaluating solutions with respect to how well they meet the criteria and constraints of a problem. (MS-ETS1-2, MS-ETS1-3)	• Gather information and explain how synthetic materials come from natural resources and impact society. [MS-PS1-3] Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem. [MS-ETS1-2]	

Earth Science Concepts	Students who demonstrate understanding will:	
MS-ESS1: Earth's Place in the Universe **ESS1.A: 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-ESS-1) • Earth and its solar system are part of the Milky Way galaxy, which is one of many galaxies in the universe. (MS-ESS1-2) **ESS1.B: Earth and the Solar System** • The solar system consists of the sun and a collection of objects, including planets, their moons, and asteroids that are held in orbit around the sun by its gravitational pull on them. (MS-ESS1-2, MS-ESS1-3) **MS-PS2: Motion and Stability: Forces and Interactions** **PS2.B: 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-PS2-4) • 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	• Develop and use a model of the Earth-Sun-Moon system to describe the cyclic patterns of lunar phases, eclipses of the sun and moon, and seasons. [ESS1-1, SD3.1, SD4.1, SD4.2] • Describe the role of gravity in the motions within galaxies and the solar system. [ESS1-2, SB4, SD4.4] • Analyze and interpret data to determine scale properties of objects in the solar system. [MS-ESS1-3, SD4.1, SD4.2 • Compare and contrast the characteristics of planets and stars including distances between them in light years [SD4.1, SD4.2]	• Star Lab with UAF Geophysical Institute. • Observe and draw the moon for 30 days. • Research seasons in Northern and Southern Hemispheres. • Create a model of solar system on playground or in school that demonstrates an understanding of the scale of the system and the objects within it.

ball, respectively). (MS-PS2-5) **AKSS:** SD 3.1, SD4.1-2, 4 **NGSS**: MS-PS2.B		

HIGH SCHOOL SCIENCE CURRICULUM
Grades 9-12

SECTION CONTENTS

COURSE DESCRIPTIONS

Earth Science

Earth Science is a required one-year course. The academic focus is to develop student reading, writing, processing, and organizational skills. The scientific focus is to improve science vocabulary, scientific observation, inquiry, experimentation, and analysis skills. Safety skills will be stressed each semester. The first semester will begin with the study of cells, cell structures and their functions, protein synthesis, genetics, and the study of heredity. Second semester will include evolution, characteristics of multi-cellular organisms with attention to organs and organ systems, and the diversity of organisms and ecology.

Physical Science

Physical Science provides an introduction to the core concepts of physics and chemistry. Laboratory work is an integral part of the inquiry-based learning process, helping students develop an understanding of the concepts as well as the process of science. The first semester includes an exploration of mechanics (motion, forces, and energy), in addition to the development of important process skills. The second semester provides an introduction to the core concepts of chemistry (matter and its interactions) with little emphasis on mathematics.

Biology

Biology is a required one-year course. The academic focus is to develop student reading, writing, processing, and organizational skills. The scientific focus is to improve science vocabulary, scientific observation, inquiry, experimentation, and analysis skills. Safety skills will be stressed each semester. The first semester will begin with the study of cells, cell structures and their functions, protein synthesis, genetics, and the study of heredity. Second semester will include evolution, characteristics of multi-cellular organisms with attention to organs and organ systems, and the diversity of organisms and ecology.

Chemistry

Chemistry is a one-year introductory general chemistry course which builds a foundation for college-level chemistry, physics, and biology courses. Students learn about chemical reactions and the structure of matter in order to explain how and why substances react the way they do. Laboratory work and laboratory reporting are an integral part of the course, helping students develop an understanding of the concepts as well as the process of science.

Physics

Physics is a science course focusing on the “rules” of the universe. Physics will be treated conceptually in this class, which means concepts are presented in familiar English, with equations and mathematical formulas as guides to thinking. The mathematics skills mastered in Algebra I will be sufficient to complete this course.

Marine Biology

Marine Biology explores the adaptations of marine organisms, ecological concepts and physical processes that structure the marine environment. The course is a study of the environmental impacts of chemistry, geology and other abiotic conditions and the organisms that live in marine environments. The course also examines human interactions with marine ecosystems and the many careers associated with it. Special attention will be given to students' knowledge of Alaska's marine environment, its importance to indigenous peoples, local economies, food production and career possibilities.

Alaska Natural Science

Alaska Natural Science studies the fundamental concepts in ecology – diversity, interdependence, and energy flow - through contemporary problems. This course will focus on local and global environmental issues that Alaskans face, such as water and air pollution, climate change, resource management and depletion, and subsistence use.

EARTH SCIENCE

Grade: 9-10	**Overview:** *Earth Science* is a required one-year course. The academic focus is to develop student reading, writing, processing, and organizational skills. The scientific focus is to improve science vocabulary, scientific observation, inquiry, experimentation, and analysis skills. Safety skills will be stressed each semester. The first semester will begin with the study of cells, cell structures and their functions, protein synthesis, genetics, and the study of heredity. Second semester will include evolution, characteristics of multi-cellular organisms with attention to organs and organ systems, and the diversity of organisms and ecology.
Length: Two semesters	
Credit: 1	
Prerequisites: None	

CORE IDEAS	PERFORMANCE OBJECTIVES	SUGGESTED ACTIVITIES
Scientific Practice and Design	**Students who demonstrate understanding will:**	
At the high school level, students are expected to engage with major global issues utilizing analytical and strategic thinking. These capabilities can be thought of in three stages--defining the problem, developing possible solutions and improving designs. **AKSS**: S.A.1-3 **NGSS**: HS-ETS1.A	• Design experiments (controls, independent and dependent variables) that require asking questions, developing hypotheses, collecting data, interpreting data and developing conclusions. [SA1.1] • Critically review current literature about scientific topics. [SA1.2]; (11) [SA2.1] • Use statistical and graphical techniques to describe data. [SA1.2] • Conduct literary and experimental research about current scientific issues. [SA3.1] • Design and evaluate a solution to a complex real-world problem that accounts for societal needs and wants. [HS-ETS1-1-3]	• Lab: Scientific measurement. • Graphing formats and data analysis. • Map/chart/table reading. • Introduction to writing standard lab reports. • Review current event articles related to the study of Earth science.
FIRST SEMESTER		
Earth Systems Overview	**Students who demonstrate understanding will:**	
ESS2.A: Earth Materials and Systems Earth's systems, being dynamic and interacting, cause feedback effects that can increase or decrease the original changes. (HS-ESS2-1, HS-ESS2-2) **ESS2.D: Weather and Climate**	• Describe how Earth's systems conserve matter and transfer energy. [SB2.1] • Use the physical properties (density, mass, buoyancy, pressure) of air and water to explain weather patterns.	• Lab: Density of a solid. • PhET online lab: http://phet.colorado.edu/en/simulation/density • Inquiry: Liquid density layers.

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, ocean, and land systems, and this energy's re-radiation into space (HS-ESS2-2, HS-ESS2-4) **AKSS:** S.B.2 **NGSS:** **Suggested Pacing:** 3 weeks	• Analyze geoscience data to make the claim that one change to Earth's surface can create feedbacks that can cause changes to other Earth systems. [HS-ESS2-2] • Develop a quantitative model to describe the cycling of carbon among the hydrosphere, atmosphere, geosphere, and biosphere. [HS-ESS2-6]	• Compare and contrast conventional and alternative energy sources. • 10-gallon aquarium convection model. • Carbon cycle game. • Investigate how pollutions (Sulfolane or Atrazine) might travel through ecosystems.
Earth's Processes and Geologic Systems	**Students who demonstrate understanding will:**	
ESS2.A: Earth Materials and Systems Earth's systems, being dynamic and interacting, cause feedback effects that can increase or decrease the original changes. (HS-ESS2-1, HS-ESS2-2) **ESS2.B: 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. 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-ESS2-1) **ESS2.D: Weather and Climate** Gradual atmospheric changes were due to plants and other organisms that captured carbon dioxide and released oxygen. (HS-ESS2-6, HS-ESS2-7) **ESS2.E: 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-ESS2-7) **AKSS:** S.B.1,3-4, S.D.1,2, S.E.1, CS.E.2	• Identify metals and non-metals on the periodic table. (9-11) [SB1.1] • Identify rock-forming minerals by inspection and using simple tests. (9-10) [SB3.1] • Explain the relationship between rocks and minerals. • Differentiate among the three major types of rocks. (9-11) [SD1.1] • Describe the processes in the rock cycle including erosion and deposition. (9) [SD1.1] (9-11) [SD2.1] • Describe the formation and extraction of minerals associated with the mining industry in Alaska. (9-11) [SE1.1] • Describe the formation of petroleum in Alaska. • Explain the connection between the fossil record and the evolution of life on Earth. • Use the theory of plate tectonics to describe the origin of earthquakes and volcanoes in Alaska. (9-11) [SD2.2] • Describe how energy released in an earthquake travels as waves and how those waves were used to determine the composition of the earth. (9) [SB4.3] • 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.	• Create periodic chart poster. • Mineral identification laboratory. • Rock lab: Identify igneous, sedimentary and metamorphic rocks. • Create plate tectonics rap, poem, or haiku. • Mapping lab: Ring of fire. • Earthquake demo: Block of wood/sandpaper/rubber band. • Create models of 3 different plate boundaries. • Lab: Mapping the epicenter of an earthquake. • Topographic map lab: Create a map **or** create a model. • PhET online lab: http://phet.colorado.edu/en/simulation/plate-tectonics • Build and label a glacier-scape model.

Suggested Pacing: 6 weeks	[HS-ESS2-1] • Develop a model based on evidence of Earth's interior to describe the cycling of matter by thermal convection. [HS-ESS2-3] • Plan and conduct an investigation of the properties of water and its effects on Earth materials and surface processes. [HS-ESS2-5]	
History of Earth	**Students who demonstrate understanding will:**	
ESS1.C: 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. 9HS-ESS1-5) • 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-ESS1-6) **ESS2.A: Earth Materials and Systems** Earth's systems, being dynamic and interacting, cause feedback effects that can increase or decrease the original changes. (HS-ESS2-1, HS-ESS2-2) **ESS2.B: 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. 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-ESS2-1)	• 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. [HS-ESS1-5] • 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. [HS-ESS1-6] • 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. [HS-ESS2-1] • Construct an argument based on evidence about the simultaneous coevolution of Earth's systems and life on Earth. [HS-ESS2-7]	• Calculate rates of sea-floor spreading for the Atlantic Ocean and Pacific Ocean. • Model geologic time scale using adding machine tape. • Jigsaw read a selection about Geologic Timescale for atmospheric changes/geologic changes/oceanic changes/biological changes. • PhET online lab: http://phet.colorado.edu/en/simulation/radioactive-dating-game

PS1.C: 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. (Secondary to HS-ESS1-1) **NGSS:** **Suggested Pacing**: 3 weeks		
Earth's Ocean System	**Students who demonstrate understanding will:**	
ESS1.B: 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 the earth. These phenomena cause a cycle of ice ages and other gradual climate. (Secondary to HS-ESS2-4) **ESS2.A: Earth Materials and Systems** Earth's systems, being dynamic and interacting, cause feedback effects that can increase or decrease the original changes. (HS-ESS2-1, HS-ESS2-2) **ESS2.B: 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. 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-ESS2-1) **ESS2.D: Weather and Climate** Gradual atmospheric changes were due to plants and other organisms that captured carbon dioxide and released oxygen. (HS-ESS2-6, HS-ESS2-7)	• Explain how water in the oceans moderates the earth's climate. [SD1.2] • Explain ocean currents in terms of density and convection. • Use the properties of salt water to illustrate the chemical nature of matter. [SB2.1] • Explain how tides are the result of the sun and moon's gravitational field. [SD3.1] • Develop a model to illustrate how Earth's internal an surface processes operate at different spatial and temporal scales to form continent and ocean-floor features. [S2-4, HS-ESS2-1] • Analyze geosciences data to make the claim that one change to Earth's surface can create feedbacks that can cause change to other Earth's systems. [HS-ESS2-2] • Use a model to describe how variations in the flow of energy into and out of Earth's systems result in changes in climate. [HS-ESS2-4]	• 10-gallon aquarium convection model. • Lab: Density of ocean water (ice vs. water, fresh water vs. salt water, hot water vs. cold water). • Lab: Solubility of an ionic solid. • Use sounding charts to convey information about the surface of ocean floor. • Oil tanker lab : Use a sounding chart to map the route of an oil tanker into Ketchikan Harbor. • Ocean current mapping- NIKE shoe spill. • Albedo, sea ice, and positive feedback cycles.

<table>
<tr><td>AKSS: S.B.2, S.D.1,3, CS.E.2

Suggested Pacing: 6 weeks</td><td></td><td></td></tr>
<tr><th colspan="3">SECOND SEMESTER</th></tr>
<tr><th>Earth's Place in the Universe</th><th colspan="2">Students who demonstrate understanding will:</th></tr>
<tr><td>ESS1.A: The Universe and Its Stars
The star called the sun is changing and will burn out over a lifespan of approximately 10 billion years. (HS-ESS1-1)
The study of stars' light spectra and brightness is used to identify compositional elements of stars, their movements, and their distances from Earth. (HS-ESS1-2, HS-ESS1-3)
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-ESS1-2)
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-ESS1-2, HS-ESS1-3)
ESS1.B: 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-ESS1-4)

ESS1.C: The History of Planet Earth
Continental rocks, which can be older than 4 billion years, are generally much older than the</td><td>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. [HS-ESS1-1]
Construct an explanation of the Big Bang theory based on astronomical evidence of light spectra, motion of distant galaxies, and composition of matter in the universe. [HS-ESS1-2, SD3.3, SD4.2, SD4.4]
Communicate scientific ideas about the way stars, over their life cycle, produce elements. [HS-ESS1-3, SD4.1]
Use mathematical or computational representations to predict the motion of orbiting objects in the solar system. [HS-ESS1-4, SD3.1, SD 3.3, SD4.2]
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. [HS-ESS1-5]
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. [HS-ESS1-6]
Explain the formation of the aurora incorporating a magnetic field, the solar wind, and an atmosphere. (9) [SB4.2]; (9-11) [SD3.2]</td><td>Construct poster of electromagnetic spectrum. [SB3.3]
Discuss the concept of the expanding universe. [SD4.2]
Flame test activity.
Make and use simple inclinometer.
Demonstrate the use of a sextant.
Construct a simple 3-D scale model of the solar system.
Use a sky map to describe the position of the sun. [SD4.1, SF1.1-3.1]
Investigate an astronomical research mission.
PhET online labs:
http://phet.colorado.edu/en/simulation/gravity-and-orbits
http://phet.colorado.edu/en/simulation/my-solar-system</td></tr>
</table>

rocks of the ocean floor, which are less than 200 million years old. (HS-ESS1-5) • 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-ESS1-6) **ESS2.B: 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. (Secondary to HS-ESS1-5) **PS1.C: 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. (Secondary to HS-ESS1-2) **PS3.D: 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. (Secondary to HS-ESS1-1) **PS4.B: Electromagnetic Radiation** 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. (Secondary to HS-ESS1-2) **AKSS**: S.B.3-4, S.D.3-4, S.F.1 **NGSS:** **Suggested Pacing**: 9 weeks		

<table>
<tr><th>Earth’s Atmospheric Systems</th><th colspan="2">Students who demonstrate understanding will:</th></tr>
<tr><td>ESS1.B: 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 the earth. These phenomena cause a cycle of ice ages and other gradual climate changes. (Secondary to HS-ESS2-4)

ESS2.A: Earth Materials and Systems
Earth’s systems, being dynamic and interacting, cause feedback effects that can increase or decrease the original changes. (HS-ESS2-1, HS-ESS2-2)

ESS2.D: 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, ocean, and land systems, and this energy’s re-radiation into space. (HS-ESS2-2, HS-ESS2-4)

ESS3.D: 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-ESS3-5)

AKSS: S.B.2, S.D.1,3, S.E.2-3

NGSS:

Suggested Pacing: 6 weeks</td>
<td>• Explain the role of solar energy in driving the water cycle and weather patterns. [SD1.2]
• Describe the physical properties of air.
• Use the physical and chemical properties of air and water to explain weather patterns.
• Identify factors that affect global wind patterns.
• Explain why seasons occur.
• Discuss how human activities can affect the atmosphere including the impact of man-made CO_2. [SE2.1, SD3.1, SE3.1]
• Use a model to describe how variations in the flow of energy into and out of Earth’s system result in changes in climate. [HS-ESS2-4]
• Analyze geoscience data and results from global climate models to make an evidence-based forecast of the current rate of global or regional climate change and future impacts to Earth systems. [HS-ESS3-5]</td>
<td>• Solar radiation and albedo. [SB2.1]
• Inquiry: Heating of sand vs. water using heat lamp.
• Water cycle in a cup.
• Water cycle poster.
• Density of air activity (Δ mass of balloon).
• Exploration of water’s density (warm vs. cold, salty vs. pure).
• Kinetic model exploration
• Tracking CO_2 changes seasonally and long-term.
• Weather reporting of past storm system (write script or make recording) (hurricane tracking, tornado typhoon).
• Construct a simple water barometer.
• Isobar activity-use isobars on weather maps to illustrate high and low pressure systems.
• PhET online lab:
http://phet.colorado.edu/en/simulation/greenhouse</td></tr>
<tr><th>Earth and Human Activity</th><th colspan="2">Students who demonstrate understanding will:</th></tr>
<tr><td>ESS2.D: 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</td>
<td>• 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. [HS-ESS3-1]
• Evaluate competing design solutions for developing,</td>
<td>• Analyze and describe the relationship between availability of natural resources and and growth of Alaskan populations.
• Compare designs for mining operations- placer, open pit, etc.</td></tr>
</table>

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. (Secondary to HS-ESS3-6) **ESS3.A: Natural Resources** Resource availability has guided the development of human society. (HS-ESS3-1) **ESS3.B: 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-ESS3-1) **ESS3.C: Human Impacts on Earth Systems** The sustainability of human societies and the biodiversity that supports them requires responsible management of natural resources. (HS-ESS3-3) **ESS3.D: 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-ESS3-5) **ETS1.B: 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. (Secondary to HS-ESS3-2, HS-ESS3-4) **AKSS**: **NGSS**: **Suggested Pacing**: 3 weeks	managing, and utilizing energy and mineral resources based on cost-benefit ratios. [HS-ESS3-2] • Create a computational simulation to illustrate the relationships among management of natural resources, the sustainability of human populations, and biodiversity. [HS-ESS3-3] • Evaluate or refine a technological solution that reduces impacts of human activities on natural systems. [HS-ESS3-4] • 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. [HS-ESS3-5] • Use a computational representation to illustrate the relationships among Earth systems and how those relationships are being modified due to human activity. [HS-ESS3-6]	• Investigate alternative energy sources such as geothermal, wind, or solar energy. • Compare current climate change models.

PHYSICAL SCIENCE

Grade: 9-12 **Length:** Two semesters **Credit:** 1 **Prerequisites:** None	**Overview:** *Physical Science* provides an introduction to the core concepts of physics and chemistry. Laboratory work is an integral part of the inquiry-based learning process, helping students develop an understanding of the concepts as well as the process of science. The first semester includes an exploration of mechanics (motion, forces, and energy), in addition to the development of important process skills. The second semester provides an introduction to the core concepts of chemistry (matter and its interactions) with little emphasis on mathematics.

CORE IDEAS	PERFORMANCE OBJECTIVES	SUGGESTED ACTIVITIES
FIRST SEMESTER	**Students who demonstrate understanding will:**	
ETS1: Engineering Design **ETS1.C: 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 may be needed. (HS-ETS1-2) **AKSS**: S.A.1 **NGSS**: **Suggested Pacing**: 2 weeks	• Recognize that all measurements have some uncertainty. [SA1.1, SA1.2] • Make and interpret line graphs and scatter plots. [SA1.1, SA1.2]	• Graphing skills packet. • Investigation: graphing volume of water in a test tube vs. height of water.
PS2: Motion and Stability: Forces and Interaction **PS2.A: Forces and Motion** • Newton's second law accurately predicts changes in the motion of macroscopic objects. (HS-PS2-1) • Momentum is defined for a particular frame of reference; it is the mass times the velocity of the object. (HS-PS2-2) • If a system interacts with objects outside itself, the total momentum of the system can change; however, any such change is balanced by changes	• Distinguish between the terms speed, velocity, and acceleration. • Use and interpret graphs that describe the motion of objects (position-time, velocity-time and acceleration-time). [SA1.1, SA1.2] • 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. [HS-PS2-1] • Apply Newton's three laws to explain inertia, acceleration when net force is not zero, and action-	• Use sonic rangers (sonars) to match position vs. time and velocity vs. time graphs. • Conduct races with electric cars and fan cars or cars rolling down ramps. • Investigate collisions between spring-loaded cars. • Conduct balloon races. • Design apparatus to protect egg in free fall using cost-effective approach.

in the momentum of objects outside the system. (HS-PS2-2, HS-PS2-3) **ETS1.A: Defining and Delimiting an Engineering Problem** 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. (Secondary to HS-PS2-3) **ETS1.C: 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 (trade-offs) may be needed. (Secondary to HS-PS2-3) **AKSS**: S.A.1, S.B.4 **Suggested Pacing**: 5 weeks	reaction forces. [SB4.1] • 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. [HS-PS2-2] • Apply scientific and engineering ideas to design, evaluate, and refine a device that minimizes the force on a macroscopic object during a collision. [HS-PS2-3]	
PS2: Motion and Stability: Forces and Interactions **PS2.B: 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 distant objects. (HS-PS2-4) • 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-PS2-4, HS-PS2-5) **PS3.A: Definitions of Energy** "Electrical energy" may mean energy stored in a battery or energy transmitted by electric currents. (Secondary to HS-PS2-5)	• Use mathematical representations of Newton's Law of Gravitation and Coulomb's Law to describe and predict the gravitational and electrostatic forces between objects. [HS-PS2-4] • 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. [HS-PS2-5]	• Static electric forces activity: Attraction and repulsion; comparison to gravitational force. • Build a simple circuit. • Build a simple electromagnet. • Build a simple motor.

AKSS: S.B.4, CS.E.2 **Suggested Pacing**: 5 weeks		
PS3: Energy **PS3.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-PS3-1, HS-PS3-2) **PS3.B: 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-PS3-1) • Energy cannot be created or destroyed, but it can be transported from one place to another and transferred between systems. (HS-PS3-1, HS-PS3-4) • Mathematical expressions, which 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 speed, allow the concept of conservation of energy to be used to predict and describe system behavior. (HS-PS3-1) • The availability of energy limits what can occur in any system. (HS-PS3-1) **AKSS**: S.B.2 **Suggested Pacing**: 6 weeks	• 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). [HS-PS3-2] • Design, build, and refine a device that works within given constraints to convert one form of energy into another form of energy. [HS-PS3-3] • Build and test the efficiency for a simple machine. • 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). [HS-PS3-4]	• Construct pendulums and conversion. • Calculate output and input work and set efficiency using multiple pulley arrangements to lift weights. • Use spring scales to compare the force needed to pull an object up a ramp and to lift it the same height. Calculate efficiency. • Thermochemistry lab: Energy in a candle. • Model dwelling construction and insulation used in traditional Alaskan dwellings before modern insulating materials became available. [SB2.1]

SECOND SEMESTER	Students who demonstrate understanding will:	
PS1: Matter and Its Interactions **PS1.A: 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-PS1-1) • 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-PS1-1, HS-PS1-2) • The structure and interactions of matter at the bulk scale are determined by electrical forces within and between atoms. (HS-PS1-3, Secondary to HS-PS2-6) **AKSS**: S.B.1 **NGSS:** **Suggested Pacing**: 5 weeks	• 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 of atoms. [HS-PS1-1] • Plan and conduct an investigation to gather evidence to compare the structure of substances at the bulk scale to infer the strength of electrical forces between particles. [HS-PS1-3]	• Phet simulation: Build an atom. • Black box experiment (for circumstantial evidence). • Adopt an element and present its "life history" in a poster. • Demo lithium vs. sodium in water. • Lab: Trends among the elements. • Periodic chart of objects (i.e., candy, shoes, hats).
PS1: Matter and Its Interactions **PS1.B: 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-PS1-2, HS-PS1-7) **AKSS**: S.B.1 **NGSS:** **Suggested Pacing**: 5 weeks	• 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. [HS-PS1-2] • Explain how the Law of Conservation of Mass help to support the atomic model of matter. • Use mathematical representations to support the claim that atoms, and therefore mass, are conserved during a chemical reaction. [HS-PS1-7] • Balance simple chemical equations. • Measure solubility of solutes in solutions. • Discuss the difference between concentration and saturation of solutes in solutions. • Use power of ten notations to explain pH; explain the difference between acids and bases.	• Lab: Decompose water by electrolysis noting. volumes and ratios of products. • Lab: Baking soda and acid. • Lab: Salts and solubility. • Lab: pH scale. • Lab: Empirical formula of zinc chloride.

	• Identify the range of the pH scale and give examples of strong and weak acids and bases.	
PS 1.C: Nuclear Processes **PS3.D: Energy in Chemical Processes** Although energy cannot be destroyed, it can be converted to less useful forms—for example, to thermal energy in the surrounding environment. (HS-PS3-3) **PS1.C: 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-PS1-8) **ETS1.C: 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 (trade-offs) may be needed. (Secondary to HS-PS1-6) **AKSS**: S.B.2 **NGSS:** **Suggested Pacing**: 4 weeks	• Explain the Law of Conservation of Energy as it applies to transfers of energy for physical and chemical changes. (10) [SB2.1] • 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. [HS-PS1-8] • Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering. [HS-ETS1-2] • Discuss the role nuclear power for electrical generation may play in reducing the emission of greenhouse gases and for smaller Alaskan communities.	• Lab: Radioactive decay. • PhET simulation *Nuclear-Fission.* • Videos *Chernobyl: A Taste of Wormwood* or the NOVA special: *Back to Chernobyl.* • Activity: Design electric power system for a small community with a given set of environmental conditions, resources, population and power needs.

BIOLOGY

Grade: 10-12 **Length:** Two semesters **Credit:** 1 **Prerequisites:** *Earth Science* or Teacher Recommendation	**Overview:** *Biology* is a required one-year course. The academic focus is to develop student reading, writing, processing, and organizational skills. The scientific focus is to improve science vocabulary, scientific observation, inquiry, experimentation, and analysis skills. Safety skills will be stressed each semester. The first semester will begin with the study of cells, cell structures and their functions, protein synthesis, genetics, and the study of heredity. Second semester will include evolution, characteristics of multi-cellular organisms with attention to organs and organ systems, and the diversity of organisms and ecology.

CORE IDEAS	PERFORMANCE OBJECTIVES	SUGGESTED ACTIVITIES
Scientific Practice and Design	**Students who demonstrate understanding will:**	
Constructing Explanations and Designing Solutions Constructing explanations and designing solutions progresses to explanations and designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific ideas, principles, and theories. **Developing and Using Models** Modeling 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. **Planning and Carrying Out Investigations** Planning and carrying out investigations progresses to include investigations that provide evidence for and test conceptual, mathematical, physical, and empirical models. **Using Mathematics and Computational Thinking** Mathematical and computational thinking progresses to using algebraic thinking and analysis, a range of linear and computational tools for statistical analysis to analyze, represent, and model data. Simple computational	• Design experiments that require asking questions, developing hypotheses, collecting data, interpreting data and developing conclusions. [Grades 9-11: SA1.1] • Critically review current literature about scientific topics. [Grade 10: SA1.2], [Grade 11: SA2.1] • Use graphical techniques to describe data. [Grade 10: SA1.2] • Recognize the value of alternative explanations of data. [Grade 11: SA1.2] • Practice formulating logical conclusions. [Grade 9: SA1.2] • 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. • Develop and use a model based on evidence to illustrate the relationships between systems or between components of a system.	

simulations are created and used based on mathematical models of basic assumptions. **Engaging in Argument from Evidence** Engaging in argument from evidence 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. **Asking Questions and Defining Problems** Asking questions and defining problems progresses to formulating, refining, and evaluating empirically testable questions and design problems using models and simulations. **Analyzing and Interpreting Data** Analyzing data progresses to introducing more detailed statistical analysis, the comparison of data sets for consistency, and the use of models to generate and analyze data. **Obtaining, Evaluating, and Communicating Information** Obtaining, evaluating, and communicating information progresses to evaluating the validity and reliability of the claims, methods, and designs. **AKSS**: S.A.1-3	• 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. • Use mathematical and/or computational representations of phenomena or design solutions to support explanations. • Evaluate the claims, evidence, and reasoning behind currently accepted explanations or solutions to determine the merits of arguments. • Ask questions that arise from examining models or a theory to clarify relationships. • Apply concepts of statistics and probability (including determining function fits to data, slope, intercept, and correlation coefficient for linear fits) to scientific and engineering questions and problems, using digital tools when feasible. • Communicate scientific information (e.g., about phenomena and/or the process of development and the design and performance of a proposed process or system) in multiple formats (including orally, graphically, textually, and mathematically).	

<table>
<tr><th colspan="3">FIRST SEMESTER</th></tr>
<tr><th>Cells</th><th colspan="2">Students who demonstrate understanding will:</th></tr>
<tr><td>LS1.A: Structure and Function
• Systems of specialized cells within organisms help them perform the essential functions of life. (HS-LS1-1)
• All cells contain genetic information in the form of DNA molecules. Genes are regions in the DNA that contain the instructions that code for the formation of proteins, which carry out most of the work of cells. (HS-LS1-1) (Note: This Disciplinary Core Idea is also addressed by HS-LS3-1.)

LS1.B: Growth and Development of Organisms
In multicellular organisms, individual cells grow and then divide via a process called mitosis, thereby allowing the organism to grow. 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. Cellular division and differentiation produce and maintain a complex organism, composed of systems of tissues and organs that work together to meet the needs of the whole organism. (HS-LS1-4)

LS1.C Organization for Matter and Energy Flow in Organisms
• 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-LS1-6)
• As matter and energy flow through different organizational levels of living systems, chemical elements are recombined in different ways to form different products. (HS-LS1-6, HS-LS1-7)
• As a result of these chemical reactions, energy is</td><td>• Describe cell organelles and their functions [SC1.1, SC2.2, SE1.1, SG2.1]
• 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. [SC2.2, HS-LS1-7]
• Use a model to illustrate how photosynthesis transforms light energy into stored chemical energy. [SC3.1, SC2.2, HS-LS1-5]
• Describe diffusion and osmosis and the importance of these processes for cells.
• Recognize that cells use DNA to store information and manage cellular functions. [SC1.1]
• Use a model to illustrate the role of cellular division (mitosis) and differentiation in producing and maintaining complex organisms. describe the process of cell division and its role in reproduction and multicellular organisms (mitosis and meiosis). [HS LS1-4, SC1.1]
• 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. [HS LS1-6]</td><td>• Models of plant and animal cells.
• Flow chart type drawings of photosynthesis and respiration.
• Make root beer, sauerkraut or yogurt.
• Labs examining the diffusion of materials into different sized objects.
• Predictions and tests of the behavior of cells in salt solutions and distilled water.
• 3-D molecular models of diffusion and osmosis.
• Computer animations of diffusion and osmosis.
• Student-built models of DNA.
• Use a cell model to work through all the steps of mitosis and meiosis.
• Microscope skills labs including wet mounts of plant and animal cells and cell drawings.</td></tr>
</table>

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-LS1-7) **PS3.D: Energy in Chemical Processes** Although energy cannot be destroyed, it can be converted to less useful forms, for example, to thermal energy in the surrounding environment. (HS-PS3-3, HS-PS3-4). **AKSS**: SC.2 **Suggested Pacing:** 6 weeks		
Heredity	**Students who demonstrate understanding will:**	
LS1.A: 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 most of the work of cells. (HS-LS1-1) *(Note: This Disciplinary Core Idea is also addressed by HS-LS3-1.)* **LS1.B: Growth and Development of Organisms** In multicellular organisms, individual cells grow and then divide via a process called mitosis, thereby allowing the organism to grow. 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. Cellular division and differentiation produce and maintain a complex organism, composed of systems of tissues and organs that work together to meet the needs of the whole organism. (HS-LS1-4) **LS3.A: Inheritance of Traits** Each chromosome consists of a single very long DNA	• Ask questions to clarify relationships about the role of DNA and chromosomes in coding the instructions for characteristic traits passed from parents to offspring**.** [SC1.1, SC1.2, HS LS3-1] • 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. [HS LS1-1] • Describe the role of chromosomes in gender determination. [SC1.1] • Recognize that all cells within a species carry a specific number of chromosomes. [SC1.2, SG2.1] • Make and defend a claim based on evidence that inheritable genetic variations may result from: (a) new genetic combinations through meiosis, (b) viable errors occurring during replication, and/or (c) mutations caused by environmental factors. [SC1.2, SC1.3, HS LS3-2] • Apply concepts of statistics and probability to explain the variation and distribution of expressed traits in a population**.** **[**SC1.1, SD1.1, SG1.1, HS LS 3-3]	• Model human chromosome sets. • Human traits activity. • Punnett squares activity. • Human karyotype activity. • Explores applications and implications of DNA technology.

<table>
<tr><td>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-LS3-1)

LS3.B: Variation of Traits
• In sexual reproduction, chromosomes can sometimes swap sections during the process of meiosis (cell division), thereby creating new genetic combinations and thus more genetic variation. Although DNA replication is tightly regulated and remarkably accurate, errors do occur and result in mutations, which are also a source of genetic variation. Environmental factors can also cause mutations in genes, and viable mutations are inherited. (HS-LS3-2)
• 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-LS3-2, HS-LS3-3)

AKSS: SC.1-2

Suggested Pacing: 4-6 weeks</td><td></td><td></td></tr>
<tr><td colspan="3">SECOND SEMESTER</td></tr>
<tr><td>Evolution</td><td colspan="2">Students who demonstrate understanding will:</td></tr>
<tr><td>LS4.A Evidence of Common Ancestry and Diversity
Genetic information, like the fossil record, 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</td><td>• Describe the changes that have occurred over geologic time.
• Chronicle the development of evolutionary theory by natural selection.
• Communicate scientific information that common ancestry and biological evolution are supported by multiple lines of empirical evidence (homologous</td><td>• UC Berkeley Evolution Website http://evolution.berkeley.edu/
• Natural selection simulations
• Build a bird
• Fossil building simulations
• Interpretation of fossil exercises
• Geological time activities</td></tr>
</table>

differences in amino acid sequences and from anatomical and embryological evidence. (HS-LS4-1) **LS4.B: Natural Selection** Natural selection occurs only if there is both (1) variation in the genetic information between organisms in a population and (2) variation in the expression of that genetic information—that is, trait variation—that leads to differences in performance among individuals. (HS-LS4-2, HS-LS4-3) **LS4.C: Adaptation** • Evolution is a consequence of the interaction of four factors: (1) the potential for a species to increase in number, (2) the genetic variation of individuals in a species due to mutation and sexual reproduction, (3) competition for an environment's limited supply of the resources that individuals need in order to survive and reproduce, and (4) the ensuing proliferation of those organisms that are better able to survive and reproduce in that environment. (HS-LS4-2) • Natural selection leads to adaptation, that is, to a population dominated by organisms that are anatomically, behaviorally, and physiologically well suited to survive and reproduce in a specific environment. That is, the differential survival and reproduction of organisms in a population that have an advantageous heritable trait leads to an increase in the proportion of individuals in future generations that have the trait and to a decrease in the proportion of individuals that do not. (HS-LS4-3, HS-LS4-4) • Adaptation also means that the distribution of traits in a population can change when conditions change. (HS-LS4-3) • 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	structures, embryology, DNA, adaptive radiation, fossil record). [HS LS4-1] • Explain how the diversity of life has arisen through evolutionary processes. [SC1.3, SG1.1] • Describe how variation within species is maintained over time through recombination and mutations of genes. [SC1.2, SC1.3] • Construct an explanation based on evidence that the process of evolution primarily results from four factors: (1) the potential for a species to increase in number, (2) the heritable genetic variation of individuals in a species due to mutation and sexual reproduction, (3) competition for limited resources, and (4) the proliferation of those organisms that are better able to survive and reproduce in the environment. [HS LS4-2] • Construct an explanation based on evidence for how natural selection leads to adaptation of populations. [HS LS 4-4, SC1.2] • Evaluate the evidence supporting claims that changes in environmental conditions may result in: (1) increases in the number of individuals of some species, (2) the emergence of new species over time, and (3) the extinction of other species. [HS LS 4-5] • Explain how variation within a species and natural selection could result in speciation or extinction. [SC1.2] • Describe classification based on evolutionary relationships. [SC1.3]	• Peppered moth activity • Rock pocket mice activity (HHMI) • Toothpick fish

drastic, the opportunity for the species' evolution is lost.(HS-LS4-5) **LS4.D: Biodiversity and Humans** Humans depend on the living world for the resources and other benefits provided by biodiversity. But human activity is also having adverse impacts on biodiversity through overpopulation, over exploitation, 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-LS4-6) *(Note: This Disciplinary Core Idea is also addressed by HS-LS2-7.)* **AK Content Standards:** S.A.1, S.C.1-2, S.G.1-3 **Suggested Pacing:** 4-6 weeks		
Diversity of Organisms	**Students who demonstrate understanding will:**	
LS1.A: Structure and Function • Feedback mechanisms maintain a living system's internal conditions within certain limits and mediate behaviors, allowing it to remain alive and functional even as external conditions change within some range. Feedback mechanisms can encourage (through positive feedback) or discourage (negative feedback) what is going on inside the living system. (HS-LS1-3) • 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-LS1-2) **AKSS**: S.C.1, S.C.2, S.C.3 **Suggested Pacing**: 6- 8 weeks	• Explain how the diversity of life has arisen through evolutionary processes. [SC1.3, SG1.1] • Describe the characteristics of domains and kingdoms of organisms. [SC2.1] • Explain the relationship between structure and function in major phyla. • Utilize tools to categorize organisms (i.e., taxonomic keys, cladograms). • Describe the structures, functions, and interdependence of organ systems. [SC2.3, SC2.4, SC2.1] • Explain how the diversity of life has arisen through evolutionary processes.	• Antibiotic resistant bacteria. • Virus mutations (common cold/Ebola). • Flip books of the major kingdoms of organisms. • Pamphlet-style reports on disease causing microorganisms. • Drawing the structures and describing the functions of human organ systems. • Lab: Flowering plant dissection. • Lab: Squid dissection. • Lab: Botany of foods. • Dichotomous key of jelly beans. • Describe adaptations of local plants and animals due to extreme environmental conditions in Alaskan biomes.

<table>
<tr><th>Ecology</th><th colspan="2">Students who demonstrate understanding will:</th></tr>
<tr><td>LS2.A: 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 such as predation, competition, and disease. Organisms would have the capacity to produce populations of great size were it not for the fact that environments and resources are finite. This fundamental tension affects the abundance (number of individuals) of species in any given ecosystem. (HS-LS2-1, HS-LS2-2)

LS2.B: Cycles of Matter and Energy Transfer in Ecosystems
• Photosynthesis and cellular respiration (including anaerobic processes) provide most of the energy for life processes. (HS-LS2-3)
• Plants or algae form the lowest level of the food web. At each link upward in a food web, only a small fraction of the matter consumed at the lower level is transferred upward, to produce growth and release energy in cellular respiration at the higher level. Given this inefficiency, there are generally fewer organisms at higher levels of a food web. Some matter reacts to release energy for life functions, some matter is stored in newly made structures, and much is discarded. The chemical elements that make up the molecules of organisms pass through food webs and into and out of the atmosphere and soil, and they are combined and recombined in different ways. At each link in an ecosystem, matter and energy are conserved. (HS-LS2-4)
• Photosynthesis and cellular respiration are important components of the carbon cycle, in which carbon is exchanged among the biosphere, atmosphere, oceans, and geosphere through chemical, physical, geological,</td><td>• Use mathematical representations to support claims for the cycling of matter and flow of energy among organisms in an ecosystem (e.g., carbon, energy, water). [HS LS 2-4]
• Develop a model to illustrate the role of photosynthesis and cellular respiration in the cycling of carbon among the biosphere, atmosphere, hydrosphere, and geosphere. [SC3.1, SC3.3, HS LS 2-5]
• Use mathematical and/or computational representations to support explanations of factors that affect carrying capacity of ecosystems at different scales, specifically in Alaskan ecosystems [SC3.3, HS LS2-1]
• Use mathematical representations to support and revise explanations based on evidence about factors affecting biodiversity and populations in ecosystems of different scales. [SC3.3, HS LS 2-2]
• describe symbiotic interactions between organisms in a community. [SC3.2]
• Design, evaluate, and refine a solution for reducing the impacts of human activities on the environment and biodiversity. [HS LS 2-7]</td><td>• Outdoor fieldwork including:
o Transects measuring plant species diversity.
o Pond water invertebrate observations.
o The GLOBE Program (www.globe.gov).
• Ecological simulations.
• Invasive plant studies.
• Discussions of current ecological issues.
• Model ecosystem energy transfers.
• Make posters of food webs/chains from local habitats.
• Describe specific ways in which indigenous peoples use local species.
• Individual research projects on local plants and animal species.
• Use web based data to graph the extent of sea ice in the Arctic Ocean since 1970.
• Explore the causes of that change and its consequences on the organisms of the Arctic.</td></tr>
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<td>and biological processes. (HS-LS2-5)

LS2.C: Ecosystem Dynamics, Functioning, and Resilience
A complex set of interactions within an ecosystem can keep its numbers and types of organisms relatively constant over long periods of time under stable conditions. If a modest biological or physical disturbance to an ecosystem occurs, it may return to its more or less original status (i.e., the ecosystem is resilient), as opposed to becoming a very different ecosystem. Extreme fluctuations in conditions or the size of any population, however, can challenge the functioning of ecosystems in terms of resources and habitat availability. (HS-LS2-2, HS-LS2-6)

LS4.D: Biodiversity and Humans
• Biodiversity is increased by the formation of new species (speciation) and decreased by the loss of species (extinction). (Secondary to HS-LS2-7)
• Humans depend on the living world for the resources and other benefits provided by biodiversity. But human activity is also having adverse impacts on biodiversity through overpopulation, overexploitation, habitat destruction, pollution, introduction of invasive species, and climate change. Thus sustaining biodiversity so that ecosystem functioning and productivity are maintained is essential to supporting and enhancing life on Earth. Sustaining biodiversity also aids humanity by preserving landscapes of recreational or inspirational value. (Secondary to HS-LS2-7) (Note: This Disciplinary Core Idea is also addressed by HS-LS4-6.)

AKSS: S.C.2-3

Suggested Pacing: 2-4 weeks</td>
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CHEMISTRY

Grade: 10-12	**Overview:** *Chemistry* is a one-year introductory general chemistry course which builds a foundation for college-level chemistry, physics, and biology courses. Students learn about chemical reactions and the structure of matter in order to explain how and why substances react the way they do. Laboratory work and laboratory reporting are an integral part of the course, helping students develop an understanding of the concepts as well as the process of science.
Length: Two semesters	
Credit: 1	
Prerequisites: *Algebra 1* **and** *Biology*	

CORE IDEAS	PERFORMANCE OBJECTIVES	SUGGESTED ACTIVITIES
Scientific Practice and Design	**Students who demonstrate understanding will:**	
Analyzing and Interpreting Data Analyzing data in 9–12 builds on K–8 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. **Using Mathematics and Computational Thinking** Mathematical and computational thinking at the 9–12 level builds on K–8 and progresses to using algebraic thinking and analysis, a range of linear and nonlinear functions including trigonometric functions, exponentials and logarithms, 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. **Developing and Using Models** Modeling in 9–12 builds on K–8 and progresses to using, synthesizing, and developing models to predict and show relationships among variables between systems and their components in the	• Recognize SI units of measurements. [SA1.1] • Convert data into scientific notation and from one unit to another. [M2.4.2] • Round numbers correctly based on the certainty of the measurement. • Use and create graphs to represent data. [SA1.2, SA1.1, SA1.1, 1.2] • 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. • Use mathematical representations of phenomena to support claims. • 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. [HS-PS1-3] • Use a model to predict the relationships between systems or between components of a system. [HS-PS1-1] • Apply scientific principles and evidence to provide an	• Make a poster of conversion tips/significant digit rules. • Lab: Density of unknown metal (slope of the line mass vs. volume gives density). [SE2.1]

natural and designed worlds. Develop a model based on evidence to illustrate the relationships between systems or between components of a system. (HS-PS1-4, HS-PS1-8) **Planning and Carrying Out Investigations** Planning and carrying out investigations 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. **Constructing Explanations and Designing Solutions** Constructing explanations and designing solutions 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. **AKSS**: SA.1, SE.2, M.2 **Suggested Pacing**: 3 weeks	explanation of phenomena and solve design problems, taking into account possible unanticipated effects. [HS-PS1-5] • 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. [HS-PS1-2] • Refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations. [HS-PS1-6]	
FIRST SEMESTER		
Changes and Interactions of Matter	**Students who demonstrate understanding will:**	
PS1.B: 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-PS1-2, HS-PS1-7) • 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-PS1-6) • Chemical processes, their rates, and whether or not energy is stored or released can be understood in terms of the collisions of	• Describe the changes and interactions that result in observable changes in the properties of matter including chemical, physical and nuclear changes such as radioactive decay. [SB3.1, 3.2, 3.3] • Explain the Law of Conservation of Mass as it relates to chemical and physical changes. • Distinguish between endothermic and exothermic reactions. [SB3.2] • 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. [HS-PS1-4]	• Lab: Separation of a mixture. • Lab: Chemical and physical changes. • Demo: Electrolysis of water.

