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# The Three Dimensions

## Dimension 1:  Science and Engineering Practices

*What the students will do.*

**This dimension describes (a) the major practices that scientists employ as they investigate and build models and theories about the world and (b) a key set of engineering practices that engineers use as they design and build systems. We use the term "practices" instead of a term such as "skills" to emphasize that engaging in scientific investigation requires not only skill but also knowledge that is specific to each practice. Similarly, because the term "inquiry," extensively referred to in previous standards documents, has been interpreted over time in many different ways throughout the science education community, part of our intent in articulating the practices in Dimension 1 is to better specify what is meant by inquiry in science and the range of cognitive, social and physical practices that it requires.  As in all inquiry-based approaches to science teaching, our expectation is that students will themselves engage in the practices and not merely learn about them secondhand.  Students cannot comprehend scientific practices, nor fully appreciate the nature of scientific knowledge itself, without directly experiencing those practices for themselves.**

## Dimension   2:  Crosscutting Concepts

*How the students will organize and connect their knowledge.*

**The crosscutting concepts have application across all domains of science.  As such, they provide one way of linking across the domains in Dimension 3.  There is a need to consider not only content but also the ideas and practices that cut across the science disciplines.**

## Dimension 3:  Disciplinary Core Ideas

*What the students will understand.*

**The continuing expansion of scientific knowledge makes it impossible to teach all the ideas related to a given discipline in exhaustive detail during the K-12 years.  But given the cornucopia of information available today virtually at a touch– people live, after all, in an information age—an important role of science education is not to teach "all the facts" but rather to prepare students with sufficient core knowledge so that they can later acquire additional information on their own.  An education focused on a limited set of ideas and practices in science and engineering should enable students to evaluate and select reliable sources of scientific information and allow them to continue their development well beyond their K-12 school years as science learners, users of scientific knowledge, and perhaps also as producers of such knowledge.**

## EIGHT SCIENCE AND ENGINEERING PRACTICES

| PRACTICE | SCIENCE | ENGINEERING |
|---|---|---|
| **Asking Questions and Defining Problems** | Science begins with a question about a phenomenon, such as “Why is the sky blue?” or “What causes cancer?,” and seeks to develop theories that can provide explanatory answers to such questions. A basic practice of the scientist is formulating empirically answerable questions about phenomena, establishing what is already known, and determining what questions have yet to be satisfactorily answered. | Engineering begins with a problem, need, or desire that suggests an engineering problem that needs to be solved. A societal problem such as reducing the nation’s dependence on fossil fuels may engender a variety of engineering problems, such as designing more efficient transportation systems, or alternative power generation devices such as improved solar cells. Engineers ask questions to define the engineering problem, determine criteria for a successful solution, and identify constraints. |
| **Developing and Using Models** | Science often involves the construction and use of a wide variety of models and simulations to help develop explanations about natural phenomena. Models make it possible to go beyond observables and imagine a world not yet seen. Models enable predictions of the form “if . . .then . . . therefore” to be made in order to test hypothetical explanations. | Engineering makes use of models and simulations to analyze existing systems so as to see where flaws might occur or to test possible solutions to a new problem. Engineers also call on models of various sorts to test proposed systems and to recognize the strengths and limitations of their designs. |
| **Planning and Carrying Out Investigations** | Scientific **investigation** may be conducted in the field or the laboratory. A major practice of scientists is planning and carrying out a systematic investigation, which requires the identification of what is to be recorded and, if applicable, what are to be treated as the dependent and independent variables (control of variables). Observations and data collected from such work are used to test existing theories and explanations or to revise and develop new ones. | Engineers use investigation both to gain data essential for specifying design criteria or parameters and to test their designs. Like scientists, engineers must identify relevant variables; decide how they will be measured, and collect data for analysis. Their investigations help them to identify how effective, efficient, and durable their designs may be under a range of conditions. |
| **Analyzing and Interpreting Data** | Scientific **investigations** produce data that must be analyzed in order to derive meaning. Because data usually do not speak for themselves, scientists use a range of tools—including tabulation, graphical interpretation, visualization, and statistical analysis—to identify the significant features and patterns in the data. Sources of error are identified and the degree of certainty calculated. Modern technology makes the collection of large data sets much easier, thus providing many secondary sources for analysis. | Engineers analyze data collected in the tests of their designs and investigations; this allows them to compare different solutions and determine how well each one meets specific design criteria—that is, which design best solves the problem within the given constraints. Like scientists, engineers require a range of tools to identify the major patterns and interpret the results. |

