Dynamic Learning Maps Science Dimensions Grade Band Progressions

This document includes tables that show how the science dimensions are applied in the Dynamic Learning Maps® (DLM®) Essential Elements across grade bands. Use these tables to understand how the practices, content, and concepts build and relate to each other across grade bands. This table of contents provides links to the sections corresponding to each dimension, and directly to each of the eight science and engineering practices (SEPs), the 14 "families" for disciplinary core ideas (DCIs), and the seven crosscutting concepts (CCCs).

Contents

Science and Engineering Practices

The following tables provide examples of the ways that each of the eight DLM science and engineering practices (SEPs), which were adapted for use in the DLM Essential Elements for science, can be applied across grade bands. These tables can help you understand where your students were and where they are going in their science learning. Use the information in the table to build on concepts from a previous grade band and make connections to new concepts to support student learning.

Asking Questions and Defining Problems

A practice of science is to ask and refine questions that lead to descriptions and explanations of how the natural and designed world works. Students with significant cognitive disabilities can engage in this practice by exploring the natural and designed world, beginning with making observations and identifying questions, and later developing and using questions to define problems that lead to investigating and understanding scientific principles.

Grades K–2	Grades 3–5	Grades 6–8	Grades 9–12
• In exploring how the natural world works, ask questions that lead to observations, descriptions, and explanations.	• Develop questions that can help determine cause-and-effect relationships. • Ask questions about how a simple design solution is used.	• Classify and compare information that answers questions about how the natural world works. • Develop questions that can be answered by an investigation. • Ask questions that help to define a simple design problem.	• Develop and evaluate testable questions. • Gain information through questioning to describe cause-and-effect relationships.

Developing and Using Models

A practice of both science and engineering is to use and construct models as helpful tools for representing ideas and explanations. Examples of these tools could include drawings, graphs, physical replicas, and dramatizations. Students with significant cognitive disabilities can engage in this practice beginning with using models that represent concrete events and later developing and using models to represent more abstract relationships, events, and systems in the natural and designed world.

Grades K–2	Grades 3–5	Grades 6–8	Grades 9–12
• Use models to describe and classify amounts, relationships, and patterns.	• Use and compare models to represent amounts, relationships, and patterns in the natural world.	• Develop and use models to identify, describe, and compare components of a system. • Use models to explain and predict relationships between variables and components of a system.	• Develop, use, and evaluate models to describe relationships between variables and components of a system. • Use models to construct and evaluate explanations in the natural world.

Planning and Carrying Out Investigations

Scientists and engineers plan and carry out investigations in the field or laboratory, working collaboratively as well as individually. Students with significant cognitive disabilities can engage in this practice beginning with collecting and using simple observations and later using tools to gather data to serve as evidence in an investigation.

Grades K–2	Grades 3–5	Grades 6–8	Grades 9–12
• Collect and compare observations to determine and describe relationships in the natural world.	• Collect and record data using tools to determine and support an explanation of a phenomenon. • Use observations and measurements to determine and describe cause-and-effect relationships.	• Gather and use data to determine answers to scientific questions. • Use observations and measurements to determine and support cause-and-effect relationships between variables.	• Manipulate variables and collect data to serve as evidence for cause-and-effect claims about the natural world. • Gather and use data to inform the improvement of a design solution.

Analyzing and Interpreting Data

Scientific investigations produce data that must be analyzed to derive meaning. Students with significant cognitive disabilities can engage in this practice beginning with identifying and describing patterns and later interpreting, analyzing, and evaluating data in relation to explanations and solutions to problems in the natural and designed world.

Grades K–2	Grades 3–5	Grades 6–8	Grades 9–12
• Identify and describe patterns in observations and measurements. • Make classifications and comparisons based on observations and measurements.	• Represent and interpret data in tables or graphs to determine and identify patterns that indicate relationships. • Use data as evidence for constructing and supporting claims about cause-and-effect relationships.	• Gather and represent data to determine and describe patterns. • Evaluate data to construct and support explanations. • Analyze data to evaluate solutions to problems.	• Represent and analyze data to determine and describe cause-and-effect relationships between variables. • Use data to construct and evaluate arguments. • Analyze data to design and evaluate solutions to problems.

Using Mathematics and Computational Thinking

In both science and engineering, mathematical and computational thinking are fundamental for representing physical variables and their relationships. They are used for a range of tasks, which can include recognizing, expressing, and applying quantitative relationships. Students with significant cognitive disabilities can engage in this practice beginning with simple mathematical representations and later applying and interpreting data as well as using mathematical reasoning to construct meaning about systems in the natural and designed world.

Grades K–2	Grades 3–5	Grades 6–8	Grades 9–12
• Recognize numbers as representations of quantity. • Recognize simple patterns.	• Use simple data tables and graphs to determine and describe relationships in the natural world. • Use measurements and simple mathematical representations to describe characteristics of the natural world.	• Apply mathematical concepts and processes to determine and describe cause-and-effect relationships between variables. • Use mathematical representations and reasoning to compare characteristics of components of a system.	• Use mathematical reasoning to construct and support claims about the cause-and-effect relationships between variables. • Analyze and interpret data to investigate the relationships and characteristics of the components of a system.

Constructing Explanations and Designing Solutions

The products of science are explanations, and the products of engineering are solutions. Students with significant cognitive disabilities can engage in this practice beginning with describing and explaining relationships and later constructing and evaluating design solutions as well as explanations about processes and relationships in the natural and designed world.

Grades K–2	Grades 3–5	Grades 6–8	Grades 9–12
• Make observations to identify patterns or compare relationships in the natural world.	• Identify observations, information, data, or models to describe and explain processes or relationships in the natural world. • Use information to determine and explain cause-and-effect relationships in the designed world.	• Use information, data, or models to construct descriptions and explanations of processes and cause-and-effect relationships in the natural world. • Use information to evaluate solutions in the designed world.	• Gather and use information to construct descriptions and explanations of processes and relationships in the natural world. • Use data and models to evaluate and improve design solutions.

Engaging in Argument from Evidence

Argumentation is the process by which explanations and solutions are reached. Students with significant cognitive disabilities can engage in this practice beginning with identifying information as evidence to support claims and later evaluating information to construct arguments about the natural and designed world.

Grades K–2	Grades 3–5	Grades 6–8	Grades 9–12
• Understand that observations and data can be used as evidence.	• Identify relevant evidence to support a claim. • Use observations, information, data, or a model to support cause-and-effect claims.	• Use observations, information, data, or a model to evaluate a claim. • Gather and use information as evidence to support a claim. • Use information to make cause-and-effect claims.	• Use observations, information, data, models, and mathematical reasoning to develop and evaluate cause-and-effect claims. • Use information to construct an argument.