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-PS1-4, HS-PS1-5) **PS1.C: Nuclear Processes** Nuclear processes, including fusion, fission, and radioactive decays of unstable nuclei, involve release or absorption of energy. (HS-PS1-8) **AKSS**: SB.3 **Suggested Pacing**: 4 weeks		
Structure of Matter	**Students who demonstrate understanding will:**	
PS1.A: 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-PS1-4) • 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-PS1-1, HS-PS1-2) • Each atom has a charged substructure consisting of a nucleus, which is made of protons and neutrons, surrounded by electrons. (HS-PS1-1) **PS1.C: Nuclear Processes** Nuclear processes, including fusion, fission, and radioactive decays of unstable nuclei, involve release or absorption of energy. (HS-PS1-8) **AKSS**: SB.1, 3, SG.1-44 **Suggested Pacing:** 4 weeks	• Draw or build models describing the nature of molecules, atoms, and sub-atomic particles. [SB1.1] • Describe how the current model of the atom is related to the structure and behavior of matter. [SB1.1, SB3.1, SE1.1, SG1.1, SG2.1, SG3.1, SG4.1] • Explain the relationship between nuclear stability and radioactivity. [SB3.2] • Compare wave and particle models of light. (9) [SB3.3]; (10) [SB3.2, SG4.1]; (9-10) [SE1.1, SG1.1, SG2.1, SG3.1] • Express the arrangements of electrons in atoms using orbital notation. (10-11) [SB3.1] • Relate the group and periodic trends (periodic table) to the electron configuration of atoms. (10-11) [SB1] • 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. [HS-PS1-8] • 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 of atoms. [HS-PS1-1]	• Lab: Isotope lab (pennies/Runts candy). • Periodic chart poster (trends and grouping). • Atomic emission spectra lab/observations. • Lab: Reactivity of the alkaline earth metals.

Ionic and Covalent Bonding	Students who demonstrate understanding will:	
PS1.A: Structure and Properties of Matter • The structure and interactions of matter at the bulk scale are determined by electrical forces within and between atoms. (HS-PS1-3) (Secondary to HS-PS2-6) • Each atom has a charged substructure consisting of a nucleus, which is made of protons and neutrons, surrounded by electrons. (HS-PS1-1) **AKSS**: SB.3 **Suggested Pacing**: 4 weeks	• Define and describe chemical bonding; differentiating between ionic, covalent, and metallic bonding. [SB3.1] • Describe how ions form. • Use and understand the current model of an atom to predict the formulas of simple ionic and covalent compounds. [SB3.1] • Write the names and formulas of simple ionic and covalent compounds. • Determine shapes/geometry of molecules. • Compare and contrast polar and non-polar molecules. • Plan and conduct an investigation to gather evidence to compare the structure of substances at the bulk scale to infer the strength of electrical forces between particles. (HS-PS1-3)	• Lab: Formation of an ionic compound. • Lab: Modeling covalent compounds using computer-based models. • Lewis structures. • Demo: Formation of NaCl. • Demo: Polarity of liquids.
SECOND SEMESTER		
Stoichiometry and Chemical Reactions	**Students who demonstrate understanding will:**	
PS1.B: 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-PS1-2, HS-PS1-7) • 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-PS1-6) • 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-PS1-4, HS-PS1-5) **AKSS**: SB.1, 3, MPS1	• Balance chemical equations ~~[9]~~ SB3.1 • Translate written descriptions of chemical reactions into chemical equations • Classify and identify chemical reactions ~~[9]~~ SB3.2 • Convert among moles, mass and number of particles • Calculate empirical and molecular formulas for compounds and determine formulas for hydrates • Solve stoichiometry problems ~~[10]~~ MPS1 • Solve limiting reactant problems • Determine the percent yield of a chemical reaction • Solve reaction stoichiometry problems • 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. (HS-PS1-2) • Refine the design of a chemical system by specifying a change in conditions that would produce increased amounts of products at equilibrium. (HS-PS1-6) • Use mathematical representations to support the claim that	• Mole poster. • Lab: Empirical formula of magnesium oxide. • Lab: Formula of a hydrate. • Lab: Formation of a precipitate/% yield. • Statistical analysis: Mean, median, mode.

Suggested Pacing: 6 weeks	atoms, and therefore mass, are conserved during a chemical reaction. (HS-PS1-7)	
Gases	**Students who demonstrate understanding will:**	
PS1.B: 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-PS1-4, HS-PS1-5) **AKSS**: SB.2, SG.1-4 **Suggested Pacing**: 3 weeks	• Use the kinetic molecular theory to explain physical properties of solids, liquids, and gases. • Describe the role of energy in phase changes. [SB2.1] • Use gas laws to calculate how pressure, temperature, volume and number of moles change. [SG1.1, SG2.1, SG3.1, SG4.1] • Apply gas laws and Avogadro's principle to chemical equations. • 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. (HS-PS1-5)	• Use the kinetic molecular theory to explain physical properties of solids, liquids, and gases. • Describe the role of energy in phase changes [SB2.1] • Use gas laws to calculate how pressure, temperature, volume and number of moles change. [SG1.1, SG2.1, SG3.1, SG4.1] • Apply gas laws and Avogadro's principle to chemical equations. • 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. (HS-PS1-5)
Acids and Bases	**Students who demonstrate understanding will:**	
PS1.A: Structure and Properties of Matter The structure and interactions of matter at the bulk scale are determined by electrical forces within and between atoms. (HS-PS1-3) (Secondary to HS-PS2-6) **PS1.B: 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-PS1-6) **AKSS**: **Suggested Pacing**: 3 weeks	• Compare acids and bases and understand why strengths vary. • Calculate pH and pOH of aqueous solutions. [SB3.1]	• Lab: Titration of vinegar.
Organic Molecules	**Students who demonstrate understanding will:**	
AKSS: SB.2, SE.1, SF.1 **Suggested Pacing**: 3 weeks	• Compare structures and name simple alkanes, alkenes, and alkynes. • Describe hydrocarbon usage and how hydrocarbons are obtained and processed. [SE1.1, SF1.1-1.3]	• Lab: Energy of paraffin/calorimetry (10-11) [SB2.1] • Field trip/guest: oil industry specialist.

PHYSICS

Grade: 10-12 **Length:** Two semesters **Credit:** 1 **Prerequisites:** *Algebra I*	**Overview:** Physics is a science course focusing on the "rules" of the universe. Physics will be treated conceptually in this class, which means concepts are presented in familiar English, with equations and mathematical formulas as guides to thinking. The mathematics skills mastered in Algebra I will be sufficient to complete this course.

CORE IDEAS	PERFORMANCE OBJECTIVES	SUGGESTED ACTIVITIES
FIRST SEMESTER	**Students who demonstrate understanding will:**	
Motion and Stability: Forces and Interactions **PS2.A: Forces and Motion** Newton's second law accurately predicts changes in the motion of macroscopic objects. **NGSS**: **Suggested Pacing**: 3 weeks	• 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. [HS-PS2-1]	• Use sonic motion detectors to gather velocity and position data in multiple applications.
AK Content Standards: S.B.4 **PS2.A: 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-PS2-2, HS-PS2-3) **ETS1.A: Defining and Delimiting an Engineering Problem** 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. (Secondary to HS-PS2-3) **ETS1.C: Optimizing the Design Solution**	• Apply Newton's three laws to practical situations and demonstrate examples of all three laws in a lab setting. [SB4.1] • Differentiate between contact and non-contact forces and create force diagrams using vectors for every day situations. • Demonstrate that when one thing exerts a force on another, an equal amount of force is exerted back on it. (11) [SB4.1] • Distinguish between weight and mass. • Predict force, position, time, or velocity for projectile motion. Explain predictions using Newton's laws. • Apply scientific and engineering ideas to design, evaluate, and refine a device that minimizes the force on a macroscopic object during a collision. [HS-PS2-3] • Use mathematical representations of Newton's Law	• Research the ways in which the success of Newton's laws impacted social, philosophical, and political thought. (9-11) [SF1.3] • "Shoot the Monkey" style-simulation.

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 (trade-offs) may be needed. (Secondary to HS-PS2-3) **Suggested Pacing**: 5 weeks	of Gravitation and Coulomb's Law to describe and predict the gravitational and electrostatic forces between objects. [HS-PS2-4] • Calculate the strength of gravitational attraction between objects of various mass and separation. [SB4.2] • 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. [HS-PS3-5]	
Energy and Momentum **PS3.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-PS3-1, HS-PS3-2) **PS3.B: 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-PS3-1) • Energy cannot be created or destroyed, but it can be transported from one place to another and transferred between systems. (HS-PS3-1, HS-PS3-4) • Mathematical expressions, which 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 speed, allow the concept of conservation of energy to be used to predict and describe system behavior. (HS-PS3-1) • The availability of energy limits what can occur in	• 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. [HS-PS2-2] • Define work by relating it to force and displacement and identify where work is being done in a variety of situations. • 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. [HS-PS3-1] • 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). [HS-PS3-2] • Identify different types of energy and distinguish between kinetic and potential energy. • Identify situations in which the Law of Conservation of Mechanical Energy can be applied. (10) [SB.2.1]; (9) [SB.3.2] • Use mathematical equations to calculate various forms of mechanical energy and solve related word problems. • Design, build, and refine a device that works within given constraints to convert one form of energy into another form of energy. [HS-PS3-3] • Define impulse by relating change in momentum to	• Egg drop experiment. • Lab: Conservation of momentum "Exploding Carts" (measure mass and velocity before and after two stationary carts spring apart). • Lab: Personal power: time students running up stairs and calculate power output. • Use spring scale to pull an object up a ramp and lift it to the same height. • Determine the acceleration of gravity using a pendulum that is displaced through a small angle from vertical and allowing it to oscillate. • Lab: Determine spring constant of a spring by doing a Hook's Law experiment.

any system. (HS-PS3-1) **ETS1.A: 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. (Secondary to HS-PS3-3) **AKSS**: S.B.2-3 **NGSS**: **Suggested Pacing**: 5 weeks	force and time. • Apply the Law of Conservation of Energy to inelastic collisions to calculate the loss of kinetic energy during the collision. • Generalize from the inelastic collision to show that whenever there is a transformation of energy, some energy is spent in ways which make it unavailable for use. (10-11) [SB2.1] • Relate the concepts of energy, time, and power to the rate at which work is done. • Use conservation of energy to find spring potential energy and kinetic energy for an oscillating mass on a spring.	
SECOND SEMESTER	**Students who demonstrate understanding will:**	
Thermal Energy **PS3.B: Conservation of Energy and Energy Transfer** • Energy cannot be created or destroyed, but it can be transported from one place to another and transferred between systems. (HS-PS3-1, HS-PS3-4) • 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-PS3-4) **AKSS**: S.B.2-4, CS.E.2 **NGSS:** **Suggested Pacing**: 2 weeks	• 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). [HS-PS3-4] • Explain that heat is the energy transferred between objects of different temperatures that come in contact. • Use conservation of energy to calculate changes in potential, kinetic, and internal energy. • Perform calculations to determine specific heat capacity and latent heat. • Interpret the various sections of a heating curve.	• Lab: Specific heat experiment.
Waves and Their Applications in Technologies for Information Transfer **PS4.A: 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	• Use mathematical representations to support a claim regarding relationships among the frequency, wavelength, and speed of waves traveling in various media. [HS-PS4-1] • Differentiate between transverse and longitudinal waves. • Evaluate questions about the advantages of using a	• Use a ripple tank to show two source standing waves with nodes and antinodes. • Tuning fork experiments. • Polaroid filters. • Standing waves on a 2-meter spring.

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medium through which it is passing. (HS-PS4-1)
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. (Boundary: The discussion at this grade level is qualitative only: it can be based on the fact that two different sounds can pass a location in different directions without getting mixed.) (HS-PS4-3)

PS4.B: 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-PS4-3)
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-PS4-4)

PS4.C: Information Technologies and Instrumentation
Multiple technologies based on the understanding of waves and their interactions with matter are part of everyday experiences in the modern world (e.g., medical imaging, communications, scanners) and in scientific research. They are essential tools for producing, transmitting, and capturing signals and for storing and interpreting the information contained in them. (HS-PS4-5)

AKSS: S.B.2-4

NGSS:

Suggested Pacing: 4 weeks
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digital transmission and storage of information. [HS-PS4-2]
Apply the relationships between wave speed, frequency, wavelength, and period to solve problems.
Differentiate between destructive and constructive interference.
Identify nodes and antinodes in an interference pattern and extend this concept to diffraction of light.
Explain how sound waves are produced.
Relate frequency to pitch and explain the Doppler effect.
Relate standing waves and harmonics.
Communicate technical information about how some technological devices use the principles of wave behavior and wave interactions with matter to transmit and capture information and energy. [HS-PS4-5]
Distinguish between harmonics in open and closed pipes and in vibrating strings.
Use protractor and ruler to model light's interaction with mirrors and lenses.
Use Snell's Law to calculate the angle of refraction.
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. [HS-PS4-3]
Evaluate the validity and reliability of claims in published materials of the effects that different frequencies of electromagnetic radiation have when absorbed by matter. [HS-PS4-4]

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Electricity and Magnetism **AKSS**: S.B.2-4 **Suggested Pacing**: 9 weeks	• Describe the relationship between electromagnetic forces and the motion of charged particles. (10-11) [SB4.2] • Know the meaning of the terms insulator, conductor, semiconductor, and superconductor. (10-11) [SB4.2] • Build simple DC circuits (series, parallel, and compound). • Calculate the relationships between currents, voltages, and resistances in different parts of a circuit. • 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. [HS-PS2-5] • Demonstrate understanding of the relationship between electricity and magnetism by building small devices such as electric motors and generators. (11) [SB4.2] • Communicate scientific and technical information about why the molecular-level structure is important in the functioning of designed materials. [HS-PS2-6] • Explain how the relationship between electricity and magnetism leads to local phenomena such as the aurora. • List some of the failures of classical physics that led to modern physics.	• Static electricity experiment. • Virtual: Electric field hockey. • Electroscope lab: Explore charging by induction and by conduction. • Plasma ball lamp or Van de Graaf generator. • Electromagnetic investigations – Compass and circuit, nail and battery. • Virtual: *Faraday's Electromagnetic Lab.* • Lab: Parallel vs. series circuits. • Demo: Gas discharge tubes.

Marine Biology

Grade: 10-12 **Length:** Two semesters **Credit:** 1 **Prerequisites:** *1 year of Science*	**Overview:** *Marine Biology* explores the adaptations of marine organisms, ecological concepts and physical processes that structure the marine environment. The course is a study of the environmental impacts of chemistry, geology and other abiotic conditions and the organisms that live in marine environments. The course also examines human interactions with marine ecosystems and the many careers associated with it. Special attention will be given to students' knowledge of Alaska's marine environment, its importance to indigenous peoples, local economies, food production and career possibilities.

CORE IDEAS	PERFORMANCE OBJECTIVES	SUGGESTED ACTIVITIES
FIRST SEMESTER		
Scientific Practice and Design	**Students who demonstrate understanding will:**	
Oceanography **AK Content Standards:** S.A.1, S.D.2, S.D.3 **Suggested Pacing:** 8 weeks	• use the properties of water, salinity, and temperature to explain water stratification • describe and explain periodic variations in the marine ecosystem such as tides, • currents and seasons • explain how the surface of the Earth changes through plate tectonics, earthquakes, • volcanoes, erosion and deposition • give examples of interactions between marine and terrestrial ecosystems • describe how weather is affected by the oceans	• Use 10 gallon aquaria to demonstrate the effects of different densities and temperatures on stratification Use 10 gallon aquaria to demonstrate the effects of different densities and temperatures on stratification • Label and color code a world map with sea/ocean names. Locations of currents • Read The Perfect Storm and use for small group discussions of weather patterns and environmental impacts of the fishing industry • Explain the impact of atmospheric CO2 on ocean acidification
Organisms and Their Effects on Ecosystems	• describe the major abiotic and biotic characteristics of the important ecological zones within the marine biome	• Build a bulletin board showing benthic habitats • Use the characteristics of preserved

AK Content Standards: S.A.1, S.C.2, S.C.3 **Suggested Pacing:** 8 weeks	• describe how biochemical and anatomical characteristics define an organism's anatomy and physiology, its behavior, survival and reproductive capabilities • explain how taxonomy is used to describe the diversity of phyla and classes • list the characteristics of major chordate and invertebrate phyla that allow them to • survive in a marine environment • compare environmental characteristics and the adaptations organisms have to adapt and survive	invertebrates to develop a classification system • Student reports on the major phyla • Discussions of the abiotic challenges of various marine habitat and the physiological and behavioral responses of organisms
PS3: Energy Biochemical Cycles **AK Content Standards:** S.C.3, S.D.3 **Suggested Pacing:** 4 weeks	• give examples of the interdependence between marine organisms and their environment • describe the levels of organization in marine ecosystems from the individuals to populations and communities • describe theories that explain patterns of diversity from the equator to the poles	• Draw food webs of local marine plant and animal species • Use individual student reports to explore the characteristics of predator/prey, symbiotic and herbivorous organism interactions
SECOND SEMESTER	**Students who demonstrate understanding will:**	
Interdependence Between Organisms **AK Content Standards:** S.C.3; CS.E.2 **Suggested Pacing:** 8 weeks	• give examples of the interdependence between marine organisms and their environment • describe the levels of organization in marine ecosystems from the individuals to populations and communities • describe theories that explain patterns of diversity from the equator to the poles	• Draw food webs of local marine plant and animal species • Use individual student reports to explore the characteristics of predator/prey, symbiotic and herbivorous organism interactions
Evolution of Marine Species **AK Content Standards:** S.C.1 **Suggested Pacing:** 4 weeks	• explain how variation in the environment provides the mechanisms for natural selection, evolution and diversity of species • give examples of how the natural variation in individuals allows species to survive in changing environments	• Do a report on one of the extinct sea species from the Cambrian

	• describe the evidence scientists use to link the evolutionary history of organisms and their classification	
Marine Sciences and Culture **AK Content Standards:** S.E.1-3, S.F.1-3, CS.A.4,7 **Suggested Pacing:** ongoing throughout the course	• recognize the importance of marine systems to society • describe how indigenous people use local marine organisms • give examples of how humans can alter ecosystems • explain why it is important for citizens to be knowledgeable on current issues and • policies of natural resource use • give examples of specific examples of Alaskan marine use issues • describe human dependence upon the marine environment, concentrating on • Alaskan uses • list and describe marine careers • give examples of how humans can alter the structures of ecosystems	• Research career possibilities in the field of marine biology • Describe the fisheries of the North Pacific

Alaska Natural Science

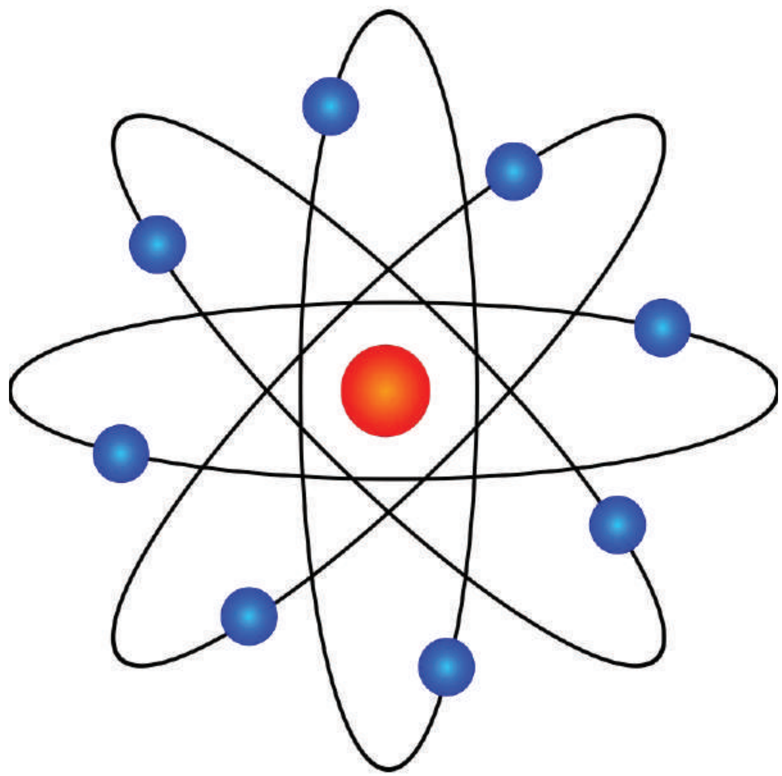
Grade: 11-12 **Length:** Two semesters **Credit:** 1 **Prerequisites:** *Biology*	**Overview:** *Alaska Natural Science* studies the fundamental concepts in ecology – diversity, interdependence, and energy flow - through contemporary problems. This course will focus on local and global environmental issues that Alaskans face, such as water and air pollution, climate change, resource management and depletion, and subsistence use.

CORE IDEAS	PERFORMANCE OBJECTIVES	SUGGESTED ACTIVITIES
FIRST SEMESTER		
Scientific Practice and Design	**Students who demonstrate understanding will:**	
Monitoring the Environment **AK Content Standards:** S.E.2, S.F.1, CS.A.4,7, CS.E.2 **Suggested Pacing:** 8 weeks	• list abiotic parameters that are important in determining water quality • use standard monitoring equipment to evaluate the water quality of a local pond, • river, stream or slough • describe the relationship between the water quality and land use surrounding the • water source [9,10,11] SE.2.1 • describe water use issues that are important to urban and rural Alaska [10] SF1.1- • 3.1 • describe global water use/shortage issues [9,10,11] SE1.1, [10] SF1.1-3.1	• Conduct a water quality monitoring project in the local area. Determine pH, DO, turbidity, nitrates, phosphates, and temperature • Research and report on water availability/quality issues • Diagram the water cycle • Use a three dimensional geologic water cycle • model to study belowground water movement • Research low-tech solutions to water purification • Visit the water treatment plant • Invite fisheries professionals to discuss the relationship between forestry and fisheries • Research effects of climate change in Alaska • Discuss/research landfill and toxic waste disposal issues
Human Effects on	• explain how farming, timber cutting, and mining could	

Ecosystems **AK Content Standards:** S.C.3, S.D.2, CS.A.4,7, CS.E.2 **Suggested Pacing:** 4 weeks	cause erosion and pollution [9,10,11] SD2.1 • explain why ecosystems need a consistent supply of energy to function [9] SC3.1 • describe evidence for global climate change, especially for Alaska [10,11] SD3.1	• *Ocean Animal Emergency*-Nova Video
SECOND SEMESTER	**Students who demonstrate understanding will:**	
Human Effects on Ecosystems (Continued) **AK Content Standards:** S.C.3, S.D.2, CS.A.4,7, CS.E.2 **Suggested Pacing:** 4 weeks	• describe the short and long term effects of climate change on Alaskan wildlife [11] SC3.1, [11] SC3.2 • explain the difference between the greenhouse effect and ozone depletion • describe how high diversity in an ecosystem allows it to function in a changing environment [9] SC3.3, [10] SC3.1	• Invite wildfire prevention personnel to discuss changes in climate and the impact on forestry • Describe the effects of wildfire on boreal systems • Invite members of the native community to comment on changes in rural practices because of climate change
Effects of the Environment on Humans **AK Content Standards:** S.C.2-3, S.E.1-2, S.F.1-3; CS.A.4,7, CS.E.2 **Suggested Pacing:** 8 weeks	• describe examples of how local species of organisms have been used in special ways by indigenous peoples [9] SE1.1, [9] SF1-3 • give examples of how humans in the arctic have responded to changes in the climate [9,10] SF1-3 • give examples of boreal and arctic species response to the changing physical environment: acclimation, migration, adaptation and extinction [9] SC2.1 • provide examples of the effects of toxic substances in the environment on human health [9,10,11] SE2.1 • explain biomagnifications [9] SC3.3	• Research some positive and negative aspects of wildlife harvesting on ecosystems • Describe characteristics of successful wildlife management policies • Conduct individual bioassay experiments to determine the LD50 and TC50 of common environmental contaminants on alfalfa seeds • Examine the information on a MSDS for common lab and household chemicals

SCIENCE CURRICULUM

APPENDEX



Alaska Content Standards

SCIENCE

A

Science as Inquiry and Process

A student should understand and be able to apply the processes and applications of scientific inquiry.

A student who meets the content standard should:

1) develop an understanding of the processes of science used to investigate problems, design and conduct repeatable scientific investigations, and defend scientific arguments;
2) develop an understanding that the processes of science require integrity, logical reasoning, skepticism, openness, communication, and peer review; and
3) develop an understanding that culture, local knowledge, history, and interaction with the environment contribute to the development of scientific knowledge, and local applications provide opportunity for understanding scientific concepts and global issues.

B

Concepts of Physical Science

A student should understand and be able to apply the concepts, models, theories, universal principles, and facts that explain the physical world.

A student who meets the content standard should:

1) develop an understanding of the characteristic properties of matter and the relationship of these properties to their structure and behavior;
2) develop an understanding that energy appears in different forms, can be transformed from one form to another, can be transferred or moved from one place or system to another, may be unavailable for use, and is ultimately conserved;
3) develop an understanding of the interactions between matter and energy, including physical, chemical, and nuclear changes, and the effects of these interactions on physical systems; and
4) develop an understanding of motions, forces, their characteristics and relationships, and natural forces and their effects.

C

Concepts of Life Science

A student should understand and be able to apply the concepts, models, theories, facts, evidence, systems, and processes of life science.

A student who meets the content standard should:

1) develop an understanding of how science explains changes in life forms over time, including genetics, heredity, the process of natural selection, and biological evolution;
2) develop an understanding of the structure, function, behavior, development, life cycles, and diversity of living organisms; and
3) develop an understanding that all organisms are linked to each other and their physical environments through the transfer and transformation of matter and energy.

D

Concepts of Earth Science

A student should understand and be able to apply the concepts, processes, theories, models, evidence, and systems of earth and space sciences.

A student who meets the content standard should:

1) develop an understanding of Earth's geochemical cycles;
2) develop an understanding of the origins, ongoing processes, and forces that shape the structure, composition, and physical history of the Earth;
3) develop an understanding of the cyclical changes controlled by energy from the sun and by Earth's position and motion in our solar system; and
4) develop an understanding of the theories regarding the origin and evolution of the universe.

E

Science and Technology

A student should understand the relationships among science, technology, and society.

A student who meets the content standard should:

1) develop an understanding of how scientific knowledge and technology are used in making decisions about issues, innovations, and responses to problems and everyday events;
2) develop an understanding that solving problems involves different ways of thinking, perspectives, and curiosity that lead to the exploration of multiple paths that are analyzed using scientific, technological, and social merits; and
3) develop an understanding of how scientific discoveries and technological innovations affect and are affected by our lives and cultures

F

Cultural, Social, Personal Perspectives and Science

A student should understand the dynamic relationships among scientific, cultural, social, and personal perspectives.

A student who meets the content standard should:

1) develop an understanding of the interrelationships among individuals, cultures, societies, science, and technology;
2) develop an understanding that some individuals, cultures, and societies use other beliefs and methods in addition to scientific methods to describe and understand the world; and
3) develop an understanding of the importance of recording and validating cultural knowledge.

G

History and Nature of Science

A student should understand the history and nature of science.

A student who meets the content standard should:

1) develop an understanding that historical perspectives of scientific explanations demonstrate that scientific knowledge changes over time, building on prior knowledge;
2) develop an understanding that the advancement of scientific knowledge embraces innovation and requires empirical evidence, repeatable investigations, logical arguments, and critical review in striving for the best possible explanations of the natural world;
3) develop an understanding that scientific knowledge is ongoing and subject to change as new evidence becomes available through experimental and/or observational confirmation(s); and
4) develop an understanding that advancements in science depend on curiosity, creativity, imagination, and a broad knowledge base.

CULTURAL STANDARDS

A

Culturally-knowledgeable students are well grounded in the cultural heritage and traditions of their community.

Students who meet this cultural standard are able to:

1) assume responsibilities for their role in relation to the well-being of the cultural community and their lifelong obligations as a community member;
2) recount their own genealogy and family history;
3) acquire and pass on the traditions of their community through oral and written history;
4) practice their traditional responsibilities to the surrounding environment;
5) reflect through their own actions the critical role that the local heritage language plays in fostering a sense of who they are and how they understand the world around them;
6) live a life in accordance with the cultural values and traditions of the local community and integrate them into their everyday behavior; and
7) determine the place of their cultural community in the regional, state, national, and international political and economic systems.

B

Culturally-knowledgeable students are able to build on the knowledge and skills of the local cultural community as a foundation from which to achieve personal and academic success throughout life.

Students who meet this cultural standard are able to:

1) acquire insights from other cultures without diminishing the integrity of their own;
2) make effective use of the knowledge, skills, and ways of knowing from their own cultural traditions to learn about the larger world in which they live;
3) make appropriate choices regarding the long-term consequences of their actions; and
4) identify appropriate forms of technology and anticipate the consequences of their use for improving the quality of life in the community.

C

Culturally-knowledgeable students are able to actively participate in various cultural environments.

Students who meet this cultural standard are able to:

1) perform subsistence activities in ways that are appropriate to local cultural traditions;
2) make constructive contributions to the governance of their community and the well-being of their family;

C *(continued)*

3) attain a healthy lifestyle through which they are able to maintain their social, emotional, physical, intellectual, and spiritual well-being; and
4) enter into and function effectively in a variety of cultural settings.

D

Culturally-knowledgeable students are able to engage effectively in learning activities that are based on traditional ways of knowing and learning.

Students who meet this cultural standard are able to:

1) acquire in-depth cultural knowledge through active participation and meaningful interaction with Elders;
2) participate in and make constructive contributions to the learning activities associated with a traditional camp environment;
3) interact with Elders in a loving and respectful way that demonstrates an appreciation of their role as culture-bearers and educators in the community;
4) gather oral and written history information from the local community and provide an appropriate interpretation of its cultural meaning and significance;
5) identify and utilize appropriate sources of cultural knowledge to find solutions to everyday problems; and
6) engage in a realistic self-assessment to identify strengths and needs and make appropriate decisions to enhance life skills.

E

Culturally-knowledgeable students demonstrate an awareness and appreciation of the relationships and processes of interaction of all elements in the world around them.

Students who meet this cultural standard are able to:

1) recognize and build upon the interrelationships that exist among the spiritual, natural, and human realms in the world around them, as reflected in their own cultural traditions and beliefs as well as those of others;
2) understand the ecology and geography of the bioregion they inhabit;
3) demonstrate an understanding of the relationship between world view and the way knowledge is formed and used;
4) determine how ideas and concepts from one knowledge system relate to those derived from other knowledge systems;
5) recognize how and why cultures change over time;
6) anticipate the changes that occur when different cultural systems come in contact with one another;
7) determine how cultural values and beliefs influence the interaction of people from different cultural backgrounds; and
8) identify and appreciate who they are and their place in the world.

Topic Arrangements of the Next Generation Science Standards

At the beginning of the NGSS development process, in order to eliminate potential redundancy, seek an appropriate grain size, and seek natural connections among the Disciplinary Core Ideas (DCIs) identified within the *Framework for K-12 Science Education*, the writers arranged the DCIs into topics around which to develop the standards. This structure provided the original basis of the standards, and is preferred by many states. However, t**he coding structure of individual performance expectations reflects the DCI arrangement** in the *Framework*.

Due to the fact that the NGSS progress toward end-of-high school core ideas, the standards may be rearranged in any order within a grade level.

Table of Contents

Elementary Standards

Students in kindergarten through fifth grade begin to develop an understanding of the four disciplinary core ideas: physical sciences; life sciences; earth and space sciences; and engineering, technology, and applications of science. In the earlier grades, students begin by recognizing patterns and formulating answers to questions about the world around them. By the end of fifth grade, students are able to demonstrate grade-appropriate proficiency in gathering, describing, and using information about the natural and designed world(s). The performance expectations in elementary school grade bands develop ideas and skills that will allow students to explain more complex phenomena in the four disciplines as they progress to middle school and high school. While the performance expectations shown in kindergarten through fifth grade couple particular practices with specific disciplinary core ideas, instructional decisions should include use of many practices that lead to the performance expectations.

Kindergarten

The performance expectations in kindergarten help students formulate answers to questions such as: "What happens if you push or pull an object harder? Where do animals live and why do they live there? What is the weather like today and how is it different from yesterday?"

Kindergarten performance expectations include PS2, PS3, LS1, ESS2, ESS3, and ETS1 Disciplinary Core Ideas from the *NRC Framework*. Students are expected to develop understanding of patterns and variations in local weather and the purpose of weather forecasting to prepare for, and respond to, severe weather. Students are able to apply an understanding of the effects of different strengths or different directions of pushes and pulls on the motion of an object to analyze a design solution. Students are also expected to develop understanding of what plants and animals (including humans) need to survive and the relationship between their needs and where they live. The crosscutting concepts of patterns; cause and effect; systems and system models; interdependence of science, engineering, and technology; and influence of engineering, technology, and science on society and the natural world are called out as organizing concepts for these disciplinary core ideas. In the kindergarten performance expectations, students are expected to demonstrate grade-appropriate proficiency in asking questions, developing and using models, planning and carrying out investigations, analyzing and interpreting data, designing solutions, engaging in argument from evidence, and obtaining, evaluating, and communicating information. Students are expected to use these practices to demonstrate understanding of the core ideas.

K.Forces and Interactions: Pushes and Pulls

K.Forces and Interactions: Pushes and Pulls

Students who demonstrate understanding can:

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. [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, and two objects colliding and pushing on each other.] [Assessment Boundary: Assessment is limited to different relative strengths or different directions, but not both at the same time. Assessment does not include non-contact pushes or pulls such as those produced by magnets.]

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

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*:

Science and Engineering Practices

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.

- ♣ With guidance, plan and conduct an investigation in collaboration with peers. (K-PS2-1)

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. (K-PS2-2)

Connections to Nature of Science

Scientific Investigations Use a Variety of Methods

- ♣ Scientists use different ways to study the world. (K-PS2-1)

Disciplinary Core Ideas

PS2.A: Forces and Motion

- ♣ Pushes and pulls can have different strengths and directions. (K-PS2-1),(K-PS2-2)
- ♣ Pushing or pulling on an object can change the speed or direction of its motion and can start or stop it. (K-PS2-1),(K-PS2-2)

PS2.B: Types of Interactions

- ♣ When objects touch or collide, they push on one another and can change motion. (K-PS2-1)

PS3.C: Relationship Between Energy and Forces

- ♣ A bigger push or pull makes things go faster. *(secondary to K-PS2-1)*

ETS1.A: Defining Engineering Problems

- ♣ 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. *(secondary to K-PS2-2)*

Crosscutting Concepts

Cause and Effect

- ♣ Simple tests can be designed to gather evidence to support or refute student ideas about causes. (K-PS2-1),(K-PS2-2)

Connections to other DCIs in kindergarten: **K.ETS1.A** (K-PS2-2); **K.ETS1.B** (K-PS2-2)

Articulation of DCIs across grade-bands: **2.ETS1.B** (K-PS2-2); **3.PS2.A** (K-PS2-1),(K-PS2-2); **3.PS2.B** (K-PS2-1); **4.PS3.A** (K-PS2-1); **4.ETS1.A** (K-PS2-2)

Common Core State Standards Connections:

ELA/Literacy –

RI.K.1 With prompting and support, ask and answer questions about key details in a text. *(K-PS2-2)*

W.K.7 Participate in shared research and writing projects (e.g., explore a number of books by a favorite author and express opinions about them). (K-PS2-1)

SL.K.3 Ask and answer questions in order to seek help, get information, or clarify something that is not understood. *(K-PS2-2)*

Mathematics –

MP.2 Reason abstractly and quantitatively. *(K-PS2-1)*

K.MD.A.1 Describe measurable attributes of objects, such as length or weight. Describe several measurable attributes of a single object. *(K-PS2-1)*

K.MD.A.2 Directly compare two objects with a measurable attribute in common, to see which object has "more of"/"less of" the attribute, and describe the difference. (K-PS2-1)

*The performance expectations marked with an asterisk integrate traditional science content with engineering through a Practice or Disciplinary Core Idea.

K.Interdependent Relationships in Ecosystems: Animals, Plants, and Their Environment

K.Interdependent Relationships in Ecosystems: Animals, Plants, and Their Environment

Students who demonstrate understanding can:

K-LS1-1. Use observations to describe patterns of what plants and animals (including humans) need to survive. [Clarification Statement: Examples of patterns could include that animals need to take in food but plants do not; the different kinds of food needed by different types of animals; the requirement of plants to have light; and that all living things need water.]

K-ESS2-2. Construct an argument supported by evidence for how plants and animals (including humans) can change the environment to meet their needs. [Clarification Statement: Examples of plants and animals changing their environment could include a squirrel digs in the ground to hide its food and tree roots can break concrete.]

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

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.* [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.]

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*:

Science and Engineering Practices

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, or storyboard) that represent concrete events or design solutions.

- ♣ Use a model to represent relationships in the natural world. (K-ESS3-1)

Analyzing and Interpreting Data

Analyzing data in K–2 builds on prior experiences and progresses to collecting, recording, and sharing observations.

- ♣ Use observations (firsthand or from media) to describe patterns in the natural world in order to answer scientific questions. (K-LS1-1)

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. (K-ESS2-2)

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 solutions with others in oral and/or written forms using models and/or drawings that provide detail about scientific ideas. (K-ESS3-3)

Connections to Nature of Science

Scientific Knowledge is Based on Empirical Evidence

- ♣ Scientists look for patterns and order when making observations about the world. (K-LS1-1)

Disciplinary Core Ideas

LS1.C: Organization for Matter and Energy Flow in Organisms

- ♣ All animals need food in order to live and grow. They obtain their food from plants or from other animals. Plants need water and light to live and grow. (K-LS1-1)

ESS2.E: Biogeology

- ♣ Plants and animals can change their environment. (K-ESS2-2)

ESS3.A: 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. (K-ESS3-1)

ESS3.C: 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. *(secondary to K-ESS2-2)*,(K-ESS3-3)

ETS1.B: Developing Possible Solutions

- ♣ Designs can be conveyed through sketches, drawings, or physical models. These representations are useful in communicating ideas for a problem's solutions to other people. *(secondary to K-ESS3-3)*

Crosscutting Concepts

Patterns

- ♣ Patterns in the natural and human designed world can be observed and used as evidence. (K-LS1-1)

Cause and Effect

- ♣ Events have causes that generate observable patterns. (K-ESS3-3)

Systems and System Models

- ♣ Systems in the natural and designed world have parts that work together. (K-ESS2-2),(K-ESS3-1)

Connections to other DCIs in kindergarten: **K.ETS1.A** (K-ESS3-3)

Articulation of DCIs across grade-bands: **1.LS1.A** (K-LS1-1),(K-ESS3-1); **2.LS2.A** (K-LS1-1); **3.LS2.C** (K-LS1-1); **3.LS4.B** (K-LS1-1); **4.ESS2.E** (K-ESS2-2); **4.ESS3.A** (K-ESS3-3); **5.LS1.C** (K-LS1-1); **5.LS2.A** (K-ESS3-1),(K-LS1-1); **5.ESS2.A** (K-ESS2-2),(K-ESS3-1); **5.ESS3.C** (K-ESS3-3)

Common Core State Standards Connections:

ELA/Literacy –

W.K.1 Use a combination of drawing, dictating, and writing to compose opinion pieces in which they tell a reader the topic or the name of the book they are writing about and state an opinion or preference about the topic or book. (K-ESS2-2)

W.K.2 Use a combination of drawing, dictating, and writing to compose informative/explanatory texts in which they name what they are writing about and supply some information about the topic. *(K-ESS2-2),(K-ESS3-3)*

W.K.7 Participate in shared research and writing projects (e.g., explore a number of books by a favorite author and express opinions about them). (K-LS1-1)

RI.K.1 With prompting and support, ask and answer questions about key details in a text. (K-ESS2-2)

SL.K.5 Add drawings or other visual displays to descriptions as desired to provide additional detail. *(K-ESS3-1)*

Mathematics –

MP.2 Reason abstractly and quantitatively. *(K-ESS3-1)*

MP.4 Model with mathematics. *(K-ESS3-1)*

K.CC Counting and Cardinality *(K-ESS3-1)*

K.MD.A.2 Directly compare two objects with a measurable attribute in common, to see which object has "more of"/"less of" the attribute, and describe the difference. *(K-LS1-1)*

*The performance expectations marked with an asterisk integrate traditional science content with engineering through a Practice or Disciplinary Core Idea.

K.Weather and Climate

K.Weather and Climate

Students who demonstrate understanding can:

K-ESS2-1. Use and share observations of local weather conditions to describe patterns over time. [Clarification Statement: Examples of qualitative observations could include descriptions of the weather (such as sunny, cloudy, rainy, and warm); examples of quantitative observations could include numbers of sunny, windy, and rainy days in a month. Examples of patterns could include that it is usually cooler in the morning than in the afternoon and the number of sunny days versus cloudy days in different months.] [Assessment Boundary: Assessment of quantitative observations limited to whole numbers and relative measures such as warmer/cooler.]

K-ESS3-2. Ask questions to obtain information about the purpose of weather forecasting to prepare for, and respond to, severe weather.* [Clarification Statement: Emphasis is on local forms of severe weather.]

K-PS3-1. Make observations to determine the effect of sunlight on Earth's surface. [Clarification Statement: Examples of Earth's surface could include sand, soil, rocks, and water] [Assessment Boundary: Assessment of temperature is limited to relative measures such as warmer/cooler.]

K-PS3-2. Use tools and materials to design and build a structure that will reduce the warming effect of sunlight on an area.* [Clarification Statement: Examples of structures could include umbrellas, canopies, and tents that minimize the warming effect of the sun.]

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*:

Science and Engineering Practices

Asking Questions and Defining Problems

Asking questions and defining problems in grades 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 designed world. (K-ESS3-2)

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) to collect data that can be used to make comparisons. (K-PS3-1)

Analyzing and Interpreting Data

Analyzing data in K–2 builds on prior experiences and progresses to collecting, recording, and sharing observations.

- ♣ Use observations (firsthand or from media) to describe patterns in the natural world in order to answer scientific questions. (K-ESS2-1)

Constructing Explanations and Designing Solutions

Constructing explanations and designing solutions 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 materials provided to design and build a device that solves a specific problem or a solution to a specific problem. (K-PS3-2)

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 information to describe patterns in the natural world. (K-ESS3-2)

Connections to Nature of Science

Scientific Investigations Use a Variety of Methods

- ♣ Scientists use different ways to study the world. (K-PS3-1)

Science Knowledge is Based on Empirical Evidence

- ♣ Scientists look for patterns and order when making observations about the world. (K-ESS2-1)

Disciplinary Core Ideas

PS3.B: Conservation of Energy and Energy Transfer

- ♣ Sunlight warms Earth's surface. (K-PS3-1),(K-PS3-2)

ESS2.D: 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. (K-ESS2-1)

ESS3.B: 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. (K-ESS3-2)

ETS1.A: Defining and Delimiting an Engineering Problem

- ♣ Asking questions, making observations, and gathering information are helpful in thinking about problems. *(secondary to K-ESS3-2)*

Crosscutting Concepts

Patterns

- ♣ Patterns in the natural world can be observed, used to describe phenomena, and used as evidence. (K-ESS2-1)

Cause and Effect

- ♣ Events have causes that generate observable patterns. (K-ESS3-2),(K-PS3-1),(K-PS3-2)

Connections to Engineering, Technology and Applications of Science

Interdependence of Science, Engineering, and Technology

- ♣ People encounter questions about the natural world every day. (K-ESS3-2)

Influence of Engineering, Technology, and Science on Society and the Natural World

- ♣ People depend on various technologies in their lives; human life would be very different without technology. (K-ESS3-2)

Connections to other DCIs in kindergarten: **K.ETS1.A** (K-PS3-2),(K-ESS3-2); **K.ETS1.B** (K-PS3-2)

Articulation of DCIs across grade-bands: **1.PS4.B** (K-PS3-1),(K-PS3-2); **2.ESS1.C** (K-ESS3-2); **2.ESS2.A** (K-ESS2-1); **2.ETS1.B** (K-PS3-2),(K-ESS3-3); **3.ESS2.D** (K-PS3-1),(K-ESS2-1); **3.ESS3.B** (K-ESS3-2); **4.ESS2.A** (K-ESS2-1); **4.ESS3.B** (K-ESS3-2); **4.ETS1.A** (K-PS3-2)

Common Core State Standards Connections:

ELA/Literacy –

W.K.7	Participate in shared research and writing projects (e.g., explore a number of books by a favorite author and express opinions about them). (K-PS3-1),*(K-PS3-2)*,(K-ESS2-1)
RI.K.1	With prompting and support, ask and answer questions about key details in a text. (K-ESS3-2)
SL.K.3	Ask and answer questions in order to seek help, get information, or clarify something that is not understood. (K-ESS3-2)

Mathematics –

MP.2	Reason abstractly and quantitatively. (K-ESS2-1)
MP.4	Model with mathematics. (K-ESS2-1),*(K-ESS3-2)*
K.CC.A	Know number names and the count sequence. (K-ESS2-1)
K.CC	Counting and Cardinality *(K-ESS3-2)*
K.CC.A	Know number names and the count sequence. (K-ESS2-1)
K.MD.A.1	Describe measurable attributes of objects, such as length or weight. Describe several measurable attributes of a single object. (K-ESS2-1)
K.MD.A.2	Directly compare two objects with a measurable attribute in common, to see which object has "more of"/"less of" the attribute, and describe the difference. (K-PS3-1),(K-PS3-2)
K.MD.B.3	Classify objects into given categories; count the number of objects in each category and sort the categories by count. (K-ESS2-1)

*The performance expectations marked with an asterisk integrate traditional science content with engineering through a Practice or Disciplinary Core Idea.

First Grade

The performance expectations in first grade help students formulate answers to questions such as: "What happens when materials vibrate? What happens when there is no light? What are some ways plants and animals meet their needs so that they can survive and grow? How are parents and their children similar and different? What objects are in the sky and how do they seem to move?" First grade performance expectations include PS4, LS1, LS3, and ESS1 Disciplinary Core Ideas from the *NRC Framework*. Students are expected to develop understanding of the relationship between sound and vibrating materials as well as between the availability of light and ability to see objects. The idea that light travels from place to place can be understood by students at this level through determining the effect of placing objects made with different materials in the path of a beam of light. Students are also expected to develop understanding of how plants and animals use their external parts to help them survive, grow, and meet their needs as well as how behaviors of parents and offspring help the offspring survive. The understanding is developed that young plants and animals are like, but not exactly the same as, their parents. Students are able to observe, describe, and predict some patterns of the movement of objects in the sky. The crosscutting concepts of patterns; cause and effect; structure and function; and influence of engineering, technology, and science on society and the natural world are called out as organizing concepts for these disciplinary core ideas. In the first grade performance expectations, students are expected to demonstrate grade-appropriate proficiency in planning and carrying out investigations, analyzing and interpreting data, constructing explanations and designing solutions, and obtaining, evaluating, and communicating information. Students are expected to use these practices to demonstrate understanding of the core ideas.