| | | |
|---|---|---|
| **Using Mathematics and Computational Thinking** | In **science,** mathematics and computation are fundamental tools for representing physical variables and their relationships. They are used for a range of tasks, such as constructing simulations, statistically analyzing data, and recognizing, expressing, and applying quantitative relationships. Mathematical and computational approaches enable predictions of the behavior of physical systems, along with the testing of such predictions. Moreover, statistical techniques are invaluable for assessing the significance of patterns or correlations. | In **engineering,** mathematical and computational representations of established relationships and principles are an integral part of design. For example, structural engineers create mathematically based analyses of designs to calculate whether they can stand up to the expected stresses of use and if they can be completed within acceptable budgets. Moreover, simulations of designs provide an effective test bed for the development of designs and their improvement. |
| **Constructing Explanations and Designing Solutions** | The goal of **science** is the construction of theories that can provide explanatory accounts of features of the world. A theory becomes accepted when it has been shown to be superior to other explanations in the breadth of phenomena it accounts for and in its explanatory coherence and parsimony. Scientific explanations are explicit applications of theory to a specific situation or phenomenon, perhaps with the intermediary of a theory-based model for the system under study. The goal for students is to construct logically coherent explanations of phenomena that incorporate their current understanding of science, or a model that represents it, and are consistent with the available evidence. | **Engineering design,** a systematic process for solving engineering problems, is based on scientific knowledge and models of the material world. Each proposed solution results from a process of balancing competing criteria of desired functions, technological feasibility, cost, safety, esthetics, and compliance with legal requirements. There is usually no single best solution but rather a range of solutions. Which one is the optimal choice depends on the criteria used for making evaluations. |
| **Engaging in Argument from Evidence** | In **science,** reasoning and argument are essential for identifying the strengths and weaknesses of a line of reasoning and for finding the best explanation for a natural phenomenon. Scientists must defend their explanations, formulate evidence based on a solid foundation of data, examine their own understanding in light of the evidence and comments offered by others, and collaborate with peers in searching for the best explanation for the phenomenon being investigated. | In **engineering,** reasoning and argument are essential for finding the best possible solution to a problem. Engineers collaborate with their peers throughout the design process, with a critical stage being the selection of the most promising solution among a field of competing ideas. Engineers use systematic methods to compare alternatives, formulate evidence based on test data, make arguments from evidence to defend their conclusions, evaluate critically the ideas of others, and revise their designs in order to achieve the best solution to the problem at hand. |
| **Obtaining, Evaluating, and Communicating Information** | **Science** cannot advance if scientists are unable to communicate their findings clearly and persuasively or to learn about the findings of others. A major practice of science is thus the communication of ideas and the results of inquiry—orally, in writing, with the use of tables, diagrams, graphs, and equations, and by engaging in extended discussions with scientific peers. Science requires the ability to derive meaning from scientific texts (such as papers, the Internet, symposia, and lectures), to evaluate the scientific validity of the information thus acquired, and to integrate that information. | **Engineers** cannot produce new or improved technologies if the advantages of their designs are not communicated clearly and persuasively. Engineers need to be able to express their ideas, orally and in writing, with the use of tables, graphs, drawings, or models and by engaging in extended discussions with peers. Moreover, as with scientists, they need to be able to derive meaning from colleagues' texts, evaluate the information, and apply it usefully. In engineering and science alike, new technologies are now routinely available that extend the possibilities for collaboration and communication. |

## SEVEN CROSSCUTTING CONCEPTS OF THE FRAMEWORK

The organizational framework that connects knowledge into a coherent and scientifically based view of the world

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|---|
| **Patterns:** Observed patterns of forms and events guide organization and classification, and they prompt questions about relationships and the factors that influence them. |
| |
| **Cause and Effect:** Events have causes, sometimes simple, sometimes multifaceted. A major activity of science is investigating and explaining causal relationships and the mechanisms by which they are mediated. Such mechanisms can then be tested across given contexts and used to predict and explain events in new contexts. |
| |
| **Scale, Proportion, and Quantity:** In considering phenomena, it is critical to recognize what is relevant at different measures of size, time, and energy and to recognize how changes in scale, proportion, or quantity affect a system's structure or performance. |
| |
| **Systems and System Models:** Defining the system under study—specifying its boundaries and making explicit a model of that system—provides tools for understanding and testing ideas that are applicable throughout science and engineering. |
| |
| **Energy and Matter:** Tracking fluxes of energy and matter into, out of, and within systems helps one understand the systems' possibilities and limitations. |
| |
| **Structure and Function:** The way in which an object or living thing is shaped and its substructure determine many of its properties and functions. |
| |
| **Stability and Change:** For natural and built systems alike, conditions of stability and determinants of rates of change or evolution of a system are critical elements of study. |

**FIRST GRADE OVERVIEW**

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

**PS = Physical Science**

**LS = Life Science**

**ESS = Earth Space Science**

**ETS = Engineering, Technology, and Application of Science**

**Physical Science K-5 Progression**

| Physical Science | K | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|---|
| **PS1 Matter and Its Interactions** | | | | | | |
| PS1A Structure and Properties of matter | | | X | | | X |
| PS1B Chemical Reactions | | | X | | | X |
| PS1C Nuclear Processes | | | | | | |
| **PS2 Motion and Stability: Forces and Interactions** | | | | | | |
| PS2A Forces and Motion | X | | | X | | |
| PS2B Types of Interactions | X | | | X | | X |
| PS2C Stability and Instability in Physical Systems | | | | | | |
| **PS3 Energy** | | | | | | |
| PS3A Definitions of Energy | | | | | X | |
| PS3B Conservation of Energy and Energy Transfer | X | | | | X | |
| PS3C Relationship Between Energy and Forces | X | | | | X | |
| PS3D Energy and Chemical Processes in Everyday Life | | | | | X | X |
| **PS4 Waves and Their Applications in Technologies for Information Transfer** | | | | | | |
| PS4A Wave Properties | | X | | | X | |
| PS4B Electromagnetic Radiation | | X | | | X | |
| PS4C Information Technologies and Instrumentation | | X | | | X | |

**Core Idea PS4**

**Waves and Their Applications in Technologies for Information Transfer**

*Essential Question: How are waves used to transfer energy and information?*

Waves are a repeating pattern of motion that transfers energy from place to place without overall displacement of matter. Light and sound are wavelike phenomena. By understanding wave properties and the interactions of electromagnetic radiation with matter, scientists and engineers can design systems for transferring information across long distances, storing information, and investigating nature on many scales—some of them far beyond direct human perception.

**PS4.A: WAVE PROPERTIES**

*Essential Question: What are the characteristic properties and behaviors of waves?*

Whether a wave in water, a sound wave, or a light wave, all waves have some features in common. A simple wave has a repeating pattern of specific wavelength, frequency, and amplitude. The wavelength and frequency of a wave are related to one another by the speed of travel of the wave, which, for each type of wave, depends on the medium in which the wave is traveling. Waves can be combined with other waves of the same type to produce complex information-containing patterns that can be decoded at the receiving end. Waves, which transfer energy and any encoded information without the bulk motion of matter, can travel unchanged over long distances, pass through other waves undisturbed, and be detected and decoded far from where they were produced. Information can be digitized (converted into a numerical representation), sent over long distances as a series of wave pulses, and reliably stored in computer memory.