Obtaining, Evaluating, and Communicating Information

Scientists and engineers must be able to communicate clearly and persuasively the ideas and methods they generate. Critiquing and communicating ideas individually and in groups is a critical activity. Students with significant cognitive disabilities can engage in this practice beginning with using and describing observations to identify scientific ideas and later comparing and combining sources of information to communicate and evaluate scientific claims and ideas.

Grades K–2	Grades 3–5	Grades 6–8	Grades 9–12
• Use observations, images, and other media to understand problems and determine how the natural world works. • Use information (e.g., observations, images, maps) to answer questions and identify scientific ideas.	• Use observations, images, simple texts, and other media to understand problems and determine how the natural world works. • Use information (e.g., observations, images, graphs, maps) to answer questions and support scientific ideas.	• Decide which observations, images, texts, data, and other media are useful for defining problems and determining how the natural world works. • Combine information (e.g., observations, texts, tables, images, graphs, maps) to answer scientific questions and evaluate scientific ideas.	• Combine multiple observations, images, texts, data, and other media to evaluate problems and explanations of how the natural world works. • Combine information (e.g., observations, texts, tables, images, graphs, maps) to pose scientific questions and scientific ideas.

Disciplinary Core Ideas

The following tables summarize key topics for each of the 14 “families” formed to organize and adapt the disciplinary core ideas (DCIs) for use in the DLM Essential Elements for science across grade bands. These tables show how scientific ideas build across grade bands and relate to each other within a DCI family. These tables can help you understand where your students have been and where they are going in their science learning. Use the information in the table to build on concepts from a previous grade band and make connections to new concepts to support student learning.

Note that the DCI family names are shortened for use in the Essential Element content codes (e.g., the Essential Element for K–2 in the DCI family Organisms: Structure and Function, Growth and Development is SCI.EE.LS.2.Org-1); these shortened names are listed in parentheses after each DCI family name in the following tables for ease of correspondence to the list of Essential Elements.

Life Science

Organisms: Structure and Function, Growth and Development (Org)

Grades K–2	Grades 3–5	Grades 6–8	Grades 9–12
Organism diversity: Plants and animals (including humans) are living organisms that contribute to the diversity of life. Plant structures: Plants have various parts like roots, stems, leaves, flowers, and fruits that support their survival, growth, and reproduction. Animal structures: Animals have body parts that perform essential functions. Their external parts help them interact with the environment (for example, to feed, move, and protect themselves).	Internal and external structures: Plants and animals have both internal and external structures that are essential for their growth, survival, and behavior. These structures enable organisms to interact with their environment and perform functions necessary for life. Life cycles and reproduction: Organisms have unique and diverse life cycles. The reproduction stage is crucial for the survival of species.	Cell structures: Living things are made of cells, which are defined as the smallest units of life. All cells have an external membrane that controls the exchange of materials between the cell and the external medium, and many have a nucleus that contains hereditary material. Cellular organization: Unicellular organisms consist of a single cell that performs all functions, while multicellular organisms have multiple cells that are often specialized and work together to support the organism's functions.	Levels of organization in organisms: Multicellular organisms are composed of specialized cells that group together to form tissues, such as muscle or nerve tissue. These tissues then combine to form organs, like the heart or lungs, and organ systems, such as the circulatory and respiratory systems. Relationships between structures and functions: Organs and body systems (structures) perform specific functions and interact with each other to carry out the life functions of an organism. Each structure is designed to perform particular tasks, and their coordinated actions allow for the organism's survival.

Plants: Cycling of Matter and Flow of Energy (Plant)

Grades K–2	Grades 3–5	Grades 6–8	Grades 9–12
Resources for plant growth: Plants need resources such as water and light to support their growth and development. Plants that receive adequate amounts of water and light can grow and develop, which is evidenced by changes in their size, height, and form.	Matter sources for plants: Plants acquire materials from the environment for growth and repair. These materials come primarily from the air and water. Energy sources for plants: Plants use and store energy from sunlight for growth, repair, and other functions.	Plant use of matter and energy: Plants use light energy from the Sun and materials from the air and water to make their food. This food becomes part of the plant's mass and is also used for their functions. For example, food is essential for growth and development (e.g., making flowers and seeds), provides energy, and can be stored for later use. Measures of plant growth: Plant growth can be described by the increase in plant matter, such as mass, height of the stalk, and the number of leaves. These changes are evidence that plants are taking in and incorporating materials from the environment.	Plant photosynthesis: Plants use energy from the Sun and material from water and the air to make their food in the process of photosynthesis. Plants can use this food to store the Sun's energy for use in growth, repair, and other functions. Oxygen is released to the environment as a product of photosynthesis. Matter and energy for organisms in an ecosystem: Plants play a crucial role in capturing energy and matter from the environment for other organisms (for this reason they are called producers). The matter and energy for animals ultimately comes from plants: some animals eat plants; others eat other animals. The matter and energy for plants comes from air, water, and sunlight. Thus, the energy that animals get from their food ultimately comes from the Sun. Organisms that get their food

Grades K–2	Grades 3–5	Grades 6–8	Grades 9–12
			from other organisms are called consumers. Matter and energy transfer across organisms: Food webs represent the transfer of energy and matter from plants to animals and decomposers. Different trophic levels are included in food webs: plants, animals, and decomposers. This transfer of matter and energy from plants supports consumers' body repair, growth, reproduction, and energy use. For example, animal motion is possible because food can be broken down into smaller parts and energy is released from the food.

