South Dakota Science Standards

Adopted by the South Dakota Board of Education *TBD*

Acknowledgements

These revised science standards are the result of the contributions of several educators from across the state. Many hours have been devoted to research and thoughtful consideration of issues to ensure the standards reflect rigorous science teaching and opportunities for students to learn essential science concepts and procedures with deep understanding. The Science Standards Revision Committee members represent the many individuals across the state dedicated to their profession and to high quality science education for all South Dakota students. Without their contributions the revision of the science content standards would not have been possible. The South Dakota Department of Education wishes to express our appreciation and gratitude to the individuals and the organizations they represent who contributed both expertise and time to the revision of South Dakota's Science Content Standards.

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Preface

In 2014, with input from K-16 educators, administrators, community members, and informal educators from across South Dakota, the Science Standards Revision Workgroup was charged with evaluating the 2005 South Dakota Science Standards. Following the evaluation of the South Dakota Science Standards, it was determined by the group that rewriting was necessary to reflect the most recent research in science teaching and learning. This document was guided by recent research in best practices in science teaching, experience in classrooms with the existing South Dakota Content Standards, the progression of recently published standards from Massachusetts and South Carolina, the Next Generation Science Standards document, the National Research Council's Framework for K-12 Science Education, and lengthy discussions by experienced kindergarten through grade sixteen South Dakota educators.

The standards were constructed from the three major dimensions: Science and Engineering Practices, Disciplinary Core Ideas, and Crosscutting Concepts. With student mastery of these dimensions, South Dakota schools will be competitive with the best educational systems in other states and nations. The standards are coherent, adaptable, rigorous, attainable, and represent South Dakota's commitment to excellence for all students. The standards have been restructured to reflect current research and science and engineering practices, and will be reevaluated in future years in accordance with the state standards adoption timeline.

SD Codified Law 13-3-48. Standards revision cycle--Content standards. The secretary of the Department of Education shall prepare and submit for approval of the South Dakota Board of Education a standards revision cycle and content standards for kindergarten through grade twelve.

Introduction

The South Dakota Science Standards realize a vision for science education in which students are expected to actively engage in science and engineering practices and apply crosscutting concepts to deepen their understanding of core ideas. These standards are designed to guide the planning of instruction and the development of assessments of learning from kindergarten through twelfth grade. This document presents a starting point for informed dialogue among those dedicated and committed to quality education in South Dakota. By providing a common set of expectations for all students in all schools, this dialogue will be strengthened and enhanced.

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KEY SHIFTS IN 2014 SOUTH DAKOTA SCIENCE STANDARDS

K-12 Science Education should reflect the interconnected nature of science as it is practiced and experienced in the real world.

These standards integrate disciplinary core ideas, crosscutting concepts, and science and engineering practices. Past South Dakota Science Standards focus almost exclusively on content. The integration of rigorous core ideas, concepts, and practices reflect how science and engineering is applied and practiced every day and is shown to enhance student learning of both.

South Dakota Science Standards are set forth to ensure graduates of South Dakota's public schools have the knowledge, skills, and competencies essential to be college, career, and life ready.

These standards detail key knowledge and skills students need to succeed in entry-level, credit- bearing science courses in postsecondary schools; certificate or workplace training programs requiring an equivalent level of science; as well as jobs and postsecondary opportunities that require scientific and technical proficiency.

The South Dakota Science Standards are expectations for student outcomes– NOT curriculum.

Each standard has a specific integration of the three dimensions (Science and Engineering Practices, Disciplinary Core Ideas, and Crosscutting Concepts). The designated integrations of the South Dakota Standards do not predetermine how the three are linked in curriculum, units, or lessons. These standards simply clarify the expectations of what students will know and be able to do by the end of the grade level or grade band.

Previous South Dakota Science Standards treated the three dimensions of science as separate entities leading to preferential treatment of singular dimensions in assessment or instruction. It is essential to understand that the emphasis placed on a particular Science and Engineering Practice or Crosscutting Concept in a standard is not intended to limit instruction, but to make clear the intent of the assessments. During the course of instruction, students will engage in multiple Science and Engineering Practices to reach the learning outcome set by the teacher.

The South Dakota Science Standards build coherently from K–12.

The focus on a few Disciplinary Core Ideas is a key aspect of a coherent science education. The Framework identified a basic set of core ideas that are meant to be understood by the time a student completes high school:

> "To develop a thorough understanding of scientific explanations of the world, students need sustained opportunities to work with and develop the underlying ideas and to appreciate those ideas' interconnections over a period of years rather than weeks or months [1]. This sense of development has been conceptualized in the idea of learning progressions [1, 25, 26]. If mastery of a core idea in a science discipline is the ultimate educational destination, then well-designed learning progressions provide a map of the routes that can be taken to reach that destination. Such progressions describe both how students' understanding of the idea matures over time and the instructional supports and experiences that are needed for them to make progress."
>
> (2011). *A Framework for K-12 Science Education: Practices, crosscutting concepts, and core ideas*. (p. 26). Washington, DC: The National Academies Press. Retrieved from http://www.nap.edu/catalog.php?record_id=13165

There are **two key points** that are important to understand:

First, focus and coherence must be a priority. What this means to teachers and curriculum developers is that the same ideas or details are not covered each year. Rather, a progression of knowledge occurs from grade band to grade band that gives students the opportunity to learn more complex material, leading to an overall understanding of science by the end of high school. Historically, science education was taught as a set of disjointed and isolated facts. The Framework and the South Dakota Science Standards provide a more coherent progression aimed at overall scientific literacy with instruction focused on a smaller set of ideas.

Second, the progressions in the South Dakota Science Standards automatically assume that previous material has been learned by the student. Choosing to omit content at any grade level or band will impact the success of the student in understanding the core ideas and put additional responsibilities on teachers later in the process.

Science and Engineering are integrated in the South Dakota Science Standards, from K–12.

The idea of integrating technology and engineering into science standards is not new. Chapters on the nature of technology and the human-built world were included in Science for All Americans (AAAS 1989) and Benchmarks for Science Literacy (AAAS 1993, 2008). Standards for "Science and Technology" were included for all grade bands in the National Science Education Standards (NRC 1996).

Engineering is integrated within the discipline specific standards in areas of Life Science, Physical Science, and Earth/Space Sciences. This integration is achieved by raising engineering design to the same level as scientific inquiry in classroom instruction. Engineering is included in the science and engineering practices and technology is included in the crosscutting concepts.

South Dakota Science Standards focus on deeper understanding and application of concepts.

These standards are focused on a small set of disciplinary core ideas that build across grades and lead to deeper understanding and application of concepts. The standards are written to articulate the broad concepts and key components that specify expected learning

South Dakota Science Standards provide relevance to students in South Dakota.

Life Science:
It is crucial that South Dakota students have a strong foundation in life science in order to maintain their own health as well as the ecosystems in which they live and work. South Dakota's agricultural economy recognizes the importance of breeding selective traits in both plants and animals. Understanding DNA and genetics can be applied to modern agriculture and medicine by emphasizing biotechnology, genetically modified organisms, and the development of resistant pests. South Dakota's geological and archeological history gives students a relevant context to understand the fossil evidence to support changes over time. Students must be able to evaluate and mitigate the effects of human activity in order to protect biodiversity within the state's diverse ecosystems. Proper management of the state's wildlife and recreational activities rely upon an understanding of carrying capacities so that these activities can continue to be enjoyed by future generations of South Dakotans.

Physical Science:
From a local context, South Dakota students will appreciate how production of ethanol for use as a gasoline additive involves chemical reactions and that developing techniques for specifying the molecular and energy changes involved in these reactions will enhance the production of this fuel. Students will be able to understand the substructure of the atom and subatomic particles and be able to use that knowledge to understand work being done at the Sanford Underground Research Facility.