Sound is a pressure wave in air or any other material medium. The human ear and brain working together are very good at detecting and decoding patterns of information in sound (e.g., speech and music) and distinguishing them from random noise.

Resonance is a phenomenon in which waves add up in phase (i.e., matched peaks and valleys), thus growing in amplitude. Structures have particular frequencies at which they resonate when some time-varying force acting on them transfers energy to them. This phenomenon (e.g., waves in a stretched string, vibrating air in a pipe) is used in the design of all musical instruments and in the production of sound by the human voice.

When a wave passes an object that is small compared with its wavelength, the wave is not much affected; for this reason, some things are too small to see with visible light, which is a wave phenomenon with a limited range of wavelengths corresponding to each color. When a wave meets the surface between two different materials or conditions (e.g., air to water), part of the wave is reflected at that surface and another part continues on, but at a different speed. The change of speed of the wave when passing from one medium to another can cause the wave to change direction or refract. These wave properties are used in many applications (e.g., lenses, seismic probing of Earth).

***Grade Band Endpoints for PS4.A***

***By the end of grade 2.*** Waves, which are regular patterns of motion, can be made in water by disturbing the surface. When waves move across the surface of deep water, the water goes up and down in place; it does not move in the direction of the wave—observe, for example, a bobbing cork or seabird—except when the water meets the beach. Sound can make matter vibrate, and vibrating matter can make sound.

***By the end of grade 5.*** Waves of the same type can differ in amplitude (height of the wave) and wavelength (spacing between wave peaks). Waves can add or cancel one another as they cross, depending on their relative phase (i.e., relative position of peaks and troughs of the waves), but they emerge unaffected by each other. (Boundary: The discussion at this grade level is qualitative only; it can be based on the fact that two different sounds can pass a location in different directions without getting mixed up.)

Earthquakes cause seismic waves, which are waves of motion in Earth's crust.

**PS4.B: ELECTROMAGNETIC RADIATION**

*Essential Questions:* *What is light?*
*How can one explain the varied effects that involve light?*
*What other forms of electromagnetic radiation are there?*

Electromagnetic radiation (e.g., radio, microwaves, light) can be modeled as a wave pattern of changing electric and magnetic fields or, alternatively, as particles. Each model is useful for understanding aspects of the phenomenon and its inter-actions with matter, and quantum theory relates the two models. Electromagnetic waves can be detected over a wide range of frequencies, of which the visible spectrum of colors detectable by human eyes is just a small part. Many modern technologies are based on the manipulation of electromagnetic waves.

All electromagnetic radiation travels through a vacuum at the same speed, called the speed of light. Its speed in any given medium depends on its wavelength and the properties of that medium. At the surface between two media, like any wave, light can be reflected, refracted (its path bent), or absorbed. What occurs depends on properties of the surface and the wavelength of the light. When shorter wavelength electromagnetic radiation (ultraviolet, X-rays, gamma rays) is absorbed in matter, it can ionize atoms and cause damage to living cells. However, because X-rays can travel through soft body matter for some distance but are more rapidly absorbed by denser matter, particularly bone, they are useful for medical imaging. Photovoltaic materials emit electrons when they absorb light of a high-enough frequency. This phenomenon is used in barcode scanners and “electric eye” systems, as well as in solar cells. It is best explained using a particle model of light.

Any object emits a spectrum of electromagnetic radiation that depends on its temperature. In addition, atoms of each element emit and preferentially absorb characteristic frequencies of light. These spectral lines allow identification of the presence of the element, even in microscopic quantities or for remote objects, such as a star. Nuclear transitions that emit or absorb gamma radiation also have distinctive gamma ray wavelengths, a phenomenon that can be used to identify and trace specific radioactive isotopes.

***Grade Band Endpoints for PS4.B***

***By the end of grade 2.***

Objects can be seen only when light is available to illuminate them. Very hot objects give off light (e.g., a fire, the sun).

Some materials allow light to pass through them, others allow only some light through, and others block all the light and create a dark shadow on any surface beyond them (i.e., on the other side from the light source), where the light cannot reach. Mirrors and prisms can be used to redirect a light beam. (Boundary: The idea that light travels from place to place is developed through experiences with light sources, mirrors, and shadows, but no attempt is made to discuss the speed of light.)

***By the end of grade 5***.

A great deal of light travels through space to Earth from the sun and from distant stars.

An object can be seen when light reflected from its surface enters the eyes; the color people see depends on the color of the available light sources as well as the properties of the surface. (Boundary: This phenomenon is observed, but no attempt is made to discuss what confers the color reflection and absorption properties on a surface. The stress is on understanding that light traveling from the object to the eye determines what is seen.)

Because lenses bend light beams, they can be used, singly or in combination, to provide magnified images of objects too small or too far away to be seen with the naked eye.

## PS4.C: INFORMATION TECHNOLOGIES AND INSTRUMENTATION

*Essential Question: How are instruments that transmit and detect waves used to extend human senses?*

Understanding of waves and their interactions with matter has been used to design technologies and instruments that greatly extend the range of phenomena that can be investigated by science (e.g., telescopes, microscopes) and have many useful applications in the modern world.

Light waves, radio waves, microwaves, and infrared waves are applied to communications systems, many of which use digitized signals (i.e., sent as wave pulses) as a more reliable way to convey information. Signals that humans cannot sense directly can be detected by appropriately designed devices (e.g., telescopes, cell phones, wired or wireless computer networks). When in digitized form, information can be recorded, stored for future recovery, and transmitted over long distances without significant degradation known how fast sound travels in water and light travels in a vacuum. The better the interaction of the wave with the medium is understood, the more detailed the information that can be extracted (e.g., medical imaging or astronomical observations at multiple frequencies).