1.Waves: Light and Sound

1.Waves: Light and Sound

Students who demonstrate understanding can:

1-PS4-1. Plan and conduct investigations to provide evidence that vibrating materials can make sound and that sound can make materials vibrate. [Clarification Statement: Examples of vibrating materials that make sound could include tuning forks and plucking a stretched string. Examples of how sound can make matter vibrate could include holding a piece of paper near a speaker making sound and holding an object near a vibrating tuning fork.]

1-PS4-2. Make observations to construct an evidence-based account that objects can be seen only when illuminated. [Clarification Statement: Examples of observations could include those made in a completely dark room, a pinhole box, and 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.]

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. [Clarification Statement: Examples of materials could include those that are transparent (such as clear plastic), translucent (such as wax paper), opaque (such as cardboard), and reflective (such as a mirror).] [Assessment Boundary: Assessment does not include the speed of light.]

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.* [Clarification Statement: Examples of devices could include a light source to send signals, paper cup and string "telephones," and a pattern of drum beats.] [Assessment Boundary: Assessment does not include technological details for how communication devices work.]

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*:

Science and Engineering Practices

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 investigations collaboratively to produce data to serve as the basis for evidence to answer a question. (1-PS4-1),(1-PS4-3)

Constructing Explanations and Designing Solutions
Constructing explanations and designing solutions 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 (1-PS4-2)
♣ Use tools and materials provided to design a device that solves a specific problem. (1-PS4-4)

Connections to Nature of Science

Scientific Investigations Use a Variety of Methods
♣ Science investigations begin with a question. (1-PS4-1)
♣ Scientists use different ways to study the world. (1-PS4-1)

Disciplinary Core Ideas

PS4.A: Wave Properties
♣ Sound can make matter vibrate, and vibrating matter can make sound. (1-PS4-1)

PS4.B: Electromagnetic Radiation
♣ Objects can be seen only when light is available to illuminate them. Some objects give off their own light. (1-PS4-2)
♣ 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. (Boundary: 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.) (1-PS4-3)

PS4.C: Information Technologies and Instrumentation
♣ People also use a variety of devices to communicate (send and receive information) over long distances. (1-PS4-4)

Crosscutting Concepts

Cause and Effect
♣ Simple tests can be designed to gather evidence to support or refute student ideas about causes. (1-PS4-1),(1-PS4-2),(1-PS4-3)

Connections to Engineering, Technology, and Applications of Science

Influence of Engineering, Technology, and Science, on Society and the Natural World
♣ People depend on various technologies in their lives; human life would be very different without technology. (1-PS4-4)

Connections to other DCIs in first grade: N/A

Articulation of DCIs across grade-bands: **K.ETS1.A** (1-PS4-4); **2.PS1.A** (1-PS4-3); **2.ETS1.B** (1-PS4-4); **4.PS4.C** (1-PS4-4); **4.PS4.B** (1-PS4-2); **4.ETS1.A** (1-PS4-4)

Common Core State Standards Connections:

ELA/Literacy –

W.1.2 Write informative/explanatory texts in which they name a topic, supply some facts about the topic, and provide some sense of closure. *(1-PS4-2)*

W.1.7 Participate in shared research and writing projects (e.g., explore a number of "how-to" books on a given topic and use them to write a sequence of instructions). (1-PS4-1),(1-PS4-2),(1-PS4-3),(1-PS4-4)

W.1.8 With guidance and support from adults, recall information from experiences or gather information from provided sources to answer a question. (1-PS4-1),(1-PS4-2),(1-PS4-3)

SL.1.1 Participate in collaborative conversations with diverse partners about grade 1 topics and texts with peers and adults in small and larger groups. *(1-PS4-1),(1-PS4-2),(1-PS4-3)*

Mathematics –

MP.5 Use appropriate tools strategically. *(1-PS4-4)*

1.MD.A.1 Order three objects by length; compare the lengths of two objects indirectly by using a third object. *(1-PS4-4)*

1.MD.A.2 Express the length of an object as a whole number of length units, by layering multiple copies of a shorter object (the length unit) end to end; understand that the length measurement of an object is the number of same-size length units that span it with no gaps or overlaps. *(1-PS4-4)*

*The performance expectations marked with an asterisk integrate traditional science content with engineering through a Practice or Disciplinary Core Idea.

1.Structure, Function, and Information Processing

1.Structure, Function, and Information Processing

Students who demonstrate understanding can:

1-LS1-1. Use 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.* [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, and animal scales; stabilizing structures by mimicking animal tails and roots on plants; keeping out intruders by mimicking thorns on branches and animal quills; and, detecting intruders by mimicking eyes and ears.]

1-LS1-2. Read texts and use media to determine patterns in behavior of parents and offspring that help offspring survive. [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).]

1-LS3-1. Make observations to construct an evidence-based account that young plants and animals are like, but not exactly like, their parents. [Clarification Statement: Examples of patterns could include features plants or animals share. Examples of observations could include leaves from the same kind of plant are the same shape but can differ in size; and, a particular breed of dog looks like its parents but is not exactly the same.] [Assessment Boundary: Assessment does not include inheritance or animals that undergo metamorphosis or hybrids.]

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*:

Science and Engineering Practices

Constructing Explanations and Designing Solutions
Constructing explanations and designing solutions 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. (1-LS3-1)

♣ Use materials to design a device that solves a specific problem or a solution to a specific problem. (1-LS1-1)

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 use media to obtain scientific information to determine patterns in the natural world. (1-LS1-2)

Connections to Nature of Science

Scientific Knowledge is Based on Empirical Evidence

♣ Scientists look for patterns and order when making observations about the world. (1-LS1-2)

Disciplinary Core Ideas

LS1.A: 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. (1-LS1-1)

LS1.B: Growth and Development of Organisms

♣ Adult plants and animals can have young. In many kinds of animals, parents and the offspring themselves engage in behaviors that help the offspring to survive. (1-LS1-2)

LS1.D: 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. (1-LS1-1)

LS3.A: 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. (1-LS3-1)

LS3.B: Variation of Traits

♣ Individuals of the same kind of plant or animal are recognizable as similar but can also vary in many ways. (1-LS3-1)

Crosscutting Concepts

Patterns

♣ Patterns in the natural world can be observed, used to describe phenomena, and used as evidence. (1-LS1-2),(1-LS3-1)

Structure and Function

♣ The shape and stability of structures of natural and designed objects are related to their function(s). (1-LS1-1)

Connections to Engineering, Technology and Applications of Science

Influence of Engineering, Technology, and Science on Society and the Natural World

♣ Every human-made product is designed by applying some knowledge of the natural world and is built by using natural materials. (1-LS1-1)

Connections to other DCIs in first grade: N/A

Articulation of DCIs across grade-bands: **K.ETS1.A** (1-LS1-1); **3.LS2.D** (1-LS1-2) **3.LS3.A** (1-LS3-1); **3.LS3.B** (1-LS3-1); **4.LS1.A** (1-LS1-1); **4.LS1.D** (1-LS1-1); **4.ETS1.A** (1-LS1-1)

Common Core State Standards Connections:

ELA/Literacy –

RI.1.1 Ask and answer questions about key details in a text. (1-LS1-2),(1-LS3-1) **RI.1.2** Identify the main topic and retell key details of a text. (1-LS1-2)

RI.1.10 With prompting and support, read informational texts appropriately complex for grade. (1-LS1-2)

W.1.7 Participate in shared research and writing projects (e.g., explore a number of "how-to" books on a given topic and use them to write a sequence of instructions). (1-LS1-1),(1-LS3-1)

W.1.8 With guidance and support from adults, recall information from experiences or gather information from provided sources to answer a question. (1-LS3-1)

Mathematics –

MP.2 Reason abstractly and quantitatively. *(1-LS3-1)*

MP.5 Use appropriate tools strategically. *(1-LS3-1)*

1.NBT.B.3 Compare two two-digit numbers based on the meanings of the tens and one digits, recording the results of comparisons with the symbols >, =, and <. *(1-LS1-2)*

1.NBT.C.4 Add within 100, including adding a two-digit number and a one-digit number, and adding a two-digit number and a multiple of 10, using concrete models or drawings and strategies based on place value, properties of operations, and/or the relationship between addition and subtraction; relate the strategy to a written method and explain the reasoning uses. Understand that in adding two-digit numbers, one adds tens and tens, ones and ones; and sometimes it is necessary to compose a ten. *(1-LS1-2)*

1.NBT.C.5 Given a two-digit number, mentally find 10 more or 10 less than the number, without having to count; explain the reasoning used. *(1-LS1-2)*

1.NBT.C.6 Subtract multiples of 10 in the range 10-90 from multiples of 10 in the range 10-90 (positive or zero differences), using concrete models or drawings and strategies based on place value, properties of operations, and/or the relationship between addition and subtraction; relate the strategy to a written method and explain the reasoning used. *(1-LS1-2)*

1.MD.A.1 Order three objects by length; compare the lengths of two objects indirectly by using a third object. *(1-LS3-1)*

*The performance expectations marked with an asterisk integrate traditional science content with engineering through a Practice or Disciplinary Core Idea.

1.Space Systems: Patterns and Cycles

1.Space Systems: Patterns and Cycles

Students who demonstrate understanding can:

1-ESS1-1. Use observations of the sun, moon, and stars to describe patterns that can be predicted. [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.] [Assessment Boundary: Assessment of star patterns is limited to stars being seen at night and not during the day.]

1-ESS1-2. Make observations at different times of year to relate the amount of daylight to the time of year. [Clarification Statement: Emphasis is on relative comparisons of the amount of daylight in the winter to the amount in the spring or fall.] [Assessment Boundary: Assessment is limited to relative amounts of daylight, not quantifying the hours or time of daylight.]

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*:

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
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) to collect data that can be used to make comparisons. (1-ESS1-2) **Analyzing and Interpreting Data** Analyzing data in K–2 builds on prior experiences and progresses to collecting, recording, and sharing observations. ♣ Use observations (firsthand or from media) to describe patterns in the natural world in order to answer scientific questions. (1-ESS1-1)	**ESS1.A: The Universe and its Stars** ♣ Patterns of the motion of the sun, moon, and stars in the sky can be observed, described, and predicted. (1-ESS1-1) **ESS1.B: Earth and the Solar System** ♣ Seasonal patterns of sunrise and sunset can be observed, described, and predicted. (1-ESS1-2)	**Patterns** ♣ Patterns in the natural world can be observed, used to describe phenomena, and used as evidence. (1-ESS1-1),(1-ESS1-2) --- ***Connections to Nature of Science*** **Scientific Knowledge Assumes an Order and Consistency in Natural Systems** ♣ Science assumes natural events happen today as they happened in the past. (1-ESS1-1) ♣ Many events are repeated. (1-ESS1-1)

Connections to other DCIs in first grade: N/A

Articulation of DCIs across grade-bands: **3.PS2.A** (1-ESS1-1); **5.PS2.B** (1-ESS1-1),(1-ESS1-2) **5-ESS1.B** (1-ESS1-1),(1-ESS1-2)

Common Core State Standards Connections:

ELA/Literacy –

W.1.7 Participate in shared research and writing projects (e.g., explore a number of "how-to" books on a given topic and use them to write a sequence of instructions). (1-ESS1-1),(1-ESS1-2)

W.1.8 With guidance and support from adults, recall information from experiences or gather information from provided sources to answer a question. (1-ESS1-1),(1-ESS1-2)

Mathematics –

MP.2 Reason abstractly and quantitatively. *(1-ESS1-2)* **MP.4** Model with mathematics. *(1-ESS1-2)*

MP.5 Use appropriate tools strategically. *(1-ESS1-2)*

1.OA.A.1 Use addition and subtraction within 20 to solve word problems involving situations of adding to, taking from, putting together, taking apart, and comparing, with unknowns in all positions, e.g., by using objects, drawings, and equations to represent the problem. *(1-ESS1-2)*

1.MD.C.4 Organize, represent, and interpret data with up to three categories; ask and answer questions about the total number of data points, how many in each category, and how many more or less are in one category than in another. *(1-ESS1-2)*

*The performance expectations marked with an asterisk integrate traditional science content with engineering through a Practice or Disciplinary Core Idea.

Second Grade

The performance expectations in second grade help students formulate answers to questions such as: "How does land change and what are some things that cause it to change? What are the different kinds of land and bodies of water? How are materials similar and different from one another, and how do the properties of the materials relate to their use? What do plants need to grow? How many types of living things live in a place?" Second grade performance expectations include PS1, LS2, LS4, ESS1, ESS2, and ETS1 Disciplinary Core Ideas from the *NRC Framework*. Students are expected to develop an understanding of what plants need to grow and how plants depend on animals for seed dispersal and pollination. Students are also expected to compare the diversity of life in different habitats. An understanding of observable properties of materials is developed by students at this level through analysis and classification of different materials. Students are able to apply their understanding of the idea that wind and water can change the shape of the land to compare design solutions to slow or prevent such change. Students are able to use information and models to identify and represent the shapes and kinds of land and bodies of water in an area and where water is found on Earth. The crosscutting concepts of patterns; cause and effect; energy and matter; structure and function; stability and change; and influence of engineering, technology, and science on society and the natural world are called out as organizing concepts for these disciplinary core ideas. In the second grade performance expectations, students are expected to demonstrate grade-appropriate proficiency in developing and using models, planning and carrying out investigations, analyzing and interpreting data, constructing explanations and designing solutions, engaging in argument from evidence, and obtaining, evaluating, and communicating information. Students are expected to use these practices to demonstrate understanding of the core ideas.

2.Structure and Properties of Matter

2.Structure and Properties of Matter

Students who demonstrate understanding can:

2-PS1-1. Plan and conduct an investigation to describe and classify different kinds of materials by their observable properties. [Clarification Statement: Observations could include color, texture, hardness, and flexibility. Patterns could include the similar properties that different materials share.]

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.* [Clarification Statement: Examples of properties could include, strength, flexibility, hardness, texture, and absorbency.] [Assessment Boundary: Assessment of quantitative measurements is limited to length.]

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. [Clarification Statement: Examples of pieces could include blocks, building bricks, or other assorted small objects.]

2-PS1-4. Construct an argument with evidence that some changes caused by heating or cooling can be reversed and some cannot. [Clarification Statement: Examples of reversible changes could include materials such as water and butter at different temperatures. Examples of irreversible changes could include cooking an egg, freezing a plant leaf, and heating paper.]

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*:

Science and Engineering Practices

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. (2-PS1-1)

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. (2-PS1-2)

Constructing Explanations and Designing Solutions
Constructing explanations and designing solutions 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. (2-PS1-3)

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. (2-PS1-4)

Connections to Nature of Science

Science Models, Laws, Mechanisms, and Theories Explain Natural Phenomena
♣ Scientists search for cause and effect relationships to explain natural events. (2-PS1-4)

Disciplinary Core Ideas

PS1.A: 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. (2-PS1-1)
♣ Different properties are suited to different purposes. (2-PS1-2),(2-PS1-3)
♣ A great variety of objects can be built up from a small set of pieces. (2-PS1-3)

PS1.B: Chemical Reactions
♣ Heating or cooling a substance may cause changes that can be observed. Sometimes these changes are reversible, and sometimes they are not. (2-PS1-4)

Crosscutting Concepts

Patterns
♣ Patterns in the natural and human designed world can be observed. (2-PS1-1)

Cause and Effect
♣ Events have causes that generate observable patterns. (2-PS1-4)
♣ Simple tests can be designed to gather evidence to support or refute student ideas about causes. (2-PS1-2)

Energy and Matter
♣ Objects may break into smaller pieces and be put together into larger pieces, or change shapes. (2-PS1-3)

Connections to Engineering, Technology, and Applications of Science

Influence of Engineering, Technology, and Science on Society and the Natural World
♣ Every human-made product is designed by applying some knowledge of the natural world and is built by using natural materials. (2-PS1-2)

Connections to other DCIs in second grade: N/A

Articulation of DCIs across grade-bands: **4.ESS2.A** (2-PS1-3); **5.PS1.A** (2-PS1-1),(2-PS1-2),(2-PS1-3); **5.PS1.B** (2-PS1-4); **5.LS2.A** (2-PS1-3)

Common Core State Standards Connections:

ELA/Literacy –

RI.2.1 Ask and answer such questions as *who*, *what*, *where*, *when*, *why*, and *how* to demonstrate understanding of key details in a text. *(2-PS1-4)*

RI.2.3 Describe the connection between a series of historical events, scientific ideas or concepts, or steps in technical procedures in a text. (2-PS1-4)

RI.2.8 Describe how reasons support specific points the author makes in a text. *(2-PS1-2)*,(2-PS1-4)

W.2.1 Write opinion pieces in which they introduce the topic or book they are writing about, state an opinion, supply reasons that support the opinion, use linking words (e.g., *because*, *and*, *also*) to connect opinion and reasons, and provide a concluding statement or section. (2-PS1-4)

W.2.7 Participate in shared research and writing projects (e.g., read a number of books on a single topic to produce a report; record science observations). (2-PS1-1),(2-PS1-2),(2-PS1-3)

W.2.8 Recall information from experiences or gather information from provided sources to answer a question. (2-PS1-1),(2-PS1-2),(2-PS1-3)

Mathematics –

MP.2 Reason abstractly and quantitatively. *(2-PS1-2)*

MP.4 Model with mathematics. *(2-PS1-1),(2-PS1-2)*

MP.5 Use appropriate tools strategically. *(2-PS1-2)*

2.MD.D.10 Draw a picture graph and a bar graph (with single-unit scale) to represent a data set with up to four categories. Solve simple put-together, take-apart, and compare problems using information presented in a bar graph. (2-PS1-1),*(2-PS1-2)*

*The performance expectations marked with an asterisk integrate traditional science content with engineering through a Practice or Disciplinary Core Idea.

2.Interdependent Relationships in Ecosystems

2.Interdependent Relationships in Ecosystems

Students who demonstrate understanding can:

2-LS2-1. Plan and conduct an investigation to determine if plants need sunlight and water to grow. [Assessment Boundary: Assessment is limited to testing one variable at a time.]

2-LS2-2. Develop a simple model that mimics the function of an animal in dispersing seeds or pollinating plants.* 2-LS4-1. Make observations of plants and animals to compare the diversity of life in different habitats. [Clarification Statement: Emphasis is on the diversity of living things in each of a variety of different habitats.] [Assessment Boundary: Assessment does not include specific animal and plant names in specific habitats.]

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*:

Science and Engineering Practices

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, or storyboard) that represent concrete events or design solutions.

♣ Develop a simple model based on evidence to represent a proposed object or tool. (2-LS2-2)

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. (2-LS2-1)

♣ Make observations (firsthand or from media) to collect data which can be used to make comparisons. (2-LS4-1)

Connections to Nature of Science

Scientific Knowledge is Based on Empirical Evidence

♣ Scientists look for patterns and order when making observations about the world. (2-LS4-1)

Disciplinary Core Ideas

LS2.A: Interdependent Relationships in Ecosystems

♣ Plants depend on water and light to grow. (2-LS2-1)

♣ Plants depend on animals for pollination or to move their seeds around. (2-LS2-2)

LS4.D: Biodiversity and Humans

♣ There are many different kinds of living things in any area, and they exist in different places on land and in water. (2-LS4-1)

ETS1.B: Developing Possible Solutions

♣ Designs can be conveyed through sketches, drawings, or physical models. These representations are useful in communicating ideas for a problem's solutions to other people. *(secondary to 2-LS2-2)*

Crosscutting Concepts

Cause and Effect

♣ Events have causes that generate observable patterns. (2-LS2-1)

Structure and Function

♣ The shape and stability of structures of natural and designed objects are related to their function(s). (2-LS2-2)

Connections to other DCIs in second grade: N/A

Articulation of DCIs across grade-bands: **K.LS1.C** (2-LS2-1); **K-ESS3.A** (2-LS2-1); **K.ETS1.A** (2-LS2-2); **3.LS4.C** (2-LS4-1); **3.LS4.D** (2-LS4-1); **5.LS1.C** (2-LS2-1); **5.LS2.A** (2-LS2-2),(2-LS4-1)

Common Core State Standards Connections:

ELA/Literacy –

W.2.7 Participate in shared research and writing projects (e.g., read a number of books on a single topic to produce a report; record science observations). (2-LS2-1),(2-LS4-1) **W.2.8** Recall information from experiences or gather information from provided sources to answer a question. (2-LS2-1),(2-LS4-1)

SL.2.5 Create audio recordings of stories or poems; add drawings or other visual displays to stories or recounts of experiences when appropriate to clarify ideas, thoughts, and feelings. *(2-LS2-2)*

Mathematics –

MP.2 Reason abstractly and quantitatively. *(2-LS2-1),(2-LS4-1)*

MP.4 Model with mathematics. *(2-LS2-1),(2-LS2-2),(2-LS4-1)*

MP.5 Use appropriate tools strategically. *(2-LS2-1)*

2.MD.D.10 Draw a picture graph and a bar graph (with single-unit scale) to represent a data set with up to four categories. Solve simple put-together, take-apart, and compare problems. *(2-LS2-2),(2-LS4-1)*

*The performance expectations marked with an asterisk integrate traditional science content with engineering through a Practice or Disciplinary Core Idea.

2.Earth's Systems: Processes that Shape the Earth

2.Earth's Systems: Processes that Shape the Earth

Students who demonstrate understanding can:

2-ESS1-1. Make observations from media to construct an evidence-based account that Earth events can occur quickly or slowly. [Clarification Statement: Examples of events and timescales could include volcanic explosions and earthquakes, which happen quickly and erosion of rocks, which occurs slowly.] [Assessment Boundary: Assessment does not include quantitative measurements of timescales.]

2-ESS2-1. Compare multiple solutions designed to slow or prevent wind or water from changing the shape of the land.* [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.]

2-ESS2-2. Develop a model to represent the shapes and kinds of land and bodies of water in an area. [Assessment Boundary: Assessment does not include quantitative scaling in models.]

2-ESS2-3. Obtain information to identify where water is found on Earth and that it can be solid or liquid.

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*:

Science and Engineering Practices

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, or storyboard) that represent concrete events or design solutions.
♣ Develop a model to represent patterns in the natural world. (2-ESS2-2)

Constructing Explanations and Designing Solutions
Constructing explanations and designing solutions 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. (2-ESS1-1)
♣ Compare multiple solutions to a problem. (2-ESS2-1)

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. (2-ESS2-3)

Disciplinary Core Ideas

ESS1.C: The History of Planet Earth
♣ Some events happen very quickly; others occur very slowly, over a time period much longer than one can observe. (2-ESS1-1)

ESS2.A: Earth Materials and Systems
♣ Wind and water can change the shape of the land. (2-ESS2-1)

ESS2.B: 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. (2-ESS2-2)

ESS2.C: 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. (2-ESS2-3)

ETS1.C: Optimizing the Design Solution
♣ Because there is always more than one possible solution to a problem, it is useful to compare and test designs. *(secondary to 2-ESS2-1)*

Crosscutting Concepts

Patterns
♣ Patterns in the natural world can be observed. (2-ESS2-2),(2-ESS2-3)

Stability and Change
♣ Things may change slowly or rapidly. (2-ESS1-1),(2-ESS2-1)

Connections to Engineering, Technology, and Applications of Science

Influence of Engineering, Technology, and Science on Society and the Natural World
♣ Developing and using technology has impacts on the natural world. (2-ESS2-1)

Connections to Nature of Science

Science Addresses Questions About the Natural and Material World
♣ Scientists study the natural and material world. (2-ESS2-1)

Connections to other DCIs in second grade: **2.PS1.A** (2-ESS2-3)

Articulation of DCIs across grade-bands: **K.ETS1.A** (2-ESS2-1); **3.LS2.C** (2-ESS1-1); **4.ESS2.A** (2-ESS1-1),(2-ESS2-1); **4.ESS1.C** (2-ESS1-1),(2-ESS1-2); **4.ESS2.B** (2-ESS2-2); **4.ETS1.A** (2-ESS2-1); **4.ETS1.B** (2-ESS2-1); **4.ETS1.C** (2-ESS2-1); **5.ESS2.A** (2-ESS2-1); **5.ESS2.C** (2-ESS2-2),(2-ESS2-3)

Common Core State Standards Connections:

ELA/Literacy –

RI.2.1 Ask and answer such questions as *who*, *what*, *where*, *when*, *why*, and *how* to demonstrate understanding of key details in a text. *(2-ESS1-1)*

RI.2.3 Describe the connection between a series of historical events, scientific ideas or concepts, or steps in technical procedures in a text. (2-ESS1-1),*(2-ESS2-1)* **RI.2.9** Compare and contrast the most important points presented by two texts on the same topic. (2-ESS2-1)

W.2.6 With guidance and support from adults, use a variety of digital tools to produce and publish writing, including in collaboration with peers. *(2-ESS1-1),(2-ESS2-3)* **W.2.7** Participate in shared research and writing projects (e.g., read a number of books on a single topic to produce a report; record science observations). (2-ESS1-1) **W.2.8** Recall information from experiences or gather information from provided sources to answer a question. (2-ESS1-1),(2-ESS2-3)

SL.2.2 Recount or describe key ideas or details from a text read aloud or information presented orally or through other media. (2-ESS1-1)

SL.2.5 Create audio recordings of stories or poems; add drawings or other visual displays to stories or recounts of experiences when appropriate to clarify ideas, thoughts, and feelings. *(2-ESS2-2)*

Mathematics –

MP.2 Reason abstractly and quantitatively. *(2-ESS21-1),(2-ESS2-1),(2-ESS2-2)*

MP.4 Model with mathematics. *(2-ESS21-1),(2-ESS2-2)*

MP.5 Use appropriate tools strategically. *(2-ESS2-1)*

2.NBT.A Understand place value. (2-ESS1-1)

2.NBT.A.3 Read and write numbers to 1000 using base-ten numerals, number names, and expanded form. *(2-ESS2-2)*

2.MD.B.5 Use addition and subtraction within 100 to solve word problems involving lengths that are given in the same units, e.g., by using drawings (such as drawings of rulers) and equations with a symbol for the unknown number to represent the problem. *(2-ESS2-1)*

*The performance expectations marked with an asterisk integrate traditional science content with engineering through a Practice or Disciplinary Core Idea.

K-2.Engineering Design

K-2.Engineering Design

Students who demonstrate understanding can:

K-2-ETS1-1. Ask questions, make observations, and gather information about a situation people want to change to define a simple problem that can be solved through the development of a new or improved object or tool.

K-2-ETS1-2. Develop a simple sketch, drawing, or physical model to illustrate how the shape of an object helps it function as needed to solve a given problem.

K-2-ETS1-3. Analyze data from tests of two objects designed to solve the same problem to compare the strengths and weaknesses of how each performs.

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*:

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Asking Questions and Defining Problems Asking questions and defining problems in K–2 builds on prior experiences and progresses to simple descriptive questions. ♣ Ask questions based on observations to find more information about the natural and/or designed world. (K-2-ETS1-1) ♣ Define a simple problem that can be solved through the development of a new or improved object or tool. (K-2-ETS1-1) **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, or storyboard) that represent concrete events or design solutions. ♣ Develop a simple model based on evidence to represent a proposed object or tool. (K-2-ETS1-2) **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. (K-2-ETS1-3)	**ETS1.A: Defining and Delimiting Engineering Problems** ♣ A situation that people want to change or create can be approached as a problem to be solved through engineering. (K-2-ETS1-1) ♣ Asking questions, making observations, and gathering information are helpful in thinking about problems. (K-2-ETS1-1) ♣ Before beginning to design a solution, it is important to clearly understand the problem. (K-2-ETS1-1) **ETS1.B: Developing Possible Solutions** ♣ Designs can be conveyed through sketches, drawings, or physical models. These representations are useful in communicating ideas for a problem's solutions to other people. (K-2-ETS1-2) **ETS1.C: Optimizing the Design Solution** ♣ Because there is always more than one possible solution to a problem, it is useful to compare and test designs. (K-2-ETS1-3)	**Structure and Function** ♣ The shape and stability of structures of natural and designed objects are related to their function(s). (K-2-ETS1-2)

Connections to other DCIs in this grade-band:
Connections to K-2-ETS1.A: Defining and Delimiting Engineering Problems include:
Kindergarten: K-PS2-2, K-ESS3-2
Connections to K-2-ETS1.B: Developing Possible Solutions Problems include:
Kindergarten: K-ESS3-3, **First Grade:** 1-PS4-4, **Second Grade:** 2-LS2-2
Connections to K-2-ETS1.C: Optimizing the Design Solution include:
Second Grade: 2-ESS2-1

Articulation of DCIs across grade-bands: **3-5.ETS1.A** (K-2-ETS1-1),(K-2-ETS1-2),(K-2 -ETS1-3); **3-5.ETS1.B** (K-2-ETS1-2); **3-5.ETS1.C** (K-2-ETS1-1),(K-2-ETS1-2),(K-2-ETS1-3)

Common Core State Standards Connections:
ELA/Literacy –
RI.2.1 Ask and answer such questions as *who*, *what*, *where*, *when*, *why*, and *how* to demonstrate understanding of key details in a text. (2-ESS1-1)
W.2.6 With guidance and support from adults, use a variety of digital tools to produce and publish writing, including in collaboration with peers. *(K-2-ETS1-1),(K-2-ETS1-3)* **W.2.8** Recall information from experiences or gather information from provided sources to answer a question. (K-2-ETS1-1),*(K-2-ETS1-3)*
SL.2.5 Create audio recordings of stories or poems; add drawings or other visual displays to stories or recounts of experiences when appropriate to clarify ideas, thoughts, and feelings. *(K-2-ETS1-2)*
Mathematics –
2.MD.D.10 Draw a picture graph and a bar graph (with single-unit scale) to represent a data set with up to four categories. Solve simple put-together, take-apart, and compare problems using information presented in a bar graph. *(K-2-ETS1-1),(K-2-ETS1-3)*

Third Grade

The performance expectations in third grade help students formulate answers to questions such as: "What is typical weather in different parts of the world and during different times of the year? How can the impact of weather-related hazards be reduced? How do organisms vary in their traits? How are plants, animals, and environments of the past similar or different from current plants, animals, and environments? What happens to organisms when their environment changes? How do equal and unequal forces on an object affect the object? How can magnets be used?" Third grade performance expectations include PS2, LS1, LS2, LS3, LS4, ESS2, and ESS3 Disciplinary Core Ideas from the *NRC Framework*. Students are able to organize and use data to describe typical weather conditions expected during a particular season. By applying their understanding of weather-related hazards, students are able to make a claim about the merit of a design solution that reduces the impacts of such hazards. Students are expected to develop an understanding of the similarities and differences of organisms' life cycles. An understanding that organisms have different inherited traits, and that the environment can also affect the traits that an organism develops, is acquired by students at this level. In addition, students are able to construct an explanation using evidence for how the variations in characteristics among individuals of the same species may provide advantages in surviving, finding mates, and reproducing. Students are expected to develop an understanding of types of organisms that lived long ago and also about the nature of their environments. Third graders are expected to develop an understanding of the idea that when the environment changes some organisms survive and reproduce, some move to new locations, some move into the transformed environment, and some die. Students are able to determine the effects of balanced and unbalanced forces on the motion of an object and the cause and effect relationships of electric or magnetic interactions between two objects not in contact with each other. They are then able to apply their understanding of magnetic interactions to define a simple design problem that can be solved with magnets. The crosscutting concepts of patterns; cause and effect; scale, proportion, and quantity; systems and system models; interdependence of science, engineering, and technology; and influence of engineering, technology, and science on society and the natural world are called out as organizing concepts for these disciplinary core ideas. In the third grade performance expectations, students are expected to demonstrate grade-appropriate proficiency in asking questions and defining problems; developing and using models, planning and carrying out investigations, analyzing and interpreting data, constructing explanations and designing solutions, engaging in argument from evidence, and obtaining, evaluating, and communicating information. Students are expected to use these practices to demonstrate understanding of the core ideas.

3.Forces and Interactions

3.Forces and Interactions

Students who demonstrate understanding can:

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. [Clarification Statement: Examples could include an unbalanced force on one side of a ball can make it start moving; and, balanced forces pushing on a box from both sides will not produce any motion at all.] [Assessment Boundary: Assessment is limited to one variable at a time: number, size, or direction of forces. Assessment does not include quantitative force size, only qualitative and relative. Assessment is limited to gravity being addressed as a force that pulls objects down.]

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. [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, and two children on a see-saw.] [Assessment Boundary: Assessment does not include technical terms such as period and frequency.]

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. [Clarification Statement: Examples of an electric force could include the force on hair from an electrically charged balloon and 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 paperclips, and 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 strength of the force and how the orientation of magnets affects the direction of the magnetic force.] [Assessment Boundary: Assessment is limited to forces produced by objects that can be manipulated by students, and electrical interactions are limited to static electricity.]

3-PS2-4. Define a simple design problem that can be solved by applying scientific ideas about magnets.* [Clarification Statement: Examples of problems could include constructing a latch to keep a door shut and creating a device to keep two moving objects from touching each other.]

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*:

Science and Engineering Practices

Asking Questions and Defining Problems
Asking questions and defining problems in grades 3–5 builds on grades K–2 experiences and progresses to specifying qualitative relationships.
- ♣ Ask questions that can be investigated based on patterns such as cause and effect relationships. (3-PS2-3)
- ♣ Define a simple problem that can be solved through the development of a new or improved object or tool. (3-PS2-4)

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. (3-PS2-1)
- ♣ 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. (3-PS2-2)

Connections to Nature of Science

Science Knowledge is Based on Empirical Evidence
- ♣ Science findings are based on recognizing patterns. (3-PS2-2)

Scientific Investigations Use a Variety of Methods
- ♣ Science investigations use a variety of methods, tools, and techniques. (3-PS2-1)

Disciplinary Core Ideas

PS2.A: 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. Forces that do not sum to zero can cause changes in the object's speed or direction of motion. (Boundary: Qualitative and conceptual, but not quantitative addition of forces are used at this level.) (3-PS2-1)
- ♣ 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. (Boundary: 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.) (3-PS2-2)

PS2.B: Types of Interactions
- ♣ Objects in contact exert forces on each other. (3-PS2-1)
- ♣ 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. (3-PS2-3),(3-PS2-4)

Crosscutting Concepts

Patterns
- ♣ Patterns of change can be used to make predictions. (3-PS2-2)

Cause and Effect
- ♣ Cause and effect relationships are routinely identified. (3-PS2-1)
- ♣ Cause and effect relationships are routinely identified, tested, and used to explain change. (3-PS2-3)

Connections to Engineering, Technology, and Applications of Science

Interdependence of Science, Engineering, and Technology
- ♣ Scientific discoveries about the natural world can often lead to new and improved technologies, which are developed through the engineering design process. (3-PS2-4)

Connections to other DCIs in third grade: N/A

Articulation of DCIs across grade-bands: **K.PS2.B** (3-PS2-1); **K.PS2.A** (3-PS2-1); **K.PS3.C** (3-PS2-1); **K.ETS1.A** (3-PS2-4); **1.ESS1.A** (3-PS2-2); **4.PS4.A** (3-PS2-2); **4.ETS1.A** (3-PS2-4); **5.PS2.B** (3-PS2-1); **MS.PS2.A** (3-PS2-1),(3-PS2-2); **MS.PS2.B** (3-PS2-3),(3-PS2-4); **MS.ESS1.B** (3-PS2-1),(3-PS2-2); **MS.ESS2.C** (3-PS2-1)

Common Core State Standards Connections:

ELA/Literacy –

RI.3.1 Ask and answer questions to demonstrate understanding of a text, referring explicitly to the text as the basis for the answers. *(3-PS2-1)*,(3-PS2-3)
RI.3.3 Describe the relationship between a series of historical events, scientific ideas or concepts, or steps in technical procedures in a text, using language that pertains to time, sequence, and cause/effect. (3-PS2-3)
RI.3.8 Describe the logical connection between particular sentences and paragraphs in a text (e.g., comparison, cause/effect, first/second/third in a sequence). *(3-PS2-3)*
W.3.7 Conduct short research projects that build knowledge about a topic. (3-PS2-1),(3-PS2-2)
W.3.8 Recall information from experiences or gather information from print and digital sources; take brief notes on sources and sort evidence into provided categories. (3-PS2-1),*(3-PS2-2)*
SL.3.3 Ask and answer questions about information from a speaker, offering appropriate elaboration and detail. *(3-PS2-3)*

Mathematics –

MP.2 Reason abstractly and quantitatively. *(3-PS2-1)*
MP.5 Use appropriate tools strategically. *(3-PS2-1)*
3.MD.A.2 Measure and estimate liquid volumes and masses of objects using standard units of grams (g), kilograms (kg), and liters (l). Add, subtract, multiply, or divide to solve one-step word problems involving masses or volumes that are given in the same units, e.g., by using drawings (such as a beaker with a measurement scale) to represent the problem. *(3-PS2-1)*

*The performance expectations marked with an asterisk integrate traditional science content with engineering through a Practice or Disciplinary Core Idea.

3.Interdependent Relationships in Ecosystems

3.Interdependent Relationships in Ecosystems

Students who demonstrate understanding can:

3-LS2-1. Construct an argument that some animals form groups that help members survive.

3-LS4-1. Analyze and interpret data from fossils to provide evidence of the organisms and the environments in which they lived long ago. [Clarification Statement: Examples of data could include type, size, and distributions of fossil organisms. Examples of fossils and environments could include marine fossils found on dry land, tropical plant fossils found in Arctic areas, and fossils of extinct organisms.] [Assessment Boundary: Assessment does not include identification of specific fossils or present plants and animals. Assessment is limited to major fossil types and relative ages.]

3-LS4-3. Construct an argument with evidence that in a particular habitat some organisms can survive well, some survive less well, and some cannot survive at all. [Clarification Statement: Examples of evidence could include needs and characteristics of the organisms and habitats involved. The organisms and their habitat make up a system in which the parts depend on each other.]

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.* [Clarification Statement: Examples of environmental changes could include changes in land characteristics, water distribution, temperature, food, and other organisms.] [Assessment Boundary: Assessment is limited to a single environmental change. Assessment does not include the greenhouse effect or climate change.]

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*:

Science and Engineering Practices

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. (3-LS4-1)

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 worlds.

- Construct an argument with evidence, data, and/or a model. (3-LS2-1)
- Construct an argument with evidence. (3-LS4-3)
- 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. (3-LS4-4)

Disciplinary Core Ideas

LS2.C: 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. *(secondary to 3-LS4-4)*

LS2.D: 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. *(Note: Moved from K–2)* (3-LS2-1)

LS4.A: Evidence of Common Ancestry and Diversity

- Some kinds of plants and animals that once lived on Earth are no longer found anywhere. *(Note: Moved from K–2)* (3-LS4-1)
- Fossils provide evidence about the types of organisms that lived long ago and also about the nature of their environments. (3-LS4-1)

LS4.C: Adaptation

- For any particular environment, some kinds of organisms survive well, some survive less well, and some cannot survive at all. (3-LS4-3)

LS4.D: Biodiversity and Humans

- Populations live in a variety of habitats, and change in those habitats affects the organisms living there. (3-LS4-4)

Crosscutting Concepts

Cause and Effect

- Cause and effect relationships are routinely identified and used to explain change. (3-LS2-1),(3-LS4-3)

Scale, Proportion, and Quantity

- Observable phenomena exist from very short to very long time periods. (3-LS4-1)

Systems and System Models

- A system can be described in terms of its components and their interactions. (3-LS4-4)

Connections to Engineering, Technology, and Applications of Science

Interdependence of Science, Engineering, and Technology

- Knowledge of relevant scientific concepts and research findings is important in engineering. (3-LS4-3)

Connections to Nature of Science

Scientific Knowledge Assumes an Order and Consistency in Natural Systems

- Science assumes consistent patterns in natural systems. (3-LS4-1)

Science is a Human Endeavor

- Most scientists and engineers work in teams. (3-LS4-3)

Connections to other DCIs in third grade: **3.ESS2.D** (3-LS4-3); **3.ESS3.B** (3-LS4-4)

Articulation of DCIs across grade -bands: **K.ESS3.A** (3-LS4-3)(3-LS4-4); **K.ETS1.A** (3-LS4-4); **1.LS1.B** (3-LS2-1); **2.LS2.A** (3-LS4-3),(3-LS4-4); **2.LS4.D** (3-LS4-3),(3-LS4-4); **4.ESS1.C** (3-LS4-1); **4.ESS3.B** (3-LS4-4); **4.ETS1.A** (3-LS4-4); **MS.LS2.A** (3-LS2-1),(3-LS4-1)(3-LS4-3),(3-LS4-4); **MS.LS2.C** (3-LS4-4); **MS.LS2.D** (3-LS2-1); **MS.LS4.A** (3-LS4-1); **MS.LS4.B** (3-LS4-3); **MS.LS4.C** (3-LS4-3),(3-LS4-4); **MS.ESS1.C** (3-LS4-1),(3-LS4-3),(3-LS4-4); **MS.ESS2.B** (3-LS4-1); **MS.ESS3.C** (3-LS4-4)

Common Core State Standards Connections:

ELA/Literacy –

RI.3.1 Ask and answer questions to demonstrate understanding of a text, referring explicitly to the text as the basis for the answers. *(3-LS2-1),(3-LS4-1),(3-LS4-3),(3-LS4-4)* **RI.3.2** Determine the main idea of a text; recount the key details and explain how they support the main idea. *(3-LS4-1),(3-LS4-3),(3LS4-4)*

RI.3.3 Describe the relationship between a series of historical events, scientific ideas or concepts, or steps in technical procedures in a text, using language that pertains to time, sequence, and cause/effect. *(3-LS2-1),(3-LS4-1),(3-LS4-3),(3-LS4-4)*

W.3.1 Write opinion pieces on topics or texts, supporting a point of view with reasons. (3-LS2-1),*(3-LS4-1)*,(3-LS4-3),*(3-LS4-4)* **W.3.2** Write informative/explanatory texts to examine a topic and convey ideas and information clearly. *(3-LS4-1),(3-LS4-3),(3-LS4-4)*

W.3.9 Recall information from experiences or gather information from print and digital sources; take brief notes on sources and sort evidence into provided categories. (3-LS4-1) **SL.3.4** Report on a topic or text, tell a story, or recount an experience with appropriate facts and relevant, descriptive details, speaking clearly at an understandable pace. *(3-LS4-3),(3-LS4-4)*

Mathematics –

MP.2 Reason abstractly and quantitatively. *(3-LS4-1),(3-LS4-4)*

MP.4 Model with mathematics. (3-LS2-1),*(3-LS4-1),(3-LS4-4)*

MP.5 Use appropriate tools strategically. *(3-LS4-1)*

3.NBT Number and Operations in Base Ten (3-LS2-1)

3.MD.B.3 Draw a scaled picture graph and a scaled bar graph to represent a data set with several categories. Solve one- and two-step "how many more" and "how many less" problems using information presented in scaled bar graphs. For example, draw a bar graph in which each square in the bar graph might represent 5 pets. *(3-LS4-3)*

3.MD.B.4 Generate measurement data by measuring lengths using rulers marked with halves and fourths of an inch. Show the data by making a line plot, where the horizontal scale is marked off in appropriate units—whole numbers, halves, or quarters. *(3-LS4-1)*

*The performance expectations marked with an asterisk integrate traditional science content with engineering through a Practice or Disciplinary Core Idea.

3.Inheritance and Variation of Traits: Life Cycles and Traits

3.Inheritance and Variation of Traits: Life Cycles and Traits

Students who demonstrate understanding can:

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. [Clarification Statement: Changes organisms go through during their life form a pattern.] [Assessment Boundary: Assessment of plant life cycles is limited to those of flowering plants. Assessment does not include details of human reproduction.]

3-LS3-1. Analyze and interpret data to provide evidence that plants and animals have traits inherited from parents and that variation of these traits exists in a group of similar organisms. [Clarification Statement: Patterns are the similarities and differences in traits shared between offspring and their parents, or among siblings. Emphasis is on organisms other than humans.] [Assessment Boundary: Assessment does not include genetic mechanisms of inheritance and prediction of traits. Assessment is limited to non-human examples.]

3-LS3-2. Use evidence to support the explanation that traits can be influenced by the environment. [Clarification Statement: Examples of the environment affecting a trait could include normally tall plants grown with insufficient water are stunted; and, a pet dog that is given too much food and little exercise may become overweight.]

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. [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 by predators; and, animals that have better camouflage coloration than other animals may be more likely to survive and therefore more likely to leave offspring.]

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*:

Science and Engineering Practices

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 models to describe phenomena. (3-LS1-1)

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. (3-LS3-1)

Constructing Explanations and Designing Solutions
Constructing explanations and designing solutions 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., observations, patterns) to support an explanation. (3-LS3-2)
♣ Use evidence (e.g., observations, patterns) to construct an explanation. (3-LS4-2)

Connections to Nature of Science

Scientific Knowledge is Based on Empirical Evidence
♣ Science findings are based on recognizing patterns. (3-LS1-1)

Disciplinary Core Ideas

LS1.B: 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. (3-LS1-1)

LS3.A: Inheritance of Traits
♣ Many characteristics of organisms are inherited from their parents. (3-LS3-1)
♣ Other characteristics result from individuals' interactions with the environment, which can range from diet to learning. Many characteristics involve both inheritance and environment. (3-LS3-2)

LS3.B: Variation of Traits
♣ Different organisms vary in how they look and function because they have different inherited information. (3-LS3-1)
♣ The environment also affects the traits that an organism develops. (3-LS3-2)

LS4.B: Natural Selection
♣ Sometimes the differences in characteristics between individuals of the same species provide advantages in surviving, finding mates, and reproducing. (3-LS4-2)

Crosscutting Concepts

Patterns
♣ Similarities and differences in patterns can be used to sort and classify natural phenomena. (3-LS3-1)
♣ Patterns of change can be used to make predictions. (3-LS1-1)

Cause and Effect
♣ Cause and effect relationships are routinely identified and used to explain change. (3-LS3-2),(3-LS4-2)

Connections to other DCIs in third grade: **3.LS4.C** (3-LS4-2)

Articulation of DCIs across grade-bands: **1.LS3.A** (3-LS3-1),(3-LS4-2); **1.LS3.B** (3-LS3-1); **MS.LS1.B** (3-LS1-1), (3-LS3-2); **MS.LS2.A** (3-LS4-2); **MS.LS3.A** (3-LS3-1); **MS.LS3.B** (3-LS3-1),(3-LS4-2); **MS.LS4.B** (3-LS4-2)

Common Core State Standards Connections:

ELA/Literacy –

RI.3.1 Ask and answer questions to demonstrate understanding of a text, referring explicitly to the text as the basis for the answers. (3-LS3-1),(3-LS3-2),*(3-LS4-2)* **RI.3.2** Determine the main idea of a text; recount the key details and explain how they support the main idea. *(3-LS3-1),(3-LS3-2),(3-LS4-2)*

RI.3.3 Describe the relationship between a series of historical events, scientific ideas or concepts, or steps in technical procedures in a text, using language that pertains to time, sequence, and cause/effect. (3-LS3-1),*(3-LS3-2),(3-LS4-2)*

RI.3.7 Use information gained from illustrations (e.g., maps, photographs) and the words in a text to demonstrate understanding of the text (e.g., where, when, why, and how key events occur). *(3-LS1-1)*

W.3.2 Write informative/explanatory texts to examine a topic and convey ideas and information clearly. *(3-LS3-1),*(3-LS3-2),(3-LS4-2)

SL.3.4 Report on a topic or text, tell a story, or recount an experience with appropriate facts and relevant, descriptive details, speaking clearly at an understandable pace. *(3-LS3-1),(3-LS3-2),(3-LS4-2)*

SL.3.5 Create engaging audio recordings of stories or poems that demonstrate fluid reading at an understandable pace; add visual displays when appropriate to emphasize or enhance certain facts or details. *(3-LS1-1)*

Mathematics –

MP.2 Reason abstractly and quantitatively. *(3-LS3-1),(3-LS3-2)*

MP.4 Model with mathematics. *(3-LS1-1),(3-LS3-1),(3-LS3-2)*

3.NBT Number and Operations in Base Ten *(3-LS1-1)*

3.NF Number and Operations—Fractions *(3-LS1-1)*

3.MD.B.3 Draw a scaled picture graph and a scaled bar graph to represent a data set with several categories. Solve one- and two-step "how many more" and "how many less" problems using information presented in scaled bar graphs. For example, draw a bar graph in which each square in the bar graph might represent 5 pets. *(3-LS4-2)*

3.MD.B.4 Generate measurement data by measuring lengths using rulers marked with halves and fourths of an inch. Show the data by making a line plot, where the horizontal scale is marked off in appropriate units—whole numbers, halves, or quarters. *(3-LS3-1),(3-LS3-2)*

*The performance expectations marked with an asterisk integrate traditional science content with engineering through a Practice or Disciplinary Core Idea.