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They will be able to understand how forces interacting can change the behavior of objects. This is essential for everything from daily activities, like driving a car, to engineering the building of structures that can withstand tornadoes or generate the electricity we use. Students will be able to analyze data and interpret graphs in order to solve problems unique to South Dakota, such as the sustainability of land, crop, water, and livestock conservation. The study of wave properties and information technology, enhanced by an understanding of wave mechanics in systems and models, will allow students to understand and appreciate the importance of electronics, digital equipment, and information storage and transfer in the global market of the 21st century.

Earth and Space Science:
South Dakota is rich in geologic resources, many unique to the Great Plains. Grasslands, the Badlands, Black Hills, and Missouri River Basin all provide unique opportunities for students to investigate the Earth and its interacting systems. In South Dakota, the use, management, and protection of natural resources have an economic, social, environmental, and geopolitical impact. Natural hazard mitigation (severe weather, flooding, and drought) has a direct impact on the people and environment of our state. Human activities in agriculture, industry, and everyday life have major impacts on the soil, air, and water of South Dakota.

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How to read the South Dakota Science Standards

Each of the three-dimensions from *A Framework for K-12 Science Education* can be referenced in every standard. This information can be used to interpret a deeper meaning for each of the three dimensions. **Below is a legend** to decode the components involved within each standard.

SEP = Science and Engineering Practices (Chapter 3: Page 41 of *Framework*)

1. Asking Questions and Defining Problems
2. Developing and Using Models
3. Planning and Carrying Out Investigations
4. Analyzing and Interpreting Data
5. Using Mathematics and Computational Thinking
6. Constructing Explanations and Designing Solutions
7. Engaging in Argument from Evidence
8. Obtaining, Evaluating, and Communicating Information

The reader will notice engineering is integrated through inclusion as a Disciplinary Core Idea, Crosscutting Concept or by use of a Science and Engineering Practice. All standards with an emphasis on engineering are marked by an asterisk (*). For more information on Engineering see the Framework page 201and Appendix C of the South Dakota Science Standards.

DCI: Disciplinary Core Idea (Chapter 5: Page 103 of *Framework*)

These are listed as written in *A Framework for K-12 Science Education*. For example PS1 stands for Physical Science Core Idea 1: Matter and Its Interactions. You will notice that next to the standard it will read, for example, PS1.A. In this case, the coding is referring to Physical Science Core Idea 1: Matter and Its Interactions, Component Idea A: Structure and Properties of Matter.

PS = Physical Science
LS = Life Science
ESS = Earth and Space Science
ETS = Engineering, Technology and Applications of Sciences

CCC = Crosscutting Concept (Chapter 4: Page 83 of *Framework*)

Patterns = Patterns
Cause/Effect = Cause and Effect
Scale/Prop. = Scale, Proportion, and Quantity
Systems = Systems and System Models
Energy/Matter = Energy and Matter
Structure/Function = Structure and Function
Stability/Change = Stability and Change

The Framework specifies two core ideas that relate science, technology, society and the environment: the interdependence of science, engineering and technology, and the influence of science, engineering and technology on society and the natural world. These two core ideas may accompany or replace crosscutting concepts related to standards that include engineering. In this instance, we refer to them as connection statements because they are not true crosscutting concepts. When this occurs, we use the following legend.

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Technology = Connections to Engineering, Technology, and Applications of Science

Kindergarten

The Core Ideas of the Kindergarten standards include:

- Motion and Stability: Forces and Interactions
- Energy
- From Molecules to Organisms: Structures and Processes
- Earth's Systems
- Earth and Human Activity

Kindergarten Physical Science Conceptual Understanding:

Pushes and pulls can have different strengths and directions, and can change the speed or direction of motion or start or stop. Bigger pushes and pulls cause bigger changes in an object's motion or shape. Sunlight warms the Earth's surface.

Kindergarten Physical Science Standards	
K-PS2-1	Plan and carry out an investigation to compare the effects of different strengths or different directions of pushes and pulls on the motion of an object. (SEP: 3; DCI: PS2.A, PS2.B, PS3.C; CCC: Cause/Effect)
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.* (SEP: 4; DCI: PS2.A, ETS1.A; CCC: Cause/Effect)
K-PS3-1	Make observations to determine the effect of sunlight on Earth's surface. (SEP: 3; DCI: PS3.B; CCC: Cause/Effect)
K-PS3-2	Design and build a structure that will reduce the warming effect of sunlight on an area.* (SEP: 6; DCI: PS3.B; CCC: Cause/Effect)

Kindergarten Life Science Conceptual Understanding:

Plants and animals (including humans) need food and water in order to grow.

Kindergarten Life Science Standards	
K-LS1-1	Describe patterns of what plants and animals (including humans) need to survive. (SEP: 4; DCI: LS1.C; CCC: Patterns)

Kindergarten Earth and Space Science Conceptual Understanding:

There are patterns and variations in local weather. Plants and animals can change their local environment. Plants and animals (including humans) need to survive and there is a relationship between their needs and where they live. The purpose of weather forecasting is to prepare for and to respond to severe weather. Things people do can affect the environment, but they can make choices to reduce their impact.

Kindergarten Earth and Space Science Standards	
K-ESS2-1	Use and share observations of local weather conditions to describe patterns over time. (SEP: 4; DCI: ESS2.D; CCC: Patterns)
K-ESS2-2	Engage in argument from evidence for how plants and animals (including humans) can change the

	environment to meet their needs. (SEP: 7; DCI: ESS2.E, ESS3.C; CCC: Systems)
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. (SEP: 2; DCI: ESS3.A; CCC: Systems)
K-ESS3-2	Ask questions to obtain information about the purpose of weather forecasting to prepare for, and respond to, severe weather.* (SEP: 1, 8; DCI: ESS3.B, ETS1. A; CCC: Cause/Effect)
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.* (SEP: 8; DCI: ESS3.C; ETS1.B; CCC: Cause/Effect)

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First Grade

The Core Ideas of the First Grade standards include:

- Waves and Their Applications in Technologies for Information Transfer
- From Molecules to Organisms: Structures and Processes
- Heredity: Inheritance and Variation of Traits
- Earth's Place in the Universe

First Grade Physical Science Conceptual Understanding:

Sound can make matter vibrate, and vibrating matter can make sound. Objects can be seen only when light is available to illuminate them. People use devices to send and receive information.

First Grade Physical Science Standards	
1-PS4-1	Plan and carry out an investigation to provide evidence that vibrating materials can make sound and that sound can make materials vibrate. (SEP: 3; DCI: PS4.A; CCC: Cause/Effect)
1-PS4-2	Construct an evidence-based account for how objects can be seen only when illuminated. (SEP: 6; DCI: PS4.B; CCC: Cause/Effect)
1-PS4-3	Plan and carry out an investigation to determine the effect of placing objects made with different materials in the path of a beam of light. (SEP: 3; DCI: PS4.B; CCC: Cause/Effect)
1-PS4-4	Design and build a device that uses light or sound to solve the problem of communicating over a distance.* (SEP: 6; DCI: PS4.C; CCC: Technology)

First Grade Life Science Conceptual Understanding:

Plants and animals use their external parts to help them survive, grow, and meet their needs. Behaviors of parents and offspring help the offspring survive. Animals sense and communicate information and respond to inputs with behaviors that help them grow and survive. Young plants and animals are similar to their parents.