Ecosystem: Cycling of Matter and Flow of Energy (Ecosys)

Grades K–2	Grades 3–5	Grades 6–8	Grades 9–12
<u>Animal food sources</u>: Animals grow and change throughout their lives, requiring food to support their growth, development, and survival. They obtain food by eating plants or other animals, ensuring they have the energy and materials needed for growth and daily functions.	<u>Animal use of matter and energy</u>: Animals obtain matter and energy from eating other organisms. Some animals eat plants, while others consume animals that eat plants. Animals live in places where they can find enough food. Food provides animals with materials needed for body repair, growth, warmth, and motion. Food also stores energy for animal functions, supporting the overall survival of animals.	<u>Energy for ecosystems</u>: The Sun provides energy which is used by plants to produce food. The matter for making plant food comes from the air. Food is used by plants for growth, energy, or storage (e.g., in fruits and bulbs). Since plants make food, they ultimately provide matter and energy to the organisms in the ecosystem. <u>Matter and energy transfer in an ecosystem</u>: Some animals eat plants, others eat both plants and animals, and some eat only animals. Decomposers play a crucial role in the ecosystem by breaking down dead plants and animals, recycling nutrients back into the soil, and supporting the cycle of matter in the ecosystem. Food webs are representations of the transfer of matter and energy across organisms of an ecosystem.	<u>Matter cycle in ecosystems</u>: Matter cycles through ecosystems, transferring from one system to another. As food matter is transferred among organisms, it is broken down and rearranged into new groupings of atoms (through chemical reactions), providing organisms with the necessary matter for their functions. <u>Energy flow for ecosystems</u>: The main energy source for organisms in an ecosystem begins with the Sun, which plants capture to produce food. Plants, animals, and decomposers use energy from food for their essential functions. This process ensures that energy flows from producers to consumers and decomposers, supporting life functions within the ecosystem. Food webs describe how matter and energy are transferred among producers, consumers, and decomposers.

Ecosystem Health (EcoHlth)

Grades K–2	Grades 3–5	Grades 6–8	Grades 9–12
Environmental conditions for living things: Living things are diverse and inhabit diverse places, which support their specific needs. A particular place provides the necessary habitat conditions for an organism to thrive. Living things require essential resources such as water, air, and land to grow, reproduce, and survive.	Healthy ecosystems: In healthy ecosystems, there is a diversity of plants and animals. Organisms can find enough food, water, space, and a place to grow and increase their populations. Two examples of the interaction of plants and animals in ecosystems are pollination and seed dispersal, which are facilitated by wind, water, and animals. Both processes ensure that plants can reproduce and thrive. Relationships between living things and habitats: Different organisms live in habitats that provide the resources and conditions for their survival needs, including food, water, reproduction, and space. Living things can impact the physical characteristics of their habitats. In addition, changes in habitats affect the populations that live there. These impacts can be positive or negative.	Organism interactions: Populations of different species interact with each other. These interactions include predation, competition, disease, migration, cooperation, and symbiosis. Organisms also interact with the environment, for example, when weather changes or water becomes less available. Human activity can also affect populations in the ecosystem, enabling or disrupting them. When resources, which are unevenly distributed, are changing or becoming limited, they can slow or stop population growth. Potentially, changes in ecosystems can lead to more permanent changes. Ecosystem relationships: Organisms (including humans) rely on their habitat for essential resources. Human activities can disrupt or improve ecosystems, impacting the connections between Earth's *spheres* (and	Ecosystem capacity factors: Ecosystems have limits on growth and the capacity to sustain populations. Factors and resources such as predation, competition, disease, immigration, weather, food, and water availability can limit, slow, or stop population growth. Unstable environments, caused by factors like drought, flood, migration, invasive species, and disease, impact populations and often decrease biodiversity. Ecosystem stability and resilience: Healthy ecosystems maintain stability and resilience by supporting diverse organisms and meeting their needs. Despite disturbances (e.g., weather, climate, or human activity), ecosystems interact dynamically with Earth's spheres (biosphere, hydrosphere, geosphere, and atmosphere) to manage disruptions and return to their

Grades K–2	Grades 3–5	Grades 6–8	Grades 9–12
		have interactions with the biosphere, hydrosphere, atmosphere, and geosphere). The relationships among living and nonliving components support populations and can result in ecosystem changes.	stable state. Human activities, weather, and climate changes can disrupt ecosystems, but their ability to adapt and recover is crucial for maintaining balance and supporting biodiversity.

Group Survival Behavior (Group)

Grades K–2	Grades 3–5	Grades 6–8	Grades 9–12
Animal learned behaviors: Animals rely on their senses to gather information from the environment. Learned behaviors, such as protecting, nesting, feeding, hunting, cleaning, grooming, and migrating, are vital for the offspring's survival. Animals have offspring, who learn essential behaviors from their parents, other family members, and community members, as well as through their own experiences. These behaviors are often reinforced by the parents' actions to ensure their young thrive.	Light and sound use in animals: Animals, including humans, use their senses to explore the world around them, guiding their actions and behaviors. They receive light and sound from the environment. Sound can cause matter to vibrate, and vibrating matter can produce sound (e.g., the strings of a guitar). Objects become visible when light reflects off their surfaces and enters the eyes. Animal brains process light and sound to interpret the environment and respond with survival behaviors. These sensory inputs are crucial for animals to navigate their environments, find food, avoid predators, and engage in other essential activities. Communication among animals: Animals rely on their senses to share information with group members. Through visual cues, sounds, and other sensory signals, animals convey messages that are vital	Receptors and information processing: Sensory inputs enable animals to convey important messages, navigate their environments, and respond to various stimuli, all of which are essential for their survival. Sound transmits through media like air or solids via vibrations, which are detected by the ears. Light travels through space and, when it shines on a nonluminous object, it is reflected, allowing the object to be seen when the reflected light enters the eyes. Luminous objects are visible when their light enters the eyes directly. Animals' response to environmental information: Animals sense and communicate information and respond to it with behaviors that help them interact with the environment and survive. Sense receptors capture various types of information, which the brain processes to generate a response. Through	Advantages of groups: Being part of a group is vital for animals as it enhances their ability to meet essential survival needs such as obtaining food and water, defending against predators, raising young, and adapting to environmental changes. This communal living not only increases the survival chances of individuals within the group but also boosts the likelihood of reproduction, thereby sustaining the population. Group behaviors: Strategies like hunting, migrating, swarming, flocking, and schooling support both individual and population survival, ensuring that animal populations can reproduce and better use available resources.

Grades K–2	Grades 3–5	Grades 6–8	Grades 9–12
	for their survival and social interactions. For example, animals might use sounds to alert others to danger or visual signals to indicate the presence of food.	these interactions, animals can alert others to danger, indicate the presence of food, or coordinate group activities, and enhance their chances of survival.	