3.Weather and Climate

3.Weather and Climate

Students who demonstrate understanding can:

3-ESS2-1. Represent data in tables and graphical displays to describe typical weather conditions expected during a particular season. [Clarification Statement: Examples of data could include average temperature, precipitation, and wind direction.] [Assessment Boundary: Assessment of graphical displays is limited to pictographs and bar graphs. Assessment does not include climate change.]

3-ESS2-2. Obtain and combine information to describe climates in different regions of the world.

3-ESS3-1. Make a claim about the merit of a design solution that reduces the impacts of a weather-related hazard.* [Clarification Statement: Examples of design solutions to weather-related hazards could include barriers to prevent flooding, wind resistant roofs, and lighting rods.]

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*:

Science and Engineering Practices

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 various graphical displays (bar graphs, pictographs and/or pie charts) to reveal patterns that indicate relationships. (3-ESS2-1)

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. (3-ESS3-1)

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 other reliable media to explain phenomena. (3-ESS2-2)

Disciplinary Core Ideas

ESS2.D: 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. (3-ESS2-1)

♣ Climate describes a range of an area's typical weather conditions and the extent to which those conditions vary over years. (3-ESS2-2)

ESS3.B: Natural Hazards

♣ A variety of natural hazards result from natural processes. Humans cannot eliminate natural hazards but can take steps to reduce their impacts. (3-ESS3-1) *(Note: This Disciplinary Core Idea is also addressed by 4-ESS3-2.)*

Crosscutting Concepts

Patterns

♣ Patterns of change can be used to make predictions. (3-ESS2-1),(3-ESS2-2)

Cause and Effect

♣ Cause and effect relationships are routinely identified, tested, and used to explain change. (3-ESS3-1)

Connections to Engineering, Technology, and Applications of Science

Influence of Engineering, Technology, and Science on Society and the Natural World

♣ Engineers improve existing technologies or develop new ones to increase their benefits (e.g., better artificial limbs), decrease known risks (e.g., seatbelts in cars), and meet societal demands (e.g., cell phones). (3-ESS3-1)

Connections to Nature of Science

Science is a Human Endeavor

♣ Science affects everyday life. (3-ESS3-1)

Connections to other DCIs in third grade: N/A

Articulation of DCIs across grade-bands: **K.ESS2.D** (3-ESS2-1); **K.ESS3.B** (3-ESS3-1); **K.ETS1.A** (3-ESS3-1); **4.ESS2.A** (3-ESS2-1); **4.ESS3.B** (3-ESS3-1); **4.ETS1.A** (3-ESS3-1); **5.ESS2.A** (3-ESS2-1); **MS.ESS2.C** (3-ESS2-1),(3-ESS2-2); **MS.ESS2.D** (3-ESS2-1),(3-ESS2-2); **MS.ESS3.B** (3-ESS3-1)

Common Core State Standards Connections:

ELA/Literacy –

RI.3.1 Ask and answer questions to demonstrate understanding of a text, referring explicitly to the text as the basis for the answers. *(3-ESS2-2)* **RI.3.9** Compare and contrast the most important points and key details presented in two texts on the same topic. (3-ESS2-2)

W.3.1 Write opinion pieces on topics or texts, supporting a point of view with reasons. *(3-ESS3-1)* **W.3.7** Conduct short research projects that build knowledge about a topic. *(3-ESS3-1)*

W.3.9 Recall information from experiences or gather information from print and digital sources; take brief notes on sources and sort evidence into provided categories. (3-ESS2-2)

Mathematics –

MP.2 Reason abstractly and quantitatively. (3-ESS2-1),(3-ESS2-2),*(3-ESS3-1)*

MP.4 Model with mathematics. (3-ESS2-1),(3-ESS2-2), *(3-ESS3-1)*

MP.5 Use appropriate tools strategically. *(3-ESS2-1)*

3.MD.A.2 Measure and estimate liquid volumes and masses of objects using standard units of grams (g), kilograms (kg), and liters (l). Add, subtract, multiply, or divide to solve one-step word problems involving masses or volumes that are given in the same units, e.g., by using drawings (such as a beaker with a measurement scale) to represent the problem. *(3-ESS2-1)*

3.MD.B.3 Draw a scaled picture graph and a scaled bar graph to represent a data set with several categories. Solve one- and two-step "how many more" and "how many less" problems using information presented in bar graphs. (3-ESS2-1)

*The performance expectations marked with an asterisk integrate traditional science content with engineering through a Practice or Disciplinary Core Idea.

Fourth Grade

The performance expectations in fourth grade help students formulate answers to questions such as: "What are waves and what are some things they can do? How can water, ice, wind and vegetation change the land? What patterns of Earth's features can be determined with the use of maps? How do internal and external structures support the survival, growth, behavior, and reproduction of plants and animals? What is energy and how is it related to motion? How is energy transferred? How can energy be used to solve a problem?" Fourth grade performance expectations include PS3, PS4, LS1, ESS1, ESS2, ESS3, and ETS1 Disciplinary Core Ideas from the *NRC Framework*. Students are able to use a model of waves to describe patterns of waves in terms of amplitude and wavelength, and that waves can cause objects to move. Students are expected to develop understanding of the effects of weathering or the rate of erosion by water, ice, wind, or vegetation. They apply their knowledge of natural Earth processes to generate and compare multiple solutions to reduce the impacts of such processes on humans. In order to describe patterns of Earth's features, students analyze and interpret data from maps. Fourth graders are expected to develop an understanding that plants and animals have internal and external structures that function to support survival, growth, behavior, and reproduction. By developing a model, they describe that an object can be seen when light reflected from its surface enters the eye. Students are able to use evidence to construct an explanation of the relationship between the speed of an object and the energy of that object. Students are expected to develop an understanding that energy can be transferred from place to place by sound, light, heat, and electric currents or from object to object through collisions. They apply their understanding of energy to design, test, and refine a device that converts energy from one form to another. The crosscutting concepts of patterns; cause and effect; energy and matter; systems and system models; interdependence of science, engineering, and technology; and influence of engineering, technology, and science on society and the natural world are called out as organizing concepts for these disciplinary core ideas. In the fourth grade performance expectations, students are expected to demonstrate grade-appropriate proficiency in asking questions, developing and using models, planning and carrying out investigations, analyzing and interpreting data, constructing explanations and designing solutions, engaging in argument from evidence, and obtaining, evaluating, and communicating information. Students are expected to use these practices to demonstrate understanding of the core ideas.

4.Energy

4.Energy

Students who demonstrate understanding can:

4-PS3-1. Use evidence to construct an explanation relating the speed of an object to the energy of that object. [Assessment Boundary: Assessment does not include quantitative measures of changes in the speed of an object or on any precise or quantitative definition of energy.]

4-PS3-2. Make observations to provide evidence that energy can be transferred from place to place by sound, light, heat, and electric currents. [Assessment Boundary: Assessment does not include quantitative measurements of energy.]

4-PS3-3. Ask questions and predict outcomes about the changes in energy that occur when objects collide. [Clarification Statement: Emphasis is on the change in the energy due to the change in speed, not on the forces, as objects interact.] [Assessment Boundary: Assessment does not include quantitative measurements of energy.]

4-PS3-4. Apply scientific ideas to design, test, and refine a device that converts energy from one form to another.* [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. Examples of constraints could include the materials, cost, or time to design the device.] [Assessment Boundary: Devices should be limited to those that convert motion energy to electric energy or use stored energy to cause motion or produce light or sound.]

4-ESS3-1. Obtain and combine information to describe that energy and fuels are derived from natural resources and their uses affect the environment. [Clarification Statement: Examples of renewable energy resources could include wind energy, water behind dams, and sunlight; non-renewable energy resources are fossil fuels and fissile materials. Examples of environmental effects could include loss of habitat due to dams, loss of habitat due to surface mining, and air pollution from burning of fossil fuels.]

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Asking Questions and Defining Problems Asking questions and defining problems in grades 3–5 builds on grades 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. (4-PS3-3) **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. ♣ Make observations to produce data to serve as the basis for evidence for an explanation of a phenomenon or test a design solution. (4-PS3-2) **Constructing Explanations and Designing Solutions** Constructing explanations and designing solutions 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 an explanation. (4-PS3-1) ♣ Apply scientific ideas to solve design problems. (4-PS3-4) **Obtaining, Evaluating, and Communicating Information** Obtaining, evaluating, and communicating information in 3–5 builds on K–2 experiences and progresses to evaluate the merit and accuracy of ideas and methods. ♣ Obtain and combine information from books and other reliable media to explain phenomena. (4-ESS3-1)	**PS3.A: Definitions of Energy** ♣ The faster a given object is moving, the more energy it possesses. (4-PS3-1) ♣ Energy can be moved from place to place by moving objects or through sound, light, or electric currents. (4-PS3-2),(4-PS3-3) **PS3.B: 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. (4-PS3-2),(4-PS3-3) ♣ Light also transfers energy from place to place. (4-PS3-2) ♣ 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. (4-PS3-2),(4-PS3-4) **PS3.C: Relationship Between Energy and Forces** ♣ When objects collide, the contact forces transfer energy so as to change the objects' motions. (4-PS3-3) **PS3.D: 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. (4-PS3-4) **ESS3.A: Natural Resources** ♣ Energy and fuels 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. (4-ESS3-1) **ETS1.A: Defining 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. *(secondary to 4-PS3-4)*	**Cause and Effect** ♣ Cause and effect relationships are routinely identified and used to explain change. (4-ESS3-1) **Energy and Matter** ♣ Energy can be transferred in various ways and between objects. (4-PS3-1), (4-PS3-2),(4-PS3-3),(4-PS3-4) --- ***Connections to Engineering, Technology and Applications of Science*** **Interdependence of Science, Engineering, and Technology** ♣ Knowledge of relevant scientific concepts and research findings is important in engineering. (4-ESS3-1) **Influence of Engineering, Technology, and Science on Society and the Natural World** ♣ Engineers improve existing technologies or develop new ones. (4-PS3-4) ♣ Over time, people's needs and wants change, as do their demands for new and improved technologies. (4-ESS3-1) --- ***Connections to Nature of Science*** **Science is a Human Endeavor** ♣ Most scientists and engineers work in teams. (4-PS3-4) ♣ Science affects everyday life. (4-PS3-4)

Connections to other DCIs in fourth grade: N/A

Articulation of DCIs across grade-bands: **K.PS2.B** (4-PS3-3); **K.ETS1.A** (4-PS3-4); **2.ETS1.B** (4-PS3-4); **3.PS2.A** (4-PS3-3); **5.PS3.D** (4-PS3-4); **5.LS1.C** (4-PS3-4); **5.ESS3.C** (4-ESS3-1); **MS.PS2.A** (4-PS3-3); **MS.PS2.B** (4-PS3-2); **MS.PS3.A** (4-PS3-1),(4-PS3-2),(4-PS3-3),(4-PS3-4); **MS.PS3.B** (4-PS3-2),(4-PS3-3),(4-PS3-4); **MS.PS3.C** (4-PS3-3); **MS.PS3.D** (4-ESS3-1); **MS.PS4.B** (4-PS3-2); **MS.ESS2.A** (4-ESS3-1); **MS.ESS3.A** (4-ESS3-1); **MS.ESS3.C** (4-ESS3-1); **MS.ESS3.D** (4-ESS3-1); **MS.ETS1.B** (4-PS3-4); **MS.ETS1.C** (4-PS3-4)

Common Core State Standards Connections:

ELA/Literacy –

RI.4.1 Refer to details and examples in a text when explaining what the text says explicitly and when drawing inferences from the text. (4-PS3-1)

RI.4.3 Explain events, procedures, ideas, or concepts in a historical, scientific, or technical text, including what happened and why, based on specific information in the text. (4-PS3-1)

RI.4.9 Integrate information from two texts on the same topic in order to write or speak about the subject knowledgeably. *(4-PS3-1)*

W.4.2 Write informative/explanatory texts to examine a topic and convey ideas and information clearly. (4-PS3-1)

W.4.7 Conduct short research projects that build knowledge through investigation of different aspects of a topic. (4-PS3-2),(4-PS3-3),(4-PS3-4),*(4-ESS3-1)*

W.4.8 Recall relevant information from experiences or gather relevant information from print and digital sources; take notes and categorize information, and provide a list of sources. (4-PS3-1),(4-PS3-2),(4-PS3-3),(4-PS3-4),(4-ESS3-1)

W.4.9 Draw evidence from literary or informational texts to support analysis, reflection, and research. (4-PS3-1),*(4-ESS3-1)*

Mathematics –

MP.2 Reason abstractly and quantitatively. *(4-ESS3-1)*

MP.4 Model with mathematics. *(4-ESS3-1)*

4.OA.A.3 Solve multistep word problems posed with whole numbers and having whole-number answers using the four operations, including problems in which remainders must be interpreted. Represent these problems using equations with a letter standing for the unknown quantity. Assess the reasonableness of answers using mental computation and estimation strategies including rounding. *(4-PS3-4)*

4.OA.A.1 Interpret a multiplication equation as a comparison, e.g., interpret 35 = 5 × 7 as a statement that 35 is 5 times as many as 7 and 7 times as many as 5. Represent verbal statements of multiplicative comparisons as multiplication equations. (4-ESS3-1)

*The performance expectations marked with an asterisk integrate traditional science content with engineering through a Practice or Disciplinary Core Idea.

4.Waves: Waves and Information

4.Waves: Waves and Information

Students who demonstrate understanding can:

4-PS4-1. Develop a model of waves to describe patterns in terms of amplitude and wavelength and that waves can cause objects to move. [Clarification Statement: Examples of models could include diagrams, analogies, and physical models using wire to illustrate wavelength and amplitude of waves.] [Assessment Boundary: Assessment does not include interference effects, electromagnetic waves, non-periodic waves, or quantitative models of amplitude and wavelength.]

4-PS4-3. Generate and compare multiple solutions that use patterns to transfer information.* [Clarification Statement: Examples of solutions could include drums sending coded information through sound waves, using a grid of 1's and 0's representing black and white to send information about a picture, and using Morse code to send text.]

Science and Engineering Practices

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. (4-PS4-1)

Constructing Explanations and Designing Solutions
Constructing explanations and designing solutions 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. (4-PS4-3)

Connections to Nature of Science

Scientific Knowledge is Based on Empirical Evidence
♣ Science findings are based on recognizing patterns. (4-PS4-1)

Disciplinary Core Ideas

PS4.A: 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. *(Note: This grade band endpoint was moved from K–2).* (4-PS4-1)
♣ Waves of the same type can differ in amplitude (height of the wave) and wavelength (spacing between wave peaks). (4-PS4-1)

PS4.C: Information Technologies and Instrumentation
♣ Digitized information transmitted over long distances without significant degradation. High-tech devices, such as computers or cell phones, can receive and decode information—convert it from digitized form to voice—and vice versa. (4-PS4-3)

ETS1.C: 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. *(secondary to 4-PS4-3)*

Crosscutting Concepts

Patterns
♣ Similarities and differences in patterns can be used to sort and classify natural phenomena. (4-PS4-1)
♣ Similarities and differences in patterns can be used to sort and classify designed products. (4-PS4-3)

Connections to Engineering, Technology, and Applications of Science

Interdependence of Science, Engineering, and Technology
♣ Knowledge of relevant scientific concepts and research findings is important in engineering. (4-PS4-3)

Connections to other DCIs in fourth grade: **4.PS3.A** (4-PS4-1); **4.PS3.B** (4-PS4-1); **4.ETS1.A** (4-PS4-3)

Articulation of DCIs across grade-bands: **K.ETS1.A** (4-PS4-3); **1.PS4.C** (4-PS4-3); **2.ETS1.B** (4-PS4-3); **2.ETS1.C** (4-PS4-3); **3.PS2.A** (4-PS4-3); **MS.PS4.A** (4-PS4-1); **MS.PS4.C** (4-PS4-3); **MS.ETS1.B** (4-PS4-3)

Common Core State Standards Connections:

ELA/Literacy –

RI.4.1 Refer to details and examples in a text when explaining what the text says explicitly and when drawing inferences from the text. *(4-PS4-3)* **RI.4.9** Integrate information from two texts on the same topic in order to write or speak about the subject knowledgeably. (4-PS4-3)

SL.4.5 Add audio recordings and visual displays to presentations when appropriate to enhance the development of main ideas or themes. *(4-PS4-1)*

Mathematics –

MP.4 Model with mathematics. *(4-PS4-1),(4-PS4-2)*

4.G.A.1 Draw points, lines, line segments, rays, angles (right, acute, obtuse), and perpendicular and parallel lines. Identify these in two-dimensional figures. *(4-PS4-1)*

*The performance expectations marked with an asterisk integrate traditional science content with engineering through a Practice or Disciplinary Core Idea.

4.Structure, Function, and Information Processing

4.Structure, Function, and Information Processing

Students who demonstrate understanding can:

4-PS4-2. Develop a model to describe that light reflecting from objects and entering the eye allows objects to be seen.
[Assessment Boundary: Assessment does not include knowledge of specific colors reflected and seen, the cellular mechanisms of vision, or how the retina works.]

Construct an argument that plants and animals have internal and external structures that function to support survival, growth, behavior, and reproduction. [Clarification Statement: Examples of structures could include thorns, stems, roots, colored petals, heart, stomach, lung, brain, and skin.] [Assessment Boundary: Assessment is limited to macroscopic structures within plant and animal systems.]

Use a model to describe that animals receive different types of information through their senses, process the information in their brain, and respond to the information in different ways. [Clarification Statement: Emphasis is on systems of **information transfer.] [Assessment Boundary: Assessment does not include the mechanisms by which the brain stores and recalls information or the mechanisms of how sensory receptors function.]**

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*:

4-LS1-1.
4-LS1-2.

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
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 to describe phenomena. (4-PS4-2) ♣ Use a model to test interactions concerning the functioning of a natural system. (4-LS1-2) **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 an argument with evidence, data, and/or a model. (4-LS1-1)	**PS4.B: Electromagnetic Radiation** ♣ An object can be seen when light reflected from its surface enters the eyes. (4-PS4-2) **LS1.A: Structure and Function** ♣ Plants and animals have both internal and external structures that serve various functions in growth, survival, behavior, and reproduction. (4-LS1-1) **LS1.D: Information Processing** ♣ Different sense receptors are specialized for particular kinds of information, which may be then processed by the animal's brain. Animals are able to use their perceptions and memories to guide their actions. (4-LS1-2)	**Cause and Effect** ♣ Cause and effect relationships are routinely identified. (4-PS4-2) **Systems and System Models** ♣ A system can be described in terms of its components and their interactions. (4-LS1-1), (LS1-2)

Connections to other DCIs in this grade-level: N/A

Articulation of DCIs across grade-bands: **1.PS4.B** (4-PS4-2); **1.LS1.A** (4-LS1-1); **1.LS1.D** (4-LS1-2); **3.LS3.B** (4-LS1-1); **MS.PS4.B** (4-PS4-2); **MS.LS1.A** (4-LS1-1),(4-LS1-2); **MS.LS1.D** (4-PS4-2),(4-LS1-2)

Common Core State Standards Connections:

ELA/Literacy –

W.4.1 Write opinion pieces on topics or texts, supporting a point of view with reasons and information. (4-LS1-1)

SL.4.5 Add audio recordings and visual displays to presentations when appropriate to enhance the development of main ideas or themes. *(4-PS4-2),(4-LS1-2)*

Mathematics –

MP.4 Model with mathematics. *(4-PS4-1),(4-PS4-2)*

4.G.A.1 Draw points, lines, line segments, rays, angles (right, acute, obtuse), and perpendicular and parallel lines. Identify these in two-dimensional figures. *(4-PS4-2)* **4.G.A.3** Recognize a line of symmetry for a two-dimensional figure as a line across the figure such that the figure can be folded across the line into matching parts. Identify line-symmetric figures and draw lines of symmetry. *(4-LS1-1)*

*The performance expectations marked with an asterisk integrate traditional science content with engineering through a Practice or Disciplinary Core Idea.

4.Earth's Systems: Processes that Shape the Earth

4.Earth's Systems: Processes that Shape the Earth

Students who demonstrate understanding can:

4-ESS1-1. Identify evidence from patterns in rock formations and fossils in rock layers to support an explanation for changes in a landscape over time. [Clarification Statement: Examples of evidence from patterns could include rock layers with shell fossils above rock layers with plant fossils and no shells, indicating a change from water to land 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.] [Assessment Boundary: Assessment does not include specific knowledge of the mechanism of rock formation or memorization of specific rock formations and layers. Assessment is limited to relative time.]

4-ESS2-1. Make observations and/or measurements to provide evidence of the effects of weathering or the rate of erosion by water, ice, wind, or vegetation. [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.] [Assessment Boundary: Assessment is limited to a single form of weathering or erosion.]

4-ESS2-2. Analyze and interpret data from maps to describe patterns of Earth's features. [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.]

4-ESS3-2. Generate and compare multiple solutions to reduce the impacts of natural Earth processes on humans.* [Clarification Statement: Examples of solutions could include designing an earthquake resistant building and improving monitoring of volcanic activity.] [Assessment Boundary: Assessment is limited to earthquakes, floods, tsunamis, and volcanic eruptions.]

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*:

Science and Engineering Practices

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.

- ♣ Make observations and/or measurements to produce data to serve as the basis for evidence for an explanation of a phenomenon. (4-ESS2-1)

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. (4-ESS2-2)

Constructing Explanations and Designing Solutions

Constructing explanations and designing solutions 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. (4-ESS1-1)
- ♣ Generate and compare multiple solutions to a problem based on how well they meet the criteria and constraints of the design solution. (4-ESS3-2)

Disciplinary Core Ideas

ESS1.C: The History of Planet Earth

- ♣ Local, regional, and global patterns of rock formations reveal changes over time due to earth forces, such as earthquakes. The presence and location of certain fossil types indicate the order in which rock layers were formed. (4-ESS1-1)

ESS2.A: 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. (4-ESS2-1)

ESS2.B: 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 areas of Earth. (4-ESS2-2)

ESS2.E: Biogeology

- ♣ Living things affect the physical characteristics of their regions. (4-ESS2-1)

ESS3.B: Natural Hazards

- ♣ A variety of hazards result from natural processes (e.g., earthquakes, tsunamis, volcanic eruptions). Humans cannot eliminate the hazards but can take steps to reduce their impacts. (4-ESS3-2) *(Note: This Disciplinary Core Idea can also be found in 3.WC.)*

ETS1.B: Designing Solutions to Engineering Problems

- ♣ Testing a solution involves investigating how well it performs under a range of likely conditions. *(secondary to 4-ESS3-2)*

Crosscutting Concepts

Patterns

- ♣ Patterns can be used as evidence to support an explanation. (4-ESS1-1),(4-ESS2-2)

Cause and Effect

- ♣ Cause and effect relationships are routinely identified, tested, and used to explain change. (4-ESS2-1),(4-ESS3-2)

Connections to Engineering, Technology, and Applications of Science

Influence of Engineering, Technology, and Science on Society and the Natural World

- ♣ Engineers improve existing technologies or develop new ones to increase their benefits, to decrease known risks, and to meet societal demands. (4-ESS3-2)

Connections to Nature of Science

Scientific Knowledge Assumes an Order and Consistency in Natural Systems

- ♣ Science assumes consistent patterns in natural systems. (4-ESS1-1)

Connections to other DCIs in fourth grade: **4.ETS1.C** (4-ESS3-2)

Articulation of DCIs across grade-bands: **K.ETS1.A** (4-ESS3-2); **2.ESS1.C** (4-ESS1-1),(4-ESS2-1); **2.ESS2.A** (4-ESS2-1); **2.ESS2.B** (4-ESS2-2); **2.ESS2.C** (4-ESS2-2); **2.ETS1.B** (4-ESS3-2); **2.ETS1.C** (4-ESS3-2); **3.LS4.A** (4-ESS1-1); **5.ESS2.A** (4-ESS2-1); **5.ESS2.C** (4-ESS2-2); **MS.LS4.A** (4-ESS1-1); **MS.ESS1.C** (4-ESS1-1),(4-ESS2-2); **MS.ESS2.A** (4-ESS1-1),(4-ESS2-2),(4-ESS3-2); **MS.ESS2.B** (4-ESS1-1),(4-ESS2-2); **MS.ESS3.B** (4-ESS3-2); **MS.ETS1.B** (4-ESS3-2)

Common Core State Standards Connections:

ELA/Literacy –

RI.4.1 Refer to details and examples in a text when explaining what the text says explicitly and when drawing inferences from the text. (4-ESS3-2)

RI.4.7 Interpret information presented visually, orally, or quantitatively (e.g., in charts, graphs, diagrams, time lines, animations, or interactive elements on Web pages) and explain how the information contributes to an understanding of the text in which it appears. (4-ESS2-2)

RI.4.9 Integrate information from two texts on the same topic in order to write or speak about the subject knowledgeably. (4-ESS3-2)

W.4.7 Conduct short research projects that build knowledge through investigation of different aspects of a topic. (4-ESS1-1),(4-ESS2-1)

W.4.8 Recall relevant information from experiences or gather relevant information from print and digital sources; take notes and categorize information, and provide a list of sources. (4-ESS1-1),(4-ESS2-1)

W.4.9 Draw evidence from literary or informational texts to support analysis, reflection, and research. *(4-ESS1-1)*

Mathematics –

MP.2 Reason abstractly and quantitatively. *(4-ESS1-1)*,(4-ESS2-1),*(4-ESS3-2)*

MP.4 Model with mathematics. *(4-ESS1-1)*,(4-ESS2-1),*(4-ESS3-2)*

MP.5 Use appropriate tools strategically. (4-ESS2-1)

4.MD.A.1 Know relative sizes of measurement units within one system of units including km, m, cm; kg, g; lb, oz.; l, ml; hr, min, sec. Within a single system of measurement, express measurements in a larger unit in terms of a smaller unit. Record measurement equivalents in a two-column table. For example, know that 1 ft is 12 times as long as 1 in. Express the length of a 4 ft snake as 48 in. Generate a conversion table for feet and inches listing the number pairs (1, 12), (2, 24), (3, 36). *(4-ESS1-1),(4-ESS2-1)*

4.MD.A.2 Use the four operations to solve word problems involving distances, intervals of time, liquid volumes, masses of objects, and money, including problems involving simple fractions or decimals, and problems that require expressing measurements given in a larger unit in terms of a smaller unit. Represent measurement quantities using diagrams such as number line diagrams that feature a measurement scale. *(4-ESS2-1),(4-ESS2-2)*

4.OA.A.1 Interpret a multiplication equation as a comparison, e.g., interpret 35 = 5 × 7 as a statement that 35 is 5 times as many as 7 and 7 times as many as 5. Represent verbal statements of multiplicative comparisons as multiplication equations. *(4-ESS3-2)*

*The performance expectations marked with an asterisk integrate traditional science content with engineering through a Practice or Disciplinary Core Idea.

Fifth Grade

The performance expectations in fifth grade help students formulate answers to questions such as: "When matter changes, does its weight change? How much water can be found in different places on Earth? Can new substances be created by combining other substances? How does matter cycle through ecosystems? Where does the energy in food come from and what is it used for? How do lengths and directions of shadows or relative lengths of day and night change from day to day, and how does the appearance of some stars change in different seasons?" Fifth grade performance expectations include PS1, PS2, PS3, LS1, LS2, ESS1, ESS2, and ESS3 Disciplinary Core Ideas from the *NRC Framework*. Students are able to describe that matter is made of particles too small to be seen through the development of a model. Students develop an understanding of the idea that regardless of the type of change that matter undergoes, the total weight of matter is conserved. Students determine whether the mixing of two or more substances results in new substances. Through the development of a model using an example, students are able to describe ways the geosphere, biosphere, hydrosphere, and/or atmosphere interact. They describe and graph data to provide evidence about the distribution of water on Earth. Students develop an understanding of the idea that plants get the materials they need for growth chiefly from air and water. Using models, students can describe the movement of matter among plants, animals, decomposers, and the environment and that energy in animals' food was once energy from the sun. Students are expected to develop an understanding of patterns of daily changes in length and direction of shadows, day and night, and the seasonal appearance of some stars in the night sky. The crosscutting concepts of patterns; cause and effect; scale, proportion, and quantity; energy and matter; and systems and systems models are called out as organizing concepts for these disciplinary core ideas. In the fifth grade performance expectations, students are expected to demonstrate grade-appropriate proficiency in developing and using models, planning and carrying out investigations, analyzing and interpreting data, using mathematics and computational thinking, engaging in argument from evidence, and obtaining, evaluating, and communicating information; and to use these practices to demonstrate understanding of the core ideas.

5.Structure and Properties of Matter

5.Structure and Properties of Matter

Students who demonstrate understanding can:

5-PS1-1. Develop a model to describe that matter is made of particles too small to be seen. [Clarification Statement: Examples of evidence could include adding air to expand a basketball, compressing air in a syringe, dissolving sugar in water, and evaporating salt water.] [Assessment Boundary: Assessment does not include the atomic-scale mechanism of evaporation and condensation or defining the unseen particles.]

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 weight of matter is conserved. [Clarification Statement: Examples of reactions or changes could include phase changes, dissolving, and mixing that forms new substances.] [Assessment Boundary: Assessment does not include distinguishing mass and weight.]

5-PS1-3. Make observations and measurements to identify materials based on their properties. [Clarification Statement: Examples of materials to be identified could include baking soda and other powders, metals, minerals, and liquids. Examples of properties could include color, hardness, reflectivity, electrical conductivity, thermal conductivity, response to magnetic forces, and solubility; density is not intended as an identifiable property.] [Assessment Boundary: Assessment does not include density or distinguishing mass and weight.]

5-PS1-4. Conduct an investigation to determine whether the mixing of two or more substances results in new substances.

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*:

Science and Engineering Practices

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 to describe phenomena. (5-PS1-1)

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.

♣ 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. (5-PS1-4)

♣ Make observations and measurements to produce data to serve as the basis for evidence for an explanation of a phenomenon. (5-PS1-3)

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.

♣ Measure and graph quantities such as weight to address scientific and engineering questions and problems. (5-PS1-2)

Disciplinary Core Ideas

PS1.A: 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 shows 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 the inflation and shape of a balloon; the effects of air on larger particles or objects. (5-PS1-1)

♣ The amount (weight) of matter is conserved when it changes form, even in transitions in which it seems to vanish. (5-PS1-2)

♣ Measurements of a variety of properties can be used to identify materials. (Boundary: At this grade level, mass and weight are not distinguished, and no attempt is made to define the unseen particles or explain the atomic-scale mechanism of evaporation and condensation.) (5-PS1-3)

PS1.B: Chemical Reactions

♣ When two or more different substances are mixed, a new substance with different properties may be formed. (5-PS1-4)

♣ No matter what reaction or change in properties occurs, the total weight of the substances does not change. (Boundary: Mass and weight are not distinguished at this grade level.) (5-PS1-2)

Crosscutting Concepts

Cause and Effect

♣ Cause and effect relationships are routinely identified, tested, and used to explain change. (5-PS1-4)

Scale, Proportion, and Quantity

♣ Natural objects exist from the very small to the immensely large. (5-PS1-1)

♣ Standard units are used to measure and describe physical quantities such as weight, time, temperature, and volume. (5-PS1-2),(5-PS1-3)

Connections to Nature of Science

Scientific Knowledge Assumes an Order and Consistency in Natural Systems

♣ Science assumes consistent patterns in natural systems. (5-PS1-2)

Connections to other DCIs in fifth grade: N/A

Articulation of DCIs across grade-bands: **2.PS1.A** (5-PS1-1),(5-PS1-2),(5-PS1-3); **2.PS1.B** (5-PS1-2),(5-PS1-4); **MS.PS1.A** (5-PS1-1),(5-PS1-2),(5-PS1-3),(5-PS1-4); **MS.PS1.B** (5-PS1-2),(5-PS1-4)

Common Core State Standards Connections:

ELA/Literacy –

RI.5.7 Draw on information from multiple print or digital sources, demonstrating the ability to locate an answer to a question quickly or to solve a problem efficiently. *(5-PS1-1)*

W.5.7 Conduct short research projects that use several sources to build knowledge through investigation of different aspects of a topic. *(5-PS1-2),(5-PS1-3),*(5-PS1-4)

W.5.8 Recall relevant information from experiences or gather relevant information from print and digital sources; summarize or paraphrase information in notes and finished work, and provide a list of sources. *(5-PS1-2),(5-PS1-3),*(5-PS1-4)

W.5.9 Draw evidence from literary or informational texts to support analysis, reflection, and research. *(5-PS1-2),(5-PS1-3),(5-PS1-4)*

Mathematics –

MP.2 Reason abstractly and quantitatively. *(5-PS1-1),*(5-PS1-2),(5-PS1-3)

MP.4 Model with mathematics. *(5-PS1-1),*(5-PS1-2),(5-PS1-3)

MP.5 Use appropriate tools strategically. (PS1-2),(PS1-3)

5.NBT.A.1 Explain patterns in the number of zeros of the product when multiplying a number by powers of 10, and explain patterns in the placement of the decimal point when a decimal is multiplied or divided by a power of 10. Use whole-number exponents to denote powers of 10. *(5-PS1-1)*

5.NF.B.7 Apply and extend previous understandings of division to divide unit fractions by whole numbers and whole numbers by unit fractions. *(5-PS1-1)*

5.MD.A.1 Convert among different-sized standard measurement units within a given measurement system (e.g., convert 5 cm to 0.05 m), and use these conversions in solving multi-step, real-world problems. *(5-PS1-2)*

5.MD.C.3 Recognize volume as an attribute of solid figures and understand concepts of volume measurement. *(5-PS1-1)*

5.MD.C.4 Measure volumes by counting unit cubes, using cubic cm, cubic in, cubic ft, and improvised units. *(5-PS1-1)*

*The performance expectations marked with an asterisk integrate traditional science content with engineering through a Practice or Disciplinary Core Idea.

5.Matter and Energy in Organisms and Ecosystems

5.Matter and Energy in Organisms and Ecosystems

Students who demonstrate understanding can:

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. [Clarification Statement: Examples of models could include diagrams, and flow charts.]

5-LS1-1. Support an argument that plants get the materials they need for growth chiefly from air and water. [Clarification Statement: Emphasis is on the idea that plant matter comes mostly from air and water, not from the soil.]

5-LS2-1. Develop a model to describe the movement of matter among plants, animals, decomposers, and 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, and the Earth.] [Assessment Boundary: Assessment does not include molecular explanations.]

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*:

Science and Engineering Practices

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.
♣ Use models to describe phenomena. (5-PS3-1)
♣ Develop a model to describe phenomena. (5-LS2-1)

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).
♣ Support an argument with evidence, data, or a model. (5-LS1-1)

Connections to Nature of Science

Science Models, Laws, Mechanisms, and Theories Explain Natural Phenomena
♣ Science explanations describe the mechanisms for natural events. (5-LS2-1)

Disciplinary Core Ideas

PS3.D: 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). (5-PS3-1)

LS1.C: Organization for Matter and Energy Flow in Organisms
♣ Food provides animals with the materials they need for body repair and growth and the energy they need to maintain body warmth and for motion. *(secondary to 5-PS3-1)*
♣ Plants acquire their material for growth chiefly from air and water. (5-LS1-1)

LS2.A: 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. Some organisms, such as fungi and bacteria, break down dead organisms (both plants or plants parts and animals) and therefore operate as "decomposers." Decomposition eventually restores (recycles) some materials back to the soil. 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. Newly introduced species can damage the balance of an ecosystem. (5-LS2-1)

LS2.B: Cycles of Matter and Energy Transfer in Ecosystems
♣ Matter cycles between the air and soil and among plants, animals, 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. (5-LS2-1)

Crosscutting Concepts

Systems and System Models
♣ A system can be described in terms of its components and their interactions. (5-LS2-1)

Energy and Matter
♣ Matter is transported into, out of, and within systems. (5-LS1-1)
♣ Energy can be transferred in various ways and between objects. (5-PS3-1)

Connections to other DCIs in fifth grade: **5.ESS2.A** (5-LS2-1); **5.PS1.A** (5-LS1-1),(5-LS2-1)

Articulation of DCIs across grade-bands: **K.LS1.C** (5-LS1-1),(5-PS3-1); **2.PS1.A** (5-LS2-1); **2.LS2.A** (5-PS3-1),(5-LS1-1); **2.LS4.D** (5-LS2-1); **4.PS3.A** (5-PS3-1); **4.PS3.B** (5-PS3-1); **4.PS3.D** (5-PS3-1); **4.ESS2.E** (5-LS2-1); **MS.PS3.D** (5-PS3-1),(5-LS2-1); **MS.PS4.B** (5-PS3-1); **MS.LS1.C** (5-PS3-1),(5-LS1-1),(5-LS2-1); **MS.LS2.A** (5-LS2-1); **MS.LS2.B** (5-PS3-1),(5-LS2-1)

Common Core State Standards Connections:
ELA/Literacy –
RI.5.1 Quote accurately from a text when explaining what the text says explicitly and when drawing inferences from the text. *(5-LS1-1)*
RI.5.7 Draw on information from multiple print or digital sources, demonstrating the ability to locate an answer to a question quickly or to solve a problem efficiently. *(5-PS3-1),(5-LS2-1)*
RI.5.9 Integrate information from several texts on the same topic in order to write or speak about the subject knowledgeably. (5-LS1-1) **W.5.1** Write opinion pieces on topics or texts, supporting a point of view with reasons and information. (5-LS1-1)
SL.5.5 Include multimedia components (e.g., graphics, sound) and visual displays in presentations when appropriate to enhance the development of main ideas or themes. *(5-PS3-1),(5-LS2-1)*
Mathematics –
MP.2 Reason abstractly and quantitatively. *(5-LS2-1)*
MP.4 Model with mathematics. *(5-LS2-1)*
5.MD.A.1 Convert among different-sized standard measurement units within a given measurement system (e.g., convert 5 cm to 0.05 m), and use these conversions in solving multi-step, real world problems. *(5-LS1-1)*

*The performance expectations marked with an asterisk integrate traditional science content with engineering through a Practice or Disciplinary Core Idea.

5.Earth's Systems

5.Earth's Systems

Students who demonstrate understanding can:

5-ESS2-1. Develop a model using an example to describe ways the geosphere, biosphere, hydrosphere, and/or atmosphere 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.] [Assessment Boundary: Assessment is limited to the interactions of two systems at a time.]

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. [Assessment Boundary: Assessment is limited to oceans, lakes, rivers, glaciers, ground water, and polar ice caps, and does not include the atmosphere.]

5-ESS3-1. Obtain and combine information about ways individual communities use science ideas to protect the Earth's resources and environment.

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*:

Science and Engineering Practices

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 example to describe a scientific principle. (5-ESS2-1)

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 and graph quantities such as area and volume to address scientific questions. (5-ESS2-2)

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. (5-ESS3-1)

Disciplinary Core Ideas

ESS2.A: 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. (5-ESS2-1)

ESS2.C: 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. (5-ESS2-2)

ESS3.C: Human Impacts on Earth Systems
♣ Human activities in agriculture, industry, and everyday life have had major effects on the land, vegetation, streams, ocean, air, and even outer space. But individuals and communities are doing things to help protect Earth's resources and environments. (5-ESS3-1)

Crosscutting Concepts

Scale, Proportion, and Quantity
♣ Standard units are used to measure and describe physical quantities such as weight, and volume. (5-ESS2-2)

Systems and System Models
♣ A system can be described in terms of its components and their interactions. (5-ESS2-1),(5-ESS3-1)

Connections to Nature of Science

Science Addresses Questions About the Natural and Material World
♣ Science findings are limited to questions that can be answered with empirical evidence. (5-ESS3-1)

Connections to other DCIs in fifth grade: N/A

Articulation of DCIs across grade-bands: **2.ESS2.A** (5-ESS2-1); **2.ESS2.C** (5-ESS2-2); **3.ESS2.D** (5-ESS2-1); **4.ESS2.A** (5-ESS2-1); **MS.ESS2.A** (5-ESS2-1); **MS.ESS2.C** (5-ESS2-1),(5-ESS2-2); **MS.ESS2.D** (5-ESS2-1); **MS.ESS3.A** (5-ESS2-2),(5-ESS3-1); **MS.ESS3.C** (5-ESS3-1); **MS.ESS3.D** (5-ESS3-1)

Common Core State Standards Connections:

ELA/Literacy –

RI.5.1 Quote accurately from a text when explaining what the text says explicitly and when drawing inferences from the text. *(5-ESS3-1)*

RI.5.7 Draw on information from multiple print or digital sources, demonstrating the ability to locate an answer to a question quickly or to solve a problem efficiently. *(5-ESS2-1),(5-ESS2-2),*(5-ESS3-1)

RI.5.9 Integrate information from several texts on the same topic in order to write or speak about the subject knowledgeably. (5-ESS3-1)

W.5.8 Recall relevant information from experiences or gather relevant information from print and digital sources; summarize or paraphrase information in notes and finished work, and provide a list of sources. (*5-ESS2-2),*(5-ESS3-1)

W.5.9 Draw evidence from literary or informational texts to support analysis, reflection, and research. *(5-ESS3-1)*

SL.5.5 Include multimedia components (e.g., graphics, sound) and visual displays in presentations when appropriate to enhance the development of main ideas or themes. *(5-ESS2-1),(5-ESS2-2)*

Mathematics –

MP.2 Reason abstractly and quantitatively. *(5-ESS2-1),*(5-ESS2-2),*(5-ESS3-1)*

MP.4 Model with mathematics. *(5-ESS2-1),*(5-ESS2-2),*(5-ESS3-1)*

5.G.2 Represent real world and mathematical problems by graphing points in the first quadrant of the coordinate plane, and interpret coordinate values of points in the context of the situation. *(5-ESS2-1)*

*The performance expectations marked with an asterisk integrate traditional science content with engineering through a Practice or Disciplinary Core Idea.

5.Space Systems: Stars and the Solar System

5.Space Systems: Stars and the Solar System

Students who demonstrate understanding can:

5-PS2-1. Support an argument that the gravitational force exerted by Earth on objects is directed down. [Clarification Statement: "Down" is a local description of the direction that points toward the center of the spherical Earth.] [Assessment Boundary: Assessment does not include mathematical representation of gravitational force.]

5-ESS1-1. Support an argument that the apparent brightness of the sun and stars is due to their relative distances from Earth. [Assessment Boundary: Assessment is limited to relative distances, not sizes, of stars. Assessment does not include other factors that affect apparent brightness (such as stellar masses, age, stage).]

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. [Clarification Statement: Examples of patterns could include the position and motion of Earth with respect to the sun and selected stars that are visible only in particular months.] [Assessment Boundary: Assessment does not include causes of seasons.]

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*:

Science and Engineering Practices

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 graphical displays (bar graphs, pictographs and/or pie charts) to reveal patterns that indicate relationships. (5-ESS1-2)

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).