***Grade Band Endpoints for PS4.C***

***By the end of grade 2***.
People use their senses to learn about the world around them. Their eyes detect light, their ears detect sound, and they can feel vibrations by touch.

People also use a variety of devices to communicate (send and receive information) over long distances.

***By the end of grade 5***.

Lenses can be used to make eyeglasses, telescopes, or microscopes in order to extend what can be seen. The design of such instruments is based on understanding how the path of light bends at the surface of a lens.

Digitized information (e.g., the pixels of a picture) can be stored for future recovery or transmitted over long distances without significant degradation. High-tech devices, such as computers or cell phones, can receive and decode information—convert it from digitized form to voice—and vice versa.

**Life Science K-5 Progression**

| Life Science | K | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|---|
| **LS1 From Molecules to Organisms: Structures and Processes** | | | | | | |
| LS1A Structure and Function | | X | | | X | |
| LS1B Growth and Development of Organisms | | X | | X | | |
| LS1C Organization for Matter and Energy Flow in Organisms | X | | | | | X |
| LS1D Information Processing | | X | | | X | |
| **LS2 Ecosystems: Interactions, Energy, and Dynamics** | | | | | | |
| LS2A Interdependent Relationships in Ecosystems | | | X | | | X |
| LS2B Cycles of Matter and Energy Transfer in Ecosystems | | | | | | X |
| LS2C Ecosystem Dynamics, Functioning, and Resilience | | | | X | | |
| LS2D Social Interactions and Group Behavior | | | | X | | |
| **LS3 Heredity: Inheritance and Variation of Traits** | | | | | | |
| LS3A Inheritance of Traits | | X | | X | | |
| LS3B Variation of Traits | | X | | X | | |
| **LS4 Biological Evolution: Unity and Diversity** | | | | | | |
| LS4A Evidence of Common Ancestry | | | | X | | |
| LS4B Natural Selection | | | | X | | |
| LS4C Adaptation | | | | X | | |
| LS4D Biodiversity and Humans | | | X | X | | |

**Core Idea LS1**

**From Molecules to Organisms: Structures and Processes**

*Essential Question: How do organisms live, grow, respond to their environment, and reproduce?*

All living organisms are made of cells. Life is the quality that distinguishes living things—composed of living cells—from nonliving objects or those that have died. While a simple definition of life can be difficult to capture, all living things—that is to say all organisms—can be characterized by common aspects of their structure and functioning. Organisms are complex, organized, and built on a hierarchical structure, with each level providing the foundation for the next, from the chemical foundation of elements and atoms, to the cells and systems of individual organisms, to species and populations living and interacting in complex ecosystems. Organisms can be made of a single cell or millions of cells working together and include animals, plants, algae, fungi, bacteria, and all other microorganisms.

Organisms respond to stimuli from their environment and actively maintain their internal environment through homeostasis. They grow and reproduce, transferring their genetic information to their offspring. While individual organisms carry the same genetic information over their lifetime, mutation and the transfer from parent to offspring produce new combinations of genes. Over generations natural selection can lead to changes in a species overall; hence, species evolve over time. To maintain all of these processes and functions, organisms require materials and energy from their environment; nearly all energy that sustains life ultimately comes from the sun.

**LS1.A: STRUCTURE AND FUNCTION**

*Essential Question: How do the structures of organisms enable life's functions?*

A central feature of life is that organisms grow, reproduce, and die. They have characteristic structures (anatomy and morphology), functions (molecular-scale processes to organism-level physiology), and behaviors (neurobiology and, for some animal species, psychology). Organisms and their parts are made of cells, which are the structural units of life and which themselves have molecular substructures that support their functioning. Organisms range in composition from a single cell (unicellular microorganisms) to multicellular organisms, in which different groups of large numbers of cells work together to form systems of tissues and organs (e.g., circulatory, respiratory, nervous, musculoskeletal), that are specialized for particular functions.

Special structures *within* cells are also responsible for specific cellular functions. The essential functions of a cell involve chemical reactions between many types of molecules, including water, proteins, carbohydrates, lipids, and nucleic acids. All cells contain genetic information, in the form of DNA. Genes are specific regions within the extremely large DNA molecules that form the chromosomes. Genes contain the instructions that code for the formation of molecules called proteins, which carry out most of the work of cells to perform the essential functions of life. That is, proteins provide structural components, serve as signaling devices, regulate cell activities, and determine the performance of cells through their enzymatic actions.

***Grade Band Endpoints for LS1.A***

***By the end of grade 2***. All organisms have external parts. Different animals use their body parts in different ways to see, hear, grasp objects, protect themselves, move from place to place, and seek, find, and take in food, water and air. Plants also have different parts (roots, stems, leaves, flowers, fruits) that help them survive, grow, and produce more plants.

***By the end of grade 5***. Plants and animals have both internal and external structures that serve various functions in growth, survival, behavior, and reproduction. (Boundary: Stress at this grade level is on understanding the macroscale systems and their function, not microscopic processes.)

**LS1.B: GROWTH AND DEVELOPMENT OF ORGANISMS**

*Essential Question: How do organisms grow and develop*?

The characteristic structures, functions, and behaviors of organisms change in predictable ways as they progress from birth to old age. For example, upon reaching adulthood, organisms can reproduce and transfer their genetic information to their offspring. Animals engage in behaviors that increase their chances for reproduction, and plants may develop specialized structures and/or depend on animal behavior to accomplish reproduction.