First Grade Life Science Standards	
1-LS1-1	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.* (SEP: 6; DCI: LS1.A, LSI.D; CCC: Structure/Function, Technology)
1-LS1-2	Read texts and use media to determine patterns in behavior of parents and offspring that help offspring survive. (SEP: 8; DCI: LS1.B; CCC: Patterns)
1-LS3-1	Construct an evidence-based account that young plants and animals are like, but not exactly like, their parents. (SEP: 6; DCI: LS3.A, LS3.B; CCC: Patterns)

First Grade Earth and Space Science Conceptual Understanding:

Patterns of movements of the sun, moon, and stars, as seen from Earth, can be observed, described, and predicted.

First Grade Earth and Space Science Standards	
1-ESS1-1	Use observations of the sun, moon, and stars to describe patterns that can be predicted. (SEP: 4; DCI: ESS1.A ; CCC: Patterns, Technology, nature of science)
1-ESS1-2	Make observations at different times of the year to relate the amount of daylight to the time of year. (SEP: 3; DCI: ESS1.B; CCC: Patterns)

Second Grade

The Core Ideas of the Second Grade standards include:

- Matter and Its Interactions
- Ecosystems: Interactions, Energy, and Dynamics
- Biological Unity and Diversity
- Earth's Place in the Universe
- Earth's Systems

Second Grade Physical Science Conceptual Understanding:

Matter exists as different substances that have observably different properties. Different properties are suited to different purposes. Objects can be built up from smaller parts. Heating and cooling substances cause changes that are sometimes reversible and sometimes not.

Second Grade Physical Science Standards	
2-PS1-1	Plan and carry out an investigation to describe and classify different kinds of materials by their observable properties. (SEP: 3; DCI: PS1.A ; CCC: Patterns)
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.* (SEP: 4; DCI: PS1.A; CCC: Cause/Effect, Technology)
2-PS1-3	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. (SEP: 6 ; DCI: PS1.A; CCC: Energy/Matter)
2-PS1-4	Construct an argument using reasoning and evidence that some changes caused by heating or cooling can be reversed and some cannot. (SEP: 7; DCI: PS1.B; CCC: Cause/Effect)

Second Grade Life Science Conceptual Understanding:

Plants depend on water and light to grow, and also depend on animals for pollination or to move their seeds around. A range of different organisms live in different places.

Second Grade Life Science Standards	
2-LS2-1	Plan and carry out an investigation to determine if plants need sunlight and water to grow. (SEP: 3; DCI: LS2.A; CCC: Cause/Effect)
2-LS2-2	Develop a simple model that mimics the function of an animal in dispersing seeds or pollinating plants.* (SEP: 2; DCI: LS2.A, ETS1.B ; CCC: Structure/Function)
2-LS4-1	Make observations of plants and animals to compare the diversity of life in different habitats. (Systems) (SEP: 3; DCI: LSD4.D; CCC: Systems)

Second Grade Earth and Space Science Conceptual Understanding:

Some events on Earth occur very quickly; others can occur very slowly. Wind and water change the shape of the land. Maps show where things are located. The shapes and kinds of land and water in any area can be mapped. Water is found in many types of places and in different forms on Earth.

Second Grade Earth and Space Science Standards	
2-ESS1-1	Use information from several sources to provide evidence that Earth events can occur quickly or slowly. (SEP: 6; DCI: ESS1.C; CCC: Stability/Change)
2-ESS2-1	Compare multiple solutions designed to slow or prevent wind or water from changing the shape of

	the land. (SEP: 6; DCI: ESS2.A, ETS1.C; CCC: Stability/Change, Technology)
2-ESS2-2	Develop a model to represent the shapes and kinds of land and bodies of water in an area. (SEP: 2; DCI: ESS2.B ; CCC: Patterns)
2-ESS2-3	Obtain information to identify where water is found on Earth and that it can be solid or liquid. (SEP: 8; DCI: ESS2.C; CCC: Patterns,)

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Third Grade

The Core Ideas of the Third Grade standards include:

- Motion and Stability: Forces and Interactions
- From Molecules to Organisms: Structures and Processes
- Ecosystems: Interactions, Energy, and Dynamics
- Heredity: Inheritance and Variation of Traits
- Biological Unity and Diversity
- Earth's Systems
- Earth and Human Activity

Third Grade Physical Science Conceptual Understanding:

The effect of unbalanced forces on an object results in a change of motion. Patterns of motion can be used to predict future motion. Some forces act through contact, some forces act even when the objects are not in contact. The gravitational force of Earth acting on an object near the Earth's surface pulls that object toward the planet's center.

Third Grade Physical Science Standards	
3-PS2-1	Plan and carry out an investigation to provide evidence of the effects of balanced and unbalanced forces on the motion of an object. (SEP: 3; DCI: PS2.A, PS2.B; CCC: Cause/Effect)
3-PS2-2	Make observations and/or measurements of an object's motion to provide evidence for how a pattern can be used to predict future motion. (SEP: 3; DCI: PS2.A; CCC: Patterns)
3-PS2-3	Ask questions about cause and effect relationships of electric or magnetic interactions between two objects not in contact with each other. (SEP: 1; DCI: PS2.B; CCC: Cause/Effect)
3-PS2-4	Define a simple design problem that can be solved by applying scientific ideas about magnets.* (SEP: 1; DCI: PS2.B; CCC: Technology)

Third Grade Life Science Conceptual Understanding:

Reproduction is essential to every kind of organism. Organisms have unique and diverse life cycles. When the environment changes, some organisms survive and reproduce, some move to new locations, some move into the transformed environment, and some die. Being part of a group helps animals obtain food, defend themselves, and cope with changes. Different organisms vary in how they look and function because they have different inherited information; the environment also affects the traits that an organism develops. Some living organisms resemble organisms that once lived on Earth. Fossils provide evidence about the types of organisms and environments that existed long ago. Differences in characteristics between individuals of the same species provide advantages in surviving and reproducing. Particular organisms can only survive in particular environments. Populations of organisms live in a variety of habitats. Change in those habitats affects the organisms living there.

Third Grade Life Science Standards	
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. (SEP: 1 ; DCI: LS1.B; CCC: Patterns)
3-LS2-1	Construct an argument that some animals form groups that help members survive. (SEP: 7; DCI: LS2.D; CCC: Cause/Effect)
3-LS3-1	Analyze and interpret data to provide evidence that plants and animals have traits inherited from parents and that variations of these traits exist in a group of similar organisms. (SEP: 4; DCI: LS3.A,

	LS3.B; CCC: Patterns)
3-LS4-1	Analyze and interpret data from fossils to provide evidence of the organisms and the environments in which they lived long ago. (SEP: 4; DCI: LS4.A; CCC: Scale/Prop.)
3-LS4-2	Use evidence and reasoning 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. (SEP: 6; DCI: LS4.B; CCC: Cause/Effect)
3-LS4-3	Construct an argument with evidence how some organisms thrive, some struggle to survive, and some cannot survive in a particular habitat. (SEP: 7; DCI: LS4.C; CCC: Cause/Effect)
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.* (SEP: 7; DCI: LS2.C, LS4.D; CCC: Systems, Technology)

Third Grade Earth and Space Science Conceptual Understanding:

Typical weather occurs during a particular season. Climate describes patterns of typical weather conditions over different scales and variations. Historical weather patterns can be analyzed. A variety of hazards result from natural processes; humans cannot eliminate hazards but can reduce their impact.