- ♣ Support an argument with evidence, data, or a model. (5-PS2-1),(5-ESS1-1)

Disciplinary Core Ideas

PS2.B: Types of Interactions

- ♣ The gravitational force of Earth acting on an object near Earth's surface pulls that object toward the planet's center. (5-PS2-1)

ESS1.A: 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. (5-ESS1-1)

ESS1.B: Earth and the Solar System

- ♣ 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. (5-ESS1-2)

Crosscutting Concepts

Patterns

- ♣ Similarities and differences in patterns can be used to sort, classify, communicate and analyze simple rates of change for natural phenomena. (5-ESS1-2)

Cause and Effect

♣ Cause and effect relationships are routinely identified and used to explain change. (5-PS2-1)

Scale, Proportion, and Quantity

- ♣ Natural objects exist from the very small to the immensely large. (5-ESS1-1)

Connections to other DCIs in fifth grade: N/A

Articulation of DCIs across grade-bands: **1.ESS1.A** (5-ESS1-2); **1.ESS1.B** (5-ESS1-2); **3.PS2.A** (5-PS2-1),(5-ESS1-2); **3.PS2.B** (5-PS2-1); **MS.PS2.B** (5-PS2-1)**; MS.ESS1.A** (5-ESS1-1),(5-ESS1-2)**; MS.ESS1.B** (5-PS2-1),(5-ESS1-1),(5-ESS1-2); **MS.ESS2.C** (5-PS2-1)

Common Core State Standards Connections:

ELA/Literacy –

RI.5.1 Quote accurately from a text when explaining what the text says explicitly and when drawing inferences from the text. *(5-PS2-1),(5-ESS1-1)*

RI.5.7 Draw on information from multiple print or digital sources, demonstrating the ability to locate an answer to a question quickly or to solve a problem efficiently. *(5-ESS1-1)* **RI.5.8** Explain how an author uses reasons and evidence to support particular points in a text, identifying which reasons and evidence support which point(s). *(5-ESS1-1)* **RI.5.9** Integrate information from several texts on the same topic in order to write or speak about the subject knowledgeably. (5-PS2-1),(5-ESS1-1)

W.5.1 Write opinion pieces on topics or texts, supporting a point of view with reasons and information. (5-PS2-1),(5-ESS1-1)

SL.5.5 Include multimedia components (e.g., graphics, sound) and visual displays in presentations when appropriate to enhance the development of main ideas or themes. *(5-ESS1-2)*

Mathematics –

MP.2 Reason abstractly and quantitatively. *(5-ESS1-1),*(5-ESS1-2) **MP.4** Model with mathematics. *(5-ESS1-1),*(5-ESS1-2)

5.NBT.A.1 Explain patterns in the number of zeros of the product when multiplying a number by powers of 10, and explain patterns in the placement of the decimal point when a decimal is multiplied or divided by a power of 10. Use whole-number exponents to denote powers of 10. *(5-ESS1-1)*

5.G.A.2 Represent real world and mathematical problems by graphing points in the first quadrant of the coordinate plane, and interpret coordinate values of points in the context of the situation. (5-ESS1-2)

*The performance expectations marked with an asterisk integrate traditional science content with engineering through a Practice or Disciplinary Core Idea.

3-5.Engineering Design

3-5.Engineering Design

Students who demonstrate understanding can:

3-5-ETS1-1. Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost.

3-5-ETS1-2. Generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem.

3-5-ETS1-3. Plan and carry out fair tests in which variables are controlled and failure points are considered to identify aspects of a model or prototype that can be improved.

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*:

Science and Engineering Practices

Asking Questions and Defining Problems

Asking questions and defining problems in 3–5 builds on grades 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. (3-5-ETS1-1)

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. (3-5-ETS1-3)

Constructing Explanations and Designing Solutions

Constructing explanations and designing solutions 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 problem. (3-5-ETS1-2)

Disciplinary Core Ideas

ETS1.A: 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. (3-5-ETS1-1)

ETS1.B: 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. (3-5-ETS1-2)
- ♣ 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. (3-5-ETS1-2)
- ♣ Tests are often designed to identify failure points or difficulties, which suggest the elements of the design that need to be improved. (3-5-ETS1-3)

ETS1.C: 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. (3-5-ETS1-3)

Crosscutting Concepts

Influence of Science, Engineering, and Technology on Society and the Natural World

- ♣ People's needs and wants change over time, as do their demands for new and improved technologies. (3-5-ETS-1)
- ♣ Engineers improve existing technologies or develop new ones to increase their benefits, decrease known risks, and meet societal demands. (3-5-ETS-2)

Connections to other DCIs in this grade-band:

Connections to 3-5-ETS1.A: Defining and Delimiting Engineering Problems include:

4th Grade: 4-PS3-4

Connections to 3-5-ETS1.B: Designing Solutions to Engineering Problems include:

4th Grade: 4-ESS3-2

Connections to 3-5-ETS1.C: Optimizing the Design Solution include:

4th Grade: 4-PS4-3

Articulation of DCIs across grade-bands: **K-2.ETS1.A** (3-5-ETS1-1),(3-5-ETS1-2),(3-5-ETS1-3); **K-2.ETS1.B** (3-5-ETS1-2); **K-2.ETS1.C** (3-5-ETS1-2),(3-5-ETS1-3); **MS.ETS1.A** (3-5-ETS1-1); **MS.ETS1.B** (3-5-ETS1-1),(3-5-ETS1-2),(3-5-ETS1-3); **MS.ETS1.C** (3-5-ETS1-2),(3-5-ETS1-3)

Common Core State Standards Connections:

ELA/Literacy –

RI.5.1 Quote accurately from a text when explaining what the text says explicitly and when drawing inferences from the text. *(3-5-ETS-2)*

RI.5.7 Draw on information from multiple print or digital sources, demonstrating the ability to locate an answer to a question quickly or to solve a problem efficiently. *(3-5-ETS2)*

RI.5.9 Integrate information from several texts on the same topic in order to write or speak about the subject knowledgeably. (3-5-ETS-2)

W.5.7 Conduct short research projects that use several sources to build knowledge through investigation of different aspects of a topic. (3-5-ETS1-1),(3-5-ETS1-3)

W.5.8 Recall relevant information from experiences or gather relevant information from print and digital sources; summarize or paraphrase information in notes and finished work, and provide a list of sources. *(3-5-ETS1-1),(3-5-ETS1-3)*

W.5.9 Draw evidence from literary or informational texts to support analysis, reflection, and research. *(3-5-ETS1-1),(3-5-ETS1-3)*

Mathematics –

MP.2 Reason abstractly and quantitatively. *(3-5-ETS1-1),(3-5-ETS1-2),(3-5-ETS1-3)*

MP.4 Model with mathematics. *(3-5-ETS1-1),(3-5-ETS1-2),(3-5-ETS1-3)*

MP.5 Use appropriate tools strategically. *(3-5-ETS1-1),(3-5-ETS1-2),(3-5-ETS1-3)*

3-5.OA Operations and Algebraic Thinking *(3-5-ETS1-1),(3-5-ETS1-2)*

Middle School Physical Science

Students in middle school continue to develop understanding of four core ideas in the physical sciences. The middle school performance expectations in the Physical Sciences build on the K – 5 ideas and capabilities to allow learners to explain phenomena central to the physical sciences but also to the life sciences and earth and space science. The performance expectations in physical science blend the core ideas with scientific and engineering practices and crosscutting concepts to support students in developing useable knowledge to explain real world phenomena in the physical, biological, and earth and space sciences. In the physical sciences, performance expectations at the middle school level focus on students developing understanding of several scientific practices. These include developing and using models, planning and conducting investigations, analyzing and interpreting data, using mathematical and computational thinking, and constructing explanations; and to use these practices to demonstrate understanding of the core ideas. Students are also expected to demonstrate understanding of several of engineering practices including design and evaluation.

The performance expectations in the topic **Structure and Properties of Matter** help students to formulate an answer to the questions: "How can particles combine to produce a substance with different properties? How does thermal energy affect particles?" by building understanding of what occurs at the atomic and molecular scale. By the end of middle school, students will be able to apply understanding that pure substances have characteristic properties and are made from a single type of atom or molecule. They will be able to provide molecular level accounts to explain states of matters and changes between states. The crosscutting concepts of cause and effect; scale, proportion and quantity; structure and function; interdependence of science, engineering, and technology; and influence of science, engineering and technology on society and the natural world are called out as organizing concepts for these disciplinary core ideas. In these performance expectations, students are expected to demonstrate proficiency in developing and using models, and obtaining, evaluating, and communicating information. Students use these scientific and engineering practices to demonstrate understanding of the core ideas.

The performance expectations in the topic **Chemical Reactions** help students to formulate an answer to the questions: "What happens when new materials are formed? What stays the same and what changes?" by building understanding of what occurs at the atomic and molecular scale during chemical reactions. By the end of middle school, students will be able to provide molecular level accounts to explain that chemical reactions involve regrouping of atoms to form new substances, and that atoms rearrange during chemical reactions. Students are also able to apply an understanding of the design and the process of optimization in engineering to chemical reaction systems. The crosscutting concepts of patterns and energy and matter are called out as organizing concepts for these disciplinary core ideas. In these performance expectations, students are expected to demonstrate proficiency in developing and using models, analyzing and interpreting data, and designing solutions. Students use these scientific and engineering practices to demonstrate understanding of the core ideas.

The performance expectations in the topic **Forces and Interactions** focus on helping students understand ideas related to why some objects will keep moving, why objects fall to the ground and why some materials are attracted to each other while others are not. Students answer the question, "How can one describe physical interactions between objects and within systems of objects?" At the middle school level, the PS2 Disciplinary Core Idea from the *NRC Framework* is broken down into two sub-ideas: Forces and Motion and Types of interactions. By the end of middle school, students will be able to apply Newton's Third Law of Motion to relate forces to explain the motion of objects. Students also apply ideas about gravitational, electrical, and magnetic forces to explain a variety of phenomena including beginning ideas about why some materials attract each other while other repel. In particular, students will develop understanding that gravitational interactions are always attractive but that electrical and magnetic forces can be both attractive and negative. Students also develop ideas that objects can exert forces on each other even though the objects are not in contact, through fields. Students are also able to apply an engineering practice and concept to solve a problem caused when objects collide. The crosscutting concepts of cause and effect; system and system models; stability and change; and the influence of science, engineering, and technology on society and the natural world serve as organizing concepts for these disciplinary core ideas. In these performance expectations, students are expected to demonstrate proficiency in asking questions, planning and carrying out investigations, and designing solutions, and engaging in argument; and to use these practices to demonstrate understanding of the core ideas.

The performance expectations in the topic **Energy** help students formulate an answer to the question, "How can energy be transferred from one object or system to another?" At the middle school level, the PS3 Disciplinary Core Idea from the *NRC Framework* is broken down into four sub-core ideas: Definitions of Energy, Conservation of Energy and Energy Transfer, the Relationship between Energy and Forces, and Energy in Chemical Process and Everyday Life. Students develop their understanding of important qualitative ideas about energy including that the interactions of objects can be explained and predicted using the concept of transfer of energy from one object or system of objects to another, and that that the total change of energy in any system is always equal to the total energy transferred into or out of the system. Students understand that objects that are moving have kinetic energy and that objects may also contain stored (potential) energy, depending on their relative positions in a field. Students will also come to know the difference between energy and temperature, and begin to develop an understanding of the relationship between force and energy. Students are also able to apply an understanding of design to the process of energy transfer. The crosscutting concepts of scale, proportion, and quantity; systems and system models; and energy are called out as organizing concepts for these disciplinary core ideas. These performance expectations expect students to demonstrate proficiency in developing and using models, planning investigations, analyzing and interpreting data, and designing solutions, and engaging in argument from evidence; and to use these practices to demonstrate understanding of the core ideas in PS3.

The performance expectations in the topic **Waves and Electromagnetic Radiation** help students formulate an answer to the question, "What are the characteristic properties of waves and how can they be used?" At the middle school level, the PS4 Disciplinary Core Idea from the *NRC Framework* is broken down into Wave Properties, Electromagnetic Radiation, and Information Technologies and Instrumentation. Students are able to describe and predict characteristic properties and behaviors of waves when the waves interact with matter. Students can apply an understanding of waves as a means to send digital information. The crosscutting concepts of patterns and structure and function are used as organizing concepts for these disciplinary core ideas. These performance expectations focus on students demonstrating proficiency in developing and using models, using mathematical thinking, and obtaining, evaluating and communicating information; and to use these practices to demonstrate understanding of the core ideas.

Middle School Life Sciences

Students in middle school develop understanding of key concepts to help them make sense of the life sciences. These ideas build upon students' science understanding from earlier grades and from the disciplinary core ideas, science and engineering practices, and crosscutting concepts of other experiences with physical and earth sciences. There are five life science topics in middle school: *1) Structure, Function, and Information Processing, 2) Growth, Development, and Reproduction of Organisms, 3) Matter and Energy in Organisms and Ecosystems, 4) Interdependent Relationships in Ecosystems, and 5) Natural Selection and Adaptations.* The performance expectations in middle school blend core ideas with scientific and engineering practices and crosscutting concepts to support students in developing useable knowledge across the science disciplines. While the performance expectations in middle school life science couple particular practices with specific disciplinary core ideas, instructional decisions should include use of many science and engineering practices integrated in the performance expectations. The concepts and practices in the performance expectations are based on the grade-band endpoints described in *A Framework for K-12 Science Education* (NRC, 2012).

The Performance Expectations in ***Structure, Function, and Information Processing*** help students formulate an answer to the question, "How do the structures of organisms contribute to life's functions?" Middle school students can plan and carry out investigations to develop evidence that living organisms are made of cells and to determine the relationship of organisms to the environment. Students can use understanding of cell theory to develop physical and conceptual models of cells. They can construct explanations for the interactions of systems in cells and organisms and how organisms gather and use information from the environment. By the end of their studies, students understand that all organisms are made of cells, that special structures are responsible for particular functions in organisms, and that for many organisms the body is a system of multiple interacting subsystems that form a hierarchy from cells to the body. Crosscutting concepts of cause and effect, structure and function, and matter and energy are called out as organizing concepts for these core ideas.

The Performance Expectations in ***Growth, Development, and Reproduction of Organisms*** help students formulate an answer to the question, "How do organisms grow, develop, and reproduce?" Students understand how the environment and genetic factors determine the growth of an individual organism. They also demonstrate understanding of the genetic implications for sexual and asexual reproduction. Students can develop evidence to support their understanding of the structures and behaviors that increase the likelihood of successful reproduction by organisms. They have a beginning understanding of the ways humans can select for specific traits, the role of technology, genetic modification, and the nature of ethical responsibilities related to selective breeding. At the end of middle school, students can explain how selected structures, functions, and behaviors of organisms change in predictable ways as they progress from birth to old age. Students can use the practices of analyzing and interpreting data, using models, conducting investigations and communicating information. Crosscutting concepts of structure and function, change and stability, and matter and energy flow in organisms support understanding across this topic.

The Performance Expectations in ***Matter and Energy in Organisms and Ecosystems*** help students formulate answers to the questions: "How do organisms obtain and use matter and energy? How do matter and energy move through an ecosystem?" Middle school students can use conceptual and physical models to explain the transfer of energy and cycling of matter as they construct explanations for the role of photosynthesis in cycling matter in ecosystems. They can construct explanations for the cycling of matter in organisms and the interactions of organisms to obtain the matter and energy from the ecosystem to survive and grow. Students have a grade-appropriate understanding and use of the practices of investigations, constructing arguments based on evidence, and oral and written communication. They understand that sustaining life requires substantial energy and matter inputs and the structure and functions of organisms contribute to the capture, transformation, transport, release, and elimination of matter and energy. Adding to these crosscutting concepts is a deeper understanding of systems and system models that ties the performances expectations in this topic together.

The Performance Expectations in ***Interdependent Relationships in Ecosystems*** help students formulate an answer to the question, "How do organisms interact with other organisms in the physical environment to obtain matter and energy? To answer the question, middle school students construct explanations for the interactions in ecosystems and the scientific, economic, political, and social justifications used in making decisions about maintaining biodiversity in ecosystems. Students can use models, construct evidence-based explanations, and use argumentation from evidence. Students understand that organisms and populations of organisms are dependent on their environmental interactions both with other organisms and with nonliving factors. They also understand the limits of resources influence the growth of organisms and populations, which may result in competition for those limited resources. Crosscutting concepts of matter and energy, systems and system models, and cause and effect are used by students to support understanding the phenomena they study.

The Performance Expectations in ***Natural Selection and Adaptations*** help students formulate answers to the questions: "How does genetic variation among organisms in a species affect survival and reproduction? How does the environment influence genetic traits in populations over multiple generations?" Middle school students can analyze data from the fossil record to describe evidence of the history of life on Earth and can construct explanations for similarities in organisms. They have a beginning understanding of the role of variation in natural selection and how this leads to speciation. They have a grade-appropriate understanding and use of the practices of analyzing graphical displays; using mathematical models; and gathering, reading, and communicating information. The crosscutting concept of cause and effect is central to this topic.

Middle School Earth and Space Sciences

Students in middle school develop understanding of a wide range of topics in Earth and space science (ESS) that build upon science concepts from elementary school through more advanced content, practice, and crosscutting themes. There are six ESS standard topics in middle school: *Space Systems*, *History of Earth*, *Earth's Interior Systems*, *Earth's Surface Systems*, *Weather and Climate*, and *Human Impacts*. The content of the performance expectations are based on current community-based geoscience literacy efforts such as the Earth Science Literacy Principles (Wysession et al., 2012), and is presented with a greater emphasis on an Earth Systems Science approach. The performance expectations strongly reflect the many societally relevant aspects of ESS (resources, hazards, environmental impacts) as well as related connections to engineering and technology.

Space Systems: Middle school students can examine the Earth's place in relation to the solar system, Milky Way galaxy, and universe. There is a strong emphasis on a systems approach, using models of the solar *system* to explain astronomical and other observations of the cyclic patterns of eclipses, tides, and seasons. There is also a strong connection to engineering through the instruments and technologies that have allowed us to explore the objects in our solar system and obtain the data that support the theories that explain the formation and evolution of the universe.

History of Earth: Students can examine geoscience data in order to understand the processes and events in Earth's history. Important concepts in this topic are "Scale, Proportion, and Quantity" and "Stability and Change," in relation to the different ways geologic processes operate over the long expanse of geologic time. An important aspect of the history of Earth is that geologic events and conditions have affected the evolution of life, but different life forms have also played important roles in altering Earth's systems.

Earth's Systems: Students understand how Earth's geosystems operate by modeling the flow of energy and cycling of matter within and among different systems. Students can investigate the controlling properties of important materials and construct explanations based on the analysis of real geoscience data. Of special importance in both topics are the ways that geoscience processes provide resources needed by society but also cause natural hazards that present risks to society; both involve technological challenges, for the identification and development of resources and for the mitigation of hazards.

Weather and Climate: Students can analyze data, including maps, and construct and use models to develop understanding of the factors that control weather and climate. A systems approach is also important here, examining the feedbacks between systems as energy from the sun is transferred between systems and circulates though the ocean and atmosphere.

Human Impacts: Students understand the ways that human activities impacts Earth's other systems. Students can use many different practices to understand the significant and complex issues surrounding human uses of land, energy, mineral, and water resources and the resulting impacts of their development.

MS.Structure and Properties of Matter

MS.Structure and Properties of Matter

Students who demonstrate understanding can:

MS-PS1-1. Develop models to describe the atomic composition of simple molecules and extended structures. [Clarification Statement: Emphasis is on developing models of molecules that vary in complexity. Examples of simple molecules could include ammonia and methanol. Examples of extended structures could include sodium chloride or diamonds. Examples of molecular-level models could include drawings, 3D ball and stick structures or computer representations showing different molecules with different types of atoms.] [Assessment Boundary: Assessment does not include valence electrons and bonding energy, discussing the ionic nature of subunits of complex structures, or a complete depiction of all individual atoms in a complex molecule or extended structure.]

MS-PS1-3. Gather and make sense of information to describe that synthetic materials come from natural resources and impact society. [Clarification Statement: Emphasis is on natural resources that undergo a chemical process to form the synthetic material. Examples of new materials could include new medicine, foods, and alternative fuels.] [Assessment Boundary: Assessment is limited to qualitative information.]

MS-PS1-4. Develop a model that predicts and describes changes in particle motion, temperature, and state of a pure substance when thermal energy is added or removed. [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 and diagrams. Examples of particles could include molecules or inert atoms. Examples of pure substances could include water, carbon dioxide, and helium.]

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*:

Science and Engineering Practices

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 a model to predict and/or describe phenomena. (MS-PS1-1),(MS-PS1-4)

Obtaining, Evaluating, and Communicating Information
Obtaining, evaluating, and communicating information in 6–8 builds on K–5 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. (MS-PS1-3)

Connections to Nature of Science

Science Models, Laws, Mechanisms, and Theories Explain Natural Phenomena
♣ Laws are regularities or mathematical descriptions of natural phenomena. (MS-PS1-5)

Disciplinary Core Ideas

PS1.A: 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-PS1-1)
♣ Each pure substance has characteristic physical and chemical properties (for any bulk quantity under given conditions) that can be used to identify it. (MS-PS1-3) *(Note: This Disciplinary Core Idea is also addressed by MS-PS1-2.)*
♣ Gases and liquids are made of molecules or inert atoms that are moving about relative to each other. (MS-PS1-4)
♣ In a liquid, the molecules are constantly 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-PS1-4)
♣ Solids may be formed from molecules, or they may be extended structures with repeating subunits (e.g., crystals). (MS-PS1-1)
♣ The changes of state that occur with variations in temperature or pressure can be described and predicted using these models of matter. (MS-PS1-4)

PS1.B: 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-PS1-3) *(Note: This Disciplinary Core Idea is also addressed by MS-PS1-2 and MS-PS1-5.)*

PS3.A: Definitions of Energy
♣ The term "heat" as used in everyday language refers both to thermal motion (the motion of atoms or molecules within a substance) and radiation (particularly infrared and light). In science, heat is used only for this second meaning; it refers to energy transferred when two objects or systems are at different temperatures. *(secondary to MS-PS1-4)*
♣ The relationship between the temperature and the total energy of a system depends on the types, states, and amounts of matter present. *(secondary to MS-PS1-4)*

Crosscutting Concepts

Cause and Effect
♣ Cause and effect relationships may be used to predict phenomena in natural or designed systems. (MS-PS1-4)

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. (MS-PS1-1)

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. (MS-PS1-3)

Connections to Engineering, Technology, and Applications of Science

Interdependence of Science, Engineering, and Technology
♣ Engineering advances have led to important discoveries in virtually every field of science, and scientific discoveries have led to the development of entire industries and engineered systems. (MS-PS1-3)

Influence of Science, Engineering and Technology on Society and the Natural World
♣ The uses of technologies and any limitations on their use are driven by individual or societal needs, desires, and values; by the findings of scientific research; and by differences in such factors as climate, natural resources, and economic conditions. Thus technology use varies from region to region and over time. (MS-PS1-3)

Connections to other DCIs in this grade-band: **MS.LS2.A** (MS-PS1-3); **MS.LS4.D** (MS-PS1-3); **MS.ESS2.C** (MS-PS1-1),(MS-PS1-4); **MS.ESS3.A** (MS-PS1-3); **MS.ESS3.C** (MS-PS1-3)

Articulation across grade-bands: **5.PS1.A** (MS-PS1-1); **HS.PS1.A** (MS-PS1-1),(MS-PS1-3),(MS-PS1-4); **HS.PS1.B** (MS-PS1-4); **HS.PS3.A** (MS-PS1-4); **HS.LS2.A** (MS-PS1-3); **HS.LS4.D** (MS-PS1-3); **HS.ESS1.A** (MS-PS1-1); **HS.ESS3.A** (MS-PS1-3)

Common Core State Standards Connections:

ELA/Literacy –

RST.6-8.1 Cite specific textual evidence to support analysis of science and technical texts, attending to the precise details of explanations or descriptions (MS-PS1-3)

RST.6-8.7 Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually (e.g., in a flowchart, diagram, model, graph, or table). *(MS-PS1-1),(MS-PS1-4)*

WHST.6-8.8 Gather relevant information from multiple print and digital sources, using search terms effectively; assess the credibility and accuracy of each source; and quote or paraphrase the data and conclusions of others while avoiding plagiarism and following a standard format for citation. (MS-PS1-3)

Mathematics –

MP.2 Reason abstractly and quantitatively. (MS-PS1-1)

MP.4 Model with mathematics. (MS-PS1-1)

6.RP.A.3 Use ratio and rate reasoning to solve real-world and mathematical problems. *(MS-PS1-1)*

6.NS.C.5 Understand that positive and negative numbers are used together to describe quantities having opposite directions or values (e.g., temperature above/below zero, elevation above/below sea level, credits/debits, positive/negative electric charge); use positive and negative numbers to represent quantities in real-world

*The performance expectations marked with an asterisk integrate traditional science content with engineering through a Practice or Disciplinary Core Idea.

contexts, explaining the meaning of 0 in each situation. (MS-PS1-4)

8.EE.A.3 Use numbers expressed in the form of a single digit times an integer power of 10 to estimate very large or very small quantities, and to express how many times as much one is than the other. *(MS-PS1-1)*

*The performance expectations marked with an asterisk integrate traditional science content with engineering through a Practice or Disciplinary Core Idea.

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MS.Chemical Reactions

MS.Chemical Reactions

Students who demonstrate understanding can:

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. [Clarification Statement: Examples of reactions could include burning sugar or steel wool, fat reacting with sodium hydroxide, and mixing zinc with HCl.] [Assessment Boundary: Assessment is limited to analysis of the following properties: density, melting point, boiling point, solubility, flammability, and odor.]

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. [Clarification Statement: Emphasis is on law of conservation of matter, and on physical models or drawings, including digital forms, that represent atoms.] [Assessment Boundary: Assessment does not include the use of atomic masses, balancing symbolic equations, or intermolecular forces.]

MS-PS1-6. Undertake a design project to construct, test, and modify a device that either releases or absorbs thermal energy by chemical processes.* [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 or calcium chloride.] [Assessment Boundary: Assessment is limited to the criteria of amount, time, and temperature of substance in testing the device.]

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*:

Science and Engineering Practices

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 a model to describe unobservable mechanisms. (MS-PS1-5)

Analyzing and Interpreting Data
Analyzing data in 6–8 builds on K–5 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. (MS-PS1-2)

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 knowledge, 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. (MS-PS1-6)

Connections to Nature of Science

Scientific Knowledge is Based on Empirical Evidence
♣ Science knowledge is based upon logical and conceptual connections between evidence and explanations. (MS-PS1-2)

Science Models, Laws, Mechanisms, and Theories Explain Natural Phenomena
♣ Laws are regularities or mathematical descriptions of natural phenomena. (MS-PS1-5)

Disciplinary Core Ideas

PS1.A: Structure and Properties of Matter
♣ Each pure substance has characteristic physical and chemical properties (for any bulk quantity under given conditions) that can be used to identify it. (MS-PS1-2) *(Note: This Disciplinary Core Idea is also addressed by MS-PS1-3.)*

PS1.B: 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-PS1-2),(MS-PS1-5) *(Note: This Disciplinary Core Idea is also addressed by MS-PS1-3.)*
♣ The total number of each type of atom is conserved, and thus the mass does not change. (MS-PS1-5)
♣ Some chemical reactions release energy, others store energy. (MS-PS1-6)

ETS1.B: Developing Possible Solutions
♣ A solution needs to be tested, and then modified on the basis of the test results, in order to improve it. *(secondary to MS-PS1-6)*

ETS1.C: Optimizing the Design Solution
♣ Although one design may not perform the best across all tests, identifying the characteristics of the design that performed the best in each test can provide useful information for the redesign process—that is, some of the characteristics may be incorporated into the new design. *(secondary to MS-PS1-6)*
♣ The iterative process of testing the most promising solutions and modifying what is proposed on the basis of the test results leads to greater refinement and ultimately to an optimal solution. *(secondary to MS-PS1-6)*

Crosscutting Concepts

Patterns
♣ Macroscopic patterns are related to the nature of microscopic and atomic-level structure. (MS-PS1-2)

Energy and Matter
♣ Matter is conserved because atoms are conserved in physical and chemical processes. (MS-PS1-5)
♣ The transfer of energy can be tracked as energy flows through a designed or natural system. (MS-PS1-6)

Connections to other DCIs in this grade-band: **MS.PS3.D** (MS-PS1-2),(MS-PS1-6); **MS.LS1.C** (MS-PS1-2),(MS-PS1-5); **MS.LS2.B** (MS-PS1-5); **MS.ESS2.A** (MS-PS1-2),(MS-PS1-5)

Articulation across grade-bands: **5.PS1.B** (MS-PS1-2),(MS-PS1-5); **HS.PS1.A** (MS-PS1-6); **HS.PS1.B** (MS-PS1-2)(MS-PS1-5),(MS-PS1-6); **HS.PS3.A** (MS-PS1-6); **HS.PS3.B** (MS-PS1-6); **HS.PS3.D** (MS-PS1-6)

Common Core State Standards Connections:

ELA/Literacy –

RST.6-8.1 Cite specific textual evidence to support analysis of science and technical texts, attending to the precise details of explanations or descriptions *(MS-PS1-2)*

RST.6-8.3 Follow precisely a multistep procedure when carrying out experiments, taking measurements, or performing technical tasks. (MS-PS1-6)

RST.6-8.7 Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually (e.g., in a flowchart, diagram, model, graph, or table). (MS-PS1-2),*(MS-PS1-5)*

WHST.6-8.7 Conduct short research projects to answer a question (including a self-generated question), drawing on several sources and generating additional related, focused questions that allow for multiple avenues of exploration. (MS-PS1-6)

Mathematics –

MP.2 Reason abstractly and quantitatively. (MS-PS1-2), (MS-PS1-5)

MP.4 Model with mathematics. (MS-PS1-5)

6.RP.A.3 Use ratio and rate reasoning to solve real-world and mathematical problems. *(MS-PS1-2),*(MS-PS1-5)

6.SP.B.4 Display numerical data in plots on a number line, including dot plots, histograms, and box plots. *(MS-PS1-2)*

6.SP.B.5 Summarize numerical data sets in relation to their context (MS-PS1-2)

*The performance expectations marked with an asterisk integrate traditional science content with engineering through a Practice or Disciplinary Core Idea.

MS.Forces and Interactions

MS.Forces and Interactions

Students who demonstrate understanding can:

MS-PS2-1. Apply Newton's Third Law to design a solution to a problem involving the motion of two colliding objects.* [Clarification Statement: Examples of practical problems could include the impact of collisions between two cars, between a car and stationary objects, and between a meteor and a space vehicle.] [Assessment Boundary: Assessment is limited to vertical or horizontal interactions in one dimension.]

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. [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), frame of reference, and specification of units.] [Assessment Boundary: Assessment is limited to forces and changes in motion in one-dimension in an inertial reference frame, and to change in one variable at a time. Assessment does not include the use of trigonometry.]

MS-PS2-3. Ask questions about data to determine the factors that affect the strength of electric and magnetic forces. [Clarification Statement: Examples of devices that use electric and magnetic forces could include electromagnets, electric motors, or generators. 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.] [Assessment Boundary: Assessment about questions that require quantitative answers is limited to proportional reasoning and algebraic thinking.]

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. [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, and orbital periods of objects within the solar system.] [Assessment Boundary: Assessment does not include Newton's Law of Gravitation or Kepler's Laws.]

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. [Clarification Statement: Examples of this phenomenon could include the interactions of magnets, electrically-charged strips of tape, and electrically-charged pith balls. Examples of investigations could include first-hand experiences or simulations.] [Assessment Boundary: Assessment is limited to electric and magnetic fields. Assessment is limited to qualitative evidence for the existence of fields.]

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*:

Science and Engineering Practices

Asking Questions and Defining Problems

Asking questions and defining problems in grades 6–8 builds from grades K–5 experiences and progresses to specifying relationships between variables, and clarifying arguments and 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. (MS-PS2-3)

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 design 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. (MS-PS2-2)

♣ Conduct an investigation and evaluate the experimental design to produce data to serve as the basis for evidence that can meet the goals of the investigation. (MS-PS2-5)

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 an object, tool, process or system. (MS-PS2-1)

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.

♣ Construct and present oral and written arguments 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. (MS-PS2-4)

Connections to Nature of Science

Scientific Knowledge is Based on Empirical Evidence

♣ Science knowledge is based upon logical and conceptual connections between evidence and explanations. (MS-PS2-2),(MS-PS2-4)

Disciplinary Core Ideas

PS2.A: 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-PS2-1)

♣ 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. (MS-PS2-2)

♣ 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-PS2-2)

PS2.B: Types of Interactions

♣ Electric and magnetic (electromagnetic) forces can be attractive or repulsive, and their sizes depend on the magnitudes of the charges, currents, or magnetic strengths involved and on the distances between the interacting objects. (MS-PS2-3)

♣ 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-PS2-4)

♣ Forces that act at a distance (electric and magnetic) can be explained by fields that extend through space and can be mapped by their effect on a test object (a ball, a charged object, or a magnet, respectively). (MS-PS2-5)

Crosscutting Concepts

Cause and Effect

♣ Cause and effect relationships may be used to predict phenomena in natural or designed systems. (MS-PS2-3),(MS-PS2-5)

Systems and System Models

♣ Models can be used to represent systems and their interactions—such as inputs, processes and outputs—and energy and matter flows within systems. (MS-PS2-1),(MS-PS2-4),

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. (MS-PS2-2)

Connections to Engineering, Technology and Applications of Science

Influence of Science, Engineering, and Technology on Society and the Natural World

♣ The uses of technologies and any limitations on their use are driven by individual or societal needs, desires, and values; by the findings of scientific research; and by differences in such factors as climate, natural resources, and economic conditions. (MS-PS2-1)

Connections to other DCIs in this grade-band: **MS.PS3.A** (MS-PS2-2); **MS.PS3.B** (MS-PS2-2); **MS.PS3.C** (MS-PS2-1); **MS.ESS1.A** (MS-PS2-4); **MS.ESS1.B** (MS-PS2-4); **MS.ESS2.C** (MS-PS2-2),(MS-PS2-4)

Articulation across grade-bands: **3.PS2.A** (MS-PS2-1),(MS-PS2-2); **3.PS2.B** (MS-PS2-3),(MS-PS2-5); **5.PS2.B** (MS-PS2-4); **HS.PS2.A** (MS-PS2-1),(MS-PS2-2); **HS.PS2.B** (MS-PS2-

*The performance expectations marked with an asterisk integrate traditional science content with engineering through a Practice or Disciplinary Core Idea.

3),(MS-PS2-4),(MS-PS2-5); **HS.PS3.A** (MS-PS2-5); **HS.PS3.B** (MS-PS2-2),(MS-PS2-5); **HS.PS3.C** (MS-PS2-5); **HS.ESS1.B** (MS-PS2-4)

Common Core State Standards Connections:

ELA/Literacy –

RST.6-8.1 Cite specific textual evidence to support analysis of science and technical texts, attending to the precise details of explanations or descriptions *(MS-PS2-1),(MS-PS2-3)*

RST.6-8.3 Follow precisely a multistep procedure when carrying out experiments, taking measurements, or performing technical tasks. *(MS-PS2-1),*(MS-PS2-2),*(MS-PS2-5)*

WHST.6-8.1 Write arguments focused on *discipline-specific content*. (MS-PS2-4)

WHST.6-8.7 Conduct short research projects to answer a question (including a self-generated question), drawing on several sources and generating additional related, focused questions that allow for multiple avenues of exploration. *(MS-PS2-1),*(MS-PS2-2),*(MS-PS2-5)*

Mathematics –

MP.2 Reason abstractly and quantitatively. (MS-PS2-1),(MS-PS2-2),(MS-PS2-3)

6.NS.C.5 Understand that positive and negative numbers are used together to describe quantities having opposite directions or values; use positive and negative numbers to represent quantities in real-world contexts, explaining the meaning of 0 in each situation. (MS-PS2-1)

6.EE.A.2 Write, read, and evaluate expressions in which letters stand for numbers. *(MS-PS2-1),(MS-PS2-2)*

7.EE.B.3 Solve multi-step real-life and mathematical problems posed with positive and negative rational numbers in any form, using tools strategically. Apply properties of operations to calculate with numbers in any form; convert between forms as appropriate; and assess the reasonableness of answers using mental computation and estimation strategies. *(MS-PS2-1),(MS-PS2-2)*

7.EE.B.4 Use variables to represent quantities in a real-world or mathematical problem, and construct simple equations and inequalities to solve problems by reasoning about the quantities. *(MS-PS2-1),(MS-PS2-2)*

*The performance expectations marked with an asterisk integrate traditional science content with engineering through a Practice or Disciplinary Core Idea.

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MS.Energy

MS.Energy

Students who demonstrate understanding can:

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. [Clarification Statement: Emphasis is on descriptive relationships between kinetic energy and mass separately from kinetic energy and speed. Examples could include riding a bicycle at different speeds, rolling different sizes of rocks downhill, and getting hit by a wiffle ball versus a tennis ball.]

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. [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 of a magnet, and a balloon with static electrical charge being brought closer to a classmate's hair. Examples of models could include representations, diagrams, pictures, and written descriptions of systems.] [Assessment Boundary: Assessment is limited to two objects and electric, magnetic, and gravitational interactions.]

MS-PS3-3. Apply scientific principles to design, construct, and test a device that either minimizes or maximizes thermal energy transfer.* [Clarification Statement: Examples of devices could include an insulated box, a solar cooker, and a Styrofoam cup.] [Assessment Boundary: Assessment does not include calculating the total amount of thermal energy transferred.]

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. [Clarification Statement: 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.] [Assessment Boundary: Assessment does not include calculating the total amount of thermal energy transferred.]

MS-PS3-5. Construct, use, and present arguments to support the claim that when the motion energy of an object changes, energy is transferred to or from the object. [Clarification Statement: Examples of empirical evidence used in arguments could include an inventory or other representation of the energy before and after the transfer in the form of temperature changes or motion of object.] [Assessment Boundary: Assessment does not include calculations of energy.]

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*:

Science and Engineering Practices

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 a model to describe unobservable mechanisms. (MS-PS3-2)

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 design 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. (MS-PS3-4)

Analyzing and Interpreting Data
Analyzing data in 6–8 builds on K–5 and progresses to extending quantitative analysis to investigations, distinguishing between correlation and causation, and basic statistical techniques of data and error analysis.
♣ Construct and interpret graphical displays of data to identify linear and nonlinear relationships. (MS-PS3-1)

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 test a design of an object, tool, process or system. (MS-PS3-3)

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 worlds.
♣ Construct, use, and present oral and written arguments supported by empirical evidence and scientific reasoning to support or refute an explanation or a model for a phenomenon. (MS-PS3-5)

Connections to Nature of Science

Scientific Knowledge is Based on Empirical Evidence
♣ Science knowledge is based upon logical and conceptual connections between evidence and explanations (MS-PS3-4),(MS-PS3-5)

Disciplinary Core Ideas

PS3.A: 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-PS3-1)
♣ A system of objects may also contain stored (potential) energy, depending on their relative positions. (MS-PS3-2)
♣ Temperature is a measure of the average kinetic energy of particles of matter. The relationship between the temperature and the total energy of a system depends on the types, states, and amounts of matter present. (MS-PS3-3),(MS-PS3-4)

PS3.B: Conservation of Energy and Energy Transfer
♣ When the motion energy of an object changes, there is inevitably some other change in energy at the same time. (MS-PS3-5)
♣ 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 size of the sample, and the environment. (MS-PS3-4)
♣ Energy is spontaneously transferred out of hotter regions or objects and into colder ones. (MS-PS3-3)

PS3.C: 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-PS3-2)

ETS1.A: 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. *(secondary to MS-PS3-3)*

ETS1.B: Developing Possible Solutions
♣ A solution needs to be tested, 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 criteria and constraints of a problem. *(secondary to MS-PS3-3)*

Crosscutting Concepts

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. (MS-PS3-1),(MS-PS3-4)

Systems and System Models
♣ Models can be used to represent systems and their interactions – such as inputs, processes, and outputs – and energy and matter flows within systems. (MS-PS3-2)

Energy and Matter
♣ Energy may take different forms (e.g. energy in fields, thermal energy, energy of motion). (MS-PS3-5)
♣ The transfer of energy can be tracked as energy flows through a designed or natural system. (MS-PS3-3)

Connections to other DCIs in this grade-band: **MS.PS1.A** (MS-PS3-4); **MS.PS1.B** (MS-PS3-3); **MS.PS2.A** (MS-PS3-1),(MS-PS3-4),(MS-PS3-4); **MS.ESS2.A** (MS-PS3-3); **MS.ESS2.C** (MS-PS3-3),(MS-PS3-4); **MS.ESS2.D** (MS-PS3-3),(MS-PS3-4)

Articulation across grade-bands: **4.PS3.B** (MS-PS3-1),(MS-PS3-3); **4.PS3.C** (MS-PS3-4),(MS-PS3-5); **HS.PS1.B** (MS-PS3-4); **HS.PS2.B** (MS-PS3-2); **HS.PS3.A** (MS-PS3-1),(MS-PS3-4),(MS-PS3-5); **HS.PS3.B** (MS-PS3-1),(MS-PS3-2),(MS-PS3-3),(MS-PS3-4),(MS-PS3-5); **HS.PS3.C** (MS-PS3-2)

*The performance expectations marked with an asterisk integrate traditional science content with engineering through a Practice or Disciplinary Core Idea.

Common Core State Standards Connections:	
ELA/Literacy –	
RST.6-8.1	Cite specific textual evidence to support analysis of science and technical texts, attending to the precise details of explanations or descriptions *(MS-PS3-1),(MS-PS3-5)*
RST.6-8.3	Follow precisely a multistep procedure when carrying out experiments, taking measurements, or performing technical tasks. *(MS-PS3-3),*(MS-PS3-4)
RST.6-8.7	Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually (e.g., in a flowchart, diagram, model, graph, or table). (MS-PS3-1)
WHST.6-8.1	Write arguments focused on discipline content. *(MS-PS3-5)*
WHST.6-8.7	Conduct short research projects to answer a question (including a self-generated question), drawing on several sources and generating additional related, focused questions that allow for multiple avenues of exploration. (MS-PS3-3)*, (MS-PS3-4)*
SL.8.5	Integrate multimedia and visual displays into presentations to clarify information, strengthen claims and evidence, and add interest. *(MS-PS3-2)*
Mathematics –	
MP.2	Reason abstractly and quantitatively. (MS-PS3-1), (MS-PS3-4),(MS-PS3-5)
6.RP.A.1	Understand the concept of ratio and use ratio language to describe a ratio relationship between two quantities. (MS-PS3-1),*(MS-PS3-5)*
6.RP.A.2	Understand the concept of a unit rate a/b associated with a ratio a:b with b ≠ 0, and use rate language in the context of a ratio relationship. *(MS-PS3-1)*
7.RP.A.2	Recognize and represent proportional relationships between quantities. (MS-PS3-1),*(MS-PS3-5)*
8.EE.A.1	Know and apply the properties of integer exponents to generate equivalent numerical expressions. (MS-PS3-1)
8.EE.A.2	Use square root and cube root symbols to represent solutions to equations of the form x2 = p and x3 = p, where p is a positive rational number. Evaluate square roots of small perfect squares and cube roots of small perfect cubes. Know that √2 is irrational. *(MS-PS3-1)*
8.F.A.3	Interpret the equation y = mx + b as defining a linear function, whose graph is a straight line; give examples of functions that are not linear. (MS-PS3-1),*(MS-PS3-5)*
6.SP.B.5	Summarize numerical data sets in relation to their context. *(MS-PS3-4)*

*The performance expectations marked with an asterisk integrate traditional science content with engineering through a Practice or Disciplinary Core Idea.

MS.Waves and Electromagnetic Radiation

MS.Waves and Electromagnetic Radiation

Students who demonstrate understanding can:

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. [Clarification Statement: Emphasis is on describing waves with both qualitative and quantitative thinking.] [Assessment Boundary: Assessment does not include electromagnetic waves and is limited to standard repeating waves.]

MS-PS4-2. Develop and use a model to describe that waves are reflected, absorbed, or transmitted through various materials. [Clarification Statement: Emphasis is on both light and mechanical waves. Examples of models could include drawings, simulations, and written descriptions.] [Assessment Boundary: Assessment is limited to qualitative applications pertaining to light and mechanical waves.]

MS-PS4-3. Integrate qualitative scientific and technical information to support the claim that digitized signals (sent as wave pulses) are a more reliable way to encode and transmit information. [Clarification Statement: Emphasis is on a basic understanding that waves can be used for communication purposes. Examples could include using fiber optic cable to transmit light pulses, radio wave pulses in wifi devices, and conversion of stored binary patterns to make sound or text on a computer screen.] [Assessment Boundary: Assessment does not include binary counting. Assessment does not include the specific mechanism of any given device.]

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*:

Science and Engineering Practices

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 use a model to describe phenomena. (MS-PS4-2)

Using Mathematics and Computational Thinking
Mathematical and computational thinking at the 6–8 level builds on K–5 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. (MS-PS4-1)

Obtaining, Evaluating, and Communicating Information
Obtaining, evaluating, and communicating information in 6-8 builds on K-5 and progresses to evaluating the merit and validity of ideas and methods.
♣ Integrate qualitative scientific and technical information in written text with that contained in media and visual displays to clarify claims and findings. (MS-PS4-3)

Connections to Nature of Science

Scientific Knowledge is Based on Empirical Evidence
♣ Science knowledge is based upon logical and conceptual connections between evidence and explanations. (MS-PS4-1)

Disciplinary Core Ideas

PS4.A: Wave Properties
♣ A simple wave has a repeating pattern with a specific wavelength, frequency, and amplitude. (MS-PS4-1)
♣ A sound wave needs a medium through which it is transmitted. (MS-PS4-2)

PS4.B: Electromagnetic Radiation
♣ When light shines on an object, it is reflected, absorbed, or transmitted through the object, depending on the object's material and the frequency (color) of the light. (MS-PS4-2)
♣ 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. (MS-PS4-2)
♣ A wave model of light is useful for explaining brightness, color, and the frequency-dependent bending of light at a surface between media. (MS-PS4-2)
♣ However, because light can travel through space, it cannot be a matter wave, like sound or water waves. (MS-PS4-2)

PS4.C: Information Technologies and Instrumentation
♣ Digitized signals (sent as wave pulses) are a more reliable way to encode and transmit information. (MS-PS4-3)

Crosscutting Concepts

Patterns
♣ Graphs and charts can be used to identify patterns in data. (MS-PS4-1)

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. (MS-PS4-2)
♣ Structures can be designed to serve particular functions. (MS-PS4-3)

Connections to Engineering, Technology, and Applications of Science

Influence of Science, Engineering, and Technology on Society and the Natural World
♣ Technologies extend the measurement, exploration, modeling, and computational capacity of scientific investigations. (MS-PS4-3)

Connections to Nature of Science

Science is a Human Endeavor
♣ Advances in technology influence the progress of science and science has influenced advances in technology. (MS-PS4-3)

Connections to other DCIs in this grade-band: **MS.LS1.D** (MS-PS4-2)

Articulation across grade-bands: **4.PS3.A** (MS-PS4-1); **4.PS3.B** (MS-PS4-1); **4.PS4.A** (MS-PS4-1); **4.PS4.B** (MS-PS4-2); **4.PS4.C** (MS-PS4-3); **HS.PS4.A** (MS-PS4-1),(MS-PS4-2),(MS-PS4-3); **HS.PS4.B** (MS-PS4-1),(MS-PS4-2); **HS.PS4.C** (MS-PS4-3)

Common Core State Standards Connections:

ELA/Literacy –

RST.6-8.1 Cite specific textual evidence to support analysis of science and technical texts. (MS-PS4-3)

RST.6-8.2 Determine the central ideas or conclusions of a text; provide an accurate summary of the text distinct from prior knowledge or opinions. *(MS-PS4-3)*

RST.6-8.9 Compare and contrast the information gained from experiments, simulations, video, or multimedia sources with that gained from reading a text on the same topic. (MS-PS4-3)

WHST.6-8.9 Draw evidence from informational texts to support analysis, reflection, and research. (MS-PS4-3)

SL.8.5 Integrate multimedia and visual displays into presentations to clarify information, strengthen claims and evidence, and add interest. *(MS-PS4-1),(MS-PS4-2)*

Mathematics –

MP.2 Reason abstractly and quantitatively. (MS-PS4-1)

MP.4 Model with mathematics. (MS-PS4-1)

6.RP.A.1 Understand the concept of a ratio and use ratio language to describe a ratio relationship between two quantities. (MS-PS4-1)

6.RP.A.3 Use ratio and rate reasoning to solve real-world and mathematical problems. (MS-PS4-1)

7.RP.A.2 Recognize and represent proportional relationships between quantities. (MS-PS4-1)

8.F.A.3 Interpret the equation $y = mx + b$ as defining a linear function, whose graph is a straight line; give examples of functions that are not linear. *(MS-PS4-1)*

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MS.Structure, Function, and Information Processing

MS.Structure, Function, and Information Processing

Students who demonstrate understanding can:

MS-LS1-1. Conduct an investigation to provide evidence that living things are made of cells, either one cell or many different numbers and types of cells. [Clarification Statement: Emphasis is on developing evidence that living things are made of cells, distinguishing between living and non-living cells, and understanding that living things may be made of one cell or many and varied cells.]