Understanding how a single cell can give rise to a complex, multicellular organism builds on the concepts of cell division and gene expression. In multi-cellular organisms, cell division is an essential component of growth, development, and repair. Cell division occurs via a process called mitosis: when a cell divides in two, it passes identical genetic material to two daughter cells. Successive divisions produce many cells. Although the genetic material in each of the cells is identical, small differences in the immediate environments activate or inactivate different genes, which can cause the cells to develop slightly differently. This process of differentiation allows the body to form specialized cells that perform diverse functions, even though they are all descended from a single cell, the fertilized egg. Cell growth and differentiation are the mechanisms by which a fertilized egg develops into a complex organism. In sexual reproduction, a specialized type of cell division called meiosis occurs and results in the production of sex cells, such as gametes (sperm and eggs) or spores, which contain only one member from each chromosome pair in the parent cell.

***Grade Band Endpoints for LS1.B***

***By the end of grade 2***. Plants and animals have predictable characteristics at different stages of development. Plants and animals grow and change. Adult plants and animals can have young. In many kinds of animals, parents and the offspring themselves engage in behaviors that help the offspring to survive.

***By the end of grade 5***. Reproduction is essential to the continued existence of every kind of organism. Plants and animals have unique and diverse life cycles that include being born (sprouting in plants), growing, developing into adults, reproducing, and eventually dying.

**LS1.D: INFORMATION PROCESSING**

*Essential Question: How do organisms detect, process, and use information about the environment?*

An organism's ability to sense and respond to its environment enhances its chance of surviving and reproducing. Animals have external and internal sensory receptors that detect different kinds of information, and they use internal mechanisms for processing and storing it. Each receptor can respond to different inputs (electromagnetic, mechanical, chemical), some receptors respond by transmitting impulses that travel along nerve cells. In complex organisms, most such inputs travel to the brain, which is divided into several distinct regions and circuits that serve primary roles, in particular functions such as visual perception, auditory perception, interpretation of perceptual information, guidance of motor movement, and decision making. In addition, some of the brain's circuits give rise to emotions and store memories. Brain function also involves multiple interactions between the various regions to form an integrated sense of self and the surrounding world.

***Grade Band Endpoints for LS1.D***

***By the end of grade 2.*** Animals have body parts that capture and convey different kinds of information needed for growth and survival—for example, eyes for light, ears for sounds, and skin for temperature or touch. Animals respond to these inputs with behaviors that help them survive (e.g., find food, run from a predator). Plants also respond to some external inputs (e.g., turn leaves toward the sun).

***By the end of grade 5***. Different sense receptors are specialized for particular kinds of information, which may then be processed and integrated by an animal's brain, with some information stored as memories. Animals are able to use their perceptions and memories to guide their actions. Some responses to information are instinctive—that is, animals' brains are organized so that they do not have to think about how to respond to certain stimuli.

**Core Idea LS3**

**Heredity: Inheritance and Variation of Traits**

*Essential Questions:* *How are characteristics of one generation passed to the next?*
*How can individuals of the same species and even siblings have different characteristics?*

Heredity explains why offspring resemble, but are not identical to, their parents and is a unifying biological principle. Heredity refers to specific mechanisms by which characteristics or traits are passed from one generation to the next via genes. Genes encode the information for making specific proteins, which are responsible for the specific traits of an individual. Each gene can have several variants, called alleles, which code for different variants of the trait in question. Genes reside in a cell's chromosomes, each of which contains many genes. Every cell of any individual organism contains the identical set of chromosomes. When organisms reproduce, genetic information is transferred to their offspring. In species that reproduce sexually, each cell contains two variants of each chromosome, one inherited from each parent. Thus sexual reproduction gives rise to a new combination of chromosome pairs with variations between parent and offspring. Very rarely, mutations also cause variations, which may be harmful, neutral, or occasionally advantageous for an individual. Environmental as well as genetic variation and the relative dominance of each of the genes in a pair play an important role in how traits develop within an individual. Complex relationships between genes and interactions of genes with the environment determine how an organism will develop and function.

**LS3.A: INHERITANCE OF TRAITS**

*Essential Question: How are the characteristics of one generation related to the previous generation?*

In all organisms, the genetic instructions for forming species' characteristics are carried in the chromosomes. Each chromosome consists of a single very long DNA molecule, and each gene on the chromosome is a particular segment of that DNA. DNA molecules contain four different kinds of building blocks, called nucleotides, linked together in a sequential chain. The sequence of nucleotides spells out the information in a gene. Before a cell divides, the DNA sequence of its chromosomes is replicated and each daughter cell receives a copy. DNA controls the expression of proteins by being transcribed into a "messenger" RNA, which is translated in turn by the cellular machinery into a protein. In effect, proteins build an organism's identifiable traits. When organisms reproduce, genetic information is transferred to their offspring, with half coming from each parent in sexual reproduction. Inheritance is the key factor causing the similarity among individuals in a species population.

***Grade Band Endpoints for LS3.A***

***By the end of grade 2***. Organisms have characteristics that can be similar or different. Young animals are very much, but not exactly, like their parents and also resemble other animals of the same kind. Plants also are very much, but not exactly, like their parents and resemble other plants of the same kind.

***By the end of grade 5***. Many characteristics of organisms are inherited from their parents. Other characteristics result from individuals' interactions with the environment, which can range from diet to learning. Many characteristics involve both inheritance and environment.

**LS3.B: VARIATION OF TRAITS**

*Essential Question: Why do individuals of the same species vary in how they look, function, and behave?*

Variation among individuals of the same species can be explained by both genetic and environmental factors. Individuals within a species have similar but not identical genes. In sexual reproduction, variations in traits between parent and offspring arise from the particular set of chromosomes (and their respective multiple genes) inherited, with each parent contributing half of each chromosome pair. More rarely, such variations result from mutations, which are changes in the information that genes carry. Although genes control the general traits of any given organism, other parts of the DNA and external environmental factors can modify an individual's specific development, appearance, behavior, and likelihood of producing offspring. The set of variations of genes present, together with the interactions of genes with their environment, determines the distribution of variation of traits in a population.