Third Grade Earth and Space Science Standards	
3-ESS2-1	Represent data in tables and graphical displays to describe typical weather conditions expected during a particular season. (SEP: 4; DCI: ESS2.D; CCC: Patterns)
3-ESS2.2	Obtain and combine information to describe climates in different regions of the world. (SEP: 8; DCI: ESS2.D ; CCC: Patterns)
3-ESS3-1	Make a claim about the merit of a design solution that reduces the impacts of a weather-related hazard.* (SEP: 7; DCI: ESS3.B ; CCC: Cause/Effect, Technology)

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Fourth Grade

The Core Ideas of the Fourth Grade standards include:

- Energy
- Waves and Their Applications in Technologies for Information Transfer
- From Molecules to Organisms: Structures and Processes
- Earth's Place in the Universe
- Earth's Systems
- Earth and Human Activity

Fourth Grade Physical Science Conceptual Understanding:

Moving objects contain energy. The faster the object moves, the more energy it has. Energy can be moved from place to place by moving objects, or through sound, light, heat, or electrical currents. Energy can be converted from one form to another form. When objects collide, energy is transferred through forces so as to change the objects' motions. Waves are regular patterns of motion which can be made in water by disturbing the surface. Waves of the same type can differ in amplitude and wavelength. Waves can make objects move. Objects can be seen when light reflected from their surface enters our eyes. Patterns can encode, send, receive, and decode information.

Fourth Grade Physical Science Standards	
4-PS3-1	Use evidence to construct an explanation relating the speed of an object to the energy of that object. (SEP: 6; DCI: PS3.A ; CCC: Energy/Matter)
4-PS3-2	Make observations to provide evidence for how energy can be transferred from place to place by sound, light, heat, and electric currents. (SEP: 3; DCI: PS3.A, PS3.B; CCC: Energy/Matter)
4-PS3-3	Ask questions and predict outcomes about the changes in energy that occur when objects collide. (SEP: 1; DCI: PS3.A, PS3.B, PS3.C; CCC: Energy/Matter)
4-PS3-4	Design, test, and refine a device that converts energy from one form to another.* (SEP: 6; DCI: PS3.B, PS3.D, ETS1.A ; CCC: Energy/Matter)
4-PS4-1	Develop a model of waves to describe patterns in terms of amplitude and wavelength and to provide evidence that waves can cause objects to move. (SEP: 2 ; DCI: PS4.A; CCC: Patterns)
4-PS4-2	Develop a model to describe how light reflecting from objects and entering the eye allows objects to be seen. (SEP: 2 ; DCI: PS4.B; CCC: Cause/Effect)
4-PS4-3	Create and compare multiple solutions that use patterns to transfer information.* (SEP: 6; DCI: PS4.C, ETS1.C; CCC: Patterns, Technology)

Fourth Grade Life Science Conceptual Understanding:

Plants and animals have internal and external structures that function to support survival, growth, behavior, and reproduction. Different sense receptors are specialized for particular kinds of information; animals use their perceptions and memories to guide their actions.

Fourth Grade Life Science Standards	
4-LS1-1	Construct an argument that plants and animals have internal and external structures that function to support survival, growth, behavior, and reproduction. (SEP: 7 ; DCI: LS1.A; CCC: Systems)
4-LS1-2	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. (SEP: 2; DCI: LS1.D; CCC: Systems)

Fourth Grade Earth and Space Science Conceptual Understanding:

Certain features on Earth can be used to order events that have occurred in a landscape. Four major Earth systems interact. Rainfall helps to shape the land and affects the types of living things found in a region. Water, ice, wind, organisms, and gravity break rocks, soils, and sediments into smaller pieces and move them around. Earth's physical features occur in patterns, as do earthquakes and volcanoes. Maps can be used to locate features and determine patterns in those events. Energy and fuels that humans use are derived from natural sources and their use affects the environment. Some resources are renewable over time, others are not. A variety of hazards result from natural processes; humans cannot eliminate hazards but can reduce their impacts.

Fourth Grade Earth and Space Science Standards	
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. (SEP: 6; DCI: ESS1.C ; CCC: Patterns)
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. (SEP: 3; DCI: ESS2.A, ESS2.E; CCC: Cause/Effect)
4-ESS2-2	Analyze and interpret data from maps to describe patterns of Earth's features. (SEP: 4; DCI: ESS2.B; CCC: Patterns)
4-ESS3-1	Obtain and combine information to describe that energy and fuels are derived from natural resources and their uses affect the environment. (SEP: 8; DCI: ESS3.A; CCC: Cause/Effect, Technology)
4-ESS3-2	Generate and compare multiple solutions to reduce the impacts of natural Earth processes on humans. (SEP: 6; DCI: ESS3.B, ETS1.B; CCC: Cause/Effect, Technology)

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Fifth Grade

The Core Ideas of the Fifth Grade standards include:

- Matter and Its Interactions
- Motion and Stability: Forces and Interactions
- Energy
- From Molecules to Organisms: Structures and Processes
- Ecosystems: Interactions, Energy, and Dynamics
- Earth's Place in the Universe
- Earth's Systems
- Earth and Human Activity

Fifth Grade Physical Science Conceptual Understanding:

Because matter exists as particles that are too small to see, matter is always conserved even if it seems to disappear. Measurements of a variety of observable properties can be used to identify particular materials. Chemical reactions that occur when substances are mixed can be identified by the emergence of substances with different properties; the total mass of substances when a reaction occurs remains the same. Energy can be "produced," "used," or "released" by converting stored energy. Plants capture energy from sunlight, which can later be used as fuel or food.

Fifth Grade Physical Science Standards	
5-PS1-1	Develop a model to describe that matter is made of particles too small to be seen. (SEP: 2; DCI: PS1.A; CCC: Scale/Prop.)
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. (SEP: 5; DCI: PS1.A, PS1.B; CCC: Scale/Prop.)
5-PS1-3	Make observations and measurements to identify materials based on their properties. (SEP: 3; DCI: PS1.A; CCC: Scale/Prop.)
5-PS1-4	Conduct an investigation to determine whether the mixing of two or more substances results in new substances. (SEP: 3; DCI: PS1.B; CCC: Cause/Effect)
5-PS2-1	Support an argument that the gravitational force exerted by Earth on objects is directed down. (SEP: 7; DCI: PS2.B; CCC: Cause/Effect)
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. (SEP: 2; DCI: PS3.D, LSI.C ; CCC: Energy/Matter)

Fifth Grade Life Science Conceptual Understanding:

Food provides animals with the materials and energy they need for body repair, growth, warmth, and motion. Plants acquire material for growth chiefly from air, water, and process matter and obtain energy from sunlight, which is used to maintain conditions necessary for survival. Movement of matter among plants, animals, decomposers, and the environment and that energy in animals' food was once energy from the sun.

Fifth Grade Life Science Standards	
5-LS1-1	Support an argument that plants get the materials they need for growth chiefly from air and water. (SEP: 7; DCI: LS1.C; CCC: Energy/Matter)

5-LS2-1	Develop a model to describe the movement of matter and energy among producers, consumers, decomposers, and the environment. (SEP: 2; DCI:LS2.A, LS2.B ; CCC: Systems)

Fifth Grade Earth and Space Science Conceptual Understanding:

Stars range greatly in size and distance from Earth, and this can explain their relative brightness. Earth's orbit and rotation and the orbit of the moon around Earth cause observable patterns, such as length and direction of shadows, day and night, and the seasonal appearance of some stars in the night sky. Four major Earth systems interact. Rainfall helps to shape the land and affects the types of living things found in a region. Water, ice, wind, organisms, and gravity break rocks, soils, and sediments into smaller pieces and move them around. The geosphere, biosphere, hydrosphere, and/or atmosphere interact. Most of Earth's water is in the ocean and much of Earth's fresh water is in glaciers or underground. Societal activities have had major effects on land, ocean, atmosphere, and even outer space. Societal activities can also help protect Earth's resources and environments.