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. [Clarification Statement: Emphasis is on the cell functioning as a whole system and the primary role of identified parts of the cell, specifically the nucleus, chloroplasts, mitochondria, cell membrane, and cell wall.] [Assessment Boundary: Assessment of organelle structure/function relationships is limited to the cell wall and cell membrane. Assessment of the function of the other organelles is limited to their relationship to the whole cell. Assessment does not include the biochemical function of cells or cell parts.]

MS-LS1-3. Use argument supported by evidence for how the body is a system of interacting subsystems composed of groups of cells. [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.] [Assessment Boundary: Assessment does not include the mechanism of one body system independent of others. Assessment is limited to the circulatory, excretory, digestive, respiratory, muscular, and nervous systems.]

MS-LS1-8. Gather and synthesize information that sensory receptors respond to stimuli by sending messages to the brain for immediate behavior or storage as memories. [Assessment Boundary: Assessment does not include mechanisms for the transmission of this information.]

Science and Engineering Practices

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. (MS-LS1-2)

Planning and Carrying Out Investigations

Planning and carrying out investigations 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 to produce data to serve as the basis for evidence that meet the goals of an investigation. (MS-LS1-1)

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).

- ♣ Use an oral and written argument supported by evidence to support or refute an explanation or a model for a phenomenon. (MS-LS1-3)

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. (MS-LS1-8)

Disciplinary Core Ideas

LS1.A: Structure and Function

- ♣ All living things are made up of cells, which is the smallest unit that can be said to be alive. An organism may consist of one single cell (unicellular) or many different numbers and types of cells (multicellular). (MS-LS1-1)
- ♣ Within cells, special structures are responsible for particular functions, and the cell membrane forms the boundary that controls what enters and leaves the cell. (MS-LS1-2)
- ♣ 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. (MS-LS1-3)

LS1.D: 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-LS1-8)

Crosscutting Concepts

Cause and Effect

- ♣ Cause and effect relationships may be used to predict phenomena in natural systems. (MS-LS1-8)

Scale, Proportion, and Quantity

- ♣ Phenomena that can be observed at one scale may not be observable at another scale. (MS-LS1-1)

Systems and System Models

- ♣ Systems may interact with other systems; they may have sub-systems and be a part of larger complex systems. (MS-LS1-3)

Structure and Function

- ♣ Complex and microscopic structures and systems can be visualized, modeled, and used to describe how their function depends on the relationships among its parts, therefore complex natural and designed structures/systems can be analyzed to determine how they function. (MS-LS1-2)

Connections to Engineering, Technology, and Applications of Science

Interdependence of Science, Engineering, and Technology

- ♣ Engineering advances have led to important discoveries in virtually every field of science, and scientific discoveries have led to the development of entire industries and engineered systems. (MS-LS1-1)

Connections to Nature of Science

Science is a Human Endeavor

- ♣ Scientists and engineers are guided by habits of mind such as intellectual honesty, tolerance of ambiguity, skepticism, and openness to new ideas. (MS-LS1-3)

Connections to other DCIs in this grade-band: N/A

Articulation to DCIs across grade-bands: **4.LS1.A** (MS-LS1-2); **4.LS1.D** (MS-LS1-8); **HS.LS1.A** (MS-LS1-1),(MS-LS1-2),(MS-LS1-3),(MS-LS1-8)

Common Core State Standards Connections:

ELA/Literacy –

RST.6-8.1 Cite specific textual evidence to support analysis of science and technical texts. (MS-LS1-3)

RI.6.8 Trace and evaluate the argument and specific claims in a text, distinguishing claims that are supported by reasons and evidence from claims that are not. (MS-LS1-3)

WHST.6-8.1 Write arguments focused on discipline content. (MS-LS1-3)

WHST.6-8.7 Conduct short research projects to answer a question (including a self-generated question), drawing on several sources and generating additional related, focused questions that allow for multiple avenues of exploration. (MS-LS1-1)

WHST.6-8.8 Gather relevant information from multiple print and digital sources; assess the credibility of each source; and quote or paraphrase the data and conclusions of others while avoiding plagiarism and providing basic bibliographic information for sources. (MS-LS1-8)

SL.8.5 Integrate multimedia and visual displays into presentations to clarify information, strengthen claims and evidence, and add interest. *(MS-LS1-2)*

Mathematics –

6.EE.C.9 Use variables to represent two quantities in a real-world problem that change in relationship to one another; write an equation to express one quantity, thought of as the dependent variable, in terms of the other quantity, thought of as the independent variable. Analyze the relationship between the dependent and

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independent variables using graphs and tables, and relate these to the equation. *(MS-LS1-1),(MS-LS1-2),(MS-LS1-3)*

*The performance expectations marked with an asterisk integrate traditional science content with engineering through a Practice or Disciplinary Core Idea.

MS.Matter and Energy in Organisms and Ecosystems

MS.Matter and Energy in Organisms and Ecosystems

Students who demonstrate understanding can:

MS-LS1-6. Construct a scientific explanation based on evidence for the role of photosynthesis in the cycling of matter and flow of energy into and out of organisms. [Clarification Statement: Emphasis is on tracing movement of matter and flow of energy.] [Assessment Boundary: Assessment does not include the biochemical mechanisms of photosynthesis.]

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. [Clarification Statement: Emphasis is on describing that molecules are broken apart and put back together and that in this process, energy is released.] [Assessment Boundary: Assessment does not include details of the chemical reactions for photosynthesis or respiration.]

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. [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 and scarce resources.]

MS-LS2-3. Develop a model to describe the cycling of matter and flow of energy among living and nonliving parts of an ecosystem. [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.] [Assessment Boundary: Assessment does not include the use of chemical reactions to describe the processes.]

MS-LS2-4. Construct an argument supported by empirical evidence that changes to physical or biological components of an ecosystem affect populations. [Clarification Statement: Emphasis is on recognizing patterns in data and making warranted inferences about changes in populations, and on evaluating empirical evidence supporting arguments about changes to ecosystems.]

Science and Engineering Practices

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 phenomena. (MS-LS2-3)

♣ Develop a model to describe unobservable mechanisms. (MS-LS1-7)

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. (MS-LS2-1)

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 knowledge, 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. (MS-LS1-6)

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 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. (MS-LS2-4)

Connections to Nature of Science

Scientific Knowledge is Based on Empirical Evidence

♣ Science knowledge is based upon logical connections between evidence and explanations. (MS-LS1-6)

♣ Science disciplines share common rules of obtaining and evaluating empirical evidence. (MS-LS2-4)

Disciplinary Core Ideas

LS1.C: Organization for Matter and Energy Flow in Organisms

♣ Plants, algae (including phytoplankton), and many microorganisms use the energy from light to make sugars (food) from carbon dioxide from the atmosphere and water through the process of photosynthesis, which also releases oxygen. These sugars can be used immediately or stored for growth or later use. (MS-LS1-6)

♣ Within individual organisms, food 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. (MS-LS1-7)

LS2.A: 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-LS2-1)

♣ 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-LS2-1)

♣ Growth of organisms and population increases are limited by access to resources. (MS-LS2-1)

LS2.B: 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. Transfers of matter into and out of the physical environment occur at every level. Decomposers recycle nutrients from dead plant or animal matter back to the soil in terrestrial environments or to the water in aquatic environments. The atoms that make up the organisms in an ecosystem are cycled repeatedly between the living and nonliving parts of the ecosystem. (MS-LS2-3)

LS2.C: 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-LS2-4)

PS3.D: Energy in Chemical Processes and Everyday Life

♣ 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. *(secondary to MS-LS1-6)*

♣ 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. *(secondary to MS-LS1-7)*

Crosscutting Concepts

Cause and Effect

♣ Cause and effect relationships may be used to predict phenomena in natural or designed systems. (MS-LS2-1)

Energy and Matter

♣ Matter is conserved because atoms are conserved in physical and chemical processes. (MS-LS1-7)

♣ Within a natural system, the transfer of energy drives the motion and/or cycling of matter. (MS-LS1-6)

♣ The transfer of energy can be tracked as energy flows through a natural system. (MS-LS2-3)

Stability and Change

♣ Small changes in one part of a system might cause large changes in another part. (MS-LS2-4)

Connections to Nature of Science

Scientific Knowledge Assumes an Order and Consistency in Natural Systems

♣ Science assumes that objects and events in natural systems occur in consistent patterns that are understandable through measurement and observation. (MS-LS2-3)

Connections to other DCIs in this grade-band: **MS.PS1.B** (MS-LS1-6),(MS-LS1-7),(MS-LS2-3); **MS.LS4.C** (MS-LS2-4); **MS.LS4.D** (MS-LS2-4); **MS.ESS2.A** (MS-LS1-6),(MS-LS2-3),(MS-LS2-4); **MS.ESS3.A** (MS-LS2-1),(MS-LS2-4); **MS.ESS3.C** (MS-LS2-1),(MS-LS2-4)

Articulation across grade-bands: **3.LS2.C** (MS-LS2-1),(MS-LS2-4); **3.LS4.D** (MS-LS2-1),(MS-LS2-4); **5.PS3.D** (MS-LS1-6),(MS-LS1-7); **5.LS1.C** (MS-LS1-6),(MS-LS1-7); **5.LS2.A** (MS-LS1-6),(MS-LS2-1),(MS-LS2-3); **5.LS2.B** (MS-LS1-6),(MS-LS1-7),(MS-LS2-3); **HS.PS1.B** (MS-LS1-6),(MS-LS1-7); **HS.PS3.B** (MS-LS2-3); **HS.LS1.C** (MS-LS1-6),(MS-LS1-7),(MS-LS2-

*The performance expectations marked with an asterisk integrate traditional science content with engineering through a Practice or Disciplinary Core Idea.

3); **HS.LS2.A** (MS-LS2-1); **HS.LS2.B** (MS-LS1-6),(MS-LS1-7),(MS-LS2-3); **HS.LS2.C** (MS-LS2-4); **HS.LS4.C** (MS-LS2-1),(MS-LS2-4) ; **HS.LS4.D** (MS-LS2-1),(MS-LS2-4); **HS.ESS2.C** (MS-LS2-3); **HS.ESS2.D** (MS-LS1-6); **HS.ESS2.E** (MS-LS2-4); **HS.ESS3.A** (MS-LS2-1); **HS.ESS3.B** (MS-LS2-4); **HS.ESS3.C** (MS-LS2-4)

Common Core State Standards Connections:

ELA/Literacy –

RST.6-8.1 Cite specific textual evidence to support analysis of science and technical texts. (MS-LS1-6),(MS-LS2-1)

RST.6-8.2 Determine the central ideas or conclusions of a text; provide an accurate summary of the text distinct from prior knowledge or opinions. *(MS-LS1-6)*

RST.6-8.7 Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually (e.g., in a flowchart, diagram, model, graph, or table). (MS-LS2-1)

RI.8.8 Trace and evaluate the argument and specific claims in a text, assessing whether the reasoning is sound and the evidence is relevant and sufficient to support the claims. (MS-LS-4)

WHST.6-8.1 Write arguments to support claims with clear reasons and relevant evidence. (MS-LS2-4)

WHST.6-8.2 Write informative/explanatory texts to examine a topic and convey ideas, concepts, and information through the selection, organization, and analysis of relevant content. (MS-LS1-6)

WHST.6-8.9 Draw evidence from informational texts to support analysis, reflection, and research. (MS-LS1-6),(MS-LS2-4)

SL.8.5 Integrate multimedia and visual displays into presentations to clarify information, strengthen claims and evidence, and add interest. *(MS-LS1-7),(MS-LS2-3)*

Mathematics –

6.EE.C.9 Use variables to represent two quantities in a real-world problem that change in relationship to one another; write an equation to express one quantity, thought of as the dependent variable, in terms of the other quantity, thought of as the independent variable. Analyze the relationship between the dependent and independent variables using graphs and tables, and relate these to the equation. *(MS-LS1-6),(MS-LS2-3)*

*The performance expectations marked with an asterisk integrate traditional science content with engineering through a Practice or Disciplinary Core Idea.

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MS.Interdependent Relationships in Ecosystems

MS.Interdependent Relationships in Ecosystems

Students who demonstrate understanding can:

MS-LS2-2. Construct an explanation that predicts patterns of interactions among organisms across multiple ecosystems. [Clarification Statement: Emphasis is on predicting consistent patterns of interactions in different ecosystems in terms of the relationships among and between organisms and abiotic components of ecosystems. Examples of types of interactions could include competitive, predatory, and mutually beneficial.]

MS-LS2-5. Evaluate competing design solutions for maintaining biodiversity and ecosystem services.* [Clarification Statement: Examples of ecosystem services could include water purification, nutrient recycling, and prevention of soil erosion. Examples of design solution constraints could include scientific, economic, and social considerations.]

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*:

Science and Engineering Practices

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 an explanation that includes qualitative or quantitative relationships between variables that predict phenomena. (MS-LS2-2)

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).

- ♣ Evaluate competing design solutions based on jointly developed and agreed-upon design criteria. (MS-LS2-5)

Disciplinary Core Ideas

LS2.A: Interdependent Relationships in Ecosystems

- ♣ Similarly, 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-LS2-2)

LS2.C: Ecosystem Dynamics, Functioning, and Resilience

- ♣ Biodiversity describes the variety of species found in Earth's terrestrial and oceanic ecosystems. The completeness or integrity of an ecosystem's biodiversity is often used as a measure of its health. (MS-LS2-5)

LS4.D: Biodiversity and Humans

- ♣ Changes in biodiversity can influence humans' resources, such as food, energy, and medicines, as well as ecosystem services that humans rely on—for example, water purification and recycling. *(secondary to MS-LS2-5)*

ETS1.B: Developing Possible Solutions

- ♣ There are systematic processes for evaluating solutions with respect to how well they meet the criteria and constraints of a problem. *(secondary to MS-LS2-5)*

Crosscutting Concepts

Patterns

- ♣ Patterns can be used to identify cause and effect relationships. (MS-LS2-2)

Stability and Change

- ♣ Small changes in one part of a system might cause large changes in another part. (MS-LS2-5)

Connections to Engineering, Technology, and Applications of Science

Influence of Science, Engineering, and Technology on Society and the Natural World

- ♣ The use of technologies and any limitations on their use are driven by individual or societal needs, desires, and values; by the findings of scientific research; and by differences in such factors as climate, natural resources, and economic conditions. Thus technology use varies from region to region and over time. (MS-LS2-5)

Connections to Nature of Science

Science Addresses Questions About the Natural and Material World

- ♣ Scientific knowledge can describes consequence of actions but does not make the decisions that society takes. (MS-LS2-5)

Connections to other DCIs in this grade-band: **MS.LS1.B** (MS-LS2-2); **MS.ESS3.C** (MS-LS2-5)

Articulation across grade-band: **1.LS1.B** (MS-LS2-2); **HS.LS2.A** (MS-LS2-2),(MS-LS2-5); **HS.LS2.B** (MS-LS2-2); **HS.LS2.C** (MS-LS2-5); **HS.LS2.D** (MS-LS2-2);**.LS4.D** (MS-LS2-5); **HS.ESS3.A** (MS-LS2-5); **HS.ESS3.C** (MS-LS2-5); **HS.ESS3.D** (MS-LS2-5)

Common Core State Standards Connections:

ELA/Literacy –

RST.6-8.1 Cite specific textual evidence to support analysis of science and technical texts. (MS-LS2-2)

RST.6-8.8 Distinguish among facts, reasoned judgment based on research findings, and speculation in a text. (MS-LS2-5)

RI.8.8 Trace and evaluate the argument and specific claims in a text, assessing whether the reasoning is sound and the evidence is relevant and sufficient to support the claims. (MS-LS2-5)

WHST.6-8.2 Write informative/explanatory texts to examine a topic and convey ideas, concepts, and information through the selection, organization, and analysis of relevant content. (MS-LS2-2)

WHST.6-8.9 Draw evidence from literary or informational texts to support analysis, reflection, and research. (MS-LS-2)

SL.8.1 Engage effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse partners on grade 8 topics, texts, and issues, building on others' ideas and expressing their own clearly. *(MS-LS2-2)*

SL.8.4 Present claims and findings, emphasizing salient points in a focused, coherent manner with relevant evidence, sound valid reasoning, and well-chosen details; use appropriate eye contact, adequate volume, and clear pronunciation. *(MS-LS2-2)*

Mathematics –

MP.4 Model with mathematics. *(MS-LS2-5)*

6.RP.A.3 Use ratio and rate reasoning to solve real-world and mathematical problems. *(MS-LS2-5)*

6.SP.B.5 Summarize numerical data sets in relation to their context. *(MS-LS2-2)*

*The performance expectations marked with an asterisk integrate traditional science content with engineering through a Practice or Disciplinary Core Idea.

MS.Growth, Development, and Reproduction of Organisms

MS.Growth, Development, and Reproduction of Organisms

Students who demonstrate understanding can:

MS-LS1-4. Use argument based on empirical evidence and scientific reasoning to support an explanation for how characteristic animal behaviors and specialized plant structures affect the probability of successful reproduction of animals and plants respectively. [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, and 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, and 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, and hard shells on nuts that squirrels bury.]

MS-LS1-5. Construct a scientific explanation based on evidence for how environmental and genetic factors influence the growth of organisms. [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, and fish growing larger in large ponds than they do in small ponds.] [Assessment Boundary: Assessment does not include genetic mechanisms, gene regulation, or biochemical processes.]

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. [Clarification Statement: Emphasis is on conceptual understanding that changes in genetic material may result in making different proteins.] [Assessment Boundary: Assessment does not include specific changes at the molecular level, mechanisms for protein synthesis, or specific types of mutations.]

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. [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.]

MS-LS4-5. Gather and synthesize information about the technologies that have changed the way humans influence the inheritance of desired traits in organisms. [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.]

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*:

Science and Engineering Practices

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. (MS-LS3-1),(MS-LS3-2)

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 knowledge, 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. (MS-LS1-5)

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).

- ♣ Use 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. (MS-LS1-4)

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. (MS-LS4-5)

Disciplinary Core Ideas

LS1.B: Growth and Development of Organisms

- ♣ Organisms reproduce, either sexually or asexually, and transfer their genetic information to their offspring. *(secondary to MS-LS3-2)*
- ♣ Animals engage in characteristic behaviors that increase the odds of reproduction. (MS-LS1-4)
- ♣ Plants reproduce in a variety of ways, sometimes depending on animal behavior and specialized features for reproduction. (MS-LS1-4)
- ♣ Genetic factors as well as local conditions affect the growth of the adult plant. (MS-LS1-5)

LS3.A: Inheritance of Traits

- ♣ Genes are located in the chromosomes of cells, with each chromosome pair containing two variants 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. 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-LS3-1)
- ♣ Variations of inherited traits between parent and offspring arise from genetic differences that result from the subset of chromosomes (and therefore genes) inherited. (MS-LS3-2)

LS3.B: Variation of Traits

- ♣ In sexually reproducing organisms, each parent contributes half of 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-LS3-2)
- ♣ In addition to variations that arise from sexual reproduction, genetic information can be 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-LS3-1)

LS4.B: Natural Selection

- ♣ In *artificial* selection, humans have the capacity to influence certain characteristics of organisms by selective breeding. One can choose desired parental traits determined by genes, which are then passed on to offspring. (MS-LS4-5)

Crosscutting Concepts

Cause and Effect

- ♣ Cause and effect relationships may be used to predict phenomena in natural systems. (MS-LS3-2)
- ♣ Phenomena may have more than one cause, and some cause and effect relationships in systems can only be described using probability. (MS-LS1-4),(MS-LS1-5),(MS-LS4-5)

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. (MS-LS3-1)

Connections to Engineering, Technology, and Applications of Science

Interdependence of Science, Engineering, and Technology

- ♣ Engineering advances have led to important discoveries in virtually every field of science, and scientific discoveries have led to the development of entire industries and engineered systems. (MS-LS4-5)

Connections to Nature of Science

Science Addresses Questions About the Natural and Material World

- ♣ Science knowledge can describe consequences of actions but does not make the decisions that society takes. (MS-LS4-5)

Connections to other DCIs in this grade-band: **MS.LS1.A** (MS-LS3-1); **MS.LS2.A** (MS-LS1-4),(MS-LS1-5)

*The performance expectations marked with an asterisk integrate traditional science content with engineering through a Practice or Disciplinary Core Idea.

MS.Growth, Development, and Reproduction of Organisms

Articulation to DCIs across grade-bands: **3.LS1.B** (MS-LS1-4),(MS-LS1-5); **3.LS3.A** (MS-LS1-5),(MS-LS3-1),(MS-LS3-2); **3.LS3.B** (MS-LS3-1),(MS-LS3-2); **HS.LS1.A** (MS-LS3-1); **HS.LS1.B** (MS-LS3-1),(MS-LS3-2); **HS.LS2.A** (MS-LS1-4),(MS-LS1-5); **HS.LS2.D** (MS-LS1-4); **HS.LS3.A** (MS-LS3-1),(MS-LS3-2); **HS.LS3.B** (MS-LS3-1),(MS-LS3-2),(MS-LS4-5); **HS.LS4.C** (MS-LS4-5)

Common Core State Standards Connections:

ELA/Literacy –

RST.6-8.1 Cite specific textual evidence to support analysis of science and technical texts. (MS-LS1-4),(MS-LS1-5),*(MS-LS3-1),(MS-LS3-2),*(MS-LS4-5)

RST.6-8.2 Determine the central ideas or conclusions of a text; provide an accurate summary of the text distinct from prior knowledge or opinions. *(MS-LS1-5)*

RST.6-8.4 Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 6-8 texts and topics. *(MS-LS3-1),(MS-LS3-2)*

RST.6-8.7 Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually (e.g., in a flowchart, diagram, model, graph, or table). (MS-LS3-1),(MS-LS3-2)

RI.6.8 Trace and evaluate the argument and specific claims in a text, distinguishing claims that are supported by reasons and evidence from claims that are not. (MS-LS1-4)

WHST.6-8.1 Write arguments focused on discipline content. (MS-LS1-4)

WHST.6-8.2 Write informative/explanatory texts to examine a topic and convey ideas, concepts, and information through the selection, organization, and analysis of relevant content. *(MS-LS1-5)*

WHST.6-8.8 Gather relevant information from multiple print and digital sources; assess the credibility of each source; and quote or paraphrase the data and conclusions of others while avoiding plagiarism and providing basic bibliographic information for sources. *(MS-LS4-5)*

WHST.6-8.9 Draw evidence from informational texts to support analysis, reflection, and research. (MS-LS1-5)

SL.8.5 Include multimedia components and visual displays in presentations to clarify claims and findings and emphasize salient points. *(MS-LS3-1),(MS-LS3-2)*

Mathematics –

MP.4 Model with mathematics. *(MS-LS3-2)*

6.SP.A.2 Understand that a set of data collected to answer a statistical question has a distribution which can be described by its center, spread, and overall shape. *(MS-LS1-4),(MS-LS1-5)*

6.SP.B.4 Summarize numerical data sets in relation to their context. *(MS-LS1-4),(MS-LS1-5)*

6.SP.B.5 Summarize numerical data sets in relation to their context. *(MS-LS3-2)*

*The performance expectations marked with an asterisk integrate traditional science content with engineering through a Practice or Disciplinary Core Idea.

MS.Natural Selection and Adaptations

MS.Natural Selection and Adaptations

Students who demonstrate understanding can:

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. [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.] [Assessment Boundary: Assessment does not include the names of individual species or geological eras in the fossil record.]

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. [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.]

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. [Clarification Statement: Emphasis is on inferring general patterns of relatedness among embryos of different organisms by comparing the macroscopic appearance of diagrams or pictures.] [Assessment Boundary: Assessment of comparisons is limited to gross appearance of anatomical structures in embryological development.]

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. [Clarification Statement: Emphasis is on using simple probability statements and proportional reasoning to construct explanations

MS-LS4-6. Use mathematical representations to support explanations of how natural selection may lead to increases and decreases of specific traits in populations over time. [Clarification Statement: Emphasis is on using mathematical models, probability statements, and proportional reasoning to support explanations of trends in changes to populations over time.] [Assessment Boundary: Assessment does not include Hardy Weinberg calculations.]

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*:

Science and Engineering Practices

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 displays of data to identify linear and nonlinear relationships. (MS-LS4-3)
- ♣ Analyze and interpret data to determine similarities and differences in findings. (MS-LS4-1)

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 support scientific conclusions and design solutions. (MS-LS4-6)

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 to construct an explanation for real-world phenomena, examples, or events. (MS-LS4-2)
- ♣ Construct an explanation that includes qualitative or quantitative relationships between variables that describe phenomena. (MS-LS4-4)

Connections to Nature of Science

Scientific Knowledge is Based on Empirical Evidence

- ♣ Science knowledge is based upon logical and conceptual connections between evidence and explanations. (MS-LS4-1)

Disciplinary Core Ideas

LS4.A: Evidence of Common Ancestry and Diversity

- ♣ The collection of fossils and their placement in chronological order (e.g., through the location of the sedimentary layers in which they are found or through radioactive dating) is known as the fossil record. It documents the existence, diversity, extinction, and change of many life forms throughout the history of life on Earth. (MS-LS4-1)
- ♣ 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-LS4-2)
- ♣ Comparison of the embryological development of different species also reveals similarities that show relationships not evident in the fully-formed anatomy. (MS-LS4-3)

LS4.B: Natural Selection

- ♣ Natural selection leads to the predominance of certain traits in a population, and the suppression of others. (MS-LS4-4)

LS4.C: Adaptation

- ♣ Adaptation by natural selection acting over generations is one important process by which species change over time in response to changes in environmental conditions. Traits that support successful survival and reproduction in the new environment become more common; those that do not become less common. Thus, the distribution of traits in a population changes. (MS-LS4-6)

Crosscutting Concepts

Patterns

- ♣ Patterns can be used to identify cause and effect relationships. (MS-LS4-2)
- ♣ Graphs, charts, and images can be used to identify patterns in data. (MS-LS4-1), (MS-LS4-3)

Cause and Effect

- ♣ Phenomena may have more than one cause, and some cause and effect relationships in systems can only be described using probability. (MS-LS4-4),(MS-LS4-6)

Connections to Nature of Science

Scientific Knowledge Assumes an Order and Consistency in Natural Systems

- ♣ Science assumes that objects and events in natural systems occur in consistent patterns that are understandable through measurement and observation. (MS-LS4-1),(MS-LS4-2)

Connections to other DCIs in this grade-band: **MS.LS2.A** (MS-LS4-3),(MS-LS4-6); **MS.LS2.C** (MS-LS4-6); **MS.LS3.A** (MS-LS4-2),(MS-LS4-3); **MS.LS3.B** (MS-LS4-2),(MS-LS4-3),(MS-LS4-6); **MS.ESS1.C** (MS-LS4-1),(MS-LS4-2),(MS-LS4-6)

Articulation across grade-bands: **3.LS3.B** (MS-LS4-4); **3.LS4.A** (MS-LS4-1),(MS-LS4-2); **3. LS4.B** (MS-LS4-4); **3.LS4.C** (MS-LS4-6); **HS.LS2.A** (MS-LS4-4),(MS-LS4-6); **HS.LS2.C** (MS-LS4-6); **HS.LS3.B** (MS-LS4-4),(MS-LS4-6); **HS.LS4.A** (MS-LS4-1),(MS-LS4-2),(MS-LS4-3); **HS.LS4.B** (MS-LS4-4),(MS-LS4-6); **HS.LS4.C** (MS-LS4-4),(MS-LS4-6); **HS.ESS1.C** (MS-LS4-1),(MS-LS4-2)

Common Core State Standards Connections:

ELA/Literacy –

RST.6-8.1 Cite specific textual evidence to support analysis of science and technical texts, attending to the precise details of explanations or descriptions *(MS-LS4-1),*(MS-LS4-2)*,(MS-LS4-3),(MS-LS4-4)*

RST.6-8.7 Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually (e.g., in a flowchart, diagram, model, graph, or table). (MS-LS4-1),(MS-LS4-3)

RST.6-8.9 Compare and contrast the information gained from experiments, simulations, video, or multimedia sources with that gained from reading a text on the same topic. *(MS-LS4-3),(MS-LS4-4)*

*The performance expectations marked with an asterisk integrate traditional science content with engineering through a Practice or Disciplinary Core Idea.

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WHST.6-8.2 Write informative/explanatory texts to examine a topic and convey ideas, concepts, and information through the selection, organization, and analysis of relevant content. (MS-LS4-2),(MS-LS4-4)

WHST.6-8.9 Draw evidence from informational texts to support analysis, reflection, and research. (MS-LS4-2),(MS-LS4-4)

SL.8.1 Engage effectively in a range of collaborative discussions (one-on-one, in groups, teacher-led) with diverse partners on grade 6 topics, texts, and issues, building on others' ideas and expressing their own clearly. *(MS-LS4-2),(MS-LS4-4)*

SL.8.4 Present claims and findings, emphasizing salient points in a focused, coherent manner with relevant evidence, sound valid reasoning, and well-chosen details; use appropriate eye contact, adequate volume, and clear pronunciation. *(MS-LS4-2),(MS-LS4-4)*

Mathematics –

MP.4 Model with mathematics. (MS-LS4-6)

6.RP.A.1 Understand the concept of a ratio and use ratio language to describe a ratio relationship between two quantities. *(MS-LS4-4),(MS-LS4-6)*

7.RP.A.2 Recognize and represent proportional relationships between quantities. *(MS-LS4-4),(MS-LS4-6)*

6.SP.B.5 Summarize numerical data sets in relation to their context. *(MS-LS4-4),(MS-LS4-6)*

6.EE.B.6 Use variables to represent numbers and write expressions when solving a real-world or mathematical problem; understand that a variable can represent an unknown number, or, depending on the purpose at hand, any number in a specified set. *(MS-LS4-1),(MS-LS4-2)*

*The performance expectations marked with an asterisk integrate traditional science content with engineering through a Practice or Disciplinary Core Idea.

The section entitled "Disciplinary Core Ideas" is reproduced verbatim from A Framework for K-12 Science Education: Practices, Cross-Cutting Concepts, and Core Ideas. Integrated and reprinted with permission from the National Academy of Sciences.

MS.Space Systems

MS.Space Systems

Students who demonstrate understanding can:

MS-ESS1-1. Develop and use a model of the Earth-sun-moon system to describe the cyclic patterns of lunar phases, eclipses of the sun and moon, and seasons. [Clarification Statement: Examples of models can be physical, graphical, or conceptual.]

MS-ESS1-2. Develop and use a model to describe the role of gravity in the motions within galaxies and the solar system. [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).] [Assessment Boundary: Assessment does not include Kepler's Laws of orbital motion or the apparent retrograde motion of the planets as viewed from Earth.]

MS-ESS1-3. Analyze and interpret data to determine scale properties of objects in the solar system. [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), surface features (such as volcanoes), and orbital radius. Examples of data include statistical information, drawings and photographs, and models.] [Assessment Boundary: Assessment does not include recalling facts about properties of the planets and other solar system bodies.]

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*:

Science and Engineering Practices

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. (MS-ESS1-1),(MS-ESS1-2)

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. (MS-ESS1-3)

Disciplinary Core Ideas

ESS1.A: 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-ESS1-1)
♣ Earth and its solar system are part of the Milky Way galaxy, which is one of many galaxies in the universe. (MS-ESS1-2)

ESS1.B: Earth and the Solar System
♣ The solar system consists of the sun and a collection of objects, including planets, their moons, and asteroids that are held in orbit around the sun by its gravitational pull on them. (MS-ESS1-2),(MS-ESS1-3)
♣ 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 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-ESS1-1)
♣ The solar system appears to have formed from a disk of dust and gas, drawn together by gravity. (MS-ESS1-2)

Crosscutting Concepts

Patterns
♣ Patterns can be used to identify cause and effect relationships. (MS-ESS1-1)

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. (MS-ESS1-3)

Systems and System Models
♣ Models can be used to represent systems and their interactions. (MS-ESS1-2)

Connections to Engineering, Technology, and Applications of Science

Interdependence of Science, Engineering, and Technology
♣ Engineering advances have led to important discoveries in virtually every field of science and scientific discoveries have led to the development of entire industries and engineered systems. (MS-ESS1-3)

Connections to Nature of Science

Scientific Knowledge Assumes an Order and Consistency in Natural Systems
♣ Science assumes that objects and events in natural systems occur in consistent patterns that are understandable through measurement and observation. (MS-ESS1-1), (MS-ESS1-2)

Connections to other DCIs in this grade-band: **MS.PS2.A** (MS-ESS1-1),(MS-ESS1-2); **MS.PS2.B** (MS-ESS1-1),(MS-ESS1-2); **MS.ESS2.A** (MS-ESS1-3)

Articulation of DCIs across grade-bands: **3.PS2.A** (MS-ESS1-1),(MS-ESS1-2); **5.PS2.B** (MS-ESS1-1),(MS-ESS1-2); **5.ESS1.A** (MS-ESS1-2); **5.ESS1.B** (MS-ESS1-1),(MS-ESS1-2),(5-ESS1-3); **HS.PS2.A** (MS-ESS1-1),(MS-ESS1-2); **HS.PS2.B** (MS-ESS1-1),(MS-ESS1-2); **HS.ESS1.A** (MS-ESS1-2); **HS.ESS1.B** (MS-ESS1-1),(MS-ESS1-2),(MS-ESS1-3); **HS.ESS2.A** (MS-ESS1-3)

Common Core State Standards Connections:

ELA/Literacy –

RST.6-8.1 Cite specific textual evidence to support analysis of science and technical texts. (MS-ESS1-3)

RST.6-8.7 Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually (e.g., in a flowchart, diagram, model, graph, or table). (MS-ESS1-3)

SL.8.5 Include multimedia components and visual displays in presentations to clarify claims and findings and emphasize salient points. *(MS-ESS1-1),(MS-ESS1-2)*

Mathematics –

MP.2 Reason abstractly and quantitatively. (MS-ESS1-3)

MP.4 Model with mathematics. (MS-ESS1-1),(MS-ESS1-2)

6.RP.A.1 Understand the concept of a ratio and use ratio language to describe a ratio relationship between two quantities. *(MS-ESS1-1),(MS-ESS1-2).*(MS-ESS1-3)

7.RP.A.2 Recognize and represent proportional relationships between quantities. *(MS-ESS1-1),(MS-ESS1-2).*(MS-ESS1-3)

6.EE.B.6 Use variables to represent numbers and write expressions when solving a real-world or mathematical problem; understand that a variable can represent an unknown number, or, depending on the purpose at hand, any number in a specified set. *(MS-ESS1-2)*

7.EE.B.4 Use variables to represent quantities in a real-world or mathematical problem, and construct simple equations and inequalities to solve problems by reasoning about the quantities. *(MS-ESS1-2)*

*The performance expectations marked with an asterisk integrate traditional science content with engineering through a Practice or Disciplinary Core Idea.

MS.History of Earth

MS.History of Earth

Students who demonstrate understanding can:

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 4.6-billion-year-old history. [Clarification Statement: Emphasis is on how analyses of rock formations and the fossils they contain are used to establish relative ages of major events in Earth's history. Examples of Earth's major events could range from being very recent (such as the last Ice Age or the earliest fossils of homo sapiens) to very old (such as the formation of Earth or the earliest evidence of life). Examples can include the formation of mountain chains and ocean basins, the evolution or extinction of particular living organisms, or significant volcanic eruptions.] [Assessment Boundary: Assessment does not include recalling the names of specific periods or epochs and events within them.]

MS-ESS2-2. Construct an explanation based on evidence for how geoscience processes have changed Earth's surface at varying time and spatial scales. [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 large mountain ranges) or small (such as rapid landslides or microscopic geochemical reactions), and how many geoscience processes (such as earthquakes, volcanoes, and meteor impacts) usually behave gradually but are punctuated by catastrophic events. 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.]

MS-ESS2-3. Analyze and interpret data on the distribution of fossils and rocks, continental shapes, and seafloor structures to provide evidence of the past plate motions. [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).] [Assessment Boundary: Paleomagnetic anomalies in oceanic and continental crust are not assessed.]

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*:

Science and Engineering Practices

Analyzing and Interpreting Data

Analyzing data in 6–8 builds on K–5 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. (MS-ESS2-3)

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. (MS-ESS1-4),(MS-ESS2-2)

Connections to Nature of Science

Scientific Knowledge is Open to Revision in Light of New Evidence

- ♣ Science findings are frequently revised and/or reinterpreted based on new evidence. (MS-ESS2-3)

Disciplinary Core Ideas

ESS1.C: 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-ESS1-4)
- ♣ Tectonic processes continually generate new ocean sea floor at ridges and destroy old sea floor at trenches. *(HS.ESS1.C GBE) (secondary to MS-ESS2-3)*

ESS2.A: 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-ESS2-2)

ESS2.B: 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-ESS2-3)

ESS2.C: The Roles 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-ESS2-2)

Crosscutting Concepts

Patterns

- ♣ Patterns in rates of change and other numerical relationships can provide information about natural and human designed systems. (MS-ESS2-3)

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. (MS-ESS1-4),(MS-ESS2-2)

Connections to other DCIs in this grade-band: **MS.PS1.B** (MS-ESS2-2); **MS.LS2.B** (MS-ESS2-2); **MS.LS4.A** (MS-ESS1-4),(MS-ESS2-3); **MS.LS4.C** (MS-ESS1-4)

Articulation of DCIs across grade-bands: **3.LS4.A** (MS-ESS1-4),(MS-ESS2-3); **3.LS4.C** (MS-ESS1-4); **3.ESS3.B** (MS-ESS2-3); **4.ESS1.C** (MS-ESS1-4),(MS-ESS2-2),(MS-ESS2-3); **4.ESS2.A** (MS-ESS2-2); **4.ESS2.B** (MS-ESS2-3); **4.ESS2.E** (MS-ESS2-2); **4.ESS3.B** (MS-ESS2-3); **5.ESS2.A** (MS-ESS2-2); **HS.PS1.C** (MS-ESS1-4); **HS.PS3.D** (MS-ESS2-2); **HS.LS2.B** (MS-ESS2-2); **HS.LS4.A** (MS-ESS1-4),(MS-ESS2-3); **HS.LS4.C** (MS-ESS1-4),(MS-ESS2-3); **HS.ESS1.C** (MS-ESS1-4),(MS-ESS2-2),(MS-ESS2-3); **HS.ESS2.A** (MS-ESS1-4),(MS-ESS2-2),(MS-ESS2-3); **HS.ESS2.B** (MS-ESS2-2),(MS-ESS2-3); **HS.ESS2.C** (MS-ESS2-2); **HS.ESS2.D** (MS-ESS2-2); **HS.ESS2.E** (MS-ESS2-2); **HS.ESS3.D** (MS-ESS2-2)

Common Core State Standards Connections:

ELA/Literacy –

RST.6-8.1 Cite specific textual evidence to support analysis of science and technical texts. (MS-ESS1-4),(MS-ESS2-2),*(MS-ESS2-3)*

RST.6-8.7 Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually (e.g., in a flowchart, diagram, model, graph, or table). (MS-ESS2-3)

RST.6-8.9 Compare and contrast the information gained from experiments, simulations, video, or multimedia sources with that gained from reading a text on the same topic. (MS-ESS2-3)

WHST.6-8.2 Write informative/explanatory texts to examine a topic and convey ideas, concepts, and information through the selection, organization, and analysis of relevant content. (MS-ESS1-4),(MS-ESS2-2)

SL.8.5 Include multimedia components and visual displays in presentations to clarify claims and findings and emphasize salient points. *(MS-ESS2-2)*

Mathematics –

MP.2 Reason abstractly and quantitatively. (MS-ESS2-2),(MS-ESS2-3)

6.EE.B.6 Use variables to represent numbers and write expressions when solving a real-world or mathematical problem; understand that a variable can represent an unknown number, or, depending on the purpose at hand, any number in a specified set. *(MS-ESS1-4),(MS-ESS2-2),(MS-ESS2-3)*

7.EE.B.4 Use variables to represent quantities in a real-world or mathematical problem, and construct simple equations and inequalities to solve problems by reasoning about the quantities. *(MS-ESS1-4),(MS-ESS2-2),(MS-ESS2-3)*

*The performance expectations marked with an asterisk integrate traditional science content with engineering through a Practice or Disciplinary Core Idea.

MS.Earth's Systems

MS.Earth's Systems

Students who demonstrate understanding can:

MS-ESS2-1. Develop a model to describe the cycling of Earth's materials and the flow of energy that drives this process. [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.] [Assessment Boundary: Assessment does not include the identification and naming of minerals.]

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. [Clarification Statement: Emphasis is on the ways water changes its state as it moves through the multiple pathways of the hydrologic cycle. Examples of models can be conceptual or physical.] [Assessment Boundary: A quantitative understanding of the latent heats of vaporization and fusion is not assessed.]

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. [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).]

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*:

Science and Engineering Practices

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. (MS-ESS2-1)
- ♣ Develop a model to describe unobservable mechanisms. (MS-ESS2-4)

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. (MS-ESS3-1)

Disciplinary Core Ideas

ESS2.A: 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-ESS2-1)

ESS2.C: 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-ESS2-4)
- ♣ Global movements of water and its changes in form are propelled by sunlight and gravity. (MS-ESS2-4)

ESS3.A: 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-ESS3-1)

Crosscutting Concepts

Cause and Effect

- ♣ Cause and effect relationships may be used to predict phenomena in natural or designed systems. (MS-ESS3-1)

Energy and Matter

- ♣ Within a natural or designed system, the transfer of energy drives the motion and/or cycling of matter. (MS-ESS2-4)

Stability and Change

- ♣ Explanations of stability and change in natural or designed systems can be constructed by examining the changes over time and processes at different scales, including the atomic scale. (MS-ESS2-1)

Connections to Engineering, Technology and Applications of Science

Influence of Science, Engineering, and Technology on Society and the Natural World

- ♣ All human activity draws on natural resources and has both short and long-term consequences, positive as well as negative, for the health of people and the natural environment. (MS-ESS3-1)

Connections to other DCIs in this grade-band: **MS.PS1.A** (MS-ESS2-1),(MS-ESS2-4),(MS-ESS3-1); **MS.PS1.B** (MS-ESS2-1),(MS-ESS3-1); **MS.PS2.B** (MS-ESS2-4); **MS.PS3.A** (MS-ESS2-4); **MS.PS3.B** (MS-ESS2-1); **MS.PS3.D** (MS-ESS2-4); **MS.PS4.B** (MS-ESS2-4); **MS.LS1.C** (MS-ESS3-1); **MS.LS2.B** (MS-ESS2-1); **MS.LS2.C** (MS-ESS2-1); **MS.ESS3.C** (MS-ESS2-1); **MS.ESS2.D** (MS-ESS3-1)

Articulation of DCIs across grade-bands: **3.PS2.A** (MS-ESS2-4); **4.PS3.B** (MS-ESS2-1),(MS-ESS2-4); **4.PS3.D** (MS-ESS3-1); **4.ESS2.A** (MS-ESS2-1); **4.ESS3.A** (MS-ESS3-1); **5.PS2.B** (MS-ESS2-4); **5.PS3.D** (MS-ESS3-1); **5.LS2.B** (MS-ESS2-1); **5.ESS1.B** (MS-ESS2-4); **5.ESS2.A** (MS-ESS2-1); **5.ESS2.C** (MS-ESS2-4); **HS.PS1.B** (MS-ESS2-1); **HS.PS2.B** (MS-ESS2-4); **HS.PS3.B** (MS-ESS2-1),(MS-ESS2-4),(MS-ESS3-1); **HS.PS4.B** (MS-ESS2-4); **HS.LS1.C** (MS-ESS2-1),(MS-ESS3-1); **HS.LS2.B** (MS-ESS2-1); **HS.ESS2.A** (MS-ESS2-1),(MS-ESS2-4),(MS-ESS3-1); **HS.ESS2.B** (MS-ESS3-1); **HS.ESS2.C** (MS-ESS2-1),(MS-ESS2-4),(MS-ESS3-1); **HS.ESS2.D** (MS-ESS2-4); **HS.ESS2.E** (MS-ESS2-1); **HS.ESS3.A** (MS-ESS3-1)

Common Core State Standards Connections:

ELA/Literacy –

RST.6-8.1 Cite specific textual evidence to support analysis of science and technical texts. (MS-ESS3-1)

WHST.6-8.2 Write informative/explanatory texts to examine a topic and convey ideas, concepts, and information through the selection, organization, and analysis of relevant content. (MS-ESS3-1)

WHST.6-8.9 Draw evidence from informational texts to support analysis, reflection, and research. (MS-ESS3-1)

SL.8.5 Include multimedia components and visual displays in presentations to clarify claims and findings and emphasize salient points. *(MS-ESS2-1)*

Mathematics –

6.EE.B.6 Use variables to represent numbers and write expressions when solving a real-world or mathematical problem; understand that a variable can represent an unknown number, or, depending on the purpose at hand, any number in a specified set. *(MS-ESS3-1)*

7.EE.B.4 Use variables to represent quantities in a real-world or mathematical problem, and construct simple equations and inequalities to solve problems by reasoning about the quantities. *(MS-ESS3-1)*

*The performance expectations marked with an asterisk integrate traditional science content with engineering through a Practice or Disciplinary Core Idea.