Traits of Organisms (Trait)

Grades K–2	Grades 3–5	Grades 6–8	Grades 9–12
Trait resemblance: Plants and animals often resemble their biological parents but are not identical, displaying both similarities and differences. These variations in characteristics among individuals of the same kind contribute to the diversity within a species.	Trait inheritance: Offspring inherit a combination of traits from their biological parents, resulting in organisms that look similar to their parents. However, individuals of the same kind (e.g., siblings) exhibit unique characteristics because they inherited a different set of genetic information. Therefore, plants and animals display variations in their traits (this is also called a phenotype), which contribute to diversity within a species and support adaptation and survival in their environments.	Environmental influence on traits: Organisms display different traits that enable them to survive in specific environments. The environment interacts with organisms and affects their behaviors and responses, such as changes in diet based on food availability, temperature, and water availability. For instance, plants' roots grow deeper during droughts or individuals' outer layers (e.g., skin, fur, bark) will thicken in response to temperature changes. This environmental-enhanced diversity is crucial for the adaptability and resilience of species in changing conditions. The traits of entire populations of organisms can change over time in response to persistent changes in their environment. This occurs through the process of natural selection, in which variations of a trait in a population are more advantageous than others, and	Factors contributing to diversity in traits: Traits are passed down from parents to offspring, affecting individuals' characteristics before they are born. Additionally, the environment also plays a significant role in shaping these traits. Factors such as resource availability, population density, ability to camouflage, disease, climate changes, and soil composition can influence the expression of traits in organisms. These environmental interactions result in diverse visible traits (or phenotypes) in the offspring, affecting how they look, behave, and function. Trait change and adaptation: The distribution of traits in a population is shaped by several mechanisms, including environmental conditions, resource availability and distribution, the relationship between traits and the potential for species to reproduce and increase in

Grades K–2	Grades 3–5	Grades 6–8	Grades 9–12
		those individuals who possess them are more likely to survive and pass it down to offspring. This process of adaptation ensures that species evolve and adapt to better suit their habitats, increasing their overall chances of survival and reproduction. <u>Trait diversity and environmental advantages</u>: The diversity of traits that organisms display can provide some advantages to some individuals over others. These beneficial traits might include physical adaptations, behavioral strategies, or physiological changes that improve an organism's ability to thrive in a particular environment. Traits that provide benefits are more likely to be inherited from parents to offspring, becoming more common over time through natural selection. Conversely, traits that do not contribute to survival are less likely to be inherited and gradually become less common. This	number, and the strength of competition for limited resources between individuals of the same species as well as between different species. Natural selection may lead to increases and decreases of specific traits over time, with traits that enhance survival becoming more common and those that do not become less common. As environmental conditions change, adaptation impacts the distribution of traits within a population, leading to shifts in characteristics over generations. Thus, there is a strong relationship between changing environmental conditions, adaptation by natural selection, and changes in the distribution of traits in a population.

Grades K–2	Grades 3–5	Grades 6–8	Grades 9–12
		process of adaptation ensures that species evolve and adapt to better suit their habitats, increasing their overall chances of survival and reproduction.	

Human Impacts on Ecosystems (Human)

Grades K–2	Grades 3–5	Grades 6–8	Grades 9–12
There are no Essential Elements in this grade band for this DCI family.	<u>Humans are members of ecosystems</u>: Humans live in diverse ecosystems, each providing essential resources like food, water, and shelter. Human activities have a profound impact on ecosystems, both positive and negative. The use of natural resources for energy and fuels affects the environment, and changes in habitats can significantly affect the organisms living there. <u>Solving human-caused problems</u>: By understanding environmental problems through asking questions, making observations, and gathering information, individuals can identify ways to reduce negative impacts and enhance positive ones. This allows for the development of strategies to protect and modify ecosystems, ensuring their health and sustainability.	<u>Ecosystem interactions</u>: Organisms, including humans, rely on their habitats for obtaining essential living and non-living resources. These resources are unevenly distributed, and their availability depends on different interactions between ecosystems components, such as predation, competition, disease, immigration of species, cooperation or symbiosis, weather, food availability, nesting, and sheltering. These interactions are crucial for the survival and growth of populations, as they provide access to resources and influence behaviors and functions within ecosystems. On a global scale, these interactions encompass the biosphere, hydrosphere, atmosphere, and geosphere. <u>Disruption in ecosystems</u>: Human activities can disrupt ecosystems and cause instability and changes that impact populations. Unstable	<u>Supporting ecosystem health</u>: Resource availability is a key factor in determining where animals and humans live, as ecosystems are limited by the availability of both living and nonliving resources. Biodiversity is crucial for maintaining healthy ecosystems and life on Earth, as it ensures resilience and stability. Changes to any part of an ecosystem, whether living or nonliving, can significantly impact the biodiversity of the organisms residing there. Human activities and the use of natural resources often adversely affect biodiversity. Therefore, humans face the challenge of meeting their needs while protecting the environment. Responsible decision-making in the use of natural resources is essential to sustain both human life and the diversity of life on Earth. <u>Science, technology, and engineering's role in protecting ecosystems</u>: Humans can

Grades K–2	Grades 3–5	Grades 6–8	Grades 9–12
		environments are affected by factors like floods, droughts, disease, excessive predation, or immigration of other species, and can decrease biodiversity. This reduction in biodiversity affects populations' access to both living and non-living resources. Changes in biodiversity and environmental conditions, whether natural or human-induced, influence the distribution and survival of species.	mitigate the negative effects of their actions on the environment by using science and technology. These fields play a vital role in addressing the impacts of human activity on natural resources and biodiversity. For example, developing and implementing solutions, such as planting trees and reintroducing species, can increase biodiversity and stability in ecosystems. Evaluating different solutions based on criteria and constraints is necessary to determine the most effective approaches to solving ecosystem problems. Through innovation and responsible practices, science and technology can help reduce adverse impacts on ecosystems, ensuring a sustainable future for both humans and living organisms.

Earth and Space Science

Earth in the Solar System (SolSys)