Fifth Grade Earth and Space Science Standards	
5-ESS1-1	Support an argument that differences in the apparent brightness of the sun compared to other stars is due to distances from the Earth. (SEP: 7; DCI: ESS1.A; CCC: Scale/Prop.)
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. (SEP: 4; DCI: ESS1.B ; CCC: Patterns)
5-ESS2-1	Develop a model to describe the interaction of geosphere, biosphere, hydrosphere, and/or atmosphere. (SEP: 2; DCI: ESS2.A; CCC: Systems)
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. (SEP: 5; DCI: ESS2.C; CCC: Scale/Prop.)
5-ESS3-1	Obtain and combine information about ways individual communities use science ideas to protect the Earth's resources and environment. (SEP:8; DCI: ESS3.C; CCC: Systems)

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Middle School Physical Science (Grades 6-8)

The Core Ideas of the Middle School Physical Science standards include:

- Matter and Its Interactions
- Motion and Stability: Forces and Interactions
- Energy
- Waves and Their Applications in Technologies for Information Transfer

Middle School Physical Science Conceptual Understanding:

Matter is composed of atoms and molecules that can be used to explain the physical and chemical properties of substances, diversity of materials, states of matter, phase changes, and conservation of matter and energy. Reacting substances rearrange to form different molecules, but the number of atoms is conserved. Some reactions release energy and others absorb energy. The role of the mass of an object must be qualitatively accounted for in any change of motion due to the application of an attractive or repulsive force. Gravitational, electrical, and magnetic forces occur through collisions and over distances. Forces that act at a distance involve fields that can be mapped by their relative strength and effect on an object. Kinetic energy can be distinguished from the various forms of potential energy. Energy changes, to and from each type, can be tracked through physical or chemical interactions. The relationship between the temperature and the total energy of a system depends on the types, states, and amounts of matter. When two objects interact, each one exerts a force on the other, and these forces can transfer energy between them. Energy is transferred in chemical processes and everyday life. A simple wave model has a repeating pattern with a specific wavelength, frequency, and amplitude, and mechanical waves need a medium through which they are transmitted. This model can explain many phenomena including sound and light. Waves can transmit energy and digital information.

Middle School Physical Science Standards (Grades 6-8)	
MS-PS1-1	Develop models to describe the atomic composition of simple molecules and extended structures. (SEP:2 ; DCI: PS1.A; CCC: Scale/Prop.)
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. (SEP: 8; DCI: PS1.A, PS1.B; CCC: Patterns)
MS-PS1-3	Obtain and evaluate information to describe that synthetic materials come from natural resources and impact society. (SEP: 8; DCI: PS1.A, PS1.B; CCC: Structure/Function, Technology)
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. (SEP: 2; DCI: PS1.A, PS3.A; CCC: Cause/Effect)
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. (SEP: 2 ; DCI: PS1.B; CCC: Energy/Matter)
MS-PS1-6	Design, construct, test, and modify a device that either releases or absorbs thermal energy by chemical processes.* (SEP: 6; DCI: PS1.B, ETS1.B, ETS1.C; CCC: Energy/Matter)
MS-PS2-1	Design a solution to a problem involving the motion of two colliding objects that illustrates Newton's Third Law.* (SEP: 6; DCI: PS2.A; CCC: Systems, Technology)
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. (SEP: 3; DCI: PS2.A; CCC: Stability/Change)
MS-PS2-3	Ask questions about data to determine the factors that affect the strength of electric and magnetic forces. (SEP: 1; DCI: PS2.B; CCC: Cause/Effect)

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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. (SEP: 7; DCI: PS2.B; CCC: Systems)
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. (SEP: 3; DCI: PS2.B; CCC: Cause/Effect)
MS-PS3-1	Construct and analyze graphical displays of data to describe the relationships of kinetic energy to the mass of an object and to the speed of an object. (SEP: 4; DCI: PS3.A; CCC: Scale/Prop.)
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. (SEP: 2; DCI: PS3.A, PS3.C ; CCC: Systems)
MS-PS3-3	Design, construct, and test a device that either minimizes or maximizes thermal energy transfer.* (SEP: 6; DCI: PS3.A, PS3.B, ETS1.A, ETS1.B, ; CCC: Energy/Matter)
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. (SEP: 3; DCI: PS3.A, PS3.B; CCC: Scale/Prop.)
MS-PS3-5	Engage in argument from evidence to support the claim that when the kinetic energy of an object changes, energy is transferred to or from the object. (SEP: 7; DCI: PS3.B; CCC: Energy/Matter)
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. (SEP: 5; DCI: PS4.A; CCC: Patterns)
MS-PS4-2	Develop and use a model to describe how waves are reflected, absorbed, or transmitted through various materials. (SEP: 2; DCI: PS4.A, PS4.B; CCC: Structure)
MS-PS4-3	Obtain, evaluate and communicate information to support the claim that digitized signals are a more reliable way to encode and transmit information than analog signals. (SEP: 8; DCI: PS4.C; CCC: Structure, Technology)

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Middle School Life Science (Grades 6-8)

The Core Ideas of the Middle School Life Science standards include:

- From Molecules to Organisms: Structures and Processes
- Ecosystems: Interactions, Energy, and Dynamics
- Heredity: Inheritance and Variation of Traits
- Biological Unity and Diversity

Middle School Life Science Conceptual Understanding:

All living things are made of cells. In organisms, cells work together to form tissues and organs that are specialized for particular body functions. Animals engage in behaviors that increase the odds of reproduction. An organism's growth is affected by both genetic and environmental factors. Plants use the energy from light to make sugars through photosynthesis. Within individual organisms, food is broken down through a series of chemical reactions that rearrange molecules and release energy. Organisms and populations are dependent on their environmental interactions both with other living things and with nonliving factors, any of which can limit their growth. Competitive, predatory, and mutually beneficial interactions vary across ecosystems but the patterns are shared. The atoms that make up the organisms in an ecosystem are cycled repeatedly between the living and nonliving parts of the ecosystem. Food webs model how matter and energy are transferred among producers, consumers, and decomposers as the three groups interact within an ecosystem. Ecosystem characteristics vary over time. Disruptions to any part of an ecosystem can lead to shifts in all of its populations. The completeness or integrity of an ecosystem's biodiversity is often used as a measure of its health.

Genes chiefly regulate a specific protein, which affect an individual's traits. In sexual reproduction, each parent contributes half of the genes acquired by the offspring resulting in variation between parent and offspring. Genetic information can be altered because of mutations, which may result in beneficial, negative, or no change to proteins in or traits of an organism. The fossil record documents the existence, diversity, extinction, and change of many life forms and their environments through Earth's history. The fossil record and comparisons of anatomical similarities between organisms enables the inference of lines of evolutionary descent. Both natural and artificial selection result from certain traits giving some individuals an advantage in surviving and reproducing, leading to predominance of certain traits in a population. Species can change over time in response to changes in environmental conditions through adaptation by natural selection acting over generations. Traits that support successful survival and reproduction in the new environment become more common. Changes in biodiversity can influence humans' resources and ecosystem services they rely on. Students must also understand the necessity of adaptation and survival to creating biodiversity.