MS.Weather and Climate

MS.Weather and Climate

Students who demonstrate understanding can:

MS-ESS2-5. Collect data to provide evidence for how the motions and complex interactions of air masses results in changes in weather conditions. [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 with condensation).] [Assessment Boundary: Assessment does not include recalling the names of cloud types or weather symbols used on weather maps or the reported diagrams from weather stations.]

MS-ESS2-6. Develop and use a model to describe how unequal heating and rotation of the Earth cause patterns of atmospheric and oceanic circulation that determine 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 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.] [Assessment Boundary: Assessment does not include the dynamics of the Coriolis effect.]

MS-ESS3-5. Ask questions to clarify evidence of the factors that have caused the rise in global temperatures over the past century. [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, 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.]

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*:

Science and Engineering Practices

Asking Questions and Defining Problems

Asking questions and defining problems in 6–8 builds on K–5 experiences and progresses to specifying relationships between variables, clarify arguments and models.

- Ask questions to identify and clarify evidence of an argument. (MS-ESS3-5)

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. (MS-ESS2-6)

Planning and Carrying Out Investigations

Planning and carrying out investigations 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. (MS-ESS2-5)

Disciplinary Core Ideas

ESS2.C: 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-ESS2-5)
- Variations in density due to variations in temperature and salinity drive a global pattern of interconnected ocean currents. (MS-ESS2-6)

ESS2.D: 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. (MS-ESS2-6)
- Because these patterns are so complex, weather can only be predicted probabilistically. (MS-ESS2-5)
- 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-ESS2-6)

ESS3.D: 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 (global warming). Reducing the level of 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-ESS3-5)

Crosscutting Concepts

Cause and Effect

- Cause and effect relationships may be used to predict phenomena in natural or designed systems. (MS-ESS2-5)

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. (MS-ESS2-6)

Stability and Change

- Stability might be disturbed either by sudden events or gradual changes that accumulate over time. (MS-ESS3-5)

Connections to other DCIs in this grade-band: **MS.PS1.A** (MS-ESS2-5); **MS.PS2.A** (MS-ESS2-5),(MS-ESS2-6); **MS.PS3.A** (MS-ESS2-5),(MS-ESS3-5); **MS.PS3.B** (MS-ESS2-5),(MS-ESS2-6); **MS.PS4.B** (MS-ESS2-6)

Articulation of DCIs across grade-bands: **3.PS2.A** (MS-ESS2-6); **3.ESS2.D** (MS-ESS2-5),(MS-ESS2-6); **5.ESS2.A** (MS-ESS2-5),(MS-ESS2-6); **HS.PS2.B** (MS-ESS2-6); **HS.PS3.B** (MS-ESS2-6),(MS-ESS3-5); **HS.PS4.B** (MS-ESS3-5); **HS.ESS1.B** (MS-ESS2-6); **HS.ESS2.A** (MS-ESS2-6),(MS-ESS3-5); **HS.ESS2.C** (MS-ESS2-5); **HS.ESS2.D** (MS-ESS2-5),(MS-ESS2-6),(MS-ESS3-5); **HS.ESS3.C** (MS-ESS3-5); **HS.ESS3.D** (MS-ESS3-5)

Common Core State Standards Connections: will be available on or before April 26, 2013.

ELA/Literacy –

RST.6-8.1 Cite specific textual evidence to support analysis of science and technical texts. (MS-ESS2-5),(MS-ESS3-5)

RST.6-8.9 Compare and contrast the information gained from experiments, simulations, video, or multimedia sources with that gained from reading a text on the same topic. (MS-ESS2-5)

WHST.6-8.8 Gather relevant information from multiple print and digital sources; assess the credibility of each source; and quote or paraphrase the data and conclusions of others while avoiding plagiarism and providing basic bibliographic information for sources. *(MS-ESS2-5)*

SL.8.5 Include multimedia components and visual displays in presentations to clarify claims and findings and emphasize salient points. *(MS-ESS2-6)*

Mathematics –

MP.2 Reason abstractly and quantitatively. (MS-ESS2-5),*(MS-ESS3-5)*

6.NS.C.5 Understand that positive and negative numbers are used together to describe quantities having opposite directions or values (e.g., temperature above/below zero, elevation above/below sea level, credits/debits, positive/negative electric charge); use positive and negative numbers to represent quantities in real-world contexts, explaining the meaning of 0 in each situation. (MS-ESS2-5)

6.EE.B.6 Use variables to represent numbers and write expressions when solving a real-world or mathematical problem; understand that a variable can represent an unknown number, or, depending on the purpose at hand, any number in a specified set. *(MS-ESS3-5)*

7.EE.B.4 Use variables to represent quantities in a real-world or mathematical problem, and construct simple equations and inequalities to solve problems by reasoning about the quantities. *(MS-ESS3-5)*

*The performance expectations marked with an asterisk integrate traditional science content with engineering through a Practice or Disciplinary Core Idea.

MS.Human Impacts

MS.Human Impacts

Students who demonstrate understanding can:

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. [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).]

MS-ESS3-3. Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment.* [Clarification Statement: Examples of the design process 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 can 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).]

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. [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 for the actions society takes.]

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*:

Science and Engineering Practices

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. (MS-ESS3-2)

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 principles to design an object, tool, process or system. (MS-ESS3-3)

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 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. (MS-ESS3-4)

Disciplinary Core Ideas

ESS3.B: 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-ESS3-2)

ESS3.C: Human Impacts on Earth Systems

- ♣ Human activities 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-ESS3-3)
- ♣ 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-ESS3-3),(MS-ESS3-4)

Crosscutting Concepts

Patterns

- ♣ Graphs, charts, and images can be used to identify patterns in data. (MS-ESS3-2)

Cause and Effect

- ♣ Relationships can be classified as causal or correlational, and correlation does not necessarily imply causation. (MS-ESS3-3)
- ♣ Cause and effect relationships may be used to predict phenomena in natural or designed systems. (MS-ESS3-4)

Connections to Engineering, Technology, and Applications of Science

Influence of Science, Engineering, and Technology on Society and the Natural World

- ♣ All human activity draws on natural resources and has both short and long-term consequences, positive as well as negative, for the health of people and the natural environment. (MS-ESS3-4)
- ♣ The uses of technologies and limitations on their use are driven by people's needs, desires, and values; by the findings of scientific research; and by differences in such factors as climate, natural resources, and economic conditions. Thus technology use varies from region to region and over time. (MS-ESS3-2),(MS-ESS3-3)

Connections to Nature of Science

Science Addresses Questions About the Natural and Material World

- ♣ Science knowledge can describe consequences of actions but does not make the decisions that society takes. (MS-ESS3-4)

Connections to other DCIs in this grade-band: **MS.PS3.C** (MS-ESS3-2**MS.LS2.A** (MS-ESS3-3),(MS-ESS3-4); **MS.LS2.C** (MS-ESS3-3),(MS-ESS3-4); **MS.LS4.D** (MS-ESS3-3),(MS-ESS3-4)

Articulation of DCIs across grade-bands: **3.LS2.C** (MS-ESS3-3),(MS-ESS3-4); **3.LS4.D** (MS-ESS3-3),(MS-ESS3-4); **3.ESS3.B** (MS-ESS3-2); **4.ESS3.B** (MS-ESS3-2); **5.LS2.A** (MS-ESS3-3),(MS-ESS3-4); **5.ESS3.C** (MS-ESS3-3),(MS-ESS3-4); **HS.LS2.A** (MS-ESS3-4); **HS.LS2.C** (MS-ESS3-3),(MS-ESS3-4); **HS.LS4.C** (MS-ESS3-3),(MS-ESS3-4); **HS.LS4.D** (MS-ESS3-3),(MS-ESS3-4); **HS.ESS2.B** (MS-ESS3-2); **HS.ESS2.C** (MS-ESS3-3); **HS.ESS2.D** (MS-ESS3-2),(MS-ESS3-3); **HS.ESS2.E** (MS-ESS3-3),(MS-ESS3-4); **HS.ESS3.A** (MS-ESS3-4); **HS.ESS3.B** (MS-ESS3-2); **HS.ESS3.C** (MS-ESS3-3),(MS-ESS3-4); **HS.ESS3.D** (MS-ESS3-2);(MS-ESS3-3)

Common Core State Standards Connections:

ELA/Literacy –

RST.6-8.1 Cite specific textual evidence to support analysis of science and technical texts. *(MS-ESS3-2)*,(MS-ESS3-4)

RST.6-8.7 Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually (e.g., in a flowchart, diagram, model, graph, or table). (MS-ESS3-2)

WHST.6-8.1 Write arguments focused on discipline content. (MS-ESS3-4)

WHST.6-8.7 Conduct short research projects to answer a question (including a self-generated question), drawing on several sources and generating additional related, focused questions that allow for multiple avenues of exploration. (MS-ESS3-3)

WHST.6-8.8 Gather relevant information from multiple print and digital sources; assess the credibility of each source; and quote or paraphrase the data and conclusions of others while avoiding plagiarism and providing basic bibliographic information for sources. (MS-ESS3-3)

WHST.6-8.9 Draw evidence from informational texts to support analysis, reflection, and research. (MS-ESS3-4)

Mathematics –

*The performance expectations marked with an asterisk integrate traditional science content with engineering through a Practice or Disciplinary Core Idea.

MS.Human Impacts

MP.2	Reason abstractly and quantitatively. (MS-ESS3-2)
6.RP.A.1	Understand the concept of a ratio and use ratio language to describe a ratio relationship between two quantities. *(MS-ESS3-3),(MS-ESS3-4)*
7.RP.A.2	Recognize and represent proportional relationships between quantities. *(MS-ESS3-3),(MS-ESS3-4)*
6.EE.B.6	Use variables to represent numbers and write expressions when solving a real-world or mathematical problem; understand that a variable can represent an unknown number, or, depending on the purpose at hand, any number in a specified set. *(MS-ESS3-2),(MS-ESS3-3),(MS-ESS3-4)*
7.EE.B.4	Use variables to represent quantities in a real-world or mathematical problem, and construct simple equations and inequalities to solve problems by reasoning about the quantities. *(MS-ESS3-2),(MS-ESS3-3),(MS-ESS3-4)*

*The performance expectations marked with an asterisk integrate traditional science content with engineering through a Practice or Disciplinary Core Idea.

MS.Engineering Design

MS.Engineering Design

Students who demonstrate understanding can:

MS-ETS1-1. Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions.

MS-ETS1-2. Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.

MS-ETS1-3. Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success.

MS-ETS1-4. Develop a model to generate data for iterative testing and modification of a proposed object, tool, or process such that an optimal design can be achieved.

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*:

Science and Engineering Practices

Asking Questions and Defining Problems

Asking questions and defining problems in grades 6–8 builds on grades K–5 experiences and progresses to specifying relationships between variables, clarify arguments and models.

- ♣ Define a design problem that can be solved through the development of an object, tool, process or system and includes multiple criteria and constraints, including scientific knowledge that may limit possible solutions. (MS-ETS1-1)

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 generate data to test ideas about designed systems, including those representing inputs and outputs. (MS-ETS1-4)

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. (MS-ETS1-3)

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.

- ♣ Evaluate competing design solutions based on jointly developed and agreed-upon design criteria. (MS-ETS1-2)

Disciplinary Core Ideas

ETS1.A: Defining and Delimiting Engineering Problems

- ♣ 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 are likely to limit possible solutions. (MS-ETS1-1)

ETS1.B: Developing Possible Solutions

- ♣ A solution needs to be tested, and then modified on the basis of the test results, in order to improve it. (MS-ETS1-4)
- ♣ There are systematic processes for evaluating solutions with respect to how well they meet the criteria and constraints of a problem. (MS-ETS1-2), (MS-ETS1-3)
- ♣ Sometimes parts of different solutions can be combined to create a solution that is better than any of its predecessors. (MS-ETS1-3)
- ♣ Models of all kinds are important for testing solutions. (MS-ETS1-4)

ETS1.C: Optimizing the Design Solution

- ♣ Although one design may not perform the best across all tests, identifying the characteristics of the design that performed the 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-ETS1-3)
- ♣ The iterative process of testing the most promising solutions and modifying what is proposed on the basis of the test results leads to greater refinement and ultimately to an optimal solution. (MS-ETS1-4)

Crosscutting Concepts

Influence of Science, Engineering, and Technology on Society and the Natural World

- ♣ All human activity draws on natural resources and has both short and long-term consequences, positive as well as negative, for the health of people and the natural environment. (MS-ETS1-1)
- ♣ The uses of technologies and limitations on their use are driven by individual or societal needs, desires, and values; by the findings of scientific research; and by differences in such factors as climate, natural resources, and economic conditions. (MS-ETS1-1)

Connections to MS-ETS1.A: Defining and Delimiting Engineering Problems include:
Physical Science: MS-PS3-3
Connections to MS-ETS1.B: Developing Possible Solutions Problems include:
Physical Science: MS-PS1-6, MS-PS3-3, **Life Science:** MS-LS2-5
Connections to MS-ETS1.C: Optimizing the Design Solution include:
Physical Science: MS-PS1-6

Articulation of DCIs across grade-bands: **3-5.ETS1.A** (MS-ETS1-1),(MS-ETS1-2),(MS-ETS1-3); **3-5.ETS1.B** (MS-ETS1-2),(MS-ETS1-3),(MS-ETS1-4); **3-5.ETS1.C** (MS-ETS1-2),(MS-ETS1-3),(MS-ETS1-4); **HS.ETS1.A** (MS-ETS1-1),(MS-ETS1-2); **HS.ETS1.B** (MS-ETS1-1),(MS-ETS1-2),(MS-ETS1-3),(MS-ETS1-4); **HS.ETS1.C** (MS-ETS1-3),(MS-ETS1-4)

Common Core State Standards Connections:

ELA/Literacy –

RST.6-8.1 Cite specific textual evidence to support analysis of science and technical texts. (MS-ETS1-1),*(MS-ETS1-2),(MS-ETS1-3)*

RST.6-8.7 Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually (e.g., in a flowchart, diagram, model, graph, or table). *(MS-ETS1-3)*

RST.6-8.9 Compare and contrast the information gained from experiments, simulations, video, or multimedia sources with that gained from reading a text on the same topic. (MS-ETS1-2),(MS-ETS1-3)

WHST.6-8.7 Conduct short research projects to answer a question (including a self-generated question), drawing on several sources and generating additional related, focused questions that allow for multiple avenues of exploration. (MS-ETS1-1),(MS-ETS1-1)

WHST.6-8.8 Gather relevant information from multiple print and digital sources; assess the credibility of each source; and quote or paraphrase the data and conclusions of others while avoiding plagiarism and providing basic bibliographic information for sources. (MS-ETS1-1)

WHST.6-8.9 Draw evidence from informational texts to support analysis, reflection, and research. *(MS-ETS1-2)*

SL.8.5 Include multimedia components and visual displays in presentations to clarify claims and findings and emphasize salient points. *(MS-ETS1-4)*

Mathematics –

MP.2 Reason abstractly and quantitatively. *(MS-ETS1-1),(MS-ETS1-2),(MS-ETS1-3),(MS-ETS1-4)*

7.EE.3 Solve multi-step real-life and mathematical problems posed with positive and negative rational numbers in any form (whole numbers, fractions, and decimals), using tools strategically. Apply properties of operations to calculate with numbers in any form; convert between forms as appropriate; and assess the reasonableness of answers using mental computation and estimation strategies. *(MS-ETS1-1),(MS-ETS1-2),(MS-ETS1-3)*

7.SP.	Develop a probability model and use it to find probabilities of events. Compare probabilities from a model to observed frequencies; if the agreement is not good, explain possible sources of the discrepancy. *(MS-ETS1-4)*

High School Physical Sciences

Students in high school continue to develop their understanding of the four core ideas in the physical sciences. These ideas include the most fundamental concepts from chemistry and physics, but are intended to leave room for expanded study in upper-level high school courses. The high school performance expectations in Physical Science build on the middle school ideas and skills and allow high school students to explain more in-depth phenomena central not only to the physical sciences, but to life and earth and space sciences as well. These performance expectations blend the core ideas with scientific and engineering practices and crosscutting concepts to support students in developing useable knowledge to explain ideas across the science disciplines. In the physical science performance expectations at the high school level, there is a focus on several scientific practices. These include developing and using models, planning and conducting investigations, analyzing and interpreting data, using mathematical and computational thinking, and constructing explanations; and to use these practices to demonstrate understanding of the core ideas. Students are also expected to demonstrate understanding of several engineering practices, including design and evaluation.

The performance expectations in the topic **Structure and Properties of Matter** help students formulate an answer to the question, "How can one explain the structure and properties of matter?" Two sub-ideas from the *NRC Framework* are addressed in these performance expectations: the structure and properties of matter, and nuclear processes. Students are expected to develop understanding of the substructure of atoms and provide more mechanistic explanations of the properties of substances. Students are able to use the periodic table as a tool to explain and predict the properties of elements. Phenomena involving nuclei are also important to understand, as they explain the formation and abundance of the elements, radioactivity, the release of energy from the sun and other stars, and the generation of nuclear power. The crosscutting concepts of patterns, energy and matter, and structure and function are called out as organizing concepts for these disciplinary core ideas. In these performance expectations, students are expected to demonstrate proficiency in developing and using models, planning and conducting investigations, and communicating scientific and technical information; and to use these practices to demonstrate understanding of the core ideas.

The performance expectations in the topic **Chemical Reactions** help students formulate an answer to the questions: "How do substances combine or change (react) to make new substances? How does one characterize and explain these reactions and make predictions about them?" Chemical reactions, including rates of reactions and energy changes, can be understood by students at this level in terms of the collisions of molecules and the rearrangements of atoms. Using this expanded knowledge of chemical reactions, students are able to explain important biological and geophysical phenomena. Students are also able to apply an understanding of the process of optimization in engineering design to chemical reaction systems. The crosscutting concepts of patterns, energy and matter, and stability and change are called out as organizing concepts for these disciplinary core ideas. In these performance expectations, students are expected to demonstrate proficiency in developing and using models, using mathematical thinking, constructing explanations, and designing solutions; and to use these practices to demonstrate understanding of the core ideas.

The Performance Expectations associated with the topic **Forces and Interactions** supports students' understanding of ideas related to why some objects will keep moving, why objects fall to the ground, and why some materials are attracted to each other while others are not. Students should be able to answer the question, "How can one explain and predict interactions between objects and within systems of objects?" The disciplinary core idea expressed in the *Framework* for PS2 is broken down into the sub ideas of Forces and Motion and Types of Interactions. The performance expectations in PS2 focus on students building understanding of forces and interactions and Newton's Second Law. Students also develop understanding that the total momentum of a system of objects is conserved when there is no net force on the system. Students are able to use Newton's Law of Gravitation and Coulomb's Law to describe and predict the gravitational and electrostatic forces between objects. Students are able to apply scientific and engineering ideas to design, evaluate, and refine a device that minimizes the force on a macroscopic object during a collision. The crosscutting concepts of patterns, cause and effect, and systems and system models are called out as organizing concepts for these disciplinary core ideas. In the PS2 performance expectations, students are expected to demonstrate proficiency in planning and conducting investigations, analyzing data and using math to support claims, and applying scientific ideas to solve design problems; and to use these practices to demonstrate understanding of the core ideas.

The Performance Expectations associated with the topic **Energy** help students formulate an answer to the question, "How is energy transferred and conserved?" The disciplinary core idea expressed in the *Framework* for PS3 is broken down into four sub-core ideas: Definitions of Energy, Conservation of Energy and Energy Transfer, the Relationship between Energy and Forces, and Energy in Chemical Process and Everyday Life. Energy is understood as quantitative property of a system that depends on the motion and interactions of matter and radiation within that system, and the total change of energy in any system is always equal to the total energy transferred into or out of the system. Students develop an understanding that energy at both the macroscopic and the atomic scale can be accounted for as either motions of particles or energy stored in fields. Students also demonstrate their understanding of engineering principles when they design, build, and refine devices associated with the conversion of energy. The crosscutting concepts of cause and effect; systems and system models; energy and matter; and the influence of science, engineering, and technology on society and the natural world are further developed in the performance expectations associated with PS3. In these performance expectations, students are expected to demonstrate proficiency in developing and using models, planning and carry out investigations, using computational thinking, and designing solutions; and to use these practices to demonstrate understanding of the core ideas.

The Performance Expectations associated with the topic **Waves and Electromagnetic Radiation** are critical to understand how many new technologies work. As such, this disciplinary core idea helps students answer the question, "How are waves used to transfer energy and send and store information?" The disciplinary core idea in PS4 is broken down into Wave Properties, Electromagnetic Radiation, and Information Technologies and Instrumentation. Students are able to apply understanding of how wave properties and the interactions of electromagnetic radiation with matter can transfer information across long distances, store information, and investigate nature on many scales. Models of electromagnetic radiation as either a wave of changing electric and magnetic fields or as particles are developed and used. Students understand that combining waves of different frequencies can make a wide variety of patterns and thereby encode and transmit information. Students also demonstrate their understanding of engineering ideas by presenting information about how technological devices use the principles of wave behavior and wave interactions with matter to transmit and capture information and energy. The crosscutting concepts of cause and effect; systems and system models; stability and change; interdependence of science, engineering, and technology; and the influence of engineering, technology, and science on society and the natural world are highlighted as organizing concepts for these disciplinary core ideas. In the PS3 performance expectations, students are expected to demonstrate proficiency in asking questions, using mathematical thinking, engaging in argument from evidence, and obtaining, evaluating and communicating information; and to use these practices to demonstrate understanding of the core ideas.

High School Life Sciences

Students in high school develop understanding of key concepts that help them make sense of life science. The ideas are building upon students' science understanding of disciplinary core ideas, science and engineering practices, and crosscutting concepts from earlier grades. There are five life science topics in high school: *1) Structure and Function, 2) Inheritance and Variation of Traits, Matter and Energy in Organisms and Ecosystems, 4) Interdependent Relationships in Ecosystems, and 5) Natural Selection and Evolution.* The performance expectations for high school life science blend core ideas with scientific and engineering practices and crosscutting concepts to support students in developing useable knowledge that can be applied across the science disciplines. While the performance expectations in high school life science couple particular practices with specific disciplinary core ideas, instructional decisions should include use of many practices underlying the performance expectations. The performance expectations are based on the grade-band endpoints described in *A Framework for K-12 Science Education* (NRC, 2012).

The performance expectations in the topic ***Structure and Function*** help students formulate an answer to the question: "How do the structures of organisms enable life's functions?" High school students are able to investigate explanations for the structure and function of cells as the basic units of life, the hierarchical systems of organisms, and the role of specialized cells for maintenance and growth. Students demonstrate understanding of how systems of cells function together to support the life processes. Students demonstrate their understanding through critical reading, using models, and conducting investigations. The crosscutting concepts of structure and function, matter and energy, and systems and system models in organisms are called out as organizing concepts.

The performance expectations in the topic ***Inheritance and Variation of Traits*** help students in pursuing an answer to the question: "How are the characteristics from one generation related to the previous generation?" High school students demonstrate understanding of the relationship of DNA and chromosomes in the processes of cellular division that pass traits from one generation to the next. Students can determine why individuals of the same species vary in how they look, function, and behave. Students can develop conceptual models for the role of DNA in the unity of life on Earth and use statistical models to explain the importance of variation within populations for the survival and evolution of species. Ethical issues related to genetic modification of organisms and the nature of science can be described. Students can explain the mechanisms of genetic inheritance and describe the environmental and genetic causes of gene mutation and the alteration of gene expression. Crosscutting concepts of structure and function, patterns, and cause and effect developed in this topic help students to generalize understanding of inheritance of traits to other applications in science.

The performance expectations in the topic ***Matter and Energy in Organisms and Ecosystems*** help students answer the questions: "How do organisms obtain and use energy they need to live and grow? How do matter and energy move through ecosystems?" High school students can construct explanations for the role of energy in the cycling of matter in organisms and ecosystems. They can apply mathematical concepts to develop evidence to support explanations of the interactions of photosynthesis and cellular respiration and develop models to communicate these explanations. They can relate the nature of science to how explanations may change in light of new evidence and the implications for our understanding of the tentative nature of science. Students understand organisms' interactions with each other and their physical environment, how organisms obtain resources, change the environment, and how these changes affect both organisms and ecosystems. In addition, students can utilize the crosscutting concepts of matter and energy and Systems and system models to make sense of ecosystem dynamics.

The performance expectations in the topic ***Interdependent Relationships in Ecosystems*** help students answer the question, "How do organisms interact with the living and non-living environment to obtain matter and energy?" This topic builds on the other topics as high school students demonstrate an ability to investigate the role of biodiversity in ecosystems and the role of animal behavior on survival of individuals and species. Students have increased understanding of interactions among organisms and how those interactions influence the dynamics of ecosystems. Students can generate mathematical comparisons, conduct investigations, use models, and apply scientific reasoning to link evidence to explanations about interactions and changes within ecosystems.

The performance expectations in the topic ***Natural Selection and Evolution*** help students answer the questions: "How can there be so many similarities among organisms yet so many different plants, animals, and microorganisms? How does biodiversity affect humans?" High school students can investigate patterns to find the relationship between the environment and natural selection. Students demonstrate understanding of the factors causing natural selection and the process of evolution of species over time. They demonstrate understanding of how multiple lines of evidence contribute to the strength of scientific theories of natural selection and evolution. Students can demonstrate an understanding of the processes that change the distribution of traits in a population over time and describe extensive scientific evidence ranging from the fossil record to genetic relationships among species that support the theory of biological evolution. Students can use models, apply statistics, analyze data, and produce scientific communications about evolution. Understanding of the crosscutting concepts of patterns, scale, structure and function, and cause and effect supports the development of a deeper understanding of this topic.

High School Earth and Space Sciences

Students in high school develop understanding of a wide range of topics in Earth and space science (ESS) that build upon science concepts from middle school through more advanced content, practice, and crosscutting themes. There are five ESS standard topics in middle school: *Space Systems*, *History of Earth*, *Earth's Systems*, *Weather and Climate*, and *Human Sustainability*. The content of the performance expectations are based on current community-based geoscience literacy efforts such as the Earth Science Literacy Principles (Wysession et al., 2012), and is presented with a greater emphasis on an Earth Systems Science approach. There are strong connections to mathematical practices of analyzing and interpreting data. The performance expectations strongly reflect the many societally relevant aspects of ESS (resources, hazards, environmental impacts) with an emphasis on using engineering and technology concepts to design solutions to challenges facing human society.

Space Systems: High school students can examine the processes governing the formation, evolution, and workings of the solar system and universe. Some concepts studied are fundamental to science, such as understanding how the matter of our world formed during the Big Bang and within the cores of stars. Others concepts are practical, such as understanding how short-term changes in the behavior of our sun directly affect humans. Engineering and technology play a large role here in obtaining and analyzing the data that support the theories of the formation of the solar system and universe.

History of Earth: Students can construct explanations for the scales of time over which Earth processes operate. An important aspect of Earth and space science involves making inferences about events in Earth's history based on a data record that is increasingly incomplete that farther you go back in time. A mathematical analysis of radiometric dating is used to comprehend how absolute ages are obtained for the geologic record. A key to Earth's history is the coevolution of the biosphere with Earth's other systems, not only in the ways that climate and environmental changes have shaped the course of evolution but also in how emerging life forms have been responsible for changing Earth.

Earth's Systems: Students can develop models and explanations for the ways that feedbacks between different Earth systems control the appearance of Earth's surface. Central to this is the tension between internal systems, which are largely responsible for creating land at Earth's surface (e.g., volcanism and mountain building), and the sun-driven surface systems that tear down the land through weathering and erosion. Students understand the role that water plays in affecting weather. Students understand chemical cycles such as the carbon cycle. Students can examine the ways that human activities cause feedbacks that create changes to other systems.

Weather and Climate: Students understand the system interactions that control weather and climate, with a major emphasis on the mechanisms and implications of climate change. Students understand the analysis and interpretation of different kinds of geoscience data allow students to construct explanations for the many factors that drive climate change over a wide range of time scales.

Human Impacts: Students understand the complex and significant interdependencies between humans and the rest of Earth's systems through the impacts of natural hazards, our dependencies on natural resources, and the environmental impacts of human activities.

HS.Structure and Properties of Matter

HS.Structure and Properties of Matter

Students who demonstrate understanding can:

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 of atoms. [Clarification Statement: Examples of properties that could be predicted from patterns could include reactivity of metals, types of bonds formed, numbers of bonds formed, and reactions with oxygen.] [Assessment Boundary: Assessment is limited to main group elements. Assessment does not include quantitative understanding of ionization energy beyond relative trends.]

HS-PS1-3. Plan and conduct an investigation to gather evidence to compare the structure of substances at the bulk scale to infer the strength of electrical forces between particles. [Clarification Statement: Emphasis is on understanding the strengths of forces between particles, and not on naming specific intermolecular forces (such as dipole-dipole). Examples of particles could include ions, atoms, molecules, and networked materials (such as graphite). Examples of bulk properties of substances could include the melting point and boiling point, vapor pressure, and surface tension.] [Assessment Boundary: Assessment does not include Raoult's law calculations of vapor pressure.]

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. [Clarification Statement: 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.] [Assessment Boundary: Assessment does not include quantitative calculation of energy released. Assessment is limited to alpha, beta, and gamma radioactive decays.]

HS-PS2-6. Communicate scientific and technical information about why the molecular-level structure is important in the functioning of designed materials.* [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, flexible but durable materials are made up of long chained molecules, and pharmaceuticals are designed to interact with specific receptors.] [Assessment Boundary: Assessment is limited to provided molecular structures of specific designed materials.]

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*:

Science and Engineering Practices

Developing and Using Models

Modeling in 9–12 builds on K–8 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. (HS-PS1-8)
- ♣ Use a model to predict the relationships between systems or between components of a system. (HS-PS1-1)

Planning and Carrying Out Investigations

Planning and carrying out investigations 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. (HS-PS1-3)

Obtaining, Evaluating, and Communicating Information

Obtaining, evaluating, and communicating information in 9–12 builds on K–8 and progresses to evaluating the validity and reliability of the claims, methods, and designs.

- ♣ Communicate scientific and technical information (e.g. about the process of development and the design and performance of a proposed process or system) in multiple formats (including orally, graphically, textually, and mathematically). (HS-PS2-6)

Disciplinary Core Ideas

PS1.A: 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-PS1-1)
- ♣ 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-PS1-1),(HS-PS1-2)
- ♣ The structure and interactions of matter at the bulk scale are determined by electrical forces within and between atoms. (HS-PS1-3),*(secondary to HS-PS2-6)*

PS1.C: 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-PS1-8)

PS2.B: 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-PS1-1),(HS-PS1-3),(HS-PS2-6)

Crosscutting Concepts

Patterns

- ♣ Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations of phenomena. (HS-PS1-1),(HS-PS1-3)

Energy and Matter

- ♣ In nuclear processes, atoms are not conserved, but the total number of protons plus neutrons is conserved. (HS-PS1-8)

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. (HS-PS2-6)

Connections to other DCIs in this grade-band: **HS.LS1.C** (HS-PS1-1); **HS.PS3.A** (HS-PS1-8); **HS.PS3.B** (HS-PS1-8); **HS.PS3.C** (HS-PS1-8); **HS.PS3.D** (HS-PS1-8); **HS.ESS1.A** (HS-PS1-8); **HS.ESS1.C** (HS-PS1-8); **HS.ESS2.C** (HS-PS1-3); **HS.ESS3.A** (HS-PS1-8); **HS.ESS3.C** (HS-PS1-8)

Articulation to DCIs across grade-bands: **MS.PS1.A** (HS-PS1-1),(HS-PS1-3),(HS-PS1-8); **MS.PS1.B** (HS-PS1-1),(HS-PS1-8); **MS.PS1.C** (HS-PS1-8); **MS.PS2.B** (HS-PS1-3),(HS-PS2-6); **MS.ESS2.A** (HS-PS1-8)

Common Core State Standards Connections:

ELA/Literacy –

RST.11-12.1 Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account. (HS-PS1-3),*(HS-PS2-6)*

RST.9-10.7 Translate quantitative or technical information expressed in words in a text into visual form (e.g., a table or chart) and translate information expressed visually or mathematically (e.g., in an equation) into words. *(HS-PS1-1)*

WHST.9-12.2 Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes. *(HS-PS2-6)*

WHST.9-12.7 Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation. (HS-PS1-3)

WHST.11-12.8 Gather relevant information from multiple authoritative print and digital sources, using advanced searches effectively; assess the strengths and limitations of each source in terms of the specific task, purpose, and audience; integrate information into the text selectively to maintain the flow of ideas, avoiding plagiarism and overreliance on any one source and following a standard format for citation. (HS-PS1-3)

WHST.9-12.9 Draw evidence from informational texts to support analysis, reflection, and research. *(HS-PS1-3)*

Mathematics –

*The performance expectations marked with an asterisk integrate traditional science content with engineering through a Practice or Disciplinary Core Idea. The section entitled "Disciplinary Core Ideas" is reproduced verbatim from A Framework for K-12 Science Education: Practices, Cross-Cutting Concepts, and Core Ideas. Integrated and reprinted with permission from the National Academy of Sciences.

MP.4	Model with mathematics. *(HS-PS1-8)*
HSN-Q.A.1	Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays. *(HS-PS1-3)*,(HS-PS1-8),*(HS-PS2-6)*
HSN-Q.A.2	Define appropriate quantities for the purpose of descriptive modeling. (HS-PS1-8),*(HS-PS2-6)*
HSN-Q.A.3	Choose a level of accuracy appropriate to limitations on measurement when reporting quantities. *(HS-PS1-3),(HS-PS1-8),(HS-PS2-6)*

*The performance expectations marked with an asterisk integrate traditional science content with engineering through a Practice or Disciplinary Core Idea. The section entitled "Disciplinary Core Ideas" is reproduced verbatim from A Framework for K-12 Science Education: Practices, Cross-Cutting Concepts, and Core Ideas. Integrated and reprinted with permission from the National Academy of Sciences.

HS.Chemical Reactions

HS.Chemical Reactions

Students who demonstrate understanding can:

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.

[Clarification Statement: Examples of chemical reactions could include the reaction of sodium and chlorine, of carbon and oxygen, or of carbon and hydrogen.] [Assessment Boundary: Assessment is limited to chemical reactions involving main group elements and combustion reactions.]

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. [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.] [Assessment Boundary: Assessment does not include calculating the total bond energy changes during a chemical reaction from the bond energies of reactants and products.]

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. [Clarification Statement: Emphasis is on student reasoning that focuses on the number and energy of collisions between molecules.] [Assessment Boundary: Assessment is limited to simple reactions in which there are only two reactants; evidence from temperature, concentration, and rate data; and qualitative relationships between rate and temperature.]

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.* [Clarification Statement: Emphasis is on the application of Le Chatlier'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.] [Assessment Boundary: Assessment is limited to specifying the change in only one variable at a time. Assessment does not include calculating equilibrium constants and concentrations.]

HS-PS1-7. Use mathematical representations to support the claim that atoms, and therefore mass, are conserved during a chemical reaction. [Clarification Statement: Emphasis is on using mathematical ideas 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 macroscopic scale. Emphasis is on assessing students' use of mathematical thinking and not on memorization and rote application of problem-solving techniques.] [Assessment Boundary: Assessment does not include complex chemical reactions.]

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*:

Science and Engineering Practices

Developing and Using Models

Modeling in 9–12 builds on K–8 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. (HS-PS1-4)

Using Mathematics and Computational Thinking

Mathematical and computational thinking at the 9–12 level builds on K–8 and progresses to using algebraic thinking and analysis, a range of linear and nonlinear functions including trigonometric functions, exponentials and logarithms, 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 representations of phenomena to support claims. (HS-PS1-7)

Constructing Explanations and Designing Solutions

Constructing explanations and designing solutions 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 principles and evidence to provide an explanation of phenomena and solve design problems, taking into account possible unanticipated effects. (HS-PS1-5)
- ♣ 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. (HS-PS1-2)
- ♣ Refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations. (HS-PS1-6)

Disciplinary Core Ideas

PS1.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-PS1-2) *(Note: This Disciplinary Core Idea is also addressed by HS-PS1-1.)*
- ♣ Stable forms of matter are those in which the electric and magnetic field energy is minimized. 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-PS1-4)

PS1.B: 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-PS1-4),(HS-PS1-5)
- ♣ 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-PS1-6)
- ♣ 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-PS1-2),(HS-PS1-7)

ETS1.C: 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 (trade-offs) may be needed. *(secondary to HS-PS1-6)*

Crosscutting Concepts

Patterns

- ♣ Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations of phenomena. (HS-PS1-2),(HS-PS1-5)

Energy and Matter

- ♣ The total amount of energy and matter in closed systems is conserved. (HS-PS1-7)
- ♣ 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. (HS-PS1-4)

Stability and Change

- ♣ Much of science deals with constructing explanations of how things change and how they remain stable. (HS-PS1-6)

Connections to Nature of Science

Scientific Knowledge Assumes an Order and Consistency in Natural Systems

- ♣ Science assumes the universe is a vast single system in which basic laws are consistent. (HS-PS1-7)

Connections to other DCIs in this grade-band: **HS.LS1.C** (HS-PS1-2),(HS-PS1-4),(HS-PS1-7); **HS.LS2.B** (HS-PS1-7); **HS.PS3.A** (HS-PS1-4),(HS-PS1-5); **HS.PS3.B** (HS-PS1-4),(HS-PS1-6),(HS-PS1-7); **HS.PS3.D** (HS-PS1-4); **HS.ESS2.C** (HS-PS1-2)

Articulation to DCIs across grade-bands: **MS.PS1.A** (HS-PS1-2),(HS-PS1-4),(HS-PS1-5),(HS-PS1-7); **MS.PS1.B** (HS-PS1-2),(HS-PS1-4),(HS-PS1-5),(HS-PS1-6),(HS-PS1-7); **MS.PS2.B** (HS-PS1-3),(HS-PS1-4),(HS-PS1-5); **MS.PS2.C** (HS-PS1-6); **MS.PS3.A** (HS-PS1-5); **MS.PS3.B** (HS-PS1-5); **MS.PS3.D** (HS-PS1-4); **MS.LS1.C** (HS-PS1-4),(HS-PS1-7); **MS.LS2.B** (HS-PS1-7); **MS.ESS2.A** (HS-PS1-7)

Common Core State Standards Connections:

ELA/Literacy –

*The performance expectations marked with an asterisk integrate traditional science content with engineering through a Practice or Disciplinary Core Idea.

HS.Chemical Reactions

RST.11-12.1	Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account. (HS-PS1-5)
WHST.9-12.2	Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes. (HS-PS1-2),*(HS-PS1-5)*
WHST.9-12.5	Develop and strengthen writing as needed by planning, revising, editing, rewriting, or trying a new approach, focusing on addressing what is most significant for a specific purpose and audience. (HS-PS1-2)
WHST.9-12.7	Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation. *(HS-PS1-6)*
SL.11-12.5	Make strategic use of digital media (e.g., textual, graphical, audio, visual, and interactive elements) in presentations to enhance understanding of findings, reasoning, and evidence and to add interest. *(HS-PS1-4)*
Mathematics –	
MP.2	Reason abstractly and quantitatively. (HS-PS1-5),(HS-PS1-7)
MP.4	Model with mathematics. *(HS-PS1-4)*
HSN-Q.A.1	Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays. (HS-PS1-2),*(HS-PS1-4),(HS-PS1-5)*,(HS-PS1-7)
HSN-Q.A.2	Define appropriate quantities for the purpose of descriptive modeling. (HS-PS1-4),*(HS-PS1-7)*
HSN-Q.A.3	Choose a level of accuracy appropriate to limitations on measurement when reporting quantities. *(HS-PS1-2),(HS-PS1-4),(HS-PS1-5),(HS-PS1-7)*

*The performance expectations marked with an asterisk integrate traditional science content with engineering through a Practice or Disciplinary Core Idea.

HS.Forces and Interactions

HS.Forces and Interactions

Students who demonstrate understanding can:

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. [Clarification Statement: 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.] [Assessment Boundary: Assessment is limited to one-dimensional motion and to macroscopic objects moving at non-relativistic speeds.]

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. [Clarification Statement: Emphasis is on the quantitative conservation of momentum in interactions and the qualitative meaning of this principle.] [Assessment Boundary: Assessment is limited to systems of two macroscopic bodies moving in one dimension.]

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.* [Clarification Statement: Examples of evaluation and refinement could include determining the success of a device at protecting an object from damage and modifying the design to improve it. Examples of a device could include a football helmet or a parachute.] [Assessment Boundary: Assessment is limited to qualitative evaluations and/or algebraic manipulations.]

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. [Clarification Statement: Emphasis is on both quantitative and conceptual descriptions of gravitational and electric fields.] [Assessment Boundary: Assessment is limited to systems with two objects.]

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. [Assessment Boundary: Assessment is limited to designing and conducting investigations with provided materials and tools.]

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*:

Science and Engineering Practices

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. (HS-PS2-5)

Analyzing and Interpreting Data

Analyzing data in 9–12 builds on K–8 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. (HS-PS2-1)

Using Mathematics and Computational Thinking

Mathematical and computational thinking at the 9–12 level builds on K–8 and progresses to using algebraic thinking and analysis, a range of linear and nonlinear functions including trigonometric functions, exponentials and logarithms, 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 representations of phenomena to describe explanations. (HS-PS2-2),(HS-PS2-4)

Constructing Explanations and Designing Solutions

Constructing explanations and designing solutions 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 to solve a design problem, taking into account possible unanticipated effects. (HS-PS2-3)

Connections to Nature of Science

Science Models, Laws, Mechanisms, and Theories Explain Natural Phenomena

- ♣ Theories and laws provide explanations in science. (HS-PS2-1),(HS-PS2-4)
- ♣ Laws are statements or descriptions of the relationships among observable phenomena. (HS-PS2-1),(HS-PS2-4)

Disciplinary Core Ideas

PS2.A: Forces and Motion

♣ Newton's second law accurately predicts changes in the motion of macroscopic objects. (HS-PS2-1)

♣ 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-PS2-2)

♣ 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-PS2-2),(HS-PS2-3)

PS2.B: 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 distant objects. (HS-PS2-4)

♣ 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-PS2-4),(HS-PS2-5)

PS3.A: Definitions of Energy

♣ …and "electrical energy" may mean energy stored in a battery or energy transmitted by electric currents. *(secondary to HS-PS2-5)*

ETS1.A: 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. *(secondary to HS-PS2-3)*

ETS1.C: 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 (trade-offs) may be needed. *(secondary to HS-PS2-3)*

Crosscutting Concepts

Patterns

♣ Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations of phenomena. (HS-PS2-4)

Cause and Effect

♣ Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. (HS-PS2-1),(HS-PS2-5)

♣ Systems can be designed to cause a desired effect. (HS-PS2-3)

Systems and System Models

♣ When investigating or describing a system, the boundaries and initial conditions of the system need to be defined. (HS-PS2-2)

Connections to other DCIs in this grade-band: **HS.PS3.A** (HS-PS2-4),(HS-PS2-5); **HS.PS3.C** (HS-PS2-1); **HS.PS4.B** (HS-PS2-5); **HS.ESS1.B** (HS-PS2-4); **HS.ESS2.A** (HS-PS2-5)

Articulation to DCIs across grade-bands: **MS.PS1.A** (HS-PS2-5); **MS.PS2.A** (HS-PS2-1),(HS-PS2-2),(HS-PS2-3); **MS.PS2.B** (HS-PS2-4),(HS-PS2-5); **MS.PS3.C** (HS-PS2-1),(HS-PS2-2),(HS-PS2-3); **MS.ESS1.B** (HS-PS2-4),(HS-PS2-5)

Common Core State Standards Connections:

*The performance expectations marked with an asterisk integrate traditional science content with engineering through a Practice or Disciplinary Core Idea.

HS.Forces and Interactions

ELA/Literacy –	
RST.11-12.1	Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account. *(HS-PS2-1)*
RST.11-12.7	Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., quantitative data, video, multimedia) in order to address a question or solve a problem. (HS-PS2-1)
WHST.9-12.7	Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation. (HS-PS2-3),(HS-PS2-5)
WHST.11-12.8	Gather relevant information from multiple authoritative print and digital sources, using advanced searches effectively; assess the strengths and limitations of each source in terms of the specific task, purpose, and audience; integrate information into the text selectively to maintain the flow of ideas, avoiding plagiarism and overreliance on any one source and following a standard format for citation. *(HS-PS2-5)*
WHST.9-12.9	Draw evidence from informational texts to support analysis, reflection, and research. *(HS-PS2-1),(HS-PS2-5)*
Mathematics –	
MP.2	Reason abstractly and quantitatively. (HS-PS2-1),(HS-PS2-2),(HS-PS2-4)
MP.4	Model with mathematics. (HS-PS2-1),(HS-PS2-2),(HS-PS2-4)
HSN-Q.A.1	Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays. (HS-PS2-1),(HS-PS2-2),(HS-PS2-4),*(HS-PS2-5)*
HSN-Q.A.2	Define appropriate quantities for the purpose of descriptive modeling. *(HS-PS2-1),(HS-PS2-2),(HS-PS2-4),(HS-PS2-5)*
HSN-Q.A.3	Choose a level of accuracy appropriate to limitations on measurement when reporting quantities. (HS-PS2-1),(HS-PS2-2),(HS-PS2-4),*(HS-PS2-5)*
HSA-SSE.A.1	Interpret expressions that represent a quantity in terms of its context. (HS-PS2-1),(HS-PS2-4)
HSA-SSE.B.3	Choose and produce an equivalent form of an expression to reveal and explain properties of the quantity represented by the expression. (HS-PS2-1),(HS-PS2-4)
HSA-CED.A.1	Create equations and inequalities in one variable and use them to solve problems. (HS-PS2-1),(HS-PS2-2)
HSA-CED.A.2	Create equations in two or more variables to represent relationships between quantities; graph equations on coordinate axes with labels and scales. *(HS-PS2-1),(HS-PS2-2)*
HSA-CED.A.4	Rearrange formulas to highlight a quantity of interest, using the same reasoning as in solving equations. *(HS-PS2-1),(HS-PS2-2)*
HSF-IF.C.7	Graph functions expressed symbolically and show key features of the graph, by in hand in simple cases and using technology for more complicated cases. *(HS-PS2-1)*
HSS-ID.A.1	Represent data with plots on the real number line (dot plots, histograms, and box plots). *(HS-PS2-1)*

*The performance expectations marked with an asterisk integrate traditional science content with engineering through a Practice or Disciplinary Core Idea.