Grades K–2	Grades 3–5	Grades 6–8	Grades 9–12
Daily patterns in celestial objects: Humans live on Earth, a planet from which we can observe various celestial objects such as the Sun, other stars, and the Moon. The Sun, a star, provides light to the Earth during the daytime and appears to rise in the morning and set in the evening. While the Sun is visible during the day, other stars and the Moon are mainly seen at night, with the Moon often appearing distinct from the stars.	Characteristics of the Sun: The Sun is a star, which gives off light and transfers energy to Earth, making it the largest and brightest star visible in the sky due to its proximity. While the Sun is one of many stars that can be seen, other stars appear dimmer because they are farther away. The Sun provides light during the daytime, and its apparent movement across the sky, rising in the morning and setting in the evening, is a daily pattern observed from Earth. Patterns in daylight and nighttime: Earth rotates on its axis, an imaginary line across the planet, resulting in the cycle of daytime and nighttime. This rotation completes one full spin every 24 hours, creating the 24-hour cycle. The part of Earth facing the Sun experiences daylight, while the part facing away experiences	Solar system: Our solar system is part of the Milky Way galaxy, which contains many stars, including the Sun. The Moon orbits the Earth, taking approximately a month to complete its revolution. Earth and other planets rotate on their axes and orbit the Sun. Sun-Earth-Moon system: The Sun shines light on the Earth and the Moon. The Moon does not produce light of its own; it reflects the Sun’s light, and some of it reflects to Earth. The cycle of the phases of the moon is due to the pattern by which the Earth orbits the Sun, the Moon orbits the Earth, and the way we observe the sunlight reflected from the Moon. Rotation and revolution: The Earth takes 24 hours to complete a full rotation and about 365 days to orbit the	Effects of sunlight on the Earth: Stars, including the Sun, spontaneously release energy, which is transferred to Earth through sunlight. The light from stars varies based on their masses and distances from Earth, with larger stars releasing more energy and closer stars appearing brighter. This energy transfer from the Sun to Earth influences seasonal temperature patterns, as Earth's tilt in relation to the Sun results in varying intensities of sunlight across different areas throughout the year. Factors affecting gravity: Gravity, an attractive force resulting from mass, affects all objects with mass. The strength of the gravitational force between two objects depends on their masses and the distance between them, with stronger forces acting

Grades K–2	Grades 3–5	Grades 6–8	Grades 9–12
	darkness. Additionally, the number of daylight hours varies throughout the year, leading to seasonal patterns, such as longer daylight hours in summer and shorter ones in winter.	Sun. The apparent motion of the Sun in the sky, including the east-west pattern of sunrise and sunset, is due to Earth's rotation on its tilted axis. This rotation results in daytime and nighttime, with Earth completing one full spin every 24 hours. Seasonal patterns in daylight hours are influenced by Earth's tilt and its orbit around the Sun, leading to variations in the number of daylight hours throughout the year. Gravity forces in the universe: Gravity is the force that holds the solar system together, controlling the orbital motions of planets and moons. It exists between all objects in the universe, attracting every celestial body to one another. The gravitational pull of the Sun keeps the planets in orbit, while the gravitational pull of planets holds their moons in orbit, ensuring the stability and movement of celestial objects within the solar system.	between larger masses and decreasing with distance. The Sun, being the most massive object in the solar system, exerts the strongest gravitational pull, which keeps the planets in orbit around it. Similarly, moons are held in orbit around their planets by the planets' gravitational pulls.

Earth Systems (Earth)

Grades K–2	Grades 3–5	Grades 6–8	Grades 9–12
Earth's water sources: Water is distributed across Earth in various forms and locations, including oceans, rivers, lakes, ponds, and glaciers. It can be found as solid ice and liquid water, playing a crucial role in Earth's ecosystems and climate. Water and wind effects on Earth's surface: Water transports soil and rocks, and wind carries soil and erodes rocks. These processes can lead to rapid or gradual changes in landforms, continuously transforming the planet's surface. As a result, they shape the Earth's surface.	Earth's water distribution: Water is distributed across Earth in various forms and locations. Nearly all of Earth's water is found in the ocean as salt water, while the amount of fresh water is limited and primarily located in streams, lakes, wetlands, and glaciers. Depending on temperature, water exists in different states—solid, liquid, or gas—and can be found almost everywhere, including as vapor in the air, droplets in clouds or flowing over land, and ice or snow sitting on the surface. Weathering processes: Water, along with ice, wind, organisms, and gravity, plays a significant role in weathering and erosion. These forces break rocks, soil, and sediments into smaller particles and move them around, leading to changes in the landscape. Examples of these processes include the formation of sand dunes, potholes, gullies, creeks,	Water cycle: Water moves continuously among land, bodies of water (like rivers, lakes and the ocean), and the atmosphere. Since matter is neither created nor destroyed, the same water particles keep cycling. This cycle involves processes such as evaporation (where liquid water absorbs the Sun's energy and changes to gas), condensation (where gaseous water cools down and forms clouds), and precipitation (where water in clouds falls back to Earth.) Many of these processes are related to changes in energy. For example, the absorption of sunlight increases the kinetic energy of water particles, causing the water to evaporate. Water impacts: The water cycle significantly impacts Earth's various levels, including the geosphere (e.g., rocks) and hydrosphere (e.g., rivers). Gravity pulls water downhill, moving soil and rocks and reshaping landforms over time.	Earth's spheres' interactions: Earth's major systems—the geosphere, hydrosphere, atmosphere, and biosphere—are interconnected and dynamic. The geosphere includes rocks, soil, and landforms; the hydrosphere encompasses water and ice; the atmosphere consists of air; and the biosphere contains all living things. These systems interact continuously, affecting each other in both immediate and long-term ways, which can have positive or negative impacts on organisms. Changes affecting Earth's systems: Changes in Earth's systems affect humans' access to resources, including both living and nonliving resources. These changes determine where and how humans can live and thrive. For example, a rise in global temperatures can melt glacial ice, which reduces water sources for people (e.g., rivers fed by glaciers). Likewise, loss of ground vegetation can

Grades K–2	Grades 3–5	Grades 6–8	Grades 9–12
	terracing, mudslides, and rivers carving out canyons.	Precipitation, such as rain, sleet, and hail, also contributes to these changes, gradually altering the landscape through weathering and erosion.	lead to increased water runoff and soil erosion, impacting local ecosystems and human activities.

Weather and Climate (Weath)

Grades K–2	Grades 3–5	Grades 6–8	Grades 9–12
Local weather characterization: Weather within a localized area is determined by the combination of sunlight, wind, precipitation, and temperature in a specific region at a particular time. Observations and recorded measurements of these conditions can reveal patterns over various time scales, including daily, monthly, seasonal, and yearly trends.	Predictions on local weather: Weather consists of local events in the atmosphere, including wind, sunlight, precipitation, and temperature. By observing and measuring these conditions, daily patterns can be identified, which help in making and supporting predictions about future weather.	Weather components: Weather is defined by temperature, humidity, precipitation, and wind; and is affected by the Sun's heat, the movement of water in the atmosphere, and interactions between air masses. Weather refers to specific, temporary events. Air masses move around the Earth, influence local weather, and can lead to significant changes when they move (e.g., storms or heat waves), especially because air masses tend to be uniform in temperature and humidity, and often related to the areas where they are formed. Climate features: Climate refers to the long-term patterns of weather in a particular area, influenced by interactions involving sunlight, ice, bodies of water, and geography. Different regions have distinct climates, such as tropical wet climates near the equator and polar climates near the poles. These varied climates	Effects of the Sun's energy on Earth's weather and climate: The transfer of solar energy to the Earth drives the average global temperature, in which the Sun's energy is absorbed and transferred though the Earth's spheres, including the atmosphere, hydrosphere, and geosphere. This absorption increases Earth's surface temperatures and influences weather (local and temporary) and climate (long-term) patterns. Impact of human activity on Earth's climate: Human action can significantly impact Earth's systems by adding gases to the atmosphere and hydrosphere that absorb or retain heat, leading to increased average global temperatures. Models predict that this trend will continue, but through science, models, and technology, humans have the potential to identify, manage, and reduce