Middle School Life Science Standards (Grades 6-8)	
MS-LS1-1	Plan and carry out an investigation to provide evidence that living things are made of cells; either one cell or many different types and numbers of cells. (SEP: 3; DCI: LS1.A; CCC: Scale/Prop., Technology)
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. (SEP: 2; DCI: LS1.A; CCC: Structure/Function)
MS-LS1-3	Construct an argument supported by evidence for how the body is a system of interacting subsystems composed of groups of cells. (SEP: 7 ; DCI: LS1.A; CCC: Systems)

MS-LS1-4	Construct an 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. (SEP: 7; DCI: LS1.B; CCC: Cause/Effect)
MS-LS1-5	Construct a scientific explanation based on evidence for how environmental and genetic factors influence the growth of organisms. (SEP: 6; DCI: LS1.B; CCC: Cause/Effect)
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. (SEP: 6, Nature Science/Empirical Evidence; DCI: LS1.C, PS3.D; CCC: Energy/Matter)
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. (SEP: 2; DCI: LS1.C, PS3.D; CCC: Energy/Matter)
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. (SEP: 4; DCI: LS2.A; CCC: Cause/Effect)
MS-LS2-2	Construct an explanation that predicts patterns of interactions among organisms across multiple ecosystems. (SEP: 6; DCI: LS2.A; CCC: Patterns)
MS-LS2-3	Develop a model to describe the cycling of matter and flow of energy among living and nonliving parts of an ecosystem. (SEP: 2; DCI: LS2.B; CCC: Energy/Matter)
MS-LS2-4	Construct an argument supported by empirical evidence that changes to physical or biological components of an ecosystem affect populations. (SEP: 7; DCI: LS2.C ; CCC: Stability/Change)
MS-LS2-5	Evaluate competing design solutions for maintaining biodiversity and ecosystem services.* (SEP: 7; DCI: LS2.C, LS4.D, ETS1.B ; CCC: Stability/Change, Technology)
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. (SEP:2 ; DCI: LS3.A, LS3.B; CCC: Structure/Function)
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. (SEP: 2; DCI: LS1.B, LS3.A, LS3.B; CCC: Cause/Effect)
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. (SEP: 4; DCI: LS4.A; CCC: Patterns)
MS-LS4-2	Apply scientific ideas to construct an explanation for similarities and differences among modern organisms and between modern and fossil organisms to infer evolutionary relationships. (SEP: 6; DCI: LS4.A; CCC: Patterns)
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. (SEP: 6; DCI: LS4.B; CCC: Cause/Effect)
MS-LS4-5	Obtain, evaluate, and communicate information about how technological advances have changed the way humans influence the inheritance of desired traits in organisms. * (SEP: 8; DCI: LS4.B; CCC: Cause/Effect, Technology)
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. (SEP: 5; DCI: LS4.C; CCC: Cause/Effect)

Middle School Earth and Space Science (Grades 6-8)

The Core Ideas of the Middle School Earth and Space Science standards include:

- Earth's Place in the Universe
- Earth's Systems
- Earth and Human Activity

Middle School Earth and Space Science Conceptual Understanding:

The Earth is a part of the solar system which is held together by gravity. The solar system is a part of the Milky Way Galaxy, which is one of billions of galaxies in the universe. The position of Earth's place in the solar system, Milky Way Galaxy, and the universe can be used to explain astronomical patterns such as eclipses, tides, and seasons. By exploring objects in the solar system and universe, theories have been formed and supported that explain the formation of the universe. Rock strata and the fossil record can be used as evidence to organize the relative occurrence of major historical events in Earth's history. Materials in and on Earth's crust change over time as result of the flow within and among different systems and the cycling of matter, including the sun and Earth's interior as primary energy sources. Plate tectonics is the unifying theory that explains movements of rocks at the Earth's surface and through geological history.

Water influences weather and weather patterns through oceanic, atmospheric and land circulation. Water movement causes weathering and erosion as well as changing landscape features. Humans depend on Earth's land, ocean, atmosphere, and biosphere for different renewable and nonrenewable resources. The availability of natural resources, such as land, energy, minerals and water, is unevenly distributed. This can affect human activities and impact the development of surroundings in a positive or negative way. Human use of resources can have an impact on the Earth and its systems. Decisions to reduce the impact on Earth and its systems depend on understanding climate, science, engineering capabilities, and social dynamics. Natural hazards can impact resource availability and development. By mapping the history of natural hazards in a region, an understanding of geological forces can be reached.

Middle School Earth and Space Science Standards (Grades 6-8)	
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. (SEP: 2; DCI: ESS1.A, ESS1.B; CCC: Patterns)
MS-ESS1-2	Develop and use a model to describe the role of gravity in the motions within galaxies and the solar system. (SEP: 2; DCI: ESS1.A, ESS1.B; CCC: Systems)
MS-ESS1-3	Analyze and interpret data to determine scale properties of objects in the solar system. (SEP: 4; DCI: ESS1.B; CCC: Scale/Prop., Technology)
MS-ESS2-1	Develop a model to describe the cycling of Earth's materials and the flow of energy that drives this process. (SEP: 2; DCI: ESS2.A; CCC: Stability/Change)
MS-ESS2-2	Construct an explanation based on evidence for how geoscience processes have changed Earth's surface at varying time and spatial scales. (SEP: 6; DCI: ESS2.A, ESS2.C; CCC: Scale/Prop.)
MS-ESS2-3	Analyze and interpret data on the age of the Earth, distribution of fossils and rocks, continental shapes, and seafloor structures to provide evidence of the past plate motions. (SEP: 4; DCI: ESS2.B, ESS1.C; CCC: Patterns)
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. (SEP: 2; DCI: ESS2.C; CCC: Energy/Matter)

MS-ESS2-5	Collect data to provide evidence for how the motions and complex interactions of air masses results in changes in weather conditions. (SEP: 3; DCI: ESS2.C, ESS2.D; CCC: Cause/Effect)
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. (SEP: 2; DCI: ESS2.C, ESS2.D; CCC: Systems)
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. (SEP: 6; DCI: ESS3.A ; CCC: Cause/Effect , Technology)
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. (SEP: 4; DCI: ESS3.B; CCC: Patterns, Technology)
MS-ESS3-3	Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment.* (SEP: 6 ; DCI: ESS3.C; CCC: Cause/Effect, Technology)
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. (SEP: 7; DCI: ESS3.C; CCC: Cause/Effect, Technology, Nature Science/Consequence-Actions)
MS-ESS3-5	Ask questions to clarify evidence of the factors that may have caused a change in global temperatures over the past century. (SEP: 1; DCI: ESS3.D; CCC: Stability/Change)

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High School Physical Science (Grades 9-12)

The Core Ideas of the High School Physical Science standards include:

- Matter and Its Interactions
- Motion and Stability: Forces and Interactions
- Energy
- Waves and Their Applications in Technology for Information Transfer

<u>High School Physical Science Conceptual Understanding:</u>

Matter and its interactions is broken down into three sub-ideas: the structure and properties of matter, chemical reactions, and nuclear processes. This includes substructure of atoms, interactions between electric charges, interactions of matter, chemical reactions, nuclear processes, and properties of substances. Chemical reactions, including rates of reactions and energy changes, involve the collisions of molecules and the rearrangements of atoms. Repeating patterns of the periodic table can be used as a tool to explain and predict the properties of elements. A stable molecule has less energy than the same set of atoms separated: one must provide at least this energy to take apart a molecule. Motion and stability focuses on building understanding of forces and interactions and Newton's Second Law. The total momentum of a system of objects is conserved when there is no net force on the system. Newton's Law of Gravitation and Coulomb's Law describe and predict the gravitational and electrostatic forces between objects. Forces at a distance are explained by fields that can transfer energy and can be described in terms of the arrangement and properties of the interacting objects and the distance between them. The forces can be used to describe the relationship between electrical and magnetic fields.

Energy 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 a 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. Energy at both the macroscopic and the atomic scale can be accounted for as either motions of particles or energy associated with relative position for configuration of particles. Photosynthesis is the primary biological means of capturing radiation from the sun. Fields contain energy that depend on the arrangement of objects in the field.

Waves are broken down into Wave Properties, Electromagnetic Radiation, and Information Technologies and Instrumentation. Wave properties and the interactions of electromagnetic radiation with matter can transfer information across long distances, store information, and investigate nature on many scales. The wavelength and frequency of a wave are related to one another by the speed of the wave, which depends on the type of wave and the medium through which it is passing. Combining waves of different frequencies can make a wide variety of patterns and thereby encode and transmit information. Technological devices use the principles of wave behavior and wave interactions with matter to transmit and capture information and energy.