***Grade Band Endpoints for LS3.B***

***By the end of grade 2***. Individuals of the same kind of plant or animal are recognizable as similar but can also vary in many ways.

***By the end of grade 5***. Offspring acquire a mix of traits from their biological parents. Different organisms vary in how they look and function because they have different inherited information. In each kind of organism there is variation in the traits themselves, and different kinds of organisms may have different versions of the trait. The environment also affects the traits that an organism develops—differences in where they grow or in the food they consume may cause organisms that are related to end up looking or behaving differently.

**Earth Space K-5 Progression**

| Earth Space Science | K | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|---|
| **ESS1 Earth's Place in the Universe** | | | | | | |
| ESS1A The Universe and Its Stars | | X | | | | X |
| ESS1B Earth and the Solar System | | X | | | | X |
| ESS1C The History of Planet Earth | | | X | | X | |
| **ESS2 Earth's Systems** | | | | | | |
| ESS2A Earth Materials and Systems | | | X | | X | X |
| ESS2B Plate Tectonics and Large-Scale System Interactions | | | X | | X | |
| ESS2C The Roles of Water in Earth's Surface Processes | | | X | | | X |
| ESS2D Weather and Climate | X | | | X | | |
| ESS2E Biogeology | X | | | | X | |
| **ESS3 Earth and Human Activity** | | | | | | |
| ESS3A Natural Resources | X | | | | X | |
| ESS3B Natural Hazards | X | | | X | | |
| ESS3C Human Impacts on Earth Systems | X | | | | | X |
| ESS3D Global Climate Change | | | | | | |

**Core Idea ESS1**

**Earth's Place in the Universe**

*Essential Question: What is the universe, and what is Earth's place in it?*

The planet Earth is a tiny part of a vast universe that has developed over a huge expanse of time. The history of the universe, and of the structures and objects within it, can be deciphered using observations of their present condition together with knowledge of physics and chemistry. Similarly, the patterns of motion of the objects in the solar system can be described and predicted on the basis of observations and an understanding of gravity. Comprehension of these patterns can be used to explain many Earth phenomena, such as day and night, seasons, tides, and phases of the moon. Observations of other solar system objects and of Earth itself can be used to determine Earth's age and the history of large-scale changes in its surface.

## ESS1.A: THE UNIVERSE AND ITS STARS

*Essential Question: What is the universe, and what goes on in stars?*

The sun is but one of a vast number of stars in the Milky Way galaxy, which is one of a vast number of galaxies in the universe.

The universe began with a period of extreme and rapid expansion known as the Big Bang, which occurred about 13.7 billion years ago. This theory is supported by the fact that it provides explanation of observations of distant galaxies receding from our own, of the measured composition of stars and non-stellar gases, and of the maps and spectra of the primordial radiation (cosmic microwave background) that still fills the universe.

Nearly all observable matter in the universe is hydrogen or helium, which formed in the first minutes after the Big Bang. Elements other than these remnants of the Big Bang continue to form within the cores of stars. Nuclear fusion within stars produces all atomic nuclei lighter than and including iron, and the process releases the energy seen as starlight. Heavier elements are produced when certain massive stars achieve a supernova stage and explode.

Stars' radiation of visible light and other forms of energy can be measured and studied to develop explanations about the formation, age, and composition of the universe. Stars go through a sequence of developmental stages—they are formed; evolve in size, mass, and brightness; and eventually burn out. Material from earlier stars that exploded as supernovas is recycled to form younger stars and their planetary systems. The sun is a medium-sized star about halfway through its predicted life span of about 10 billion years.

### *Grade Band Endpoints for ESS1.A*

***By the end of grade 2***. Patterns of the motion of the sun, moon, and stars in the sky can be observed, described, and predicted. At night one can see the light coming from many stars with the naked eye, but telescopes make it possible to see many more and to observe them and the moon and planets in greater detail.

***By the end of grade 5.*** The sun is a star that appears larger and brighter than other stars because it is closer. Stars range greatly in their size and distance from Earth.

**ESS1.B: EARTH AND THE SOLAR SYSTEM**

*Essential Question: What are the predictable patterns caused by Earth's movement in the solar system?*

The solar system consists of the sun and a collection of objects of varying sizes and conditions—including planets and their moons—that are held in orbit around the sun by its gravitational pull on them. This system appears to have formed from a disk of dust and gas, drawn together by gravity.

Earth and the moon, sun, and planets have predictable patterns of movement. These patterns, which are explainable by gravitational forces and conservation laws, in turn explain many large-scale phenomena observed on Earth. Planetary motions around the sun can be predicted using Kepler's three empirical laws, which can be explained based on Newton's theory of gravity. These orbits may also change somewhat due to the gravitational effects from, or collisions with, other bodies. Gradual changes in the shape of Earth's orbit around the sun (over hundreds of thousands of years), together with the tilt of the planet's spin axis (or axis of rotation), have altered the intensity and distribution of sunlight falling on Earth. These phenomena cause cycles of climate change, including the relatively recent cycles of ice ages.

Gravity holds Earth in orbit around the sun, and it holds the moon in orbit around Earth. The pulls of gravity from the sun and the moon cause the patterns of ocean tides. The moon's and sun's positions relative to Earth cause lunar and solar eclipses to occur. The moon's monthly orbit around Earth, the relative positions of the sun, the moon, and the observer and the fact that it shines by reflected sunlight explain the observed phases of the moon.

Even though Earth's orbit is very nearly circular, the intensity of sunlight falling on a given location on the planet's surface changes as it orbits around the sun. Earth's spin axis is tilted relative to the plane of its orbit, and the seasons are a result of that tilt. The intensity of sunlight striking Earth's surface is greatest at the equator. Seasonal variations in that intensity are greatest at the poles.