Grades K–2	Grades 3–5	Grades 6–8	Grades 9–12
		contribute to Earth's biodiversity, and the climate of an area affects the weather in other regions. It has been observed that the Earth's global climate is warming. Weather system interactions: The movement of air masses has significant effects on weather and climate. When winds move these air masses, they carry their weather conditions, such as hot or cold, dry or moist, from their source region to new areas. These movements can lead to significant changes in local weather, such as colder weather occurring when a cold air mass pushes a warmer mass out of the way. These interactions, when occurring annually, contribute to shaping local climates.	their impact on global temperatures.

Reducing Impacts of Severe Weather (Impact)

Grades K–2	Grades 3–5	Grades 6–8	Grades 9–12
Problems related to severe weather: Forecasting severe weather allows people to prepare and respond effectively, since severe weather can cause significant harm, including loss of shelter, access to food, and power. To address such situations, it is crucial to clearly understand a severe weather-related problem by asking questions, making observations, and gathering information.	Severe weather hazard mitigation: Severe weather can cause harmful effects like unpassable roads, building damage, and restricted power and communication systems. Natural hazards such as floods, tornadoes, blizzards, and mudslides cannot be prevented, but humans can take steps to mitigate their impacts. To address these hazards, it is essential to approach them as problems to be solved through engineering. Understanding the problem involves asking questions, making observations, and gathering information. Solutions can include lightning rods, wind-resistant roofs, advanced warning systems, and community emergency plans.	Solutions for severe weather hazards: Science helps us understand why severe weather occurs and how these events can be predicted (even though predictions can sometimes be inaccurate). Engineering approaches can be designed to address these problems by first clearly understanding them through questions, observations, and information gathering. A key step is to evaluate different solutions based on criteria and constraints to ensure the best possible outcome and mitigate harmful impacts.	Refining design solutions for severe weather: Given the importance of designing solutions that address severe weather hazards, evaluating and improving solutions involves understanding the problem and systematically assessing different solutions based on assessment criteria and design constraints such as cost, safety, reliability, and aesthetics. Although one design may not excel in all tests, identifying the best-performing characteristics can inform the redesign process. These iterative testing and modification processes lead to refined and optimal solutions to mitigate harmful impacts on human safety and resources.

Matter and Chemical Reactions (Matter)

Grades K–2	**Grades 3–5**	**Grades 6–8**	**Grades 9–12**
Matter classification: There are different kinds of matter, such as wood, metal, and water. Matter can change between solid and liquid states depending on temperature (e.g., butter, water). Matter is described and classified by its observable properties (e.g., color, texture), which help distinguish different substances based on their characteristics.	Properties of substances and phase change: Observations and measurements of properties such as mass, volume, size, and temperature can be used to describe matter and characterize physical changes (i.e., a change that does not alter the composition of the particles of matter.) One example is phase change (also named change of state), in which a material changes from one state to another. When heat is added, a solid melts or a liquid boils. When heat is removed from a liquid substance, it can solidify. Particle nature of matter: Matter has mass, takes up space, and is composed of particles too small to be seen. Matter is observed as solid, liquid, and gas. We can indirectly observe the particle nature of matter in different phenomena; for instance, the	Particle model of matter for different states: Matter is made of different types of particles and can exist as a solid, liquid, or gas, depending on temperature. In solids, particles are closely spaced and vibrate in position; while in liquids, the particles move but are constantly in contact. In gases, they move freely and are widely spaced. Phase changes occur with variations in temperature. Adding heat changes solids to liquids and liquids to gases; removing heat reverses these changes. The observation of some properties of materials, such as the ability to flow or take the shape of a container, can be explained by the particle model. Chemical reactions and properties: When two or more substances mix, they can chemically react to form new substances with different	Matter consists of atoms: Substances are composed of specific types and numbers of atoms (i.e., the smallest particles of matter), forming molecules or compounds like sodium chloride (NaCl), carbon dioxide (CO_2), oxygen (O_2), and water (H_2O). During chemical reactions, the way atoms are grouped together changes, resulting in new substances with different properties. Factors that affect chemical reactions: A chemical reaction occurs when atoms in substances are rearranged to form new substances. Driven by particle collisions, some substances break down and rearrange into new ones. Factors that increase the likelihood of a chemical reaction include the concentration of substances (i.e., more particles have a

Grades K–2	Grades 3–5	Grades 6–8	Grades 9–12
	way a closed syringe will not compress all the way, the increase of pressure in an inflating balloon, or even in the creation of bubbles. Conservation of matter: Matter can change in different ways, for example, in a phase change (when heat is added or removed) or when two or more substances are mixed. Regardless of the change, matter is never created or destroyed—it is always *conserved*—even if it seems to appear or disappear.	properties from the original ones. These chemical reactions result in substances with unique physical and chemical properties, such as mass, hardness, solubility, flammability, and conductivity, among others. The formation of rust, for example, is the result of a chemical reaction between iron, water, and oxygen. The properties of rust (e.g., its reddish-brown color or flakiness) are different than the initial iron, water, or oxygen, which is indicative of a chemical reaction. These properties can be used to identify substances and differentiate them from each other. Conservation of mass in closed systems: Matter is always conserved, meaning it is neither created nor destroyed during chemical or physical changes. This means that in a closed system (i.e., where no matter can leave or enter), the mass of the starting substances equals the mass of	greater likelihood of colliding) and higher temperatures (which increase the kinetic energy and movement of atoms, leading to more frequent collisions). Conservation of mass and atoms: Matter is conserved at the particle level during chemical reactions, meaning the same types and numbers of atoms are present at the beginning and end of the reaction in a closed system; they are only rearranged into different substances. Thus, the total mass of the starting substances equals the mass of the ending substances, providing evidence for the conservation of matter. Models of molecules, atoms, and compounds can serve to illustrate chemical reactions and conservation of matter.