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High School Physical Science Standards (Grades9-12)	
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. (SEP: 2; DCI: PS1.A, PS2.B; CCC: Patterns)
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. (SEP: 6; DCI: PS1.A, PS1.B; CCC: Patterns)
HS-PS1-3	Plan and carry out an investigation to gather evidence to compare the structure of substances at the bulk scale to infer the strength of electrical forces between particles. (SEP: 3; DCI: PS1.A, PS2.B; CCC: Patterns)
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. (SEP: 2; DCI: PS1.A, PS1.B; CCC: Energy/Matter)
HS-PS1-5	Construct an explanation based on evidence about the effects of changing the temperature or concentration of the reacting particles on the rate at which a reaction occurs. (SEP: 6; DCI: PS1.B; CCC: Patterns)
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.* (SEP: 6; DCI: PS1.B, ETS1.C; CCC: Stability/Change)
HS-PS1-7	Use mathematical representations to support the claim that atoms, and therefore mass, are conserved during a chemical reaction. (SEP: 5; DCI: PS1.B; CCC: Energy/Matter, Nature of Science/Consistency)
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. (SEP: 2; DCI: PS1.C; CCC: Energy/Matter)
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. (SEP: 4; DCI: PS2.A; CCC: Cause/Effect)
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. (SEP: 5; DCI: PS2.A ; CCC: Systems)
HS-PS2-3	Design, evaluate, and refine a device that minimizes the force on a macroscopic object during a collision.* (SEP: 6; DCI: PS2.A, ETS1.A, ETS1.C; CCC: Cause/Effect)
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. (SEP: 5; DCI: PS2.B; CCC: Patterns)
HS-PS2-5	Plan and carry out 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. (SEP: 3; DCI: PS2.B, PS3.A; CCC: Cause/Effect)
HS-PS2-6	Communicate scientific and technical information about why the molecular-level structure is important in the functioning of designed materials.* (SEP: 8; DCI: PS1.A, PS2.B; CCC: Structure/Function)
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. (SEP: 5; DCI: PS3.A, PS3.B ; CCC: Systems)
HS-PS3-2	Develop and use models to illustrate that energy at the macroscopic scale can be accounted for as a combination of energy associated with the motions of particles (objects) and energy associated with the relative position of particles (objects). (SEP: 2 ; DCI: PS3.A; CCC: Energy/Matter)
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. (SEP: 6; DCI: PS3.A, PS3.D, ETS1.A; CCC: Energy/Matter, Technology)
HS-PS3-4	Plan and carry out an investigation to provide evidence that the transfer of thermal energy when

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	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). (SEP: 3; DCI: PS3.B, PS3.D; CCC: Systems)
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. (SEP: 2; DCI: PS3.C; CCC: Cause/Effect)
HS-PS4-1	Use mathematical representations to support a claim regarding relationships among the frequency, wavelength, and speed of waves traveling in various media. (SEP: 5; DCI: PS4.A; CCC: Cause/Effect)
HS-PS4-2	Evaluate questions about the advantages of using a digital transmission and storage of information. (SEP: 1; DCI: PS4.A; CCC: Stability/Change, Technology)
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. (SEP: 7; DCI: PS4.A, PS4.B; CCC: Systems)
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. (SEP: 8; DCI: PS4.B; CCC: Cause/Effect)
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.* (SEP: 8; DCI: PS3.D, PS4.A, PS4.B, PS4.C; CCC: Cause/Effect, Technology)

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High School Life Science (Grades 9-12)

The Core Ideas of the High School Life Science standards include:

- From Molecules to Organisms: Structures and Processes
- Ecosystems: Interactions, Energy, and Dynamics
- Heredity: Inheritance and Variation of Traits
- Biological Unity and Diversity

<u>High School Life Science Conceptual Understanding:</u>

Cells are the basic unit of organization of all living things. DNA determines the structure of proteins which in turn determines the structures of specialized cells. Systems of cells function together to support critical life processes such as maintenance, growth, and reproduction. The energy for these processes comes from photosynthesis and cellular respiration. Photosynthesis transforms light energy into stored chemical energy. Cellular respiration, both aerobic and anaerobic, breaks the chemical bonds of food resulting in new compounds and a net transfer of energy. As carbon, hydrogen, and oxygen from sugar molecules break down, they combine with other elements to form amino acids and/or other carbon-based macromolecules.

Ecosystems are complex interactions between biotic and abiotic factors. When stable, ecosystems will support relatively consistent numbers of organisms; however, when subjected to extreme changes, new ecosystems or reduced biodiversity may occur. Plants form the lowest level of the food web, and as they are consumed, only a small portion of the matter is transferred upward. Matter and energy are conserved at each food web link as some matter is used for growth, some matter is used to release energy for life processes, and some is discarded. Photosynthesis and cellular respiration are key components of the global carbon cycle as matter and energy flow between the biosphere, atmosphere, hydrosphere, and geosphere. The carrying capacity of a particular ecosystem limits the amount and type of organisms it can support. The more biodiversity an ecosystem can support the more resilient it is to environmental changes.

Heredity is the passing of characteristics from one generation to the next via genes. Chromosomes are single long DNA molecules which carry the instructions for forming particular species characteristics. Genes are a segment on the DNA that code for a particular trait. An alternative form of a gene found at the same place on a chromosome is called an allele. Genetic variations may result from new genetic combinations through meiosis, replication errors, or mutations. Environmental factors may cause mutations in genes or affect the expression of traits. The interactions of genes with their environment and the relative presence or absence of different alleles, determines the distribution of traits within a population.

The ideas of common ancestry and biological unity and diversity are supported by extensive scientific evidence and form the foundation of modern biological studies. This evidence includes the fossil record, similar DNA sequences, comparative anatomy, and embryological evidence. Evolution is driven by the potential of a species to increase in number, the genetic variation of individuals, competition for resources, and propagation of organisms that are better able to survive and reproduce in the environment. Changes to an environment could see individual species increase in number, new

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species emerge, or the extinction of some species. Human activity can have an adverse effect on the biodiversity of an ecosystem.

High School Life Science Standards (Grades 9-12)	
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. (SEP: 6; DCI: LS1.A; CCC: Structure/Function)
HS-LS1-2	Develop and use a model to illustrate the hierarchical organization of interacting systems that provide specific functions within multicellular organisms. (SEP: 2; DCI: LS1.A; CCC: Systems)
HS-LS1-3	Plan and carry out an investigation to provide evidence that feedback mechanisms maintain homeostasis. (SEP: 3; DCI: LS1.A; CCC: Stability/Change)
HS-LS1-4	Use a model to illustrate the role of cellular division (mitosis) and differentiation in producing and maintaining complex organisms. (SEP: 2; DCI: LS1.B; CCC: Systems)
HS-LS1-5	Use a model to illustrate how photosynthesis transforms light energy into stored chemical energy. (SEP: 2; DCI: LS1.C; CCC: Systems, Energy/Matter)
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. (SEP: 6; DCI: LS1.C; CCC: Energy/Matter)
HS-LS1-7	Use a model of the major inputs and outputs of cellular respiration (aerobic and anaerobic) to exemplify the chemical process in which the bonds of food molecules are broken, the bonds of new compounds are formed, and a net transfer of energy results. (SEP: 2; DCI: LS1.C; CCC: Energy/Matter)
HS-LS2-1	Use mathematical and/or computational representations to support explanations of factors that affect carrying capacity of ecosystems at different scales. (SEP: 5; DCI: LS2.A; CCC: Scale/Prop.)
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. (SEP: 5; DCI: LS2.A, LS2.C; CCC: Scale/Prop.)
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. (SEP:6; DCI: LS2.B; CCC: Energy/Matter)
HS-LS2-4	Use mathematical representations to support claims for the cycling of matter and flow of energy among organisms in an ecosystem. (SEP: 5; DCI: LS2.B; CCC: Energy/Matter)
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. (SEP: 2; DCI: LS2.B, PS3.D; CCC: Systems)
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 but moderate to extreme fluctuations in conditions may result in a new ecosystem. (SEP: 7; DCI: LS2.C; CCC: Stability/Change)
HS-LS2-7	Design, evaluate, and refine a solution for reducing the impacts of human activities on the environment and biodiversity.* (SEP: 6; DCI: LS2.C, LS4.D, ETS1.B; CCC: Stability/Change)
HS-LS2-8	Evaluate the evidence for the role of group behavior on individual and species' chances to survive and reproduce. (SEP: 7; DCI: LS2.D; CCC: Cause/Effect)
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. (SEP: 1; DCI: LS1.A, LS3.A; CCC: Cause/Effect)
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. (SEP: 7; DCI: LS3.B; CCC: Cause/Effect)
HS-LS3-3	Apply concepts of statistics and probability to explain the variation and distribution of expressed traits in a population. (SEP: 4; DCI: LS3.B; CCC: Scale/Prop.)