***Grade Band Endpoints for ESS1.B***

***By the end of grade 2***. Seasonal patterns of sunrise and sunset can be observed, described, and predicted.

***By the end of grade 5***. The orbits of Earth around the sun and of the moon around Earth, together with the rotation of Earth about an axis between its North and South poles, cause observable patterns. These include day and night; daily and seasonal changes in the length and direction of shadows; phases of the moon; and different positions of the sun, moon, and stars at different times of the day, month, and year.

Some objects in the solar system can be seen with the naked eye. Planets in the night sky change positions and are not always visible from Earth as they orbit the sun. Stars appear in patterns called constellations, which can be used for navigation and appear to move together across the sky because of Earth's rotation.

# A Closer Look at the Scope and Sequence
## First Grade Unit 1

This is a **performance expectation**. Performance expectations describe what students should be able to do at the end of instruction and incorporates a science and engineering practice, a disciplinary core idea (DCI) and a crosscutting concept. Performance expectations are not instructional strategies or objectives for a lesson. Instead, they are intended to guide the development of assessments. Clarification statements and assessment boundary statements are provided in the original documents to render additional support and clarification of the performance expectation.

**1-ESS1-1** 1 = grade level
ESS1 = Core Idea
1 = the number within the core idea (so this is the first performance expectation in the core idea ESS1)

### 1-ESS1-1. Use observations of the sun, moon and stars to describe patterns that can be predicted.

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|---|---|
| **Science and Engineering Practice**<br>• **Analyzing and Interpreting Data** – Use observation to describe patterns in the natural world in order to answer scientific questions. | what they will do |
| **Disciplinary Core Idea**<br>• **ESS1.A: The Universe and Its Stars –** Patterns of the motion of the sun, moon, and stars in the sky can be observed, described, and predicted. | what they will understand |
| **Crosscutting Concept**<br>• **Patterns** - Patterns in the natural world can be observed, used to describe phenomena, and used as evidence. | how they will organize and connect their knowledge |

BLUE VALLEY DISTRICT CURRICULUM

# Science | Grade 1

| ORGANIZING THEME/TOPIC | FOCUS STANDARDS & SKILLS |
|---|---|
| **Sun, Moon and Stars**<br><br>**Bring Science Alive!**<br>Unit 3: Sky Patterns<br>Lessons 1 - 5<br><br>**STAR LAB**<br><br>Suggested Time Frame: 45 days | **1-ESS1-1.** **Use observations** of the sun, moon, and stars **to describe patterns** that can be predicted.<br><br>**Science and Engineering Practice**<br>• **Analyzing and Interpreting Data –** Use observations to describe patterns in the natural world in order to answer scientific questions.<br>**Disciplinary Core Idea**<br>• **ESS1.A: The Universe and Its Stars -** Patterns of the motion of the sun, moon, and stars in the sky can be observed, described, and predicted.<br>**Crosscutting Concept**<br>• **Patterns –** Patterns in the natural world can be observed, used to describe phenomena, and used as evidence.<br><br>**1-ESS1-2.** **Make observations** at different times of year **to relate the amount of daylight to the time of year.**<br><br>**Science and Engineering Practice**<br>• **Planning and Carrying Out Investigations –** Make observations to collect data that can be used to make comparisons.<br>**Disciplinary Core Ideas**<br>• **ESS1.B: Earth and the Solar System -** Seasonal patterns of sunrise and sunset can be observed, described, and predicted.<br>**Crosscutting Concept**<br>• **Patterns –** Patterns in the natural world can be observed, used to describe phenomena, and used as evidence. |

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| **Parents and Offspring: Similarities and Differences**<br><br>**Bring Science Alive!**<br>Unit 1: Plant and Animal Parts<br>Lessons 1 - 2<br><br>Suggested Time Frame: 19 days | **1-LS3-1. Make observations to construct an evidence-based account that** young plants and animals **are like, but not exactly like, their parents.**<br><br>**Science and Engineering Practice**<br>• **Constructing Explanations and Designing Solutions –** Make observations to construct an evidence-based account for natural phenomena.<br>**Disciplinary Core Ideas**<br>• **LS3.A: Inheritance of Traits -** Young animals are very much, but not exactly, like their parents. Plants also are very much, but not exactly, like their parents.<br>• **LS3.B: Variation of Traits -** Individuals of the same kind of plant or animal are recognizable as similar but can also vary in many ways.<br>**Crosscutting Concept**<br>• **Patterns –** Patterns in the natural and human designed world can be observed, used to describe phenomena, and used as evidence. |
| **Plant and Animal Parts**<br><br>**Bring Science Alive!**<br>Unit 1: Plant and Animal Parts<br>Lessons 3-4<br><br>Suggested Time Frame: 21 days | **1-LS1-1. Use materials to design a solution to a human problem by mimicking how plants and/or animals** use their external parts to help them survive, grow, and meet their needs.<br><br>**Science and Engineering Practice**<br>• **Constructing Explanations and Designing Solutions -** Use materials to design a device that solves a specific problem or a solution to a specific problem.<br>**Disciplinary Core Ideas**<br>• **LS1.A: Structure and Function -** All organisms have external parts. Different animals use their body parts in different ways to see, hear, grasp objects, protect themselves, move from place to place, and seek, find, and take in food, water and air. Plants also have different parts (roots, stems, leaves, flowers, fruits) that help them survive and grow.<br>• **LS1.D: Information Processing -** Animals have body parts that capture and convey different kinds of information needed for growth and survival. Animals respond to these inputs with behaviors that help them survive. Plants also respond to some external inputs<br>**Crosscutting Concept**<br>• **Structure and Function** – The shape and stability of structures of natural and designed objects are related to their functions. |