Grades K–2	Grades 3–5	Grades 6–8	Grades 9–12
		ending substances. That explains why observations and measures of the mass of smoke or bubbles can be used to infer conservation of matter at the particle level.	

Interacting Forces (Forces)

Grades K–2	Grades 3–5	Grades 6–8	Grades 9–12
Pushes and pulls affecting movement (contact forces): The motion of objects is influenced by forces like pushes and pulls. These forces can vary in strength and direction and together can change an object's speed or direction, start or stop its movement, and keep it in place. Stronger pushes or pulls make objects move faster, and when objects collide, they exert forces on each other.	Balanced and unbalanced forces: Forces can act on an object from multiple directions and strengths, such as when objects in contact exert forces (push or pull) on each other. When forces are balanced, there is no change in an object's motion, whether at rest or moving at a constant speed. Unbalanced forces can change an object's motion by speeding it up, slowing it down, stopping it, or changing its direction. Balanced and unbalanced forces can affect the movement of an object (e.g., its speed and direction). Noncontact forces: Some forces (electric, magnetic, and gravitational forces) act on objects without direct contact. These forces can pull objects together ("attraction") or push them apart ("repulsion"). Gravitational force (gravity) pulls all objects on Earth's surface downward toward the center of the planet. Gravity influences the movement and	Newton's third law of motion: Newton's third law of motion states that for every action (i.e., force), there is an equal force exhibited in the opposite direction. For instance, when a person walks, their feet push against the ground and, in turn, the ground pushes back against their feet, moving them forward. By rapidly burning fuel, a rocket expels a great deal of gas downward, which produces an equal force up on the rocket, propelling it upward. Forces affecting motion: The motion of an object depends on the total forces acting on it. The greater the object's mass, the greater the force needed to achieve a given change in motion. Similarly, a stronger force will move an object faster and farther.	Newton's second law of motion: Newton's second law of motion describes the relationship between force (*f*), mass (*m*), and acceleration (*a*): *f* = ma. Acceleration is the rate of change of an object's velocity—an object exhibiting a greater acceleration than another is speeding up more quickly. A greater force is needed for a heavier object to achieve the same acceleration as a lighter object. When a force applied to an object is constant, a heavier object will have less acceleration compared to a lighter object. Effects of electric and magnetic forces: Both types of forces can be either attractive or repulsive, depending on the magnitude of the electric charges, the strengths of the magnets involved, and the distances between the interacting objects. The greater the magnitude of the charges or strengths of the magnets, the stronger the force between

Grades K–2	Grades 3–5	Grades 6–8	Grades 9–12
	behavior of objects and maintains the stability of Earth's environment.		them. Conversely, the greater the distance between the objects, the weaker the force.

Energy (Energy)

Grades K–2	Grades 3–5	Grades 6–8	Grades 9–12
<u>Evidence of energy</u>: Energy manifests in various forms, such as moving objects, sound, light, and heat. Pushes and pulls with different strengths and directions provide evidence of energy. Energy manifests in daily life examples like a rolling marble, hearing or feeling a sound, feeling warmth from the Sun or a light source, and seeing light from a bulb or flame.	<u>Energy attributes and perception</u>: Energy can be defined as the ability to do work, enabling things to change, grow, and move. It exists in various forms, such as moving objects, sound, light, and heat. In such cases, energy is transferred from one place (or object) to another. The amount of energy transferred can be inferred from how much sound is heard, light is seen, heat is felt, and how an object moves. Sound can make matter vibrate (e.g., in a musical instrument) and louder sounds possess more energy than softer sounds. Light travels in a straight path from its source, with brighter light having more energy than dimmer light. Heat flows from warmer objects to cooler ones, with hot objects having more heat energy than cold ones.	<u>Kinetic energy and heat</u>: The kinetic energy of particles (or objects) is directly related to their motion and temperature. Faster-moving particles have greater kinetic energy, which is often associated with higher temperatures. Heat refers to the motion of particles, with hot substances having particles that move more quickly compared to those in cold substances. Temperature refers to a measure of the average kinetic energy of an object. <u>Energy transfer</u>: Energy can transfer from one object to another. Energy cannot be created or destroyed, only transferred. Energy transfer occurs when objects (and their particles) collide, causing kinetic energy to flow from one object to another. Energy transfer can change the motion of the objects involved, such as when a moving marble collides with a stationary marble.	<u>Thermal energy</u>: Heat, or thermal energy, refers to the motion of particles in matter, with hotter substances having faster-moving particles than colder substances. Thermal energy can be transferred between objects or substances in contact, flowing from hotter to cooler objects until they reach equal temperatures. The type, size, and temperature of matter affect the amount of heat needed to change its temperature. Some materials are better than others to transfer heat. <u>Sound energy:</u> This form of energy allows us to hear and communicate, traveling through media like air, water, and solids via vibrations. Louder sounds have greater vibrations and more energy than softer sounds. As sound moves away from its source, its volume decreases, indicating a reduction in energy.

Grades K–2	Grades 3–5	Grades 6–8	Grades 9–12
		Light energy: This form of energy behaves differently when it travels through various media. It can be reflected, absorbed, or transmitted depending on the material it encounters. Transparent materials allow light to pass through, opaque materials block light, and translucent materials scatter light. Light travels in a straight path but bends at surfaces between different transparent materials.	

Crosscutting Concepts

The following tables present descriptions of the seven crosscutting concepts (CCCs) from *A Framework for K–12 Science Education* (National Research Council, 2012) and used in the Next Generation Science Standards (NGSS; NGSS Lead States, 2013). Note that these concepts have not been reduced in depth, breadth, and complexity from the general education standards for use in the DLM Essential Elements for science, because that reduction was accomplished through the other dimensions (SEPs and DCIs). The text within each table is quoted from the National Science Teachers Association (NSTA) Matrix of CCCs (NSTA, 2013), which was developed from *A Framework for K–12 Science Education* (National Research Council, 2012) and NGSS Appendix G (NGSS Lead States, 2013). These tables can help you understand where your students have been and where they are going in their science learning. Use the information in the tables to build on concepts from a previous grade band and make connections to new concepts to support student learning.

Patterns

Observed patterns in nature guide organization and classification, and prompt questions about relationships and underlying causes.