HS-LS4-1	Communicate scientific information that common ancestry and biological evolution are supported by multiple lines of empirical evidence. (SEP: 8; DCI: LS4.A; CCC: Patterns)
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. (SEP: 6; DCI: LS4.B, LS4.C; CCC: Cause/Effect)
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. (SEP: 4; DCI: LS4.B, LS4.C; CCC: Patterns)
HS-LS4-4	Construct an explanation based on evidence for how natural selection leads to adaptation of populations. (SEP: 6; DCI: LS4.C ; CCC: Cause/Effect)
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. (SEP: 7; DCI: LS4.C; CCC: Cause/Effect)
HS-LS4-6	Use a simulation to research and analyze possible solutions for the adverse impacts of human activity on biodiversity. (SEP: 5; DCI: LS4.C, LS4.D, ETS1.B; CCC: Cause/Effect)
HS-LS4-7	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. (SEP: 4; DCI: LS4.A ; CCC: Patterns)

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High School Earth and Space Science (Grades 9-12)

The Core Ideas of the High School Earth and Space Science standards include:

- Earth's Place in the Universe
- Earth's Systems
- Earth and Human Activity

<u>High School Earth and Space Science Conceptual Understanding:</u>

Light spectra from stars are used to determine their characteristics, processes, and lifecycles. Solar activity creates the elements through nuclear fusion. The development of technologies has provided the astronomical data that provide the empirical evidence for the Big Bang Theory. Kepler's Laws describe common features of the motions of orbiting objects. Observations from astronomy and space probes provide evidence for explanations of solar system formation. The rock record resulting from tectonic and other geoscience processes as well as objects from the solar system can provide evidence of Earth's early history and the relative ages of major geologic formations. Feedback effects exist within and among Earth's systems. Radioactive decay within Earth's interior contributes to thermal convection in the mantle. The planet's dynamics are greatly influenced by water's unique chemical and physical properties.

The role of radiation from the sun and its interactions with the atmosphere, ocean, and land are the foundation for the global climate system. Global climate models are used to predict future changes, including changes influenced by human behavior and natural factors. The role of radiation from the sun and its interactions with the atmosphere, ocean, and land are the foundation for the global climate system. Resource availability has guided the development of human society and use of natural resources has associated costs, risks, and benefits. Natural hazards and other geological events have shaped the course of human history at local, regional, and global scales. Sustainability of human societies and the biodiversity that supports them requires responsible management of natural resources, including the development of technologies. Global climate models used to predict changes continue to be improved, although discoveries about the global climate system are continually needed.

South Dakota is a rich source of geologic resources unique to the Great Plains. Grasslands, the Badlands, Black Hills, and Missouri River Basin all provide unique opportunities for students to investigate the Earth and its many interacting systems. In South Dakota, the use, management, and protection of natural resources have an economic, social, environmental, and geopolitical impact. Natural hazard mitigation (severe weather, flooding, and drought) has a direct impact on the people and environment of our state. Human activities in agriculture, industry, and everyday life have major impacts on the soil, air, and water of South Dakota.

High School Earth and Space Science Standards (Grades 9-12)	
HS-ESS1-1	Develop a model based on evidence to illustrate the life span of the sun and the role of nuclear fusion in the sun's core to release energy that eventually reaches Earth in the form of radiation. (SEP: 2; DCI: ESS1.A, PS3.D; CCC: Scale/Prop.)
HS-ESS1-2	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. (SEP: 6; DCI: PS4.B, ESS1.A; CCC: Energy/Matter, Technology)

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HS-ESS1-3	Communicate scientific ideas about the way stars, over their life cycle, produce elements. (SEP: 8; DCI: ESS1.A; CCC: Energy/Matter)
HS-ESS1-4	Use mathematical or computational representations to predict the motion of orbiting objects in the solar system. (SEP: 5; DCI: ESS1.B; CCC: Scale/Prop., Technology)
HS-ESS1-5	Evaluate evidence of the past and current movements of continental and oceanic crust and the theory of plate tectonics to explain the ages of crustal rocks. (SEP: 7; DCI: ESS1.C, ESS2.B, PS1.C; CCC: Patterns)
HS-ESS1-6	Apply scientific reasoning and evidence from ancient Earth materials, meteorites, and other planetary surfaces to construct an account of Earth's formation and early history. (SEP: 6; DCI: ESS1.C, PS1.C; CCC: Stability/Change)
HS-ESS2-1	Analyze geoscience data to make the claim that one change to Earth's surface can create feedback that cause changes to other Earth systems. (SEP: 2; DCI: ESS2.A, ESS2.B; CCC: Stability/Change)
HS-ESS2-2	Develop a model based on evidence of Earth's interior to describe the cycling of matter by thermal convection. (SEP: 4; DCI: ESS2.A, ESS2.D; CCC: Stability/Change, Technology)
HS-ESS2-3	Use a model to describe how variations in the flow of energy into and out of Earth's systems result in changes in climate. (SEP: 2; DCI: ESS2.A, ESS2.B, PS4.A; CCC: Energy/Matter, Technology)
HS-ESS2-4	Plan and carry out an investigation of the properties of water and its effects on Earth materials and surface processes. (SEP: 2; DCI: ESS1.B, ESS2.A, ESS2.D; CCC: Cause/Effect)
HS-ESS3-1	Construct an explanation based on evidence for how the availability of natural resources, occurrence of natural hazards, and changes in climate have influenced human activity. (SEP: 6; DCI: ESS3.A, ESS3.B ; CCC: Cause/Effect, Technology)
HS-ESS3-2	Evaluate competing design solutions for developing, managing, and utilizing energy and mineral resources based on cost-benefit ratios.* (SEP: 7; DCI: ESS3.A, ETS1.B; CCC: Technology)
HS-ESS3-3	Create a computational simulation to illustrate the relationships among management of natural resources, the sustainability of human populations, and biodiversity. (SEP: 5; DCI: ESS3.C; CCC: Stability/Change, Technology)
HS-ESS3-4	Evaluate or refine a technological solution that reduces impacts of human activities on natural systems.* (SEP: 6; DCI: ESS3.C, ETS1.B; CCC: Stability/Change, Technology)
HS-ESS3-5	Analyze geoscience data and the results from global climate models to make an evidence-based forecast of the current rate of global or regional climate change and associated future impacts to Earth systems. (SEP: 4; DCI: ESS3.D; CCC: Stability/Change)
HS-ESS3-6	Use a computational representation to illustrate the relationships among Earth systems and how those relationships are being modified due to human activity. (SEP: 5; DCI: ESS2.D, ESS3.D; CCC: Systems)

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