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| **Parents and Offspring: Behaviors**<br><br>**Bring Science Alive!**<br>Unit 1: Plant and Animal Parts<br>Lessons 5-8<br><br>Suggested Time Frame: 36 days | **1-LS1-2. Read texts and use media to determine patterns in** behavior of parents and offspring that help offspring survive.<br><br>**Science and Engineering Practice**<br>• **Obtaining, Evaluating and Communicating Information** – Read grade-appropriate texts and use media to obtain scientific information to determine patterns in the natural world.<br>**Disciplinary Core Idea**<br>• **LS1.B: Growth and Development of Organisms -** Adult plants and animals can have young. In many kinds of animals, parents and offspring themselves engage in behaviors that help the offspring to survive.<br>**Crosscutting Concept**<br>• **Patterns** – Patterns in the natural and human designed world can be observed, used to describe phenomena, and used as evidence. |
| **Light**<br><br>**Bring Science Alive!**<br>Unit 2: Light and Sound<br>Lessons 1 - 3<br><br>Suggested Time Frame: 30 days | **1-PS4-2. Make observations to construct an evidence-based account** that objects in darkness can be seen **only when illuminated.**<br><br>**1-PS4-3. Plan and conduct investigations to determine the effect of** placing objects made with different materials in the path of a beam of light.<br><br>**Science and Engineering Practice**<br>• **Planning and Carrying Out Investigations –** Plan and conduct investigations collaboratively to produce evidence to answer a question.<br>**Disciplinary Core Ideas**<br>• **PS4.B: Electromagnetic Radiation -** Objects can be seen if light is available to illuminate them or if they give off their own light.<br><br>**Crosscutting Concept**<br>• **Cause and Effect –** Simple tests can be designed to gather evidence to support or refute student ideas about causes. |

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| **Sound Waves**<br><br>**Bring Science Alive!**<br>Unit 1: Plant and Animal Parts<br>Lessons 4 - 6<br><br>Suggested Time Frame: 29 days | **1-PS4-1. Plan and conduct investigations to provide evidence** that vibrating materials **can make** sound and that sound **can make** materials vibrate.<br><br>**1-PS4-4. Use tools and materials to design and build** a device that uses light or sound **to solve the problem of communicating over a distance.**<br><br>**Science and Engineering Practices**<br>• **Planning and Carrying Out Investigations** – Plan and conduct investigation collaboratively to produce evidence to answer a question.<br>• **Constructing Explanations and Designing Solutions** – Use tools and materials provided to design a device that solves a specific problem.<br>**Disciplinary Core Idea**<br>• **PS4.A: Wave Properties -** Sound can make matter vibrate, and vibrating matter can make sound.<br>• **PS4.C: Information Technologies and Instrumentation -** People also use a variety of devices to communicate (send and receive information) over long distances.<br>**Crosscutting Concepts**<br>• **Cause and Effect** – Simple tests can be designed to gather evidence to support or refute student ideas about causes. |

**Materials for Investigations**: It is recommended that you keep track of the materials you use throughout the year so that you can replenish the necessary materials for the following year. All expenses for materials will be paid for by the building. A unit by unit materials checklist is provided on our website.

| **TCI Kit Materials** | | | | **Teacher/Student Provided Materials** | |
|---|---|---|---|---|---|
| Consumables Materials | | Non-Consumables Materials | | | |
| Aluminum foil, roll | | Bin, plastic, shoe box size | | Scissors | |
| Soil, potting | | Cloth, felt | | Glue sticks | |
| Craft Sticks, pkg/30 | | Overhead Transparency | | Tape | |
| Cotton Balls, pkg/300 | | Sponge | | Water | |
| Gloves, plastic, pkg/100 | | Mirrors, pkg/6 | | Paper Towels | |
| Seeds, Lima Bean | | Box, cardboard | | Spray Bottle | |
| Feathers, down, pkg/200 | | Flashlight | | Ice | |
| Shortening, sticks | | Jar, plastic, 12 oz | | Towels | |
| Cup, waxed paper, 200 mL | | Ruler | | Glue | |
| Balloons, round pkg/35 | | Tuning Fork, 256 vps | | Brown Paper Bag | |
| Bags, plastic sandwich size, pkg/80 | | Hermit Crab Habitat | | | |
| Rubber Bands, assorted | | **Non-consumables** are the materials that will be used over and over. However, sometimes things break or get lost so you may have to purchase something from this list at some point. Again, most things can be purchased at Wal-mart or the Dollar Store but some may need to be purchased through Ward's Science at https://wardsci.com/ . | | Beef Jerky | |
| Yarn | | | | Cardboard | |
| Batteries, size D, pkg/6 | | | | Fruit Juice | |
| Cardboard, whit, 8 1/2" X 11" | | | | Straw | |
| Pan, aluminum | | | | Cup | |
| **Consumables** are the materials that will need to be replenished yearly or bi-yearly. The cost of these materials will be covered through your building (Instructional expenses). Most of these items can be purchased at Wal-Mart or the Dollar Store. The highlighted item(s) will need to be purchased through Ward's Science at https://wardsci.com/. | | | | Index Cards | |
| | | | | Plastic plate | |
| | | | | Stapler | |
| | | | | Construction Paper | |
| | | | | Copy Paper | |
| | | | | Markers, Colored Pencils, Crayons | |
| | | | | Wax Paper | |
| | | | | Sticky Notes | |
| | | | | Newspaper | |
| | | | | Cloth | |
| | | | | Screen for Puppet Show | |
| | | | | Sand | |
| | | | | Cup or Bowl | |
| | | | | Paper Clips | |
| | | | | Envelopes | |
| | | | | **Teacher/student provided materials** are (for the most part) things that you have in your classroom already. Highlighted items will most likely need to be purchased for the investigations. They can be purchased at Wal-Mart or a hardware store. | |