Grades K–2	Grades 3–5	Grades 6–8	Grades 9–12
• Patterns in the natural and human designed world can be observed, used to describe phenomena, and used as evidence.	• Similarities and differences in patterns can be used to sort, classify, communicate, and analyze simple rates of change for natural phenomena and designed products. • Patterns of change can be used to make predictions. • Patterns can be used as evidence to support explanation.	• Macroscopic patterns are related to the nature of microscopic and atomic-level structure. • Patterns in rates of change and other numerical relationships can provide information about natural and human designed systems. • Patterns can be used to identify cause and effect relationships. • Graphs, charts, and images can be used to identify patterns in data.	• 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. • Classifications or explanations used at one scale may fail or need revision when information from smaller or larger scales is introduced; thus requiring improved investigations and experiments. • Patterns of performance of designed systems can be analyzed and interpreted to reengineer and improve the system. • Mathematical representations are needed to identify some patterns. • Empirical evidence is needed to identify patterns.

Cause and Effect: Mechanism and Explanation

Events have causes, sometimes simple, sometimes multifaceted. Deciphering causal relationships, and the mechanisms by which they are mediated, is a major activity of science and engineering.

Grades K–2	Grades 3–5	Grades 6–8	Grades 9–12
• Events have causes that generate observable patterns. • Simple tests can be designed to gather evidence to support or refute student ideas about causes.	• Cause and effect relationships are routinely identified, tested, and used to explain change. • Events that occur together with regularity might or might not be a cause and effect relationship.	• Relationships can be classified as causal or correlational, and correlation does not necessarily imply causation. • Cause and effect relationships may be used to predict phenomena in natural or designed systems. • Phenomena may have more than one cause, and some cause and effect relationships in systems can only be described using probability.	• Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. • 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. • Systems can be designed to cause a desired effect. • Changes in systems may have various causes that may not have equal effects.

Scale, Proportion, and Quantity

In considering phenomena, it is critical to recognize what is relevant at different size, time, and energy scales, and to recognize proportional relationships between different quantities as scales change.

Grades K–2	Grades 3–5	Grades 6–8	Grades 9–12
• Relative scales allow objects and events to be compared and described (e.g., bigger and smaller; hotter and colder; faster and slower). • Standard units are used to measure length.	• Natural objects and/or observable phenomena exist from the very small to the immensely large or from very short to very long time periods. • Standard units are used to measure and describe physical quantities such as weight, time, temperature, and volume.	• Time, space, and energy phenomena can be observed at various scales using models to study systems that are too large or too small. • The observed function of natural and designed systems may change with scale. • 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. • Scientific relationships can be represented through the use of algebraic expressions and equations. • Phenomena that can be observed at one scale may not be observable at another scale.	• The significance of a phenomenon is dependent on the scale, proportion, and quantity at which it occurs. • Some systems can only be studied indirectly as they are too small, too large, too fast, or too slow to observe directly. • Patterns observable at one scale may not be observable or exist at other scales. • Using the concept of orders of magnitude allows one to understand how a model at one scale relates to a model at another scale. • 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).

Systems and System Models

A system is an organized group of related objects or components; models can be used for understanding and predicting the behavior of systems.

Grades K–2	Grades 3–5	Grades 6–8	Grades 9–12
• Objects and organisms can be described in terms of their parts. • Systems in the natural and designed world have parts that work together.	• A system is a group of related parts that make up a whole and can carry out functions its individual parts cannot. • A system can be described in terms of its components and their interactions.	• Systems may interact with other systems; they may have sub-systems and be a part of larger complex systems. • Models can be used to represent systems and their interactions—such as inputs, processes and outputs—and energy, matter, and information flows within systems. • Models are limited in that they only represent certain aspects of the system under study.	• Systems can be designed to do specific tasks. • 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. • Models (e.g., physical, mathematical, computer models) can be used to simulate systems and interactions—including energy, matter, and information flows—within and between systems at different scales. • Models can be used to predict the behavior of a system, but these predictions have limited precision and reliability due to the assumptions and approximations inherent in models.

Energy and Matter: Flows, Cycles, and Conservation

Tracking energy and matter flows into, out of, and within systems helps one understand their system's behavior.

Grades K–2	Grades 3–5	Grades 6–8	Grades 9–12
• Objects may break into smaller pieces, be put together into larger pieces, or change shapes.	• Matter is made of particles. • Matter flows and cycles can be tracked in terms of the weight of the substances before and after a process occurs. The total weight of the substances does not change. This is what is meant by conservation of matter. Matter is transported into, out of, and within systems. • Energy can be transferred in various ways and between objects.	• Matter is conserved because atoms are conserved in physical and chemical processes. • Within a natural or designed system, the transfer of energy drives the motion and/or cycling of matter. • Energy may take different forms (e.g., energy in fields, thermal energy, energy of motion). • The transfer of energy can be tracked as energy flows through a designed or natural system.	• The total amount of energy and matter in closed systems is conserved. • 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. • Energy cannot be created or destroyed—only moves between one place and another place, between objects and/or fields, or between systems. • Energy drives the cycling of matter within and between systems. • In nuclear processes, atoms are not conserved, but the total number of protons plus neutrons is conserved.

Structure and Function

The way an object is shaped or structured determines many of its properties and functions.

Grades K–2	Grades 3–5	Grades 6–8	Grades 9–12
• The shape and stability of structures of natural and designed objects are related to their function(s).	• Different materials have different substructures, which can sometimes be observed. • Substructures have shapes and parts that serve functions.	• 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. • Structures can be designed to serve particular functions by taking into account properties of different materials, and how materials can be shaped and used.	• 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. • The functions and properties of natural and designed objects and systems can be inferred from their overall structure, the way their components are shaped and used, and the molecular substructures of its various materials.

Stability and Change

For both designed and natural systems, conditions that affect stability and factors that control rates of change are critical elements to consider and understand.

Grades K–2	Grades 3–5	Grades 6–8	Grades 9–12
• Some things stay the same while other things change. • Things may change slowly or rapidly.	• Change is measured in terms of differences over time and may occur at different rates. • Some systems appear stable, but over long periods of time will eventually change.	• Explanations of stability and change in natural or designed systems can be constructed by examining the changes over time and forces at different scales, including the atomic scale. • Small changes in one part of a system might cause large changes in another part. • Stability might be disturbed either by sudden events or gradual changes that accumulate over time. • Systems in dynamic equilibrium are stable due to a balance of feedback mechanisms.	• Much of science deals with constructing explanations of how things change and how they remain stable. • Change and rates of change can be quantified and modeled over very short or very long periods of time. Some system changes are irreversible. • Feedback (negative or positive) can stabilize or destabilize a system. • Systems can be designed for greater or lesser stability.

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