HS.Energy

HS.Energy

Students who demonstrate understanding can:

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. [Clarification Statement: Emphasis is on explaining the meaning of mathematical expressions used in the model.] [Assessment Boundary: Assessment is limited to basic algebraic expressions or computations; to systems of two or three components; and to thermal energy, kinetic energy, and/or the energies in gravitational, magnetic, or electric fields.]

HS-PS3-2. Develop and use models to illustrate that energy at the macroscopic scale can be accounted for as either motions of particles or energy stored in fields. [Clarification Statement: Examples of phenomena at the macroscopic scale could include the conversion of kinetic energy to thermal energy, the energy stored due to position of an object above the earth, and the energy stored between two electrically-charged plates. Examples of models could include diagrams, drawings, descriptions, and computer simulations.]

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.* [Clarification Statement: Emphasis is on both qualitative and quantitative evaluations of devices. Examples of devices could include Rube Goldberg devices, wind turbines, solar cells, solar ovens, and generators. Examples of constraints could include use of renewable energy forms and efficiency.] [Assessment Boundary: Assessment for quantitative evaluations is limited to total output for a given input. Assessment is limited to devices constructed with materials provided to students.]

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). [Clarification Statement: Emphasis is on analyzing data from student investigations and using mathematical thinking to describe the energy changes both quantitatively and conceptually. Examples of investigations could include mixing liquids at different initial temperatures or adding objects at different temperatures to water.] [Assessment Boundary: Assessment is limited to investigations based on materials and tools provided to students.]

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. [Clarification Statement: 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, including an explanation of how the change in energy of the objects is related to the change in energy of the field.] [Assessment Boundary: Assessment is limited to systems containing two objects.]

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*:

Science and Engineering Practices

Developing and Using Models

Modeling in 9–12 builds on K–8 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 use a model based on evidence to illustrate the relationships between systems or between components of a system. (HS-PS3-2),(HS-PS3-5)

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. (HS-PS3-4)

Using Mathematics and Computational Thinking

Mathematical and computational thinking at the 9–12 level builds on K–8 and progresses to using algebraic thinking and analysis, a range of linear and nonlinear functions including trigonometric functions, exponentials and logarithms, 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. (HS-PS3-1)

Constructing Explanations and Designing Solutions

Constructing explanations and designing solutions 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

Disciplinary Core Ideas

PS3.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-PS3-1),(HS-PS3-2)
- ♣ At the macroscopic scale, energy manifests itself in multiple ways, such as in motion, sound, light, and thermal energy. (HS-PS3-2) (HS-PS3-3)
- ♣ These relationships are better understood at the microscopic scale, at which all of the different manifestations of energy can be modeled as either motions of particles or energy 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-PS3-2)

PS3.B: 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-PS3-1)
- ♣ Energy cannot be created or destroyed, but it can be transported from one place to another and transferred between systems. (HS-PS3-1),(HS-PS3-4)
- ♣ Mathematical expressions, which 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 speed, allow the concept of conservation of energy to be used to predict and describe system behavior. (HS-PS3-1)
- ♣ The availability of energy limits what can occur in any system. (HS-PS3-1)
- ♣ 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-PS3-4)

PS3.C: Relationship Between Energy and Forces

- ♣ When two objects interacting through a field change relative position, the energy stored in the field is changed. (HS-PS3-5)

PS3.D: Energy in Chemical Processes

- ♣ Although energy cannot be destroyed, it can be converted to less useful forms—for example, to thermal energy in the surrounding environment. (HS-PS3-3),(HS-PS3-4)

Crosscutting Concepts

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. (HS-PS3-5)

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. (HS-PS3-4)
- ♣ 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. (HS-PS3-1)

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. (HS-PS3-3)
- ♣ Energy cannot be created or destroyed—only moves between one place and another place, between objects and/or fields, or between systems. (HS-PS3-2)

Connections to Engineering, Technology, and Applications of Science

Influence of Science, Engineering, and Technology on Society and the Natural World

- ♣ Modern civilization depends on major technological systems. Engineers continuously modify these technological systems by applying scientific knowledge and engineering design practices to increase benefits while decreasing costs and risks. (HS-PS3-3)

Connections to Nature of Science

*The performance expectations marked with an asterisk integrate traditional science content with engineering through a Practice or Disciplinary Core Idea.

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. (HS-PS3-3)	**ETS1.A: 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. *(secondary to HS-PS3-3)*	**Scientific Knowledge Assumes an Order and Consistency in Natural Systems** ♣ Science assumes the universe is a vast single system in which basic laws are consistent. (HS-PS3-1)

Connections to other DCIs in this grade-band: **HS.PS1.A** (HS-PS3-2); **HS.PS1.B** (HS-PS3-1),(HS-PS3-2); **HS.PS2.B** (HS-PS3-2),(HS-PS3-5); **HS.LS2.B** (HS-PS3-1); **HS.ESS2.A** (HS-PS3-1),(HS-PS3-4); **HS.ESS3.A** (HS-PS3-3)

Articulation to DCIs across grade-bands: **MS.PS1.A** (HS-PS3-2); **MS.PS2.B** (HS-PS3-2),(HS-PS3-5); **MS.PS3.A** (HS-PS3-1),(HS-PS3-2),(HS-PS3-3); **MS.PS3.B** (HS-PS3-1),(HS-PS3-3),(HS-PS3-4); **MS.PS3.C** (HS-PS3-2), (HS-PS3-5); **MS.ESS2.A** (HS-PS3-1),(HS-PS3-3)

Common Core State Standards Connections:

ELA/Literacy –

RST.11-12.1 Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account. *(HS-PS3-4)*

WHST.9-12.7 Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation. *(HS-PS3-3,*(HS-PS3-4),*(HS-PS3-5)*

WHST.11-12.8 Gather relevant information from multiple authoritative print and digital sources, using advanced searches effectively; assess the strengths and limitations of each source in terms of the specific task, purpose, and audience; integrate information into the text selectively to maintain the flow of ideas, avoiding plagiarism and overreliance on any one source and following a standard format for citation. (HS-PS3-4),*(HS-PS3-5)*

WHST.9-12.9 Draw evidence from informational texts to support analysis, reflection, and research. *(HS-PS3-4),(HS-PS3-5)*

SL.11-12.5 Make strategic use of digital media (e.g., textual, graphical, audio, visual, and interactive elements) in presentations to enhance understanding of findings, reasoning, and evidence and to add interest. *(HS-PS3-1),(HS-PS3-2),(HS-PS3-5)*

Mathematics –

MP.2 Reason abstractly and quantitatively. (HS-PS3-1),(HS-PS3-2),(HS-PS3-3),(HS-PS3-4),(HS-PS3-5)

MP.4 Model with mathematics. (HS-PS3-1),(HS-PS3-2),(HS-PS3-3),*(HS-PS3-4),*(HS-PS3-5)

HSN-Q.A.1 Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays. (HS-PS3-1),(HS-PS3-3)

HSN-Q.A.2 Define appropriate quantities for the purpose of descriptive modeling. (HS-PS3-1),(HS-PS3-3)

HSN-Q.A.3 Choose a level of accuracy appropriate to limitations on measurement when reporting quantities. (HS-PS3-1),(HS-PS3-3)

*The performance expectations marked with an asterisk integrate traditional science content with engineering through a Practice or Disciplinary Core Idea.

HS.Waves and Electromagnetic Radiation

HS.Waves and Electromagnetic Radiation

Students who demonstrate understanding can:

HS-PS4-1. Use mathematical representations to support a claim regarding relationships among the frequency, wavelength, and speed of waves traveling in various media. [Clarification Statement: Examples of data could include electromagnetic radiation traveling in a vacuum and glass, sound waves traveling through air and water, and seismic waves traveling through the Earth.] [Assessment Boundary: Assessment is limited to algebraic relationships and describing those relationships qualitatively.]

HS-PS4-2. Evaluate questions about the advantages of using a digital transmission and storage of information. [Clarification Statement: Examples of advantages could include that digital information is stable because it can be stored reliably in computer memory, transferred easily, and copied and shared rapidly. Disadvantages could include issues of easy deletion, security, and theft.]

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. [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.] [Assessment Boundary: Assessment does not include using quantum theory.]

HS-PS4-4. Evaluate the validity and reliability of claims in published materials of the effects that different frequencies of electromagnetic radiation have when absorbed by matter. [Clarification Statement: Emphasis is on the idea that 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.] [Assessment Boundary: Assessment is limited to qualitative descriptions.]

HS-PS4-5. Communicate technical information about how some technological devices use the principles of wave behavior and wave interactions with matter to transmit and capture information and energy.* [Clarification Statement: Examples could include solar cells capturing light and converting it to electricity; medical imaging; and communications technology.] [Assessment Boundary: Assesments are limited to qualitative information. Assessments do not include band theory.]

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*:

Science and Engineering Practices

Asking Questions and Defining Problems

Asking questions and defining problems in grades 9–12 builds from grades K–8 experiences and progresses to formulating, refining, and evaluating empirically testable questions and design problems using models and simulations.

- ♣ Evaluate questions that challenge the premise(s) of an argument, the interpretation of a data set, or the suitability of a design. (HS-PS4-2)

Using Mathematics and Computational Thinking

Mathematical and computational thinking at the 9-12 level builds on K-8 and progresses to using algebraic thinking and analysis, a range of linear and nonlinear functions including trigonometric functions, exponentials and logarithms, 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 representations of phenomena or design solutions to describe and/or support claims and/or explanations. (HS-PS4-1)

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 worlds. 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. (HS-PS4-3)

Obtaining, Evaluating, and Communicating Information

Obtaining, evaluating, and communicating information in 9–12 builds on K–8 and progresses to evaluating the validity and reliability of the claims, methods, and designs.

- ♣ Evaluate the validity and reliability of multiple claims that appear in scientific and technical texts or media reports, verifying the data when possible. (HS-PS4-4)
- ♣ Communicate 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 (including orally, graphically, textually, and mathematically). (HS-PS4-5)

Connections to Nature of Science

Science Models, Laws, Mechanisms, and Theories Explain Natural Phenomena

- ♣ A scientific theory is a substantiated explanation of some aspect of the natural world, based on a body of facts that have been repeatedly confirmed through observation and experiment and the

Disciplinary Core Ideas

PS3.D: Energy in Chemical Processes

- ♣ Solar cells are human-made devices that likewise capture the sun's energy and produce electrical energy.

(secondary to HS-PS4-5)

PS4.A: 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-PS4-1)
- ♣ Information can be digitized (e.g., a picture stored as the values of an array of pixels); in this form, it can be stored reliably in computer memory and sent over long distances as a series of wave pulses. (HS-PS4-2),(HS-PS4-5)
- ♣ [From the 3–5 grade band endpoints] 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. (Boundary: The discussion at this grade level is qualitative only; it can be based on the fact that two different sounds can pass a location in different directions without getting mixed up.) (HS-PS4-3)

PS4.B: 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-PS4-3)
- ♣ 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-PS4-4)
- ♣ Photovoltaic materials emit electrons when they absorb light of a high-enough frequency. (HS-PS4-5)

PS4.C: Information Technologies and Instrumentation

- ♣ Multiple technologies based on the understanding of waves and their interactions with matter are part of everyday experiences in the modern world (e.g., medical imaging, communications, scanners) and in scientific research. They are essential tools for producing, transmitting, and capturing signals and for storing and interpreting the information contained in them. (HS-PS4-5)

Crosscutting Concepts

Cause and Effect

- ♣ Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. (HS-PS4-1)
- ♣ 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. (HS-PS4-4)
- ♣ Systems can be designed to cause a desired effect. (HS-PS4-5)

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. (HS-PS4-3)

Stability and Change

- ♣ Systems can be designed for greater or lesser stability. (HS-PS4-2)

Connections to Engineering, Technology, and Applications of Science

Interdependence of Science, Engineering, and Technology

- ♣ Science and engineering complement each other in the cycle known as research and development (R&D). (HS-PS4-5)

Influence of Engineering, Technology, and Science on Society and the Natural World

- ♣ Modern civilization depends on major technological systems. (HS-PS4-2),(HS-PS4-5)
- ♣ Engineers continuously modify these technological systems by applying scientific knowledge and engineering design practices to increase benefits while decreasing costs and risks. (HS-PS4-2)

*The performance expectations marked with an asterisk integrate traditional science content with engineering through a Practice or Disciplinary Core Idea.

science community validates each theory before it is accepted. If new evidence is discovered that the theory does not accommodate, the theory is generally modified in light of this new evidence. (HS-PS4-3)

Connections to other DCIs in this grade-band: **HS.PS1.C** (HS-PS4-4); **HS.PS3.A** (HS-PS4-4),(HS-PS4-5); **HS.PS3.D** (HS-PS4-3),(HS-PS4-4); **HS.ESS1.A** (HS-PS4-3); **HS.ESS2.A** (HS-PS4-1); **HS.ESS2.D** (HS-PS4-3)

Articulation to DCIs across grade-bands: **MS.PS3.D** (HS-PS4-4); **MS.PS4.A** (HS-PS4-1),(HS-PS4-2),(HS-PS4-5); **MS.PS4.B** (HS-PS4-1),(HS-PS4-2),(HS-PS4-3),(HS-PS4-4),(HS-PS4-5); **MS.PS4.C** (HS-PS4-2),(HS-PS4-5); **MS.LS1.C** (HS-PS4-4); **MS.ESS2.D** (HS-PS4-4)

Common Core State Standards Connections:

ELA/Literacy –

RST.11-12.1 Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account. *(HS-PS4-2),(HS-PS4-3),(HS-PS4-4)*

RST.11-12.7 Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., quantitative data, video, multimedia) in order to address a question or solve a problem. *(HS-PS4-1),*(HS-PS4-4)

RST.9-10.8 Assess the extent to which the reasoning and evidence in a text support the author's claim or a recommendation for solving a scientific or technical problem. (HS-PS4-2),(HS-PS4-3),(HS-PS4-4)

RST.11-12.8 Evaluate the hypotheses, data, analysis, and conclusions in a science or technical text, verifying the data when possible and corroborating or challenging conclusions with other sources of information. (HS-PS4-2),(HS-PS4-3),(HS-PS4-4)

WHST.9-12.2 Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes. *(HS-PS4-5)*

WHST.11-12.8 Gather relevant information from multiple authoritative print and digital sources, using advanced searches effectively; assess the strengths and limitations of each source in terms of the specific task, purpose, and audience; integrate information into the text selectively to maintain the flow of ideas, avoiding plagiarism and overreliance on any one source and following a standard format for citation. (HS-PS4-4)

Mathematics –

MP.2 Reason abstractly and quantitatively. (HS-PS4-1),(HS-PS4-3)

MP.4 Model with mathematics. (HS-PS4-1)

HSA-SSE.A.1 Interpret expressions that represent a quantity in terms of its context. (HS-PS4-1),*(HS-PS4-3)*

HSA-SSE.B.3 Choose and produce an equivalent form of an expression to reveal and explain properties of the quantity represented by the expression. *(HS-PS4-1),(HS-PS4-3)*

HSA.CED.A.4 Rearrange formulas to highlight a quantity of interest, using the same reasoning as in solving equations. *(HS-PS4-1),(HS-PS4-3)*

*The performance expectations marked with an asterisk integrate traditional science content with engineering through a Practice or Disciplinary Core Idea.

HS.Structure and Function

HS.Structure and Function

Students who demonstrate understanding can:

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. [Assessment Boundary: Assessment does not include identification of specific cell or tissue types, whole body systems, specific protein structures and functions, or the biochemistry of protein synthesis.]

HS-LS1-2. Develop and use a model to illustrate the hierarchical organization of interacting systems that provide specific functions within multicellular organisms. [Clarification Statement: Emphasis is on functions at the organism system level such as nutrient uptake, water delivery, and organism movement in response to 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.] [Assessment Boundary: Assessment does not include interactions and functions at the molecular or chemical reaction level.]

HS-LS1-3. Plan and conduct an investigation to provide evidence that feedback mechanisms maintain homeostasis. [Clarification Statement: Examples of investigations could include heart rate response to exercise, stomate response to moisture and temperature, and root development in response to water levels.] [Assessment Boundary: Assessment does not include the cellular processes involved in the feedback mechanism.]

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*:

Science and Engineering Practices

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.
- ♣ Develop and use a model based on evidence to illustrate the relationships between systems or between components of a system. (HS-LS1-2)

Planning and Carrying Out Investigations
Planning and carrying out 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. (HS-LS1-3)

Constructing Explanations and Designing Solutions
Constructing explanations and designing solutions 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. (HS-LS1-1)

Connections to Nature of Science

Scientific Investigations Use a Variety of Methods
- ♣ Scientific inquiry is characterized by a common set of values that include: logical thinking, precision, open-mindedness, objectivity, skepticism, replicability of results, and honest and ethical reporting of findings. (HS-LS1-3)

Disciplinary Core Ideas

LS1.A: Structure and Function
- ♣ Systems of specialized cells within organisms help them perform the essential functions of life. (HS-LS1-1)
- ♣ All cells contain genetic information in the form of DNA molecules. Genes are regions in the DNA that contain the instructions that code for the formation of proteins, which carry out most of the work of cells. (HS-LS1-1) *(Note: This Disciplinary Core Idea is also addressed by HS-LS3-1.)*
- ♣ 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-LS1-2)
- ♣ Feedback mechanisms maintain a living system's internal conditions within certain limits and mediate behaviors, allowing it to remain alive and functional even as external conditions change within some range. Feedback mechanisms can encourage (through positive feedback) or discourage (negative feedback) what is going on inside the living system. (HS-LS1-3)

Crosscutting Concepts

Systems and System Models
- ♣ Models (e.g., physical, mathematical, computer models) can be used to simulate systems and interactions—including energy, matter, and information flows—within and between systems at different scales. (HS-LS1-2)

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. (HS-LS1-1)

Stability and Change
- ♣ Feedback (negative or positive) can stabilize or destabilize a system. (HS-LS1-3)

Connections to other DCIs in this grade-band: **HS.LS3.A** (HS-LS1-1)

Articulation across grade-bands: **MS.LS1.A** (HS-LS1-1),(HS-LS1-2),(HS-LS1-3); **MS.LS3.A** (HS-LS1-1); **MS.LS3.B** (HS-LS1-1)

Common Core State Standards Connections:

ELA/Literacy –

RST.11-12.1 Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account. (HS-LS1-1)

WHST.9-12.2 Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes. (HS-LS1-1)

WHST.9-12.7 Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation. (HS-LS1-3)

WHST.11-12.8 Gather relevant information from multiple authoritative print and digital sources, using advanced searches effectively; assess the strengths and limitations of each source in terms of the specific task, purpose, and audience; integrate information into the text selectively to maintain the flow of ideas, avoiding plagiarism and overreliance on any one source and following a standard format for citation. *(HS-LS1-3)*

WHST.9-12.9 Draw evidence from informational texts to support analysis, reflection, and research. (HS-LS-1-1)

SL.11-12.5 Make strategic use of digital media (e.g., textual, graphical, audio, visual, and interactive elements) in presentations to enhance understanding of findings, reasoning, and evidence and to add interest. *(HS-LS1-2)*

*The performance expectations marked with an asterisk integrate traditional science content with engineering through a Practice or Disciplinary Core Idea.

HS.Matter and Energy in Organisms and Ecosystems

HS.Matter and Energy in Organisms and Ecosystems

Students who demonstrate understanding can:

HS-LS1-5. Use a model to illustrate how photosynthesis transforms light energy into stored chemical energy. [Clarification Statement: Emphasis is on illustrating inputs and outputs of matter and the transfer and transformation of energy in photosynthesis by plants and other photosynthesizing organisms. Examples of models could include diagrams, chemical equations, and conceptual models.] [Assessment Boundary: Assessment does not include specific biochemical steps.]

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. [Clarification Statement: Emphasis is on using evidence from models and simulations to support explanations.] [Assessment Boundary: Assessment does not include the details of the specific chemical reactions or identification of macromolecules.]

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. [Clarification Statement: Emphasis is on the conceptual understanding of the inputs and outputs of the process of cellular respiration.] [Assessment Boundary: Assessment should not include identification of the steps or specific processes involved in cellular respiration.]

HS-LS2-3. Construct and revise an explanation based on evidence for the cycling of matter and flow of energy in aerobic and anaerobic conditions. [Clarification Statement: Emphasis is on conceptual understanding of the role of aerobic and anaerobic respiration in different environments.] [Assessment Boundary: Assessment does not include the specific chemical processes of either aerobic or anaerobic respiration.]

HS-LS2-4. Use a mathematical representation to support claims for the cycling of matter and flow of energy among organisms in an ecosystem. [Clarification Statement: Emphasis is on using a mathematical model of stored energy in biomass to describe the transfer of energy from one trophic level to another and that matter and energy are conserved as matter cycles and energy flows through ecosystems. Emphasis is on atoms and molecules such as carbon, oxygen, hydrogen and nitrogen being conserved as they move through an ecosystem.] [Assessment Boundary: Assessment is limited to proportional reasoning to describe the cycling of matter and flow of energy.]

HS-LS2-5. Develop a model to illustrate the role of photosynthesis and cellular respiration in the cycling of carbon among the biosphere, atmosphere, hydrosphere, and geosphere. [Clarification Statement: Examples of models could include simulations and mathematical models.] [Assessment Boundary: Assessment does not include the specific chemical steps of photosynthesis and respiration.]

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*:

Science and Engineering Practices

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.

♣ Use a model based on evidence to illustrate the relationships between systems or between components of a system. (HS-LS1-5),(HS-LS1-7)

♣ Develop a model based on evidence to illustrate the relationships between systems or components of a system. (HS-LS2-5)

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 trigonometric functions, exponentials and logarithms, 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 representations of phenomena or design solutions to support claims. (HS-LS2-4)

Constructing Explanations and Designing Solutions

Constructing explanations and designing solutions 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. (HS-LS1-6),(HS-LS2-3)

Connections to Nature of Science

Scientific Knowledge is Open to Revision in Light of New Evidence

♣ Most scientific knowledge is quite durable, but is, in principle, subject to change based on new evidence and/or reinterpretation of existing evidence. (HS-LS2-3)

Disciplinary Core Ideas

LS1.C: 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-LS1-5)

♣ 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-LS1-6)

♣ As matter and energy flow through different organizational levels of living systems, chemical elements are recombined in different ways to form different products. (HS-LS1-6),(HS-LS1-7)

♣ As a result of these chemical reactions, energy is transferred from one system of interacting molecules to another and release energy to the surrounding environment and to maintain body temperature. Cellular respiration is a chemical process whereby the bonds of food molecules and oxygen molecules are broken and new compounds are formed that can transport energy to muscles. (HS-LS1-7)

LS2.B: Cycles of Matter and Energy Transfer in Ecosystems

♣ Photosynthesis and cellular respiration (including anaerobic processes) provide most of the energy for life processes. (HS-LS2-3)

♣ Plants or algae form the lowest level of the food web. At each link upward in a food web, only a small fraction of the matter consumed at the lower level is transferred upward, to produce growth and release energy in cellular respiration at the higher level. Given this inefficiency, there are generally fewer organisms at higher levels of a food web. Some matter reacts to release energy for life functions, some matter is stored in newly made structures, and much is discarded. The chemical elements that make up the molecules of organisms pass through food webs and into and out of the atmosphere and soil, and they are combined and recombined in different ways. At each link in an ecosystem, matter and energy are conserved. (HS-LS2-4)

♣ Photosynthesis and cellular respiration are important components of the carbon cycle, in which carbon is exchanged among the biosphere, atmosphere, oceans, and geosphere through chemical, physical, geological, and biological processes. (HS-LS2-5)

PS3.D: Energy in Chemical Processes

♣ The main way that solar energy is captured and stored on Earth is through the complex chemical process known as photosynthesis. *(secondary to HS-LS2-5)*

Crosscutting Concepts

Systems and System Models

♣ Models (e.g., physical, mathematical, computer models) can be used to simulate systems and interactions—including energy, matter, and information flows—within and between systems at different scales. (HS-LS2-5)

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. (HS-LS1-5), (HS-LS1-6)

♣ Energy cannot be created or destroyed—it only moves between one place and another place, between objects and/or fields, or between systems.(HS-LS1-7),(HS-LS2-4)

♣ Energy drives the cycling of matter within and between systems. (HS-LS2-3)

Connections to other DCIs in this grade-band: **HS.PS1.B** (HS-LS1-5),(HS-LS1-6),(HS-LS1-7),(HS-LS2-3),(HS-LS2-5); **HS.PS2.B** (HS-LS1-7); **HS.PS3.B** (HS-LS1-5),(HS-LS1-7),(HS-LS2-3),(HS-LS2-4); **HS.PS3.D** (HS-LS2-3),(HS-LS2-4); **HS.ESS2.A** (HS-LS2-3); **HS.ESS2.D** (HS-LS2-5)

Articulation across grade-bands: **MS.PS1.A** (HS-LS1-6); **MS.PS1.B** (HS-LS1-5),(HS-LS1-6),(HS-LS1-7),(HS-LS2-3); **MS.PS3.D** (HS-LS1-5),(HS-LS1-6),(HS-LS1-7),(HS-LS2-3),(HS-LS2-4),(HS-LS2-5); **MS.LS1.C** (HS-LS1-5),(HS-LS1-6),(HS-LS1-7),(HS-LS2-3),(HS-LS2-4),(HS-LS2-5); **MS.LS2.B** (HS-LS1-5),(HS-LS1-7),(HS-LS2-3),(HS-LS2-4),(HS-LS2-5); **MS.ESS2.A** (HS-LS2-5); **MS.ESS2.E** (HS-LS1-6)

Common Core State Standards Connections:

ELA/Literacy –

RST.11-12.1 Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account. (HS-LS1-6),(HS-LS2-3)

WHST.9-12.2 Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes. (HS-LS1-6),(HS-LS2-3)

WHST.9-12.5 Develop and strengthen writing as needed by planning, revising, editing, rewriting, or trying a new approach, focusing on addressing what is most significant for a specific purpose and audience. (HS-LS1-6),(HS-LS2-3)

WHST.9-12.9 Draw evidence from informational texts to support analysis, reflection, and research. (HS-LS1-6)

Mathematics –

MP.2 Reason abstractly and quantitatively. (HS-LS2-4)

MP.4 Model with mathematics. *(HS-LS2-4)*

HSN-Q.A.1 Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays. (HS-LS2-4)

HSN-Q.A.2 Define appropriate quantities for the purpose of descriptive modeling. *(HS-LS2-4)*

HSN-Q.A.3 Choose a level of accuracy appropriate to limitations on measurement when reporting quantities. (HS-LS2-4)

*The performance expectations marked with an asterisk integrate traditional science content with engineering through a Practice or Disciplinary Core Idea.

HS.Interdependent Relationships in Ecosystems

HS.Interdependent Relationships in Ecosystems

Students who demonstrate understanding can:

HS-LS2-1. Use mathematical and/or computational representations to support explanations of factors that affect carrying capacity of ecosystems at different scales. [Clarification Statement: Emphasis is on quantitative analysis and comparison of the relationships among interdependent factors including boundaries, resources, climate and competition. Examples of mathematical comparisons could include graphs, charts, histograms, or population changes gathered from simulations or historical data sets.] [Assessment Boundary: Assessment does not include deriving mathematical equations to make comparisons.]

HS-LS2-2. Use mathematical representations to support and revise explanations based on evidence about factors affecting biodiversity and populations in ecosystems of different scales. [Clarification Statement: Examples of mathematical representations include finding the average, determining trends, and using graphical comparisons of multiple sets of data.] [Assessment Boundary: Assessment is limited to provided data.]

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. [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.]

HS-LS2-7. Design, evaluate, and refine a solution for reducing the impacts of human activities on the environment and biodiversity.* [Clarification Statement: Examples of human activities can include urbanization, building dams, and dissemination of invasive species.]

HS-LS2-8. Evaluate the evidence for the role of group behavior on individual and species' chances to survive and reproduce. [Clarification Statement: Emphasis is on: (1) distinguishing between group and individual behavior, (2) identifying evidence supporting the outcomes of group behavior, and (3) developing logical and reasonable arguments based on evidence. Examples of group behaviors could include flocking, schooling, herding, and cooperative behaviors such as hunting, migrating, and swarming.]

HS-LS4-6. Create or revise a simulation to test a solution to mitigate adverse impacts of human activity on biodiversity.* [Clarification Statement: Emphasis is on designing solutions for a proposed problem related to threatened or endangered species, or to genetic variation of organisms for multiple species.]

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*:

Science and Engineering Practices

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 trigonometric functions, exponentials and logarithms, 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 and/or computational representations of phenomena or design solutions to support explanations. (HS-LS2-1)
- ♣ Use mathematical representations of phenomena or design solutions to support and revise explanations. (HS-LS2-2)
- ♣ Create or revise a simulation of a phenomenon, designed device, process, or system. (HS-LS4-6)

Constructing Explanations and Designing Solutions

Constructing explanations and designing solutions 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 refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations. (HS-LS2-7)

Engaging in Argument from Evidence

Engaging in argument from evidence in 9–12 builds from 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. (HS-LS2-6)
- ♣ Evaluate the evidence behind currently accepted explanations or solutions to determine the merits of arguments. (HS-LS2-8)

Connections to Nature of Science

Scientific Knowledge is Open to Revision in Light of New Evidence

- ♣ Most scientific knowledge is quite durable, but is, in principle, subject to change based on new evidence and/or reinterpretation of existing evidence. (HS-LS2-2)

Disciplinary Core Ideas

LS2.A: 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 such as predation, competition, and disease. Organisms would have the capacity to produce populations of great size were it not for the fact that environments and resources are finite. This fundamental tension affects the abundance (number of individuals) of species in any given ecosystem. (HS-LS2-1),(HS-LS2-2)

LS2.C: Ecosystem Dynamics, Functioning, and Resilience

- ♣ A complex set of interactions within an ecosystem can keep its numbers and types of organisms relatively constant over long periods of time under stable conditions. If a modest biological or physical disturbance to an ecosystem occurs, it may return to its more or less original status (i.e., the ecosystem is resilient), as opposed to becoming a very different ecosystem. Extreme fluctuations in conditions or the size of any population, however, can challenge the functioning of ecosystems in terms of resources and habitat availability. (HS-LS2-2),(HS-LS2-6)
- ♣ 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-LS2-7)

LS2.D: Social Interactions and Group Behavior

- ♣ Group behavior has evolved because membership can increase the chances of survival for individuals and their genetic relatives. (HS-LS2-8)

LS4.C: 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-LS4-6)

LS4.D: Biodiversity and Humans

- ♣ Biodiversity is increased by the formation of new species (speciation) and decreased by the loss of species (extinction). *(secondary to HS-LS2-7)*

Crosscutting Concepts

Cause and Effect

- ♣ Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. (HS-LS2-8),(HS-LS4-6)

Scale, Proportion, and Quantity

- ♣ The significance of a phenomenon is dependent on the scale, proportion, and quantity at which it occurs. (HS-LS2-1)
- ♣ Using the concept of orders of magnitude allows one to understand how a model at one scale relates to a model at another scale. (HS-LS2-2)

Stability and Change

- ♣ Much of science deals with constructing explanations of how things change and how they remain stable. (HS-LS2-6),(HS-LS2-7)

*The performance expectations marked with an asterisk integrate traditional science content with engineering through a Practice or Disciplinary Core Idea.

HS.Interdependent Relationships in Ecosystems

♣ Scientific argumentation is a mode of logical discourse used to clarify the strength of relationships between ideas and evidence that may result in revision of an explanation. (HS-LS2-6),(HS-LS2-8)	♣ Humans depend on the living world for the resources and other benefits provided by biodiversity. But human activity is also having adverse impacts on biodiversity through overpopulation, overexploitation, habitat destruction, pollution, introduction of invasive species, and climate change. Thus sustaining biodiversity so that ecosystem functioning and productivity are maintained is essential to supporting and enhancing life on Earth. Sustaining biodiversity also aids humanity by preserving landscapes of recreational or inspirational value. *(secondary to HS-LS2-7),* (HS-LS4-6) **ETS1.B: 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. *(secondary to HS-LS2-7),(secondary to HS-LS4-6)* ♣ Both physical models and computers can be used in various ways to aid in the engineering design process. Computers are useful for a variety of purposes, such as running simulations to test different ways of solving a problem or to see which one is most efficient or economical; and in making a persuasive presentation to a client about how a given design will meet his or her needs. *(secondary to HS-LS4-6)*	

Connections to other DCIs in this grade-band: **HS.ESS2.D** (HS-LS2-7),(HS-LS4-6); **HS.ESS2.E** (HS-LS2-2),(HS-LS2-6),(HS-LS2-7),(HS-LS4-6); **HS.ESS3.A** (HS-LS2-2),(HS-LS2-7), (HS-LS4-6); **HS.ESS3.C** (HS-LS2-2),(HS-LS2-7),(HS-LS4-6); **HS.ESS3.D** (HS-LS2-2),(HS-LS4-6)**; HS.ESS3.E** (HS-LS4-6)

Articulation across grade-bands: **MS.LS1.B** (HS-LS2-7); **MS.LS2.A** (HS-LS2-1),(HS-LS2-2),(HS-LS2-6); **MS.LS2.C** (HS-LS2-1),(HS-LS2-2),(HS-LS2-6),(HS-LS2-7),(HS-LS4-6); **MS.ESS3.A** (HS-LS2-1); **MS.ESS3.C** (HS-LS2-1),(HS-LS2-2),(HS-LS2-6),(HS-LS2-7),(HS-LS4-6); **MS.ESS3.D** (HS-LS2-7); **MS.ESS2.E** (HS-LS2-6)

Common Core State Standards Connections:

ELA/Literacy –

RST.11-12.1 Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account. *(HS-LS2-1),(HS-LS2-2),*(HS-LS2-6),(HS-LS2-8)

RST.11-12.7 Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., quantitative data, video, multimedia) in order to address a question or solve a problem. *(HS-LS2-6),(HS-LS2-7),(HS-LS2-8)*

RST.9-10.8 Assess the extent to which the reasoning and evidence in a text support the author's claim or a recommendation for solving a scientific or technical problem. (HS-LS2-6),*(HS-LS2-7),(HS-LS2-8)*

RST.11-12.8 Evaluate the hypotheses, data, analysis, and conclusions in a science or technical text, verifying the data when possible and corroborating or challenging conclusions with other sources of information. (HS-LS2-6),(HS-LS2-7),(HS-LS2-8)

WHST.9-12.2 Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes. *(HS-LS2-1),(HS-LS2-2)*

WHST.9-12.5 Develop and strengthen writing as needed by planning, revising, editing, rewriting, or trying a new approach, focusing on addressing what is most significant for a specific purpose and audience. (HS-LS2-3),*(HS-LS4-6)*

WHST.9-12.7 Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation. (HS-LS2-7),(HS-LS4-6)

Mathematics –

MP.2 Reason abstractly and quantitatively. (HS-LS2-1),(HS-LS2-2),(HS-LS2-6),*(HS-LS2-7)*

MP.4 Model with mathematics. *(HS-LS2-1),(HS-LS2-2)*

HSN-Q.A.1 Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays. (HS-LS2-1),(HS-LS2-2),*(HS-LS2-7)*

HSN-Q.A.2 Define appropriate quantities for the purpose of descriptive modeling. *(HS-LS2-1),(HS-LS2-2),(HS-LS2-7)*

HSN-Q.A.3 Choose a level of accuracy appropriate to limitations on measurement when reporting quantities. (HS-LS2-1),(HS-LS2-2),*(HS-LS2-7)*

HSS-ID.A.1 Represent data with plots on the real number line. *(HS-LS2-6)*

HSS-IC.A.1 Understand statistics as a process for making inferences about population parameters based on a random sample from that population. *(HS-LS2-6)*

HSS-IC.B.6 Evaluate reports based on data. *(HS-LS2-6)*

*The performance expectations marked with an asterisk integrate traditional science content with engineering through a Practice or Disciplinary Core Idea.

HS.Inheritance and Variation of Traits

HS.Inheritance and Variation of Traits

Students who demonstrate understanding can:

HS-LS1-4. Use a model to illustrate the role of cellular division (mitosis) and differentiation in producing and maintaining complex organisms. [Assessment Boundary: Assessment does not include specific gene control mechanisms or rote memorization of the steps of mitosis.]

HS-LS3-1. Ask questions to clarify relationships about the role of DNA and chromosomes in coding the instructions for characteristic traits passed from parents to offspring. [Assessment Boundary: Assessment does not include the phases of meiosis or the biochemical mechanism of specific steps in the process.]

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. [Clarification Statement: Emphasis is on using data to support arguments for the way variation occurs.] [Assessment Boundary: Assessment does not include the phases of meiosis or the biochemical mechanism of specific steps in the process.]

HS-LS3-3. Apply concepts of statistics and probability to explain the variation and distribution of expressed traits in a population. [Clarification Statement: Emphasis is on the use of mathematics to describe the probability of traits as it relates to genetic and environmental factors in the expression of traits.] [Assessment Boundary: Assessment does not include Hardy-Weinberg calculations.]

The performance expectations above were developed using the following elements from the NRC document, *A Framework for K-12 Science Education*:

Science and Engineering Practices

Asking Questions and Defining Problems

Asking questions and defining problems 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 relationships. (HS-LS3-1)

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.

- ♣ Use a model based on evidence to illustrate the relationships between systems or between components of a system. (HS-LS1-4)

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 (including determining function fits to data, slope, intercept, and correlation coefficient for linear fits) to scientific and engineering questions and problems, using digital tools when feasible. (HS-LS3-3)

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 that reflects scientific knowledge, and student-generated evidence. (HS-LS3-2)

Disciplinary Core Ideas

LS1.A: 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. *(secondary to HS-LS3-1) (Note: This Disciplinary Core Idea is also addressed by HS-LS1-1.)*

LS1.B: Growth and Development of Organisms

- ♣ In multicellular organisms individual cells grow and then divide via a process called mitosis, thereby allowing the organism to grow. 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. Cellular division and differentiation produce and maintain a complex organism, composed of systems of tissues and organs that work together to meet the needs of the whole organism. (HS-LS1-4)

LS3.A: 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-LS3-1)

LS3.B: Variation of Traits

- ♣ In sexual reproduction, chromosomes can sometimes swap sections during the process of meiosis (cell division), thereby creating new genetic combinations and thus more genetic variation. Although DNA replication is tightly regulated and remarkably accurate, errors do occur and result in mutations, which are also a source of genetic variation. Environmental factors can also cause mutations in genes, and viable mutations are inherited. (HS-LS3-2)
- ♣ 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-LS3-2),(HS-LS3-3)

Crosscutting Concepts

Cause and Effect

- ♣ Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. (HS-LS3-1),(HS-LS3-2)

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). (HS-LS3-3)

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. (HS-LS1-4)

Connections to Nature of Science

Science is a Human Endeavor

- ♣ Technological advances have influenced the progress of science and science has influenced advances in technology. (HS-LS3-3)
- ♣ Science and engineering are influenced by society and society is influenced by science and engineering. (HS-LS3-3)

Connections to other DCIs in this grave-band: **HS.LS2.A** (HS-LS3-3); **HS.LS2.C** (HS-LS3-3); **HS.LS4.B** (HS-LS3-3); **HS.LS4.C** (HS-LS3-3)

Articulation across grade-bands: **MS.LS1.A** (1-LS1-4); **MS.LS1.B** (1-LS1-4); **MS.LS2.A** (HS-LS3-3); **MS.LS3.A** (1-LS1-4),(HS-LS3-1),(HS-LS3-2); **MS.LS3.B** (HS-LS3-1),(HS-LS3-2),(HS-LS3-3); **MS.LS4.C** (HS-LS3-3)

Common Core State Standards Connections:

ELA/Literacy –

RST.11-12.1 Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account. *(HS-LS3-1),(HS-LS3-2)*

RST.11-12.9 Synthesize information from a range of sources (e.g., texts, experiments, simulations) into a coherent understanding of a process, phenomenon, or concept resolving conflicting information when possible. *(HS-LS3-1)*

WHST.9-12.1 Write arguments focused on *discipline-specific content.* (HS-LS3-2)

SL.11-12.5 Make strategic use of digital media (e.g., textual, graphical, audio, visual, and interactive elements) in presentations to enhance understanding of findings, reasoning, and evidence and to add interest. *(HS-LS1-4)*

Mathematics –

*The performance expectations marked with an asterisk integrate traditional science content with engineering through a Practice or Disciplinary Core Idea.

HS.Inheritance and Variation of Traits

MP.2	Reason abstractly and quantitatively. (HS-LS3-2),(HS-LS3-3)
MP.4	Model with mathematics. *(HS-LS1-4)*
HSF-IF.C.7	Graph functions expressed symbolically and show key features of the graph, by hand in simple cases and using technology for more complicated cases. *(HS-LS1-4)*
HSF-BF.A.1	Write a function that describes a relationship between two quantities. *(HS-LS1-4)*

*The performance expectations marked with an asterisk integrate traditional science content with engineering through a Practice or Disciplinary Core Idea.

HS.Natural Selection and Evolution

HS.Natural Selection and Evolution

Students who demonstrate understanding can:

HS-LS4-1. Communicate scientific information that common ancestry and biological evolution are supported by multiple lines of empirical evidence. [Clarification Statement: Emphasis is on a conceptual understanding of the role each line of evidence has relating to common ancestry and biological evolution. Examples of evidence could include similarities in DNA sequences, anatomical structures, and order of appearance of structures in embryological development.]

HS-LS4-2. Construct an explanation based on evidence that the process of evolution primarily results from four factors: (1) the potential for a species to increase in number, (2) the heritable genetic variation of individuals in a species due to mutation and sexual reproduction, (3) competition for limited resources, and (4) the proliferation of those organisms that are better able to survive and reproduce in the environment. [Clarification Statement: Emphasis is on using evidence to explain the influence each of the four factors has on number of organisms, behaviors, morphology, or physiology in terms of ability to compete for limited resources and subsequent survival of individuals and adaptation of species. Examples of evidence could include mathematical models such as simple distribution graphs and proportional reasoning.] [Assessment Boundary: Assessment does not include other mechanisms of evolution, such as genetic drift, gene flow through migration, and co-evolution.]

HS-LS4-3. Apply concepts of statistics and probability to support explanations that organisms with an advantageous heritable trait tend to increase in proportion to organisms lacking this trait. [Clarification Statement: Emphasis is on analyzing shifts in numerical distribution of traits and using these shifts as evidence to support explanations.] [Assessment Boundary: Assessment is limited to basic statistical and graphical analysis. Assessment does not include allele frequency calculations.]

HS-LS4-4. Construct an explanation based on evidence for how natural selection leads to adaptation of populations. [Clarification Statement: Emphasis is on using data to provide evidence for how specific biotic and abiotic differences in ecosystems (such as ranges of seasonal temperature, long-term climate change, acidity, light, geographic barriers, or evolution of other organisms) contribute to a change in gene frequency over time, leading to adaptation of populations.]

HS-LS4-5. Evaluate the evidence supporting claims that changes in environmental conditions may result in: (1) increases in the number of individuals of some species, (2) the emergence of new species over time, and (3) the extinction of other species. [Clarification Statement: Emphasis is on determining cause and effect relationships for how changes to the environment such as deforestation, fishing, application of fertilizers, drought, flood, and the rate of change of the environment affect distribution or disappearance of traits in species.]

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*:

Science and Engineering Practices

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 (including determining function fits to data, slope, intercept, and correlation coefficient for linear fits) to scientific and engineering questions and problems, using digital tools when feasible. (HS-LS4-3)

Constructing Explanations and Designing Solutions

Constructing explanations and designing solutions 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. (HS-LS4-2),(HS-LS4-4)

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 or historical episodes in science.

- ♣ Evaluate the evidence behind currently accepted explanations or solutions to determine the merits of arguments. (HS-LS4-5)

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 information (e.g., about phenomena and/or the process of development and the design and performance of a proposed process or system) in multiple formats (including orally, graphically, textually, and mathematically). (HS-LS4-1)

Connections to Nature of Science

Science Models, Laws, Mechanisms, and Theories Explain Natural Phenomena

- ♣ A scientific theory is a substantiated explanation of some aspect of

Disciplinary Core Ideas

LS4.A: 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 anatomical and embryological evidence. (HS-LS4-1)

LS4.B: Natural Selection

- ♣ Natural selection occurs only if there is both (1) variation in the genetic information between organisms in a population and (2) variation in the expression of that genetic information—that is, trait variation—that leads to differences in performance among individuals. (HS-LS4-2),(HS-LS4-3)
- ♣ The traits that positively affect survival are more likely to be reproduced, and thus are more common in the population. (HS-LS4-3)

LS4.C: Adaptation

- ♣ Evolution is a consequence of the interaction of four factors: (1) the potential for a species to increase in number, (2) the genetic variation of individuals in a species due to mutation and sexual reproduction, (3) competition for an environment's limited supply of the resources that individuals need in order to survive and reproduce, and (4) the ensuing proliferation of those organisms that are better able to survive and reproduce in that environment. (HS-LS4-2)
- ♣ Natural selection leads to adaptation, that is, to a population dominated by organisms that are anatomically, behaviorally, and physiologically well suited to survive and reproduce in a specific environment. That is, the differential survival and reproduction of organisms in a population that have an advantageous heritable trait leads to an increase in the proportion of individuals in future generations that have the trait and to a decrease in the proportion of individuals that do not. (HS-LS4-3),(HS-LS4-4)
- ♣ Adaptation also means that the distribution of traits in a population can change when conditions change. (HS-LS4-3)
- ♣ 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-LS4-5)
- ♣ Species become extinct because they can no longer survive

Crosscutting Concepts

Patterns

- ♣ Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations of phenomena. (HS-LS4-1),(HS-LS4-3)

Cause and Effect

- ♣ Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. (HS-LS4-2),(HS-LS4-4),(HS-LS4-5)

Connections to Nature of Science

Scientific Knowledge Assumes an Order and Consistency in Natural Systems

- ♣ Scientific knowledge is based on the assumption that natural laws operate today as they did in the past and they will continue to do so in the future. (HS-LS4-1),(HS-LS4-4)

*The performance expectations marked with an asterisk integrate traditional science content with engineering through a Practice or Disciplinary Core Idea.